



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 404 16TH AVENUE OVERPASS
REPLACEMENT AND WIDENING
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
SITE 37-666
G.W.P. 2930-17-00**

GEOCRES NO. 30M14-487

**Latitude 43.865195°
Longitude -79.375403°**

Report

to

WSP Canada Inc.

Date: January 30, 2018
File: 15786



TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	1
2.	PROJECT AND SITE DESCRIPTION.....	2
3.	SITE INVESTIGATION AND FIELD TESTING.....	3
4.	LABORATORY TESTING	6
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	6
5.1	Topsoil.....	7
5.2	Pavement Structure	8
5.3	Embankment Fill.....	8
5.4	Upper Silty Clay Till with Sand and Silt Interlayers.....	9
5.5	Silty Sand to Sand and Silt Till.....	11
5.6	Lower Silty Clay to Clayey Silt Till.....	12
5.7	Groundwater Conditions	13
6.	CORROSIVITY TEST RESULTS.....	15
7.	MISCELLANEOUS	15

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8.	GENERAL.....	18
9.	STRUCTURE CLASSIFICATION.....	20
10.	STRUCTURE FOUNDATIONS.....	20
10.1	Foundation Alternatives.....	20
10.2	Driven Steel H-Piles	22
10.2.1	Axial Resistance.....	23
10.2.2	Downdrag on Abutment Piles	24
10.2.3	Abutment Design Considerations	24
10.2.4	Lateral Resistance.....	25
10.2.5	Pile Installation	28
10.2.6	Frost Cover	29
11.	RETAINING WALLS	29
11.1	Stability of the Retained Soil System	31
11.2	Settlement of the Retained Soil System	32
12.	LATERAL EARTH PRESSURES	32
13.	APPROACH EMBANKMENTS	34
13.1	Settlement.....	34



13.2	Side Slope Stability	35
14.	EARTH CUT	36
14.1	Earth Cut Temporary Stability.....	37
15.	TEMPORARY EXCAVATION	38
16.	GROUNDWATER AND SURFACE WATER CONTROL.....	38
17.	TEMPORARY PROTECTION	39
18.	SEISMIC CONSIDERATIONS	40
19.	ADJACENT STRUCTURES AND BURIED UTILITIES	41
20.	CORROSION AND SULPHATE ATTACK POTENTIAL	42
21.	CONSTRUCTION CONCERNS.....	43
22.	CLOSURE	44

APPENDICES

Appendix A	Record of Borehole Sheets (Present Site Investigation)
Appendix B	Laboratory Test Results and Analytical Laboratory Test Results (Present Site Investigation)
Appendix C	Record of Borehole Sheets and Laboratory Test Results (Previous Site Investigation)
Appendix D	Selected Site Photographs
Appendix E	Borehole Locations and Soil Strata Drawings
Appendix F	Foundation Comparison
Appendix G	Selected Slope Stability Output
Appendix H	List of OPSS Documents and NSSP Wording



**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 404 16TH AVENUE OVERPASS
REPLACEMENT AND WIDENING
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
SITE 37-666
G.W.P. 2930-17-00**

GEOCRES NO. 30M14-487

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the design and construction of the proposed replacement and widening of the existing mainline bridge structures at the Highway 404 16th Avenue Overpass in the Regional Municipality of York, Ontario. The proposed works form a part of the project which includes rehabilitation and widening of Highway 404 with the addition of one High Occupancy Vehicle (HOV) lane in each direction from 407 ETR to Stouffville Road.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profiles and cross-sections, and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and approach cuts for the structures.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Assignment Number 2016-E-0014.

Reference has been made to information on subsurface conditions contained in previous foundation reports prepared for this site. The titles of these reports are as follows:



- Preliminary Foundation Investigation and Design Report for 16th Avenue Overpass Structures, Highway 404 HOV Lane Expansion from Highway 407 to Green Lane, WO 03-20024, Regional Municipality of York, Ontario, prepared by Peto MacCallum Ltd., PML Ref. 14TF003A-16, Index No. 037FIDR, GEOCRES No. 30M14-417, dated May 27, 2015. (Reference 1).
- Foundation Investigation and Design Report Highway 404-16th Avenue Overpass Widening, Town of Markham, prepared by Terraprobe, File No. 97430, MTO WO 97-23059; Site 37-666/2, GWP 293-89-00, GEOCRES No. 30M14-256a, dated November 17, 1998. (Reference 2).
- Engineering Materials Office, Foundation Design Section, Highway 404 Overpass Widening at 16th Avenue, WP 38-87-01, District 6, Site 37-366, Geocres 30M14-192, Dated October 27, 1988. (Reference 3).
- Foundation Investigation Report prepared by The Ministry of Transportation, W.P. 160-74-25, Dated 1970, 1971 and April 1977. (Reference 4).

2. PROJECT AND SITE DESCRIPTION

The site is located at the Highway 404 and 16th Avenue Overpass in the Region of York.

The project involves replacement of each of the existing northbound and southbound lane (NBL and SBL) bridges with a wider and longer two-span bridge, to address the Highway 404 median widening and the 16th Avenue widening. The widening of 16th Avenue at this location involves formation of a permanent cut on the north side of the existing road.

The approximate location of the proposed bridge replacement and widening is shown on the key plan on the Borehole Locations and Soil Strata Drawing in Appendix E.

The land use adjacent to the site is largely commercial. Buttonville Airport is located on the southeast side of the Highway 404 and 16th Avenue overpass.

Photographs of the site and surrounding areas are presented in Appendix D.

The site is located within the physiographic region known as the Peel Plain. The topography is flat to gently undulating. The soil cover in the region typically comprises silty clay glacial tills



with sand and silt layers. Shale bedrock of the Georgian Bay Formation is anticipated at an approximate depth of 50 m.

3. SITE INVESTIGATION AND FIELD TESTING

The current borehole investigation and field testing program for this site was carried out from May 31 to September 4, 2018 and consisted of drilling and sampling nine (9) boreholes, designated as Boreholes 16TH-01 to 16TH-09. These boreholes were drilled near the locations of the foundation elements and approaches.

Boreholes 16TH-03, 16TH-04, 16TH-05 were drilled near the proposed north abutment, Boreholes 16TH-06 and 16TH-07 were drilled near the proposed pier and south abutment, respectively, and ranged in depth from 29.6 m to 39.5 m (Elevations 150.8 to 166.5). Four boreholes, 16TH-01, 16TH-02, 16TH-08 and 16TH-09, were drilled near the immediate approaches to the bridge. Termination depths for the approach boreholes ranged from 9.8 m to 11.3 m (Elevations 183.9 to 185.4). The records of borehole sheets for the current investigation are included in Appendix A.

A geotechnical investigation was carried out at this site between June 3 and 10 in 1998 (Reference 2), and consisted of advancing two boreholes (labelled 101 and 102). Boreholes 101 and 102 were drilled within the median, near the north abutment and south approach, respectively, of the proposed replacement bridges. The depths of the boreholes were 36.6 m and 36.9 m (Elevations 158.5 and 158.6). The Record of Borehole sheets for the boreholes from this previous investigation are included in Appendix C.

Four boreholes (numbered 13 to 16) were drilled at the north and south abutments of the existing structure in 1988 (Reference 3). The boreholes were terminated at depths ranging from 36.8 m to 38.6 m (Elevations 151.0 to 153.1). The Record of Borehole sheets of Boreholes 13 to 16 are also included in Appendix C.

Six boreholes (numbered 3, 4, and 7 to 10) were drilled in proximity to the structure during geotechnical investigations conducted in 1970, 1971 and April 1977 (Reference 4). Boreholes 3, 4, 7 and 8 were terminated at depths ranging from 35.5 m to 40.4 m (Elevations 153.9 to 158.7), and Boreholes 9 and 10 at 12.7 m and 12.2 m (Elevations 181.5 to 182.0), respectively. Records of Boreholes 3, 4, and 7 to 10 are also included in Appendix C.



Lane closures and traffic control were planned for drilling each borehole for the current investigation. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The approximate locations of the boreholes from the current and previous investigations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix E. The coordinates and elevations of the boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendices A and C. Northing and easting co-ordinates at the current borehole locations were obtained by Thurber using a GPS unit, and the corresponding ground surface elevations were provided by WSP based on the project DTM survey. The precision of the horizontal survey of the boreholes is rated at within 1 m, whereas the precision of the elevation is the same as that of the DTM survey.

The current boreholes were advanced using a drill rig and track-mounted D-53 and D-55 drill rigs. Hollow stem augers were used to advance the boreholes, and soil samples were obtained at selected intervals using a 50-mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT). The tricone method was also used to advance Boreholes 16TH-03, 16TH-05, 16TH-06 and 16TH-07. In situ vane shear testing was carried out to assess the undrained shear strength firm cohesive deposits.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full-time basis. The supervisor logged the boreholes, visually examined the recovered soil samples, and transported them to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the current drilling operations. Five standpipe piezometers were installed during the current investigation at the abutments and approaches, to permit monitoring of groundwater levels. The standpipe piezometers consisted of a 19 mm diameter Schedule 40 PVC pipe with a 3.0 m long slotted screen and were installed within a column of filter sand. One standpipe piezometer was installed in Borehole 101 during the 1998 investigation. Upon completion, the boreholes were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372 (O.Reg. 903). Once the final readings are taken, the piezometers will be decommissioned in general accordance with O.Reg. 903. The details of current borehole completion are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit		Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth/ Elevation (m)	Completion Details
Hwy 404	South Approach	16TH-08	11.3/183.9	None installed	Borehole caved to 9.1 m. Borehole backfilled with bentonite holeplug and auger cuttings to surface.
		16TH-09	9.8/185.4	9.1/186.1	Piezometer with 3.0 m slotted screen installed with sand filter from 9.8 m to 5.5 m, bentonite holeplug from 5.5 m to 3.0 m, then auger cuttings from 3.0 m to ground surface.
	South Abutment	16TH-07	34.6/155.4	33.5/156.5	Borehole caved to 33.5 m. Piezometer with 3.0 m slotted screen installed with sand filter from 33.5 m to 22.2 m, bentonite holeplug from 22.2 m to 0.3 m, then concrete to from 0.3 m to ground surface.
	Pier	16TH-06	39.2/150.8	23.1/166.8	Piezometer with 3.0 m slotted screen installed with concrete from 39.2 m to 23.4 m, sand filter from 23.4 m to 19.0 m, bentonite holeplug from 19.0 m to 0.6 m, the concrete from 0.6m to ground surface.
	North Abutment	16TH-03	29.6/166.5	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
		16TH-04	39.5/156.2	39.5/156.2	Piezometer with 3.0 m slotted screen installed with sand filter from 39.5 m to 32.2 m, bentonite holeplug from 32.2 m to 25.8 m, bentonite mixed with auger cuttings from 25.8 m to ground surface.

		16TH-05	38.4/156.9	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	North Approach	16TH-01	11.3/184.2	7.6/187.9	Piezometer with 3.0 m slotted screen installed with sand filter from 11.3 m to 4.3 m, bentonite holeplug from 4.3 m to 2.4 m, bentonite mixed with auger cuttings from 2.4 m to ground surface.
		16TH-02	11.3/184.1	None installed	Borehole backfilled with 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 of current and previous investigations are summarized on the Record of Borehole sheets in Appendices A and C, 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 metal corrosion associated with the structure, a sample of the existing native soil was collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing for corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendices A and C for details of the encountered soil stratigraphy. A soil profile along the Highway 404 bridge alignment and sections along the foundation elements are presented on the "Borehole Locations and Soil Strata" drawings in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets



governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

Boreholes 3, 4, 7 to 10, 13 to 16, 101 and 102 from the previous geotechnical investigations conducted in 1971, 1972, 1977, 1988 and 1998 (References 2 to 4) have been incorporated in this report.

In general, the subsurface conditions encountered in the boreholes drilled during the current investigation consist of topsoil or pavement structure overlying embankment fill which typically consists of layers of sand and silty clay/clayey silt. Below the fill lies a native upper silty clay till with interlayers of sand to sand and silt. Silty sand to sand and silt till was encountered below the upper silty clay till. The above soils are underlain by a lower, hard silty clay to clayey silt till.

It is noted that previous records of boreholes from References 2 to 4 contain descriptions which did not refer to some soil deposits as tills. It is considered appropriate to describe such soil deposits as glacial tills based on further laboratory testing results and visual observations carried out during the present investigation. It is also noted that some of the older boreholes were advanced before the existing interchange was constructed. As such, many of the surficial soils may have been excavated, replaced or otherwise altered. The local groundwater table may also have been altered.

More detailed descriptions of the individual stratum are presented below.

5.1 Topsoil

A layer of topsoil was encountered surficially in Boreholes 16TH-01, 16TH-02, 16TH-04, 16TH-05, 16TH-08. The thickness of the topsoil ranged from 50 mm to 125 mm, except in Borehole 16TH-08 where the thickness is up to 800 mm.

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



5.2 Pavement Structure

Pavement structure consisting of approximately 175 mm of asphalt overlying granular (sand and gravel fill) road base was encountered in Boreholes 16TH-06 and 16TH-07 drilled from the 16th Avenue grade. Borehole 16TH-03, drilled in close proximity to the E-S ramp, revealed 200 mm of asphalt.

The thickness of the granular road fill measured in Boreholes 16TH-06 and 16TH-07 was 600mm.

5.3 Embankment Fill

Embankment fill was contacted below the pavement structure and the topsoil in Boreholes 16TH-01 to 16TH-02, 16TH-04, 16TH-05 and 16TH-08, and surficially in Boreholes 16TH-09, 13 to 16, 101 and 102. The embankment fill generally consists of layers of cohesionless and cohesive soils.

The cohesionless fill generally consists of brown to grey sand containing trace silt, trace to some gravel, and sandy silt containing some clay. The thickness of the cohesionless fill ranged from 0.5 m to 2.9 m. A 600 mm to 900 mm thick layer of sand and gravel fill was encountered in Boreholes 13 to 16.

In Boreholes 16TH-03, 16TH-04, 101 and 102, the cohesive fill consists of brown to grey silty clay to clayey silt, some to with sand and trace gravel. The thickness of the silty clay/clayey silt fill ranged from 1.4 m to 3.0 m.

In general, the depths to the base of the fill ranged from 0.6 m to 5.2 m depth (Elevations 190.9 to 195.1) in Boreholes 16TH-01 to 16TH-05, 16TH-08, 16TH-09, 101 and 102, which were drilled from the top of the Highway 404 embankments. In Boreholes 13 to 16, drilled from 16th Avenue grade, the depths of the base of the sand and gravel fill varied from 0.6 m to 0.9 m (Elevations 188.7 to 189.3).

SPT 'N' values for the cohesionless fill layer typically ranged from 11 to 28 blows per 0.3 m penetration indicating a generally compact state. An SPT 'N' value of 37 blows per 0.3 m of penetration was measured in the sand fill in Borehole 16TH-05, indicating a dense state.



Measured moisture contents of the cohesionless fill samples ranged from 8 percent to 23 percent.

SPT 'N' values measured in the cohesive fill ranged from 10 to 36 blows per 0.3 m penetration, indicating a stiff to hard consistency. Moisture contents measured in the cohesive fill ranged from 11 percent to 20 percent.

The results of grain size distribution analyses carried out on selected samples of the cohesionless fill are presented on the Record of Borehole sheets included in Appendices A and C. A grain size distribution curve of a sandy silt fill sample tested during the present investigation is presented in Figure B1 of Appendix B. The results of the grain size distribution analyses from present and past investigations are summarized below:

Soil Particle	Sand/Silt Fill (percent)	Silty Clay and Sand Fill
Gravel	0	6
Sand	24	43
Silt	63	44
Clay	13	7

5.4 Upper Silty Clay Till with Sand and Silt Interlayers

A native upper deposit of brown to grey silty clay till containing some sand to with sand and trace gravel was contacted below the topsoil and fill in all the boreholes at depths ranging from 0.6 m to 5.2 m. Interlayers of sand, silt, silty sand and, sand and silt were encountered within the upper silty clay till at various depths and elevations. Where fully penetrated, the thickness of the upper silty clay till ranged from 12.0 to 28.6 m. The sand and silt interlayers varied in thickness from 0.3 m to 5.0 m.

The depths to the base of the upper silty clay till varied from 15.5 m to 29.2 m (Elevations 180.2 to 160.7). Boreholes 16TH-01, 16TH-02, 16TH-08, 9 and 10, were terminated within the upper silty clay till at depths ranging from 11.3 m to 12.7 m (Elevations 181.5 to 184.2). Borehole 16TH-09 was terminated within the sand and silt interlayers at 9.8 m depth (Elevation 185.4).



SPT 'N' values for the upper silty clay till ranged from 2 to 94 blows per 0.3 m penetration, indicating a soft to hard consistency. The consistency generally increases with depth. Occasional SPT 'N' values greater than 100 blows for less than 0.3 m of penetration were measured in Boreholes 3, 4, 7 and 8 near Elevations 172.4 to 178.7. SPT 'N' values ranging from 4 to 6 blows per 0.3 m of penetration, was encountered from Elevations 187.0 to 182.0 in Boreholes 16TH-06 and 16TH-07. Within this zone, in situ vane shear tests indicated undrained shear strengths ranging from 20 to 86 kPa, which correspond to a typically soft to stiff consistency.

SPT 'N' values measured in the sand and silt interlayers typically ranged from 4 to 39 blows per 0.3 m of penetration, indicating a loose to dense state. An SPT 'N' value of 71 blows per 0.3 m of penetration, indicating a very dense state, was measured in Borehole 3. SPT 'N' values of 0 and 1 blows per 0.3 m of penetration, indicating a very loose state, were measured in Boreholes 16TH-08, 13, and 15 near Elevations 185.7, 170.5 and 178.3, respectively.

Moisture contents in the upper cohesive glacial till ranged from 10 to 37 percent, and moisture contents in the interlayers of sands and silts varied between 6 and 27 percent.

The results of grain size distribution analyses carried out on selected samples of the upper silty clay till and the interbedded sands and silts are presented on the Record of Borehole sheets included in Appendices A and C. Grain size distribution curves of samples tested during the present investigation are presented in Figures B2 to B4 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Upper Silty Clay Till (percent)	Sand and Silt Interlayers (percent)
Gravel	0 to 10	0
Sand	0 to 38	0 to 46
Silt	21 to 78	50 to 85
Clay	15 to 70	4 to 15
Silt and Clay	72	-



The results of Atterberg Limits tests conducted during the present investigation on samples of the upper silty clay till are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figures B7 and B8 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	19 to 42
Plasticity Index	8 to 24

The results of the Atterberg Limits testing indicate that the upper silty clay till is low to medium plastic with group symbols CL and CI.

Glacial tills inherently contain cobbles and boulders.

5.5 Silty Sand to Sand and Silt Till

A deposit of grey silty sand to sand and silt till containing some gravel and trace clay was contacted below the upper silty clay till at depths ranging from 14.7 m to 23.3 in Boreholes 16TH-03, 16TH-04, 16TH-05, 16TH-06 and 16TH-07 from the present investigation, and in Boreholes 3, 4, 13, 14, 15, 16, 101 and 102 from previous investigations. The thickness of the silty sand to sand and silt till ranged from 3.1 m to 13.0 m. The depth to the base of the cohesionless till ranged from 15.5 m to 21.6 m (Elevations 177.1 to 161.8).

In Boreholes 16TH-04, 16TH-05, 16TH-07, 3, 4, 14, 16 and 101, the silty sand to sand and silt till was found to contain interlayers of silty clay to clayey silt till. Below the cohesive till, the lower deposit of cohesionless till was encountered at depths ranging from 27.7 m to 36.8 m. The thickness of this lower cohesionless till varied from 1.6 m to 5.3 m. Boreholes 16TH-05, 3, 4, 101 and 102 were terminated within the silty sand to sand and silt till at depths ranging from 35.5 m to 38.4 m (Elevations 158.7 to 155.9).

Most SPT 'N' values for the silty sand to sand and silt till varied from 11 to 95 blows per 0.3m of penetration indicating typically compact to very dense state. SPT 'N' values ranging from 1 to 9 blows per 0.3 m of penetration indicate the presence of very loose to loose zones in Boreholes 16TH-07, 14, 15 and 101 near Elevations 160.0 to 172.2. SPT 'N' values higher than 100 blows for less than 0.3 m of penetration inferred the presence of cobbles and



boulders within the cohesionless till. Moisture contents measured in the cohesionless till ranged from 12 percent to 24 percent.

The results of grain size distribution analyses carried out on selected samples of the silty sand till and sand and silt till are presented on the Record of Borehole sheets included in Appendices A and C. Grain size distribution curves of samples tested during the present investigation are presented in Figure B5 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Silty Sand to Sand and Silt Till (percent)
Gravel	0 to 8
Sand	36 to 70
Silt	18 to 60
Clay	4 to 13

Glacial tills inherently contain cobbles and boulders.

5.6 Lower Silty Clay to Clayey Silt Till

A lower silty clay to clayey silt till, some sand to with sand and trace gravel was encountered in Boreholes 16TH-03, 16TH-04, 16TH-05, 16TH-06 and 16TH-07 from the present investigation, and in Boreholes 13, 14, 15 and 16 from previous investigations, below the silty sand to sand and silt till at depths ranging from 18.6 m to 33.0 m. In Borehole 16TH-04, this till was found to contain a zone of very dense silty sand till between depths of 36.8 to 38.4 m (Elevations 158.9 to 157.3).

Boreholes 16TH-04, 16TH-06, 16TH-07, and 13 to 16 were terminated within the lower silty clay to clayey silt till at depths ranging from 34.6 m to 40.4 m (Elevations 150.8 to 156.2). Borehole 16TH-03 was terminated at 29.6 m depth (Elevation 166.5).

SPT 'N' values in this lower cohesive till are typically greater than 30 blows per 0.3 m penetration indicating a hard consistency throughout. The higher SPT 'N' values measured near the borehole termination depth of greater than 100 blows for less than 0.3 m of



penetration inferred the presence of cobbles or boulders. SPT 'N' values of 7 and 8 blows per 0.3 m of penetration, indicating a firm consistency, were measured in the lower silty clay till near Elevations 164.5 and 167.8 in Boreholes 16TH-06 and 16TH-07, respectively. Moisture contents measured in this lower till ranged from 9 percent to 27 percent.

The results of grain size distribution analyses carried out on selected samples of the lower silty clay till are presented on the Record of Borehole sheets included in Appendices A and C. Grain size distribution curves of samples tested during the present investigation are presented on Figure B6 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Lower Silty Clay to Clayey Silt Till Percentage (%)
Gravel	0 to 4
Sand	0 to 37
Silt	37 to 83
Clay	17 to 62

The results of Atterberg Limits tests conducted on samples of the lower cohesive till are presented on the Record of Borehole sheets in Appendix A, and illustrated in Figure B9 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	28 to 31
Plasticity Index	13 to 15

The results of the Atterberg Limits testing indicate that the lower silty clay till is of low plasticity with a group symbol CL.

Glacial tills inherently contain cobbles and boulders.

5.7 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Standpipe piezometers were installed in Boreholes



16TH-01, 16TH-04, 16TH-06, 16TH-07 and 16TH-09 to permit monitoring of groundwater levels. During a previous investigation (Reference 1), one piezometer was installed in Borehole 101. Water levels measured in the six installed standpipes and open boreholes are presented in Table 5.1 below.

Table 5.1- Groundwater Level Measurements

	Borehole	Date	Groundwater Level		
			Depth (m)	Elevation (m)	
South Approach	16TH-08	May 31, 2018	8.5	186.7	Open borehole
	16TH-09	May 31, 2018	8.4	186.8	Open borehole
		August 22, 2018	6.0	189.2	Piezometer
	10	February 25, 1977	0.7	193.5	Open borehole
South Abutment	16TH-07	August 20, 2018	0.0	190.0	Piezometer
		October 9, 2018	0.8	189.2	
	3	January 15, 1971	0.4	193.8	Open borehole
	16	June 14 ,1988	0.7	189.2	Open borehole
	14	June 10, 1988	0.8	188.8	Open borehole
Pier	16TH-06	October 9, 2018	3.1	186.9	Piezometer
	4	December 9, 1970	0.2	193.8	Open borehole
	7	August 31, 1971	3.7	190.5	Open borehole
	8	August 24, 1971	3.4	190.5	Open borehole
	9	February 22, 1977	0.0	194.2	Open borehole
	13	June 21, 1988	1.0	188.5	Open borehole
	15	June 16, 1988	0.5	188.8	Open borehole
North Abutment	16TH-03	August 23, 2018	7.0	189.1	Open borehole
	16TH-04	August 22, 2018	6.7	189.0	Piezometer
	101	July 9, 1998	5.5	190.0	Piezometer
		November 11, 1998	5.7	189.8	
North Approach	16TH-01	June 4, 2018	4.6	190.9	Open borehole
		August 22, 2018	5.7	189.8	Piezometer
	16TH-02	June 1, 2018	6.1	189.3	Open borehole

The values shown in Table 5.1 are short-term readings, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY TEST RESULTS

Samples of the sandy silt fill, silty clay till and silty sand till from Boreholes 16TH-03 and 16TH-06 to 16TH-08, were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1 below. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1- Analytical Test Results

Parameter	Units (Soil)	Test Results			
		16TH-03 SS 5 Depth 3.0m	16TH-06 SS 9 Depth 9.9m	16TH-07 SS 15 Depth 22.0m	16TH-08 SS 4 Depth 2.3m
		Sandy Silt Fill	Silty Clay Till	Silty Sand Till	Silty Clay Till
Sulphide	%	0.05	0.15	0.05	0.03
Chloride	µg/g	1000	25	4.4	240
Sulphate	µg/g	180	220	63	120
pH	-	9.13	8.69	9.18	8.49
Electrical Conductivity	µS/cm	1020	199	106	646
Resistivity	Ohm.cm	980	5000	9500	1500
Redox Potential	mV	89	172	166	244

7. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates at this site, and WSP provided the ground surface elevations.

Walker Drilling of Utopia, Ontario, supplied and operated track-mounted D-53 and D-55 drill rigs to carry out the drilling, sampling and in-situ testing operations for the boreholes.

The drilling and sampling operations in the field were supervised on a full-time basis by Ms. Jacqueline Pigeon, Mr. Saeed Bastan and Mr. Bryan Lui of Thurber. Geotechnical laboratory

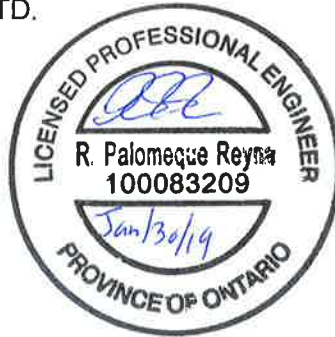


testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. Rocío Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.



Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer



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

Client: WSP
File No.: 15786

E file: H:\15000-15999\15786 Hwy 404 Widening 2016-E-0014\Reports and Memos\Contract 2\16th Avenue Interchange\FINAL\15786 16th Avenue Hwy 404 FIDR jan 19.docx

Date: January 30, 2018
Page: 17 of 45



**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 404 16TH AVENUE OVERPASS
REPLACEMENT AND WIDENING
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
SITE 37-666
G.W.P. 2930-17-00**

GEOCRES NO. 30M14-487

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation design recommendations to assist the design team to select and design a suitable foundation system and approach cuts for the proposed replacement and widening of the Highway 404 16th Avenue Overpass located in Markham, Ontario.

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 existing Highway 404 16th Avenue Overpass consists of two single-span structures, one for each of the Highway 404 northbound and southbound lane (NBL and SBL). Both existing structures are precast prestressed concrete girder twin bridges. Each bridge is supported on two abutments. According to available design drawings, the existing abutments are founded on battered HP 310 x 110 steel H-piles driven to refusal into the hard silty clay till at approximate Elevation 160.0 or to a depth in the order of 35.0 m. The bridge span is 20.4 m in length and 11.9 m in width. The approach slopes are in the order of 6.0 m high with a design inclination of 2H : 1V for the side and forward slopes. The existing grades of Highway 404 and 16th Avenue are at approximate Elevations 195.5 and 189.9 m, respectively.

Visual observations of the existing bridges did not reveal obvious signs of settlement or distress at the foundation elements. The approach slopes appeared to be stable with no obvious signs of instability. The slope faces were generally well vegetated.

Based on the preliminary General Arrangement (GA) drawing provided by WSP, dated August 2018, each of the existing bridges will be replaced by a new, wider and longer bridge. It is understood that 16th Avenue will be widened towards the north. Earth cut of approximately 5.5 m to 6.0 m in height will be required for the proposed widening of 16th Avenue. The new bridge will be a two-span structure supported on two integral abutments and one pier. The proposed length of each span is 22.8 m. The combined width of the new bridges will be approximately 69.5 m. The replacement structure will essentially span over the air gap between the two existing structures. It is understood that the new south abutment will be located approximately 1.5 m to 2.0 m away from the existing south abutment centreline. Information from WSP indicates that the replacement bridges will be constructed along the original Highway 404 alignment. Highway 404 grade within the structure limits will be at approximate Elevations 195.5 to 196.0, and 16th Avenue finished grade will be near Elevation 189.9. Each integral abutment is proposed to be supported on a single row of driven steel H-piles, and the pier is proposed to be supported on two rows of vertical driven H-piles.

The new north abutment will be located in a cut at about 22.5 m north of the existing north abutment. Based on the GA drawing, the new pier and the new south abutment will be located in close proximity to the existing north and south abutments, respectively. It is important to confirm that the new piles will not interfere with existing battered piles and that the minimum



separation between any adjacent piles, new or existing, will not be closer than 3 times the pile width, centre-to-centre.

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

9. STRUCTURE CLASSIFICATION

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

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

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

10. STRUCTURE FOUNDATIONS

The stratigraphy identified in the foundation investigations consisted primarily of topsoil/pavement structure and embankment fill overlying an upper firm to hard silty clay till containing sand and silt interlayers. Compact to very dense silty sand to sand and silt till was encountered below the upper silty clay till. The cohesionless till is underlain by a lower, typically hard silty clay to clayey silt till. The groundwater levels measured in the piezometers were generally at or just below 16th Avenue grade.

10.1 Foundation Alternatives

Based on the subsurface information discussed above and the design requirements, initial consideration was given to the following foundation types:



- Spread footings on native soils or engineered fill
- Augered caissons (drilled shafts) in hard glacial till
- Steel H-piles driven to a specified resistance.

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

Spread Footings on Native Soils or Engineered Fill

From geotechnical and constructability points of view, spread footings on native soils or engineered fill are not recommended at the abutments or pier due to the low geotechnical capacities available in the native firm to stiff silty clay till encountered at shallow depths. A suitable bearing stratum is not available within a reasonable and practical depth of excavation. In addition, post construction settlements are anticipated to occur if loaded footings are placed on these compressible native cohesive soils. Foundation recommendations for spread footings are therefore not developed further.

Augered Caissons (Drilled Shafts)

If integral abutments are not used, augered caisson foundations founded on the hard silty clay till and very dense silty sand till may be considered for foundation support of the proposed bridges at this site. However, this alternative carries a relatively high risk due to the presence of water-bearing cohesionless soils at this site. Construction of caissons through these soils will require use of a temporary steel liner and/or slurry methods to control the ingress of groundwater, support the sidewalls of the hole and mitigate basal instability. Potential loss of ground associated with caisson installation could have adverse impacts on the existing bridges. Accordingly, foundation recommendations for this alternative have not been developed further.

Driven Steel H-Piles

Given the subsurface conditions at the site, it is considered feasible to support the abutments and pier on steel H-piles driven to a specified resistance within the lower hard silty clay to clayey silt till and very dense silty sand till.

At the new south abutment and pier locations, the proposed H-piles are to be installed in close proximity to the existing battered H-piles. It is recommended that the designers reconfirm that

the proposed locations of the new piles are well clear of the existing piles. Prior to pile driving operations, it is imperative to expose and confirm the locations of the existing piles.

Vibration as a result of pile driving through the dense or stiff soils, and seating within hard silty clay till, could have adverse effects on the adjacent existing foundations and structures. A vibration and settlement monitoring program should be implemented before, during and after construction operations.

Recommended Foundations

An integral abutment design is considered feasible at this site. From a foundation engineering perspective and based on current information, the recommended abutment and pier foundations for the proposed Highway 404 NBL and SBL replacement bridges may consist of steel H-piles driven into the hard silty clay to clayey silt till and/or very dense silty sand till.

10.2 Driven Steel H-Piles

It is anticipated that the driven steel H-piles will achieve a specified resistance within the hard silty clay to clayey silt till and very dense silty sand till ("100-blow till").

For planning and design purposes, the estimated elevations at which the piles are expected to develop the required resistance are given in Table 10.1 below.

Table 10.1 – Estimated Pile Tip Elevations

Foundation Unit	Borehole	Approximate Embedded Pile Length⁽¹⁾ (m)	Approx. Pile Tip Elevation⁽²⁾ (m)
South Abutment	16TH-07 3 14 16	34 ⁽¹⁾	156
Pier	16TH-06 4 13 15	34 ⁽²⁾	154
North Abutment	16TH-04 101 16TH-05	32 ⁽¹⁾	158



- (1) Bottom of integral abutment CSP at approximate Elevation 190, and approximate pile cap underside at Elevation 188.
- (2) Piles could achieve capacity above or below the estimated elevations.

For piles achieving capacity above the estimated pile tip elevations in Table 10.1, an NSSP should be included in the contract to facilitate termination of pile driving and to avoid pile damage by overdriving (see Section 10.2.5 Pile Installation).

10.2.1 Axial Resistance

The proposed integral abutments will typically be supported on a single row of steel H-piles. A standard HP 310 X 110 pile section or heavier HP 360 x 174 section driven to a specified resistance into the “100-blow” till may be used. The pier may also be supported on two rows of steel H-piles driven to practical refusal. For axial resistance, the geotechnical resistances presented in Table 10.2 below may be used.

Table 10.2 – Design Axial Resistance for H-Piles

Foundation Element	Pile Section HP 310 X 110		Pile Section HP 360 X 174	
	Factored ULS (kN)	SLS (kN)	Factored ULS (kN)	SLS (kN)
North and south abutments And Pier	1,400	1,200	1,800	1,500

The above axial resistances were based on the pile tip elevations provided in Table 10.1.

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



geotechnical resistance 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.

10.2.2 Downdrag on Abutment Piles

Downdrag forces could be induced on piles embedded within the firm silty clay till deposit due to consolidation of the firm silty clay till under the weight of the new fill to be placed within the air gap at the south abutment. These forces can be minimized by sub-excavating some of the existing firm soils and replaced with compacted granular materials (see below for RSS design). Reference should be made to the CHBDC (2014) Clauses 6.11.4.10 and C6.11.4.10 (commentary) for downdrag calculations.

It is estimated that unfactored downdrag loads in the order of 350 kN and 400 kN per pile may act on each HP 310 x 110 and HP 360 x 174 pile, respectively. These values should be used to evaluate the impact of downdrag on the abutment piles. The location of the neutral plane for a pile or pile group should be determined by using unfactored loads and unfactored geotechnical parameters.

For structural design of a pile, the downdrag loads above should be multiplied by a load factor of 1.25 as per the CHBDC 2014. In accordance with the code, the sum of the factored downdrag load and the factored permanent loads acting on the pile should not exceed the structural resistance of the pile. In geotechnical analysis of downdrag, live load effects should not be considered.

10.2.3 Abutment Design Considerations

From a foundation engineering perspective, the conditions at this site are considered to be suitable for integral abutments.

For integral abutments, the flexibility of the upper portion of the pile is provided by a single corrugated steel pipe (CSP) system. For a single CSP system where the pile is installed through a 600 mm diameter, 3 m long, CSP, the void between the pile and the sidewall of the 600 mm CSP is to be backfilled with uncompacted uniformly graded sand. A double CSP system may be considered where typically a concentric 800 mm outer CSP and a 600 mm inner CSP are used. The sand for filling the hole is to be placed within the inner CSP, should



meet the gradation requirements presented in Table 10.3 and should be placed after driving the pile through the CSP.

Table 10.3 – Integral Abutment Sand Grading

Sieve Designation	Percentage Passing By Mass
2 mm (#10)	100%
600 µm (#30)	80% - 100%
425 µm (#40)	40% - 80%
250 µm (#60)	5% - 25%
150 µm (#100)	0% - 6%

Reference should be made to the integral abutment manual for details of the system.

10.2.4 Lateral Resistance

Lateral bridge loadings can be geotechnically resisted by the driven H-piles through passive pressure developed along the embedded portion of the piles below the CSPs under the abutment stems.

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (k_s) as follows:

Silty Clay Till (cohesive soils)

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

$$p_{ult} = 9 C_u \quad (\text{kPa})$$

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

Sands and Silts,

Silty Sand to Sand and Silt Till (cohesionless soils)

$$k_s = n_h \cdot z / B \quad (\text{kN/m}^3)$$



$$p_{ult} = 3 \cdot \gamma' \cdot z \cdot K_p \quad (\text{kPa})$$

where z = depth of embedment of pile, m
 B = width of pile, m
 n_h = coefficient related to soil density, kN/m^3 , Table 10.4
 γ' = bouyant unit weight of soil, kN/m^3 , Table 10.4
 K_p = passive earth pressure coefficient, Table 10.4

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, p_{ult} .

The spring constant, K , for analysis may be obtained by the expression, $K = k_s \times d_z \times B$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), B is the pile width (m), d_z is the length (m) of the pile segment 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 the contact between the pile and the surrounding soil, 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 coefficient of horizontal subgrade reaction values provided in Table 10.4 below.

Table 10.4 – 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
South Abutment	16TH-07 16 14	190.0 to 189.0	-	10*	3.0	3,000	Sand and gravel fill
		189.2 to 188.5	-	11*	3.2	4,000	Dense sand
		188.5 to 181.8	40	10*	-	-	Stiff to firm silty clay till

		181.8 to 180.0	-	11*	3.2	3,500	Compact silty sand
		180.0 to 172.0	150	11*	-	-	Very stiff to hard silty clay till
		172.0 to 168.0	-	11*	3.2	3,000	Compact to loose silty sand till
		168.0 to 162.0	150	11*	-	-	Hard silty clay till
		162.0 to 157.0	-	11*	3.4	6,000	Very dense sand and silt till/silty sand till
		157.0 to 155.5	250	11*	-	-	Hard silty clay till
North Abutment	16TH-04 101	195.5 to 193.5	-	20	3.0	3,000	Compact sand fill, silty clay fill
		193.5 to 192.0	-	20	3.0	3,000	Compact to loose sand
		192.0 to 189.0	50	20	-	-	Firm silty clay till
		189.0 to 186.0	-	11*	3.2	3,000	Compact sand and silt
		186.0 to 180.0	150	11*	-	-	Stiff to hard silty clay till
		180.0 to 177.0	-	11*	3.2	3,500	Compact silty sand till
		177.0 to 162.0	150	11*	-	-	Stiff to hard silty clay till
		162.0 to 159.0	200	11*	-	-	Hard clayey silt till



		159.0 to 157.0	-	11*	3.4	6,000	Very dense silty sand till
		157.3 to 156.0	250	11*	-	-	Hard clayey silt till

* Buoyant unit weight of cohesionless soil below water table

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

10.2.5 Pile Installation

All piles shall be installed in accordance with OPSS.PROV 903. An up to date version of an NSSP titled "Amendment to OPSS.PROV 903" is attached in Appendix H for inclusion into the tender document.

Pile driving must be controlled in accordance with Standard 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. In addition, high strain dynamic testing (also commonly known as PDA testing) should be carried out for selected piles as stipulated in the NSSP referenced above.

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

Glacially derived soils inherently contain cobbles and boulders. At this site, the piles will have to be driven through occasionally very dense or hard soils, and therefore difficult driving conditions should be expected near the design tip elevations. In order to protect the piles while being driven through boulders, cobbles and harder/denser zones to achieve the required tip elevations and soil resistance, it is recommended that the pile tips be reinforced with Titus Steel Standard H-points or an approved equivalent. Should a pile achieve the design ultimate



geotechnical resistance at an elevation higher than that indicated above, the Contract Administrator (CA) should be informed immediately. Over-driving must be avoided to minimize the risk of damaging the pile.

The Contract Documents must contain a NSSP alerting the Bidders to the pile driving conditions, testing, pile protection, avoidance of over-driving etc. as outlined above. Suggested texts for the NSSP are included in Appendix H.

10.2.6 Frost Cover

The design depth of frost penetration for this site is 1.4 m with reference to OPSD 3090.101. The undersides of all pile caps must be provided with at least 1.4 m of soil cover or its thermal equivalent.

11. RETAINING WALLS

The GA drawings dated August 2018 show that false abutments comprising Reinforced Soil Systems (RSS) will be used. The retaining walls will be approximately 10 m in length parallel to the highway. It is understood that the current design calls for the RSS walls to be stepped up from 16th Avenue grade towards Highway 404. The 16th Avenue grade is at approximate Elevation 190.

Final details regarding the alignment, height or design founding levels of the retaining walls are not available to date. The required lengths of the retaining walls will depend on the configuration of the new cut, road embankment and the proposed structures, as well as the length of any permanent open cut sections that may be feasible with inclined side slopes.

RSS walls used for this project must be specified to be “High Performance” and “High Appearance”. Therefore, it is important that the RSS walls be founded on soils capable of supporting the imposed loading and limiting settlements to within acceptable magnitudes.

Provided the RSS design takes into account the subsurface conditions at this site and proper foundation preparation is carried out prior to construction of the walls, RSS systems are expected to meet the aesthetic and structural requirements.



The GA drawing indicates that the front face of the RSS wall is proposed to be founded at approximate Elevations 188.0 and 188.5 at the south and north abutments, respectively. The RSS should be founded on the firm to very stiff silty clay till. Within this till, there are some firm to stiff zones at shallow depths below the proposed founding levels. In order to have an adequate and uniform geotechnical resistances for RSS design, it is recommended that sub-excavation be carried out to 1 m depth below final grade and the sub-excavation backfilled with a 1 m thick engineered fill pad, say between approximate Elevations 187 and 188.

For RSS walls founded on a 1 m thick engineered fill pad placed on the native, stiff to very stiff silty clay till with some firm zones, the recommended design factored geotechnical resistance at Ultimate Limit States (ULS) is 250 kPa and a geotechnical resistance at Serviceability Limit States (SLS) is 175 kPa, which corresponds up to 25 mm settlement.

Engineered fill placed under the RSS mass to achieve the design founding level must consist of OPSS Granular "A" compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC (2014) Clauses 6.10.3 and 6.10.4.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall or engineered granular fill in contact with the silty clay till may be estimated using an ultimate friction coefficient of 0.4. As per the CHBDC 2014, a resistance factor of 0.8 should be applied to the above value.

Topsoil, organics, loose fill, and any soft/wet material must be stripped from the footprint of the RSS. The subgrade under the RSS foundation should be inspected and any soft spots sub-excavated and replaced with compacted granular materials prior to placing fill. The subgrade preparation for the RSS wall and placement and compaction of the granular fill must be carried out in the dry.



The proprietary RSS system must meet MTO's specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall must be analyzed by the supplier/designer of the proprietary product selected for this site.

Lateral earth pressures acting on the walls should be computed as described in Section 12. If the wall is retaining sloping backfill, appropriate earth pressure parameters for sloping backfill should be used.

Reference should be made to MTO RSS Design Guideline (2008) and, the TAC Design, Construction, Maintenance and Inspection Guide for MSE Walls (2017) for design and construction of retaining wall structures.

RSS walls must be constructed in accordance with MTO RSS SP 599S22 and SP 599S23.

11.1 Stability of the Retained Soil System

Global stability of the RSS wall (false abutment) was conducted for a maximum 6.0 m high vertical wall founded on a 1 m thick granular pad placed on the native firm to very stiff silty clay till.

For the purpose of stability analyses, a commercially available slope stability program GEO-SLOPE was used and the Morgenstern-Price method was employed. It is noted that the selected analysis scenario only considers the lowest tier (front face) of the RSS block. The stability of the RSS wall was also checked under seismic loading assuming an acceleration of 0.13 g. The computed factors of safety are as shown in Table 11.1. Slope stability computation outputs are included in Appendix G.

Table 11.1 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix G)
RSS wall up to 6.0 m high (front portion only)		
Static Drained	> 2	G1
Seismic = 0.13 g	1.5	G2



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 long term (drained) conditions. Accordingly, the computed factors of safety are considered to be acceptable for the proposed RSS wall configuration.

The global stability of the RSS wall system must be analyzed after the final location and details of the wall are confirmed.

11.2 Settlement of the Retained Soil System

The new fill placed at this site will induce settlement in the general vicinity of the RSS walls. At the north abutment, it is estimated that immediate settlement of the retaining walls will occur as the wall is constructed. Total settlement is not expected to exceed 25 mm and post construction settlement should be negligible.

At the south abutment, immediate settlement of the retaining walls will occur as the wall is constructed and it is estimated that post construction settlement should not exceed 25 mm. The RSS wall supplier must be consulted if the proprietary can accommodate the settlement.

In general, inspection of the RSS walls and placing of additional granular material to re-establish grades should be implemented, as necessary, during and after construction.

12. LATERAL EARTH PRESSURES

Backfill to the abutment walls should consist of Granular A or Granular B Type II material meeting the requirements of OPSS.PROV 1010 and in accordance with OPSS 902. The backfill should be placed to the extents shown on OPSD 3101.150 where applicable.

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

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

where: p_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see Table 12.1)



- γ = unit weight of retained soil (see Table 12.1)
 h = depth below top of fill where pressure is computed (m)
 q = value of any surcharge (kPa).

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. Compaction equipment to be used adjacent to the walls 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 12.1.

Table 12.1 – 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) might be 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 C6.16 in the Commentary to the CHBDC 2014.

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

13. APPROACH EMBANKMENTS

Based on the preliminary GA drawing dated June 2018, the finished grade level of the Highway 404 is at approximate Elevation 195.5 m at the abutments. The finished grade level of 16th Avenue is near Elevation 190.0. The existing embankment fills are in the order of 5 m to 6 m in height with slope inclinations of 2H : 1V.

Placement of new fill on the existing forward slopes within the existing air gap will be required for the new bridge. Given that the existing median is more or less at grade, the majority of the new fill will be the backfill behind the new abutments. It must be noted that placement of new fill behind the south abutment will be about 5.5 m to 6.0 m high.

All embankment fill must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements. As abutment backfill, OPSS.PROV 1010 Granular A or B Type II materials should be used.

It is 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 must be provided for the slopes.

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. Any existing slope, where new fill is to be placed, must be benched in accordance with OPSD 208.010 prior to fill placement.

13.1 Settlement



Placement of new fill for the proposed highway inside widening, will induce immediate (elastic) and consolidation settlements in the underlying existing embankment fill and native firm silty clay till deposit with interbedded sands/silts layers.

North Abutment

Earth cut will be required to widen 16th Avenue to the north. Since the existing median grade is relatively close to the proposed Highway 404 grade, the additional fill that will be required to raise the grade should be within the range of 1.0 m to 1.5 m.

It is estimated that the magnitude of the immediate settlement would be less than 25 mm. This settlement is anticipated to take place as the fill is placed and be completed by the end of construction.

South Abutment

At the south approach, the existing median grade is also relatively close to the proposed Highway 404 grade; therefore, the additional fill that will be required to raise the grade should also be about 1.0 m to 1.5 m. However, the new abutment backfill will be up to 6.0 m high within the existing air gap immediately behind the new south abutment.

It is estimated that the total settlement under the new fill would be up to 50 mm with about one half of it occurring as the fill is placed. The magnitude of the consolidation settlement would be up to the order of 25 mm which is anticipated to take place within six months of fill placement.

The anticipated ground settlement at the south abutment, especially within the middle section corresponding to the existing air gap, could cause downdrag on the new piles that should be checked as outlined in section 10.2.2.

13.2 Side Slope Stability

The 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. The existing embankment fill typically comprises compact sand and stiff to very stiff silty clay overlying native typically stiff firm to hard silty clay till containing interlayers of loose to compact sands and silts, and will remain stable at an inclination of 2H : 1V.



The upper portion of the existing forward slopes within the air gap will be reconstructed to accommodate the replacement bridge. Analyses of global stability was conducted for a new forward slope configuration assuming a false abutment (RSS wall placed on a granular pad) founded on the firm to stiff silty clay till and presented in Section 11.1 of this report. This section presents the slope stability results of a typical side slope configuration. The maximum embankment height was estimated to be 5.5 m.

The computed factors of safety are as shown in Table 13.1. Graphical outputs of these analyses are included in Appendix G.

Table 13.1 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix G)
Side Slope, Maximum height: 5.5 m		
Static Drained	1.5	G3
Seismic	1.5	G4

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. The above factors of safety for the side slopes are considered to be acceptable for this site.

14. EARTH CUT

Earth cut is required for the proposed widening of 16th Avenue. The cut will be required on the north side and formed through about 5 m to 6 m of compact sand fill, firm to very stiff silty clay fill, into the native firm to hard upper silty clay till with interlayers of loose to compact sands and silts. The groundwater levels measured in the piezometers ranged 0.0 m to 6.7 m depth below ground surface (approximate Elevations 189 to 190).

Drainage will be required to remove water originating from storm runoff and seepage from the sides of the cut and cohesionless soils. It is recommended that the seepage be controlled by means of permanent drains incorporated within the abutment design.



Temporary drainage of the cuts should be provided to maintain a relatively dry, stable excavation.

Where space permits, permanent open cut slopes may be formed at inclinations not steeper than 2H : 1V.

Vegetative cover may be required on all exposed earth cut slopes to protect against surficial erosion. Reference may be made to OPSS.PROV 804.

Temporary protection (shoring) will be required for the temporary earth cut operations. Recommendations for temporary protection (shoring) are presented in Section 17 of this report. The cut slopes will be backfilled as part of the new north abutment construction.

14.1 Earth Cut Temporary Stability

Analyses of global stability was conducted for forward cut slope configuration assuming firm to hard silty clay till containing interlayers of loose to compact sands and silts with a 1.5H : 1V and 1H : 1V slope inclinations.

The computed factors of safety are as shown in Table 14.1. Graphical outputs of these analyses are included in Appendix G.

Table 14.1 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix G)
Cut Slope 1.5H : 1V		
Static Drained	1.4	G5
Static Undrained	1.4	G6
Cut Slope 1H : 1V		
Static Drained	1.3	G7
Static Undrained	1.3	G8

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. The factors of safety for 1.5H : 1V shown above are considered to be acceptable for the temporary cut slopes. For the 1H : 1V slopes, the factor of safety for drained conditions are considered marginal but may still be acceptable if adequate drainage



and erosion protection, as discussed in this report, are provided during construction. Alternatively, temporary protection (shoring) may be used to limit the size of the excavation required for new abutment construction.

15. 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.

Earth excavations for pile caps required at this site will penetrate through the embankment fill, native very loose to compact sand, and firm to stiff silty clay till. For the purposes of OHSA, the embankment fill and the native soils may be classified as Type 3.

All excavations must be carried out in a manner that avoids undermining or destabilising the foundations of the existing bridges and slopes.

Where required, construction will need to be carried out in conjunction with temporary protection (shoring) which is discussed in more details in Section 17 below.

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. The requirements for groundwater control during excavation are discussed in Section 16.

16. GROUNDWATER AND SURFACE WATER CONTROL

The groundwater levels measured in the piezometers ranged between 0 to 6 m depth below ground surface (approximate Elevations 189 to 190). Seasonal fluctuations of the groundwater level are to be expected.



The new abutments are expected to be constructed above the groundwater table. Seepage or perched water from the embankment is to be expected. Groundwater control measures such as perimeter ditches and pumping from filtered sumps should be implemented to remove any accumulation of water from the pile cap base prior to placing concrete. Surface runoff and precipitation should be diverted away from the excavations at all times. The possibility exists that additional pumps may be required if localized zones of perched water are encountered.

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. Filtered sumps must be properly designed to control loss of fines and ground loss. Suggesting wording for an NSSP in this regard is included in Appendix H.

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 and NSSP FOUN0003. It is recommended that a pre-construction condition survey of existing structures within 100 m of the piling locations be carried out prior to commencement of piling. There is no design engineer requirement for dewatering at this site.

17. TEMPORARY PROTECTION

It is anticipated that the replacement bridges will be constructed in stages and that at least one highway lane per direction will be maintained open for traffic at any given time.

Temporary protection (shoring) will be required during construction of the proposed bridges. An item titled "Protection System" as per OPSS.PROV 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 roadway protection 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. A temporary soldier pile and lagging wall may be designed using the geotechnical parameters given below:

$$\begin{aligned}\gamma &= 20 \text{ kN/m}^3 \\ \gamma_w &= 10 \text{ kN/m}^3\end{aligned}$$

K_a	=	0.33 (approach fills)
	=	0.31 (native sand, silty sand, silty sand till)
	=	0.31 (native silty clay till/clayey silt till)
K_p	=	3.0 (approach fills)
	=	3.2 (native sand, silty sand, silty sand till)
	=	3.2 (native silty clay till/clayey silt till)

It is recommended that lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2014. The surcharge should include soil loadings above the top of the pile and other loadings adjacent to the wall. A properly designed and constructed soldier pile and lagging wall will be permeable and therefore water pressure acting on the retained height may be set to zero. 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.

18. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. In general, the stratigraphy of the site consists of embankment fill consisting of compact sand and stiff to very stiff silty clay overlying interlayers of native firm to very stiff silty clay till and loose to compact sand to silty sand, which are underlain by deposits of very dense silty sand till and stiff to hard silty clay to clayey 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. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site, is 0.105 g as per the National Building Code of Canada (NBCC). The factored PGA for a 2% in 50-year probability of exceedance at this site is 0.13 g.

In accordance with Clause 4.6.5 of the CHBDC 2014, the abutments 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:



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})*	0.32	0.36
Passive (K_{PE})	3.5	3.1
At Rest (K_{OE})**	0.6	0.64

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

** After Woods

Based on the soil conditions outlined above, liquefaction is not considered to be a concern at this site.

19. 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.

Pile driving may be required at locations within 2 m from the edges of the adjacent existing bridges. Therefore, it is recommended that the following be carried out prior to commencement of foundation construction:

- Carry out pre-construction condition survey including documentation of any existing distress on the bridge foundations and super-structures.



- Implement a vibration and settlement monitoring program during and after construction of the new abutments to assess any potential adverse impact on the existing operating bridges. Suggested wording of this program is included in Appendix H.
- Inspection of the existing operating bridges during foundation construction to monitor if there is any movement or distress.
- The structural designers should assess the magnitude of settlement or horizontal displacement that would constitute a concern for the stability or serviceability of the existing operational structures prior to their demolition. These limits should be incorporated into the monitoring program as review and alert levels.

20. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of corrosivity and sulphate analytical tests conducted on selected soil samples during the current investigation are included in Appendix B. Based on the test results, the following statements can be made:

- The potential for sulphate attack on concrete from the surrounding fill and native soils is considered to be negligible due to the low concentration of sulphate and slightly alkaline pH values. However, the levels of chloride are high in the sandy silt till taken at 3.0 m depth (elevation 193.1), indicating a corrosive soil.
- The overall potential for corrosion on metal is considered moderate to very severe for the sandy silt fill and native silty clay till samples tested near Elevations 192.3 and 192.9 (3.8m and 2.3 m depth). It is anticipated, however, that the piles will not be affected since these elevations are higher than the proposed top of piles. Results from a sample of the silty sand till collected at 22 depth (Elevation 168) revealed that its potential for corrosion on metal is mild.
- The effects of road de-icing salts should also be considered when selecting the class of concrete and corrosion mitigation measures.



21. CONSTRUCTION CONCERNS

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

Interference and Impact on Existing Piles

- Care must be taken to ensure that interference with, and adverse impact on, existing piles will not occur during construction.

Protection of the Existing Structure and Roadway Remaining in Service

- During the staged construction of the highway widening structure and widening of 16th Avenue (earth cut), some of the existing structures and travelled lanes of the roadway are to remain in service. The Contractor must provide adequate protection to ensure that the performance of the existing foundations are not compromised and the existing roadway is protected.

Piles driven through the very dense/hard soils may achieve the required geotechnical resistance at varying elevations. These elevations must be checked against the design pile tip elevations to confirm that driving is not terminated prematurely. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a cobble/boulder. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the Contract Administrator (CA). If the CA cannot resolve the issue, it must be referred to the design team for resolution.

- During borehole drilling, there was no direct indication of the presence of cobbles and boulders within glacially derived deposits. However, glacial till inherently contains cobbles and boulders which may affect installation of H-piles. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the piles to design tip elevations.
- Settlement monitoring of the existing bridge foundations and buried utilities close to the work areas during construction is recommended. In addition, vibration monitoring and pre-construction condition survey may also be required.
- Abutment construction and earth cut must be carried out in the dry. Diversion of surface runoff, precipitation and other forms of temporary dewatering may be required.

Impact of excavation on the existing pavement surface

- Daily visual inspection of the highway pavement surface must be carried out in the vicinity of the construction works. If cracks form in the pavement or settlement is observed to occur, these matters must immediately be brought to the attention of the CA for determining if further action is required.
- Confirmation that the backfill to the abutments are adequately placed and compacted to specifications.

Existing Slopes and Temporary Cut Slopes

- The forward and side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, remedial measures such as re-vegetation and/or placement of gravel sheeting may be required.
- For temporary earth cut, the slopes should be inspected for surficial disturbance.

Earth Cut, Excavation and Dewatering

- For new abutment construction, adequate shoring must be in place to maintain stability of the excavation and to prevent loss of ground under the structure or embankment. Seepage and perched groundwater may be encountered within the embankment fill. The impact of seepage or surface water could destabilize the sides and or base of the excavation. Proper groundwater and surface water control measures must be in place prior to commencing excavation.

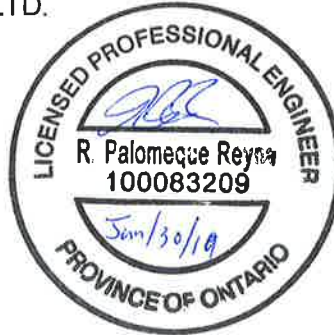
It is recommended that provision(s) be included in the contract requiring the Contractor to confirm that the above issues are adequately addressed. Should there be any doubts about issues such as pile driving and pile termination, these provision(s) should require the Contractor to retain qualified geotechnical personnel to assess the site conditions and to alert the Contract Administrator.

22. CLOSURE

Engineering analysis and preparation of the foundation design report was conducted by Ms. Rocío Palomeque Reyna, P.Eng and Dr. Sydney Pang, P.Eng. Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.



THURBER ENGINEERING LTD.



Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer



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

Client: WSP
File No.: 15786

E file: H:\15000-15999\15786 Hwy 404 Widening 2016-E-0014\Reports and Memos\Contract 2\16th Avenue Interchange\FINAL\15786 16th Avenue
Hwy 404 FIDR jan 19.docx

Date: January 30, 2018
Page: 45 of 45



Appendix A

Record of Borehole Sheets

(Present Site Investigation)

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

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


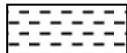



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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 16TH-01

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 407.9 E 314 803.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.01 - 2018.06.04 LATITUDE 43.865575 LONGITUDE -79.375544 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						
195.5	GROUND SURFACE							20	40	60	80	100		
0.0	TOPSOIL: (125mm)													
0.1	SAND, trace silt, trace gravel Compact Brown		1	SS	19		195							
194.7	Moist (FILL)													
0.8	Silty CLAY, with sand, trace gravel Very Stiff Brown		2	SS	18		194							
193.9	Moist (TILL)													
1.6	SAND, some silt Compact Brown		3	SS	14		193							
193.2	Moist													
2.3	Silty CLAY, with sand, trace gravel Stiff to Very Stiff Brown to Grey Moist (TILL)		4	SS	10		192							
			5	SS	17		191							
191.8	SAND, some silt, occasional cobbles Compact Grey Wet						190							
3.7			6	SS	11		189							
							188							
189.4	Silty CLAY, with sand, trace gravel Stiff Grey Wet (TILL)		7	SS	12		187							
6.1							186							
186.7	SAND, some silt Grey Wet		8	SS	15									
8.8														
186.3	Hard		9	SS	59									
9.2														

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-01 2 OF 2 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 407.9 E 314 803.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.01 - 2018.06.04 LATITUDE 43.865575 LONGITUDE -79.375544 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 (%) 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					W _p	W	W _L			
184.2	Silty CLAY , with sand, trace gravel Hard Grey Wet (TILL)		10	SS	50		185											
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 4.6m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.22 5.7 189.8 2018.11.23 4.8 190.7																	


METRIC[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

RECORD OF BOREHOLE No 16TH-02 2 OF 2 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 407.4 E 314 812.8 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.01 - 2018.06.01 LATITUDE 43.865570 LONGITUDE -79.375430 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									
184.1	Continued From Previous Page Silty CLAY , with sand, trace gravel Very Stiff Grey Moist (TILL)		10	SS	25		185										
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 6.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No 16TH-03

1 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 390.2 E 314 777.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.20 - 2018.08.23 LATITUDE 43.865416 LONGITUDE -79.375868 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			
196.1	GROUND SURFACE							20 40 60 80 100			
0.0	ASPHALT: (200mm)						196	20 40 60 80 100			
0.2	SAND, trace gravel Brown Moist (FILL)		1	GS				20 40 60 80 100			
195.3								20 40 60 80 100			
0.8	Silty CLAY, with sand, trace gravel Stiff to Very Stiff Brown Moist (FILL)		1	SS	15		195	20 40 60 80 100			
								20 40 60 80 100			
			2	SS	18		194	20 40 60 80 100			
193.8								20 40 60 80 100			
2.3	Sandy SILT, some clay Compact Brown Moist (FILL)		3	SS	28		193	20 40 60 80 100			
								20 40 60 80 100			
			4	SS	27		192	20 40 60 80 100			
								20 40 60 80 100			
			5	SS	22		191	20 40 60 80 100			
190.9								20 40 60 80 100			
5.2	Silty CLAY, some sand, trace gravel Firm to Very Stiff Grey Wet (TILL)		6	SS	6		190	20 40 60 80 100			
								20 40 60 80 100			
							189	20 40 60 80 100			
			7	SS	19		188	20 40 60 80 100			
188.5								20 40 60 80 100			
7.6	SAND and SILT, trace to some clay, trace gravel Compact Grey Wet		8	SS	26		187	20 40 60 80 100			

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-03

2 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 390.2 E 314 777.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.20 - 2018.08.23 LATITUDE 43.865416 LONGITUDE -79.375868 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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
								20 40 60 80 100	20 40 60								
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
185.1	SAND and SILT , trace to some clay, trace gravel Dense Grey Wet		9	SS	39		186						○			0 46 50 4	
11.0	Silty CLAY , with sand, trace to some gravel Very Stiff to Hard Grey Wet (TILL)						185						○				
							184										
							183						○				
							182										
							181						○				
							180										
							179						○				
							178							○			
							177										
		178.3															
17.8	Silty SAND , trace gravel Dense Grey Moist to Wet (TILL)		14	SS	37								○				
	Cobbles from 19.8m to 20.4m																

Continued Next Page

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

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div> <div>UNIT WEIGHT γ</div> <div>REMARKS & GRAIN SIZE DISTRIBUTION (%)</div>					
	Continued From Previous Page				
171.4	Silty SAND, trace gravel, trace to some clay, occasional cobbles Compact Grey Moist to Wet (TILL)		15 SS 14		176
24.7	Silty CLAY, trace sand, trace gravel Very Stiff Grey Moist (TILL)		16 SS 11		173
			17 SS 19		170
	Occasional inferred cobbles at 28.5m		18 SS 27		167
166.5	END OF BOREHOLE AT 29.6m. WATER LEVEL IN OPEN BOREHOLE AT 7.0m DEPTH UPON				
29.6					

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16TH-03

4 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 390.2 E 314 777.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.20 - 2018.08.23 LATITUDE 43.865416 LONGITUDE -79.375868 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									
	Continued From Previous Page																
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No 16TH-04 1 OF 5 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 397.5 E 314 804.7 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.06 - 2018.06.12 LATITUDE 43.865481 LONGITUDE -79.375532 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						
195.7	GROUND SURFACE							20	40	60	80	100		
0.0	TOPSOIL: (50mm) SAND , some silt, trace clay and gravel, occasional organics Compact Brown Moist (FILL)		1	SS	15								○	
195.1	Silty CLAY , some sand, trace gravel Very Stiff to Stiff Brown Moist (FILL)		2	SS	17								○	
193.7			3	SS	11								○	
2.0	SAND , some silt Compact to Loose Brown Moist		4	SS	18								○	
			5	SS	8								○	
192.2	Silty CLAY , trace sand Firm Grey Moist (TILL)		6	SS	4								○	
3.5			7	SS	6								○	
189.0	SAND and SILT , trace clay Compact Grey Wet		8	SS	12								○	
6.7			9	SS	20								○	
186.6	Silty CLAY , some sand to sandy, trace gravel Very Stiff Grey Wet (TILL)													
9.1														

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16TH-04

3 OF 5

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 397.5 E 314 804.7 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.06 - 2018.06.12 LATITUDE 43.865481 LONGITUDE -79.375532 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								
	Continued From Previous Page															
	Silty CLAY , some to trace sand, trace gravel Stiff to Hard Grey Wet (TILL)		18	SS	11		175									
							174									
							173									
			19	SS	31		172									
							171									
							170									
			20	SS	24		169									0 0 55 45
							168									
							167									
							166									

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-04

4 OF 5

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 397.5 E 314 804.7 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.06 - 2018.06.12 LATITUDE 43.865481 LONGITUDE -79.375532 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 (%)
	Continued From Previous Page		21	SS	24			20	40	60	80	100					
	Silty CLAY , trace sand Very Stiff to Hard Grey Moist (TILL)																
161.4																	
34.3	Clayey SILT , trace sand, trace gravel Hard Grey Moist (TILL)		22	SS	31												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16TH-04

5 OF 5

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 397.5 E 314 804.7 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.06 - 2018.06.12 LATITUDE 43.865481 LONGITUDE -79.375532 CHECKED BY RPR

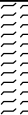

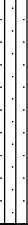
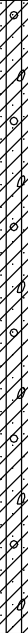

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page pipe with a 3.05m slotted screen.																
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.22 6.7 189.0 2018.11.23 5.2 190.5																

RECORD OF BOREHOLE No 16TH-05

1 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
195.3	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL , rootlets, grass Dark Brown Moist (800mm)		1	GS			195							
194.5														
0.8	SAND , trace gravel Dense Brown Moist (FILL)		1	SS	37		194							
193.9														
1.4	Sandy SILT , trace gravel, trace clay Compact Brown Moist		2	SS	29		193							
			3	SS	19		192							
192.3														
3.0	Silty CLAY , trace sand, trace gravel Stiff to Firm Grey Moist (TILL)		4	SS	9		191							
			5	SS	7		190							
			6	SS	5		189							
188.1														
7.2	SAND and SILT , trace to some clay, trace gravel Compact to Dense Grey Moist		7	SS	26		188							
							187							
			8	SS	32		186							

Augers grinding
at 9.9m

Continued Next Page

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

Augers grinding
at 9.9m

RECORD OF BOREHOLE No 16TH-05

2 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 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									
183.1	SAND and SILT , trace to some clay, trace gravel Dense Grey Moist		9	SS	47		185											0	36	60	4
							184														
12.2	Silty CLAY , with sand, trace to some gravel Stiff Grey Moist (TILL)		10	SS	14		183														
							182														
			11	SS	13		181														
							180														
			12	SS	11		179														
							178														
	Hard to Very Stiff		13	SS	47		177											1	27	44	28
							176														
			14	SS	29																

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-05

3 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 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 (%) 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				
	Silty CLAY , trace to some sand, trace to some gravel Hard Grey Moist (TILL)		15	SS	41		175							○		
							174									
							173									
172.0			16	SS	45		172							○		
23.3	SAND and SILT , trace to some clay, trace gravel Dense to Compact Grey Moist (TILL)						171									
							170									
			17	SS	11		169							○		
168.5																
26.8	Silty CLAY , trace to some sand, trace gravel Very Stiff Grey Moist (TILL)						168									
							167									
	Occasional inferred cobbles		18	SS	27		166							○		

Augers grinding at 24.4m

8 45 34 13

Continued Next Page

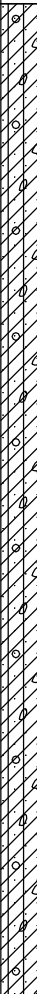
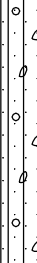
+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16TH-05

4 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT			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					
158.7	Silty CLAY , trace to some sand, trace gravel Very Stiff to Hard Grey Moist (TILL)						165										1 73 20 6
							164										
			19	SS	20		163										
							162										
							161										
36.6	Silty SAND , trace clay, trace gravel Very Dense Grey Moist (TILL)		20	SS	101/ 0.125		160										
							159										
							158										
156.9			21	SS	102/ 0.075												
38.4	END OF BOREHOLE AT 38.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.		22	SS	100/ 0.125		157										

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

RECORD OF BOREHOLE No 16TH-06

1 OF 5

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 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					
190.0	GROUND SURFACE												
0.0	ASPHALT: (175mm)												
0.2	SAND and GRAVEL Brown Moist (FILL)		1	GS									
189.2													
0.8	SAND, trace gravel, trace silt Dense to Compact Brown to Grey Moist		1	SS	33		189						
			2	SS	23		188						
187.7													
2.3	Silty CLAY, trace sand, trace gravel Very Stiff to Firm Grey Moist (TILL)		3	SS	21		187						
			4	SS	6								
			5	SS	5		186						
			6	SS	12		185						
	Stiff						184						
183.3													
6.7	Silty SAND, trace clay Compact Grey Wet		7	SS	20		183						
							182						
181.3			8	SS	22								
8.7	Silty CLAY, some sand, trace gravel Very Stiff Grey Wet (TILL)						181						

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-06

2 OF 5

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 374.0 E 314 817.1 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.13 - 2018.06.15 LATITUDE 43.865269 LONGITUDE -79.375377 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					W _P W W _L WATER CONTENT (%)				GR	SA	SI	CL	
	Continued From Previous Page							20	40	60	80	100									
	Silty CLAY , some sand, trace gravel Stiff Grey Moist (TILL)		9	SS	11		179							○							
			10	SS	12		178							○							
177.5																					
12.5							177							○							
	Hard		11	SS	58		176							○							
			12	SS	75		175							○							
			13	SS	57		174							○							
			14	SS	30		173							○							
			15	SS	27		172							○							
170.4							171							○							
19.6	Silty SAND , some gravel Compact																	0	5	66	29

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div> <div>UNIT WEIGHT γ</div> <div>REMARKS & GRAIN SIZE DISTRIBUTION (%)</div> <div>GR SA SI CL</div>					
	Continued From Previous Page				
157.4	Silty SAND, trace gravel, trace clay Very Dense Grey Wet (TILL)		19 SS 100/ 0.125		
32.6	Silty CLAY, with sand, trace gravel Hard Grey Moist (TILL)		20 SS 68		
			21 SS 100/ 0.200		
			22 SS 100/ 0.250		
150.8			23 SS 100/ 0.175		
39.2	END OF BOREHOLE AT 39.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.				

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16TH-07

2 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 357.8 E 314 812.8 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.25 - 2018.06.27 LATITUDE 43.865124 LONGITUDE -79.375431 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT 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
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE									
	Continued From Previous Page																			
10.0	Silty CLAY , some sand, trace gravel Very Stiff to Hard Grey Wet (TILL)		8	SS	17															
			9	SS	17															
			10	SS	17															
			11	SS	62															
			12	SS	35															
			13	SS	21															
171.1																				
18.9	Silty SAND , some clay, trace gravel Compact Grey Wet (TILL)		14	SS	19															
170.0																				

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 1/31/19

RECORD OF BOREHOLE No 16TH-07 4 OF 4 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 357.8 E 314 812.8 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.06.25 - 2018.06.27 LATITUDE 43.865124 LONGITUDE -79.375431 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									
	Continued From Previous Page				0.200			20	40	60	80	100					
	SAND and SILT Very Dense Grey Wet (TILL)						159										
157.7			19	SS	100/ 0.100												
32.3	Silty CLAY , some sand, trace gravel Hard Grey Moist (TILL)						158										
			20	SS	65		157										
155.4							156										
			21	SS	100/ 0.175												
34.6	END OF BOREHOLE AT 34.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 6.10m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.20 0.0 190.0 2018.10.09 0.8 189.2																

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

RECORD OF BOREHOLE No 16TH-08

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 338.4 E 314 812.1 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.05.31 - 2018.05.31 LATITUDE 43.864949 LONGITUDE -79.375440 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
195.2	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL: (100mm)							20	40	60	80	100							
0.1	Silty SAND , trace clay and gravel, occasional organics Compact Brown Moist (FILL)		1	SS	14		195							○					
			2	SS	21		194							○					
193.8																			
1.4	Silty CLAY , with sand, trace gravel Firm to Stiff Grey Moist (TILL)		3	SS	6		193							○					
			4	SS	7									○					
			5	SS	9		192							○					
			6	SS	6		191							○					
			7	SS	8		189							○					
			8	SS	10		188												
			9	SS	11		187							○					
186.7							186							○					
8.5	SAND and SILT , trace clay, trace gravel Compact to Very Loose Grey Wet		10	SS	0*														

▽

0 0 85 15

0 40 56 4

* Disturbed due to drilling

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-08

2 OF 2

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 338.4 E 314 812.1 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.05.31 - 2018.05.31 LATITUDE 43.864949 LONGITUDE -79.375440 CHECKED BY RPR



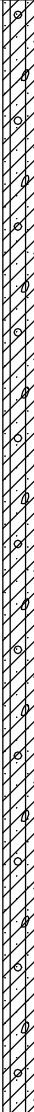


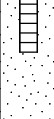
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	SHEAR STRENGTH kPa		WATER CONTENT (%)							
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
184.2	SAND and SILT , trace clay Compact Grey Wet		11	SS	14		185											
11.0	Silty CLAY , some sand, trace gravel																	
183.9	Stiff Grey																	
11.3	Wet (TILL)						184											
END OF BOREHOLE AT 11.3m. WATER LEVEL AT 8.5m AND BOREHOLE CAVED TO 9.1m DEPTH UPON COMPLETION. BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																		

RECORD OF BOREHOLE No 16TH-09

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 344.4 E 314 828.2 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.05.31 - 2018.05.31 LATITUDE 43.865003 LONGITUDE -79.375240 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						
195.2	GROUND SURFACE													
0.0	Silty SAND , some gravel, trace clay, occasional organics Compact Brown to Grey Moist (FILL) black silt seams		1	SS	13		195							0 38 35 27
			2	SS	12		194							
193.8														
1.4	Silty CLAY , with sand, trace gravel Stiff Grey Moist (TILL)		3	SS	11		193							
			4	SS	9									
			5	SS	14									
			6	SS	10									
			7	SS	8									
			8	SS	15									
186.4														
8.8	SAND and SILT , trace to some clay Compact Grey Wet		9	SS	15		186							
185.4														
9.8	END OF BOREHOLE AT 9.8m.													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16TH-09

2 OF 2

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 344.4 E 314 828.2 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.05.31 - 2018.05.31 LATITUDE 43.865003 LONGITUDE -79.375240 CHECKED BY RPR

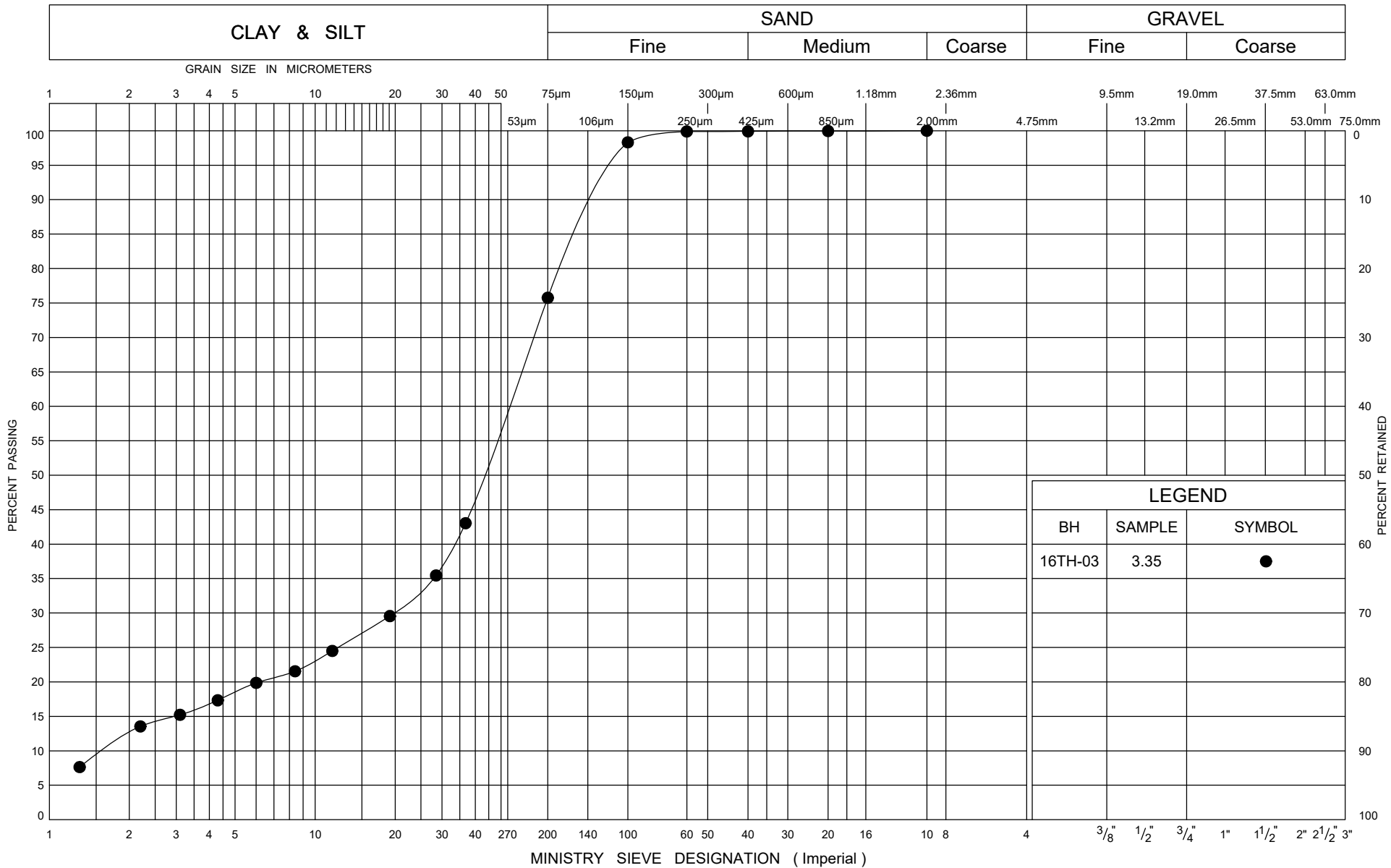
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	WATER LEVEL AT 8.4m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.22 6.0 189.2 2018.11.23 4.8 190.4																

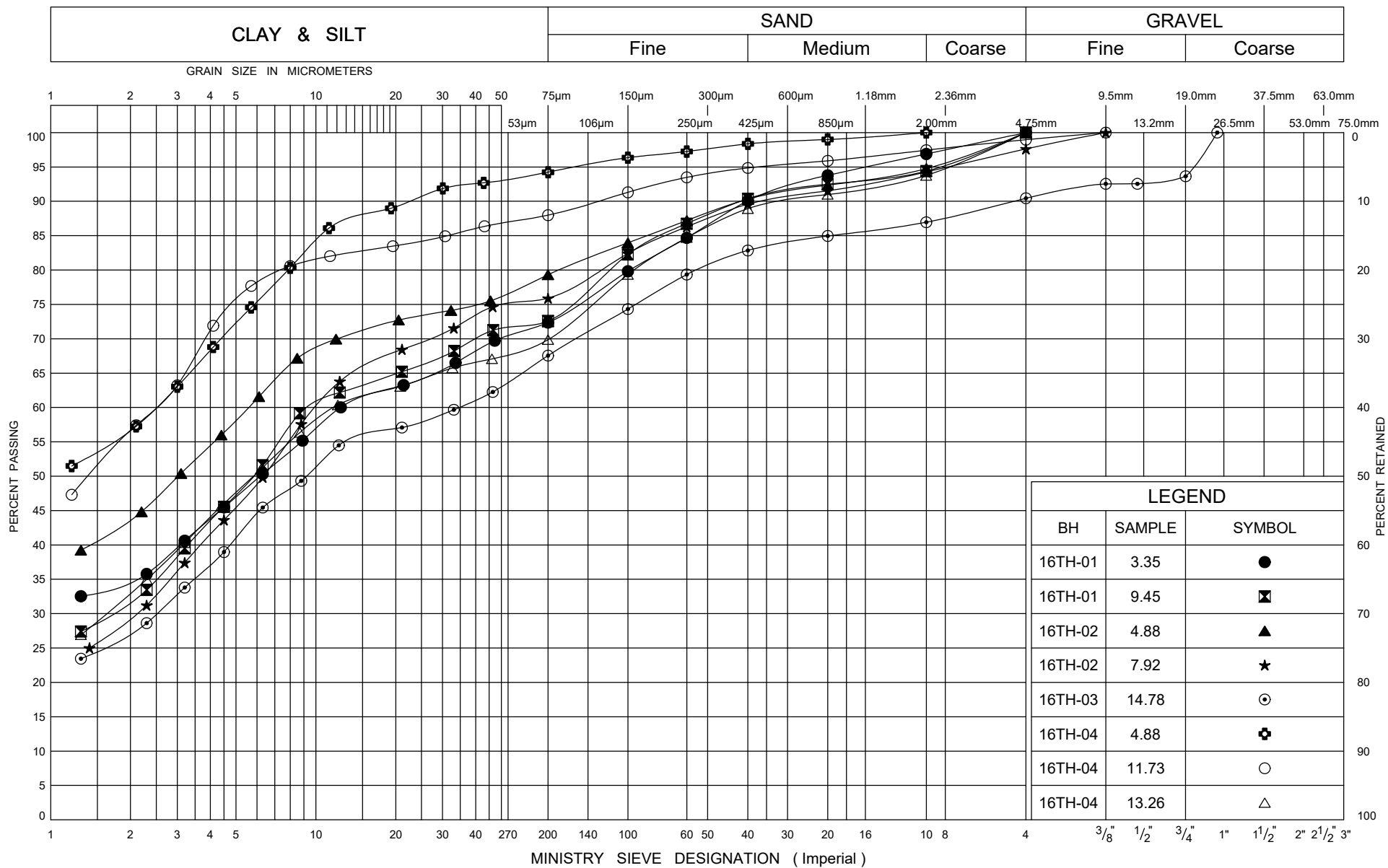


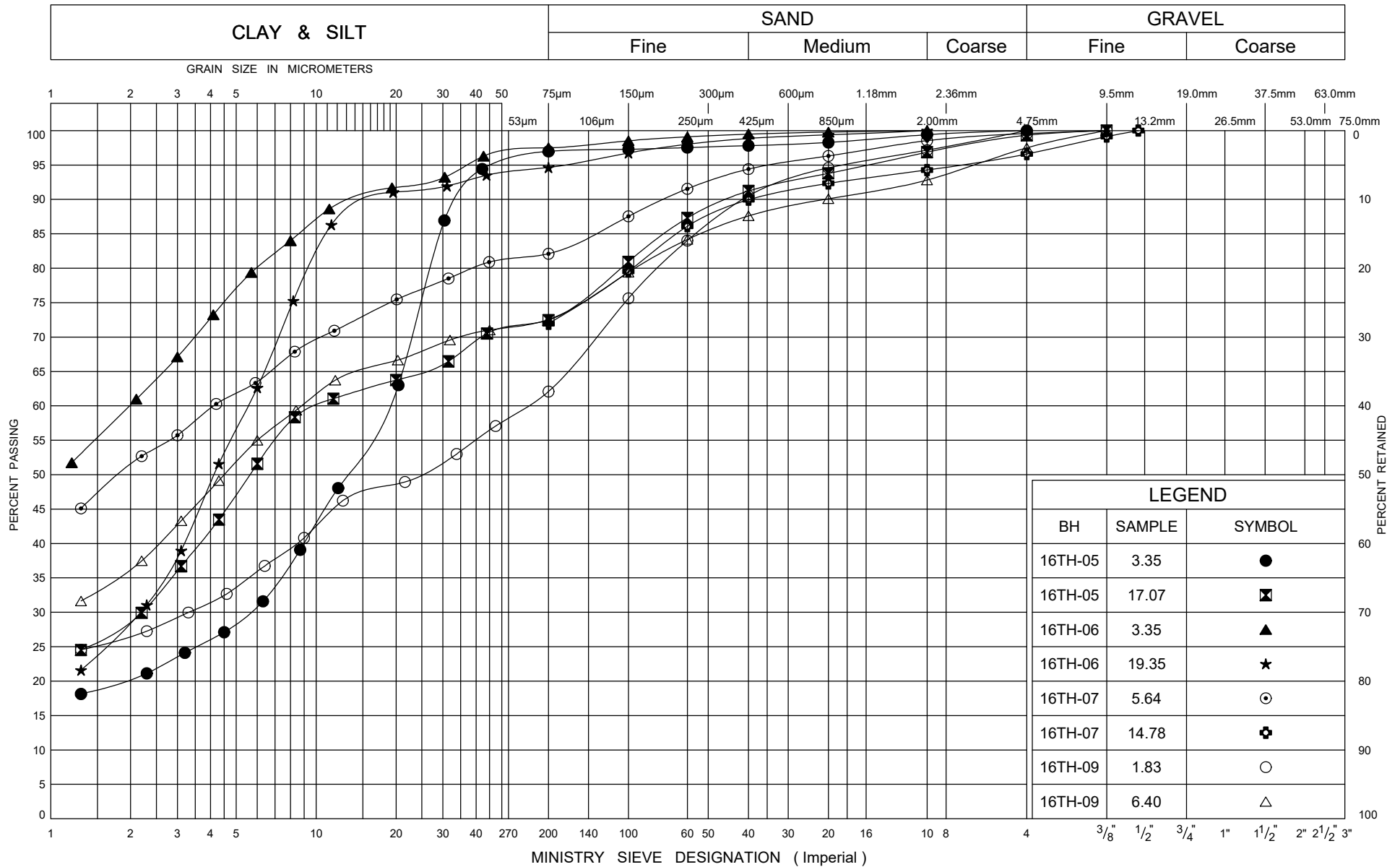
Appendix B

Geotechnical and Analytical Laboratory Test Results

(Present Site Investigation)







Ministry of
Transportation

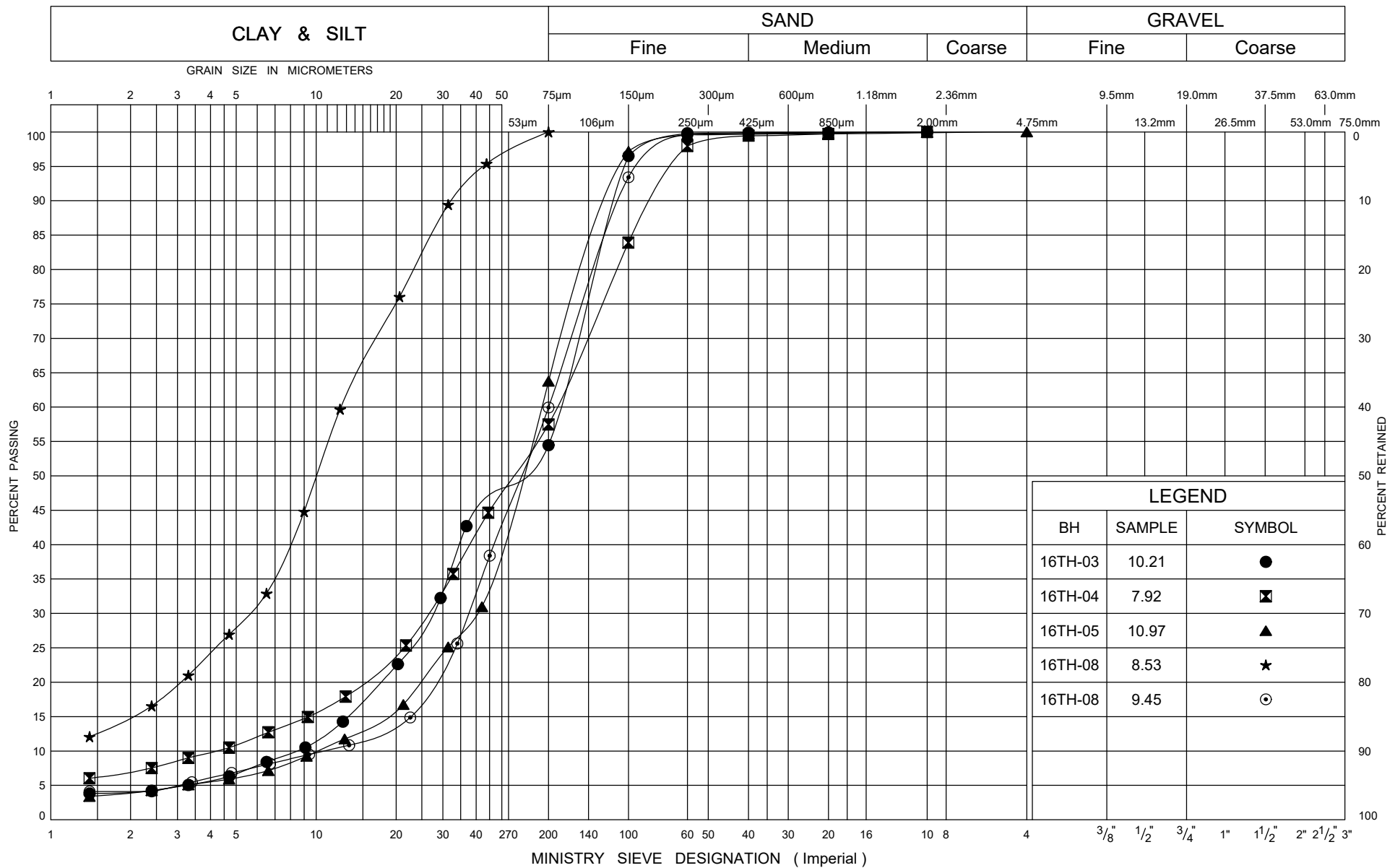
GRAIN SIZE DISTRIBUTION

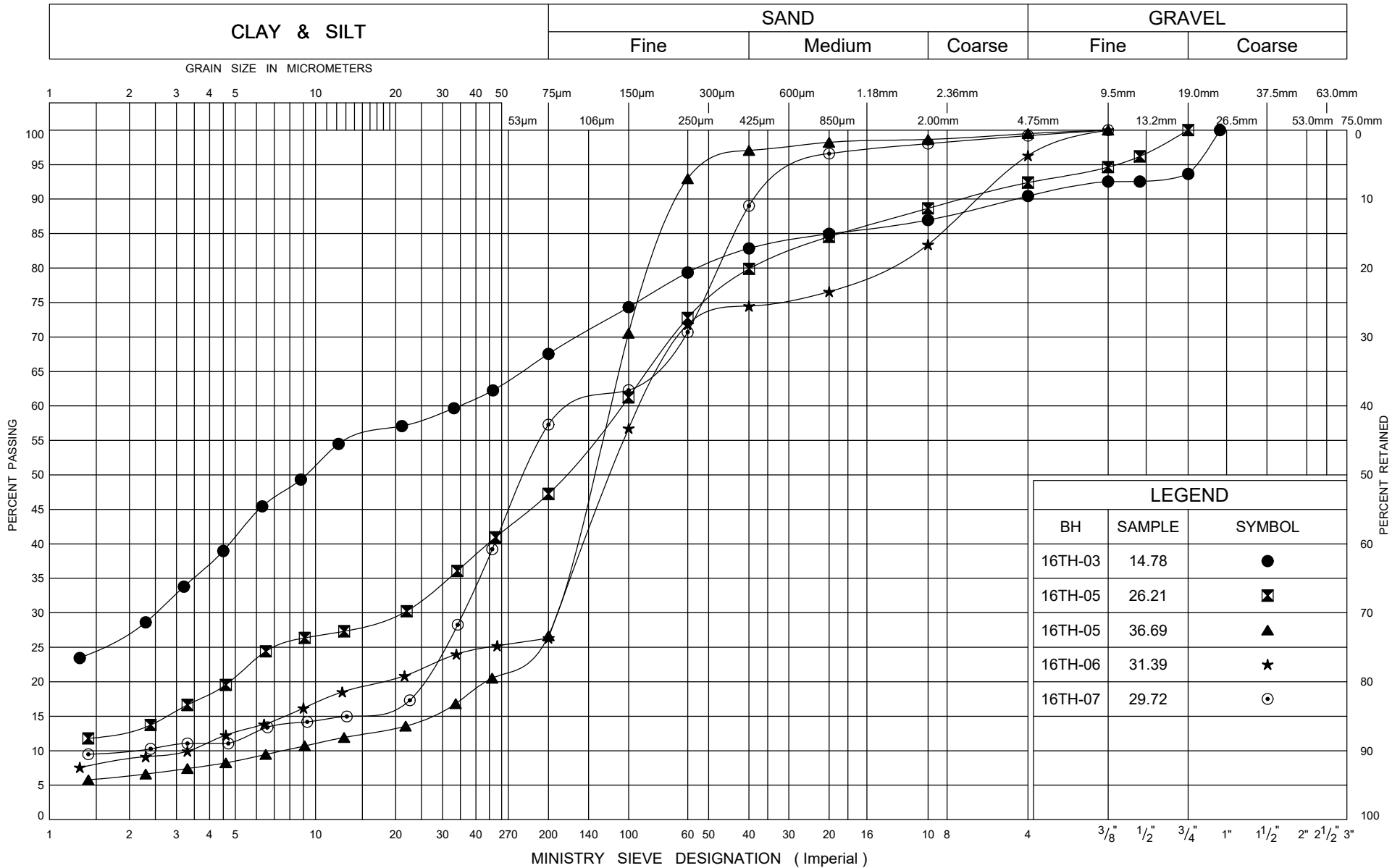
Upper Silty CLY TILL

FIG No B3

G W P. 2930-17-00

16th Ave. Overpass





Ministry of
Transportation

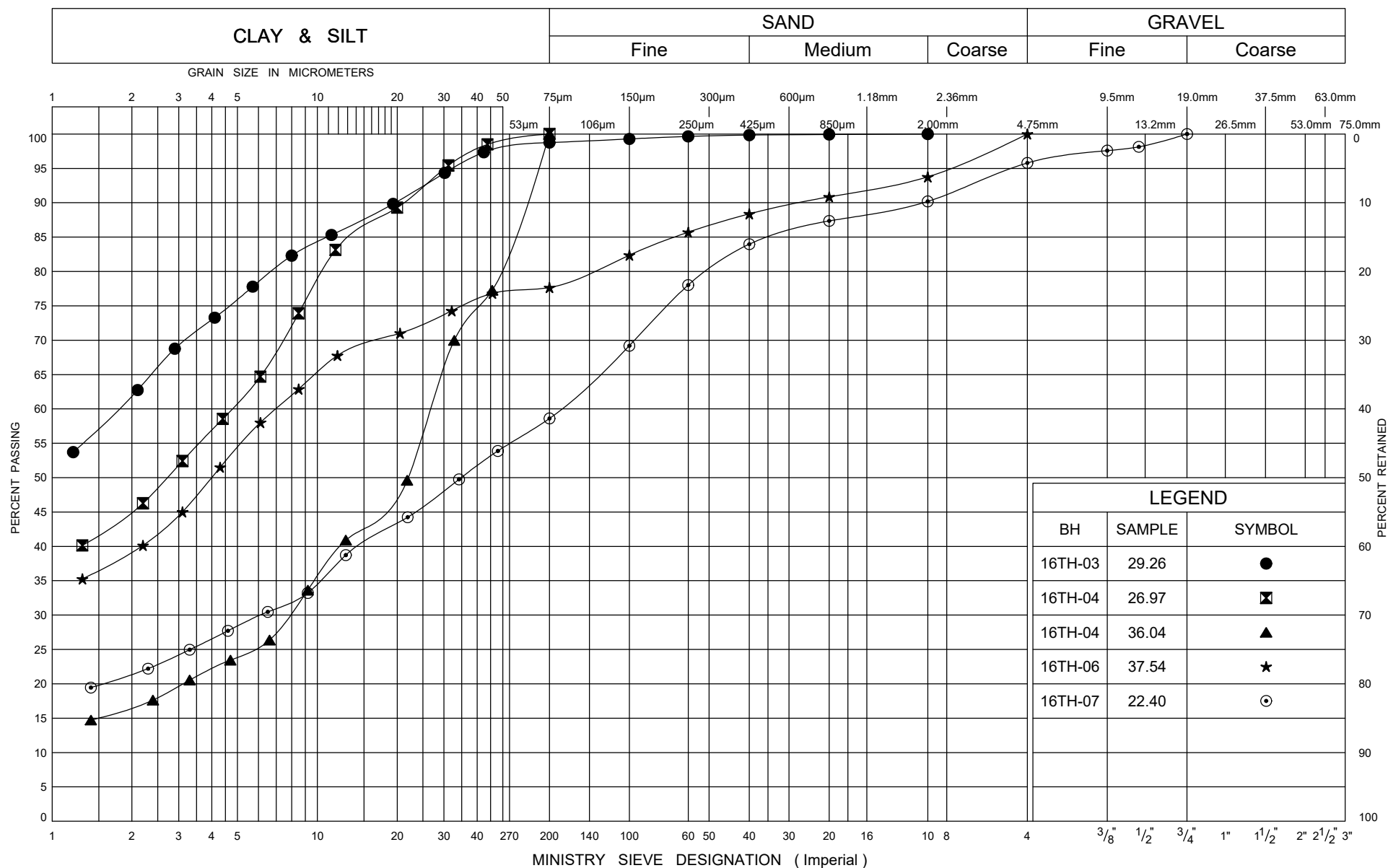
GRAIN SIZE DISTRIBUTION

Silty SAND TILL to SAND and SILT TILL

FIG No B5

G W P. 2930-17-00

16th Ave. Overpass



Ministry of
Transportation

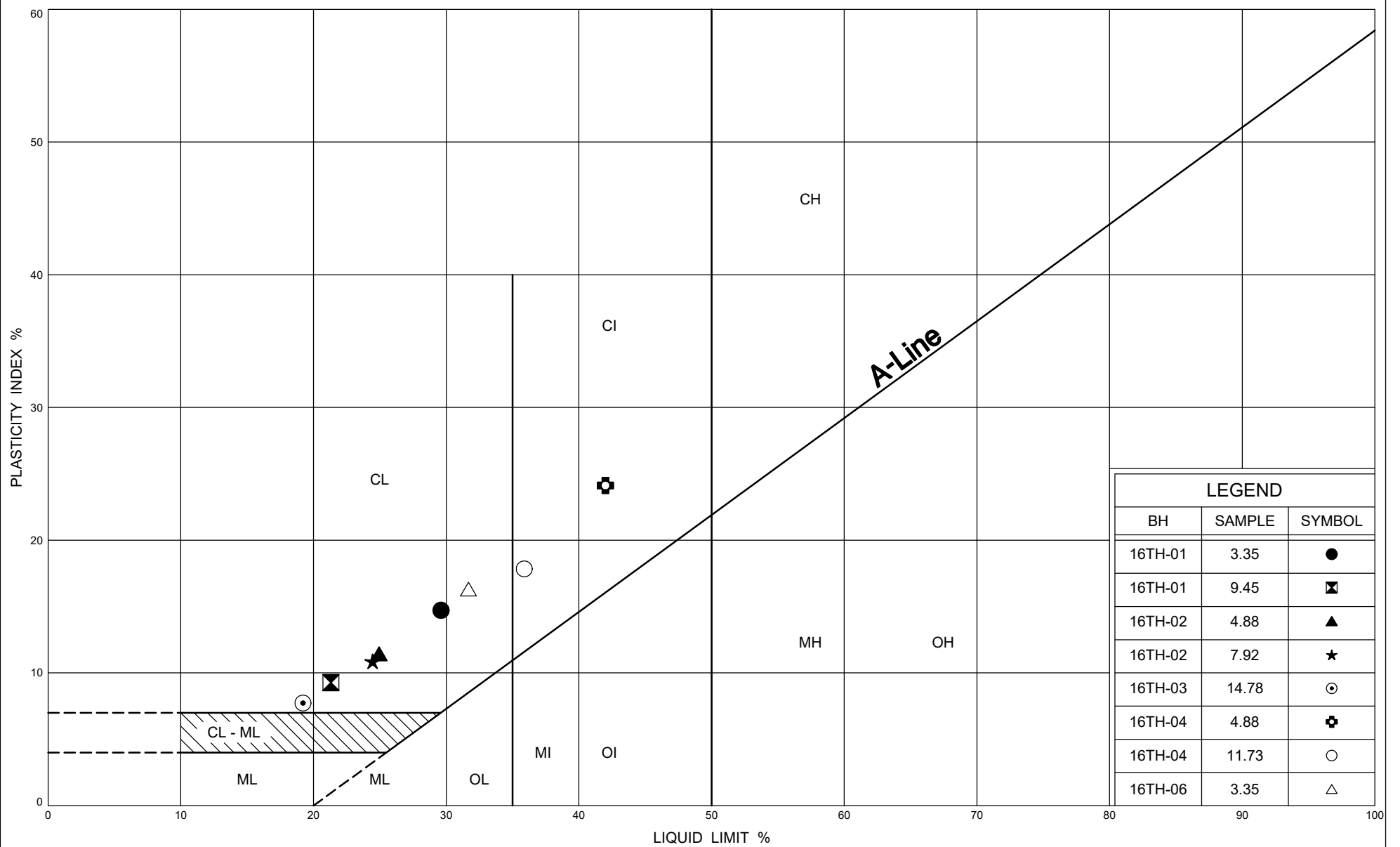
GRAIN SIZE DISTRIBUTION

Lower Silty CLAY TILL

FIG No B6

G W P. 2930-17-00

16th Ave. Overpass



Ministry of
Transportation

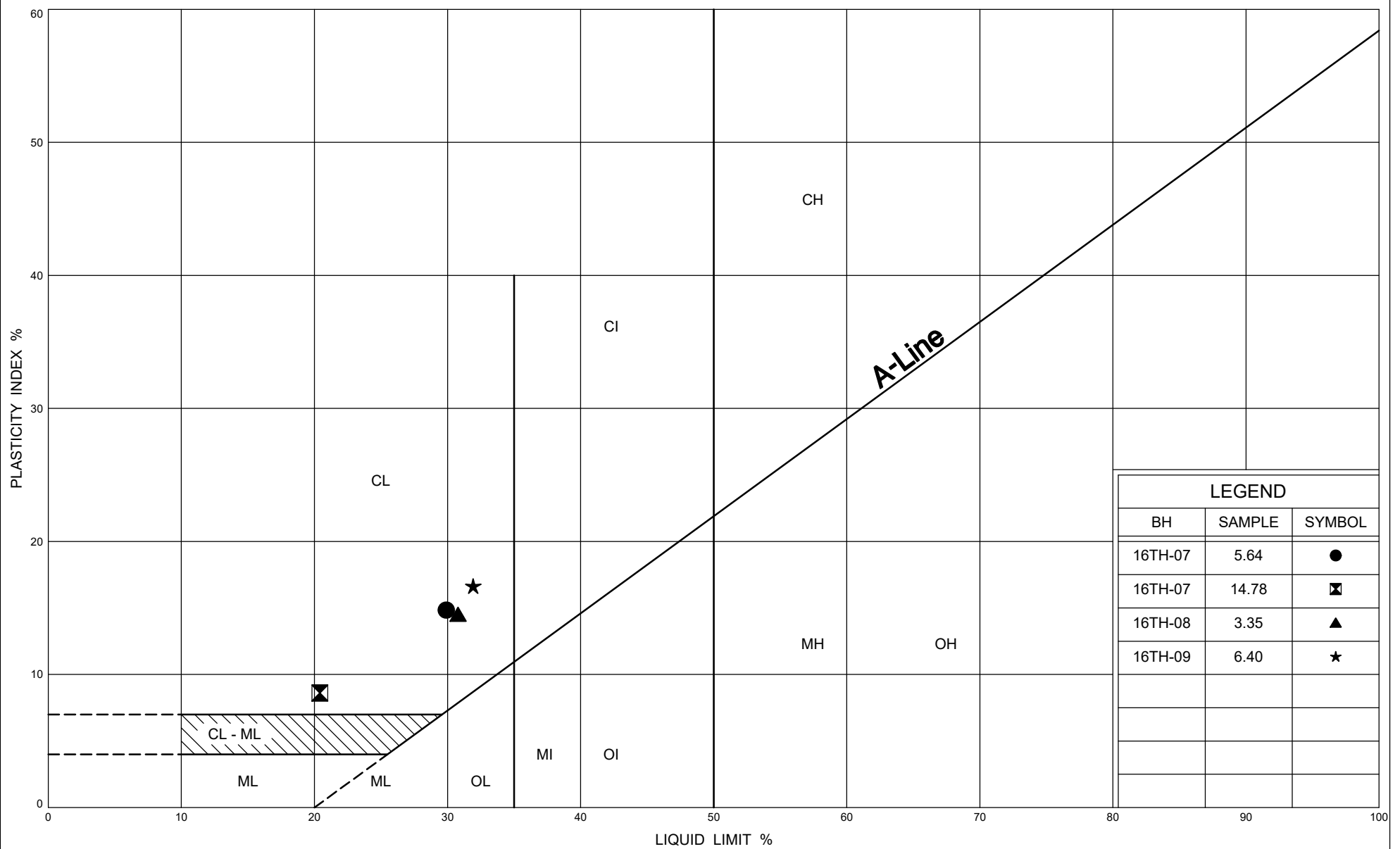
PLASTICITY CHART

Upper Silty CLAY TILL

FIG No B7

G W P. 2930-17-00

16th Ave. Overpass



LEGEND

BH	SAMPLE	SYMBOL
16TH-07	5.64	●
16TH-07	14.78	⊠
16TH-08	3.35	▲
16TH-09	6.40	★



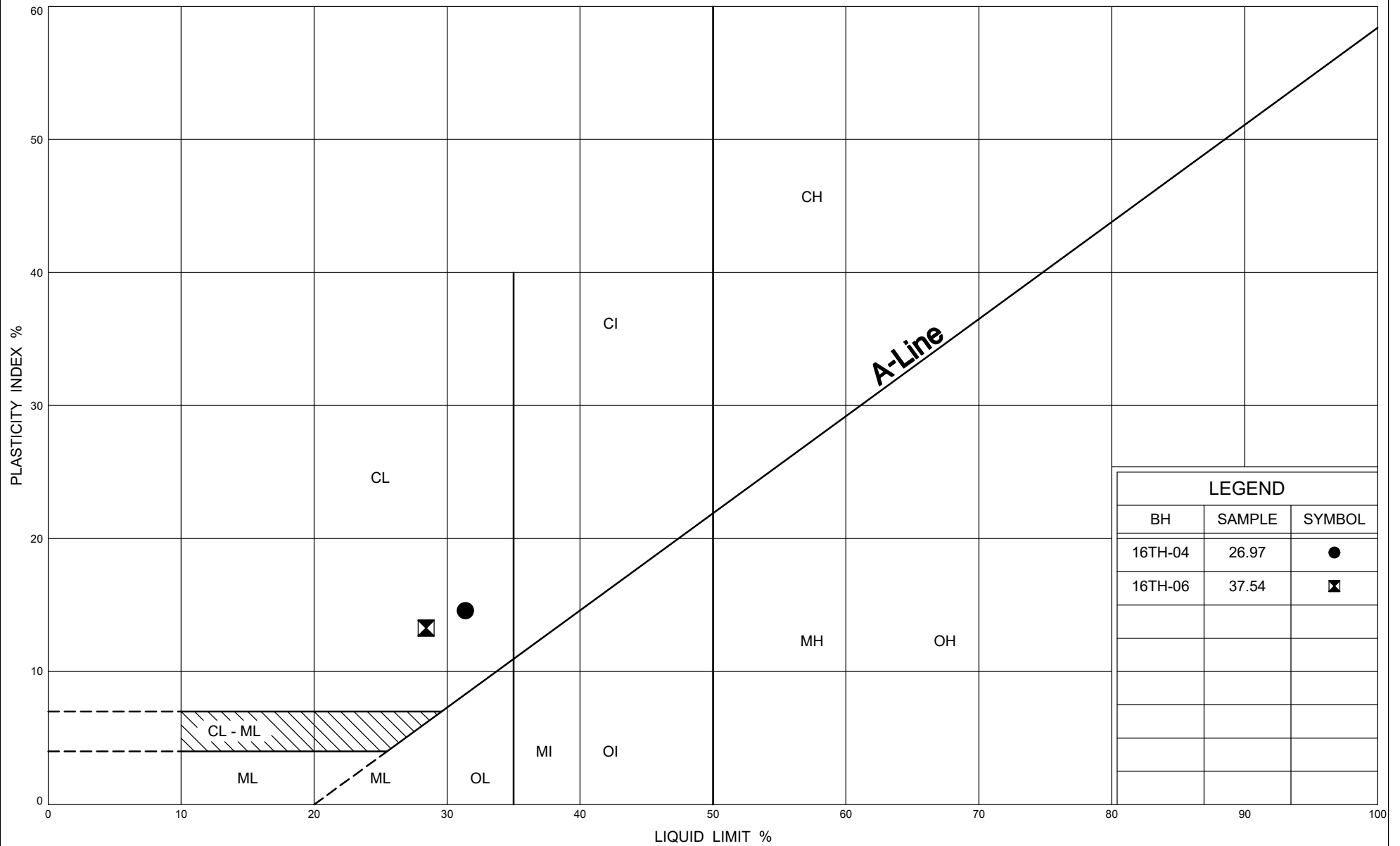
Ministry of
Transportation

PLASTICITY CHART Upper Silty CLAY TILL

FIG No B8

G W P. 2930-17-00

16th Ave. Overpass



Ministry of
Transportation

PLASTICITY CHART

Lower Silty CLAY TILL

FIG No B9

G W P. 2930-17-00

16th Ave. Overpass



FINAL REPORT

CA14627-JUL18 R1

15786

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Rocio Reyna

Telephone 905-829-8666 x 263

Facsimile

Email rreyna@thurber.ca

Project 15786

Order Number

Samples Soil (4)

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 CA14627-JUL18

Received 07/23/2018

Approved 07/27/2018

Report Number CA14627-JUL18 R1

Date Reported 07/27/2018

COMMENTS

Temperature of Sample upon Receipt: 4 degrees C

Cooling Agent Present: No

Custody Seal Present: No

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

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





TABLE OF CONTENTS

First Page..... 1

Index..... 2

Results..... 3-4

QC Summary..... 5-6

Legend..... 7

Annexes..... 8-9



FINAL REPORT

CA14627-JUL18 R1

Client: Thurber Engineering Ltd.

Project: 15786

Project Manager: Rocío Reyna

Samplers: N/A

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8
Sample Name	16TH-03 SS5	16TH-06 SS9	16TH-07 S15	16TH-08 S4
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	20/06/2018	31/05/2018	25/06/2018	31/05/2018

Parameter	Units	RL		Result	Result	Result	Result
Corrosivity Index							
Corrosivity Index	none	1		20.0	9.5	7.5	12.5
Soil Redox Potential	mV	-		89	172	166	244
Sulphide	%	0.02		0.05	0.15	0.05	0.03
pH	no unit	0.05		9.13	8.69	9.18	8.49
Resistivity (calculated)	ohms.cm	-9999		980	5000	9500	1500

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8
Sample Name	16TH-03 SS5	16TH-06 SS9	16TH-07 S15	16TH-08 S4
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	20/06/2018	31/05/2018	25/06/2018	31/05/2018

Parameter	Units	RL		Result	Result	Result	Result
General Chemistry							
Conductivity	uS/cm	2		1020	199	106	646

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8
Sample Name	16TH-03 SS5	16TH-06 SS9	16TH-07 S15	16TH-08 S4
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	20/06/2018	31/05/2018	25/06/2018	31/05/2018

Parameter	Units	RL		Result	Result	Result	Result
Metals and Inorganics							
Moisture Content	%	0.1		16.3	23.1	10.7	15.6
Sulphate	µg/g	0.4		180	220	63	120



FINAL REPORT

CA14627-JUL18 R1

Client: Thurber Engineering Ltd.

Project: 15786

Project Manager: Rocío Reyna

Samplers: N/A

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8
Sample Name	16TH-03 SS5	16TH-06 SS9	16TH-07 S15	16TH-08 S4
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	20/06/2018	31/05/2018	25/06/2018	31/05/2018

Parameter	Units	RL		Result	Result	Result	Result
Other (ORP)							
Chloride	µg/g	0.4		1000	25	4.4	240



FINAL REPORT

CA14627-JUL18 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	DIO0347-JUL18	µg/g	0.4	<0.4	3	20	93	80	120	111	75	125
Sulphate	DIO0347-JUL18	µg/g	0.4	<0.4	1	20	97	80	120	100	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	ECS0038-JUL18	%	0.02	<0.02	3	20	108	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	EWL0311-JUL18	uS/cm	2	< 0.002	1	10	95	90	110	NA		



FINAL REPORT

CA14627-JUL18 R1

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	EWL0311-JUL18	no unit	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 --



SAMPLE INTEGRITY REPORT

Project Number:

15786

SGS Sample ID

CA14627-JUL18

Date / Time Sampled

see CoFC

Client Sample ID

see CoFC

ONTARIO REGULATION 153/04

ALL

Sample Submission General Sample Integrity Violations

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

☐
☐
☐
☐
☐
☐
☐
☐
☐

Sample Specific Sample Integrity Violations

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

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Sediment Log

- Groundwater samples contain visible sediment / particulate
- 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"/>	<input type="checkbox"/>
<input type="checkbox"/>	<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:

VAS



Appendix C

Record of Borehole Sheets, Laboratory Test Results

(Previous Site Investigation)

RECORD OF BOREHOLE No 3 (Formerly WP 160-74-25) METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 125.5; E 314 812.4 ORIGINATED BY VK
DIST 6 HWY 404 BOREHOLE TYPE Washboring, NX, BX Casing & Cone Test COMPILED BY VK
DATUM Geodetic DATE 1971 01 15 CHECKED BY TCK

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y 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	20 40 60 80 100	20 40 60 80 100					
194.2	Ground Level													
0.0	Silty Sand Trace of Clay Compact	Brown Grey	1	SS	24									
191.3			2	SS	27									0 47 50 3
2.9	Clayey Silt to Silt Trace of Sand (Till)		3	SS	15									
189.3	Firm to Stiff		4	TW	PM									
4.9	Silt to Silty Sand Compact		5	TW	PM									21.2
186.9			6	SS	22									20.4 0 0 53 47
7.3			7	SS	14									
	Clayey Silt to Silt Stiff to Very Stiff (Till)		8	SS	12									
			9	TW	PH									19.5 0 0 46 54
			10	TW	PM									18.4
			11	SS	22									
178.7			12	SS	71									
15.5	Silty Sand Some Gravel Trace of Clay Very Dense													
176.8			13	SS	31									
17.4														
	Clayey Silt to Silt Trace of Sand and Gravel (Till) Hard		14	SS	165									
168.9			15	SS	71									
25.3														
	Silty Sand Some Gravel Occ. Clayey Silt Seams (Till) Dense to Very Dense		16	SS	36									
164.0														

Continued

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 3 Continued METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 125.5; E 314 812.4 ORIGINATED BY VK
 DIST 6 HWY 404 BOREHOLE TYPE Washboring, NX, BX Casing & Cone Test COMPILED BY VK
 DATUM Geodetic DATE 1971 01 15 CHECKED BY TCK

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100			
164.0	Continued													
30.2	Silty Sand, Some Gravel, Occ. Clayey Silt Seams, Dense to Very Dense (Till)													
162.2														
32.0	Clayey Silt to Silt Some Sand (Till) Hard		17	SS	68	162								
159.2			18	SS	240	160								1 22 60 17
158.7	Silty Sand (Till) Very Dense		19	SS	316									
35.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4 (formerly WP 160-74-25) METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 144.1; E 314 790.4 ORIGINATED BY VK
DIST 6 HWY 404 BOREHOLE TYPE Washboring, BX Casing and Cone Test COMPILED BY VK
DATUM Geodetic DATE 1970 12 09 CHECKED BY TCK

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 80 100	SHEAR STRENGTH kPa					
194.0	Ground Level							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE					
0.0	Sand to Silty Sand Loose to Compact		1	SS	6									
	Brown Grey		2	SS	17		192						2	54 32 12
191.0			3	SS	26									
3.0			4	SS	21		190							
	Clayey Silt to Silt Some Sand Stiff to Hard (Till)		5	SS	13									
			6	SS	15		188						0	16 40 44
			7	SS	17		186							
			8	SS	35		184							
183.9			9	SS	19		182						0	11 82 7
10.1	Silt to Silty Sand Compact to Dense		10	SS	39		180							
			11	SS	49		178					22.5	3	23 52 22
180.9			12	SS	184		176							
13.1	Clayey Silt to Silt Some Sand Trace of Gravel Very Stiff to Hard (Till)		13	SS	94		174							
			14	SS	29		172							
173.6			15	SS	16		170							
20.4	Silty Sand Some Gravel Compact to Dense (Till)		16	SS	30		168							
	Clayey Silt		17	SS	34		166							
			18	SS	138		164							
164.3	Clayey Silt to Silt (Till) Hard													
29.7														

Continued

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 4 Continued METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 144.1; E 314 790.4 ORIGINATED BY VK
 DIST 6 HWY 404 BOREHOLE TYPE Washboring, BX Casing and Cone Test COMPILED BY VK
 DATUM Geodetic DATE 1970 12 09 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
163.8	Continued						○ UNCONFINED + FIELD VANE									
30.2							● QUICK TRIAXIAL x LAB VANE									
159.9	Clayey Silt to Silt Trace of Sand and Gravel Hard (Till)					162										
34.1																
155.9	Silty Sand Some Gravel Very Dense (Till)		19 SS	150	8 cm	160										
38.1																
155.9	End of Borehole						158									
38.1																
							156									

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NO 7

W.P. 165-74-23 LOCATION: Corridor R15 935 885 E 1 032 871
 DIST. 404 RECORD DATE: August 31, 1971
 DATE: 1971 BORING TIME: 11:00 AM - 12:00 PM
 ORIGINATED BY: RD
 COMPILED BY: RE
 CHECKED BY:

ELEV DEPTH	DESCRIPTION	SAMPLING NO.	TYPE	VALUES	ELEV	DYNAMIC CONE PENETRATION RESISTANCE - P.C.F.					LIQUID LIMIT PLASTIC LIMIT		UNIT WEIGHT	REMARKS
						7C	60	80	100	120	WATER CONTENT %	WATER CONTENT %		
637.1	Ground Level													
637.1	Impassible	1	SS	3										
628.6	Sandy silt with trace of gravel & organic Very Loose to Compact	2	SS	26	630									
623.3	Clayey silt. Loose to Dense	3	SS	47										
	Grey	4	SS	110	620									
613.1		5	SS	8										
610.0	Silty Sand. Compact: Grey	6	SS	15	610									
		7	SS	21										
601.1		8	SS	26	600									
593.6	Clayey silt with trace of sand and gravel. Very Stiff. Grey	9	SS	27										
593.5	Silty sand.	10	SS	30	590									
588.6	Compact. Grey													
580.5	Clayey silt with some sand and gravel Very Stiff to Hard Grey	11	SS	38	580									
		12	SS	118	570									
564.1		13	SS	28										
553.0	Silty sand to sandy silt with some gravel and occ. layer of clayey silt Loose to Very Dense	14	SS	17	560									
		15	SS	13	550									
		16	SS	4	540									
532.3	Grey													

Continued

20
15-25 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 7, Continued

WP 140-74-25
DIST 405
DATE August 31, 1972
DATUM Gneissic
ORIGINATOR'S NAME Highway-M & E
ENGINEERED BY BH
COMPILED BY BH
CHECKED BY

ELEV. DEPTH	DESCRIPTION	STAGE	SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT - PLASTIC LIMIT		UNIT WEIGHT γ	REMARKS
			NUMBER	TYPE	VALUES		0	20	40	60	80	WATER CONTENT %	WATER CONTENT %		
532.3			17	SS	110.0										
504.8			18	SS	110.0	530									
			19	SS	110.0										
516.8			20	SS	94.0	520									
170.5	Clayey silt with some sand and gravel.		21	SS	142.5										
	Hard Grey					510									
506.8			22	SS	130.0										
130.3	End of borehole														

20
15 0-5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 8

W.P. 166-75-25 LOCATION: Concrete R 15 938 822 L F 1 032 723 ORIGINATED BY: ED
 DIST: 6 H.W.T. 404 BORING DATE: August 28, 1971 COMPILED BY: RS
 DATA: Geologic BOREHOLE TYPE: Washboring - SX & XV Casing CHECKED BY:

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES		ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PILOT					LIQUID LIMIT PLASTIC LIMIT		UNIT WEIGHT	REMARKS
			NUMBER	TYPE		70	20	25	40	450	WATER CONTENT %	WATER CONTENT %		
637.3	Ground Level													
630.0	Topsoil		1	SS	6									
	Silty sand		2	SS	57									
	Loose to Very Dense													
626.3	Brown													
611.0			3	SS	16									
	Clayey silt with		4	SV	24									
	trace of sand and													
	gravel		5	SS	6									
	Stiff to Very Stiff		6	SS	11									
	Grey		7	SV	24									
			8	SV	24									
			9	SS	11									
597.4														
592.2	Sandy silt to silty		10	SS	20									
	sand.													
	Compact to Dense		11	SS	20									
586.4	Grey													
580.3			12	SS	17									
	Clayey silt with some													
	sand and gravel		13	SS	21									
			14	SS	30									
	Very Stiff to Hard		15	SS	105									
	Grey		16	SS	66									
			17	SS	64									
554.3			18	SS	40									
83.0			19	SS	30									
	Silty sand to sandy													
	silt with some gravel		20	SS	11									
			21	SS	28									
			22	SS	28									
532.5														
104.8														

Continue

70
15-0-5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 8 Continued

W.P. 160-74-25 LOCATION Co-ords. N 15 938 827 E 1 932 723 ORIGINATED BY SD
 DIST 6 HWY 404 BORING DATE August 24, 1971 COMPILED BY ES
 DAYUM Cordatic BOREHOLE TYPE Washboring - KY & PL Casing CHECKED BY

SOIL PROFILE		SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE (PLOT)		LIQUID LIMIT PLASTIC LIMIT		UNIT WEIGHT	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER TYPE	IN VALUES	ELEV	70 20 25 80 200	WATER CONTENT %		
104.8	Compact to Very Dense Grey				530				
532.5									
513.8	Clayey silt with some sand and gravel.				520				
123.5									
504.8	Hard Grey				510				
132.5	End of Borehole								

20
15 0-5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9 (Formerly WP 160-74-25) METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 160.5; E 314 808.1 ORIGINATED BY VK
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY VK
 DATUM Geodetic DATE 1977 02 22 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION [%]
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
194.2	Ground Level						194							GR SA SI CL
0.0	Topsoil													
193.4														
0.8	Sandy Silt		1	SS	8									
192.1	Compact		2	SS	11									0 26 72 2
2.1			3	SS	12									
			4	SS	11									
	Silty Sand		5	SS	8									
			6	SS	8									
	Clayey Silt to Silt		7	TH	PM									0 0 55 45
	Stiff to Very Stiff		8	SS	8									
	(Till)		9	SS	7									
			10	SS	8									
185.1			11	SS	4									0 80 (20)
9.1	Silty Sand to													
	Sandy Silt													
	Loose to Compact													
182.9	(Till)		12	SS	12									0 55 41 4
11.3	Clayey Silt to Silt													
	Trace of Sand, Gravel													
181.5	Hard (Till)		13	SS	28									
12.7	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10 (Formerly WP 160-74-25) METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 120.9; E 314 793.8 ORIGINATED BY VK
 DIST 6 HWY 404 BOREHOLE TYPE Solid Stem Auger and Cone Test COMPILED BY VK
 DATUM Geodetic DATE 1977 02 25 CHECKED BY TCR

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
194.2	Ground Level						194							
0.0	Topsoil													
	Clayey Silt to Silt (Till)		1	SS	19									0 0 78 22
	Silty Sand		2	SS	33									0 9 87 4
	Stiff to Very Stiff		3	SS	13									
191.0			4	SS	8									0 22 63 15
3.2	Silty Sand Loose to Compact		5	SS	10									
189.3	Clayey Silt		6	SS	7									
4.9	Clayey Silt to Silt Occ. Silty Clay Layers		7	SS	6									0 13 39 48
	Firm to Stiff (Till)		8	TW	PM									0 1 29 70
186.2			9	SS	13									
8.0	Silt to Silty Sand Loose to Dense (Till)		10	SS	9									0 39 56 5
			11	SS	13									
			12	SS	39									
182.9	Clayey Silt to Silt Some Sand													
11.3	Hard (Till)		13	SS	42									0 15 42 43
182.0														
12.2	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13

METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 163.3; E 314 826.8 ORIGINATED BY KZ
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger, NX-Casing, Washboring & Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 06 17, 20, 21 CHECKED BY TCK

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT C W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER TYPE 'N' VALUES						
189.5	Ground Level								
0.0 188.9	Sand & Gravel (Fill)								
0.6	Fine Sand Trace of Silt and Gravel Very Loose		1 SS 2		188				
186.3	Brown Grey		2 SS 2		186			49%	1 10 23 66
3.2	Silty Sand Trace of Clay and Gravel		3 SS 8		184				
			4 SS 16		182				
	Clayey Silt to Silt Some Sand Trace of Gravel Occ. Silty Clay Layers Soft to Hard (Till)		5 SS 14		180				
			6 SS 68		178				
			7 SS 51		176				
172.5					174				0 11 57 32
17.0	Silty Sand Trace of Clay (Lacustrine) Very Loose		8 SS 1		172				
169.5					170				
20.0	Silty Sand Trace of Gravel and Clay Occ. Silt Layers Loose to Compact (Till)		9 SS 9		168				
			10 SS 11		166				
					164				5 44 40 11
161.8					162				
27.7	Silty Sand Very Dense (Lacustrine)		11 SS 62		160				
159.3									
30.2									

Continued

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 13 Continued METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 163.3; E 314 826.8 ORIGINATED BY KZ
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger, NX-Casing, Washboring, Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 06 17, 20, 21 CHECKED BY TCK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100		W _p	W	W _L		
159.3	Continued												
30.2													
	Silty Sand (Lacustrine)		11A	WS		158							
156.5													
33.0	Clayey Silt to Silt Some Sand Trace of Gravel (Till)		12	SS	118/23cm	156							
	Hard					154							
152.7			13	SS	60/10cm								
36.8	End of Borehole												3 18 38 41

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (% STRAIN AT FAILURE)

RECORD OF BOREHOLE No 14

METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 144.8; E 314 831.3
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem, NX-Casing, Washboring, Cone Test
 DATUM Geodetic DATE 88 06 7 - 10
 ORIGINATED BY KZ
 COMPILED BY KZ
 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa						
189.6	Ground Level														
0.0	Sand and Gravel														
188.7	(Fill)	Brown	1	SS	5										
0.9		Grey	2	SS	14										
	Sand		3	SS	8										
	Trace of Silt		4	SS	14										
	Clayey Silt to Silt		5	SS	16									8 22 36 34	
	Some Sand		6	SS	19										
	Trace of Gravel		7	SS	41										
	Occ. Silt Layers		8	SS	64										
	(Till)		9	SS	43									6 14 45 35	
	Stiff to Hard		10	SS	36										
176.4			11	SS	17									0 5 90 5	
13.2	Silt, Trace of Clay and Sand		12	SS	15										
174.9	Compact		13	SS	8									8 49 34 9	
14.7	Silty Sand		14	SS	10										
	Trace of Clay and Gravel		15	SS	11										
	(Till)		16	SS	22										
	Loose to Compact		17	SS	18										
170.3			18	SS	41										
19.3	Clayey Silt to Silt With/Some Sand		19	SS	53									15 33 37 15	
	Some Gravel		20	SS	49										
	Occ. Silt and Sand Layers		21	SS	31										
	(Till)														
	Stiff to Hard														
162.7	Clayey Silt (Lacustrine)														
26.9	Hard														
161.2	Silty Sand (Lacustrine)														
28.4	Dense to Very Dense														
159.4															

Continued

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 14 Continued METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 144.8 E 314 831.3 ORIGINATED BY KZ
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem, NX-Casing, Washboring, Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 06 7, 8, 9, 10 CHECKED BY TCK

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
159.4	Continued															
158.8	Silty Sand		22	SS	95											
30.8	Dense to Very Dense															
156.6	Silty Sand		24	SS	65											
	Some Gravel															
	(Till)															
151.0	Very Dense															
33.0	Clayey Silt to Silt		27	SS	52											
	Some Sand															
	Trace of Gravel		28	SS	120	15 cm										
	Occ. Sand and Gravel															
	layers															
	(Till)															
	Hard															
151.0			29	SS	193											
38.6	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 15

METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 142.9; E 314 771.9 ORIGINATED BY KZ
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem, NX Casing, Washboring, Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 06 15, 16 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
189.3	Ground Level																
0.0	Sand and Gravel (Fill)																
188.7	Brown																
0.6	Clayey Silt																
186.8	Some Sand		1	SS	6		188										
2.5	Firm																
	Clayey Silt		2	SS	23		186										
	Silty Sand to																
	Sand Silt		3	SS	6		184										0 12 77 11
183.7	Loose to Dense																
5.6	Clayey Silt to Silt		4	SS	3		182										
	Some Sand																
	Trace Gravel		5	SS	5		180										4 14 31 51
	Occ. Silt Pockets (Till)		6	SS	15												
179.2	Soft to Stiff																
10.1	Silt to		7	SS	1		178										
	Silty Sand																
	Very Loose		8	SS	29												
	to Compact																
176.1							176										
13.2	Clayey Silt to Silt		9	SS	16												
	Some Sand																
	Trace of Gravel		10	SS	12		174										
	(Till)																
	Stiff to Hard		11	SS	34		172										2 22 49 27
			12	SS	20		170										
167.7																	
21.6	Silty Sand						168										
	Trace of Gravel		13	SS	1		166										
	(Till)																
	Very Loose																
164.7							164										
24.6	Clayey Silt to Silt		14	SS	40		162										4 28 43 25
	with Sand																
	Trace of Gravel																
	(Till)																
	Hard																
161.6							160										
27.1	Fine Sand		15	SS	7												
	Loose																
159.1																	
30.2																	

Continued

*3, *5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 15 Continued METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 142.9; E 314 771.9 ORIGINATED BY KZ
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem, NX Casing, Washboring, Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 06 15, 16 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
159.1	Continued															
30.2	Fine Sand Very Loose					158										
156.3			15A	WS	-											
33.0	Clayey Silt to Silt With Sand Some Gravel (Till)		16	SS	128	156										
	Hard					154										
152.4			17	SS	176											
36.9	End of Borehole															10 38 37 15

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁶: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 16

METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 122.3; E 314 777.1 ORIGINATED BY KZ
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem, NX-Casing, Washboring, Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 06 10, 13, 14 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa						
189.9	Ground Level														
189.3	Sand and Gravel (Fill)														
0.6															
	Silty Clay to Clayey Silt Some Sand Trace of Gravel (Till)		1	SS	7		188								
185.9	Firm		2	SS	4		186							46.5%	5 10 21 64
4.0			3	SS	17		184								
	Clayey Silt		4	SS	17		182								0 0 95 5
			5	SS	29		180								
	Clayey Silt to Silt Some Sand Trace of Gravel (Till) Occ. Silt and Sand Pockets Stiff to Hard		6	SS	41		178								
			7	SS	26		176								
			8	SS	22		174								
			9	SS	34		172								6 34 45 15
			10	SS	14		170								
165.3							168								
24.6							166								
	Silty Clay (Lacustrine) Layers of Silt and Clay Hard		11	SS	68		164								
			12	SS	34		162								
160.7							160								
159.2	Fine Sand to Silty Sand (Lacustrine)														
159.7															
160.3															

Continued

*3, *5: Numbers refer to
Sensitivity

20
15 → 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 16 Continued METRIC

W P 38-87-01 LOCATION Co-ords. N 4 858 122.3; E 314 777.1 ORIGINATED BY K2
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem, NX Casing, Washboring, Cone Test COMPILED BY K2
 DATUM Geodetic DATE 88 06 10, 13, 14 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
159.7 30.2	Continued		12A	WS	-												
157.1 32.8	Fine Sand to Silty Sand (Lacustrine) Trace of Gravel Very Dense		13	SS	100/	15 cm	158										
	Clayey Silt to Silt with Sand Trace of Gravel (Till) Hard		14	SS	113/	23 cm	156										
153.1 36.8	End of Borehole		15	SS	100/	13 cm	154										
																	4 36 41 19

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 101

1 OF 3

METRIC

FILE NO. 97431 PROJECT Highway 404 Widening DRILLED BY K.M.B.
CLIENT Giffels Associates Ltd. LOCATION 4 858 167.0 N; 314 789.2 E CHECKED BY I.C.
DATUM Geodetic DRILLING METHOD Bombardier Mounted BOA 6M DATE June 05, 1998 - June 10, 1998

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
							● QUICK TRIAXIAL	x LAB VANE							
195.5	Ground Surface														
0.0															
	FILL - Sandy to Clayey Silt occasional organics grey/brown		1	SS	36										
			2	SS	12										
	stiff to hard		3	SS	31										
			4	SS	10										
192.5															
192.2	SAND AND SILT		5	SS	25										
3.3															
	SILTY CLAY TILL trace sand, trace gravel grey														
	very stiff		6	SS	16										
188.5															
7.0															
	SILT some clay grey		7	SS	22										
	very stiff														
185.5															
10.0															
	SILTY CLAY TO CLAYEY SILT TILL some sand, trace gravel		8	SS	22										
	very stiff to hard														
			9	SS	56										

ON MOT 97429 GPJ ON MOT GDT 11/12/98

Continued Next Page

+ 3. x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

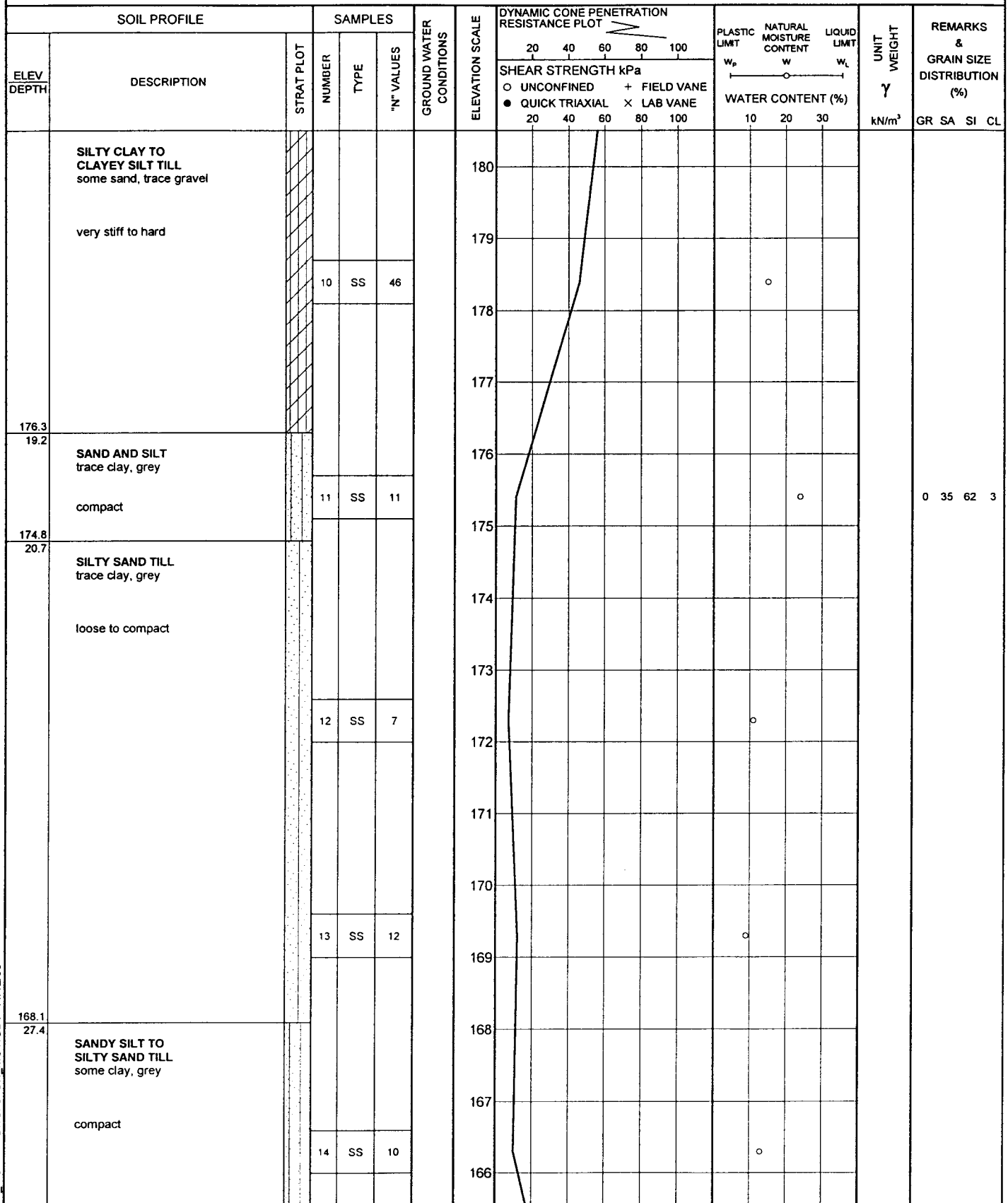


RECORD OF BOREHOLE No 101

2 OF 3

METRIC

FILE NO. 97431 PROJECT Highway 404 Widening DRILLED BY K.M.B.
 CLIENT Giffels Associates Ltd. LOCATION 4 858 167.0 N; 314 789.2 E CHECKED BY I.C.
 DATUM Geodetic DRILLING METHOD Bombardier Mounted BOA 6M DATE June 05, 1998 - June 10, 1998



Continued Next Page

+³ ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



RECORD OF BOREHOLE No 101

3 OF 3

METRIC

FILE NO. 97431 PROJECT Highway 404 Widening DRILLED BY K.M.B.

CLIENT Giffels Associates Ltd. LOCATION 4 858 167.0 N; 314 789.2 E CHECKED BY I.C.

DATUM Geodetic DRILLING METHOD Bombardier Mounted BOA 6M DATE June 05, 1998 - June 10, 1998

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
165.0 30.5	SILTY CLAY varved, grey hard		15	SS	39		165							
								164						
								163						
161.7 33.8	SILT trace sand and clay very dense		16	SS	68		162							
								161						
								160						
158.6 36.9	End of Borehole		17	SS	50/13cm		159							
			18	SS	50/13cm									
	Standpipe piezometer installed to 6.1m depth upon completion of drilling.													
	WATER LEVEL READINGS:													
	Date Depth Elevation													
	July 9/98 5.49 190.01m													
	Nov. 11/98 5.70 189.80m													

ON MOT 97429 GPJ ON MOT GDT 11/12/98


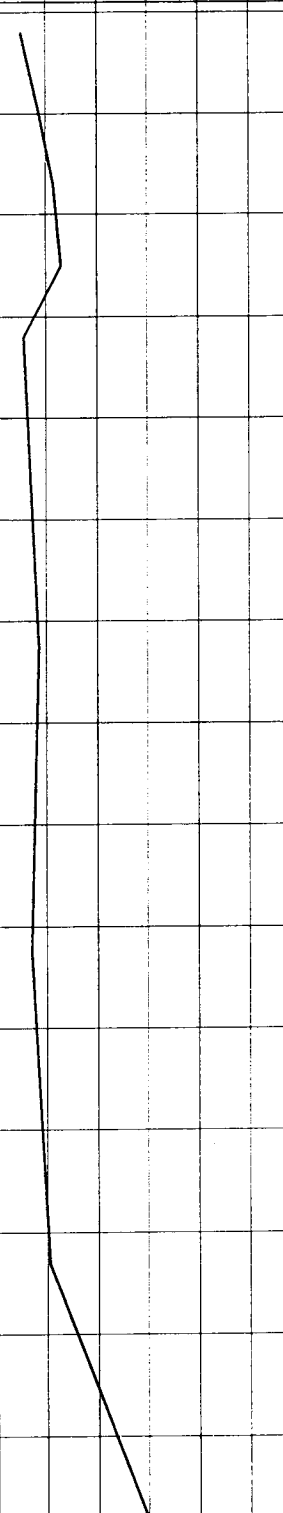






RECORD OF BOREHOLE No 102

1 OF 3

METRIC

FILE NO. 97429 PROJECT Highway 404 Widening DRILLED BY K.M.B.
CLIENT Giffels Associates Ltd. LOCATION 4 858 111.9 N; 314 796.1 E CHECKED BY I.C.
DATUM Geodetic DRILLING METHOD Bombardier Mounted BOA 6M DATE June 03, 1998 - June 04, 1998

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT 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 (%)				
								○ UNCONFINED + FIELD VANE		w _p w w _L				
								● QUICK TRIAXIAL × LAB VANE						
195.1	Ground Surface					20 40 60 80 100	20 40 60 80 100	10 20 30				GR SA SI CL		
0.0	FILL mixture of Silty Clay & Sand brown/grey stiff to very stiff		1	SS	10								6 43 44 7	
			2	SS	17									
			3	SS	23									
192.9														
2.2	SAND AND SILT trace clay, trace gravel, brown compact		4	SS	26									1 46 44 9
			5	SS	11									
191.8														
3.3	CLAYEY SILT TILL some sand, trace gravel grey very stiff													
			6	SS	17									
188.1														
7.0	SILTY FINE SAND grey compact													
			7	SS	14									
185.1														
10.0	SILTY CLAY TILL some sand, trace gravel grey very stiff													
			8	SS	21									
180.7														
14.4														

ON MOT 97429 GPJ ON MOT GDT 07/09/98

Continued Next Page

+ 3 x 3 Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**METRIC**

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 ○ QUICK TRIAXIAL					
	CLAYEY SILT TILL some sand, trace gravel, grey		9	SS	68		180							
	hard						179							
							178							
	-- lenses of silt, some clay		10	SS	46		177							
							176							
							175							
174.4 20.7	SILT AND SAND TILL trace clay, trace gravel, grey		11	SS	9		174							
loose to compact						173								
						172								
						171								
						170								
						169								
			12	SS	13		168							
							167							
							166							

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**METRIC**

ON_MOT 9/429.GPJ ON_MOT.GDI 07/09/98

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



Appendix D

Selected Site Photographs



Photo 1 Highway 404 SBL, west side



Photo 2 Highway 404 SBL, south abutment, east side



Photo 3 Highway 404 SBL, north abutment, east side



Photo 4 Highway 404 NBL (west side), and 16th Avenue

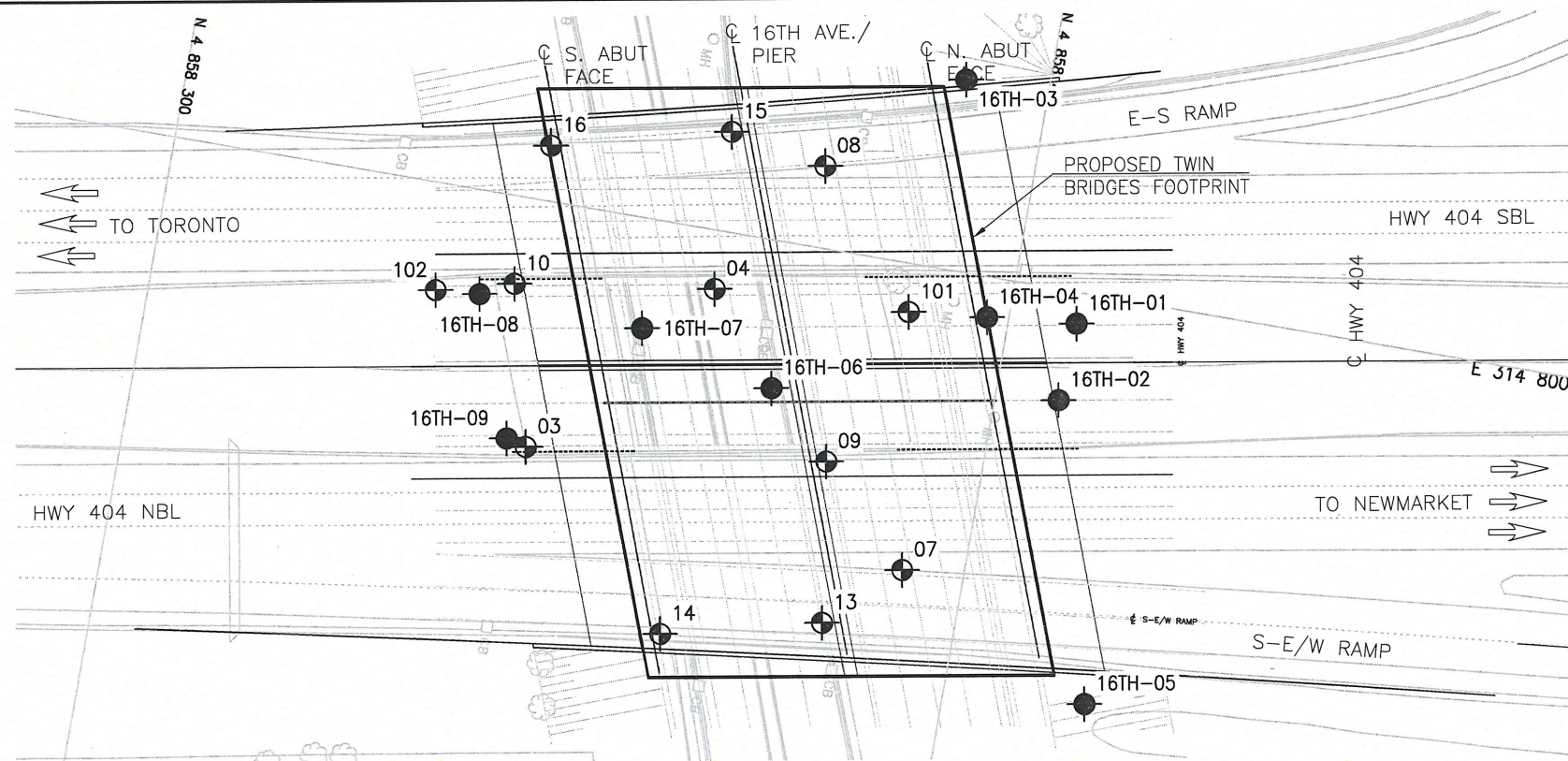


Photo 5 Highway 404 NBL (east side), and 16th Avenue



Appendix E

Borehole Locations and Soil Strata Drawings



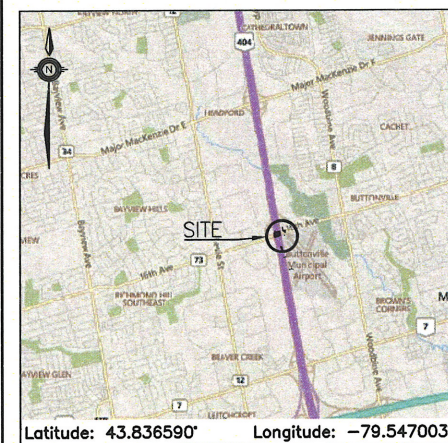
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 2930-17-00

HIGHWAY 404
OVERPASS
AT 16TH AVENUE
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



Latitude: 43.836590° Longitude: -79.547003°

KEYPLAN

LEGEND

- ◆ Borehole (Current Investigation)
- ◊ Borehole (Previous Investigations)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level (Open Borehole)
- ⊥ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
03	194.2	4 858 346.8	314 828.8
04	194.0	4 858 365.4	314 806.8
07	194.2	4 858 392.8	314 835.5
08	194.2	4 858 375.7	314 790.4
09	194.2	4 858 381.8	314 824.5
10	194.2	4 858 342.2	314 810.2
13	189.5	4 858 384.6	314 843.2
14	189.6	4 858 366.1	314 847.7
15	189.3	4 858 364.2	314 788.3
16	189.9	4 858 343.6	314 793.5
101	195.5	4 858 388.3	314 805.6
102	195.1	4 858 333.2	314 812.5

NOTES-

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

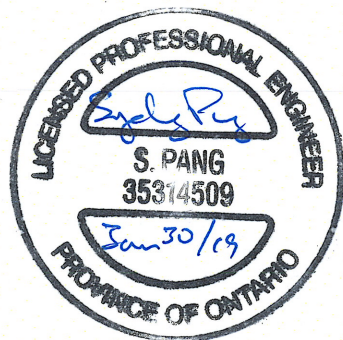
GEOCRES No. 30M14-487

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE
			LOAD
			DATE JAN 2019
			STRUCT
			DWG 1

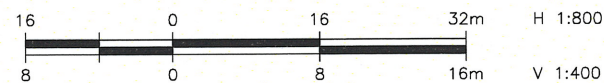


PLAN

SCALE 1:800

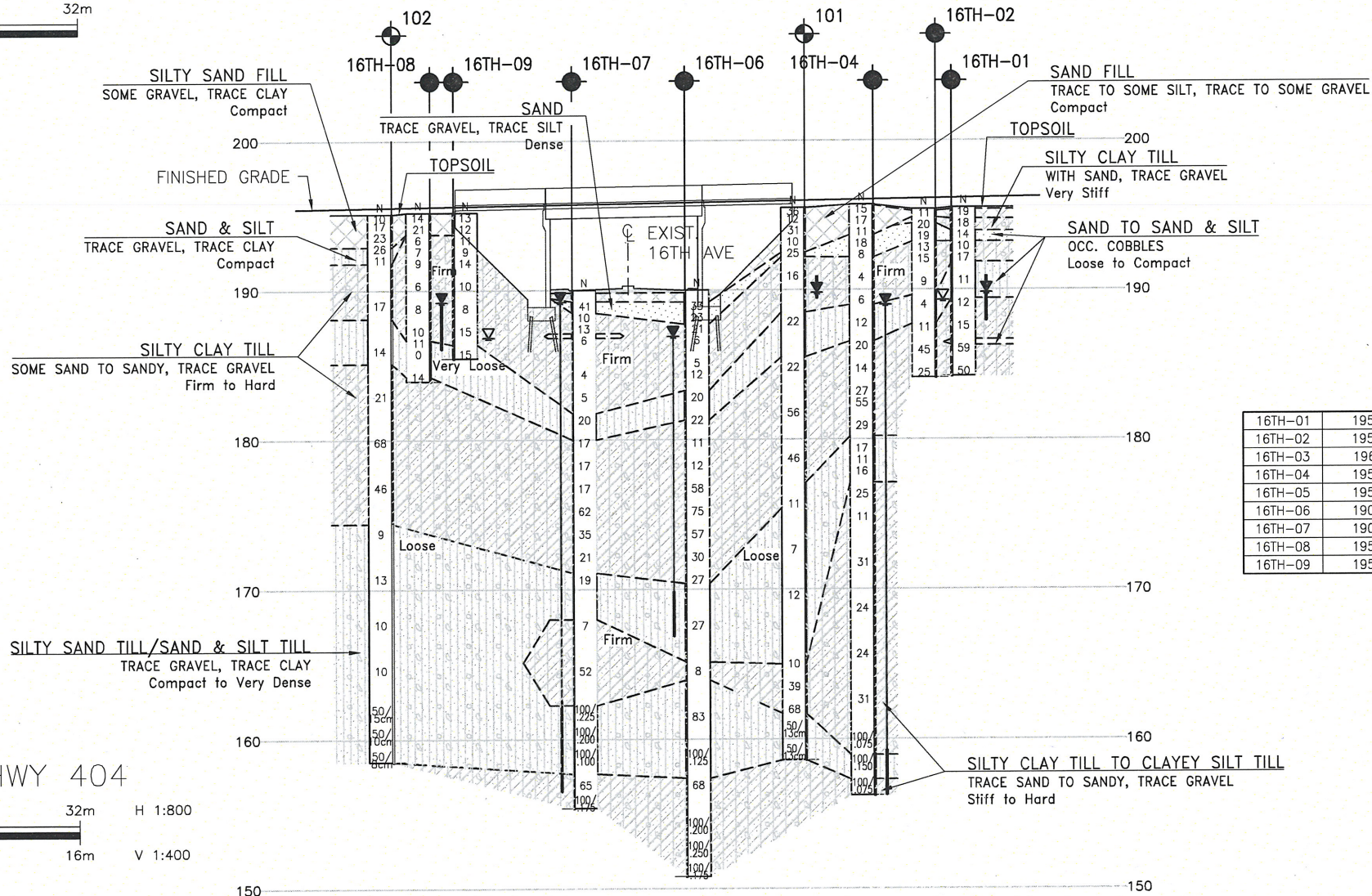


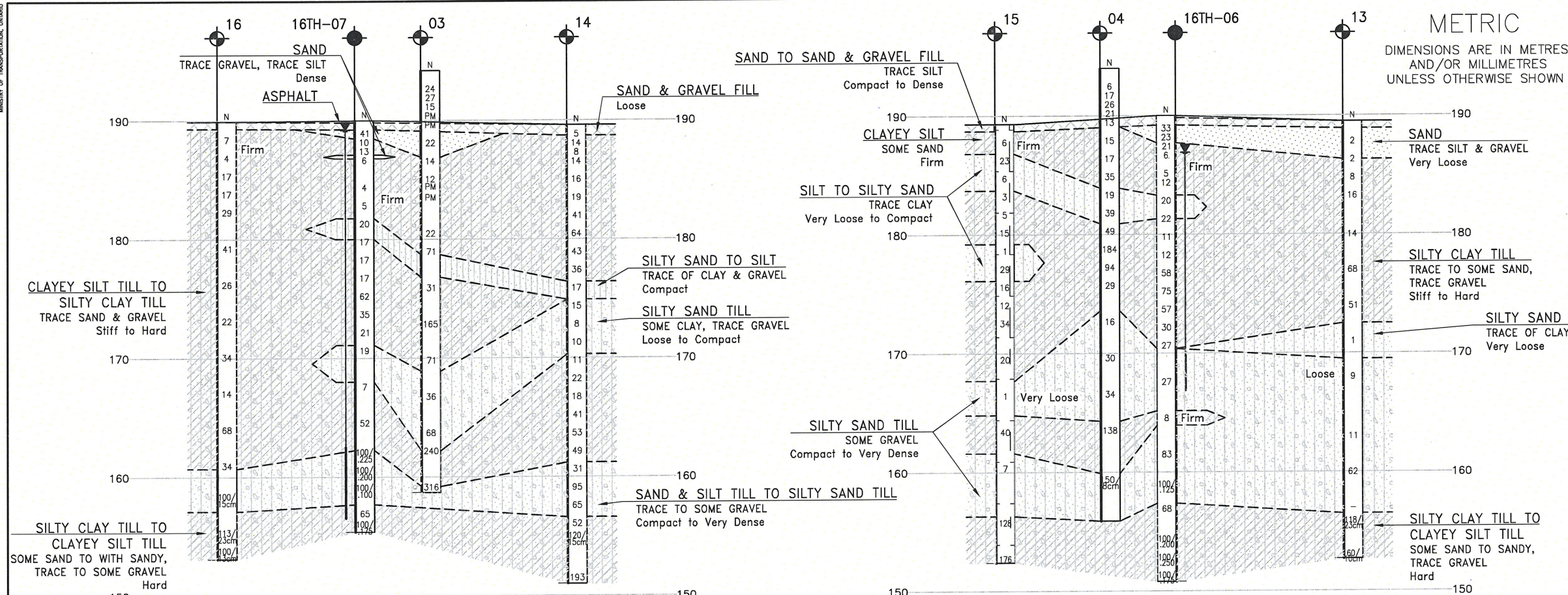
PROFILE ALONG C HWY 404



H 1:800

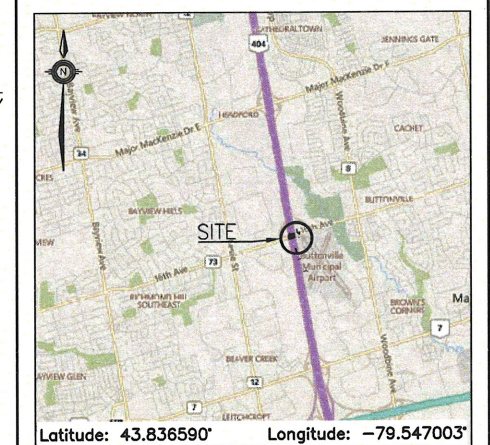
V 1:400





CONT No
GWP No 2930-17-00

HIGHWAY 404
OVERPASS
AT 16TH AVENUE
BOREHOLE LOCATIONS AND SOIL STRATA



LEGEND

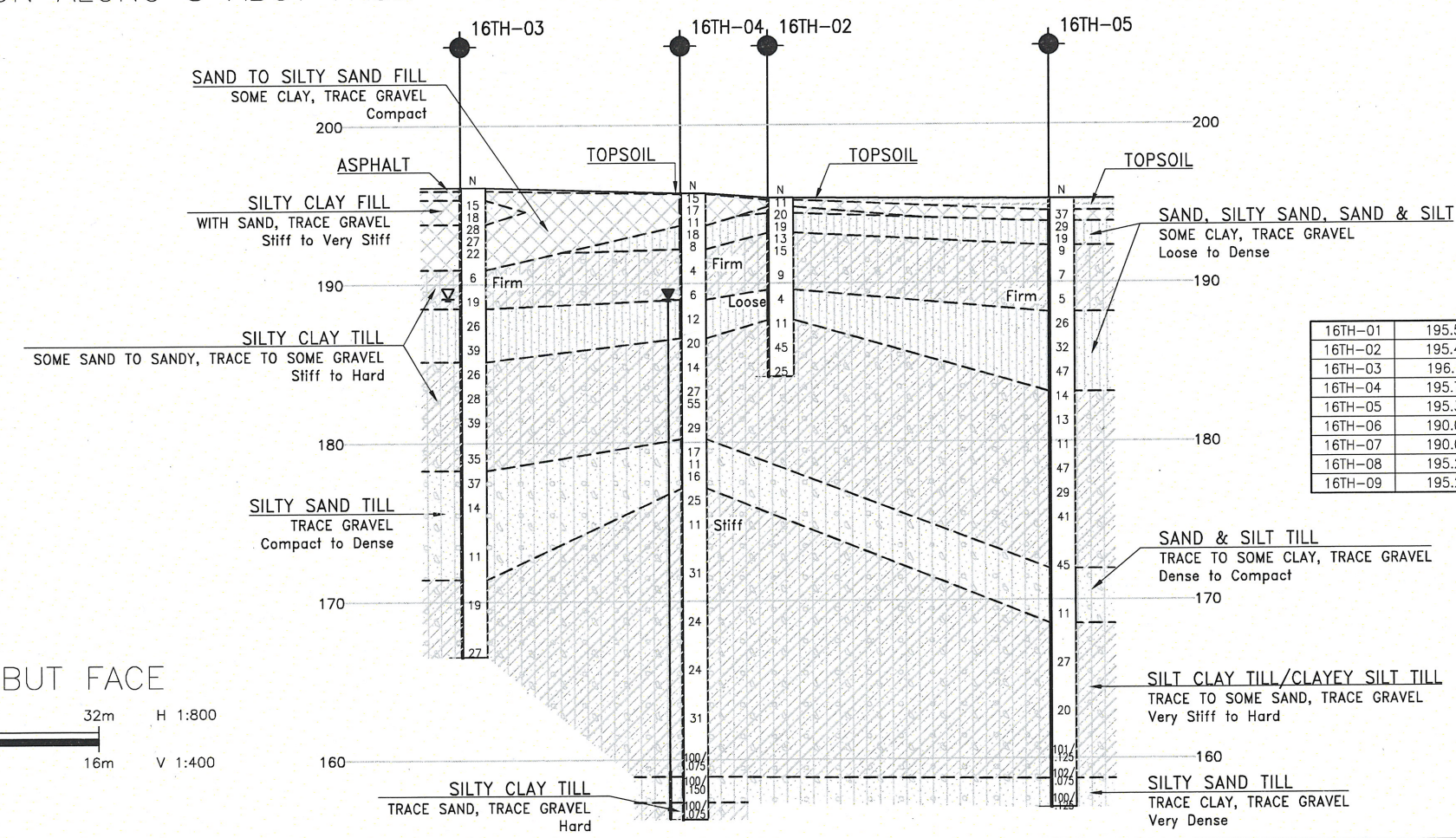
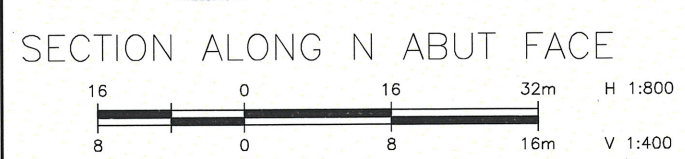
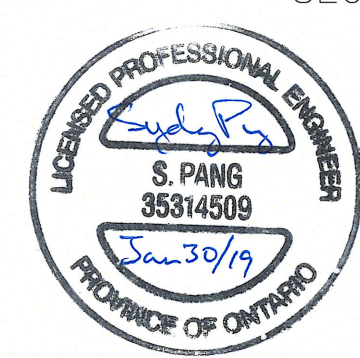
- ◆ Borehole (Current Investigation)
- ◆ Borehole (Previous Investigations)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- ▽ Water Level (Open Borehole)
- ⊥ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
03	194.2	4 858 346.8	314 828.8
04	194.0	4 858 365.4	314 806.8
07	194.2	4 858 392.8	314 835.5
08	194.2	4 858 375.7	314 790.4
09	194.2	4 858 381.8	314 824.5
10	194.2	4 858 342.2	314 810.2
13	189.5	4 858 384.6	314 843.2
14	189.6	4 858 366.1	314 847.7
15	189.3	4 858 364.2	314 788.3
16	189.9	4 858 343.6	314 793.5
101	195.5	4 858 388.3	314 805.6
102	195.1	4 858 333.2	314 812.5

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

GEOCRES No. 30M14-487

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE
			LOAD
			DATE JAN 2019
			STRUCT
			DWG 2



16TH-01	195.5	4 858 407.9	314 803.6
16TH-02	195.4	4 858 407.4	314 812.8
16TH-03	196.1	4 858 390.2	314 777.6
16TH-04	195.7	4 858 397.5	314 804.7
16TH-05	195.3	4 858 416.6	314 847.4
16TH-06	190.0	4 858 374.0	314 817.1
16TH-07	190.0	4 858 357.8	314 812.8
16TH-08	195.2	4 858 338.4	314 812.1
16TH-09	195.2	4 858 344.4	314 828.2



Appendix F

Foundation Comparison

**COMPARISON OF FOUNDATION ALTERNATIVES
HIGHWAY 404 16TH AVENUE INTERCHANGE RECONSTRUCTION**

Spread Footings on Native Soils or Engineered Fill	Steel H-Piles Driven to Specified Resistance in “100-blow” Tills	Augered Caissons
<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. ii. Relative ease of construction. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Relatively deep excavations (more than 9 m) would be required to bear footings on native competent soils. ii. Temporary protection (shoring) and dewatering will be required 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into “100-blow” tills. ii. Suitable for integral abutment design. iii. Foundation construction requires less volume of excavation than footings. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Potential cobbles and boulders could impede pile penetration to the desired depths. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance available for units founded on very dense/hard till. ii. Likely requires smaller work zone than other alternatives during construction. iii. Sub-excavation of fill and variable material should be minimal. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher cost than spread footings ii. Specific installation measures such as temporary liners and drilling water/slurry will be required to install caissons under the water table. iii. Potential loss of ground during installation could have adverse impacts on existing bridges. iv. Potential difficulties during augering to dislodge, remove or otherwise penetrate cobbles, boulders and hard/very dense zones within the tills.
RELATIVE COSTS		
MEDIUM	MEDIUM	HIGH
RELATIVE RISKS		
MEDIUM	LOW	HIGH
NOT RECOMMENDED	RECOMMENDED FOR ABUTMENTS AND PIER	TECHNICALLY FEASIBLE BUT NOT PREFERABLE

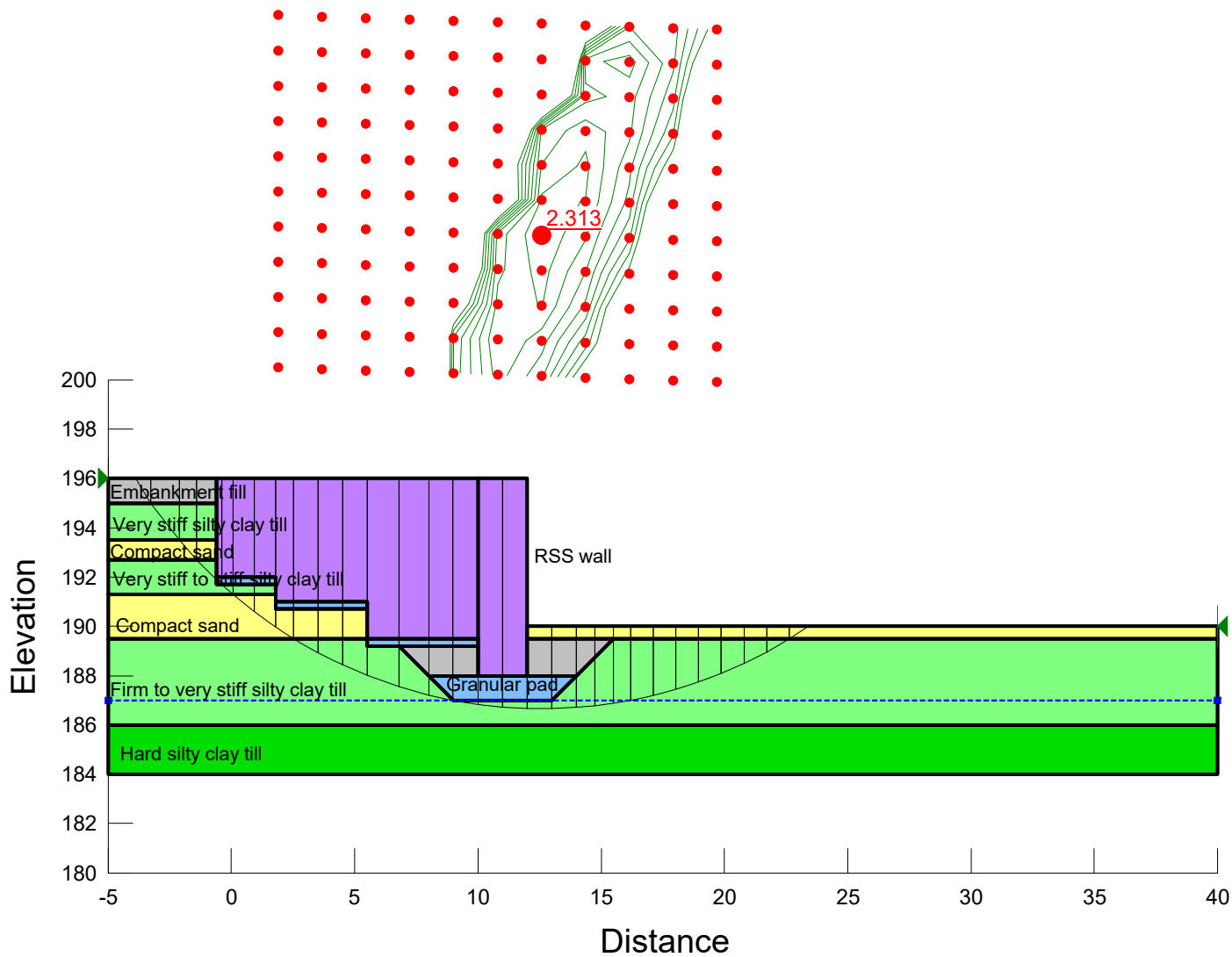


Appendix G

Selected Slope Stability Output

Project Number: 15786
Highway 404 and 16th Avenue
Overpass
False Abutment , Height 6.0 m
Drained analysis

Name: RSS Wall Unit Weight: 22 kN/m³ Cohesion: 200 kPa Phi: 45 ° Phi-B: 0 ° Piezometric Line: 1
Name: Granular pad Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment fill (silty clay and sand layers) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Firm to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 29 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 2 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1



Project Number: 15786
Highway 404 and 16th Avenue
Overpass
False Abutment , Height 6.0 m
Seismic analysis PGA=0.13g

Name: RSS Wall Unit Weight: 22 kN/m³ Cohesion: 200 kPa Phi: 45 ° Phi-B: 0 ° Piezometric Line: 1
Name: Granular pad Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1
Name: Embankment fill (silty clay and sand layers) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Firm to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

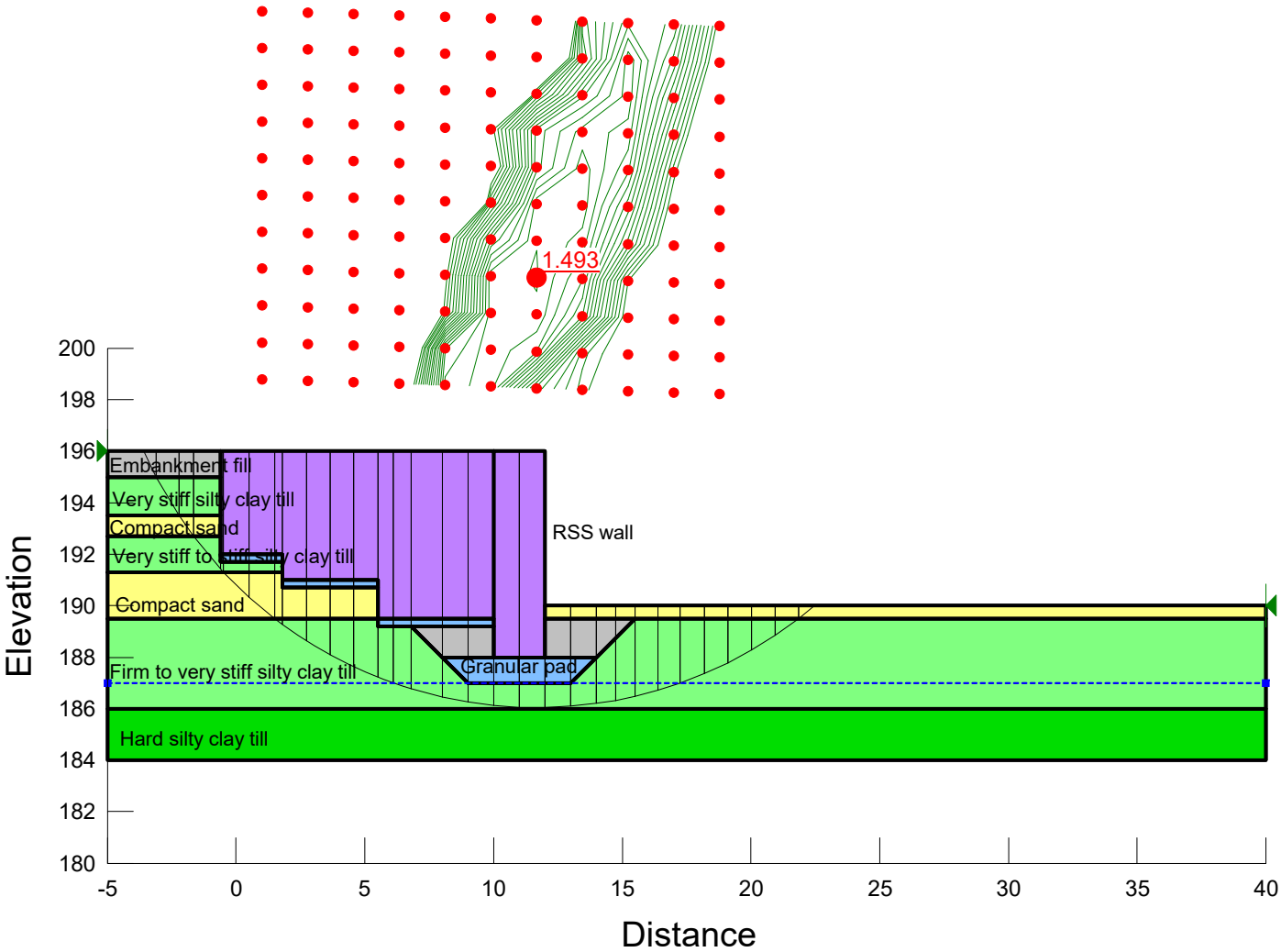
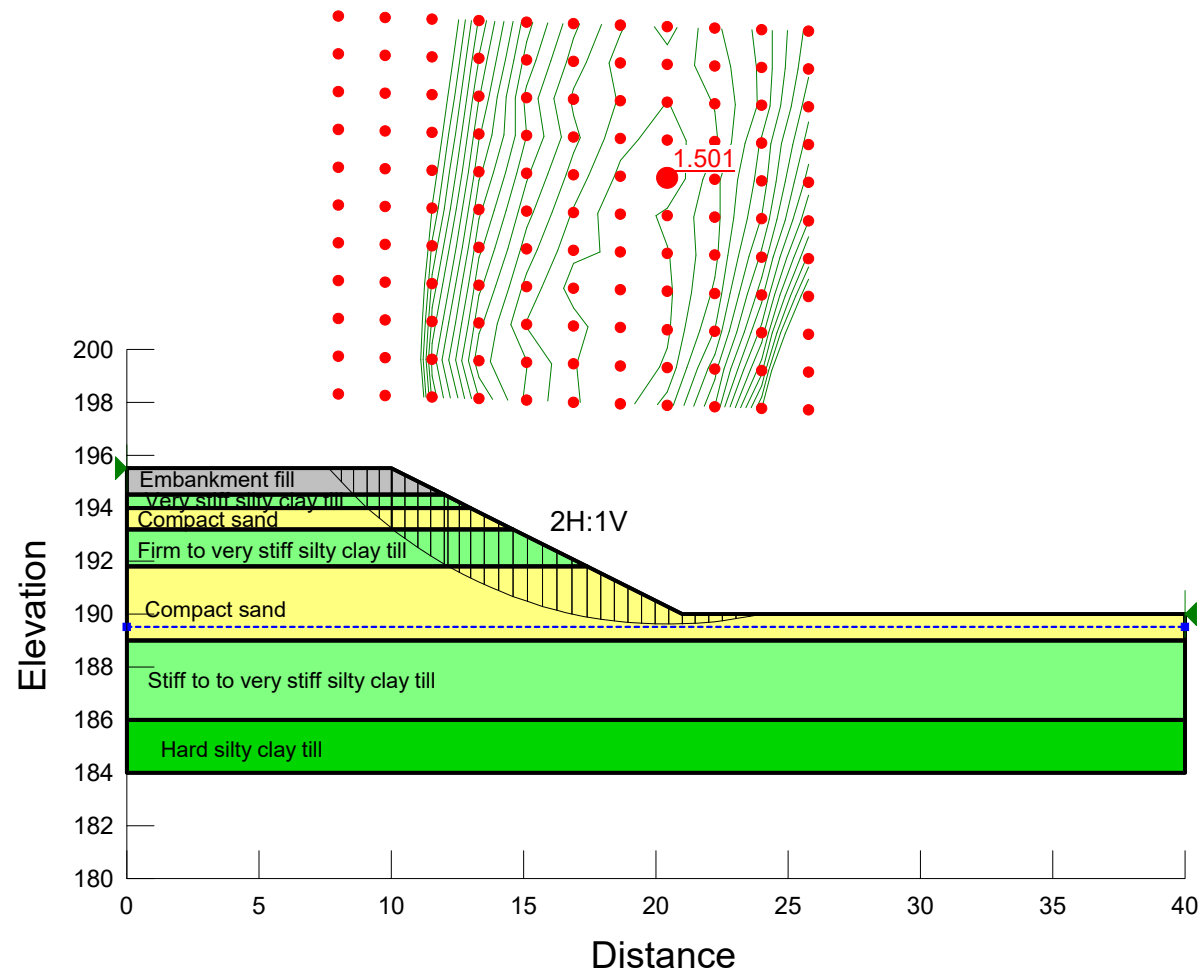


Figure G2

Project Number: 15786
Highway 404 and 16th Avenue
Overpass
Side slope, Height 5.5 m
Drained Analysis

Name: Embankment fill (silty clay and sand layers) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Firm to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 29 ° Phi-B: 0 ° Piezometric Line: 1
Name: Hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 2 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1



Project Number: 15786
 Highway 404 and 16th Avenue
 Overpass
 Side slope, Height 5.5 m
 Seismic Analysis PGA=0.13g

Name: Embankment fill (silty clay and sand layers)	Unit Weight: 19 kN/m ³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Compact sand	Unit Weight: 20 kN/m ³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Stiff to very stiff silty clay till	Unit Weight: 19 kN/m ³	Cohesion: 50 kPa	Phi: 0 °	Phi-B: 0 °	Piezometric Line: 1
Name: Hard silty clay till	Unit Weight: 20 kN/m ³	Cohesion: 150 kPa	Phi: 0 °	Phi-B: 0 °	Piezometric Line: 1

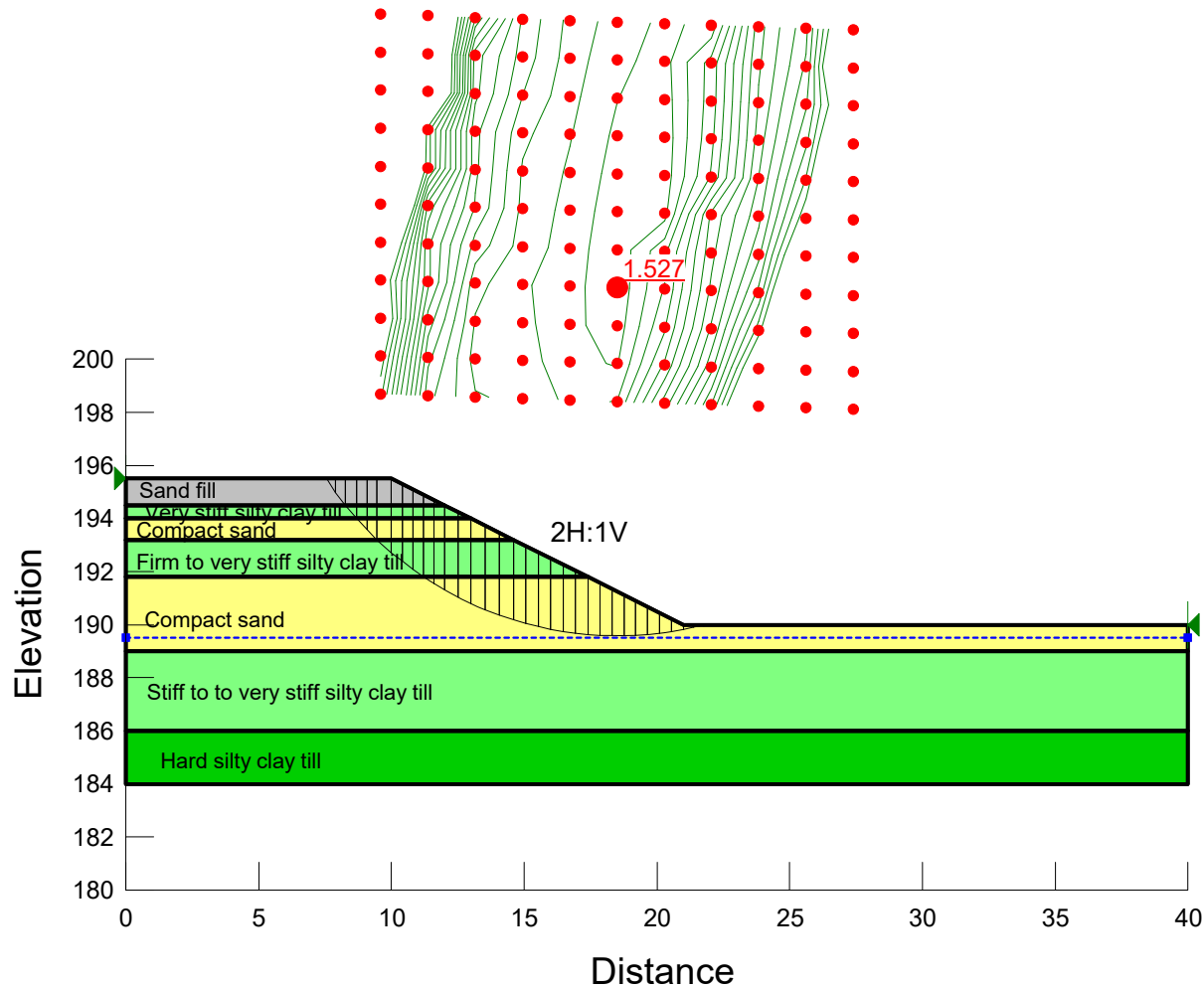


Figure G4

Project Number: 15786
Highway 404 and 16th Avenue Overpass
Temporary cut, Height 6.0 m
Drained Analysis
Slope 1.5H :1V

Name: Embankment fill (silty clay and sand layers)	Unit Weight: 19 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Compact sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Firm to very stiff silty clay till	Unit Weight: 19 kN/m³	Cohesion: 1 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Very stiff to hard silty clay till	Unit Weight: 20 kN/m³	Cohesion: 2 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1

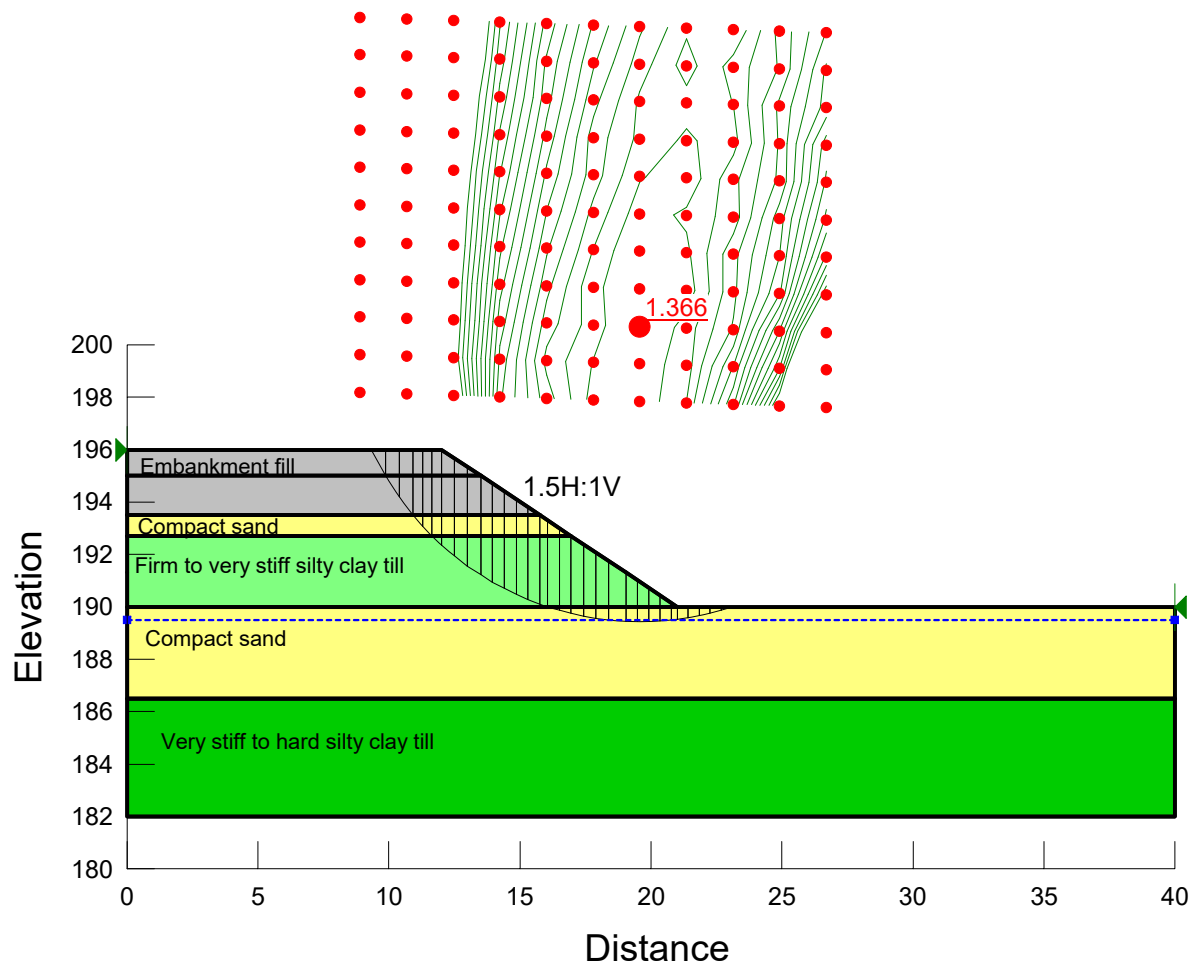


Figure G5

Project Number: 15786
Highway 404 and 16th Avenue Overpass
Temporary cut, Height 6.0 m
Undrained Analysis
Slope 1.5H :1V

Name: Embankment fill (silty clay and sand layers) Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Firm to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 35 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Very stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1

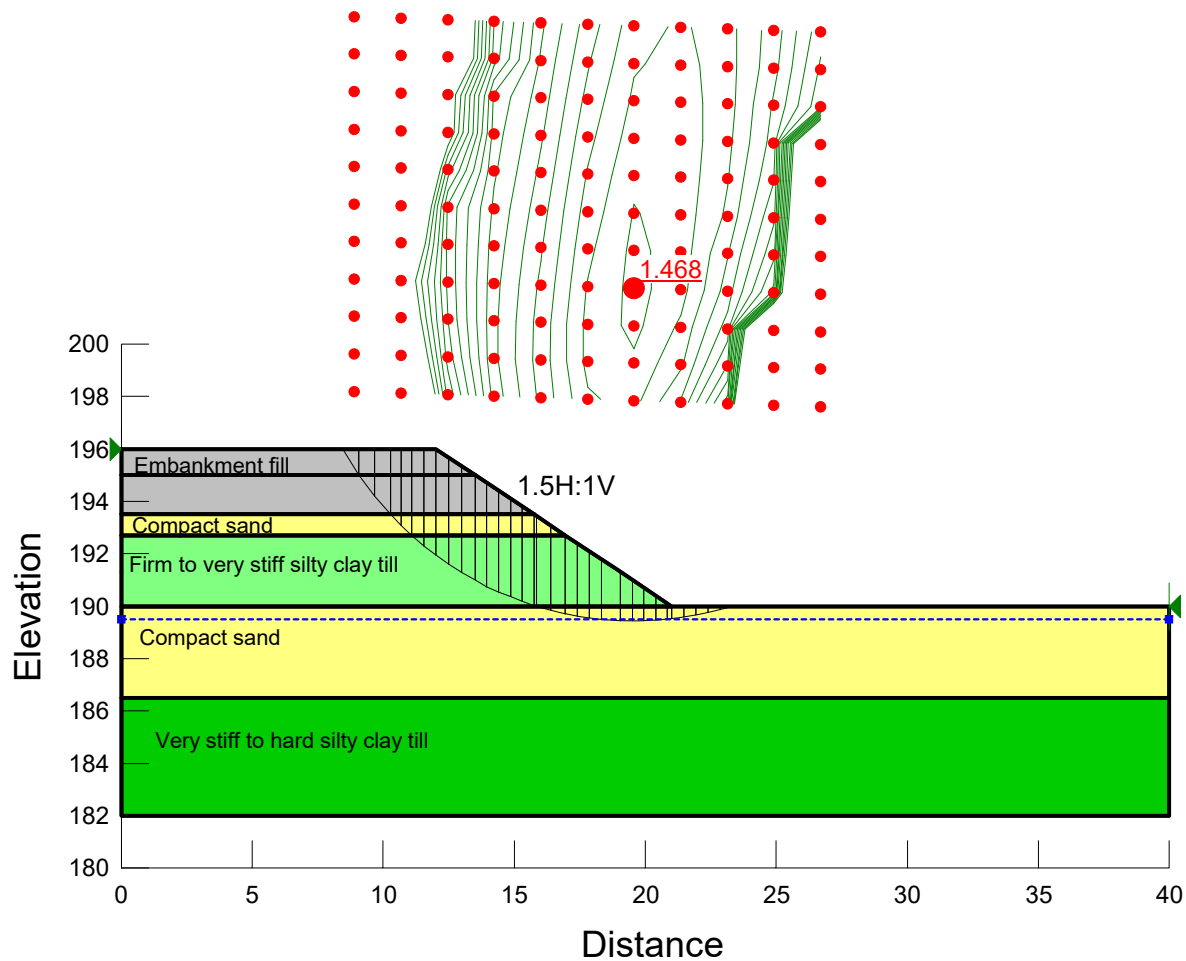


Figure G6

Project Number: 15786
 Highway 404 and 16th Avenue
 Overpass
 Temporary cut, Height 6.0 m
 Drained Analysis
 Slope 1H :1V

Name: Embankment fill (silty clay and sand layers)	Unit Weight: 19 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Compact sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Firm to very stiff silty clay till	Unit Weight: 19 kN/m³	Cohesion: 1 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Very stiff to hard silty clay till	Unit Weight: 20 kN/m³	Cohesion: 2 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1

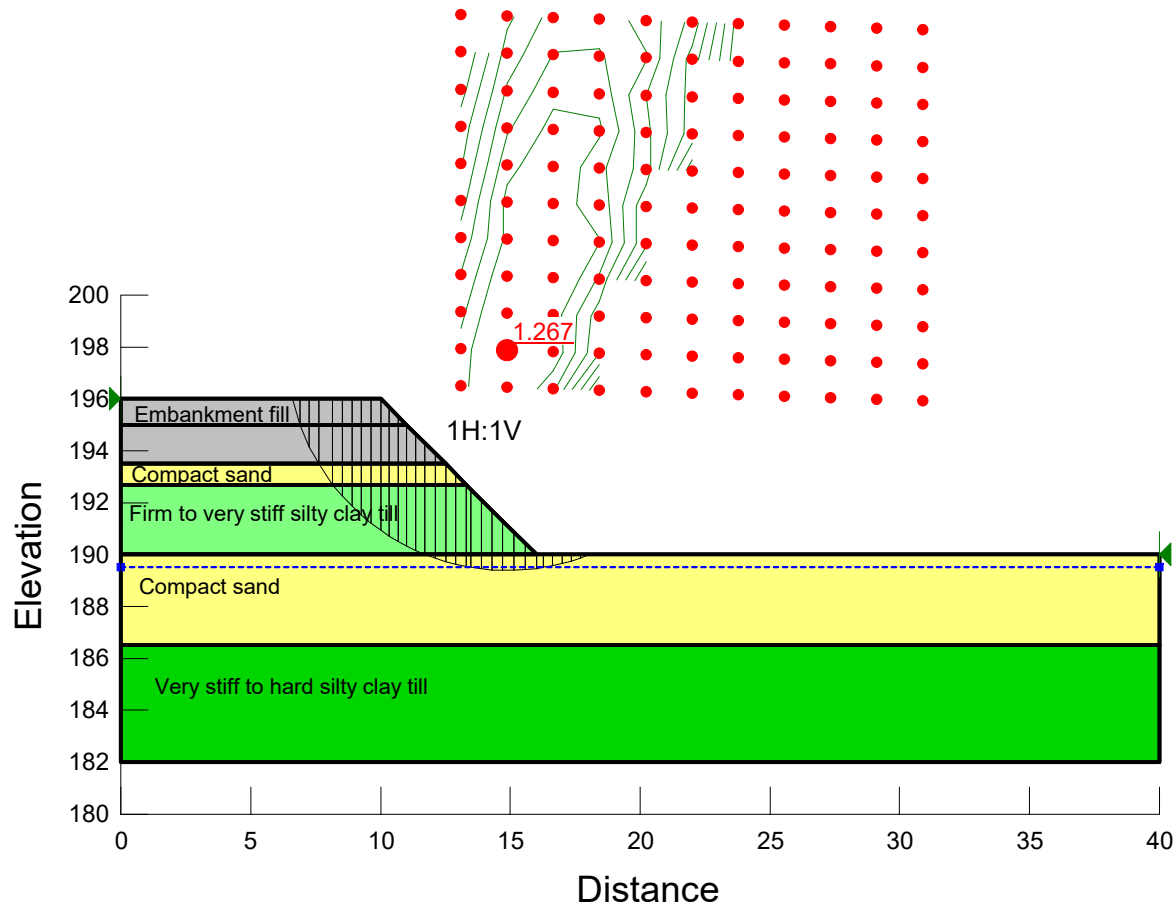


Figure G7

Project Number: 15786
 Highway 404 and 16th Avenue
 Overpass
 Temporary cut, Height 6.0 m
 Undrained Analysis
 Slope 1H :1V

Name: Embankment fill (silty clay and sand layers)	Unit Weight: 19 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Compact sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Firm to very stiff silty clay till	Unit Weight: 19 kN/m³	Cohesion: 35 kPa	Phi: 0 °	Phi-B: 0 °	Piezometric Line: 1
Name: Very stiff to hard silty clay till	Unit Weight: 20 kN/m³	Cohesion: 150 kPa	Phi: 0 °	Phi-B: 0 °	Piezometric Line: 1

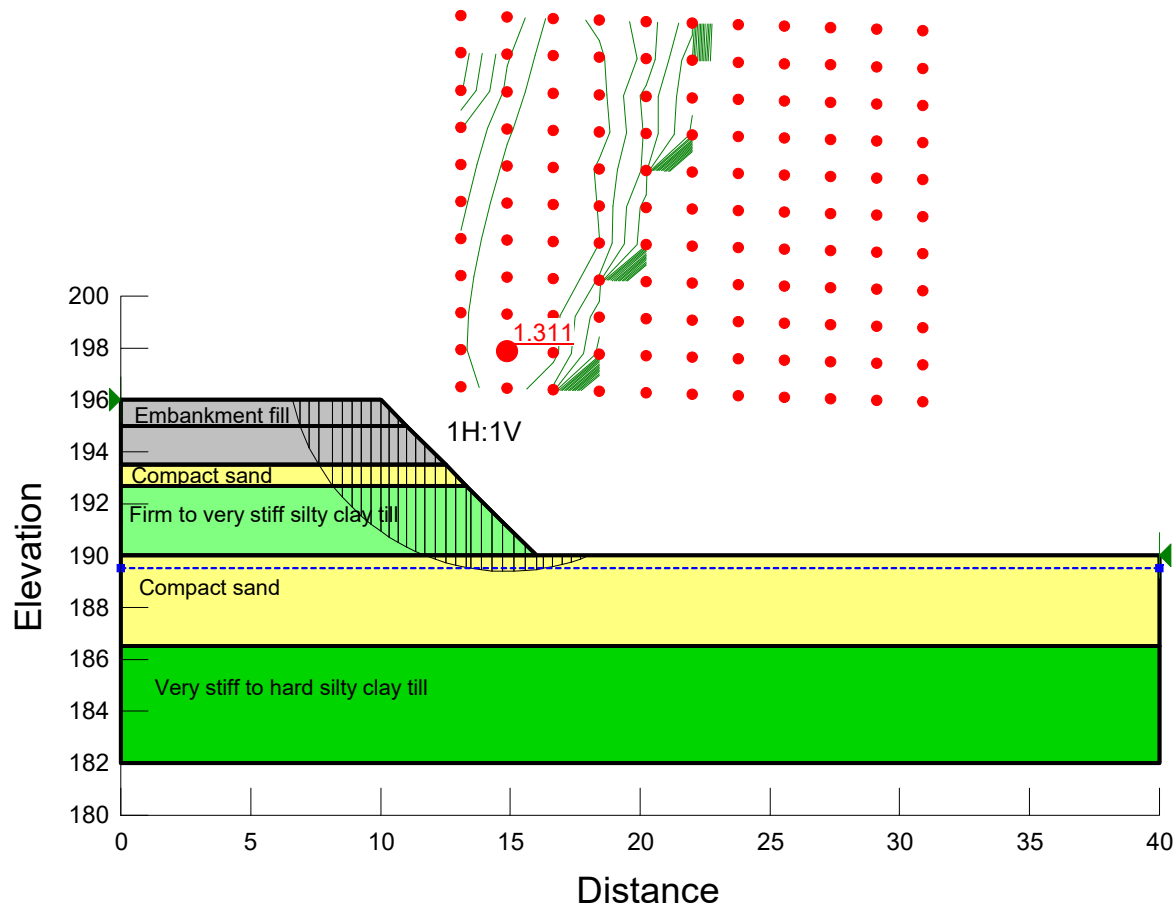


Figure G8



Appendix H

List of Special Provisions and Suggested Wording for NSSP



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
- NSSP FOUN0003 Amendment to OPSS.PROV 902
- OPSS PROV 903 Construction specification for deep foundations
- 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

The Contractor is alerted that there are risks of encountering obstructions such as cobbles, boulders and other man-made debris within the embankment fill and native soils. Such obstructions and hard/very dense zones in the soils can impede pile penetration. 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 an 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 “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 the following adjacent structures:

- The lanes of the Highway 404 during excavation and foundation construction at the new north and south abutments.
- Protection of the existing structure foundations, back slopes at median, and utilities (if present at this site) during excavation and pile driving.
- Protection of existing approach fills.

4. Suggested Text for NSSP on “Vibration and Settlement Monitoring”

The Contractor shall monitor vibration levels on the existing structure during pile driving for the new structure. The vibration monitoring equipment shall be placed on the ground adjacent to the existing structure such that it will not be disturbed. The monitoring locations should be strategically selected to characterize vibration propagation at the site. Vibration levels due to pile driving are measured in peak particle velocity (ppv) and the monitoring criteria that have been established for this project are as follows:

- a) For a vibration frequency of 30 Hz or less (typical of impact pile driver), a review ppv level of 9 mm/sec and an alert ppv level of 12 mm/sec shall be used. For a vibration frequency of greater than 30 Hz, a review ppv level of 12 mm/sec and an alert ppv level of 15 mm/sec shall be used.
- b) Survey markers consisting of fluorescent paint marks shall be established as survey targets on bridge abutments located within 20 m of any pile to be driven. Two (2) survey markers shall be established on each wall face (abutment walls and wing walls). A minimum of two (2) survey markers (concrete nails may be used as substitution) shall be established on the pavement at each bridge immediate approach. Prior to commencement of pile driving, baseline elevation readings shall be established and the results submitted to the Contract Administrator (CA) for approval and record purposes.



- c) The benchmark elevations at the survey markers shall be surveyed to an accuracy of ± 2 mm or better. An acceptable set of baseline readings shall consist of three (3) readings taken on three (3) consecutive days. All survey elevations must be established with reference to survey monuments located outside of the immediate vicinities of the piling operation and monitoring areas.
- d) Upon commencement of pile driving, vibration monitoring, elevation surveys of survey markers, and visual field inspection shall be carried out by the Contractor on a continual basis.

As a minimum, all survey markers shall be surveyed once after the baseline readings and immediately prior to the commencement of pile driving. For the first day of piling at the site, each marker shall be surveyed three (3) times a day, say, morning before piling, mid-day and end of day. Assuming the readings do not show any sign of movement, then the monitoring frequency may be reduced to twice a day (say beginning and end of day). The monitoring frequency (more or less) may be changed when deemed necessary by the Contract Administrator during the course of the work.

- g) Vibration monitoring shall be carried out by the Contractor, or its representatives, using vibration monitoring equipment such as the Instantel Blast Mate Monitors, or equal. These monitors shall be deployed at selected locations on site including the ground surfaces adjacent to bridge elements where survey monitoring is to be carried out.
- h) At each site, continual monitoring shall be carried out for the first day to establish vibration patterns. Thereafter, vibration monitoring shall be carried out during the first 3 m of driving and during seating of each pile. In any case, the monitoring frequency shall not be less than that required for survey monitoring outlined above.
- i) Any exceedance of the review or alert levels must be reported to the Contract Administrator immediately. Should the vibration level reach or exceed the review level as specified in Clause a), but less than the alert level, and provided that settlement or other forms of distress are not evident, the pile driving operation may proceed with caution and in conjunction with precautionary measures including more frequent survey of the survey markers. If the vibration and/or settlement monitoring readings are not acceptable, the Contractor must alter the pile driving procedures (including reduction of the hammer energy) until the measured vibrations are within acceptable limits.



- j) Should there be any sign of potential adverse effect on the bridge elements and pavement surface as a result of visual inspections, or if the measured vibration level approaches the alert level, or if there is a change in the baseline elevations that indicate settlement or the development of a trend of settlement, the Contractor shall immediately stop the piling work. The Contract Administrator will then review the situation and in conjunction with the Contractor, come up with a plan for re-commencing any piling operation in the area.
- k) All settlement and vibration monitoring results must be submitted to the Contract Administrator at the end of each day.

AMENDMENT TO OPSS.PROV 903, APRIL 2016

Special Provision No. 109F57M

April 2018

903.01 SCOPE

Section 903.01 of OPSS.PROV 903 is amended by the addition of the following:

Under the above tender items, the Contractor shall:

- a) Supply and install H-Piles
- b) Provide Styrofoam sheet to cover CSP.
- c) Coordinate with the Contractor Administrator or an independent testing company retained by the Contract Administrator for dynamic formula and high-strain dynamic testing.

All as shown on the Contract Drawings.

903.03 DEFINITIONS

Section 903.03 of OPSS.PROV 903 is amended by the deletion of the definitions for Certificate of Conformance and Quality Verification Engineer.

903.04 DESIGN AND SUBMISSION REQUIREMENTS

903.04.02.04.02.01 Milestone Inspections

Clause 903.04.02.04.02.01 of OPSS.PROV 903 is deleted in its entirety.

903.04.02.06 Review of Splice Test Results and Permission to Proceed

Clause 903.04.02.06 of OPSS.PROV 903 is deleted in its entirety.

903.07 CONSTRUCTION

903.07.02.07.01 General

Clause 903.07.02.07.01 of OPSS.PROV 903 is amended by deleting the first paragraph in its entirety and replacing it with the following:

The driving of piles shall be carefully monitored and controlled and pile driving records produced for each pile under the direction of the Contractor. The pile driving records shall be submitted to the Contract Administrator.

903.07.02.07.03 Driving to a Specified Ultimate Resistance

903.07.02.07.03.01 General

Clause 903.07.02.07.03.01 of OPSS.PROV 903 is deleted in its entirety and replaced with the following:

When piles are specified to be driven to a specified ultimate resistance, the specified ultimate resistance will be validated using dynamic formula analysis and high-strain dynamic testing at end of drive (EOD) as performed by the Contract Administrator or an independent testing company retained by the Contract Administrator. If the specified ultimate resistance is not achieved, retap / restrike should be conducted after sufficient time has passed to allow soil setup. The requirements for soil setup are as specified in the Contract Documents.

All piles are to be driven to the geodetic elevations indicated in the Contract Documents.

A Request to Proceed shall be submitted to the Contract Administrator after the design ultimate resistance is achieved.

The next operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

903.07.02.07.03.03 Driving to Bedrock

Clause 903.07.02.07.03.03 of OPSS.PROV 903 is amended by deleting the last sentence in its entirety.

903.07.02.07.04 Wave Equation Analysis

Clause 903.07.02.07.04 of OPSS.PROV 903 is deleted in its entirety and replaced with the following:

903.07.02.07.04 Dynamic Formula Analysis and High-Strain Dynamic Testing

The Contractor shall supply all equipment, material, and personnel necessary for the Contract Administrator or an independent testing company retained by the Contract Administrator to conduct the dynamic formula analysis and high-strain dynamic testing at the end of drive (EOD).

High-strain dynamic testing shall be performed by the Contract Administrator or an independent testing company retained by the Contract Administrator using the Pile Driving Analyzer (PDA), or approved equivalent, for the determination of pile ultimate resistance, establishment of pile installation criteria, assessment of pile integrity, monitoring of hammer/drive system performance and driving stresses, as specified in the Contract Documents. The method and equipment for testing and its reporting shall be according to ASTM D 4945.

The location, sequencing and scheduling of the individual pile analysis/testing shall be proposed by the Contractor based on the purpose of the analysis/testing and shall be submitted to the Contract Administrator for review. The final selection of the piles to be analyzed/tested will be determined by the Contract Administrator.

Dynamic formula testing shall be carried out at the end of initial driving on all piles. High-strain dynamic testing shall be carried out on a minimum of 10% of the piles in each pile group, rounded up, but no fewer than two piles, or as specified in the Contract Documents.

Additional testing (i.e. restrike testing) shall be carried out during the re-tapping of piles, as specified in Clause 903.07.02.07.06 (see below). Restrike testing shall be performed on a minimum of 10% of the piles in each pile group, rounded up to the next whole number, but no fewer than two piles, or as specified in the Contract Documents.

The pile driving hammer shall be at operational temperature prior to performing any restrrike testing. Where required, the hammer shall not be brought to operational temperature by striking the intended test piles.

903.07.02.07.06 Retapping Tests on Piles

Section 903.07.02.07.06 is deleted in its entirety and replaced by the following:

In each pile group, 10% of the piles rounded up to the next whole number, but no fewer than two piles, shall be re-tapped no sooner than 48 hours after installation of the individual pile to confirm that the ultimate axial geotechnical resistance has been achieved and/or sustained.

903.07.03.07 Concrete

903.07.03.07.01 General

Clause 903.07.03.07.01 of OPSS.PROV 903 is deleted in its entirety and replaced with the following:

A Request to Proceed shall be submitted to the Contract Administrator before the concrete placement.

The reinforcement shall not be displaced or distorted during the construction of the caisson.

The placement of concrete shall not proceed until the Contract Administrator has inspected the caisson hole and issued to the Contractor a Notice to Proceed.

Concrete shall be placed immediately after the Notice to Proceed has been received and shall be placed in the caisson according to OPSS.PROV 904 and as specified herein.

Arching of concrete during casing withdrawal shall be prevented.

903.07.03.07.05 Founding Elevation

Clause 903.07.03.07.05 of OPSS.PROV 903 is amended by deleting the last paragraph in its entirety and replacing it with the following:

Complete access to inspect the bearing area of the caisson pile prior to the placement of concrete shall be given to the Contract Administrator.

903.07.06 Load Test

Subsection 903.07.06 of OPSS.PROV 903 is amended by deleting the first paragraph in its entirety and replacing it with the following:

When a load test is specified in the Contract Documents, the testing shall be according to ASTM D 1143M for piles under vertical static load, ASTM D 3689 for piles under tensile load, and ASTM D 3966 for piles under lateral loads. The Contract Administrator shall witness the pile load test. All records and results of the pile load test shall be submitted to the Contract Administrator.

903.07.08.01.02 Visual Inspection of Welds

Clause 903.07.08.01.02 of OPSS.PROV 903 is deleted in its entirety and replaced with the following:

Complete access to visually inspect the welds shall be given to the Contract Administrator.

A representative sample of not less than 30% of the welds, as determined by the Contract Administrator, shall be visually inspected for conformance to the requirements of CSA W59 and the Contract Documents.

903.07.08.01.03 Non-Destructive Testing of Welds

Clause 903.07.08.01.03 of OPSS.PROV 903 is deleted in its entirety and replaced with the following:

Radiographic or ultrasonic testing shall be carried out using procedures according to CSA W59.

Ultrasonic or radiographic testing shall be carried out on the entire length of selected splice welds chosen at random by the Contractor's welding inspector assigned to carry out visual inspections.

Selection shall be based on the following criteria:

- a) For pile groups other than at integral abutments, 10% of the splice welds, rounded to the next highest number, but no fewer than two.
- b) For pile groups at integral abutments, 10% of the splice welds, rounded to the next highest number, but no fewer than two of when the welds are below 6 m of the pile cut-off elevation.
- c) For pile groups at integral abutments, all splice welds within 6 m of the pile cut-off elevation.

903.07.08.03 Certificate of Conformance

Clause 903.07.08.03 of OPSS.PROV 903 is deleted in its entirety.

903.10 BASIS FOR PAYMENT

903.10.01 Supply Equipment for Installing Driven Piles - Item
Supply Equipment for Installing Caisson Piles - Item
Supply Equipment for Installing Displacement Caisson Piles - Item

Subsection 903.10.01 of OPSS.PROV 903 is amended by deleting the second paragraph in its entirety and replacing it with the following:

For payment purposes, 50% of the work under this item shall be paid when the satisfactory performance of the equipment has been demonstrated to the Contract Administrator by the installation of 1% of piles.

Another 40% shall be paid by progress payments proportional to the work completed. The remaining 10% shall be paid on the satisfactory completion of the installation of piles.