



FOUNDATION INVESTIGATION AND DESIGN REPORT

PROPOSED OVERHEAD SIGN SUPPORT STRUCTURES

TOWN OF NIAGARA-ON-THE-LAKE NIAGARA REGION, ONTARIO

SITE LOCATION (LAT: 43.160074°, LONG: -79.162193°)

MINISTRY OF TRANSPORTATION ONTARIO.

GWP 2423-15-00

GEOCRES NO. 30M3-317

WSP PROJECT NO.: 18M-01021-12

DECEMBER 21, 2019

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1 INTRODUCTION

WSP Canada Inc. (WSP) was retained by the Ministry of Transportation, Ontario (MTO) Central Region to conduct a peer review of the preliminary design plan, prepare a Design-Build Ready Package and assist MTO and Niagara Region during the Design Builder Procurement phase of the Queen Elizabeth Way (QEW) / Glendale Avenue interchange improvements project in the Town of Niagara-on-the-Lake, Ontario. This work is carried out under the MTO Central Region Mega 4 Retainer, Assignment No: 2017-E-0018 and forms Work Order No. 12.

As part of the preparation of the Design-Build Ready Package, foundation engineering services were required for the detail design of the following components:

- one 40 m long 2 m high Retaining Wall at Glendale Avenue and York Road Roundabout;
- one 30 m long 7 m high Retaining Wall for the Airport Road Structure;
- three 13 m long and 7 m high Retaining Walls for the Airport Road Structure;
- five Overhead Sign Support (OHS) Structures; and,
- nine High Mast Light (HML) Poles.

This report addresses the foundation investigation carried out in support of the proposed Overhead Sign Support Structures at the QEW/Glendale Avenue Interchange located in the Town of Niagara-On-The-Lake, Ontario. Five (5) proposed Overhead Sign Supports (OHS) as indicated in the Terms of Reference (TOR), was initially approved by MTO but, three (3) additional OHS structures was later added. However, was one of them (OHS5) was cancelled after the field work was carried out. The purpose of the Geotechnical Investigation was to determine the sub-surface conditions and groundwater observations at the site by means of boreholes, field and laboratory tests. Based on the information obtained, the engineering characteristics of the subsurface soils were assessed and site conditions described to develop geotechnical recommendations to address the foundation scope.

Part A of this report presents factual information concerning the subsurface conditions based on all of the subsurface information at hand and is followed by Part B wherein engineering discussion and foundation recommendations are made for the design and construction of the proposed Overhead Signs Support Structures foundation.

2 BACKGROUND INFORMATION

2.1 GEOLOGICAL SETTING

The project site is located within the physiographic region of Southern Ontario known as the Iroquois Plain, which lies between Lake Ontario and Niagara Escarpment. The Iroquois Plain was inundated by glacial Lake Iroquois in late Pleistocene times. The Iroquois Plain is flat with little relief and is covered by lacustrine deposits of sands, silt and silty-clays overlying glacial clayey silt (Halton Till). These deposits are underlain by red shale of the Queenston formation of the Upper Ordovician.

2.2 PREVIOUS GEOTECHNICAL INFORMATION

The following foundation report pertains to the general area of the proposed OHS locations.

- Foundation Investigation and Design Report, QEW/Glendale Avenue Underpass Replacement, Niagara-On-The-Lake, GWP 2423-15-00, GEOCREST NO. 30M3-309, dated May 16, 2019.

According to the report the soil stratigraphy comprised of a fill material underlain by a silty clay to clayey silt deposit (consisting of a very stiff to hard crust and becoming firm to stiff with depth). This in turn is underlain by deposits of generally hard clayey silt, hard clayey silt to silty clay till, and/or dense to very dense sand and silt, overlying shale bedrock.

2.3 SITE DESCRIPTION

The key site plan is shown on **Drawing No. 1**. For reporting purposes, the Queen Elizabeth Way (QEW) is oriented in the east-west direction with respect to the geographic north while the Glendale Avenue is oriented in the north-south direction. The locations of the proposed Overhead Sign Supports (OHS) Structures generally span along Glendale Avenue (Regional Road 89) between Taylor Road (Regional Road 70) and the intersection of the On-ramp and Off-ramp at Glendale Avenue (Refer to Drawing No 1). The topography of the project site is generally flat and well vegetated with trees, shrubs and bushes. There are commercial businesses situated around the project site. Site photographs (taken during reconnaissance visit) indicating some of the OHS borehole locations are shown in **Appendix C**.

3 FIELD AND LABORATORY INVESTIGATIONS

3.1 FIELD INVESTIGATION

Site reconnaissance field visit observations (carried out on June 6, 2019) to assess the nature of the local terrain and access constraints (supplemented by ground information obtained from previous report) were carefully considered in planning the field investigation program. This led to the understanding that the locational access to the boreholes permitted the use of conventional drilling approach such as rubber track mounted CME 55/75 & M5T type of machine. The proposed borehole OHS3-2 has been substituted with GUA8 from previous geotechnical investigation given in section 2.3 (Geocres 30M3-309).

The first phase of field investigation commenced June 26, 2019 with notification to MTO and ended on June 28, 2019 with the completion of OHS2-1, OHS2-2, OHS4-1, OHS4-2 & OHS5. The drilling for the rest of the Overhead Sign Support boreholes began August 23, 2019 and ended September 25, 2019. Photos C2-1 & C2-2 indicating some of the field investigation locations are shown in **Appendix C**. Generally, traffic protection was not needed for the borehole drilling operation except for OHS7-1 & OHS7-2 located on the Southbound and Northbound lanes of Glendale Avenue respectively. Borings were achieved by means of solid/hollow stem continuous flight auger as indicated in Table 3-1.

The traffic set-up indicated a single lane closure on Glendale Avenue adopting TL-23 in accordance with MTO Book 7.

The fieldwork was carried out as indicated above under the full-time supervision of WSP technical staff who directed the exploration and sampling operations, logged borehole data in accordance with MTO Soil Classification System and took custody of soil samples retrieved for subsequent laboratory testing and identification. Soil samples were visually classified in the field and later re-evaluated by an engineer. The recovered soil samples were placed in labelled moisture-proof bags and returned to WSP's laboratory for further assessment and testing.

Table 3-1 presents the exploratory hole details of the WSP foundation investigation program.

Table 3-1 Summary of Exploratory Hole Details

Borehole No.	MTM NAD83 Co-Ordinates: Eastings/ Northings (m)	Ground El. (m)	Explored Depth (m)	Drilling Methodology/Remarks
OHS1-1	E 332064.5 N 4779591.2	116.8	8.2	Track Mount M5T/Solid Stem Auger
OHS1-2	E 332052.99 N 4779600.6	116.9	8.2	Track Mount M5T/Solid Stem Auger
OHS2-1	E 332170.8 N 4779861.7	117.8	8.2	Track Mount CME 75/Hollow Stem Auger
OHS2-2	E 332160 N 4779861.7	118.0	8.2	Track Mount CME 75/Hollow Stem Auger

OHS3-1	E 332115.6 N 4779691.7	115.1	8.2	Track Mounted M5T/Solid Stem Auger
OHS4-1	E 332134.4 N 4779786	122.2	8.2	Track Mount CME 75/Hollow Stem Auger
OHS4-2	E 332121.2 N 4779791.2	122.8	8.2	Track Mount CME 75/Hollow Stem Auger
OHS5	E 332183.8 N 4779853	117.9	8.2	Track Mount CME 75/Hollow Stem Auger
OHS6-1	E 332013.5 N 4779711.1	117.2	8.2	Track Mount M5T/Solid Stem Auger
OHS6-2	E 332026 N 4779723.2	115.8	8.2	Track Mount M5T/Solid Stem Auger
OHS7-1	E 331934.4 N 4779468.8	118.3	8.2	Track Mount M5T/Solid Stem Auger
OHS7-2	E 331952 N 4779463	119.1	8.2	Track Mount M5T/Solid Stem Auger
OHS8-1	E 332176.8 N 4779769.4	119.0	8.2	Track Mount CME 55/Hollow Stem Auger
OHS8-2	E 332196.9 N 4779790.1	118.3	8.2	Track Mount CME 55/Hollow Stem Auger

Notes:

- 1) Locates done by PVS with participating companies such as Niagara-On-The-Lake Hydro One, Enbridge Gas, Bell Canada and COGECO Cable.
- 2) The spacing and quantity of boreholes generally conform to RFP requirements;
- 3) Type of drilling rig Used: Track Mounted - CME 55 & 75 drilling rigs (used by Pontil Drilling Services Inc.) and Track Mounted M5T rig (used by DrillTech Drilling Ltd.);
- 4) Co-ordinates: based on MTM NAD 83 Zone 10 coordinates; Terminology of directions, e.g., Reference to North is geographic;
- 5) Traffic control to Book 7 by Geotechnical Support Services Inc., Markham, Ontario;
- 6) Names of Drilling Company: DrillTech Drilling Ltd, Newmarket, Ontario (for drilling boreholes OHS1-1, OHS1-2, OHS3-1, OHS6-1, OHS6-2, OHS7-1 & OHS7-2) and Pontil Drilling Services Inc., Mount Albert, Ontario (for drilling boreholes OHS2-1, OHS2-2, OHS4-1, OHS4-2, OHS5, OHS8-1 & OHS8-2);
- 7) Drilling Supervision: by WSP staff from Toronto office;
- 8) Borehole Survey by WSP representative using Sokkia Archer Global Positioning System (GPS) unit with a horizontal and vertical accuracy of 0.01 m and 0.05 m respectively.

Samples were retrieved at regular intervals with a 50 mm Outer Diameter (O.D.), split-barrel sampler driven with a hammer weighing 63.5kg and dropping a vertical distance of 760 mm in accordance with the Standard Penetration Test (ASTM D1586) method. This sampling method recovers samples from the soil strata, and the number of blows required to drive the sampler

300 mm depth into the undisturbed soil (SPT ‘N’-values) gives an indication of the compactness condition or consistency of the sampled soil material. The SPT ‘N’ values are indicated on the Record of Borehole Sheets (Refer to **Appendix A**). The borehole termination criteria are as specified in the Terms of Reference. Pocket penetrometer testing was also carried out on the recovered soil samples. Field vane shear tests were carried-out in accordance with ASTM D2573.

3.2 LABORATORY INVESTIGATIONS

Visual examination and classification were undertaken on the soil samples returned to WSP laboratory. A routine laboratory testing program consisting of natural water content tests, grain size analysis, hydrometer testing and Atterberg Limits Test was carried out on selected representative soil samples. The grain size distribution curves and the plasticity charts are presented in **Appendix B**. In addition, conductivity / resistivity, pH, sulphate and chloride content testing were carried out on selected samples by a specialist analytical laboratory. The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets in **Appendix D**.

3.3 GROUNDWATER INVESTIGATION

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

Standpipe piezometers (50 mm) were installed in boreholes OHS1-1, OHS7-1 and OHS8-1 upon completion to enable long-term groundwater level monitoring. The rest of the boreholes were grouted (decommissioned) using a cement/bentonite mixture as per MTO procedures. As part of the construction, the piezometers need to be decommissioned in accordance with Ontario Regulation 903 (amended to Ontario Regulation 327/07).

Table 3-2 provides information about the piezometers installed for this investigation, including ground surface elevation, depths and the approximate elevations of the screen interval.

Table 3-2 Piezometer Installation Details

BH No.	Ground Surface Elevation (m)	Borehole Bottom		Well Screen Interval Depth, m		Well Screen Interval Elevation, m		Remarks
		Depth (m)	Elevation (m)	From	To	From	To	
OHS1-1	116.8	8.2	108.6	6.7	8.2	110.1	108.6	Refer to Drawing 1 for the locations of the OHS boreholes
OHS7-1	118.3	8.2	110.1	6.7	8.2	111.6	110.1	
OHS8-1	119.0	8.2	110.8	6.7	8.2	112.3	110.8	

4 SUBSURFACE CONDITIONS

4.1 GENERAL

The subsurface conditions encountered at the overhead sign locations are described in the following sections. The borehole location plan is shown on **Drawing 1**. The soil descriptions are based on visual and tactile observations and complemented by the results of field and laboratory soil test results.

For purposes of soil description, the MTO Soil Classification Manual was generally followed and the secondary components were classified as per CFEM 2006. It should be noted that the subsurface conditions and the topsoil thicknesses encountered might vary in between and beyond the borehole locations and the topsoil thicknesses could vary especially in depressed areas and near watercourses. **Drawing Nos. 2 & 3** show cross sections of the subsoil strata for ease of visualization. All topsoil thicknesses reported should not be relied upon for quantity estimation as they may vary beyond the borehole locations. Unless otherwise stated, all SPT 'N' values quoted are for 300 mm of penetration.

Groundwater observations on completion of drilling were recorded. The observed borehole stability conditions upon completion of boreholes are also described. All groundwater levels observed in the exploratory holes are subject to seasonal fluctuations and variations due to precipitation events.

An overview of subsurface conditions is described below. All depths quoted are below the existing ground surface.

4.2 OVERVIEW

Fill overlying a native silty clay deposit was predominantly intercepted in all the boreholes and were advanced to approximately 8 m depth (see **Drawing No. 2 & 3**). Cohesive fill thicknesses varying from 1.3 m to 5.3 m were intercepted in all the boreholes. The composition of the fill material is predominately silty clay. As a terminal deposit a clayey silt fill was intercepted in borehole OHS8-1. In general, the fill had SPT 'N' blow counts in each borehole ranging from 6 to 15 which typically can be described as a firm to very stiff consistency.

The native stratigraphy (underlying the topsoil and fill deposit) consist mainly of silty clay with proven thicknesses varying from 2.9 m to 6.9 m intercepted in all the boreholes. Generally, the measured moisture contents for the predominant native deposit ranged from 3% - 35% indicating moist to wet condition. The recorded SPT 'N' Values ranged from 9 to 31 which is indicative of a stiff to hard consistency.

Measured groundwater levels in three boreholes installed with monitoring wells recorded water levels that ranged from El. 115.6 m to 108.8 m.

Overlying the fill, a veneer of topsoil was intercepted in boreholes OHS1-1, OHS1-2, OHS2-1, OHS2-2, OHS3-1, OHS5, OHS6-1, OHS6-2, OHS8-1 & OHS8-2 with thicknesses ranging from 50 mm to 150 mm. OHS7-1 & OHS7-2 were advanced from the road surface on the NBL & SBL of Glendale Avenue and the asphalt thicknesses ranged from 150 mm to 210 mm.

4.3 SUBSURFACE CONDITIONS FOR OHS 1

4.3.1 FILL (SILTY CLAY)

Underlying a veneer of topsoil of 150 mm thickness, a fill comprised of silty clay was intercepted in OHS1-1 & OHS1-2 each with an explored thickness of 1.3 m and corresponding base elevations of Elev. 115.3 m and 115.4 m respectively.

The grain size distributions of selected sample from the fill were determined in the laboratory and gave the following grain size distribution shown in **Table 4-1**.

Table 4-1 Grain Size Distribution Summary - Fill (Silty Clay)

Sample Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS1-1/SS2	0	3	52	45	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above fill and the test indicated the following index value as shown in **Table 4-2**.

Table 4-2 Atterberg Limits Test Results - Fill (Silty Clay)

Sample Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS1-1/SS2	36	18	18	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of intermediate plasticity (CI).

Measured moisture contents of the spoon samples were from 22% to 26% indicative of a moist to wet condition. The SPT 'N' values of 8 -19 indicate the deposit to be of stiff to very stiff consistency.

4.3.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS1-1 & OHS1-2 each with an explored thickness of 6.7 m and corresponding base elevations of Elev. 108.6 m and Elev. 108.7 m respectively, on termination of the boreholes.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distributions shown in **Table 4-3**.

Table 4-3 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS1-1/SS5 OHS1-2/SS3 OHS1-2/SS7	0	2	29-31	67-69	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheets

Three (3) Atterberg limits tests were also performed on the above native deposit and the tests indicated the following index values as shown in **Table 4-4**.

Table 4-4 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS1-1/SS5 OHS1-2/SS3 OHS1-2/SS7	55-58	22-24	22-34	Shown in Figure B-4, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of high plasticity (CH).

Measured moisture contents of the spoon samples were in the range of 21% to 28% indicative of a moist to wet condition. SPT 'N' values ranged from 7 to 24 which indicate the deposit to be of firm to very stiff consistency.

4.4 SUBSURFACE CONDITIONS FOR OHS 2

4.4.1 FILL (SILTY CLAY)

Underlying a veneer of topsoil of 50 mm thickness, a fill comprised of silty clay was intercepted in OHS2-1 & OHS2-2 with explored thicknesses of 1.4 m & 3.0 m and corresponding base elevations of Elev. 116.3 m & 115.0 m respectively.

The grain size distributions of selected samples from the fill were determined in the laboratory and gave the following grain size distribution shown in **Table 4-5**.

Table 4-5 Grain Size Distribution Summary – Fill (Silty Clay)

Sample Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS2-2/SS3	0	2	41	57	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above fill and the test indicated the following index value as shown in **Table 4-6**.

Table 4-6 Atterberg Limits Test Results – Fill (Silty Clay)

Sample Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS2-2/SS3	44	20	24	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of intermediate plasticity (CI).

Measured moisture contents of the spoon samples were 19% to 21% indicative of a moist condition. SPT ‘N’ values of 9 to 10 indicate the deposit to be of stiff consistency.

4.4.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS2-1 & OHS2-2 with explored thicknesses of 6.7 m & 5.1 m and corresponding base elevations of Elev. 109.6 m & 109.8 m respectively, on termination of the boreholes.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distributions shown in **Table 4-7**.

Table 4-7 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS2-1/SS4 OHS2-1/SS8 OHS2-2/SS7	0	2	30-32	66-68	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheets

Three (3) Atterberg limits tests were also performed on the above native deposit and the tests indicated the following index values as shown in **Table 4-8**.

Table 4-8 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS2-1/SS4 OHS2-1/SS8 OHS2-2/SS7	53-55	22	31-33	Shown in Figure B-4, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of high plasticity (CH).

Measured moisture contents of the spoon samples were in the range of 20% to 25% indicative of a moist to wet condition. SPT ‘N’ values ranged from 7 to 27 which indicate the deposit to be of firm to very stiff consistency.

4.5 SUBSURFACE CONDITIONS FOR OHS 3

4.5.1 FILL (SILTY CLAY)

Underlying a veneer of topsoil of 150 mm thickness, a fill comprised of silty clay was intercepted in OHS3-1 with an explored thickness of 1.9 m and a corresponding base elevation of Elev. 113.0 m.

The grain size distributions of selected samples from the fill were determined in the laboratory and gave the following grain size distribution shown in **Table 4-9**.

Table 4-9 Grain Size Distribution Summary – Fill (Silty Clay)

Sample Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS3-1/SS3	0	2	41	57	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above fill and the test indicated the following index value as shown in **Table 4-10**.

Table 4-10 Atterberg Limits Test Results – Fill (Silty Clay)

Sample Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS3-1/SS3	44	21	23	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of intermediate plasticity (CI).

Measured moisture contents of the spoon samples were from 21% to 24% indicative of a moist condition. SPT ‘N’ values of 6 to 23 indicate the deposit to be of firm to very stiff consistency.

4.5.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS3-1 with an explored thickness of 6.1 m and a corresponding base elevation of Elev. 106.9 m on termination of the borehole.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distribution shown in **Table 4-11**.

Table 4-11 Grain Size Distribution Summary - Silty Clay

Sample Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS3-1/SS9	0	1	31	68	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above native deposit and the test indicated the following index value as shown in **Table 4-12**.

Table 4-12 Atterberg Limits Test Results - Silty Clay

Sample Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS3-1/SS9	56	22	34	Shown in Figure B-4, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of high plasticity (CH).

Measured moisture contents of the spoon samples were from 21 to 29% indicative of a moist to wet condition. SPT 'N' values of 6 to 23 indicate the deposit to be of firm to very stiff consistency.

4.6 SUBSURFACE CONDITIONS FOR OHS 4

4.6.1 FILL (SILTY CLAY)

A fill comprised of silty clay was intercepted in OHS4-1 & OHS4-2 with explored thicknesses of 5.3 m & 3.8 m and a corresponding base elevations of Elev. 116.9 m & 119.0 m respectively.

The grain size distributions of selected samples from the fill were determined in the laboratory and gave the following grain size distributions shown in **Table 4-13**.

Table 4-13 Grain Size Distribution Summary – Fill (Silty Clay)

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS4-1/SS5 OHS4-2/SS4	0	3-4	33-37	59-64	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheets

Two (2) Atterberg limits tests were also performed on the above fill and the tests indicated the following index values as shown in **Table 4-14**.

Table 4-14 Atterberg Limits Test Results – Fill (Silty Clay)

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS4-1/SS5 OHS4-2/SS4	47-53	21-23	26-30	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of intermediate to high plasticity (CI/CH).

Measured moisture contents of the spoon samples were in the range of 3% to 26% indicative of a moist to wet condition. SPT ‘N’ values ranged from 6 to 20 which indicate the deposit to be of firm to very stiff consistency.

4.6.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS4-1 & OHS4-2 with explored thicknesses of 2.9 m & 4.4 m and corresponding base elevations of Elev. 114.0 m & 114.6 m respectively, on termination of the boreholes.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distribution shown in **Table 4-15**.

Table 4-15 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS4-1/SS10 OHS4-2/SS9	0	2	29	69	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheets

Two (2) Atterberg limits tests were also performed on the above native deposit and the tests indicated the following index values as shown in **Table 4-16**.

Table 4-16 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS4-1/SS10 OHS4-2/SS9	40-55	19-23	21-32	Shown in Figure B-4, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of intermediate to high plasticity (CI/CH).

Measured moisture contents of the spoon samples were in the range of 3% to 28% indicative of a moist to wet condition. SPT ‘N’ values ranged from 6 to 21 which indicate the deposit to be of firm to very stiff consistency.

4.7 SUBSURFACE CONDITIONS FOR OHS 5

4.7.1 FILL (SILTY CLAY)

Underlying a veneer of topsoil of 150 mm thickness, a fill comprised of silty clay was intercepted in OHS5 with an explored thickness of 1.4 m and a corresponding base elevation of Elev. 116.4 m.

The grain size distributions of selected sample from the fill was determined in the laboratory and gave the following grain size distribution shown in **Table 4-17**.

Table 4-17 Grain Size Distribution Summary – Fill (Silty Clay)

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS5/SS2	0	3	32	65	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limit test was also performed on the above fill and the test indicated the following index value as shown in **Table 4-18**.

Table 4-18 Atterberg Limits Test Results – Fill (Silty Clay)

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS5/SS2	50	22	28	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of intermediate/high plasticity (CI/CH).

Measured moisture contents of the spoon samples were from 21% to 22% indicative of a moist condition. SPT ‘N’ values of 11 to 16 indicate the deposit to be of stiff to very stiff consistency.

4.7.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS5 with an explored thickness of 6.7 m and a corresponding base elevation of Elev. 109.7 m on termination of the borehole.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distribution shown in **Table 4-19**.

Table 4-19 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS5/SS6	0	2	28	70	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above native deposit and the test indicated the following index value as shown in **Table 4-20**.

Table 4-20 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS5/SS6	56	21	35	Shown in Figure B-5, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of high plasticity (CH).

Measured moisture contents of the spoon samples were from 21% to 27% indicative of a moist to wet condition. SPT ‘N’ values of 10 to 28 indicate the deposit to be of stiff to very stiff consistency.

4.8 SUBSURFACE CONDITIONS FOR OHS 6

4.8.1 FILL (SILTY CLAY)

Underlying a veneer of topsoil of 150 mm thickness, a fill comprised of silty clay was intercepted in OHS6-1 & OHS6-2 each with an explored thickness of 1.3 m and a corresponding base elevation of Elev. 115.7 m & 114.3 m respectively.

The grain size distributions of selected samples from the fill were determined in the laboratory and gave the following grain size distribution shown in **Table 4-21**.

Table 4-21 Grain Size Distribution Summary – Fill (Silty Clay)

Sample Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS6-1/SS2	0	2	30	68	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above fill and the test indicated the following index value as shown in **Table 4-22**.

Table 4-22 Atterberg Limits Test Results – Fill (Silty Clay)

Sample Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS6-1/SS2	55	25	30	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of high plasticity (CH).

Measured moisture contents of the spoon samples were from 22% to 27% indicative of a moist to wet condition. SPT ‘N’ values of 8 to 12 indicate the deposit to be of stiff consistency.

4.8.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS6-1 & OHS6-2 each with an explored thickness of 6.7 m and corresponding base elevations of Elev. 109.0 m & 107.6 m respectively on termination of the boreholes.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distribution shown in **Table 4-23**.

Table 4-23 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS6-1/SS5 OHS6-1/SS10 OHS6-2/SS4 OHS6-2/SS9	0-2	3-10	30-32	54-68	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheets

Four (4) Atterberg limits tests were also performed on the above native deposit and the tests indicated the following index values as shown in **Table 4-24**.

Table 4-24 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS6-1/SS5 OHS6-1/SS10 OHS6-2/SS4 OHS6-2/SS9	46-58	19-23	27-36	Shown in Figure B-5, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of intermediate to high plasticity (CI/CH).

Measured moisture contents of the spoon samples were in the range of 15% to 29% indicative of a moist to wet condition. SPT ‘N’ values ranged from 6 to 25 which indicate the deposit to be of firm to very stiff consistency.

4.9 SUBSURFACE CONDITIONS FOR OHS 7

4.9.1 ASPHALT

The asphalt thickness intercepted in OHS7-1 and OHS 7-2 ranged from 150 mm to 210 mm.

4.9.2 EMBANKMENT FILL (SILTY CLAY)

Underlying the asphalt, an embankment fill comprised predominately of silty clay was intercepted in OHS7-1 & OHS 7-2 each with an explored thickness of 2.1 m and corresponding base elevations of Elev. 116.0 m & 116.8 m respectively.

The grain size distributions of selected samples from this embankment fill were determined in the laboratory and gave the following grain size distribution shown in **Table 4-25**.

Table 4-25 Grain Size Distribution Summary – EMBANKMENT Fill (Silty Clay)

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS7-2/SS2	0	5	38	57	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limit test was also performed on the above embankment fill and the test indicated the following index value as shown in **Table 4-26**.

Table 4-26 Atterberg Limits Test Results – Fill (Silty Clay)

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS7-2/SS2	46	21	25	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as silty clay of intermediate plasticity (CI).

Measured moisture contents of the spoon samples were from 4% to 24% indicative of a moist condition. SPT ‘N’ values of 10 to 19 indicate the deposit to be of stiff to very stiff consistency.

4.9.3 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS7-1 & OHS7-2 each with an explored thickness of 5.9 m and corresponding base elevations of Elev. 110.1 m & 110.9 m respectively, on termination of the boreholes.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distribution shown in **Table 4-27**.

Table 4-27 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS7-1/SS6 OHS7-1/SS10 OHS7-2/SS6 OHS7-2/SS10	0-1	2	31-33	65-67	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheets

Four (4) Atterberg limits tests were also performed on the above native deposit and the tests indicated the following index values as shown in **Table 4-28**.

Table 4-28 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS7-1/SS6 OHS7-1/SS10 OHS7-2/SS6 OHS7-2/SS10	52-59	22-23	30-36	Shown in Figure B-5, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of high plasticity (CH).

Measured moisture contents of the spoon samples were in the range of 4% to 29% indicative of a moist to wet condition. SPT ‘N’ values ranged from 6 to 25 which indicate the deposit to be of firm to very stiff consistency.

4.10 SUBSURFACE CONDITIONS FOR OHS 8

4.10.1 FILL (CLAYEY SILT)

Underlying a veneer of topsoil of 130 mm thickness, a fill comprised of reworked clayey silt (till) material was intercepted in OHS8-1 and OHS8-2 with explored thicknesses of 1.4 m and 0.6 m respectively, each with a corresponding base elevation of Elev. 117.5 m.

The grain size distributions of selected samples from this fill were determined in the laboratory and gave the following grain size distribution shown in **Table 4-29**.

Table 4-29 Grain Size Distribution Summary – Fill (Clayey Silt)

Sample Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS8-1/SS2	7	36	33	24	Shown in Figure B-1, Appendix B Summarized on the relevant Record of Borehole Sheet

One (1) Atterberg limits test was also performed on the above fill and the tests indicated the following index value as shown in **Table 4-30**.

Table 4-30 Atterberg Limits Test Results – Fill (Clayey Silt)

Sample Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS8-1/SS2	30	18	12	Shown in Figure B-2, Appendix B Summarized on the relevant Record of Borehole Sheet

Based on the laboratory test results, the tested sample can be classified (according to MTC & CFEM 2006) as clayey silt of intermediate plasticity (CI).

Measured moisture contents of the spoon samples were 16% to 19% indicative of a moist condition. SPT ‘N’ values of 14 to 16 indicate the deposit to be of very stiff consistency.

4.10.2 SILTY CLAY

Underlying the fill, a silty clay deposit was intercepted in OHS8-1 and OHS8-2 with explored thicknesses of 6.7 m and 7.4 m with corresponding base elevations of Elev. 110.8 m and Elev. 110.1 m respectively, on termination of the boreholes.

The grain size distributions of selected samples from this deposit were determined in the laboratory and gave the following grain size distribution shown in **Table 4-31**.

Table 4-31 Grain Size Distribution Summary – Silty Clay

Samples Tested (BH No.)	Size Fraction (%)				Remarks
	Gravel	Sand	Silt	Clay	
OHS8-1/SS4 OHS8-1/SS9 OHS8-2/SS5 OHS8-2/SS10	0	3-10	34-52	38-68	Shown in Figure B-3, Appendix B Summarized on the relevant Record of Borehole Sheets

Four (4) Atterberg limits tests were also performed on the above native deposit and the tests indicated the following index values as shown in **Table 4-32**.

Table 4-32 Atterberg Limits Test Results – Silty Clay

Samples Tested (BH No.)	Atterberg Limits (%)			Remarks
	Liquid Limit	Plastic Limit	Plasticity Index	
OHS8-1/SS4 OHS8-1/SS9 OHS8-2/SS5 OHS8-2/SS10	29-50	15-23	14-27	Shown in Figure B-6, Appendix B Summarized on the relevant Record of Borehole Sheets

Based on the laboratory test results, the tested samples can be classified (according to MTC & CFEM 2006) as silty clay of low to high plasticity (CL/CI/CH).

Measured moisture contents of the spoon samples were in the range of 16% to 32% indicative of a moist to wet condition. SPT 'N' values ranged from 6 to 28 which indicate the deposit to be of a firm to very stiff consistency.

4.11 GROUNDWATER LEVEL OBSERVATIONS

Upon completion, groundwater levels were measured in all the boreholes. As regard the stability of the boreholes no cave-ins were observed upon completion.

As earlier mentioned in section 3.3, 50 mm monitoring wells were installed in three (3) boreholes – OHS1-1, OHS7-1, & OHS8-1. Groundwater levels in each of the monitoring wells were taken at least a week after completion. It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events. Findings are summarized in **Table 4-33**.

Table 4-33 Summary of Groundwater Level Observations

BH No.	Existing Ground Elevation	Date of Measurement	Groundwater Level- Depth (m)	Groundwater Level - Elevation (m)	Notes
OHS1-1	116.8	August 23, 2019 (upon completion)	dry	dry	Solid Stem Auger used No cave-in
		September 20, 2019	7.2	109.6	
		September 25, 2019	8.0	108.8	
		October 29, 2019	6.1	110.7	
OHS1-2	116.9	August 23, 2019 (upon completion)	dry	dry	Solid Stem Auger used No cave-in
OHS2-1	117.8	June 27, 2019 (upon completion)	dry	dry	Hollow Stem Auger used
OHS2-2	118.0	June 26, 2019 (upon completion)	dry	dry	Hollow Stem Auger used
OHS3-1	115.1	August 22, 2019 (upon completion)	dry	dry	Hollow Stem Auger used
OHS4-1	122.2	June 28, 2019 (upon completion)	dry	dry	Hollow Stem Auger used

OHS4-2	122.8	June 28, 2019 (upon completion)	dry	dry	Hollow Stem Auger used
OHS5	117.9	June 26, 2019 (upon completion)	dry	dry	Hollow Stem Auger used
OHS6-1	117.2	September 19, 2019 (upon completion)	dry	dry	Solid Stem Auger Used No cave-in
OHS6-2	115.8	September 19, 2019 (upon completion)	dry	dry	Solid Stem Auger Used No cave-in
OHS7-1	118.3	September 18, 2019 (upon completion)	dry	dry	Solid Stem Auger Used No cave-in
		October 29, 2019	2.7	115.6	Solid Stem Auger used No cave-in
OHS7-2	119.1	September 18, 2019 (upon completion)	7.5	111.6	Solid Stem Auger used No cave-in
OHS8-1	119.0	September 19, 2019 (upon completion)	dry	dry	Solid Stem Auger used No cave-in
		October 29, 2019	4.2	114.8	Hollow Stem Auger used

OHS8-2	118.3	September 25, 2019 (upon completion)	7.0	111.3	Hollow Stem Auger used
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4.12 CORROSIVITY AND WATER-SOLUBLE SULPHATE TESTING OF SOILS

Five (5) soil samples (OHS1-1 SS3, OHS1-2 SS4, OHS2-1 SS3, OHS3-1 SS5 & OHS4-2 SS5) were analyzed for corrosivity parameters, including the resistivity of the soil, pH, Electrical Conductivity and sulphide concentration for corrosion protection to the proposed Overhead Sign Support Structures. The test results are summarized as follows:

- Resistivity measured ranged from 469 to 1350 ohm.cm;
- pH measured range from 7.95 to 8.35;
- Electrical Conductivity was measured at 0.74 to 2.13 mS/cm; and,
- Sulphide concentration was measured at less than 0.05%.

The sulphate (SO_4) resistance of the concrete in contact with the soils was evaluated by performing water-soluble sulphate test on same soil samples taken from selected OHS boreholes listed above at depths ranging from 1.5 to 13.7 m below grade. The tests revealed that the sulphate concentration in the tested soil samples ranged from 150 to 1690 $\mu\text{g/g}$.

SIGNATURES



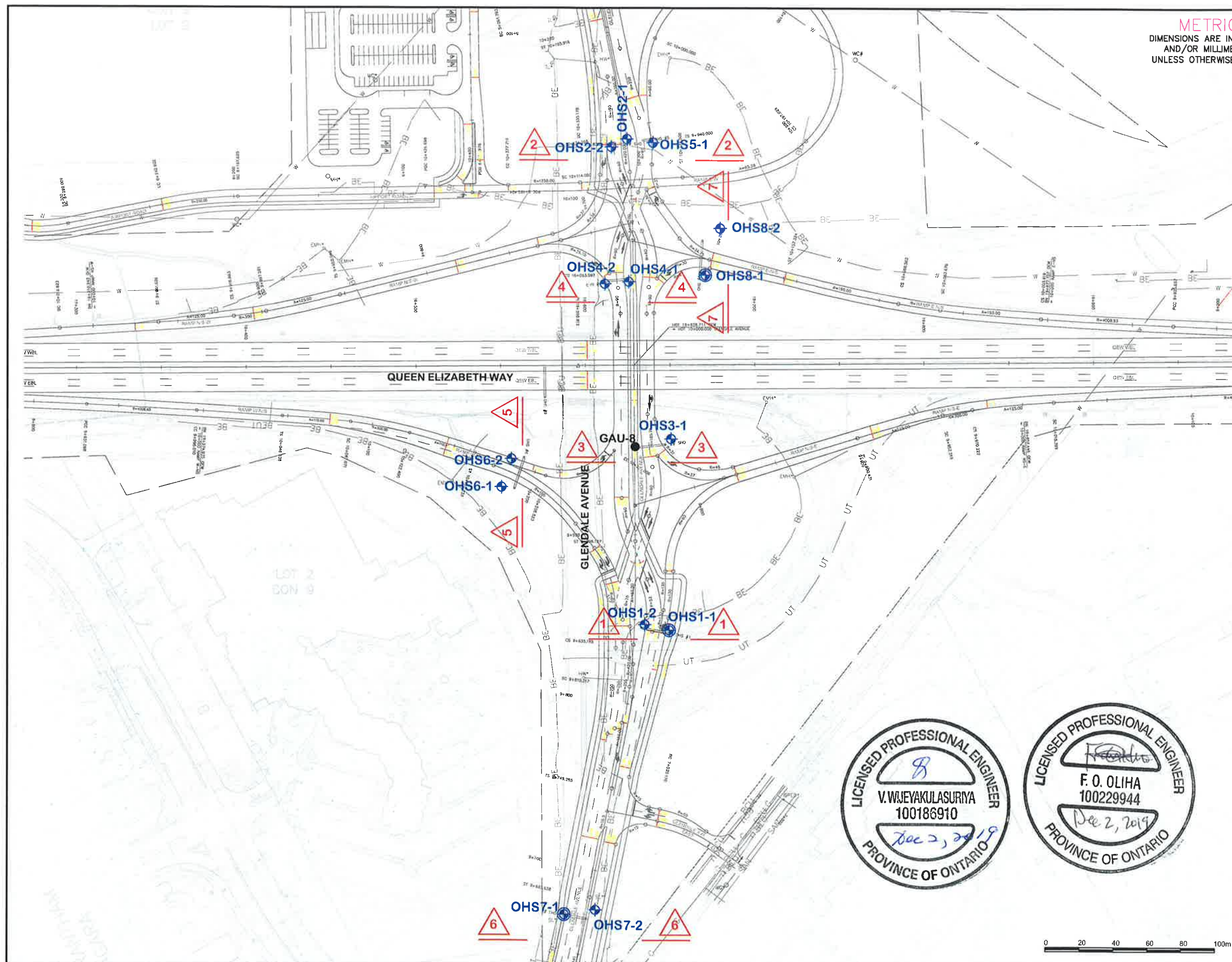
Franklin Oliha, MSc., P.Eng.
Geotechnical Engineer



Vasantha Wijeyakulasuriya, M.Eng., P.Eng.
MTO Designate (Foundations).



DRAWINGS



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DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

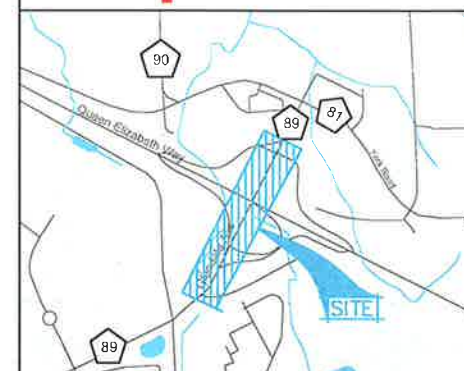
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QEW/ GLENDALE AVENUE
INTERCHANGE IMPROVEMENT
Overhead Sign
BOREHOLE LOCATIONS PLAN

SHEET
S-1

wsp 2 International Blvd, Suite 201
Toronto, Ontario
M9W 1A2



KEY PLAN

LEGEND

- Borehole (WSP, 2019)
- Borehole with Monitoring Well (WSP, 2019)
- Geocres Report Borehole (30M3-308)

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTH (m)	EAST (m)
OHS1-1	116.8	4779591.2	332064.5
OHS1-2	116.9	4779600.6	332053.0
OHS2-1	117.8	4779861.7	332170.8
OHS2-2	118.0	4779861.7	332160.4
OHS3-1	115.1	4779691.7	332115.6
OHS4-1	122.2	4779786.0	332134.4
OHS4-2	122.8	4779791.2	332121.2
OHS5-1	117.9	4779853.0	332183.8
OHS6-1	117.2	4779711.1	332013.5
OHS6-2	115.9	4779723.2	332026.0
OHS7-1	118.3	4779468.8	331934.4
OHS7-2	119.1	4779463.0	331952.0
OHS8-1	119.0	4779769.4	332176.8
OHS8-2	118.3	4779790.1	332196.9



0 20 40 60 80 100m

SITE LOCATION (LAT: 43.180074; LONG: -79.162193)

REV	DATE	BY	DESCRIPTION
1	Oct 11/19	ZMO	Submission for MTO review
GEOCRES NO : 30M3-317 WSP NO : 18M-01021-12			
HWY No QEW	CHECKED FO	DATE Oct 11/19	DIST CENTRAL
SUBM'D	CHECKED FO	APPROVED MK	SITE
DRAWN ZMO	CHECKED FO	APPROVED MK	DWG 1

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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST
CONT
WP No: 2423-15-00

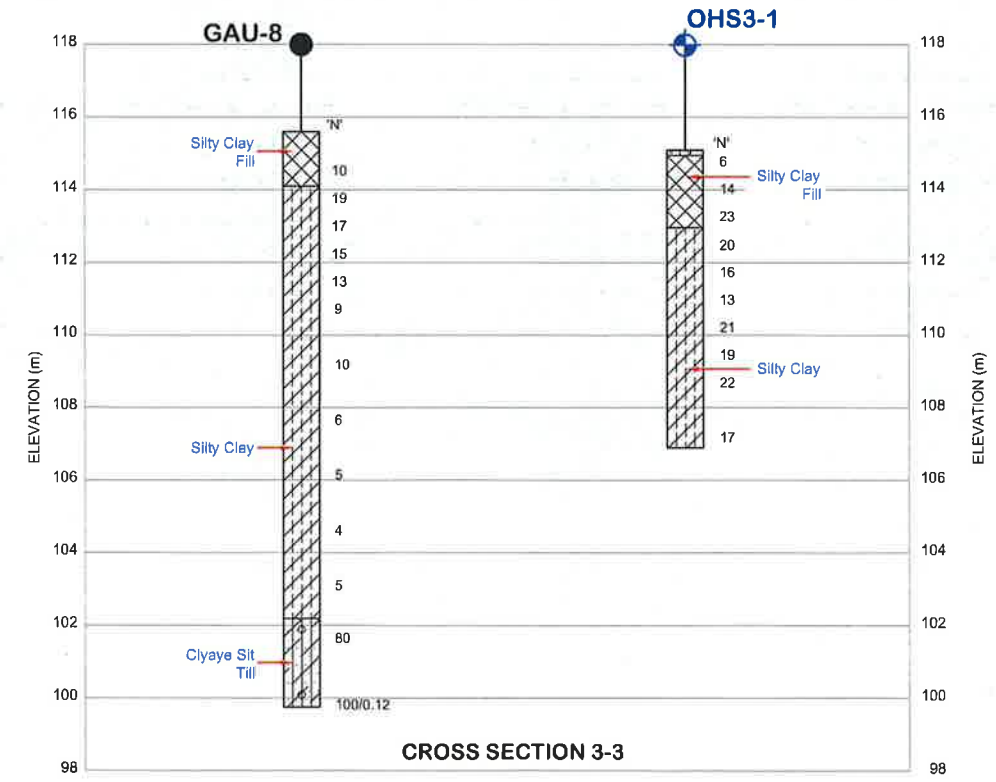
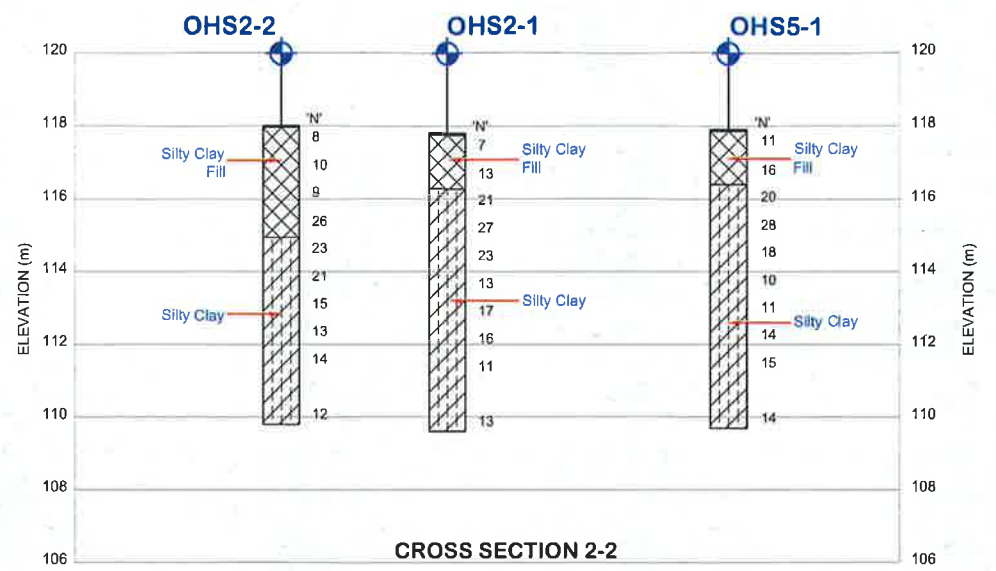
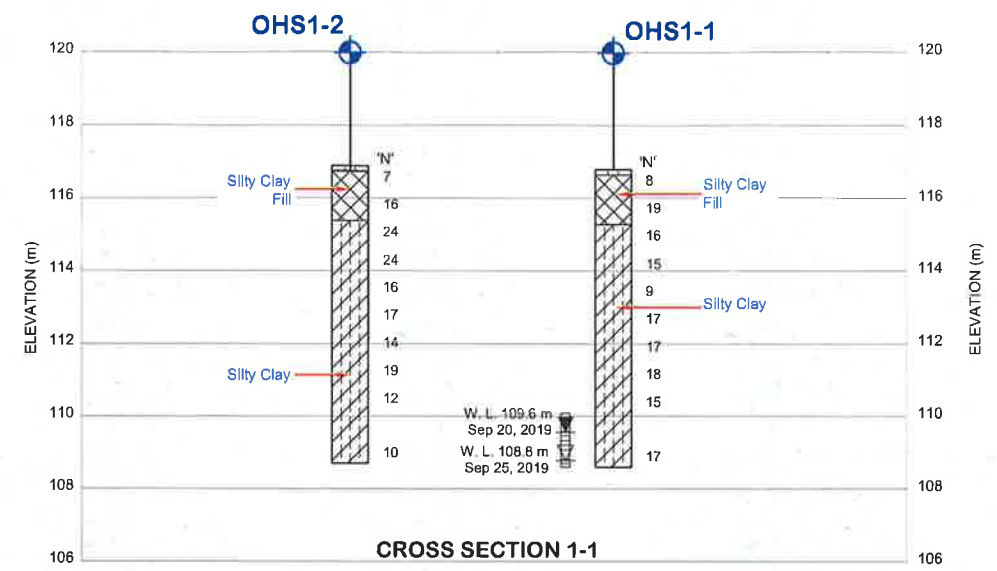
QEW/ GLENDALE AVENUE
INTERCHANGE IMPROVEMENT
Overhead Sign
SOIL STRATA

SHEET
S-2

2 International Blvd, Suite 201
Toronto, Ontario
M9W 1A2



KEY PLAN



- LEGEND
- Topsoil
 - Fill (Silty Clay/ Gravelly Sand/ Clayey Silt)
 - Clayey Silt Till
 - Asphalt
 - Silty Clay

- LEGEND
- Borehole (WSP, 2019)
 - Borehole with Monitoring Well (WSP, 2019)
 - Geocres Report Borehole (30M3-308)
 - N Blows/0.3m (Std Pen Test, 475 J/blow)
 - WL in Piezometer
 - Piezometer
 - WL upon Completion

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTH (m)	EAST (m)
OHS1-1	116.8	4779591.2	332064.5
OHS1-2	116.9	4779600.6	332053.0
OHS2-1	117.8	4779861.7	332170.8
OHS2-2	118.0	4779861.7	332160.4
OHS3-1	115.1	4779691.7	332115.6
OHS4-1	122.2	4779786.0	332134.4
OHS4-2	122.8	4779791.2	332121.2
OHS5-1	117.9	4779853.0	332183.8
OHS6-1	117.2	4779711.1	332013.5
OHS6-2	115.9	4779723.2	332026.0
OHS7-1	118.3	4779468.8	331934.4
OHS7-2	119.1	4779463.0	331952.0
OHS8-1	119.0	4779769.4	332176.8
OHS8-2	118.3	4779790.1	332196.9

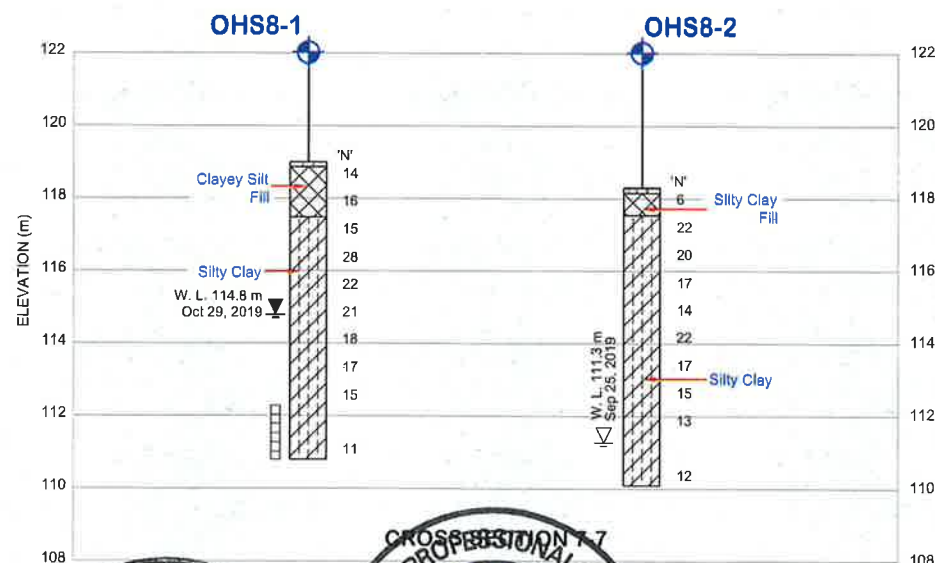
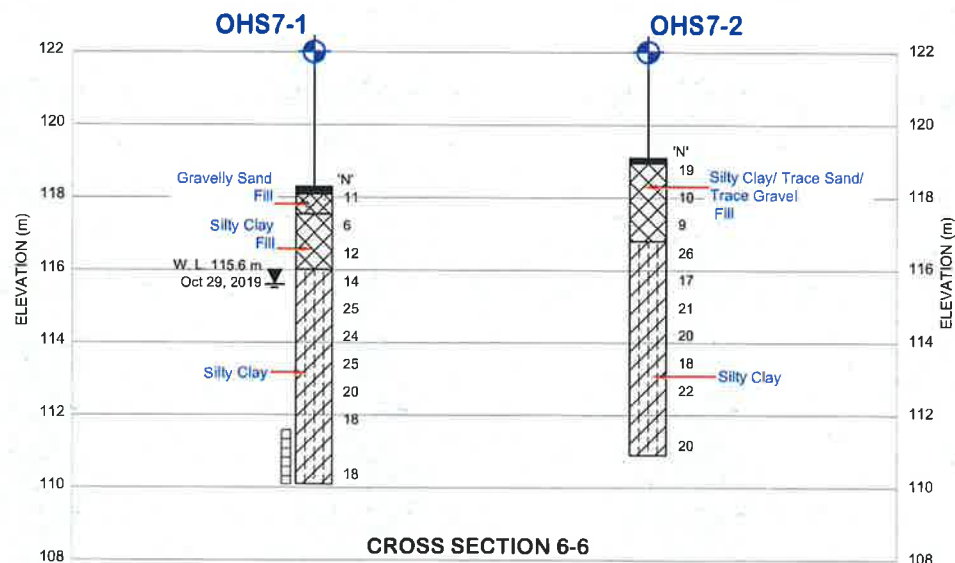
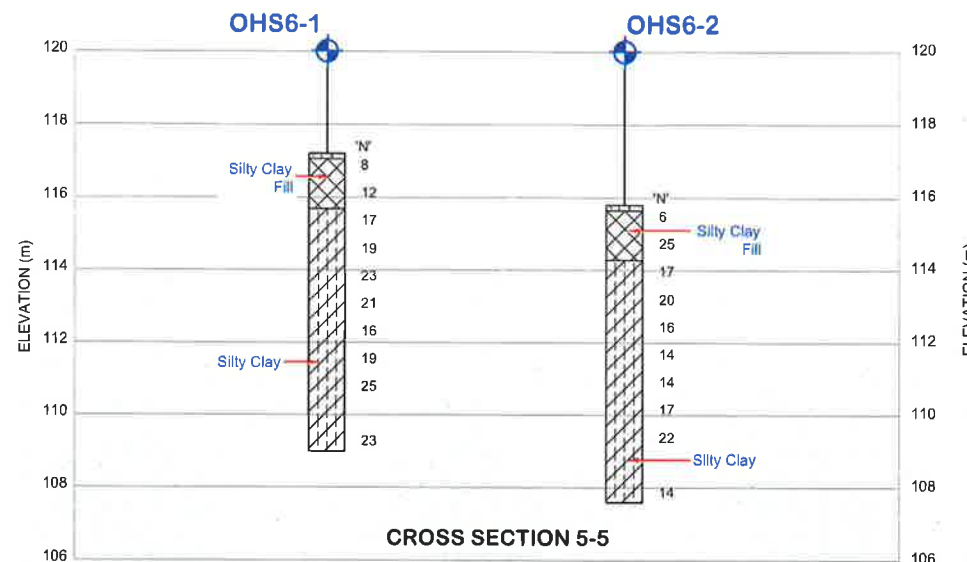
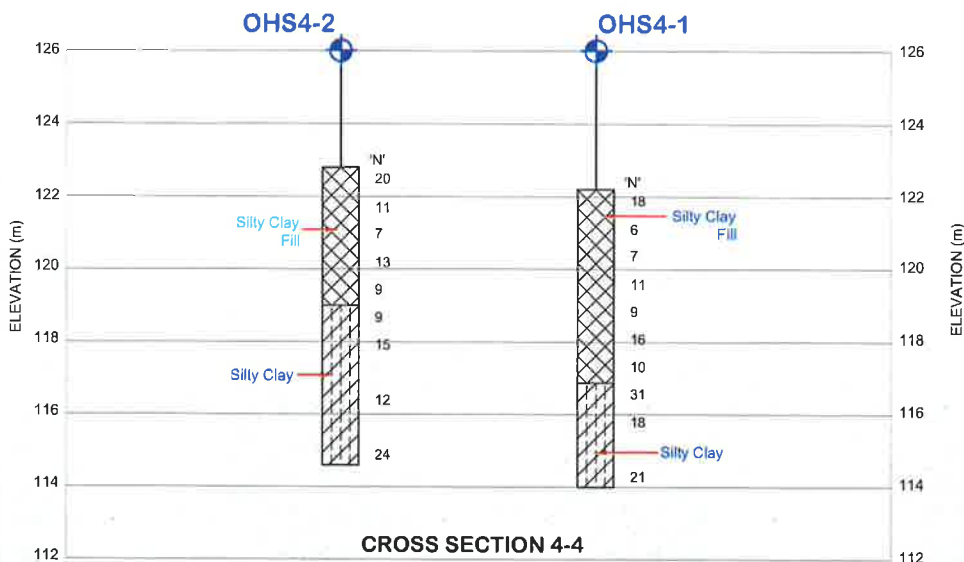


SITE LOCATION (LAT: 43.160074; LONG: -79.182193)

REVISIONS	DATE	BY	DESCRIPTION
1	Oct 11/18	ZMO	Submission for MTO review

GEOCRES NO : 30M3-317 WSP NO : 18M-01021-12

HWY No QEW	CHECKED FO	DATE	Oct 11/18	DIST	CENTRAL
SUBM'D	CHECKED FO	APPROVED	MK	SITE	
DRAWN	ZMO	CHECKED FO		DWG	2

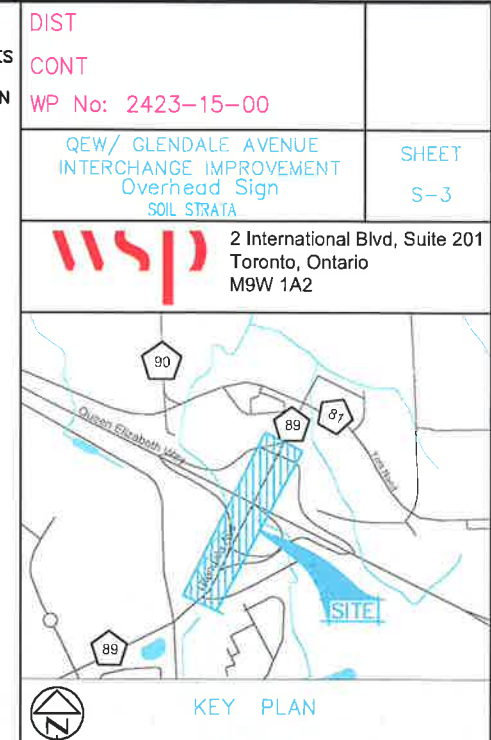


LEGEND

Topsoil Asphalt

Fill (Silty Clay/ Gravelly Sand/ Clayey Silt) Silty Clay

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



LEGEND

- Borehole (WSP, 2019)
- Borehole with Monitoring Well (WSP, 2019)
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL In Piezometer
- Piezometer
- WL upon Completion

BH No.	APPROX. ELEV. (m)	MTM NAD83 ZONE 10 CO-ORDINATES	
		NORTH (m)	EAST (m)
OHS1-1	116.8	4779591.2	332064.5
OHS1-2	116.9	4779600.6	332053.0
OHS2-1	117.8	4779861.7	332170.8
OHS2-2	118.0	4779861.7	332160.4
OHS3-1	115.1	4779691.7	332115.6
OHS4-1	122.2	4779786.0	332134.4
OHS4-2	122.8	4779791.2	332121.2
OHS5-1	117.9	4779853.0	332183.8
OHS6-1	117.2	4779711.1	332013.5
OHS6-2	115.9	4779723.2	332026.0
OHS7-1	118.3	4779468.8	331934.4
OHS7-2	119.1	4779463.0	331952.0
OHS8-1	119.0	4779769.4	332176.8
OHS8-2	118.3	4779790.1	332196.9



SITE LOCATION (LAT: 43.180074°, LONG: -79.182193°)

REVISIONS	DATE	BY	DESCRIPTION
1	Oct 11/19	ZMO	Submission for MTO review
GEOCRES No : 30M3-317 WSP NO : 18M-01021-12			
HWY No QEW	CHECKED FO	DATE	DIST CENTRAL
SUBM'D	CHECKED FO	Oct 11/19	SITE
DRAWN ZMO	CHECKED FO	APPROVED MK	DWG 3

Vertical Scale 1m 0 1 2 3m

APPENDIX

A

RECORD OF BOREHOLE SHEETS

METRIC 1 OF 1

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		POCKET PEN. (C _u) (MPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p		W			W _L		GR	SA	SI	CL	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)												
116.8	Ground Surface																							
116.7	TOPSOIL 150 mm																							
0.2	FILL: silty clay, trace rootlets, trace sand, brown to reddish brown, moist, stiff to very stiff		1	SS	8																			
			2	SS	19																			
115.3	SILTY CLAY: trace sand, brown to greyish brown, moist, stiff to very stiff		3	SS	16																			
			4	SS	15																			
			5	SS	9																			
			6	SS	17																			
			7	SS	17																			
			8	SS	18																			
			9	SS	15																			
			10	SS	17																			
108.6	END OF BOREHOLE																							
8.2	Notes: 1) No Cave-in 2) No water at bottom of borehole upon completion Water Level: Date W.L. Depth (m) Elevation (m) September 20, 2019 7.2 109.6 September 25, 2019 8.0 108.8																							





+³, ×³: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

18M-01021-12

METRIC

1 OF 1

[illegible]

	1st	2nd	3rd	4th
Measurement				

+³, ×³: Numbers refer to Sensitivity

○ **$\epsilon=3\%$** Strain at Failure





18M-01021-12

METRIC 1 OF 1

[illegible]WSP-SOIL-ROCK-MAY-29-2017.GLB
N-MTO-2016-WITH WSP 18M-01021-12 QEW GLENDALE -OHS NOV. 29 FO.GPJ 11/29/19

18M-01021-12

+³, ×³: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

	1st	2nd	3rd	4th
Measurement				

METRIC 1 OF 1

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	POCKET PEN. (CJ) (MPa) γ	NATURAL UNIT WT (kN/m³)	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							
118.0	Ground Surface														
0.1	TOPSOIL 50 mm														
	FILL: silty clay, trace rootlets, trace gravel, trace sand, reddish brown, moist, stiff to very stiff		1	SS	8										
1			2	SS	10		117								
2			3	SS	9		116					44		0 2 41 57	
			4	SS	26										
3 115.0							115								
3.1	SILTY CLAY: trace sand, greyish brown, moist, stiff to very stiff		5	SS	23							> 225			
4			6	SS	21		114					> 225			
5			7	SS	15		113					54	200	0 2 32 66	
			8	SS	13		112					125			
6															
			9	SS	14		111					125			
7															
8			10	SS	12		110					125			
109.8															
8.2	END OF BOREHOLE														
<div>Notes:</div> <div>1) No Cave-in</div> <div>2) No water at bottom of borehole upon completion</div>															

18M-01021-12

METRIC 1 OF 1

[illegible]

18M-01021-12

RECORD OF BOREHOLE No OHS4-1

METRIC

1 OF 1

W.P. 2423-15-00 LOCATION MTM NAD 1983 (Zone 10) (LAT. 43.157442° LONG. -79.163876°), E 332134.4, N 4779786 ORIGINATED BY TO
DIST HWY QEW BOREHOLE TYPE CME 75 Track Mount/Hollow Stem Auger (150 mm O.D.) COMPILED BY SU
DATUM Geodetic DATE Jun/28/2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	×				
122.2 0.0	Ground Surface		1	SS	18								GR SA SI CL	
	FILL: silty clay, trace gravel, trace sand, trace rootlets, brown to blackish brown, moist, stiff to very stiff													
	gravelly sand		2	SS	6									
			3	SS	7									
			4	SS	11									
			5	SS	9									
			6	SS	16									
			7	SS	10									
116.9 5.3	SILTY CLAY: trace sand, trace gravel, greyish brown to grey, moist, very stiff to hard		8	SS	31									
			9	SS	18									
			10	SS	21									
114.0 8.2	END OF BOREHOLE													
	Notes: 1) No Cave-in 2) No water at bottom of borehole upon completion													

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3: Numbers refer to
Sensitivity





○ 6=3% Strain at Failure

18M-01021-12

METRIC 1 OF 1

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		w _p	w				w _L
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
122.8 0.0	Ground Surface														
	FILL: silty clay, trace to some red sand, trace rootlets, brown, moist, firm to stiff		1	SS	20										
	gravelly sand		2	SS	11										
			3	SS	7										
			4	SS	13										
			5	SS	9										
119.0 3.8	SILTY CLAY: trace sand, geyish brown to grey, moist, stiff to very stiff		6	SS	9										
			7	SS	15										
			8	AS											
			9	SS	12										
			10	SS	24										
114.6 8.2	END OF BOREHOLE														
Notes: 1) No Cave-in 2) No water at bottom of borehole upon completion															





18M-01021-12

	1st	2nd	3rd	4th
Measurement				

METRIC 1 OF 1

[illegible]

18M-01021-12

	1st	2nd	3rd	4th
Measurement				

RECORD OF BOREHOLE No OHS6-1

METRIC 1 OF 1

W.P. 2423-15-00 LOCATION MTM NAD 1983 (Zone 10) (LAT. 43.156753° LONG. -79.165341°), E 332013.5, N 4779711.1 ORIGINATED BY FO
DIST HWY QEW BOREHOLE TYPE M5T Track Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO
DATUM Geodetic DATE Sep/19/2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			
117.2	Ground Surface														
117.1	TOPSOIL 150 mm														
0.2	FILL: silty clay, trace rootlets, trace gravel, trace sand, brown to greyish brown, moist, stiff		1	SS	8		117								
1			2	SS	12		116						55		0 2 30 68
115.7	SILTY CLAY: trace sand, brown to greyish brown, moist, very stiff		3	SS	17		115						> 225		
1.5			4	SS	19		114						> 225		
2			5	SS	23		113						58	225	1 2 30 67
3			6	SS	21		112						225		
4			7	SS	16		111						188		
5			8	SS	19		110						200		
6			9	SS	25		109						188		
7			10	SS	23		108						58	175	0 2 30 68
8.2	END OF BOREHOLE						107								
Notes: 1) No Cave-in 2) No water at the bottom of borehole upon completion															

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

18M-01021-12

RECORD OF BOREHOLE No OHS6-2

METRIC 1 OF 1

W.P. 2423-15-00 LOCATION MTM NAD 1983 (Zone 10) (LAT. 43.156859° LONG. -79.165166°), E 332026, N 4779723.2 ORIGINATED BY FO
DIST HWY QEW BOREHOLE TYPE M5T Track Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO
DATUM Geodetic DATE Sep/19/2019 CHECKED BY MK

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	POCKET PEN. (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
115.8	Ground Surface							20 40 60 80 100	20 40 60 80 100	10 20 30					GR SA SI CL
115.7	TOPSOIL 150 mm														
0.2	FILL: silty clay, trace rootlets, trace gravel, trace sand, brown, moist, firm to very stiff		1	SS	6										
			2	SS	25		115								
114.3															
1.5	SILTY CLAY: trace sand, red brown to greyish brown, moist, stiff to very stiff		3	SS	17		114						225		
			4	SS	20		113						225	2 3 32 63	
			5	SS	16		112						200		
			6	SS	14		111						150		
			7	SS	14		110						175		
			8	SS	17		109						200		
			9	SS	22		108						138	1 10 35 54	
			10	SS	14								100		
107.6	END OF BOREHOLE														
8.2	Notes: 1) No Cave-in 2) No water at the bottom of borehole upon completion														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

18M-01021-12

RECORD OF BOREHOLE No OHS7-1

METRIC 1 OF 1

W.P. 2423-15-00 LOCATION MTM NAD 1983 (Zone 10) (LAT. 43.154591° LONG. -79.166365°), E 331934.4, N 4779468.8 ORIGINATED BY FO
DIST HWY QEW BOREHOLE TYPE M5T Track Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO
DATUM Geodetic DATE Sep/18/2019 CHECKED BY MK

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	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						
118.3	Ground Surface														
0.0 118.1	ASPHALT 210 mm														
0.2	FILL: gravelly sand, trace rootlets, trace clay, brown, moist, compact		1	SS	11										
117.5 0.8	FILL: silty clay, trace rootlets, trace gravel, trace sand, brown, moist, firm to stiff		2	SS	6										
116.0 2.3	SILTY CLAY: trace sand, brown to greyish brown, moist, stiff to very stiff		3	SS	12										
			4	SS	14										
			5	SS	25										
			6	SS	24										
			7	SS	25										
			8	SS	20										
			9	SS	18										
			10	SS	18										
110.1 8.2	END OF BOREHOLE Notes: 1) No Cave-in 2) No water at the bottom of borehole upon completion Water Level: Date October 29, 2019 W.L. Depth (m) 2.7 Elevation (m) 115.6														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ 5=3% Strain at Failure

18M-01021-12

RECORD OF BOREHOLE No OHS7-2

METRIC

1 OF 1

W.P. 2423-15-00 LOCATION MTM NAD 1983 (Zone 10) (LAT. 43.154516° LONG. -79.166195°), E 331952, N 4779463 ORIGINATED BY FO
DIST HWY QEW BOREHOLE TYPE M5T Track Mount/Solid Stem Auger (150 mm O.D.) COMPILED BY FO
DATUM Geodetic DATE Sep/18/2019 CHECKED BY MK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
119.1	Ground Surface							20 40 60 80 100							
119.0	ASPHALT 150 mm							20 40 60 80 100							
0.2	FILL: silty clay, trace rootlets, trace gravel, trace sand, brown to greyish brown, moist, stiff to very stiff		1	SS	19		119								
			2	SS	10		118								0 5 38 57
			3	SS	9		117								
116.8	SILTY CLAY: trace sand, brown to greyish brown, moist, very stiff		4	SS	26		116								
2.3			5	SS	17		115								
			6	SS	21		114								
			7	SS	20		113								
			8	SS	18		112								
			9	SS	22		111								
			10	SS	20										
110.9	END OF BOREHOLE														
8.2	Notes: 1) No Cave-in 2) water level measured at a depth of 7.5 m upon completion														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to
Sensitivity

○ 3% Strain at Failure

18M-01021-12

RECORD OF BOREHOLE No OHS8-1

METRIC 1 OF 1

W.P. 2423-15-00 LOCATION MTM NAD 1983 (Zone 10) (LAT. 43.157289° LONG. -79.163394°), E 332176.8, N 4779769.4 ORIGINATED BY BS
DIST HWY QEW BOREHOLE TYPE CME 55 Track Mount/Hollow Stem Auger (150 mm O.D.) COMPILED BY FO
DATUM Geodetic DATE Sep/19/2019 CHECKED BY MK

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	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
119.0	Ground Surface													
118.9	TOPSOIL 130 mm													
0.1	FILL: clayey silt (till), trace rootlets, trace gravel, trace sand, brown, moist, stiff to very stiff		1	SS	14									
1			2	SS	16		118							7 36 33 24
117.5	SILTY CLAY: trace sand, brown to reddish brown to greyish brown, moist, stiff to very stiff		3	SS	15		117							
1.5			4	SS	28		116							0 4 41 55
2			5	SS	22		115							
3			6	SS	21		114							
4			7	SS	18		113							
5			8	SS	17		112							
6			9	SS	15		111							0 2 30 68
7			10	SS	11		110							
8.2	END OF BOREHOLE													
Notes: 1) No Cave-in 2) No water at the bottom of the borehole upon completion 3) No water level measured in the monitoring well a week after completion Date W.L. Depth (m) Elevation (m) October 29, 2019 4.2 114.8														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3: Numbers refer to Sensitivity ○ 3% Strain at Failure

18M-01021-12

METRIC

1 OF 1

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	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED	+ FIELD VANE						
118.3	Ground Surface														
118.2	TOPSOIL 150 mm														
0.2	FILL: silty clay, trace rootlets, trace gravel, trace sand, brown, moist, firm		1	SS	6										
117.5	SILTY CLAY: trace sand, brown to greyish brown, moist, stiff to very stiff		2	SS	22										
0.8			3	SS	20										
1			4	SS	17										
2			5	SS	14										
3			6	SS	22										
4			7	SS	17										
5			8	SS	15										
6			9	SS	13										
7															
8			10	SS	12										
110.1	END OF BOREHOLE														
8.2	Notes: 1) No Cave-in 2) Water level measured at a depth of 7.0 m upon completion														

	1st	2nd	3rd	4th
Measurement				

+³, ×³: Numbers refer to Sensitivity

○ **$\epsilon=3\%$** Strain at Failure

18M-01021-12

PREVIOUS BOREHOLE LOG



S:\CLIENTS\MTQ\QEW-GLENDALE\02_DATA\GINT\QEW-GLENDALE.GPJ GAL-GTA.GDT 19-5-10

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE



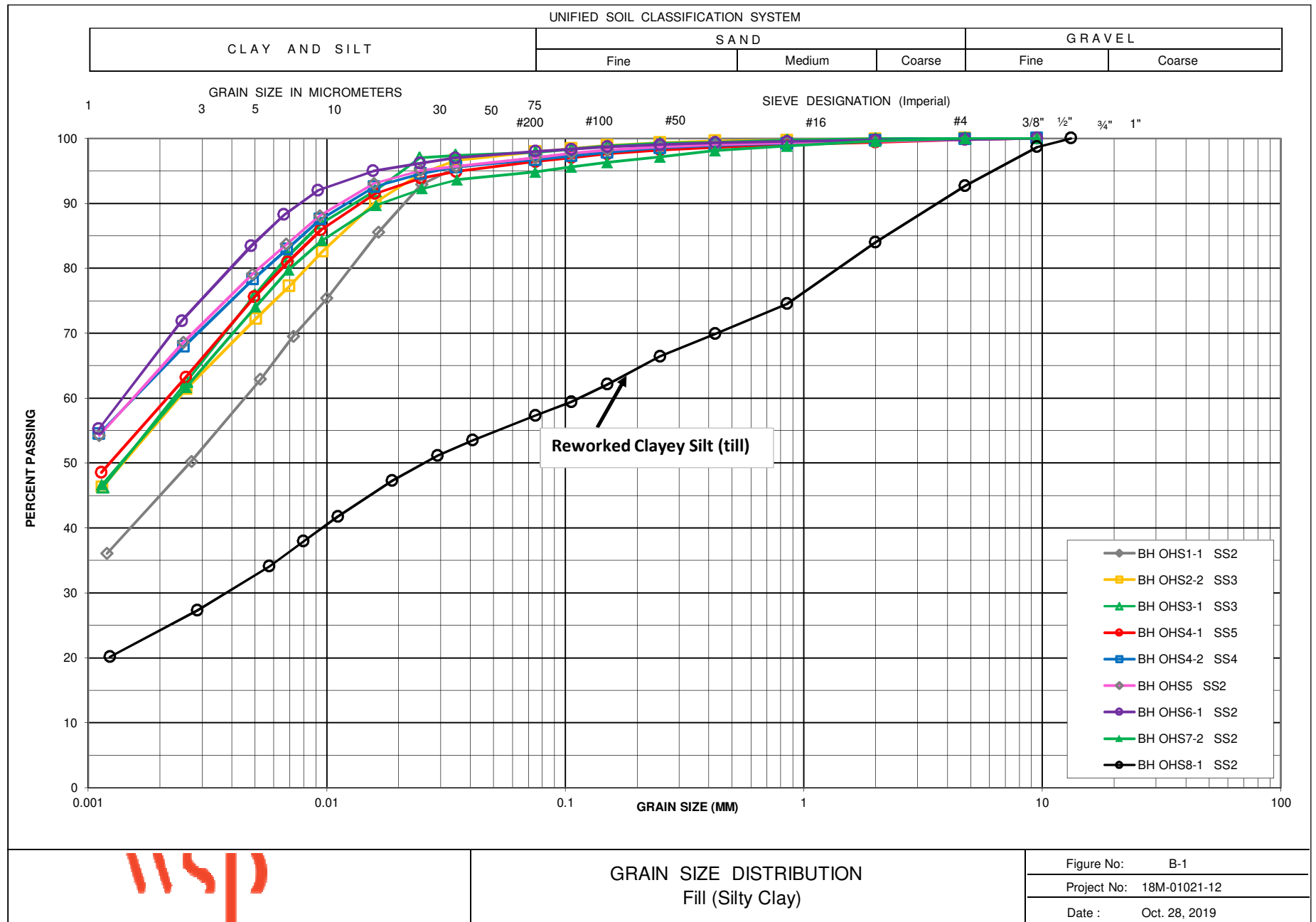
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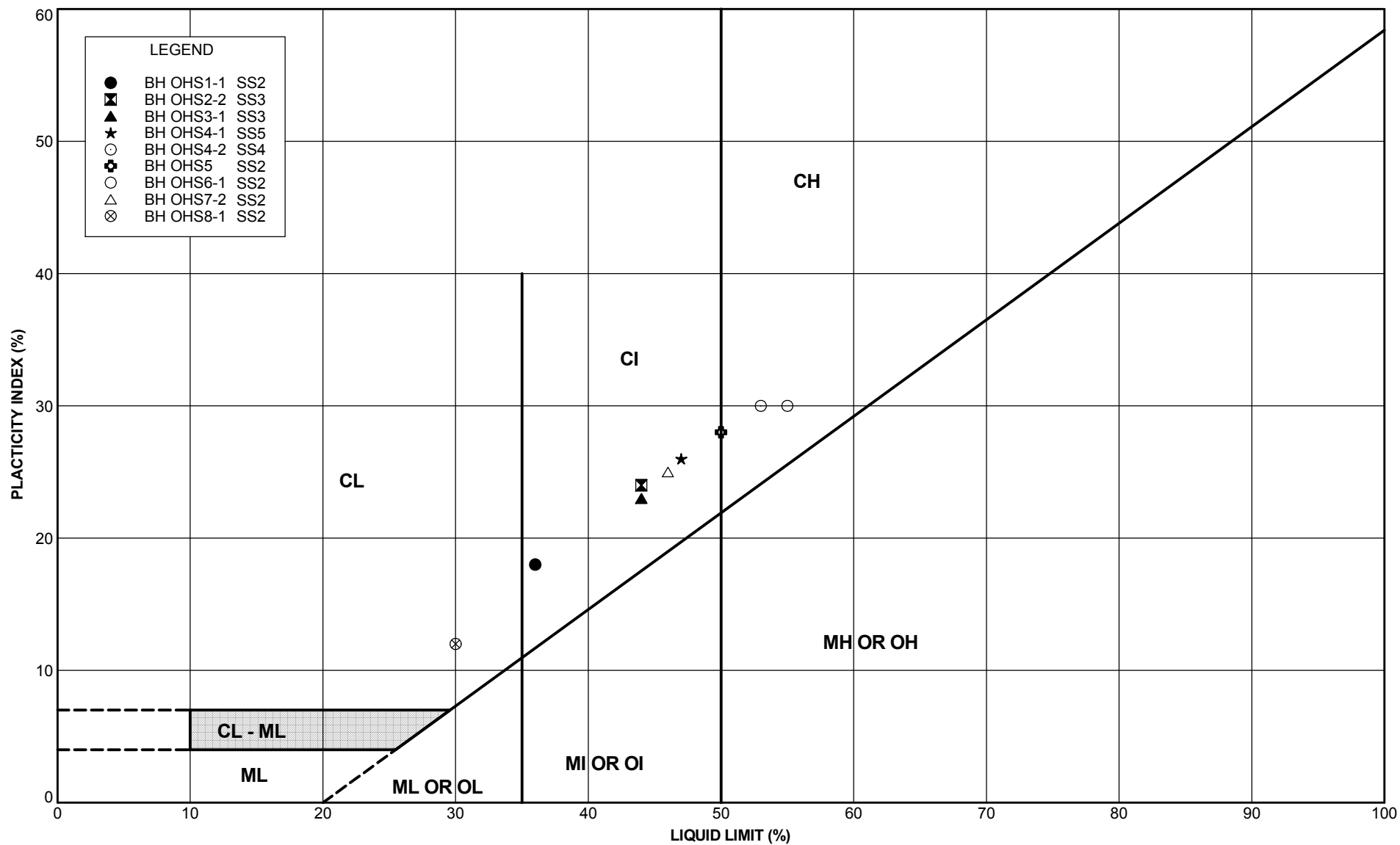
+3, X3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

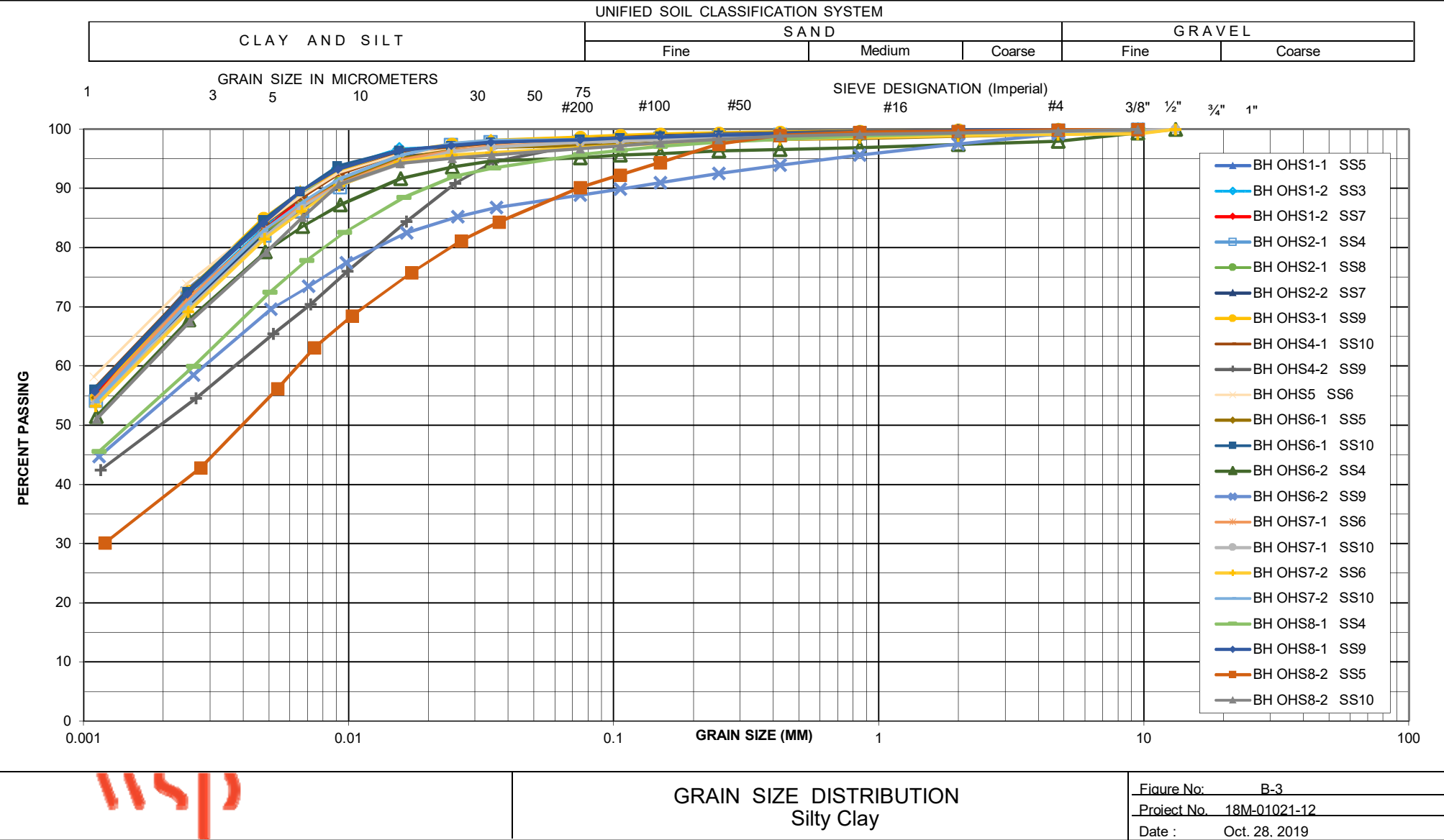
APPENDIX

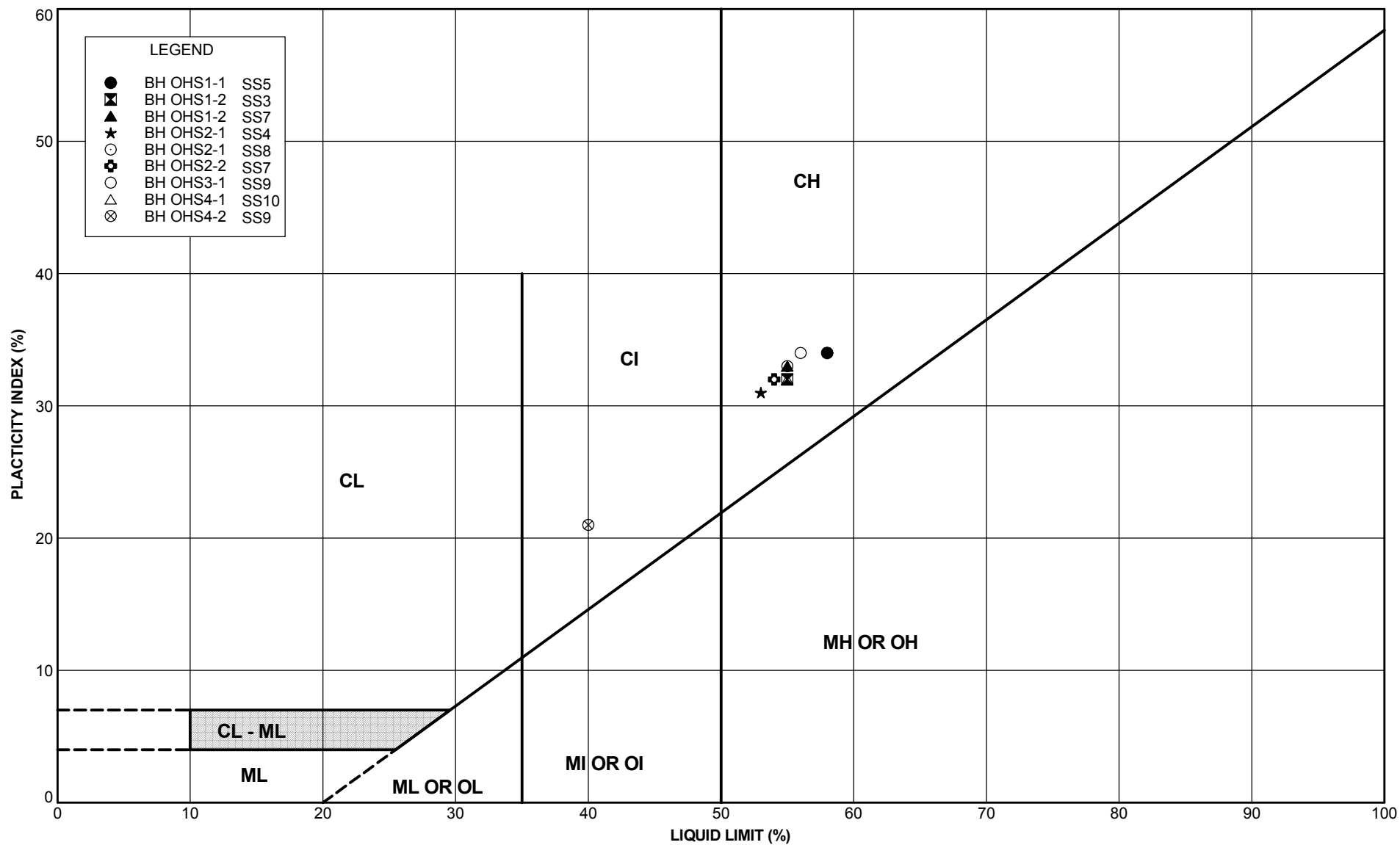
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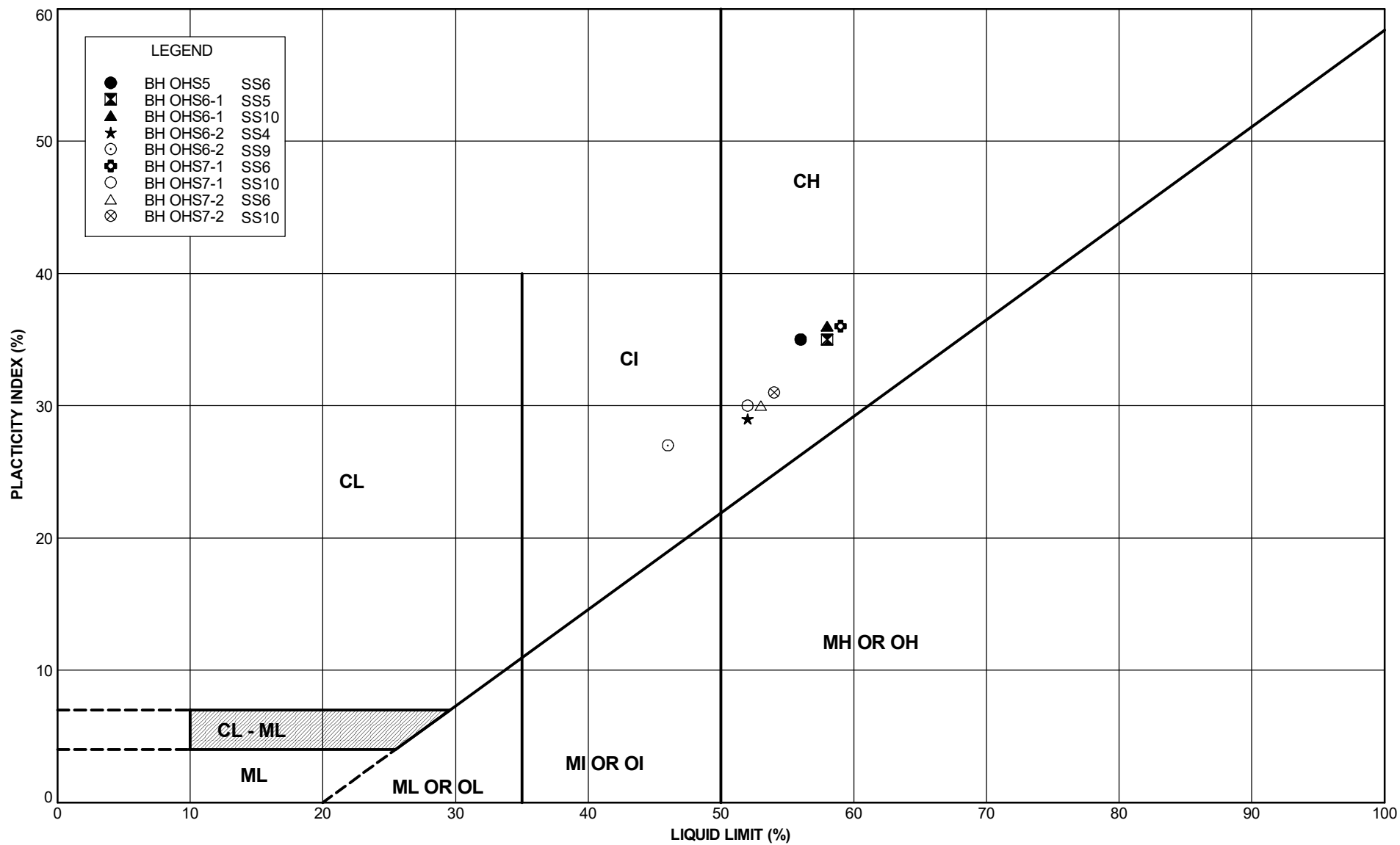
LABORATORY TEST RESULTS

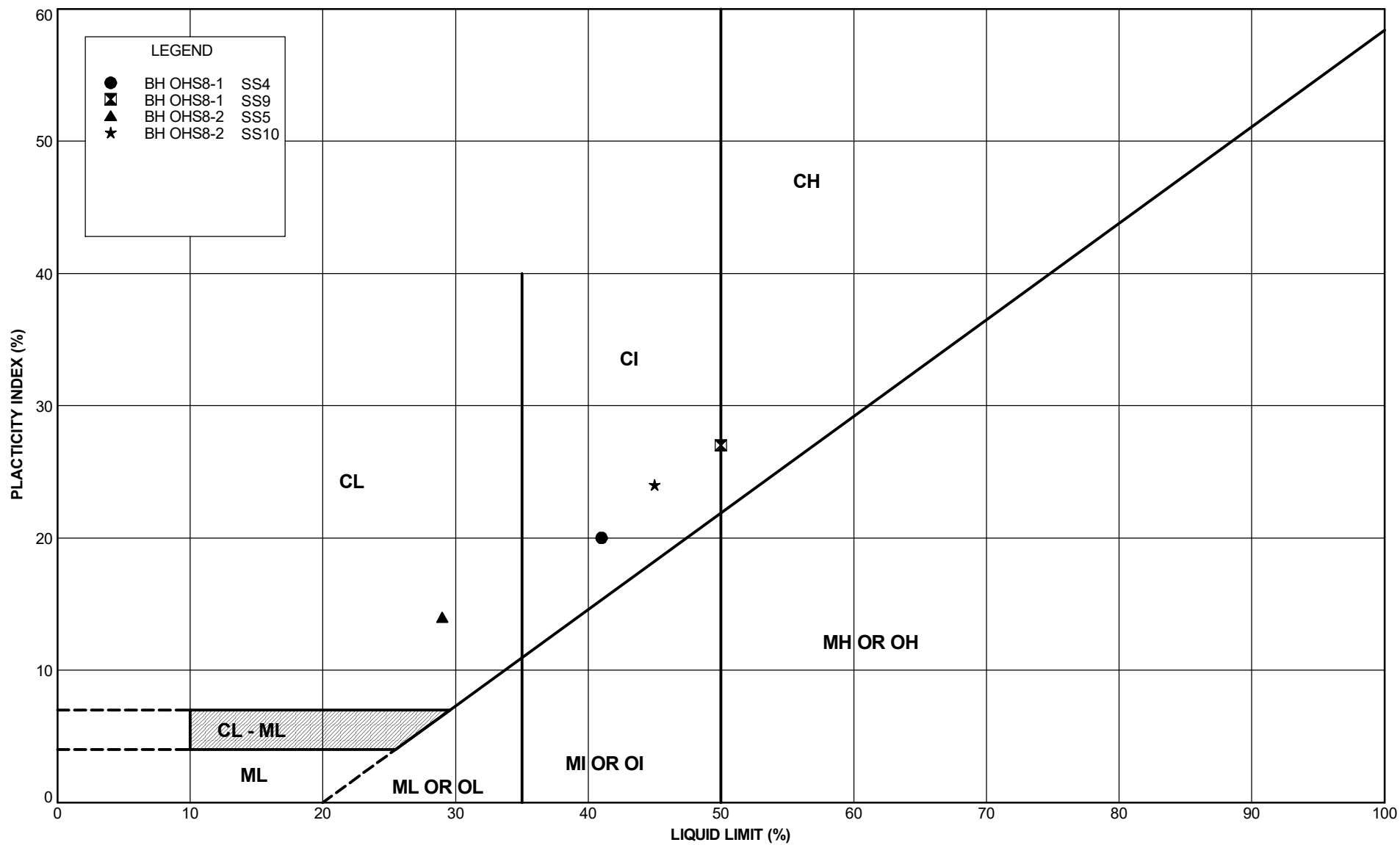












APPENDIX

C

SITE PHOTOGRAPHS

Project: Over Head Signs Support Structures

Assignment No. 2017 – E – 0018

SITE VISIT PHOTOGRAPHS

C1: Site Description Photographs

C2: Field Investigation Photographs

C1 Site Description Photographs



Photo C1-1 Looking towards west: Entrance to OHS1-1 & OHS1-2 Location (Aug 2019)



Photo C1-2 Looking towards south: Entrance to OHS4-1 & OHS4-2 Location (July 2019)

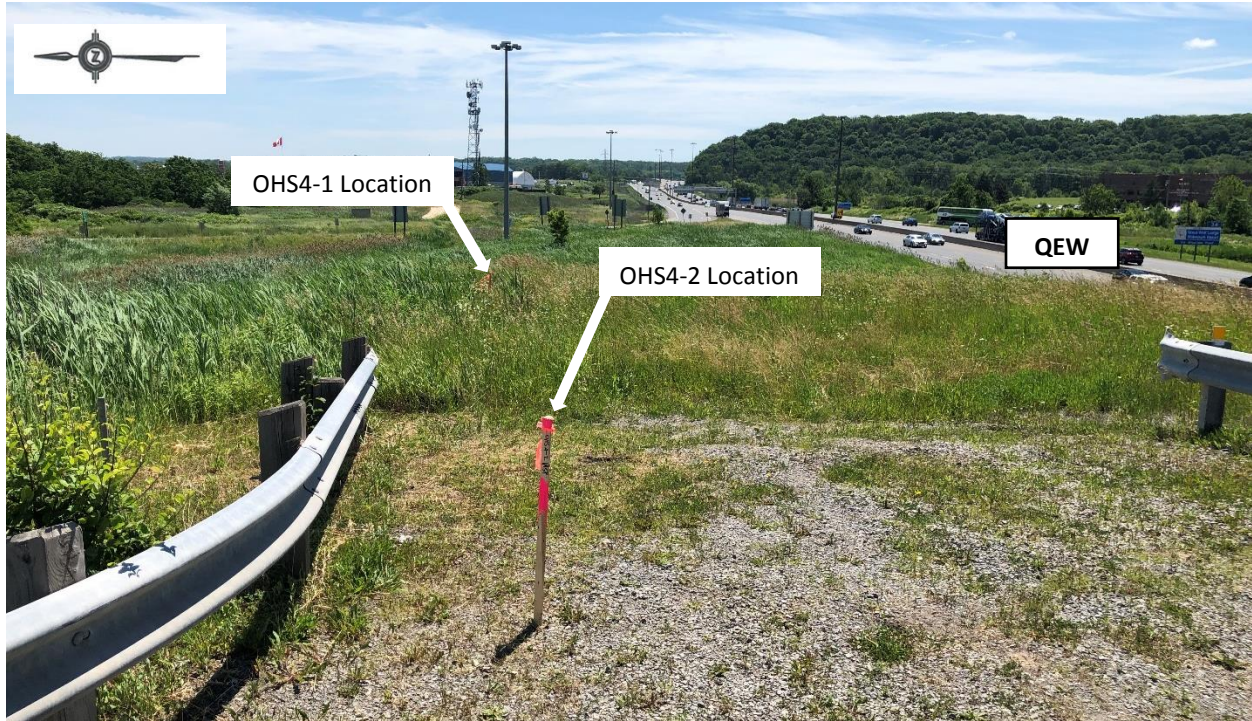


Photo C1-3 Looking towards east: OHS4-1 & OHS4-2 Location (July 2019)

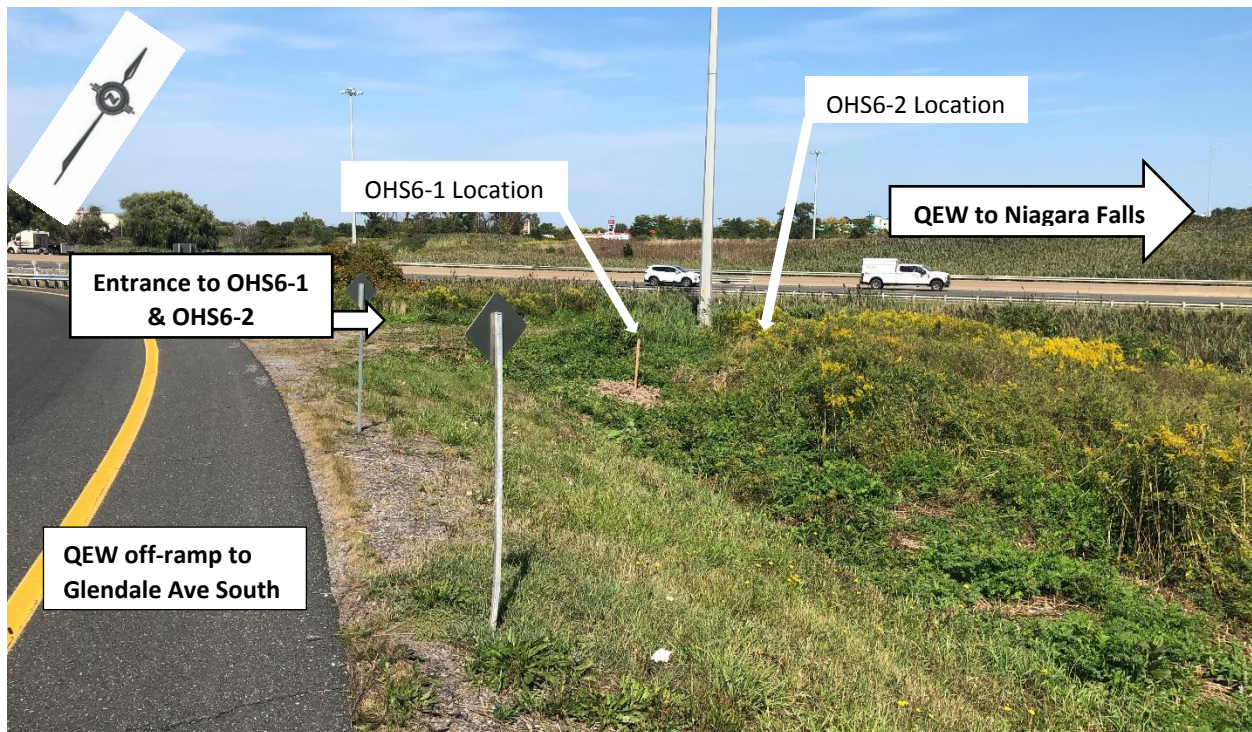


Photo C1-4 Looking towards Northwest: OHS6-1 & OHS6-2 Location (Sept 2019)



Photo C1-5 Looking towards southwest on Glendale Ave: OHS7-1 & OHS7-2 Location (Sept 2019)



Photo C1-6 Looking towards west: OHS8-1 & OHS8-2 Location (Sept 2019)

C2 Field Investigation Photographs

Photo C2-1 Field investigation on BH OHS1-1 with M5T Track Mount Rig (Aug 2019)



Photo C2-2 Field investigation on BH OHS8-2 with CME 55 Truck Mount Rig (Sept 2019)

APPENDIX

D

CORROSIVITY AND WATER SOLUBLE SULPHATE SOIL
TEST

**CLIENT NAME: WSP CANADA INC.
51 CONSTELLATION COURT
TORONTO, ON M9W1K4
(416) 798-0065**

ATTENTION TO: Joeline Chan

PROJECT: 18M-01021-12

AGAT WORK ORDER: 19T511922

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Sep 11, 2019

PAGES (INCLUDING COVER): 6

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T511922

PROJECT: 18M-01021-12

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

SAMPLING SITE:

ATTENTION TO: Joeline Chan

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-08-30

DATE REPORTED: 2019-09-11

		SAMPLE DESCRIPTION:		OHS1-1 SS3	OHS1-2 SS4	OHS3-1 SS5
		SAMPLE TYPE:		Soil	Soil	Soil
		DATE SAMPLED:		2019-08-27	2019-08-27	2019-08-27
Parameter	Unit	G / S	RDL	486042	486044	486045
Chloride (2:1)	µg/g	NA	8	193	186	179
Sulphate (2:1)	µg/g		8	150	1690	267
pH (2:1)	pH Units		NA	8.35	7.95	8.21
Electrical Conductivity (2:1)	mS/cm	0.7	0.005	0.739	2.13	0.800
Resistivity (2:1) (Calculated)	ohm.cm		1	1350	469	1250
Redox Potential 1	mV		NA	265	245	253
Redox Potential 2	mV		NA	268	245	254
Redox Potential 3	mV		NA	268	245	254

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Table 3: Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition - Soil - Residential/Parkland/Institutional Property Use - Coarse Textured Soils
Guideline values are for general reference only. The guidelines provided may or may not be relevant for the intended use. Refer directly to the applicable standard for regulatory interpretation.

486042-486045 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
PI note: Redox Potential is not an accredited parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:





Guideline Violation

AGAT WORK ORDER: 19T511922

PROJECT: 18M-01021-12

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Joeline Chan

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	UNIT	GUIDEVALUE	RESULT
486042	OHS1-1 SS3	ON T3 S RPI CT	Corrosivity Package	Electrical Conductivity (2:1)	mS/cm	0.7	0.739
486044	OHS1-2 SS4	ON T3 S RPI CT	Corrosivity Package	Electrical Conductivity (2:1)	mS/cm	0.7	2.13
486045	OHS3-1 SS5	ON T3 S RPI CT	Corrosivity Package	Electrical Conductivity (2:1)	mS/cm	0.7	0.800

Quality Assurance

CLIENT NAME: WSP CANADA INC.

PROJECT: 18M-01021-12

SAMPLING SITE:

AGAT WORK ORDER: 19T511922

ATTENTION TO: Joeline Chan

SAMPLED BY:

Soil Analysis

RPT Date: Sep 11, 2019			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Corrosivity Package

Chloride (2:1)	503270		1910	2130	10.9%	< 2	101%	80%	120%	87%	80%	120%	99%	70%	130%
Sulphate (2:1)	503270		203	190	6.6%	< 2	90%	80%	120%	93%	80%	120%	100%	70%	130%
pH (2:1)	483050		7.47	7.59	1.6%	NA	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	486062		2.55	2.56	0.4%	< 0.005	102%	90%	110%	NA			NA		
Redox Potential 1	1						109%	90%	110%						

Comments: NA signifies Not Applicable.

Duplicate Qualifier: 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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:




Method Summary

CLIENT NAME: WSP CANADA INC.

PROJECT: 18M-01021-12

SAMPLING SITE:

AGAT WORK ORDER: 19T511922

ATTENTION TO: Joeline Chan

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE

**CLIENT NAME: WSP CANADA INC.
51 CONSTELLATION COURT
TORONTO, ON M9W1K4
(416) 798-0065**

ATTENTION TO: Joeline Chan

PROJECT: 19T511922

AGAT WORK ORDER: 19T515275

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Sep 11, 2019

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**

All samples are stored at no charge for 90 days. Please contact the lab if you require additional sample storage time.



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T515275

PROJECT: 19T511922

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Joeline Chan

(201-042) Sulfide

DATE SAMPLED: Sep 08, 2019

DATE RECEIVED: Sep 09, 2019

DATE REPORTED: Sep 11, 2019

SAMPLE TYPE: Other

Analyte: Sulfide

Unit: %

Sample ID (AGAT ID) RDL: 0.05

OHS1-1 SS3 (509428) <0.05

OHS1-2 SS4 (509429) <0.05

OHS3-1 SS5 (509430) <0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Hoossaf



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 19T515275

PROJECT: 19T511922

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Joeline Chan

(201-042) Sulfide

REPLICATE #1															
Parameter	Sample ID	Original	Replicate	RPD											
S	509428	0.020	0.019	5.1%											
Sulfate	509428	< 0.01	<0.01	0.0%											
Sulfide	509428	< 0.05	<0.05	0.0%											



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 19T515275

PROJECT: 19T511922

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Joeline Chan

(201-042) Sulfide

CRM #1															
Parameter	Expect	Actual	Recovery	Limits											
S	0.8	0.81	101%	90% - 110%											
Sulfate	0.01	0.01	100%	90% - 110%											
Sulfide	0.8	0.8	100%	90% - 110%											

Method Summary

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 19T515275

PROJECT: 19T511922

ATTENTION TO: Joeline Chan

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO

**CLIENT NAME: WSP CANADA INC.
51 CONSTELLATION COURT
TORONTO, ON M9W1K4
(416) 798-0065**

ATTENTION TO: Mike Wilson

PROJECT: 18M-01021-12

AGAT WORK ORDER: 19T509150

SOIL ANALYSIS REVIEWED BY: Yris Verastegui, Report Reviewer

DATE REPORTED: Sep 04, 2019

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

***NOTES**

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



Certificate of Analysis

AGAT WORK ORDER: 19T509150

PROJECT: 18M-01021-12

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

SAMPLING SITE:

ATTENTION TO: Mike Wilson

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2019-08-23

DATE REPORTED: 2019-09-04

		SAMPLE DESCRIPTION: BH RW1 SS4				BH RSS2 SS5		BH RSS4 SS9		BH OHS2-1 SS3		BH OHS4-2 SS9	
		SAMPLE TYPE: Soil				Soil		Soil		Soil		Soil	
		DATE SAMPLED: 2019-06-27				2019-06-27		2019-06-27		2019-06-27		2019-06-27	
Parameter	Unit	G / S	RDL	467503	RDL	467514	RDL	467515	467516	RDL	467517		
Chloride (2:1)	µg/g		4	308	2	21	4	59	47	8	287		
Sulphate (2:1)	µg/g		4	971	2	302	4	1420	845	8	1410		
pH (2:1)	pH Units		NA	8.15	NA	8.35	NA	8.21	8.15	NA	7.83		
Electrical Conductivity (2:1)	mS/cm		0.005	1.49	0.005	0.459	0.005	1.52	0.930	0.005	1.74		
Resistivity (2:1) (Calculated)	ohm.cm		1	671	1	2180	1	658	1080	1	575		
Redox Potential 1	mV		NA	57.9	NA	69.4	NA	-120.6	61.1	NA	63.8		
Redox Potential 2	mV		NA	65.2	NA	74.1	NA	-113.7	57.8	NA	60.9		
Redox Potential 3	mV		NA	63.8	NA	62.6	NA	-120.2	59.9	NA	61.2		

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

467503 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
PI note: Redox Potential is not an accredited parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument.

467514 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
PI note: Redox Potential is not an accredited parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

467515 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
PI note: Redox Potential is not an accredited parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
The negative value reported for Redox is possibly due to the presence of reducing agents in the sample.

Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument.

467516-467517 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
PI note: Redox Potential is not an accredited parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.

Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Iris Veraestegui

Quality Assurance

CLIENT NAME: WSP CANADA INC.

PROJECT: 18M-01021-12

SAMPLING SITE:

AGAT WORK ORDER: 19T509150

ATTENTION TO: Mike Wilson

SAMPLED BY:

Soil Analysis

RPT Date: Sep 04, 2019			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Corrosivity Package

Chloride (2:1)	467503	467503	308	307	0.3%	< 2	101%	80%	120%	104%	80%	120%	103%	70%	130%
Sulphate (2:1)	467503	467503	971	976	0.5%	< 2	101%	80%	120%	108%	80%	120%	110%	70%	130%
pH (2:1)	467503	467503	8.15	8.14	0.1%	NA	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	467503	467503	1.49	1.52	2.0%	< 0.005	100%	90%	110%	NA			NA		

Comments: NA signifies Not Applicable.

Duplicate Qualifier: 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

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By:


Method Summary

CLIENT NAME: WSP CANADA INC.

PROJECT: 18M-01021-12

SAMPLING SITE:

AGAT WORK ORDER: 19T509150

ATTENTION TO: Mike Wilson

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-09, SM 2580 B	REDOX POTENTIAL ELECTRODE



Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: WSP Canada Inc.
Contact: Mike Wilson
Address: 51 Constellation court
Toronto, ON
416-798-0065 Fax: 416-798-0518
Reports to be sent to:
1. Email: Michael.Wilson@wsp.com
2. Email: Sharif.Willah@wsp.com

Regulatory Requirements:

(Please check all applicable boxes)

☒ Regulation 153/04

Table Indicate One

☐ Ind/Com

☐ Res/Park

☐ Agriculture

Soil Texture (Check One)

☐ Coarse

☐ Fine

☐ Sewer Use

☐ Sanitary

☐ Storm

Region Indicate One

☐ MISA

☐ Regulation 558

☐ CCME

☐ Prov. Water Quality Objectives (PWQO)

☐ Other

Indicate One

Is this submission for a
Record of Site Condition?

☐ Yes

☐ No

Report Guideline on
Certificate of Analysis

☐ Yes

☐ No

Project Information:

Project: ISM-01021-12
Site Location: GEW/Glenade
Sampled By: _____
AGAT Quote #: _____ PO: _____

Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐

Company: _____
Contact: _____
Address: _____
Email: payables.ontario@wsp.com

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Y / N	Field Filtered - Metals, Hg, CrVI	Metals and Inorganics	0. Reg 153	Regulation/Custom Metals	Nutrients	Volatiles:	PHCs F1 - F4	ABNs	PAHs	PCBs: <input type="checkbox"/> Total <input type="checkbox"/> Aroclors	Organochlorine Pesticides	TCLP: <input type="checkbox"/> M&I <input type="checkbox"/> VOCs <input type="checkbox"/> ABNs <input type="checkbox"/> B(a)P <input type="checkbox"/> PCBs	Sewer Use	Potentially Hazardous or High Concentration (Y/N)
BH RW1 SS4	June 27	-	1	Soil				<input type="checkbox"/> All Metals <input type="checkbox"/> 153 Metals (excl. Hydrides) <input type="checkbox"/> Hydride Metals <input type="checkbox"/> 153 Metals (incl. Hydrides)		<input type="checkbox"/> B-HWS <input type="checkbox"/> Cl <input type="checkbox"/> CN <input type="checkbox"/> Cu <input type="checkbox"/> EC <input type="checkbox"/> FOC <input type="checkbox"/> Hg <input type="checkbox"/> pH <input type="checkbox"/> SAR	<input type="checkbox"/> TP <input type="checkbox"/> NH ₄ <input type="checkbox"/> TKN <input type="checkbox"/> NO ₃ <input type="checkbox"/> NO ₂ <input type="checkbox"/> NO ₃ + NO ₂	<input type="checkbox"/> VOC <input type="checkbox"/> BTEX <input type="checkbox"/> THM								
BH RSS2 SS5	June 28	-	1	Soil																
BH RSS4 SS9	June 28	-	1	Soil																
BH OHS2-1 SS3	June 27	-	1	Soil																
BH OHS4-2 SS5	June 27	-	1	Soil																

Samples Relinquished By (Print Name and Sign): <u>Michael Wilson</u>	Date: <u>Aug 23, 2019</u>	Time: <u>3:07 PM</u>	Samples Received By (Print Name and Sign): <u>Simon Z</u>	Date: <u>19/8/23</u>	Time: <u>3:04</u>
Samples Relinquished By (Print Name and Sign):	Date:	Time:	Samples Received By (Print Name and Sign):	Date:	Time:
Samples Relinquished By (Print Name and Sign):	Date:	Time:	Samples Received By (Print Name and Sign):	Date:	Time:

Page 1 of 1
N°: **T 093250**

Laboratory Use Only

Work Order #: 19T509150

Cooler Quantity: 96 94 98

Arrival Temperatures: _____

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes: on ice

Turnaround Time (TAT) Required:

Regular TAT

☒ 5 to 7 Business Days

Rush TAT (Rush Surcharge Apply)

☐ 3 Business Days

☐ 2 Business Days

☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
*TAT is exclusive of weekends and statutory holidays

For 'Same Day' analysis, please contact your AGAT CPM

**CLIENT NAME: WSP CANADA INC.
51 CONSTELLATION COURT
TORONTO, ON M9W1K4
(416) 798-0065**

ATTENTION TO: Mike Wilson

PROJECT: 19T509150

AGAT WORK ORDER: 19T511287

SOLID ANALYSIS REVIEWED BY: Sherin Moussa, Senior Technician

DATE REPORTED: Sep 04, 2019

PAGES (INCLUDING COVER): 5

Should you require any information regarding this analysis please contact your client services representative at (905) 501-9998

***NOTES**



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 19T511287

PROJECT: 19T509150

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Mike Wilson

(201-042) Sulfide

DATE SAMPLED: Aug 28, 2019

DATE RECEIVED: Aug 29, 2019

DATE REPORTED: Sep 04, 2019

SAMPLE TYPE: Other

Analyte:	Sulfide
Unit:	%
Sample ID (AGAT ID)	RDL: 0.05

BH RW1 SS4 (481286) <0.05

BH RSS2 SS5 (481287) <0.05

BH RSS4 SS9 (481288) 0.14

BH OHS2-1 SS3 (481289) <0.05

BH OHS4-2 SS9 (481290) <0.05

Comments: RDL - Reported Detection Limit

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Sherin Hoossaf



AGAT Laboratories

Quality Assurance - Replicate

AGAT WORK ORDER: 19T511287

PROJECT: 19T509150

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Mike Wilson

(201-042) Sulfide

(201-042) Sulfide															
	REPLICATE #1														
Parameter	Sample ID	Original	Replicate	RPD											
S	481287	0.048	0.048	0.0%											
Sulfate	481287	< 0.01	<0.01	0.0%											
Sulfide	481287	< 0.05	<0.05	0.0%											



AGAT Laboratories

Quality Assurance - Certified Reference materials

AGAT WORK ORDER: 19T511287

PROJECT: 19T509150

5623 McADAM ROAD
MISSISSAUGA, ONTARIO
CANADA L4Z 1N9
TEL (905)501-9998
FAX (905)501-0589
<http://www.agatlabs.com>

CLIENT NAME: WSP CANADA INC.

ATTENTION TO: Mike Wilson

(201-042) Sulfide

CRM #1															
Parameter	Expect	Actual	Recovery	Limits											
S	0.8	0.81	101%	90% - 110%											
Sulfate	0.01	0.01	100%	90% - 110%											
Sulfide	0.8	0.8	100%	90% - 110%											

Method Summary

CLIENT NAME: WSP CANADA INC.

AGAT WORK ORDER: 19T511287

PROJECT: 19T509150

ATTENTION TO: Mike Wilson

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Solid Analysis			
Sulfide	MIN-200-12037		LECO



FOUNDATION DESIGN REPORT PROPOSED OVERHEAD SIGN SUPPORT STRUCTURES, TOWN OF NIAGARA-ON-THE-LAKE, NIAGARA REGION, ONTARIO

SITE LOCATION (LAT: 43.160074°, LONG: -79.162193°)

MINISTRY OF TRANSPORTATION ONTARIO

G.W.P 2423-15-00

GEOCRES NO. 30M3-317

WSP PROJECT NO.: 18M-01021-12

DECEMBER 21, 2019

WSP CANADA INC.
2 INTERNATIONAL BOULEVARD
TORONTO, ON
CANADA, M9W 1A2

T: +1 416 679-9410
WWW.WSP.COM

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TABLES

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FIG. 6. Lateral Pile Analysis (Horizontal Load)
FIG. 7. Lateral Pile Analysis (Bending Moment)

APPENDICES

APPENDIX E LIST OF SSPs, OPSS AND OPSD
APPENDIX F LIMITATIONS OF REPORT

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

This section of the report provides recommendations for the foundation aspects for the proposed seven Overhead Sign Support (OHS) Structures along the proposed Glendale Avenue of the QEW/the proposed Glendale Avenue Underpass Interchange (See Drawing No. 1). The recommendations are based on our understanding of the project and on the interpretation of factual data compiled from both field and laboratory investigations carried out by WSP.

The discussions and recommendations presented in this report are intended to assist the designers with sufficient information that would enable them to proceed with the design of the proposed OHS Structure foundations.

Construction comments made herein are based on geotechnical considerations only and should not be relied upon without further independent assessment and qualification in the selection of means and methods for construction.

In what follows, Canadian Highway Bridge Design Code (CHBDC, 2014: CSA S6-14) will be referred to as **CHBDC (2014)**, the Commentary on CSA S6-14, Canadian Highway Bridge Design Code will be referred to as **CHBDC (2014) Commentary** and the MTO Sign Support Manual (February 2019) will be referred to as **MTO SSM (2019)**.

According to the information at hand, the proposed OHS structures are portals (two-legged) and hence the likely locations of the structure legs would be on the proposed Glendale Ave. embankment side slopes.

5.2 GROUND CHARACTERISATION

5.2.1 OVERVIEW OF SUB-SURFACE CONDITIONS

The stratigraphy at the site generally consists of a cohesive fill underlying a veneer of topsoil with thickness ranging from 1.3 m to 5.3 m. The fill was generally found to be of firm to very stiff consistency. Underlying the fill was found a silty clay deposit with intercepted thickness ranging from 2.9 m to 6.9 m within the explored depths. Except for one borehole, drilling was terminated within the silty clay deposit. The consistency of the deposit based on SPT 'N' values generally ranged from firm to very stiff. The explored depth of the boreholes was 8.2 m.

The intercepted ground conditions are in general agreement with the findings of the previous Golder investigation for the Glendale Avenue Underpass Replacement mentioned in Section 2.2.

Long-term groundwater level observations were carried out in three boreholes. The observed maximum groundwater levels ranged from Elev. 109.6 m (BH OHS1-1) to Elev. 115.6 m (BH OHS7-1).

5.2.2 SHEAR STRENGTH CHARACTERISATION

In order to develop an undrained shear strength profile for purposes of foundation design, the observed SPT 'N' blow counts were plotted against elevation for all the OHS boreholes and is shown in Fig. 2. This plot shows that

- The SPT 'N' values within the native deposit show a decreasing trend of N values with decreasing elevation, i.e. with depth

Within the native deposit, Figure 3 shows the trend of SPT 'N' values with elevation.

In order to develop a shear strength profile, borehole information from WSP boreholes and Golder boreholes adjacent to the OHS boreholes (See Fig. 1) were combined. Figure 4 shows the Field Vane based undrained shear strengths with averaged SPT

`N` values corresponding to the elevations where field vane shear strength measurements have been made. Based on site specific undrained shear strengths and SPT `N` values, a lower-bound undrained shear strength envelope is estimated that gives the following empirical relationship:

$$S_u = 8N \text{ (kPa) -Equation (1)}$$

Based on the above site specific empirical characterization between undrained shear strength and SPT N, i.e. Eqn. (1), the geotechnical strength models at the individual HML locations are given in Table 5-1.

Table 5-1 Undrained Shear Strength Models for OHS Locations (Unfactored)

OHS Location		Fill (below frost depth) Unit Weight: 20kN/m ³			Native Deposits								
					Very Stiff Clay Unit Weight: 20kN/m ³			Stiff Clay Unit Weight: 20kN/m ³			Firm Clay Unit Weight: 20kN/m ³		
		Depth (m)	Elev.	S _u (kPa)	Depth (m)	Elev.	S _u (kPa)	Depth (m)	Elev.	S _u (kPa)	Depth (m)	Elev.	S _u (kPa)
OHS 1	OHS 1-1	1.2 - 1.5	115.5 – 115.3	75	1.5 – 8.2	115.3 – 108.6	125						
	OHS 1-2	1.2 – 1.5	115.7 – 115.4	65	1.5 – 5.9	115.4 – 111.0	150	5.9 – 8.2	111.0 – 108.7	85			
OHS 2	OHS 2-1/OHS5	1.2 – 1.5	116.6 – 116.3	55	1.5 – 5.9	116.3 – 111.8	150	5.9 – 8.2	111.8 – 109.6	95			
	OHS 2-2	1.2 – 3.1	116.8 – 115.0	70	3.1 – 5.2	115.0 – 112.8	140	5.2 – 8.2	112.8 – 109.8	100			
OHS 3	OHS 3-1	1.2 -2.1	113.9 - 115.5	90	2.1 – 8.2	115.5 – 106.9	140						
	GAU-8	1.2 – 1.5	114.4 – 114.0	40	1.5 – 3.6	114.0 - 112.0	135	3.6 – 6.6	112.0 – 109.0	85	6.6 – 13.6	109 - 102	40
OHS 4	OHS 4-1	1.2 – 5.3	121.0 – 116.9	45	5.3 – 8.2	116.9 – 114.0	185						
	OHS 4-2	1.2 – 3.8	121.0 - 119.0	40	3.8 – 8.2	119.0 – 114.6	100						
OHS 6	OHS 6-1	1.2 – 1.5	116.0 – 115.7	50	1.5 – 8.2	115.7 – 109.0	160						
	OHS 6-2	1.2 – 1.5	114.6 – 114.3	100	1.5 – 8.2	114.3 – 107.6	130						
OHS 7	OHS 7-1	1.2 – 2.3	117.1 – 116.0	50	2.3 – 8.2	116.0 – 110.1	165						

	OHS 7-2	1.2 – 2.3	117.9 – 116.8	40	2.3 – 8.2	116.8 – 110.9	165						
OHS 8	OHS 8-1	1.2 – 1.5	117.8 – 117.5	65	1.5 – 8.2	117.5 – 110.8	155						
	OHS 8-2				1.2 – 6.0	112.3 – 112.3	140	6.0 – 8.2	112.3 – 110.1	100			

The undrained shear strength within the first 1.2 m (i.e. frost depth) below built-ground surface should be neglected for strength/passive resistance purposes.

5.2.3 GROUND MOTION PARAMETERS

Based on the borehole information and our review of the general subsurface conditions in the area, the subject site for the proposed HML pole foundations can be classified as ‘Site Class D’ for seismic site response according to Table 4.1.8.4.A of **National Building Code (NBC) 2015** and Table 4.1 of the CHBDC (2014).

The Peak Ground Acceleration (PGA) and spectral acceleration $S_a(T)$ values for $T = 0.2, 0.5, 1.0, 2.0, 5.0$ and 10.0 for the Town of Niagara-On-The-Fall was obtained from the Natural Resources Canada (NRC) website on September 9, 2019 (<http://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/calc-en.php>). NRC reports seismic parameters for each region in Canada for the 2% in 50-year probability of exceedance, for Site Class C conditions. The PGA and $S_a(T)$ parameters for the above T values for site Class C for the subject region are 0.207g and 0.321, 0.157, 0.072, 0.032, 0.0076 and 0.0030, respectively.

Since the seismic site class classification at the project site is Site Class D, the regional value for PGA reported for Site Class C need to be modified to reflect Site Class D. This subject site adjustment was carried out in accordance with Section 4.4.3.3 Table 4.8 of the CHBDC (2014). As per Section 4.4.3.3 of the CHBDC (2014), Table 4.8, the site adjusted PGA value (for Site Class D) is 0.241g for a 2% in 50-year probability of exceedance (2,475 return period).

For the calculation of the design spectral acceleration, $S(T)$, associated with the governing structural vibration mode of the HML structures (a structural dynamic consideration), a value of 0.1656 for PGA_{ref} can be used along with the Seismic Site Class to compute Site Coefficients, $F(T)$. These Site Coefficients, $F(T)$ with the above $S_a(T)$ values can then be used in Cl. 4.4.3.4 of CHBDC (2014) to compute the relevant structural dynamic parameters.

5.2.4 FROST DEPTH AND FROST SUSCEPTIBILITY

The minimum earth cover required for a structure subjected to frost action at the project site is 1.2 m in accordance with Ontario Provincial Standard Drawing (**OPSD 3090.101**) (Foundation, Frost Penetration Depths for Southern Ontario). Based on Fig. B1 (in DFIR i.e. Draft Foundation Investigation Report), the frost susceptibility of the near surface soils within the first 1.2 m can be classified as predominantly of Low frost susceptible nature.

5.2.5 CONSEQUENCE AND SITE UNDERSTANDING CLASSIFICATION

The proposed OHS structure foundations are classified as having a “Low Consequence Level” associated with exceeding limit states design, as per Section 6.5 and C6.16.2.1 of the CHBDC (2014) and its Commentary.

Based on the level of foundation investigations completed at the proposed OHS structure locations in comparison to the degree of site understanding outlined in Section 6.5 of CHBDC (2014), a “Typical Degree of Site and Prediction Model Understanding” is considered appropriate for the proposed OHS structure foundations.

Values for the corresponding consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} , from Tables 6.1 and 6.2 of the CHBDC (2014) have been used for the appropriate aspects of the foundation design.

5.3 FOUNDATION RECOMMENDATIONS

5.3.1 GENERAL

OHS structure foundations are typically founded on short caisson foundations (MTO SSM (2019)) unless this is not possible due to shallow bedrock which is not the ground conditions intercepted at the subject site as discussed. SLS conditions typically dictate OHS structure foundation design (CHBDC (2014) Commentary, Section C6.16) for lateral loading. Vertical loading effects are not considered significant for OHS structure foundations.

Based on the above considerations, the following LRFD resistance factors are applicable (based on Table 6.2 of CHBDC (2014)):

$$\Psi = 1.15$$

ULS: Lateral, $\phi_{gu} = 0.5$; Compression, $\phi_{gu} = 0.4$

SLS: Lateral, $\phi_{gs} = 0.8$; Compression, $\phi_{gs} = 0.8$

5.3.2 FOUNDATIONS

Based on the borehole findings, the subsurface geology at the proposed OHS structure locations is typically cohesive fill underlain by native cohesive deposits, of firm or better consistency down to about 8.2 m of explored depth. The typical type of foundation of OHS structures is caissons (MTO SSM (2019)) and based on this document, the length of the caissons is unlikely to be more than 7.5 m (with 1.5 m diameter) as shown in Drawing SS118-3 in the MTO document, under ground conditions less favourable than those intercepted on site. Therefore, use of MTO standard drawings (MTO SSM (2019)) can be used once the type and nature of the OHS structures are known. This should be addressed by the Design-Builder. In the alternative, if foundation designs need to be optimized by the Design-Builder, then recommendations are given below to facilitate this.

GEOTECHNICAL CONSIDERATIONS – LATERAL LOADING

Geotechnical considerations (pertaining to lateral capacity and lateral deformations) are addressed in the following with respect to lateral loading of OHS structure foundations as relevant to the intercepted ground conditions, i.e. cohesive soils:

- Lateral capacity of piles: the estimated undrained strengths, S_u , (for cohesive soils) address pile lateral capacity issues
- Lateral deformation of piles: the coefficient of horizontal subgrade reaction, k_s (via S_u for cohesive soils) provides the input for lateral deformation analyses

The geotechnical lateral resistance is greatly affected by the soil properties close to the ground level (about 10 pile diameters, Ref: Piling Engineering, Fleming, et. al.).

As the sub-soils within the depth range of the proposed caissons are primarily cohesive, the coefficient of horizontal subgrade reaction can be estimated from:

$$k_s = 67 S_u / d$$

where S_u = undrained shear strength (individual OHS site specific S_u values are given in Table 5.1) and d is the caisson diameter.

The design water level should be assumed at existing ground elevations for lateral pile resistance considerations.

For an indicative analysis of the effects of lateral loading for OHS Structures, in the absence of specific caisson geometries, the following caisson geometries were adopted based on MTO SSM (2019):

Lower bound: 5 m length and 1.0 m diameter

Upper bound: 7.5 m length and 1.5 m diameter

As no SLS lateral deformation criteria are given for OHS structure foundations in MTO SSM (2019), the more onerous MTO High Mast Pole Foundation deformation criteria were adopted as follows:

SLS lateral displacement = 12 mm

SLS lateral rotation = 0.005 radians

Using the ground model shown in Fig. 5 and the above noted caisson geometries, an indicative lateral pile analysis was undertaken (using Rocscience, RSPile (2018)) giving the following horizontal load (H) and bending moment (BM) combinations that satisfy the above noted SLS deformation criteria (See Figs. 6 and 7):

Lower bound: 5 m length and 1.0 m diameter: H = 60 kN and BM = 750 kNm

Upper bound: 7.0 m length and 1.5 m diameter: H = 200 kN and BM = 1500 kNm

It is to be noted that the above H and BM combinations are not necessarily the only combinations that could satisfy the above SLS criteria and the above analysis is for illustrative purposes only.

Lateral resistance contribution from embankment side slopes has been neglected due to the absence of any embankment specific location details.

The proposed OHS structures at the subject site discussed in this report are all portal frame structures, i.e. two-legged. The wind loading in the plane of the portal is the minor wind load direction compared to the wind load perpendicular to the portal. If any minor wind loading in the plane of the portal should act, then one foundation caisson will be subjected to a loading towards the slope (negatively impacted) but the opposite caisson will be subjected to the horizontal loading into the embankment slope (positively impacted), in a counteracting manner. Therefore, the connecting overhead portal bracing will act to restrain the negatively impacted foundation element. This should be dealt with in the structural design, if considered warranted by the structural designers.

GEOTECHNICAL CONSIDERATIONS – AXIAL LOADING

The recommended factored ultimate geotechnical resistance and factored serviceability geotechnical resistance for (i) a 1.5 m diameter, 7.5 m long caisson and (ii) 1.0 m diameter, 5.0 m long caisson embedded in the geotechnical model in Fig. 5 (the upper clay ($S_u = 80$ kPa; with the shaft resistance within the top 1.2 m neglected) and the lower clay ($S_u = 95$ kPa)) are as follows:

Table 5-2 Geotechnical Resistances – Axial Loading

Pile Geometry	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance (kPa) [for 25 mm Settlement]
1.5 m diameter, 7.5 m long caisson	1000	700
1.0 m diameter, 5.0 m long caisson	375	275

*Based on the geotechnical model shown in Fig. 5. Geotechnical resistance of the top 1.2 m neglected. Any geotechnical axial resistance contribution from embankment side slopes has been neglected due to the absence of any embankment specific

location details.

Construction considerations are discussed in Section 5.4.

5.4 CONSTRUCTION CONSIDERATIONS

5.4.1 SITE PREPARATION

If for some reason, any OHS structure foundation need to be placed outside the toe of the proposed Glendale Avenue embankment, then it is recommended that all topsoil, organics loosened/softened and deleterious materials should be stripped from the proposed OHS structure foundation locations and should backfill the area in accordance with **OPSS 902** (Excavating and Backfilling Structures). Otherwise, site preparation issues will pertain to the proposed embankment construction recommendations as given in the Golder Report (Geocres No. 30M3-311).

5.4.2 EXCAVATIONS

All excavations should be carried out in accordance with the **Occupational Health and Safety Act (OHSA). O. Reg. 213/91**. Where space permits, and appropriate groundwater control measures are in place, temporary open cut excavations may be undertaken subject to the following specifications:

In accordance with OHSA and based on the geotechnical understanding of the site conditions, the sub-soils intercepted can be classified as follows:

- Silty Clay/ Fill Material above water table Type 3
- Silty Clay below water table Type 4

The above slopes are for short-term open excavations only and should be visually monitored especially when people are working inside.

Excavations in the native soils should be possible using heavy equipment such as a hydraulic excavator and cobbles and boulders within the fill and native deposits should be anticipated.

Requirements for shoring are not anticipated for the construction of OHS foundations consisting of caissons. Additional geotechnical engineering input will be required if any proposed temporary excavation were to abut an existing embankment.

5.4.3 GROUNDWATER CONTROL

Given the varved nature of some of the native silty clay deposits reported by Golder and observed by WSP in the only Shelby tube retrieved from the HML series, i.e. in HM 4, Sample 14 (documented in the draft FIDR for the HML Pole Foundations) and the groundwater level observations reported in Table 4-29 of the DFIR, inflows into the caisson bores should be minimal but cannot be ruled out (in view of the varved clay structure). Therefore, use of temporary liners may be required. Preparedness for bailing/pumping out any groundwater inflow can be anticipated.

The control of groundwater during construction should be undertaken as per **OPSS.PROV 517** (Construction Specification for Dewatering) as amended by SP 517F01.

5.4.4 CONSTRUCTION OF CAISSONS

In addition to the possible requirement for the use of temporary liners discussed in Section 5.4.3, it is necessary to ensure that concrete is placed within four hours following the caisson bore excavations, cleaning and inspection to minimize the potential for softening of the bore walls/bases comprising intermediate to high plasticity cohesive soils. Construction should be compliant with **OPSS.PROV 903** - Construction Specifications for Deep foundations as amended by SP 109F57.

5.5 POTENTIAL FOR SULPHATE ATTACK/CORROSION ON CAISSONS

Laboratory testing carried out on five samples of soil was reported in Section 4.12 of the DFIR.

The Canadian Standards Association (**CAN/CSA-A23.1-04**) recognizes four categories of potential sulphate attack of buried concrete based on percent sulphate in soil. From 0 to 0.10 percent the potential is negligible, from 0.10 to 0.20 percent the potential is mild but positive, from 0.20 to 0.50 percent the potential is considerable and 0.50 percent and greater the potential is severe. Based on the above, given the tested soil samples indicated sulphate percentages ranging from 0.015% to 0.17%, the vulnerability to sulphate attack on buried concrete is considered to be from negligible to mild. This information should be noted in the structural design/concrete specifications of the caissons.

Based on **MTO Gravity Pipe Design Guideline (April 2014)**, subgrade soil corrosiveness is categorized into four (4) groups in accordance with Table 3.2 of the MTO guideline. The soil resistivity for the samples tested at this site indicated resistivity ranging from 469 to 1350 ohm-cm, which would categorize the subject soils as severe. Due to the corrosiveness condition of the soils, protection measures such as adequate concrete cover should be provided for steel reinforcement within the caissons.

CLOSURE

The "Limitations of Report" as presented in **Appendix Fare** an integral part of this report.

SIGNATURES

We trust that the information contained in this foundation investigation report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

WSP Canada Inc.



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REFERENCES

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-14. 2014. CSA Special Publication, S6.1 14. Canadian Standard Association.

National Building Code (NBC) 2015, NRC.

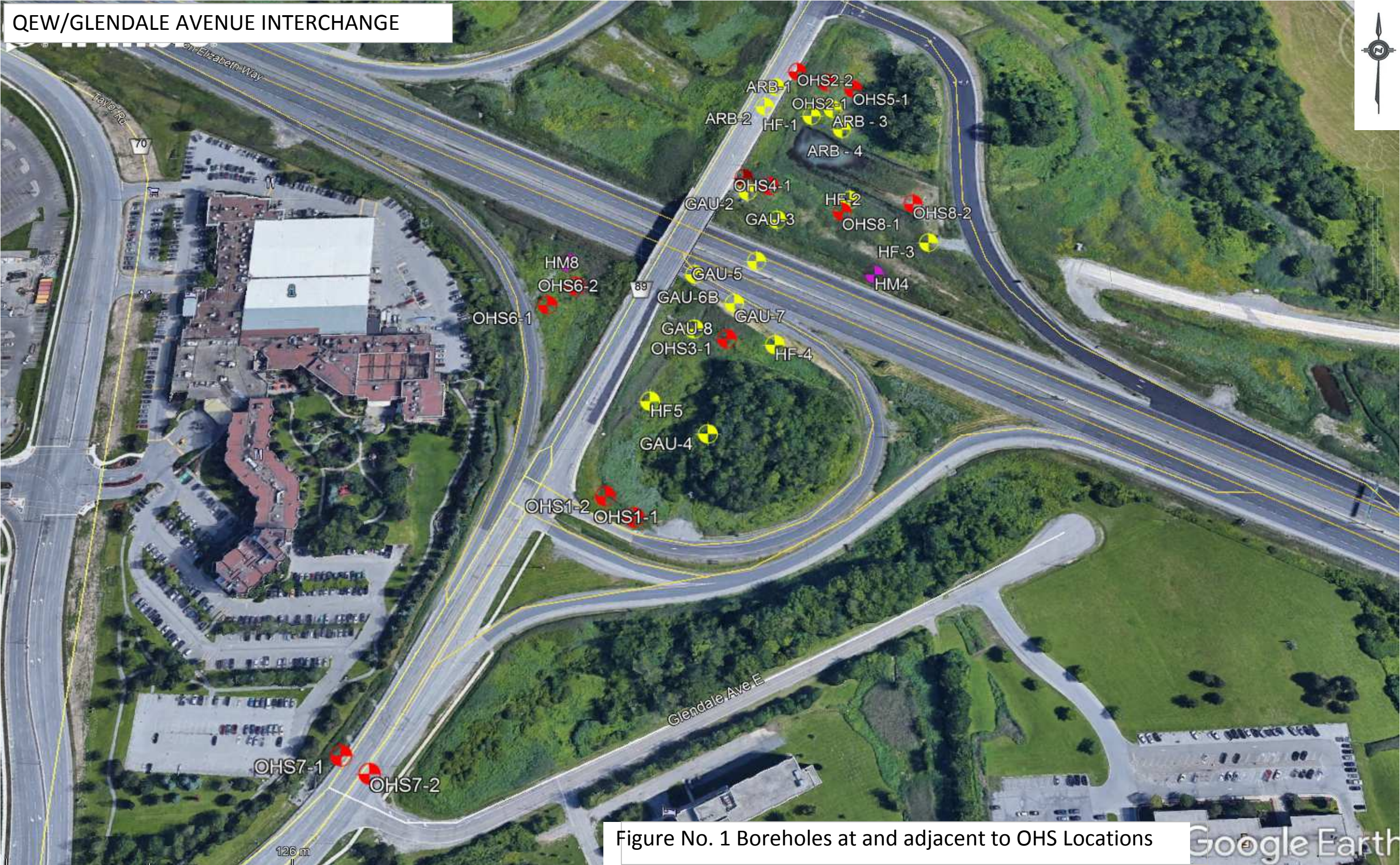
Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

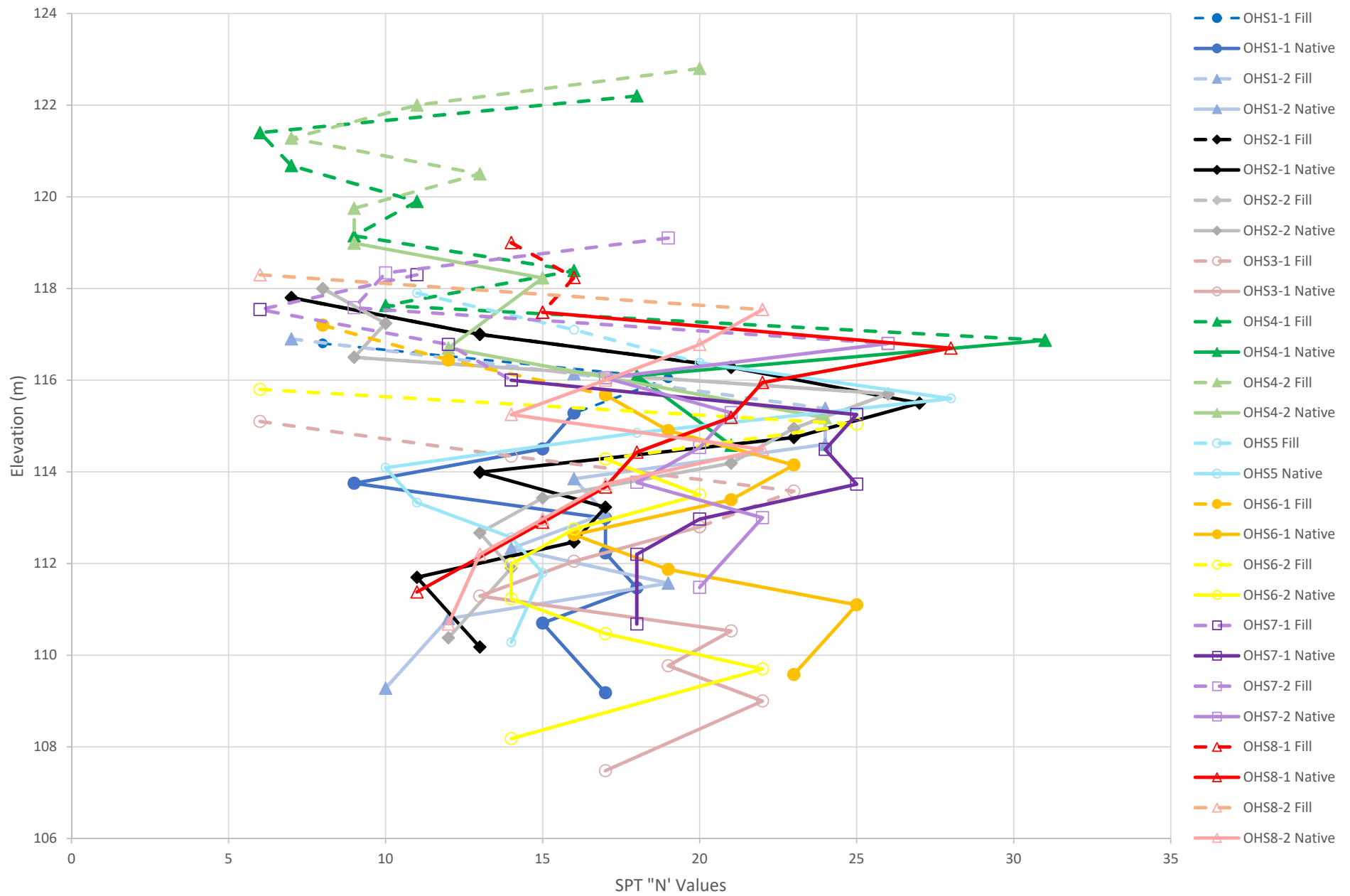
MTO Guidelines for the Design of High Mast Pole Foundations (4th edition, 2004)

MTO Gravity Pipe Design Guideline, (April 2014)

CAC/CSA A23.1-14/A23.2-14 Concrete Materials and Method of Concrete Construction

LIST OF FIGURES





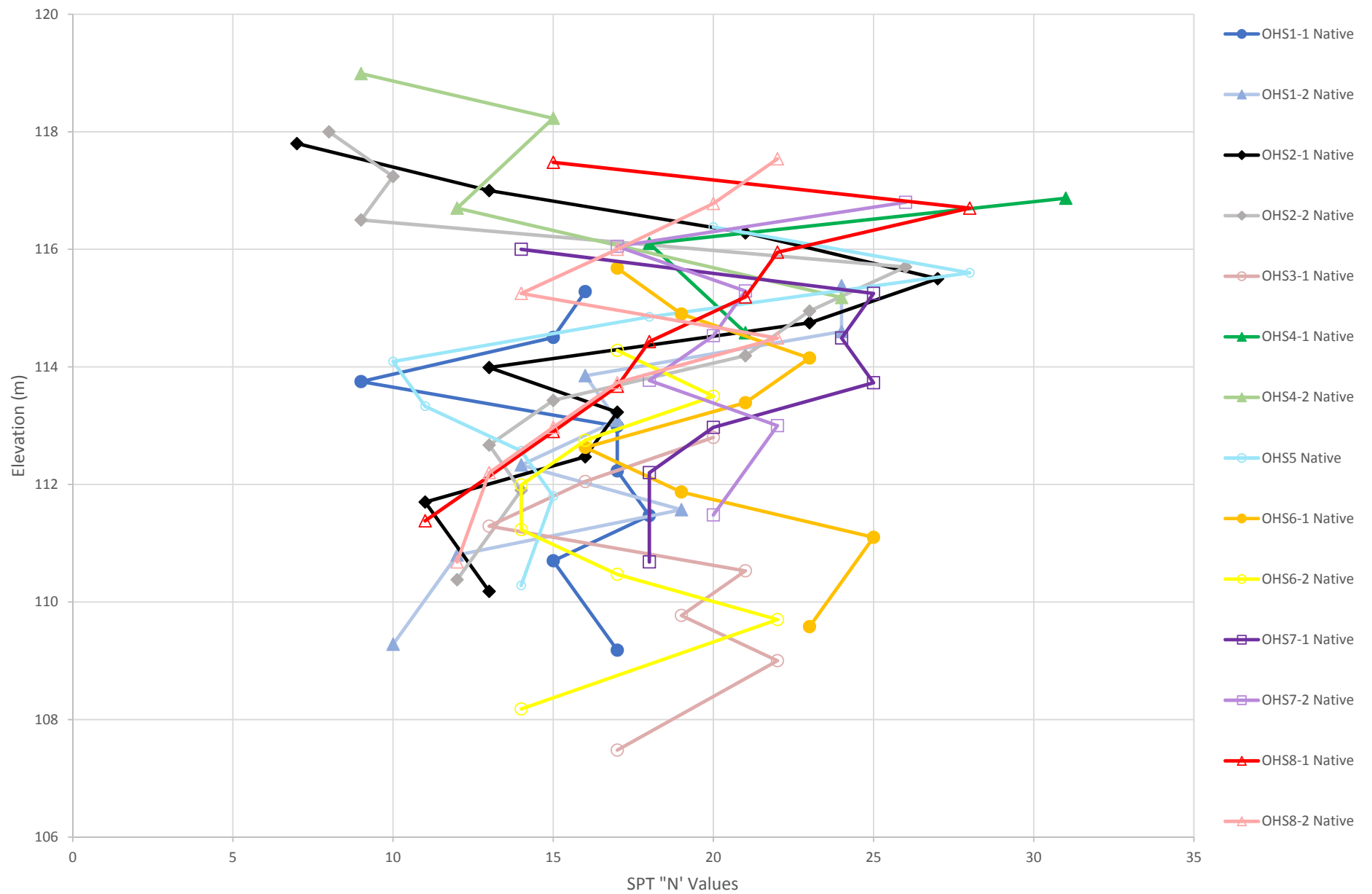
SPT 'N' Value Vs Elevation

OHS

Figure No. 2

Project No. 18M-01021-12

Date : Nov-18-2019



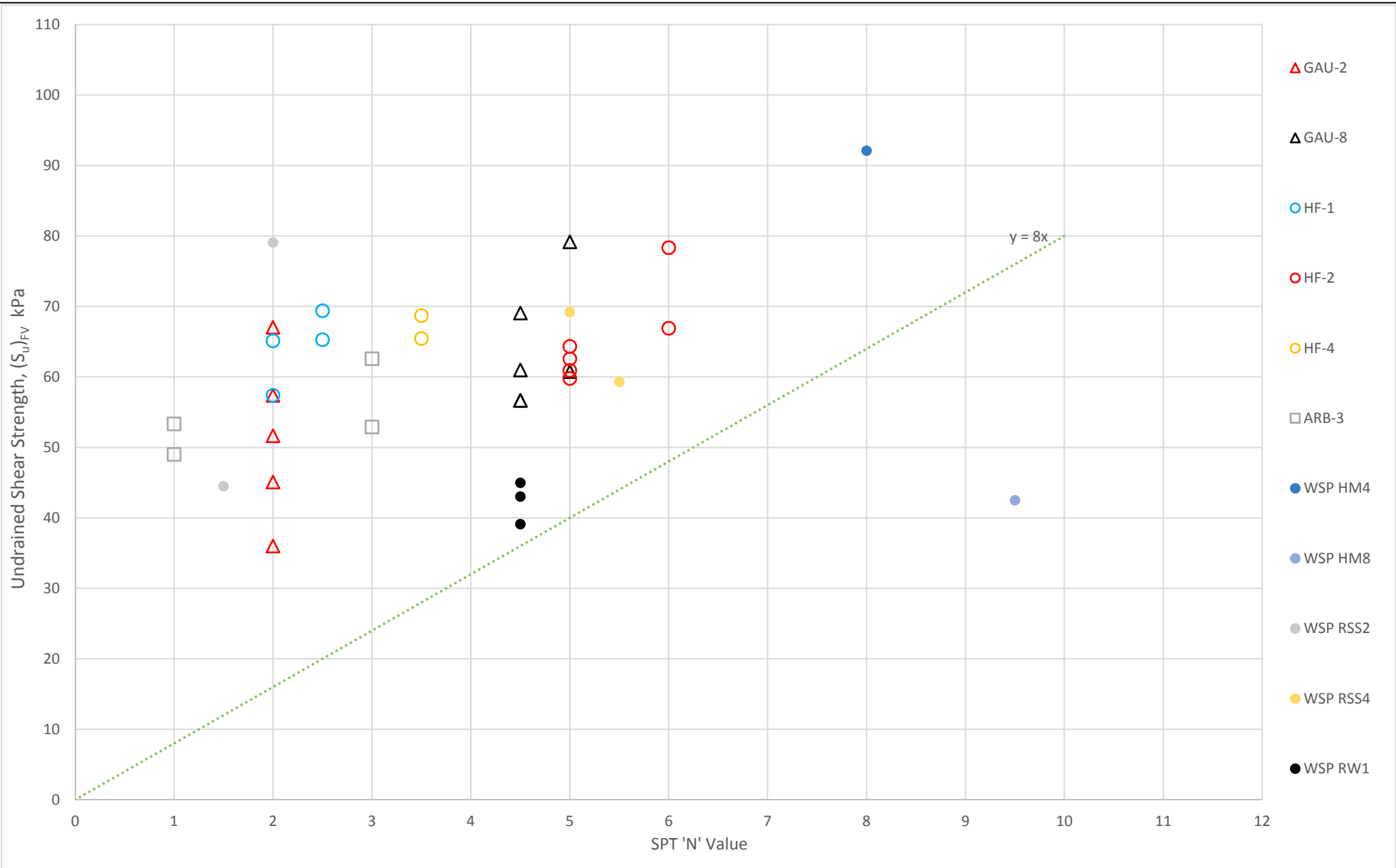
SPT 'N' Value Vs Elevation

OHS Native

Figure No. 3

Project No. 18M-01021-12

Date : Nov-18-2019

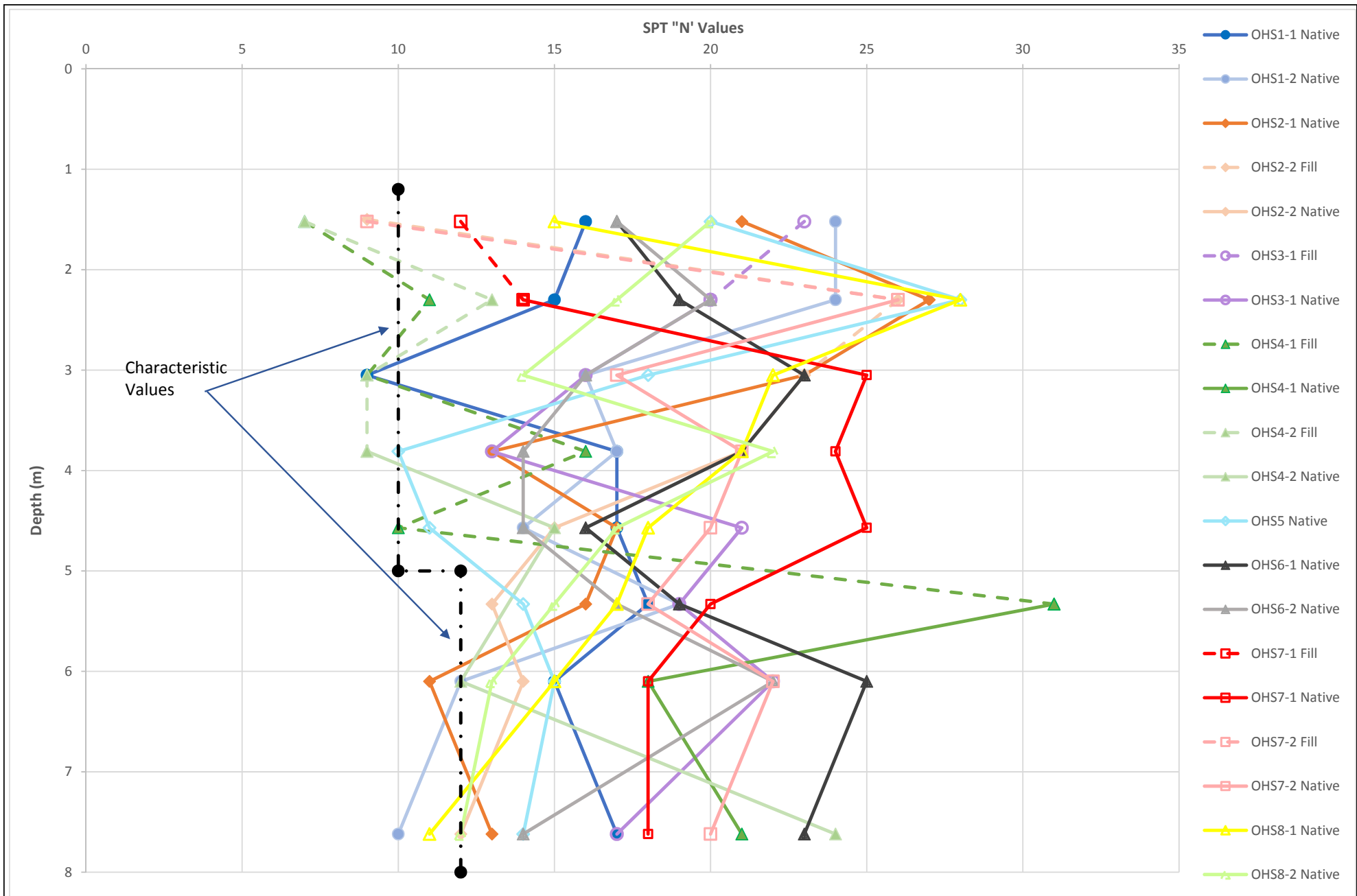


SPT 'N' Value vs. Undrained Shear Strength (kPa)
Native Deposits

Figure No: 4

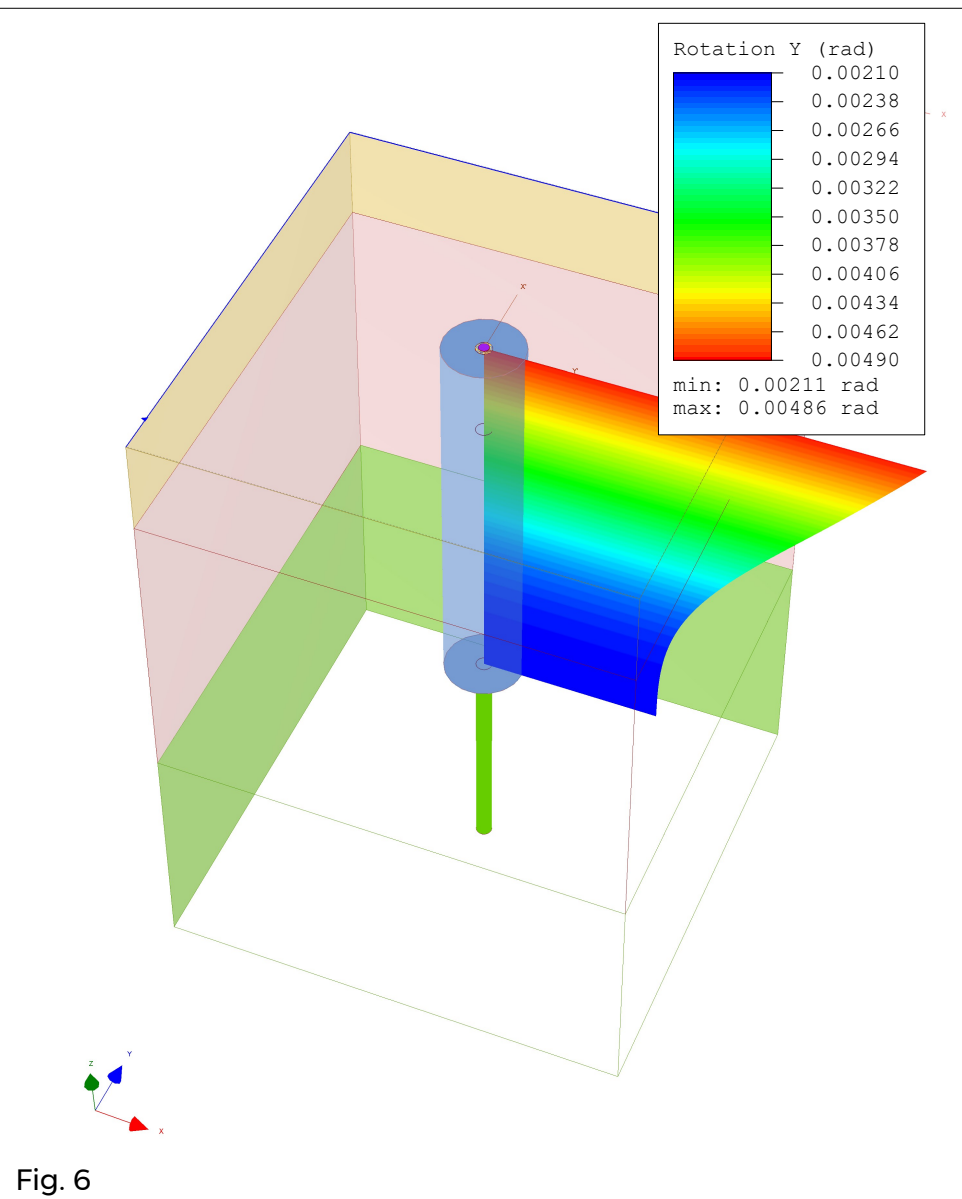
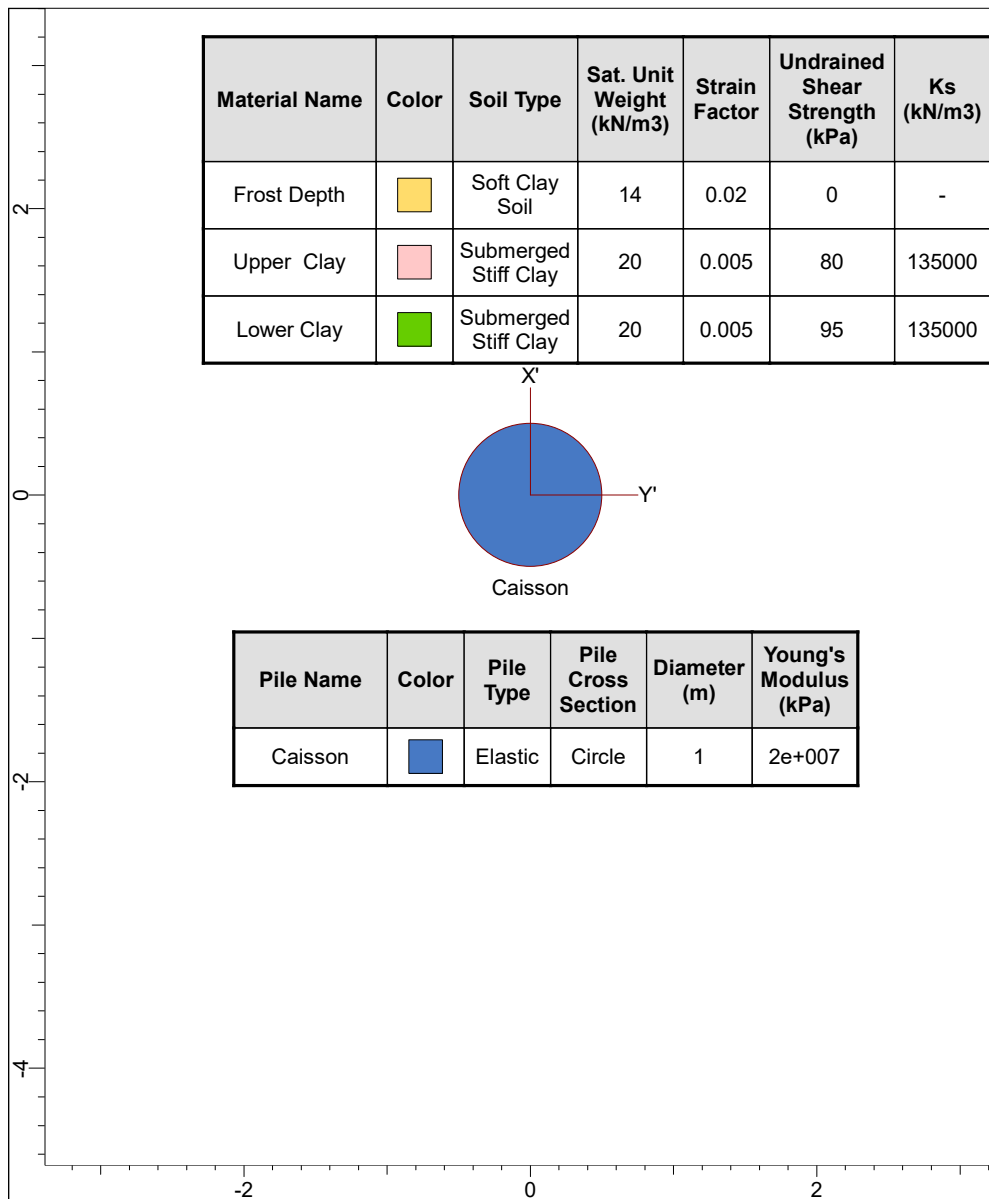
Project No. 18M-01021-12


Date : Nov. 19, 2019



Characteristic SPT 'N' Profile for Indicative Analysis
OHS (Below Frost Depth)

Figure No.	5
Project No.	18M-01021-12
Date :	Dec. 01-2019



	Project	
	Analysis Description	
	Drawn By	Company
	Date	File Name
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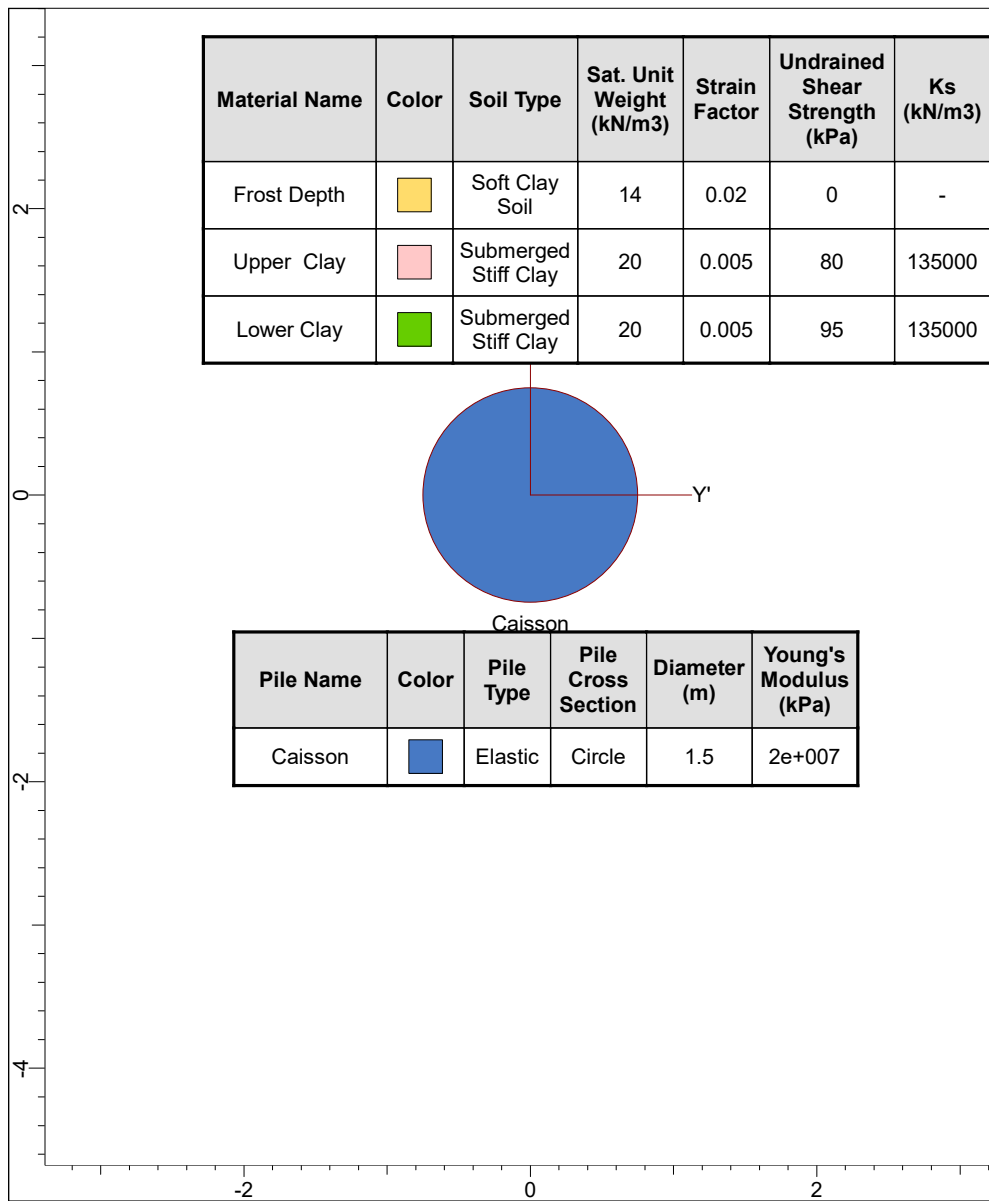
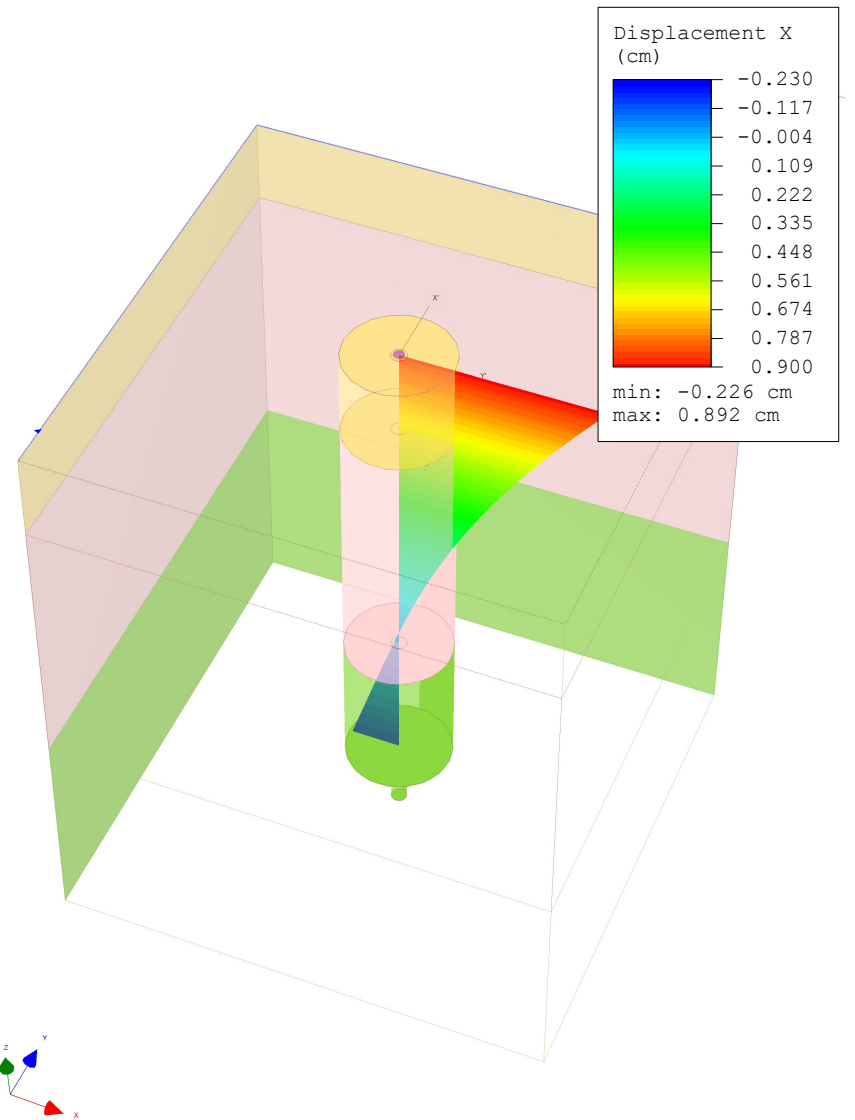


Fig. 7



APPENDIX

E

LIST OF SSPs, OPSS AND OPSD

List of SSPs, OPSSs, and OPSDs referenced in the Report

OPSD	3090.101	FOUNDATION FROST PENETRATION DEPTHS FOR SOUTHERN ONTARIO
OPSD	3190.100	WALLS RETAINING AND ABUTMENT WALL DRAIN
OPSD	3190.101	FOUNDATION FROST PENETRATION DEPTHS FOR SOUTHERN ONTARIO
OPSD	3121.150	WALLS RETAINING, BACKFILL - MINIMUM GRANULAR REQUIREMENT
OPSS.PROV	501	CONSTRUCTION SPECIFICATION FOR COMPACTING
OPSS.PROV	512	CONSTRUCTION SPECIFICATION FOR INSTALLATION OF GABIONS
OPSS.PROV	517	CONSTRUCTION SPECIFICATION FOR DEWATERING OF PIPELINE, UTILITY AND ASSOCIATED STRUCTURE EXCAVATION
OPSS.PROV	539	CONSTRUCTION SPECIFICATION FOR TEMPORARY PROTECTION
OPSS.PROV	902	CONSTRUCTION SPECIFICATION FOR EXCAVATING AND BACKFILLING STRUCTURES
OPSS.PROV	903	CONSTRUCTION SPECIFICATION FOR DEEP FOUNDATIONS
OPSS.PROV	1010	MATERIAL SPECIFICATION FOR AGGREGATES – BASE, SUBBASE, SELECT SUBGRADE AND BACKFILL MATERIAL
OPSS.PROV	1860	MATERIAL SPECIFICATION FOR GEOTEXTILES
SSP	109S12	AMENDMENT TO OPSS 902
SP	517F01	AMENDMENT TO OPSS.PROV 517
SP	109f57	AMENDMENT TO OPSS.PROV 903

APPENDIX



F

LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP Canada Inc. at the time of preparation. Unless otherwise agreed in writing by WSP Canada Inc., it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP Canada Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

