FOUNDATION INVESTIGATION REPORT

Overhead Sign Supports and High Mast Light Poles, QEW Widening from West of Mississauga Road to West of Hurontario Street, City of Mississauga Ministry of Transportation, Ontario, G.W.P. 2002-13-00

Submitted to:

Morrison Hershfield Limited
125 Commerce Valley Drive West, Suite 300
Markham, Ontario
L3T 7W4

Submitted by:

Golder Associates Ltd.
6925 Century Avenue, Suite #100 Mississauga
Ontario, L5N 7K2 Canada
+1 905 567 4444
1662333 - 7

December 13, 2018

GEOCRES No. 30M12-433

Latitude: 43.557930
Longitude: -79.610152

Distribution List

1 PDF & 3 Copies - Ministry Transportation, Ontario (Central Region)

1 PDF & 1 Copy - Ministry Transportation, Ontario (Foundations Section)

1 PDF - Morrison Hershfield Limited

1 PDF - Golder Associates Ltd.

Table of Contents

Appendix B Current Investigation - Record of Borehole and Record of Drillhole Sheets and Bedrock Core Photographs

Appendix C Geotechnical Laboratory Test Results

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Queen Elizabeth Way (QEW) widening from west of Mississauga Road to west of Hurontario Street in the City of Mississauga, in the Regional Municipality of Peel, Ontario, including three bridges; replacement of two culverts; two storm water management ponds; an access road, retaining walls; noise barrier walls; and high mast light pole supports in and overhead sign supports. This report addresses the results of the foundation investigation carried out for the overhead sign (OHS) supports and high mast light poles (HMLP) supports.

The purpose of this investigation is to establish the subsurface soil, bedrock and groundwater conditions at the location of the proposed OHS and HMLP supports / foundations, by borehole drilling, rock coring and geotechnical laboratory testing on selected soil and rock core samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated July 2016, which forms part of the Consultant's Assignment Number (Number 2015-E-0033) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated February 3, 2017.

2.0 SITE DESCRIPTION

The section of the QEW along which of the OHS support and HMLP foundation investigation was carried out extends from west of Mississauga Road at about Station 15+527 to about Credit River bridge. at about Station 17+425 west of Credit River Bridge, in the City of Mississauga. The QEW alignment in the project area is oriented generally in a southwest-northeast direction; for the purposes of this report, the QEW alignment is described as being in an east-west orientation.

The ground (roadway) surface of the QEW along the project area gradually slopes downwards easterly the from about Elevation 101.6 m at the west limit of the project area to Elevation 95.5 m at near the Credit River bridge and then gradually slopes upwards to about Elevation 98.5 m to the east limit of the project area. Land use adjacent to both sides of to the QEW corridor is primarily residential, and a golf course is located immediately to the north of the Mississauga Road interchange. The Credit River flows in the north to south direction beneath the QEW Credit River bridge.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

Golder carried out a foundation investigation in December 1997 in the vicinity of the QEW – Mississauga Road Interchange within the current project limits. At that time, four boreholes (Boreholes 1 to 4) were drilled to depths between 2.9m to 4.6 m below ground surface and the results of the investigation are presented in a report titled:

- "Foundation Investigation, High Mast Lighting, W.P. 167-86-00, Mississauga Road Interchange, Queen Elizabeth Way (QEW)", Report No. 971-8040, dated March 1998, GEOCRES No. 30M12-238.

The approximate location of the Boreholes 1 to 4 are shown on Drawing 1 and the Record of Boreholes 1 to 4 are included in Appendix A. The ground surface elevation at each boreholes advanced during this investigation was not obtained at the time of the investigation; however, the northing and easting coordinates from the previous investigation were interpreted from Drawing 1 (in GEOCRES 30M12-238) and then coordinates were plotted on the digital terrain model provided by MH, to obtain the approximate ground surface elevations based on the current

grades. The borehole locations in MTM NAD 83 (Zone 10) coordinates, ground surface elevations referenced to Geodetic datum and the drilled depths are as follows:

Borehole No.	Location (MTM NAD 83 Zone 10)		Approximate Ground Surface Elevation* (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
1	4,823,501.3 (43.551389)	295,453.6 (-79.615677)	99.7	4.6
2	4,823,416.0 (43.550619)	295,317.2 (-79.617363)	100.3	3.1
3	4,823,369.0 (43.550195)	295,245.5 (-79.618250)	100.8	2.9
4	4,823,418.1 (43.550638)	295,302.7 (-79.617542)	100.5	3.8

* Based on current grades at the borehole locations.

3.2 Current Investigation

Field work for the current foundation investigation was carried out between July 16 and September 6, 2018, during which time a total of seven sampled boreholes (designated as Boreholes OHS-1 to OHS-5 and HMLP-1 to HMLP-2) were advanced at the location of the proposed Overhead Sign and High Mast Lighting Pole foundations. This information was supplemented with Boreholes SWMW-3, MO-08A, M0-08B and NRW7-1 drilled for other immediately adjacent structures associated with the project, such as the storm water management pond, Mississauga Road overpass and noise barrier walls. The location of the boreholes are shown on Drawing 1.

The field borehole investigation was carried out using track-mounted CME 55 and truck-mounted CME 75 drill rigs supplied and operated by Davis Drilling of Milton, Ontario, truck-mounted CME 55 drill rigs, supplied and operated by Aardvark Drilling Inc. of Guelph, Ontario and portable drilling equipment (tripod) supplied and operated by Walker Drilling of Utopia, Ontario. With the exception of Borehole OHS-4, the boreholes were advanced using 150 mm solid-stem augers or 200 mm outside diameter hollow-stem augers through the overburden, and HW-size casing and an HQ core barrel through the bedrock. Borehole OHS-4 was advanced using a portable tripod drill equipped with NW-size casing throughout the overburden and an NQ core barrel through the bedrock.

Soil and bedrock surface samples were obtained at 0.75 m intervals of depth, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer on the drill rigs or cathead/safety hammer on the portable drilling rig (for Borehole OHS-4), performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08)[1].

With the exception of Borehole OHS-3, the boreholes were cored into bedrock, to depths ranging from about 5.6 m to 8.0 m below existing ground surface as detailed below. Samples of the bedrock were obtained using an ‘NQ’ or ‘HQ’-size rock core barrel and coring techniques in the seven boreholes.

[1] ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the soil.

The groundwater conditions and water levels in the open boreholes were observed during and immediately following overburden drilling operations. All boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in-situ testing operations, logged the boreholes and examined the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected soil samples. Unconfined compression (UC) tests (including assessment of Young's modulus, Poisson's ratio, and core density) were carried out on selected specimens of the bedrock core samples by Geomechanica Inc., on behalf of Golder.

The as-drilled borehole locations and the ground surface elevations of Boreholes OHS-4, HMLP-1 and HMLP-2 were obtained using a GPS (Trimble XH 3.5G), having an accuracy of 0.1 m in the vertical and 0.1 m in the horizontal directions. The as-drilled locations of Boreholes OHS-1 to OHS-3 and OHS-5 were referenced to site features and then plotted on the borehole location drawing to obtain the coordinates of the locations; and the ground surface elevations were obtained by plotting the coordinates on the digital terrain model and interpreting the elevation. The locations given on the Record of Borehole/ Drillhole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole No. (Structure Location)	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
OHS-1 (STA 15+529)	4,823,166.2 (43.548372)	295,038.8 (-79.620817)	101.6	7.3 (including 3.7 m of bedrock core)
OHS-2 (STA 15+989)	4,823,411.0 (43.550588)	295,425.9 (-79.616021)	100.6	7.5 (including 3.7 m bedrock core)
OHS-3 (STA 17+425)	4,824,956.0 (43.561460)	296,389.4 (-79.606530)	95.0	7.8
OHS-4 (STA 16+512)	4,823,828.9 (43.554333)	295,734.3 (-79.612205)	97.3	5.6 (including 3.9 m bedrock core)
OHS-5 (STA 16+052)	4,823,467.9 (43.551058)	295,463.2 (-79.615622)	100.5	8.0 (including 3.9 m bedrock core)
HMLP-1 (STA 15+875)	4,823,418.1 (43.550638)	295,302.7 (-79.617543)	100.5	6.5 (including 3.5 m bedrock core)

Borehole No. (Structure Location)	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
HMLP-2 (STA 16+275)	4,823,653.9 (43.552765)	295,615.1 (-79.613680)	98.8	5.8 (including 3.4 m bedrock core)
MO-08A (STA 16+275)	4,823,630.5 (43.552545)	295,614.5 (-79.613684)	98.9	2.2
MO-08B (STA 16+275)	4,823,632.0 (43.552559)	295,615.8 (-79.613668)	98.9	2.1
SWMW-03 (STA 16+052)	4,823,513.7 (43.551490)	295,424.7 (-79.616000)	99.4	6.9 (including 4.5 m of bedrock core)
NRW7-1 (STA 17+425)	4,824,601.6 (43.564250)	296,209.0 (-79.603826)	95.0	11.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The project area is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putman, 1984)[2].

The glacial Iroquois Plain stretches along the northern shoreline of Lake Ontario, extending from the Niagara Escarpment in the west to the Scarborough Bluffs in the east. The Iroquois Plain soils consist of glaciolacustrine sediments deposited in Lake Iroquois, primarily sands, silts and gravels, with a shallow cover of till remaining over the bedrock.

The bedrock of the Georgian Bay Formation that underlies the study area consists mainly of blue-grey shale, containing siltstone, sandstone and limestone interbeds. Outcrops of this formation are commonly found along water courses on the west side of Toronto and in Mississauga, notably in the Humber River, Mimico Creek, Etobicoke Creek and Credit River valleys.

4.2 Subsurface Conditions

The relevant Record of Borehole sheets from the previous investigation (Boreholes 1 to 4) carried out by Golder are presented in Appendix A. As part of the current subsurface investigation, seven boreholes were advanced at the location of the proposed overhead signs and high mast light poles, and the subsurface information of a numbers of these locations is supplemented with addition four boreholes drilled for other structures associated with this project. The detailed subsurface soil, bedrock and groundwater conditions encountered in the eleven boreholes, as well as the summary results of in-situ testing and laboratory testing carried out on selected soil and bedrock core samples are presented on the Records of Borehole and Drillhole sheets provided in Appendix B. The results of the

[2] Chapman, L.J. and Putman, D.F., 1984, The Physiography of Southern Ontario, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

geotechnical laboratory test on soil and bedrock core specimens are presented in Appendix C, respectively. The results of the in-situ field tests (i.e. SPT "N" values) as presented on the Record of Borehole sheets and in sub-sections of Section 4.2.1 are uncorrected.

The stratigraphic boundaries shown on the Record of Borehole/ Drillhole sheets are inferred from observations of drilling progress and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsoil conditions will vary between and beyond the borehole locations.

A detailed description of the subsurface conditions encountered at each of the proposed overhead sign and high mast light pole locations is provided in the following sub-sections.

4.2.1 Overburden Conditions

4.2.1.1 Overhead Sign 1 – Station 15+529

Borehole OHS-1 was advanced on the QEW Toronto bound right lane at the proposed location of Overhead Sign 1 as shown on Drawing 1.

In general, the subsoil conditions encountered in Borehole OHS-1 consist of asphalt, underlain by concrete and fill consisting of gravelly sand and silt and sand, underlain by a till deposit consisting of silty clay, which in turn is further underlain by clayey silt residual soil and shale bedrock. A description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit/Layer Description	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm) Consistency or Compactness	Laboratory Testing Results
Asphalt and Concrete	0.13	101.6	n/a	n/a
Concrete	0.25	101.5	n/a	n/a
Gravelly sand (FILL)	0.5	101.2	N = 24 **Compact**	n/a
Silt and sand (FILL)	0.6	100.7	N = 20 **Compact**	w = 22% 1 – MH (Fig. C-1)
Silty Clay, trace to some gravel, trace to some sand (TILL)	1.3	100.1	N = 12, 35 **Stiff to Hard**	w = 12%, 22% w_l = 36% w_p= 21% I_p = 15% 1 – MH (Fig. C-7) 1 – AL (Fig. C-8)
Clayey Silt, some sand to sandy, some shale fragments (RESIDUAL SOIL)	0.8	98.8	N = 61 **Hard**	w = 15%, 18%
SHALE (BEDROCK)	--	98.0	See Section 4.2.2 for details of bedrock core and laboratory testing results.	

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)

4.2.1.2 High Mast Lighting Pole 1 – Station 15+875

Boreholes 3 and 4 from GEOCRES 30M12-238 were advanced east and west of the proposed location of HMPL-1. During the current investigation, Borehole HMLP-1 was advanced in the grassy area near the proposed location of HMLP-1, as shown on Drawing 1.

In general, the subsoil conditions encountered in Borehole HMLP-1 consist of fill materials comprising sandy clayey silt and silty sand, underlain by a deposit of clayey silt residual soil and shale bedrock. A description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit/Layer Description	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm) Consistency or Compactness	Laboratory Testing Results
Sandy clayey silt, some gravel (FILL)	0.7	100.5	N = 8 **Firm**	n/a
Silty sand, trace to some gravel, trace to some clay (FILL)	0.8	99.8	N = 8 **Loose**	w = 10% 1 – MH (Fig. C-1)
Sandy clayey silt (FILL)	0.7	99.0	N = 3 **Soft**	w = 35%
Clayey Silt, some sand, some gravel, some shale fragments (RESIDUAL SOIL)	0.8	98.3	N = 100/250 mm **Hard**	w = 10% w_l = 32% w_p= 21% I_p = 12% 1 – AL (Fig. C-12)
SHALE (BEDROCK)	--	97.5	See Section 4.2.2 for details on bedrock core and laboratory testing results.	

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)

4.2.1.3 Overhead Sign 2 – Station 16+989

Borehole OHS-2 was advanced on the QEW Toronto bound right shoulder at the proposed location of Overhead Sign 2 as shown on Drawing 1.

In general, the subsoil conditions encountered in Borehole OHS-2 consist of asphalt, underlain by fill comprised of gravelly sand, underlain by a till deposit consisting of clayey silt, and shale bedrock. A description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit/Layer Description	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm) Consistency or Compactness	Laboratory Testing Results
Asphalt	0.10	100.6	n/a	n/a
Gravelly sand, trace to some silt (FILL)	1.4	100.5	N = 25, 19 **Compact**	n/a
Clayey Silt, trace gravel, some sand, some shale fragments (TILL)	2.2	99.1	N = 9, 35, 66 **Stiff to Hard**	w = 9% - 24% w_l = 31% w_p= 17% I_p = 14% 1 – MH (Fig. C-7) 1 – AL (Fig. C-8)
SHALE (BEDROCK)	--	96.9	See Section 4.2.2 for details on bedrock core and laboratory testing results.	

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)

4.2.1.4 Overhead Sign 5 – Station 16+052

Borehole OHS-5 was advanced on the QEW Niagara bound left shoulder – Mississauga Road Off-Ramp at the proposed the location of Overhead Sign 5, and Borehole SWME-3 was advanced about 20 m north of the overhead sign location on the southeast end of the proposed storm water management pond located within the grassy area in Off-Ramp loop, as shown in Drawing 1.

In general, the subsoil conditions encountered Borehole OHS-5 consist of asphalt, underlain by fill comprised of a layer of gravelly sand and a layer of silty clay, underlain by clayey silt residual soil, underlain by shale bedrock. A description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit / Layer Description	Borehole	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm) Consistency or Compactness	Laboratory Testing Results
Asphalt	OHS-5	0.20	100.5	n/a	n/a
Gravelly sand, trace to some silt (FILL)	OHS-5	1.6	100.3	N = 19, 37 **Compact to Dense**	w = 23% 1 – MH (Fig. C-1)
Silty clay, trace sand, trace gravel (FILL)	OHS-5	1.2	98.7	N = 5, 48 **Firm to Hard**	w = 25% w_l = 42% w_p= 20% I_p = 23% 1 – MH (Fig. C-2) 1 – AL (Fig. C-3)
Silty Clay	SWMW-3	0.6	99.3	N = 9 **Stiff**	w = 15% w_l = 45% w_p= 15% I_p = 30% 1 – MH (Fig. C-5) 1 – AL (Fig. C-6)
Sandy Clayey Silt to Clayey Silt, some sand, some shale fragments (RESIDUAL SOIL)	OHS-5 SWMW-3	0.7 1.5	97.5 98.7	N = 18, 55, 100/200 mm **Very Stiff to Hard**	n/a
SHALE (BEDROCK)	OHS-5 SWMW-3	--	96.8 97.2	See Section 4.2.2 for details on bedrock core and laboratory testing results.	

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)

4.2.1.5 High Mast Lighting Pole 2 – Station 16+275

Borehole HMLP-2 was advanced in the grassy area north of the QEW Hamilton bound lanes and east of Mississauga Road, near the proposed location of HMLP 2; and as part of the investigation for the Mississauga Road underpass Boreholes MO-08A and MO-08B were advanced about 15 m south of the proposed HMLP-2, at the location shown on Drawing 2.

In general, the subsoil conditions encountered in Borehole HMLP-2, MO-08A and MO-08B consist of fill materials comprising clayey silt / sandy silt, silty sand, underlain by a deposit of clayey silt residual soil, underlain by shale bedrock. A description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit/Layer Description	Borehole Numbers	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm) Consistency or Compactness	Laboratory Testing Results
Sandy silt to silty sand topsoil (FILL)	HMLP-2 MO-08A MO-08B	0.5	98.9- 98.8	N = 10-19 **Compact**	w = 10%, 11%, 14%, 15%, 16%, 19% 1 – MH (Fig. C-1) 1-AL (NP)
Clayey Silt, trace sand, trace gravel, some rootlets (FILL)	MO-08B	0.5	98.8	N = 9 **Stiff**	w = 14%
Clayey Silt	MO-08A MO-08B	0.9 0.4	97.7 97.5	N = 20, 35, 100/0.25 **Very Stiff to Hard**	w = 11%, 14%, 15%, 20% w = 11% w_l = 33% w_p= 20% I_p = 13% 1 – MH (Fig. C-5) 1 – AL (Fig. C-6)
Clayey Silt, some sand, some shale fragments (RESIDUAL SOIL)	HMLP-2	1.3	97.8	N = 31, 50/0.08 **Hard**	w = 9%, 11% w_l = 33% w_p= 21% I_p = 12% 1 – MH (Fig C-11) 1 – AL (Fig. C-12)
SHALE (BEDROCK)	HMLP-2 MO-08A MO-08B	--	96.5 96.8 97.1	See Section 4.2.2 for details on bedrock core and laboratory testing results.	

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)
NP = Non-plastic

4.2.1.6 Overhead Sign 4 – Station 16+512

Borehole OHS-4 was advanced on the grassy area north of the QEW Niagara bound lanes near the proposed location of Overhead Sign 4, as shown on Drawing 2.

In general, the subsoil conditions encountered in Borehole OHS-4 consists of topsoil, underlain by fill consisting of gravel some sand, underlain by clayey silt residual soil and shale bedrock. A description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit/Layer Description	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm)	Laboratory Testing Results
			Consistency or Compactness	
Topsoil	0.3	97.3	64 **Hard**	n/a
Gravel, some sand, some silt (FILL)	0.4	97.0	n/a	n/a
Clayey Silt, some sand, trace gravel, some shale fragments (RESIDUAL SOIL)	1.0	96.6	N = 47, 100/0.10 **Hard**	w = 16% w_l = 39% w_p= 21% I_p = 18% 1 – MH (Fig. C-11) 1 – AL (Fig. C-12)
SHALE (BEDROCK)	--	95.6	See Section 4.2.2 for details on bedrock core and laboratory testing results.	

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)

4.2.1.7 Overhead Sign 3 – Station 17+425

Borehole OHS-3 was advanced on the QEW Toronto bound left lane at the proposed location of Overhead Sign 3; and Borehole NRW7-1 was advanced on the QEW Toronto bound right lane for a proposed retaining wall, as shown on Drawing 3.

In general, the subsoil conditions encountered in Borehole OHS-3 and silty sand NRW7-1 consist of asphalt, underlain by concrete, underlain by fill comprised of interlayers of silt / sandy silt / silt and sand / gravelly sand underlain by deposits of sandy silt to sand and silt, gravelly silt and sand till, and sandy clayey silt residual soil. A

description of the soil deposits depths/elevation, results of SPT testing carried out in the boreholes and the geotechnical laboratory test results are provided below.

Deposit/Layer Description	Borehole Numbers	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows/300 mm) Consistency or Compactness	Laboratory Testing Results
Asphalt	OHS-3 NRW7-1	0.13 0.20	95.0 95.0	n/a	n/a
Concrete	OHS-3 NRW7-1	0.23 0.20	94.9 94.8	n/a	n/a
Gravelly sand (FILL)	OHS-3 NRW7-1	0.5	94.6 94.6	N = 31, 32 **Dense**	n/a
Silt, Sandy Silt, Silt and Sand, Silty Sand to Sand (FILL)	OHS-3 NRW7-1	2.1 4.1	94.1 94.1	N = 1 to 27 **Very Loose to Compact**	w = 13% - 29% org = 4.5% 3 – MH (Fig. C-1)
Sandy Silt to Sand and Silt	OHS-3	2.6	92.0	N = 7 to 37 **Loose to Dense**	w = 13% - 29% 2 – MH (Fig. C-4)
Sandy Clayey Silt, trace to some gravel (TILL)	NRW7-1	2.7	92.0	N = 5, 12 **Firm to Stiff**	oc = 4.5% w = 12% w_l = 22% w_p= 14% I_p = 8% 1 – MH (Fig. C-7) 1 – AL (Fig. C-8)
Gravelly Silt and Sand, trace to some clay, to Silt and Sand, some gravel (TILL)	OHS-3 NRW7-1	1.6 3.0	89.4 87.8	N = 48, 50/0.06, 50/0.05 **Dense to Very Dense**	w = 9% w_l = 17% w_p= 14% I_p = 3% 2 – MH (Fig. C-9) 2 – AL (Fig. C-10)
Sand, some cobble fragments	NRW7-1	1.1	84.8	N = 60 **Very Dense**	W = 6%
Sandy Clayey Silt, some gravel, some cobble and shale fragments (RESIDUAL SOIL)	OHS-3	0.6	87.8	N = 50/0.17 **Hard**	n/a

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
w = natural moisture content (%)
oc = organic content (%)
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
w_p = plastic limit (%)
w_l = liquid limit (%)
I_p = plasticity index (%)

4.2.2 Bedrock / Refusal Conditions

Bedrock was cored in Boreholes OHS-1, OHS-2, OHS-4, OHS-5, HMLP-1 and HMLP-2 and SWMW-03. Split-spoon refusal was encountered in Borehole OHS-3, which was terminated within the sandy clayey silt residual soils deposit. The depths and elevations of the bedrock surface (cored or inferred from split-spoon refusal) at of each borehole locations are presented below.

Borehole Number	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
OHS-1	3.6	98.0	Bedrock cored 3.7 m
HMLP-1	3.0	97.5	0.1 m spilt-spoon penetration plus bedrock cored 3.4 m
OHS-2	3.7	96.9	0.1 m spilt-spoon penetration plus bedrock cored 3.7 m
OHS-5	3.7	96.8	0.1 m spilt-spoon penetration plus bedrock cored 3.9 m
HMLP-2	2.3	96.5	0.2 m spilt-spoon penetration plus bedrock cored 3.5 m
OHS-4	1.7	95.6	Bedrock cored 3.9 m
OHS-3	7.8	87.2	Inferred from refusal to split-spoon advancement

Based on a review of the bedrock core samples, the bedrock consists of shale of the Georgian Bay Formation. In general, the bedrock core samples are described as fresh to moderately weathered, thinly to thickly bedded, fine grained, faintly porous to non-porous, weak, grey shale with limestone interbeds at varying intervals and ranging in thickness from about 10 mm to 170 mm, as presented in the Record of Drillhole sheets in Appendix B, and shown on the photographs of the recovered core samples on Figures B-1 to B-7, in Appendix B.

The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W3), and the strength classification of the intact rock mass based on field identification (i.e. weak – R2) are described in accordance with the International Society for Rock Mechanics (ISRM[3]) standard classification system. More detailed descriptions of the bedrock cores are presented on the Record of Drillhole sheets in Appendix B, including data regarding the discontinuity frequency and type. The bedrock properties, as encountered in the cored boreholes, are summarized

[3] International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

below.

Borehole Number	Total Core Recovery (TCR)	Solid Core Recovery (SCR)	Rock Quality Designation (RQD) [4]	Field Estimation of Rock Hardness[4]	Laboratory Testing Results
OHS-1	97% – 100%	72% - 100%	72% – 100%	R2	1 – UC (Appendix C): UCS (shale) = 13.0 MPa ɣ (shale) = 2.59 g/cm^3
			Fair to Excellent	**Weak**	
HMLP-1	100%	50% – 79%	65% – 100%	R2	1 – UC (Appendix C): UCS (shale) = 11.8 MPa E (shale) = 0.50 GPa ɣ (shale) = 2.57 g/cm^3
			Fair to Excellent	**Weak**	
OHS-2	87% – 100%	69% – 93%	67% – 90%	R2	1 – UC (Appendix C): UCS (shale / limestone layers) = 23.4 MPa ɣ (shale) = 2.45 g/cm^3
			Fair to Good	**Weak**	
OHS-5	100%	65% – 97%	65% – 97%	R2	1 – UC (Appendix C): UCS (shale) = 16.7 MPa ɣ (shale) = 2.60 g/cm^3
			Fair to Excellent	**Weak**	
SWMW-03	100%	94% - 100%	**67% - 100%**	R3	N/A
			Fair to Excellent	**Medium Strong to Strong**	
HMLP-2	94% – 100%	78% – 87%	62% – 79%	R2	1 – UC (Appendix C): UCS (shale) = 13.7 MPa E (shale) = 0.88 GPa ɣ (shale) = 2.59 g/cm^3
			Fair to Good	**Weak**	
OHS-4	43% – 100%	0% – 79%	0% – 89%	R2	N/A
			Very Poor to Good	**Weak**	

Where:
UC = unconfined compression test
UCS = uniaxial compressive strength
E = Tangent Young's modulus
ɣ = bulk density

4.2.3 Groundwater Conditions

The overburden samples obtained from the boreholes were generally moist. Upon completion of drilling Borehole NRW7-1 and OHS-3 the water level was measured at a depth of 8.5 m and 3.6 m below ground surface (Elevation 86.5 m and Elevation 91.4 m), respectively. The remaining boreholes advanced for the overhead sign structures and high mast light poles or adjacent nearby boreholes advanced for other structures were observed to be dry upon completion of drilling; however, these observations are not necessarily representative of the stabilized groundwater level at the site.

[4] International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

Standpipe piezometers were installed in selected boreholes advanced throughout the site for other structures to allow for measurements of the groundwater levels at these locations of the site. Details of the piezometer installations and measured groundwater levels are presented in other reports prepared for this project. The groundwater levels recorded are summarized below. The groundwater levels on the west side of the Credit River range from about 2.4 m to 3.3 m below ground surface (between Elevation 99.9 m and 93.0 m). East of the Credit River the groundwater levels range from a depth of about 4.9 m (Elevation 86.8 m) near the proposed east abutment to 2.8 m below ground surface (Elevation 95.4 m) near the east limit of the project.

Borehole Number	Station (m)*	Stratum Sealed Into	Depth to Water Level (m)	Water Level Elevation (m)	Date
NW1-3	15+425	Shale Bedrock	2.6	99.8	August 14, 2018
			2.5	99.9	November 6, 2018
SWMW-04	15+950	Shale Bedrock	2.4	97.4	November 14, 2017
			2.4	97.4	November 21, 2017
			2.4	97.4	November 28, 2017
NW5-1	16+350	Shale Bedrock	3.3	93.8	August 14, 2018
			3.1	94.0	November 6, 2018
CRB-2	16+670	Fill/Clayey Silt Till	2.6	93.0	March 12, 2018
			2.6	93.0	April 30, 2018
CRB-6	16+925	Shale Bedrock	5.6	86.0	November 12, 2017
			5.0	86.7	March 12, 2018
			4.9	86.8	April 30, 2018
PED-03A	17+075	Sand and silt to silty sand (FILL)	4.3	89.8	November 14, 2017
			4.4	89.7	November 21, 2017
			4.4	89.7	November 28, 2017
NRW3-2	17+325	Sandy Clayey Silt Till	4.0	92.1	August 14, 2018
			4.0	92.1	November 6, 2018
NRW3-9	17+645	Shale Bedrock	2.8	95.4	August 14, 2018
			2.8	95.4	November 6, 2018

* Referenced to QEW mainline stationing.

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events and should be expected to be higher during wet periods of the year. Also during and following precipitation events perched groundwater conditions should be expected.

5.0 CLOSURE

This report was prepared by Ms. Mo'oud Nasr, P.Eng., a Geotechnical Engineer with Golder. Ms. Sandra McGaghran, M.Eng., P.Eng., a Geotechnical Engineer and Associate with Golder reviewed the report. Mr. Jorge Costa, P.Eng., MTO Foundations Designated Contact for Golder and Senior Consultant, conducted a quality control audit of the report.

Golder Associates Ltd.

Mo'oud Nasr, P.Eng.
Geotechnical Engineer

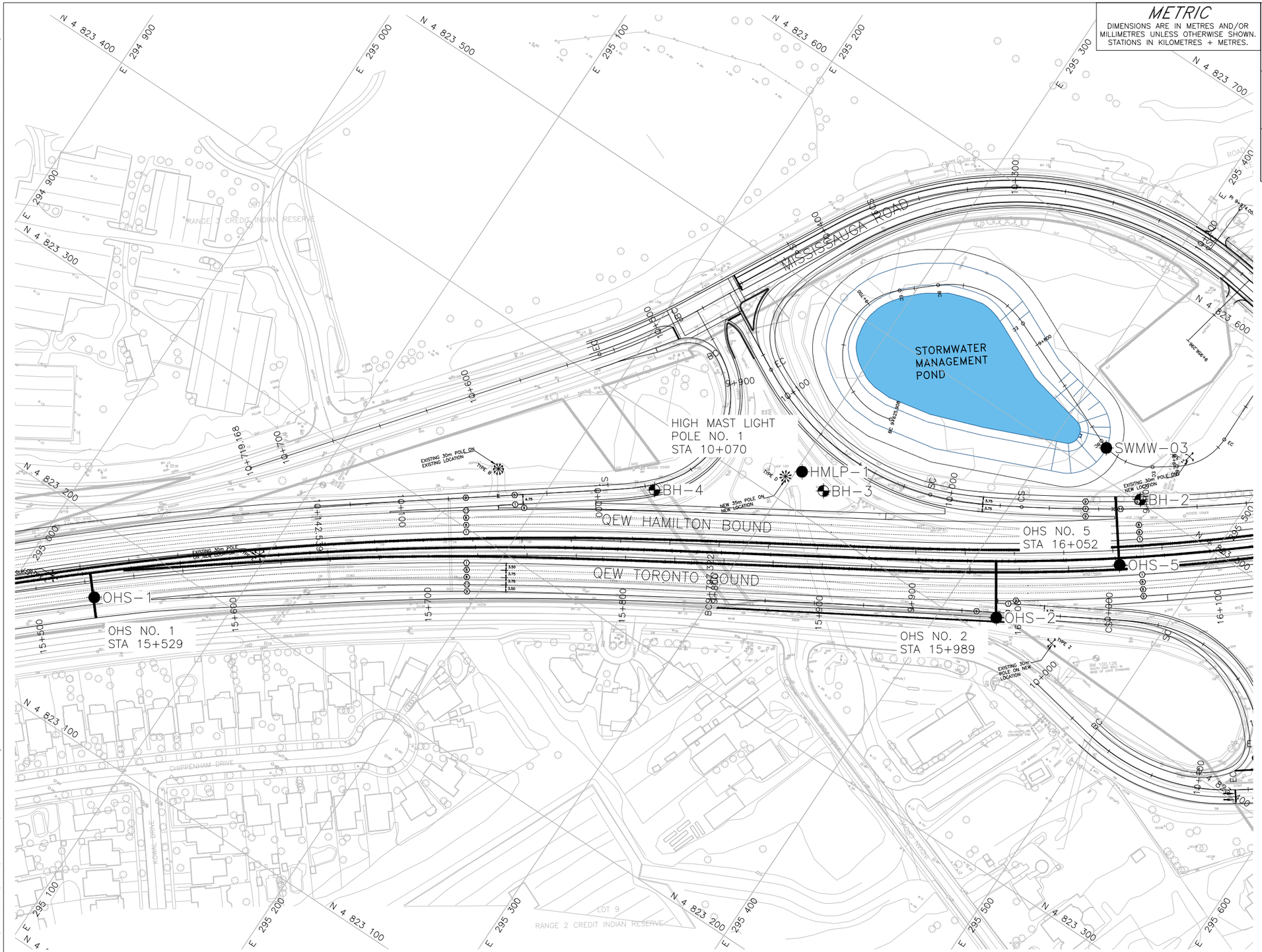
Sandra McGaghran, M.Eng., P.Eng.
Senior Geotechnical Engineer, Associate

Jorge M.A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

MN/SMM/JMAC/rb

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO



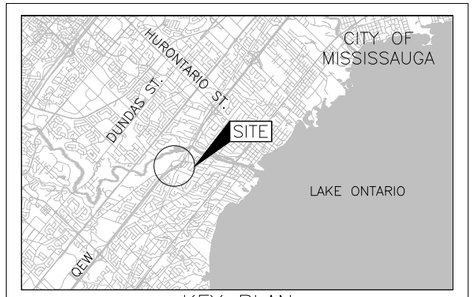
PLAN
SCALE
20 0 20 40 m

CONT No.
GWP No. 2002-13-00

QEW WIDENING MISSISSAUGA RD TO HURONTARIO ST
OVERHEAD SIGN SUPPORTS AND
HIGH MAST LIGHT POLES
BOREHOLE LOCATIONS

SHEET

GOLDER



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Borehole – GEOCRES No, 30M12-238

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
BH-2	99.7 *	4823501.3*	295453.6*
BH-3	100.3*	4823416.0*	295317.2*
BH-4	100.8*	4823369.0*	295245.5*
HMLP-1	100.5	4823418.1	295302.7
OHS-1	101.6	4823166.2	295038.8
OHS-2	100.6	4823411.0	295425.9
OHS-5	100.5	4823467.9	295463.2
SWMW-03	99.4	4823513.7	295424.7

* Obtained from Digital Terrain Model by plotting previous investigation borehole relative to stations given on Borehole Records.

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file no. X11609340Base.dwg, received April 12, 2018.
Design plan provided in digital format by Morrison Hershfield, drawing file no. QEW Credit River DP OHS HML.dwg, received March 9, 2018.
Alignment plan provided in digital format by Morrison Hershfield, drawing file no. X1160934_Align.dwg, received November 19, 2018.

LICENSED PROFESSIONAL ENGINEER
J.M.A.COSTA
Dec. 13, 2018
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. McGaghran
Dec. 13, 2018
PROVINCE OF ONTARIO

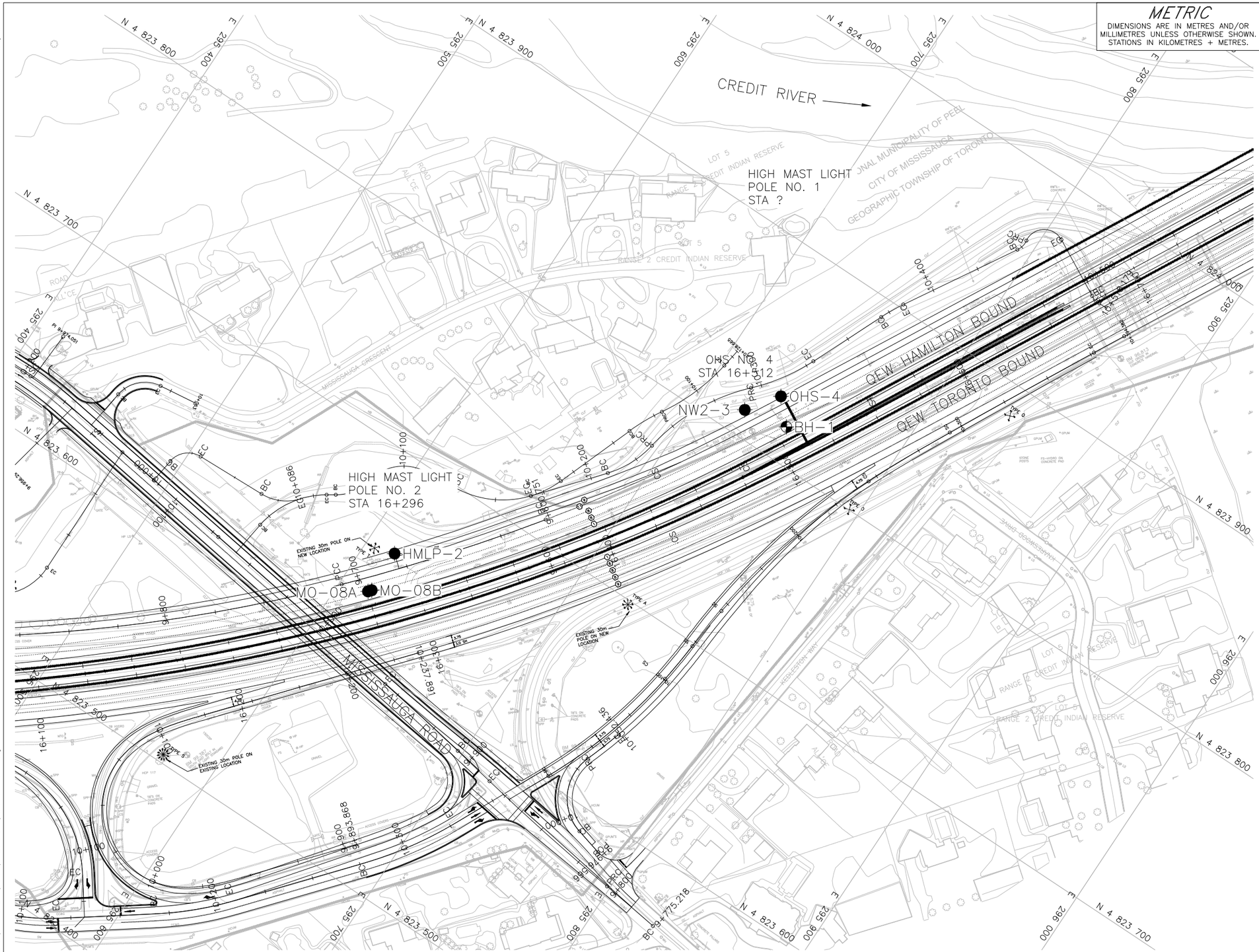
NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 30M12-433

HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. CL/AM	CHKD. DM	DATE: 12/13/2018	SITE: .
DRAWN: DD	CHKD. SMM	APPD. JMAC	DWG. 1

PLOT DATE: December 14, 2018
FILENAME: S:\Clients\MTO\QEW-CreekL_River\DP_PROJ\1662333_MM_PMP\40_PROD\016_OHS_&_HML\1662333-0016-BE-0001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
20 0 20 40 m

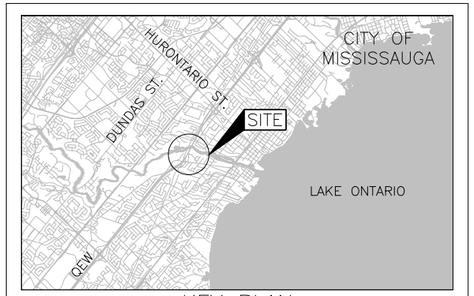
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2002-13-00

QEW WIDENING MISSISSAUGA RD TO HURONTARIO ST
OVERHEAD SIGN SUPPORTS AND HIGH MAST LIGHT POLES
BOREHOLE LOCATIONS

SHEET

GOLDER



KEY PLAN
SCALE
2 0 2 4 km

LEGEND
- Borehole – Current Investigation
- Borehole – GEOCRES No, 30M12-238

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
BH-1	97.4 *	4823817.5	295745.2
HMLP-2	98.8	4823653.9	295615.1
MO-08A	98.9	4823630.5	295614.5
MO-08B	98.9	4823632.0	295615.8
NW2-3	97.8	4823813.0	295722.8
OHS-4	97.3	4823828.9	295734.3

* Obtained from Digital Terrain Model by plotting previous investigation borehole relative to stations given on Borehole Records.

NOTES
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

REFERENCE
Base plans provided in digital format by Morrison Hershfield, drawing file no. X11609340Base.dwg, received April 12, 2018.
Design plan provided in digital format by Morrison Hershfield, drawing file no. QEW Credit River DP OHS HML.dwg, received March 9, 2018.
Alignment plan provided in digital format by Morrison Hershfield, drawing file no. X1160934_Align.dwg, received November 19, 2018.

LICENSED PROFESSIONAL ENGINEER J.M.A. COSTA Dec. 13, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Dec. 13, 2018 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 30M12-433

HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. CL/AM	CHKD. DM	DATE: 11/20/2018	SITE: .
DRAWN: DD	CHKD. SMM	APPD. JMAC	DWG. 2

PLOT DATE: December 14, 2018
FILENAME: S:\Clients\MTO\QEW-Credit_River\09_PROJ\1662333_MH_P&P\40_PROD\0016_OHS_&_HML\1662333-0016-BD-0002.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

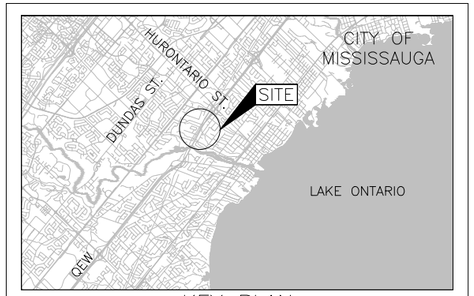
CONT No.
GWP No. 2002-13-00

QEW WIDENING MISSISSAUGA RD TO HURONTARIO ST
OVERHEAD SIGN SUPPORTS AND
HIGH MAST LIGHT POLES
BOREHOLE LOCATIONS

SHEET

GOLDER

PLAN
SCALE
20 0 20 40 m



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

● Borehole – Current Investigation

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
NRW7-1	95.0	4824601.8	296209.0
OHS-3	95.0	4824620.8	296190.9

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file no. X11609340Base.dwg, received April 12, 2018.
Design plan provided in digital format by Morrison Hershfield, drawing file no. QEW Credit River DP OHS HML.dwg, received March 9, 2018.
Alignment plan provided in digital format by Morrison Hershfield, drawing file no. X1160934_Align.dwg, received November 19, 2018.

LICENSED PROFESSIONAL ENGINEER
C.M.A.COSTA
Dec. 13, 2018
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. McGaghran
Dec. 13, 2018
PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 30M12-433

HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. CL/AM	CHKD. DM	DATE: 12/13/2018	SITE: .
DRAWN: DD	CHKD. SMM	APPD. JMAC	DWG. 3

PLOT DATE: December 14, 2018
FILENAME: S:\Clients\MTO\QEW-Credit_River\09_PROJ\1662333_MH_PMP\40_PROD\0016_OHS_&_HML\1662333-0016-BS-0003.dwg

APPENDIX A

Data from Previous Investigation (GEOCRES NO. 30M12-238)

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):
An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_S)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:
1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π = 3.1416
ln x, natural logarithm of x
$\log_{10}$ x or log x, logarithm of x to base 10
g acceleration due to gravity
t time
F factor of safety
V volume
W weight

II. STRESS AND STRAIN

γ shear strain
Δ change in, e.g. in stress: $\Delta \sigma$
ε linear strain
ε_v volumetric strain
η coefficient of viscosity
ν Poisson's ratio
σ total stress
σ' effective stress ($\sigma' = \sigma - u$)
σ'_{vo} initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$ principal stresses (major, intermediate, minor)
σ_{oct} mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ shear stress
u porewater pressure
E modulus of deformation
G shear modulus of deformation
K bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$ bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$ dry density (dry unit weight)
$\rho_w(\gamma_w)$ density (unit weight) of water
$\rho_s(\gamma_s)$ density (unit weight) of solid particles
γ' unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R relative density (specific gravity)of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e void ratio
n porosity
S degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

(a) Index Properties (con't.)

w water content
w_l liquid limit
w_p plastic limit
I_P plasticity Index = $(w_l - w_p)$
w_S shrinkage limit
I_L liquidity index = $(w - w_p) / I_p$
I_C consistency index = $(w_l - w) / I_p$
e_{max} void ratio in loosest state
e_{min} void ratio in densest state
I_D density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h hydraulic head or potential
q rate of flow
v velocity of flow
i hydraulic gradient
k hydraulic conductivity (coefficient of permeability)
j seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c compression index (normally consolidated range)
C_r recompression index (overconsolidated range)
C_S swelling index
C_α coefficient of secondary consolidation
m_v coefficient of volume change
c_v coefficient of consolidation
T_v time factor (vertical direction)
U degree of consolidation
σ'_p pre-consolidation pressure
OCR Overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

(e) Shear Strength

τ_p, τ_r peak and residual shear strength
ϕ' effective angle of internal friction
δ angle of interface friction
μ coefficient of friction = tan δ
c' effective cohesion
c_u, s_u undrained shear strength ($\phi = 0$ analysis)
p mean total stress $(\sigma_1 + \sigma_3)/2$
p' mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q $(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u compressive strength $(\sigma_1 - \sigma_3)$
S_t sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$
2. Shear strength = (Compressive strength)/2

W.P. 167-86-00
DIST.
LOCATION: Sta. 16+780/28m Rt

RECORD OF BOREHOLE 1

BORING DATE: DEC. 19/97

SHEET 1 OF 1
DATUM:
PROJECT: 981-8040

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER DRILL RIG	GROUND SURFACE						SHEAR STRENGTH Cu, kPa: nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp — W — Wl		
		Topsoil		0.00							
		Clayey Silt, trace sand and gravel Stiff to very stiff Grey (Glacial Till)		0.30	1	50 DO	11				
1											
2					2	50 DO	26				
				2.13	3	50 DO	50/.03				
3		Shale with limestone and dolomite interbeds Weathered to fresh Grey									
4											
		END OF BOREHOLE		4.57							Open hole dry on completion of drilling.
5											
6											
7											
8											
9											
10											

N6040001.BHS

DATA INPUT: PS MAR 12/98

SOILM6

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: JY
CHECKED: ASP

W.P. 167-86-00
DIST.
LOCATION: Sta. 17+200/35m Rt

RECORD OF BOREHOLE 2

BORING DATE: DEC.19/97

SHEET 1 OF 1
DATUM:
PROJECT: 981-8040

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER DRILL RIG	GROUND SURFACE									
		Topsoil		0.00							
		Clayey Silt, some sand Very stiff Brown to grey (Fill)		0.25							
1		Clayey Silt, trace sand and gravel Very stiff to hard Grey (Glacial Till)		0.91	1	50 DO	21				
2					2	50 DO	71				
		Shale with limestone and dolomite interbeds Weathered to fresh Grey		2.13		50 DO	50/.05				
3		END OF BOREHOLE Refusal to further auger penetration		3.05							Open hole dry on completion of drilling.
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: JY
CHECKED: ASP

N8040002.BHS
DATA INPUT: PS MAR.12/98
SOILM6

W.P. 167-86-00
DIST.
LOCATION: Sta. 17+365/35m Rt

RECORD OF BOREHOLE 3

BORING DATE: DEC.16/97

SHEET 1 OF 1
DATUM:
PROJECT: 981-8040

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT Wp W Wl	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER DRILL RIG	GROUND SURFACE									
		Topsoil		0.00							
		Clayey Silt, trace sand and gravel Hard Grey (Glacial Till)		0.25	1	50 DO	50				
1											
					2	50 DO	87				
2											
		Shale with limestone interbeds Weathered Grey		2.13	3	50 DO	60/.08				
3		END OF BOREHOLE Refusal to further auger penetration		2.90							Open hole dry on completion of drilling.
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: JY
CHECKED: ASP

N8040003.BHS
DATA INPUT: PS MAR.12/98
SOILM6

W.P. 167-86-00

DIST.

LOCATION: Sta. 17+450/30m Rt

RECORD OF BOREHOLE 4

BORING DATE: DEC.19/97

SHEET 1 OF 1

DATUM:

PROJECT: 981-8040

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	POWER AUGER DRILL RIG	GROUND SURFACE						SHEAR STRENGTH Cu, kPa: nat V - + Q - ● ; rem V - ⊕ U - ○	WATER CONTENT, PERCENT: Wp — W — Wl		
		Gravelly Sand Brown (Fill)		0.00	1	AS					
1				0.61	2	50 DO	20				
2		Silty Clay, trace sand and organics (wood fragments) Firm to very stiff Grey to brown (Fill)			3	50 DO	21				
3					4	50 DO	7				
					5	50 DO	8				
		Shale Weathered Grey		3.66		50 DO	50				
4		END OF BOREHOLE Refusal to further auger penetration		3.83							Open hole dry on completion of drilling.
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: JY

CHECKED: ASP

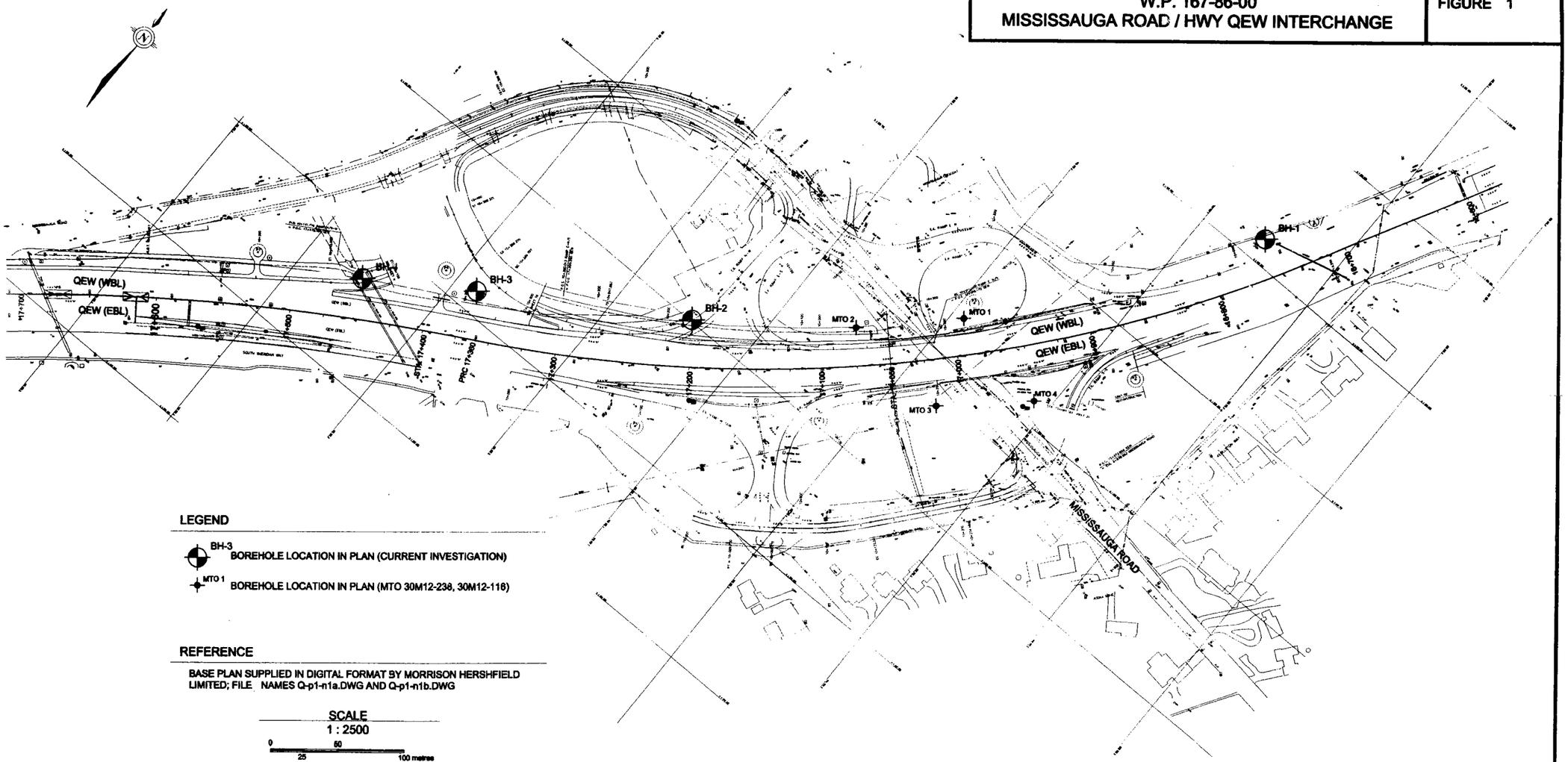
N8040004.BHS

DATA INPUT: PS MAR.12/98

SOILM6

BOREHOLE LOCATION PLAN
W.P. 167-86-00
MISSISSAUGA ROAD / HWY QEW INTERCHANGE

FIGURE 1



LEGEND

BH-3 BOREHOLE LOCATION IN PLAN (CURRENT INVESTIGATION)

MTO 1 BOREHOLE LOCATION IN PLAN (MTO 30M12-238, 30M12-118)

REFERENCE

BASE PLAN SUPPLIED IN DIGITAL FORMAT BY MORRISON HERSHFIELD LIMITED; FILE NAMES Q-p1-n1a.DWG AND Q-p1-n1b.DWG

SCALE
1 : 2500
0 50
25 100 metres

M8040001

Date FEBRUARY, 1998
Project 971-8040

Golder Associates

Drawn TDR
Chkd ASP

APPENDIX B

Current Investigation - Borehole and Drillhole Records and Bedrock Core Photographs

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

GOLDER

RECORD OF BOREHOLE No OHS-1

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823166.2; E 295038.8 MTM NAD 83 ZONE 10 (LAT. 43.548372; LONG. -79.620817)
BOREHOLE TYPE CME 75, 152 mm O.D. Solid Stem Augers
DATE July 16, 2018

ORIGINATED BY CC
COMPILED BY SK
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.6	GROUND SURFACE										
0.0	ASPHALT (130 mm)										
	CONCRETE (250 mm)										
0.4	Gravelly sand (FILL) Compact Brown Moist		1	SS	24		101				
100.7											
0.9	Silt and sand (FILL) Compact Brown to grey below 1.2 m Moist to wet		2	SS	20				○		0 58 39 3
100.1											
1.5	SILTY CLAY, trace to some gravel, trace to some sand, trace rootlets from 1.5 m to 2.1 m (TILL) Stiff to hard Grey Moist		3	SS	12		100		○		
			4	SS	35		99		○ ——		6 7 60 27
98.8											
2.8	CLAYEY SILT, some sand to sandy, some shale fragments (RESIDUAL SOIL) Hard Brown Wet		5A 5B	SS	61		98		○ ○		
98.0											
3.6	SHALE (BEDROCK) Grey		1	RC	REC 100%						RQD = 72%
	Bedrock cored from a depth of 3.6 m to 7.3 m For bedrock coring details, refer to Record of Drillhole OHS-1		2	RC	REC 97%		97 96				RQD = 86%
			3	RC	REC 100%		95				RQD = 100%
94.3											
7.3	END OF BOREHOLE										

NOTES:

1. Borehole dry prior to rock coring.

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1662333

RECORD OF DRILLHOLE: OHS-1

SHEET 1 OF 1

LOCATION: N 4823166.2 ;E 295038.8

DRILLING DATE: July 16, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Davis Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Borehole OHS-1		97.95															
4	HQ Core	Moderately to slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		3.61	1							BD,PL,SM PC, He	1	3					
												BD,PL,SM SA	1	2					
5					2							BD,PL,SM CC	1	4					UCS = 13.0 MPa
												BD,UN,SM SA	2	2					
6												BD,PL,SM SA	1	2					
7				94.30	3							BD,CU,SM IN, Cl	2	10				R1	
		END OF DRILLHOLE		7.26															
8																			
9																			
10																			
11																			
12																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: CC

CHECKED: SK

GTA-RCK 054 S:\CLIENTS\MTO\CEW-CREDIT_RIVER\02_DATA\GINT\CEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 12/14/18

GOLDER

RECORD OF BOREHOLE No OHS-2

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823411.0; E 295425.9 MTM NAD 83 ZONE 10 (LAT. 43.550588; LONG. -79.616021)
BOREHOLE TYPE CME 55, 210 mm O.D., Hollow Stem Augers
DATE July 16, 2018

ORIGINATED BY AM
COMPILED BY SK
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.6	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.1	Gravelly sand, trace to some silt (FILL) Compact Brown Moist		1	SS	25		100				
			2	SS	19						
99.1							99				
1.5	CLAYEY SILT, trace gravel, some sand, some shale fragments (TILL) Stiff to hard Grey to brown Moist		3	SS	9						3 15 47 35
			4	SS	35		98				
			5A 5B	SS	66						
96.9							97				
3.7	SHALE (BEDROCK) Grey Bedrock cored from a depth of 3.8 m to 7.5 m For bedrock coring details, refer to Record of Drillhole OHS-2		6	SS	100/0.08						
			1	RC	REC 87%		96				RQD = 69%
			2	RC	REC 96%		95				RQD = 89%
			3	RC	REC 100%		94				RQD = 93%
93.1											
7.5	END OF BOREHOLE NOTES: 1. Borehole dry prior to rock coring.										

$+^3, \times^3$: Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1662333

RECORD OF DRILLHOLE: OHS-2

SHEET 1 OF 1

LOCATION: N 4823411.0 ;E 295425.9

DRILLING DATE: July 16, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Aardvark Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Borehole OHS-2		96.80															
4	HQ Core	Slightly weathered to fresh, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		3.81	1							BD,UN,SM IN, Cl	2	10					
5					2							BD,UN,SM PC, Cl	2	3					UCS = 23.4 MPa
6												BD,IR,SM SA	2	2					
7				93.14	3														
		END OF DRILLHOLE		7.47															
8																			
9																			
10																			
11																			
12																			

FEATURES LEGEND

BROKEN CORE; CLAY SEAM; LIMESTONE; LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AM

CHECKED: SK

GOLDER

RECORD OF BOREHOLE No OHS-3

SHEET 1 OF 1

METRIC

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4824620.8; E 296190.9 MTM NAD 83 ZONE 10 (LAT. 43.561475; LONG. -79.606570) ORIGINATED BY CC

DIST Central HWY QEW BOREHOLE TYPE CME 75, 152 mm O.D., Solid Stem Augers COMPILED BY SK

DATUM Geodetic DATE July 17, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.0	GROUND SURFACE										
0.0	ASPHALT (130 mm)										
	CONCRETE (230 mm)										
0.4	Gravelly sand (FILL) Dense Brown Moist		1	SS	31						
94.1							94				
0.9	Silt and sand, trace clay (FILL) Very loose to compact Brown Moist to wet below 1.9 m		2	SS	26				○		0 62 35 3
			3	SS	3		93		○		
			4	SS	11				○		
92.0							92				
3.0	Sandy SILT to SAND and SILT, trace to some clay Loose to dense Grey Wet		5	SS	7	▽			○		0 47 49 4
			6	SS	25		91		○		
			7	SS	37		90		○		0 23 69 8
89.4											
5.6	Gravelly SILT and SAND, trace to some clay (TILL) Dense Grey Moist		8	SS	48		89		○ H		27 31 35 7
87.8							88				
7.2	Sandy CLAYEY SILT, some gravel, trace cobbles and shale fragments (RESIDUAL SOIL) Hard Grey Moist		9	SS	50/0.17						
87.2											
7.8	END OF BOREHOLE SPLIT-SPOON REFUSAL										

NOTES:

1. Water level in open borehole at a depth of 3.6 m below ground surface (Elev. 91.4 m) upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-GTA.GDT 12/14/18

GOLDER

RECORD OF BOREHOLE No OHS-4

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
LOCATION N 4823828.9; E 295734.3 MTM NAD 83 ZONE 10 (LAT. 43.554333; LONG. -79.612205)
ORIGINATED BY AM
DIST Central HWY QEW
BOREHOLE TYPE Portable Tripod
COMPILED BY DH
DATUM Geodetic
DATE September 6, 2018
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.3	GROUND SURFACE										
0.0 / 97.0	TOPSOIL (300mm)		1	SS	64		97				
96.6	Gravel, some sand, some silt (FILL)										
0.7	Hard Brown Moist		2	SS	47						
	SILTY CLAY, some sand, trace gravel, some shale fragments (RESIDUAL SOIL)		3	SS	100/0.10		96		○		5 14 49 32
95.6 / 1.7	Brown, oxidation staining Hard Moist		1	RC	REC 100%						RQD = 0%
	SHALE (BEDROCK) Grey		2	RC	REC 43%		95				RQD = 0%
	Bedrock cored from a depth of 1.7 m to 5.6 m		3	RC	REC 53%						RQD = 0%
	For bedrock coring details, refer to Record of Drillhole OHS-4		4	RC	REC 82%		94				RQD = 35%
			5	RC	REC 92%		93				RQD = 89%
91.7							92				
5.6	END OF BOREHOLE										

NOTES:

1. Borehole dry prior to rock coring.

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

$\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 1662333

RECORD OF DRILLHOLE: OHS-4

SHEET 1 OF 1

LOCATION: N 4823828.9 ;E 295734.3

DRILLING DATE: September 6, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Tripod

DRILLING CONTRACTOR: Walker Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE		95.60															
2	NQ Core	Slightly weathered to fresh, thinly bedded, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with limestone interbeds.		1.73	1							CO,PL,SM CC CL JN,UN,RO Sa HE CO,UN,SM CC CL			R4 R3 R2 R1	W1 W2 W3 W4 W5 W6			
3					2							BD,PL,SM Sa HE BD,UN,SM SO							
4					3							BD,PL,SM SO CO,UN,SM CC BD,UN,SM SO BD,UN,RO SO							
5					4							BD,ST,SM SO JN,PL,RO Sa HE							
					5							UN,UN,RO Sa HE							
				91.77															
		END OF DRILLHOLE		5.56															
6																			
7																			
8																			
9																			
10																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AM

CHECKED: AB

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 12/14/18

GOLDER

RECORD OF BOREHOLE No OHS-5

SHEET 1 OF 1

METRIC

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4823467.9; E 295463.2 MTM NAD 83 ZONE 10 (LAT. 43.551058; LONG. -79.615622) ORIGINATED BY CC/AM

DIST Central HWY QEW BOREHOLE TYPE CME 75, 152 mm O.D., Solid Stem Augers COMPILED BY SK

DATUM Geodetic DATE July 9, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.5	GROUND SURFACE										
0.0	ASPHALT (200 mm)										
0.2	Silty sand, trace to some silt (FILL) Compact to dense Brown Moist		1	SS	37		100				
			2A 2B	SS	19				w = 20		0 53 (47)
98.7							99				
1.8	Silty clay, trace sand, trace gravel (FILL) Firm to hard Grey Moist - Cobble fragments encountered between depths of about 2.6 m and 2.9 m		3A 3B	SS	5						
			4A 4B	SS	48		98		w = 20, w_L = 42		2 11 45 42
97.5											
3.0	CLAYEY SILT, some sand, trace shale fragments (RESIDUAL SOIL) Hard Brown Moist		5	SS	100/0.20						
96.8							97				
3.7	SHALE (BEDROCK) Grey Bedrock cored from a depth of 4.1 m to 8.0 m For bedrock coring details, refer to Record of Drillhole OHS-5		6	SS	50/0.10						
			1	RC	REC 100%		96				RQD = 65%
			2	RC	REC 100%		95				RQD = 87%
			3	RC	REC 93%		94				RQD = 91%
92.5							93				
8.0	END OF BOREHOLE NOTE: 1. Borehole dry prior to rock coring.										

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

PROJECT: 1662333

RECORD OF DRILLHOLE: OHS-5

SHEET 1 OF 1

LOCATION: N 4823467.9 ;E 295463.2

DRILLING DATE: July 9, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Davis Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Borehole OHS-5		96.43															
5	HQ casing	Slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		4.06	1							BD,PL,SM CL BD,PL,SM CL BD,PL,SM SA BD,PL,SM SA BD,PL,SM SA BD,UN,SM SA BD,UN,SM SA	1 1 1 1 1 2 2	1 1 2 2 2 2 2					
6	HQ Core				2							BD,UN,SM SA	2	2					UCS = 16.7 MPa
7					3							BD,PL,SM SA BD,UN,SM SO BD,UN,SM PC, CI	1 2 2	1 1 3					
8				92.49															
		END OF DRILLHOLE		8.00															

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: CC/AM

CHECKED: SK

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 12/14/18

GOLDER

PROJECT 1662333

RECORD OF BOREHOLE No HMLP-1

SHEET 1 OF 1

METRIC

G.W.P. 2002-13-00 LOCATION N 4823418.1; E 295302.7 MTM NAD 83 ZONE 10 (LAT. 43.550638; LONG. -79.617543) ORIGINATED BY AM

DIST Central HWY QEW BOREHOLE TYPE CME 55, 210 mm O.D., Hollow Stem Augers COMPILED BY SK

DATUM Geodetic DATE August 8, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.5	GROUND SURFACE										
0.0	Sandy clayey silt, some gravel (FILL) Firm		1	SS	8						
99.8	Brown						100				
0.7	Moist										
	Silty sand, trace to some gravel, trace to some clay, trace rootlets (FILL)		2	SS	8				○		8 62 22 8
99.0	Loose						99				
1.5	Brown Wet		3	SS	3				○		
98.3	Sandy clayey silt (FILL)										
2.2	Soft Dark brown Moist		4	SS	100/0.25		98		○ —		
97.5	CLAYEY SILT, some sand, some gravel, some shale fragments, oxidation staining (RESIDUAL SOIL)		5	SS	50/0.10						
3.0	Hard Grey Dry		1	RC	REC 100%						RQD = 65%
	SHALE (BEDROCK) Grey		2	RC	REC 100%		97				RQD = 89%
	Bedrock cored from a depth of 3.1 m to 6.5 m						96				
	For bedrock coring details, refer to Record of Drillhole HMLP-1		3	RC	REC 100%		95				RQD = 100%
94.0							94				
6.5	END OF BOREHOLE										
	NOTE: 1. Borehole open and dry prior to coring.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-GTA.GDT 12/14/18

PROJECT: 1662333

RECORD OF DRILLHOLE: HMLP-1

SHEET 1 OF 1

LOCATION: N 4823418.1 ;E 295302.7

DRILLING DATE: August 8, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Davis Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole HMLP-1		97.43															
4	HQ Core	Moderately to slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		3.05	1													R1	
												BD,UN,SM SA, He	2	2					
												BD,UN,RO SA, He	3	2				R1	
					2							BD,UN,SM SA	2	2				R1	
5																		R1	UCS = 11.8 MPa
												BD,IR,SM SA	2	2					
					3							BD,IR,RO SA	3	2					
6				93.95															
		END OF DRILLHOLE		6.53															
7																			
8																			
9																			
10																			
11																			
12																			

FEATURES LEGEND

BROKEN CORE; CLAY SEAM; LIMESTONE; LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AM

CHECKED: SK

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 12/14/18

GOLDER

RECORD OF BOREHOLE No HMLP-2

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
LOCATION N 4823653.9; E 295615.1 MTM NAD 83 ZONE 10 (LAT. 43.552765; LONG. -79.613680)
ORIGINATED BY AM
DIST Central HWY QEW
BOREHOLE TYPE CME 75, 210 mm O.D., Hollow Stem Augers
COMPILED BY SK
DATUM Geodetic
DATE August 7, 2018
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
98.8	GROUND SURFACE										
0.0 / 98.3	Sandy silt (FILL) Compact Light brown Wet		1A 1B	SS	11						
0.5 / 97.8	Silty sand (FILL) Compact Light brown Moist		2A 2B 2C	SS	31		98				4 41 44 11
1.0 / 96.5	CLAYEY SILT with sand, trace gravel, some shale fragments, oxidation staining (RESIDUAL SOIL) Hard		3A 3B	SS	50/0.08		97				
2.3	Grey - brown Dry		4	SS	100/0.23						
	SHALE (BEDROCK) Grey Bedrock cored from a depth of 2.3 m to 5.8 m For bedrock coring details, refer to Record of Drillhole HMLP-2		1	RC	REC 100%		96				RQD = 95%
			2	RC	REC 100%		95				RQD = 87%
							94				
93.0			3	RC	REC 100%						RQD = 81%
5.8	END OF BOREHOLE NOTE: 1. Borehole dry prior to rock coring.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-GTA.GDT 12/14/18

PROJECT: 1662333

RECORD OF DRILLHOLE: HMLP-2

SHEET 1 OF 1

LOCATION: N 4823653.9 ;E 295615.1

DRILLING DATE: August 7, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Davis Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX R4	ROCK STRENGTH INDEX R3	ROCK STRENGTH INDEX R2	ROCK STRENGTH INDEX R1	WEATHERING INDEX W1	WEATHERING INDEX W2	WEATHERING INDEX W3	WEATHERING INDEX W4	WEATHERING INDEX W5	WEATHERING INDEX W6	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole HMLP-2		96.53																							
		Broken core from 2.29 m to 2.53 m as result of split spoon sampling		2.29 96.29																							
		Slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		2.53	1							BD,CU,RO CL	3	1													
3																											
	HQ Core				2							BD,PL,SM PC, CI	1	3													UCS = 13.7 MPa
4																											
												BD,UN,RO CC, CI	3	4												R1	
																										R1	
												BD,UN,SM CC, CI	2	4												R1	
5																										R1	
					3							BD,PL,SM CC, CI	1	4												R1	
												BD,PL,SM CC, CI	1	4												R1	
												BD,PL,RO SA	1.5	2												R1	
				93.05																						R1	
		END OF DRILLHOLE		5.77																							
6																											
7																											
8																											
9																											
10																											
11																											

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AM

CHECKED: SK

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 12/14/18

GOLDER

RECORD OF BOREHOLE No MO-08A

SHEET 1 OF 1

METRIC

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4823630.5; E 295614.5 MTM NAD 83 ZONE 10 (LAT. 43.552545; LONG. -79.613684) ORIGINATED BY JL

DIST Central HWY QEW BOREHOLE TYPE 64 mm O.D. 51 mm I.D. Split Spoon Sampler COMPILED BY DM

DATUM Geodetic DATE December 21, 2017 CHECKED BY GDS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
98.9	GROUND SURFACE										
0.0	TOPSOIL (180 mm)		1A								
0.2	Silty sand, trace gravel, some organics (FILL) Compact Brown Moist to wet		1B	SS	10				○		
97.7			2	SS	19		98		○		
1.2	CLAYEY SILT, trace to some sand, trace to some gravel Very stiff to hard Grey to brown Moist		3A 3B	SS	20				○		
96.8	SHALE (BEDROCK) Grey		4A 4B	SS	100/0.25		97		○ —		9 20 56 15
2.2	END OF BOREHOLE										

NOTE:

1. Borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No MO-08B

SHEET 1 OF 1 **METRIC**

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4823632.0; E 295615.8 MTM NAD 83 ZONE 10 (LAT. 43.552559; LONG. -79.613668) ORIGINATED BY JL

DIST Central HWY QEW BOREHOLE TYPE 64 mm O.D. 51 mm I.D. Split Spoon Sampler COMPILED BY DM

DATUM Geodetic DATE December 21, 2017 CHECKED BY GDS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
98.9	GROUND SURFACE										
0.0	TOPSOIL (100 mm)										
0.1	Clayey silt, trace sand, trace gravel, some rootlets (FILL)		1	SS	9				○		
98.3	Stiff										
0.6	Brown to black		2	SS	11		98		○		
	Moist										
	Silty sand, trace to some clay, trace gravel, some rootlets (FILL)		3A						○		NP 0 70 22 8
97.5	Compact		3B	SS	35				○		
1.4	Brown										
97.1	Moist to wet		4	SS	100/0.13		97				
96.8	CLAYEY SILT										
2.1	Hard										
	Brown to grey										
	Moist										
	SHALE (BEDROCK)										
	Grey										
	END OF BOREHOLE										

NOTE:

1. Borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 \\GOLDER.GDS\GAL\MISSISSAUGA\SIM\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-GTA.GDT 5/7/18

GOLDER

RECORD OF BOREHOLE No SWMW-03 SHEET 1 OF 1 METRIC

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823513.7; E 295424.7 MTM NAD 83 ZONE 10 (LAT. 43.551490; LONG. -79.616000)
BOREHOLE TYPE CME 55, 152 mm O.D., Solid Stem Augers (Auto Hammer)
DATE August 14, 2017

ORIGINATED BY FC
COMPILED BY KN
CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.4	GROUND SURFACE										
0.0	TOPSOIL (80mm)										
0.1	SILTY CLAY, some sand, trace gravel, trace rootlets		1	SS	9		99		○ 45		1 14 51 34
98.7	Stiff										
0.7	Brown Moist Sandy CLAYEY SILT, contains shale fragments (RESIDUAL SOIL) Very stiff to hard Brown		2	SS	18		98		○		
			3	SS	55				○		
97.2	Moist										
2.2	SHALE (BEDROCK) Grey		4	SS	100/0.08		97				
			1	RC	REC 100%						RQD = 67%
			2	RC	REC 100%		96				RQD = 92%
	Bedrock cored from depths of 2.4 m to 6.9 m For bedrock coring details refer to Record of Drillhole SWMW-03						95				
			3	RC	REC 100%		94				RQD = 93%
			4	RC	REC 100%		93				RQD = 100%
92.5											
6.9	END OF BOREHOLE NOTES: 1. Borehole dry prior to rock coring.										

$+^3, \times^3$: Numbers refer to Sensitivity
$\circ^{3\%}$ STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-GTA.GDT 12/14/18

PROJECT: 1662333

RECORD OF DRILLHOLE: SWMW-03

SHEET 1 OF 1

LOCATION: N 4823513.7 ;E 295424.7

DRILLING DATE: August 14, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Aardvark Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATH-ERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Borehole SWMW-03		97.07															
3	HQ Core	Slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		2.36	1							BD,UN,SM SA BD,UN,SM SA BD,PL,RO SA BD,UN,RO SA BD,PL,SM CL	2 2 1.5 3 1	2 2 2 2 1	R4 R3 R2 R1	W1 W2 W3 W4 W5 W6			
4					2							CO,UN,SM SA BD,UN,RO PC, CI BD,UN,RO SA BD,UN,SM PC, CI CO,UN,SM SA CO,UN,SM IN, CI	2 2 3 2 2 2	2 3 2 3 2 6				R1	
5					3							BD,UN,SM CL BD,UN,RO SA BD,IR,RO PC, CI BD,UN,SM SA BD,UN,SM SA BD,PL,SM CL BD,PL,SM SA BD,PL,SM CL BD,PL,SM SA BD,PL,SM CL	2 3 3 2 2 1 1 1 1 1	1 2 3 2 2 1 2 1 2 1					
6					4							BD,PL,SM PC, CI BD,PL,SM IN, CI CO,PL,SM SA	1 1 1	3 6 2					
		END OF DRILLHOLE		92.54 6.89															
7																			
8																			
9																			
10																			
11																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: FC

CHECKED: AC

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 12/14/18

GOLDER

RECORD OF BOREHOLE No NRW7-1

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4824601.8; E 296209.0 MTM NAD 83 ZONE 10 (LAT. 43.561304; LONG. -79.606346)
BOREHOLE TYPE CME 75, 76 mm I.D., 190 mm O.D., Hollow Stem Augers
DATE July 12, 2018

ORIGINATED BY CC
COMPILED BY SK
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.0	GROUND SURFACE										
0.0	ASPHALT (200 mm)										
	CONCRETE (200 mm)										
0.4	Gravelly sand (FILL) Dense Brown Moist		1	SS	32						
94.1							94				
0.9	Silty sand to sand, trace clay (FILL) Very loose to compact Brown Moist to wet		2	SS	27						
			3	SS	5		93				0 68 29 3
	- Wet below 2.3 m		4	SS	4						
92.0							92				
3.0	Sandy silt, some organics, trace to some clay, topsoil leaves, rootlets (FILL) Very loose Brown / grey Wet		5	SS	1				49.3		
91.3							91				
3.7	Silt, some sand, trace clay (FILL) Very loose to loose Brown Wet		6	SS	4						0 15 78 7
90.5							90			OC = 4.5%	
4.5	Sandy CLAYEY SILT, trace to some gravel, trace organics to 5.2 m depth (TILL) Firm to hard Brown to grey Moist to wet below 4.9 m		7	SS	5						
			8	SS	12		89				6 29 48 17
	- Cobbles at 6.7 m										
87.8							88				
7.2	SILT and SAND, some gravel, trace clay (TILL) Very dense Grey Moist		9	SS	50/0.06						19 39 37 5
						▼	87				
	- Cobbles within Till matrix between 7.2 m and 10.2 m depth		10	SS	50/0.05		86				
84.8							85				
10.2	SAND, some cobble fragments Very dense Grey Moist		11	SS	60		84				
83.7											
11.3	END OF BOREHOLE										

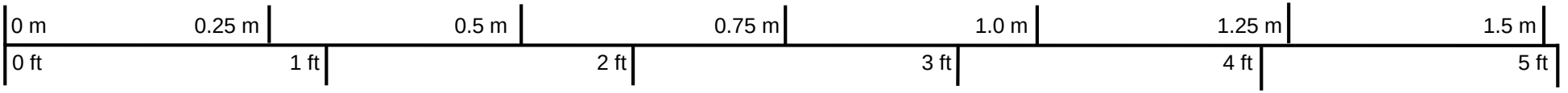
NOTES:

1. Borehole caved to a depth of 10.1 m below ground surface upon removal of augers.

2. Water level measured at a depth of about 8.5 m below ground surface (Elev. 86.5 m) upon completion of drilling.

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

$\circ^{3\%}$ STRAIN AT FAILURE



Scale

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between
Mississauga Road and Hurontario Street

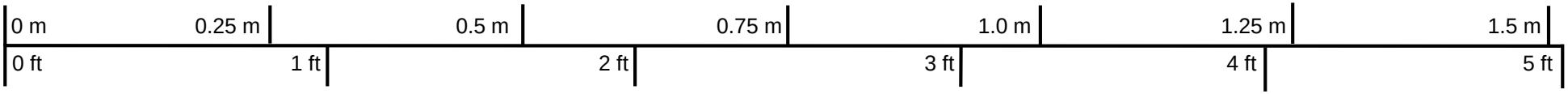
TITLE

Bedrock Core Photograph
Borehole OHS-1 (3.61 m to 7.26 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DRAFT	SE	20180821	SCALE	AS SHOWN	VER. 1.
CADD	--		**FIGURE B-1**		
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

REVISION DATE: August 21, 2018 BY: SE Project: 1662333



Scale

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between
Mississauga Road and Hurontario Street

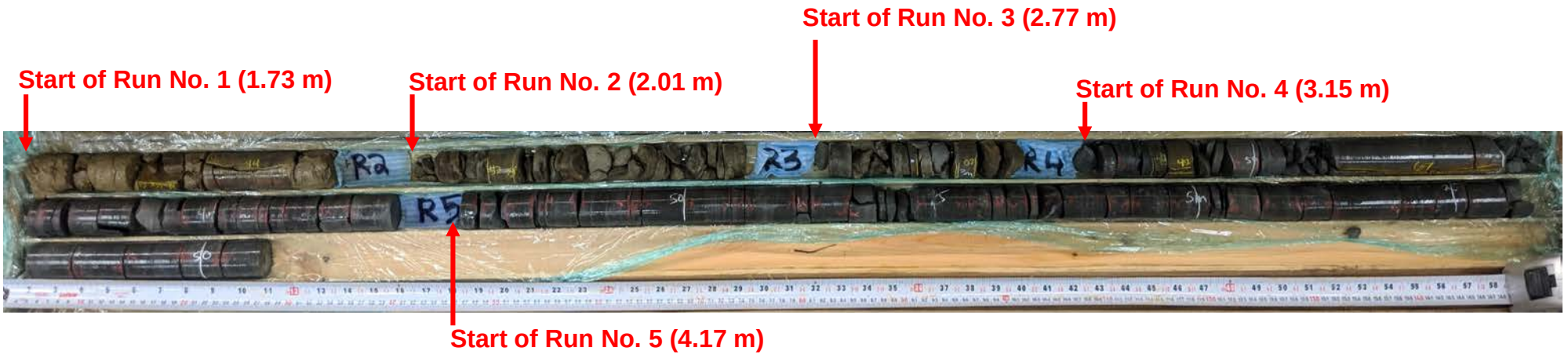
TITLE

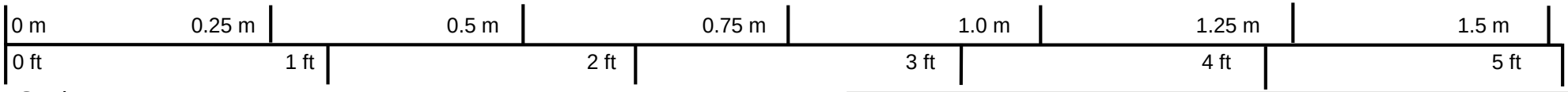
Bedrock Core Photograph
Borehole OHS-2 (3.81 m to 7.47 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DRAFT	SE	20180821	SCALE	AS SHOWN	VER. 1.
CADD	--		**FIGURE B-2**		
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

REVISION DATE: August 21, 2018 BY: SE Project: 1662333





Scale

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between
Mississauga Road and Hurontario Street

TITLE

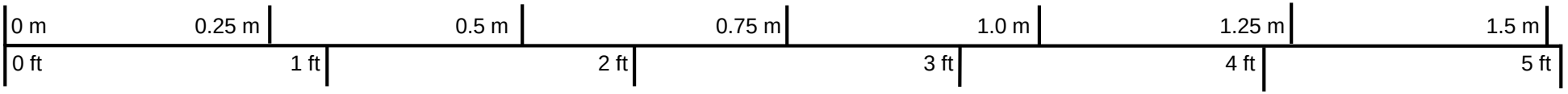
Bedrock Core Photograph
Borehole OHS-4 (1.73 m to 5.56 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	20181112	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

FIGURE B-3

REVISION DATE: August 21, 2018 BY: SE Project: 1662333



Scale

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between
Mississauga Road and Hurontario Street

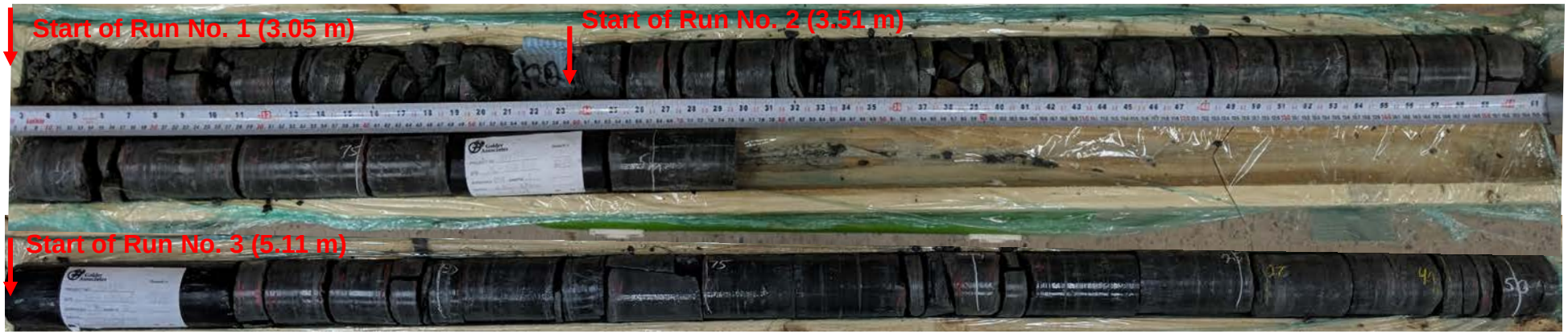
TITLE

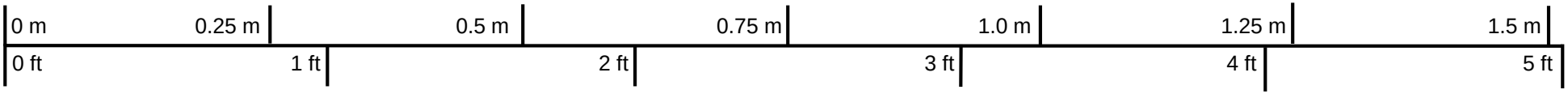
Bedrock Core Photograph
Borehole OHS-5 (4.06 m to 7.95 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DRAFT	SE	20180821	SCALE	AS SHOWN	VER. 1.
CADD	--		**FIGURE B-4**		
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

REVISION DATE: August 21, 2018 BY: SE Project: 1662333





Scale

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between
Mississauga Road and Hurontario Street

TITLE

Bedrock Core Photograph
Borehole HMLP-1 (3.05 m to 6.53 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DRAFT	SE	20180821	SCALE	AS SHOWN	VER. 1.
CADD	--		**FIGURE B-5**		
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

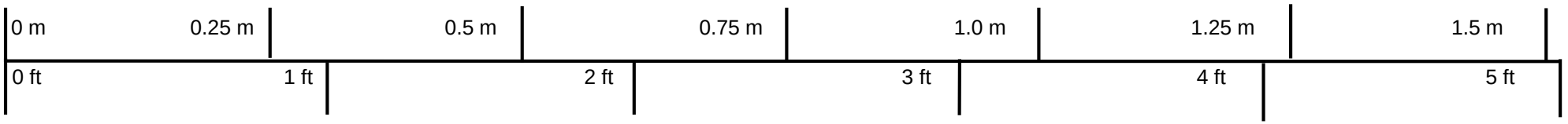
REVISION DATE: August 21, 2018 BY: SE Project: 1662333

Broken Core due to Split-spoon sampling

Start of Run No. 1 (2.29 m)

Start of Run No. 2 (3.58 m)

Start of Run No. 3 (5.08 m)



Scale

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between
Mississauga Road and Hurontario Street

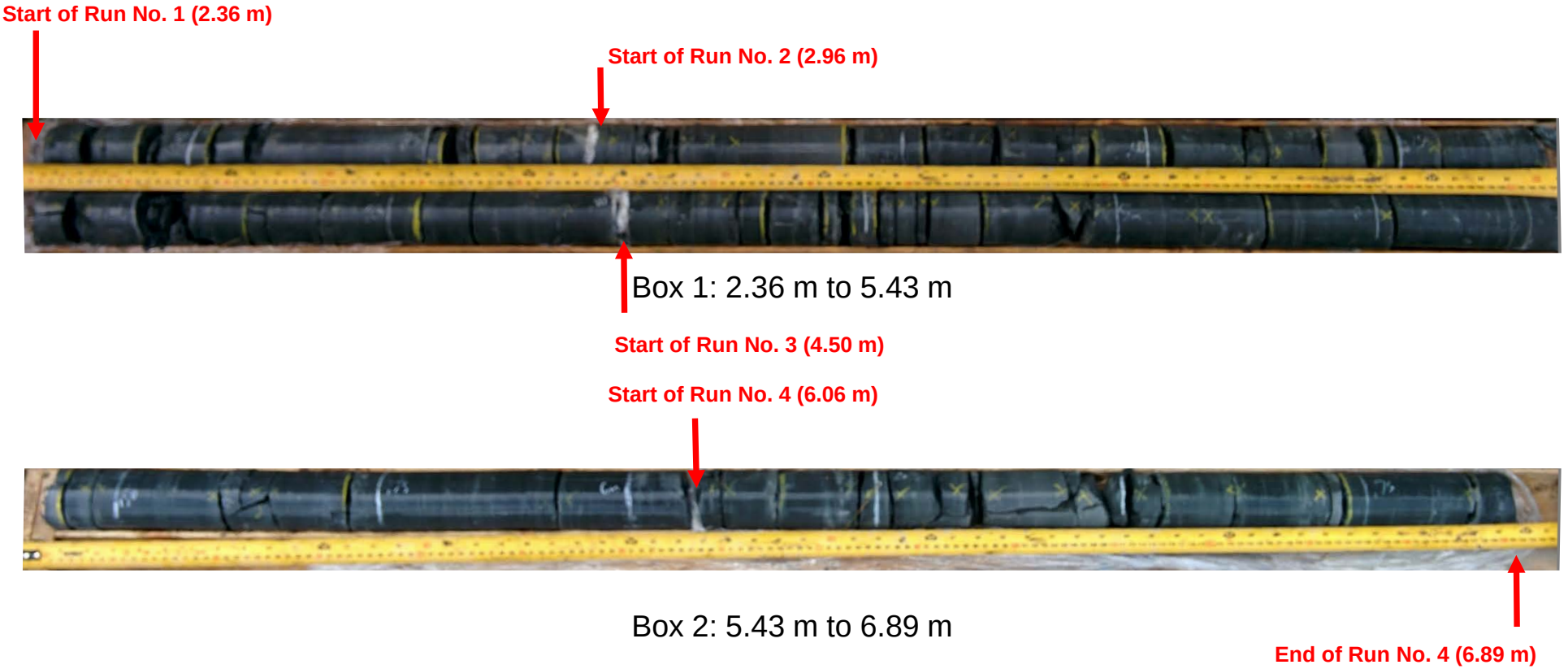
TITLE

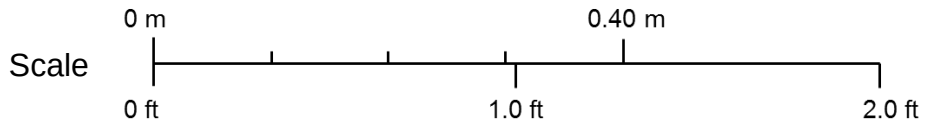
Bedrock Core Photograph
Borehole HMLP-2 (2.29 m to 5.77 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	20181112	SCALE	AS SHOWN	VER. 1.
CADD	--		**FIGURE B-6**		
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

REVISION DATE: August 21, 2018 BY: SE Project: 1662333





REVISION DATE October 3, 2017 BY: AC Project: 1662333

PROJECT

MTO Assignment 2015-E-0033
QEW Widening Between Mississauga Road and Hurontario Street

TITLE

Bedrock Core Photographs
Borehole SWMW-03 (2.36 m to 6.89 m)

Golder Associates

PROJECT No. 1662333			FILE No. ----		
DESIGN	AC	20171003	SCALE	NTS	REV.
CADD	--		**FIGURE B-7**		
CHECK	SMM	20181120			
REVIEW	JMAC	20181120			

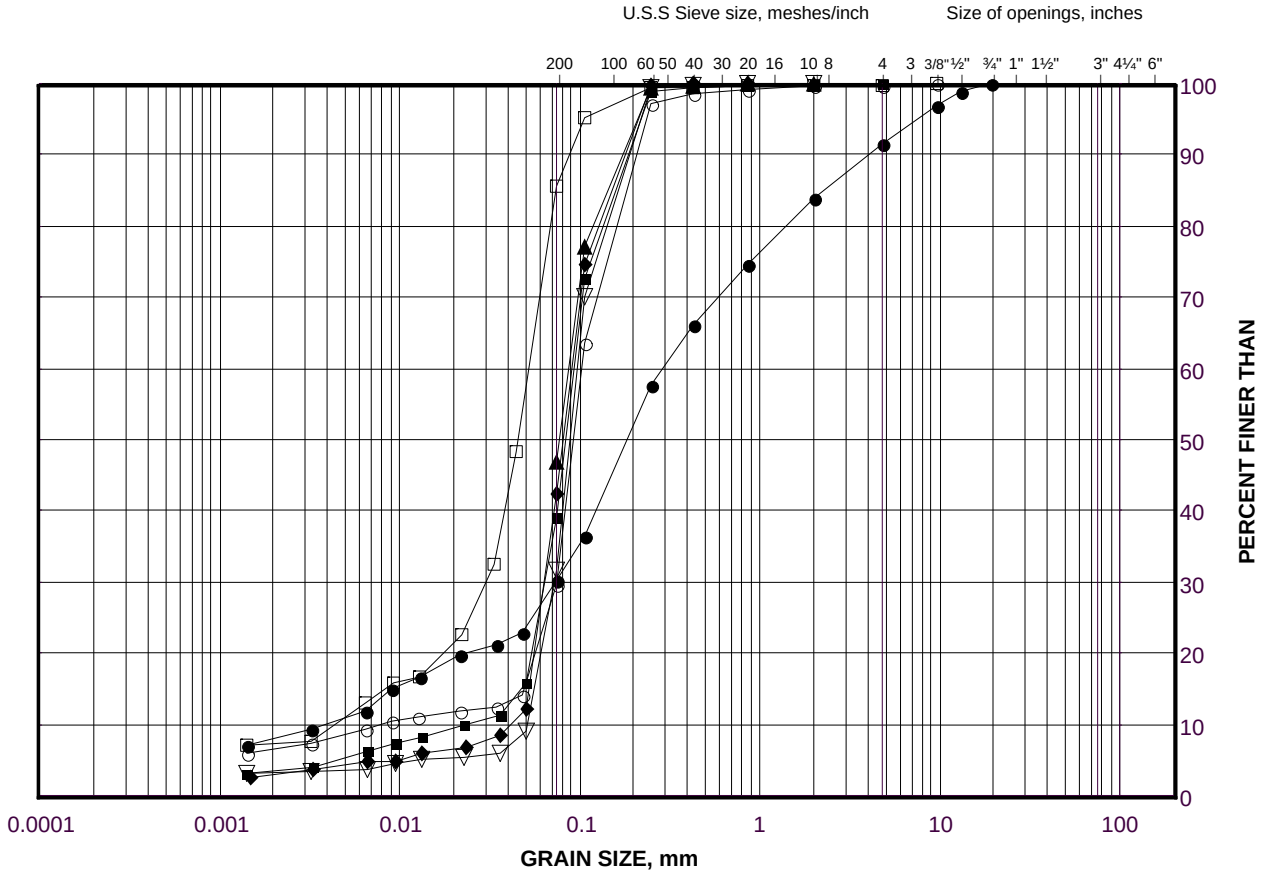
APPENDIX C

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silt / Silt and Sand / Silty Sand (Fill)

FIGURE C-1



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HMLP-1	2	99.4
■	OHS-3	2	93.8
◆	OHS-1	2	100.4
▲	OHS-5	2B (LENS)	99.4
▽	NRW7-1	3	93.1
❍	MO-08B	3A	97.7
□	NRW7-1	6	90.8

Project Number: 1662333

Checked By: SMM

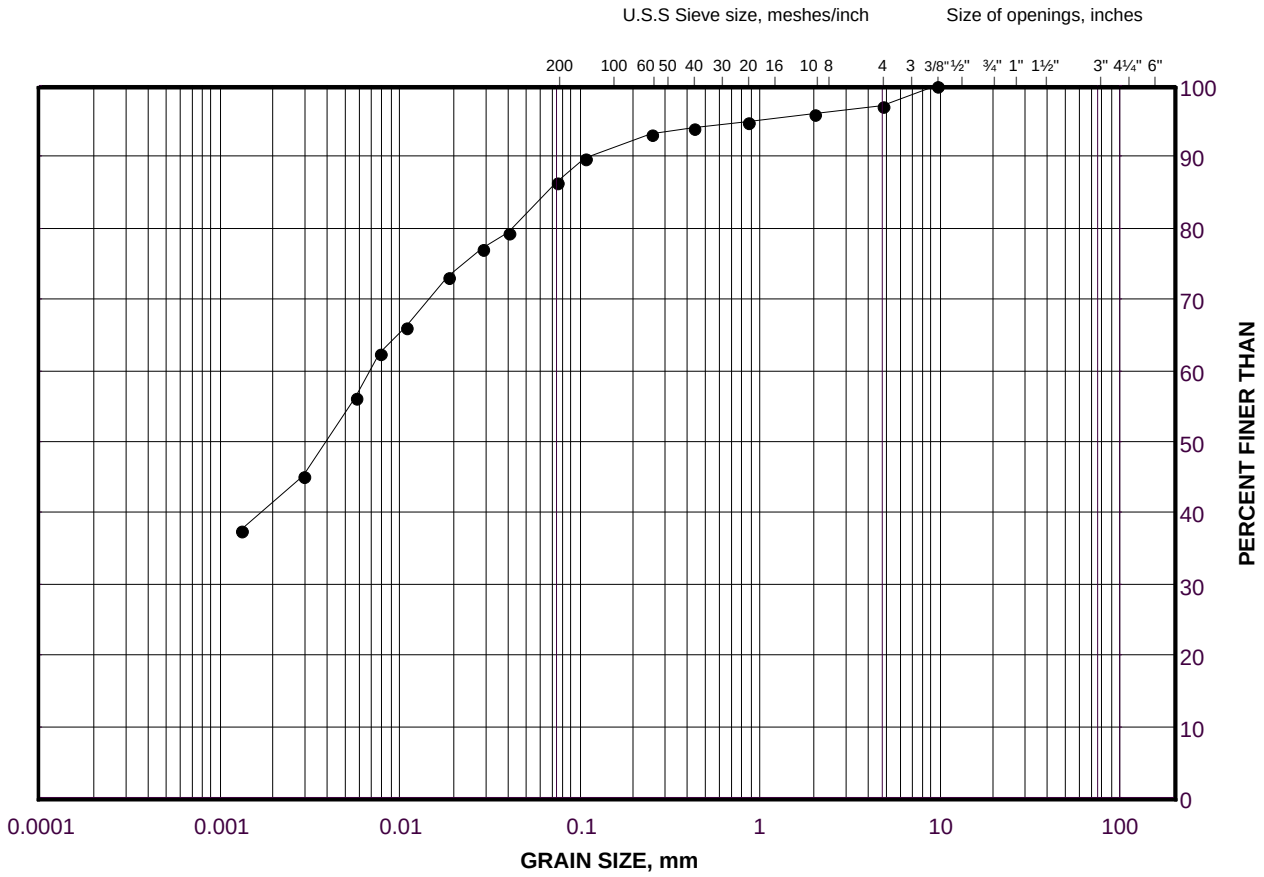
Golder Associates

Date: 12-Nov-18

GRAIN SIZE DISTRIBUTION

Silty Clay (Fill)

FIGURE C-2



LEGEND

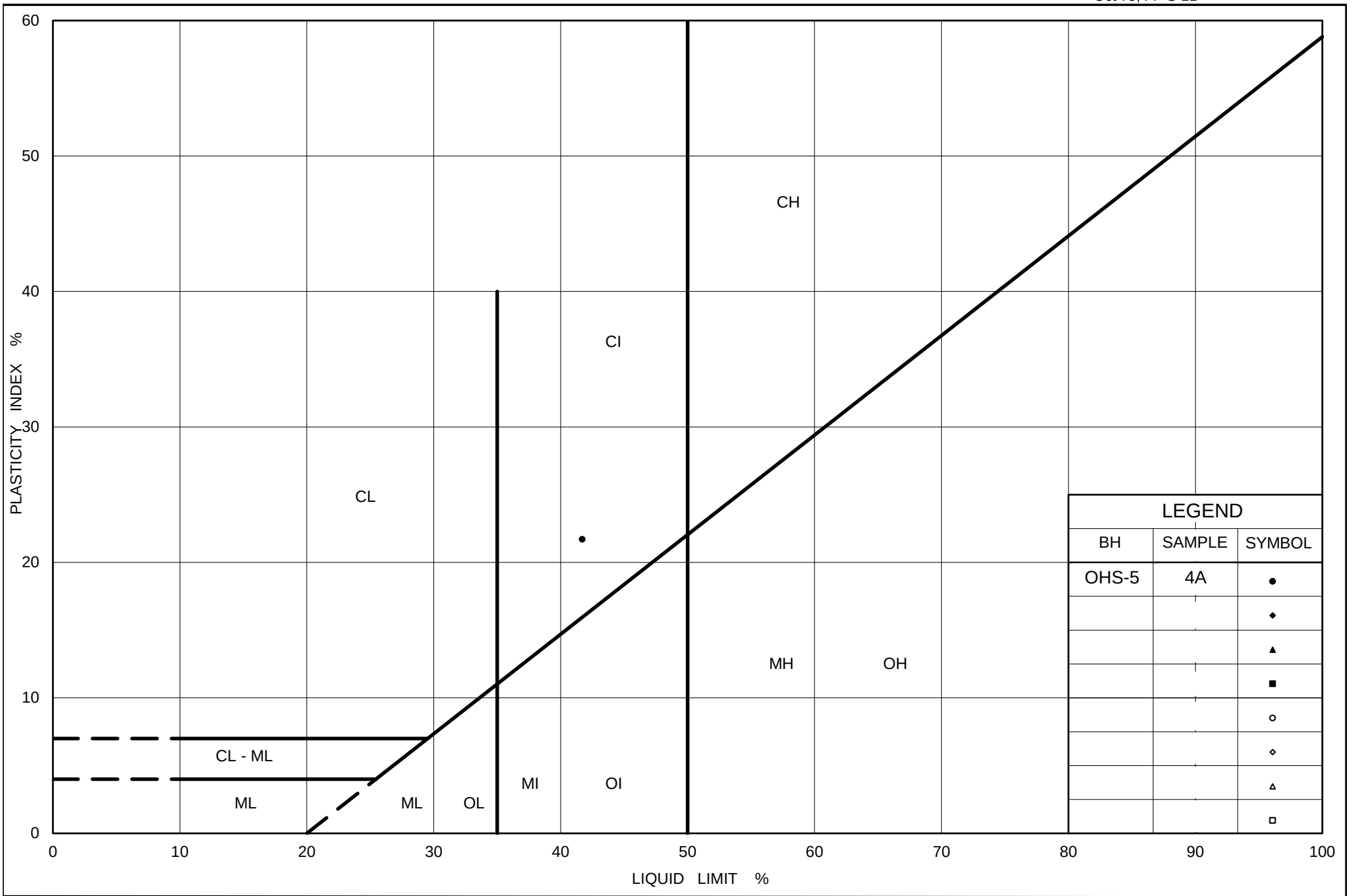
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OHS-5	4A	98.1

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 12-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay (Fill)

Figure No. C-3

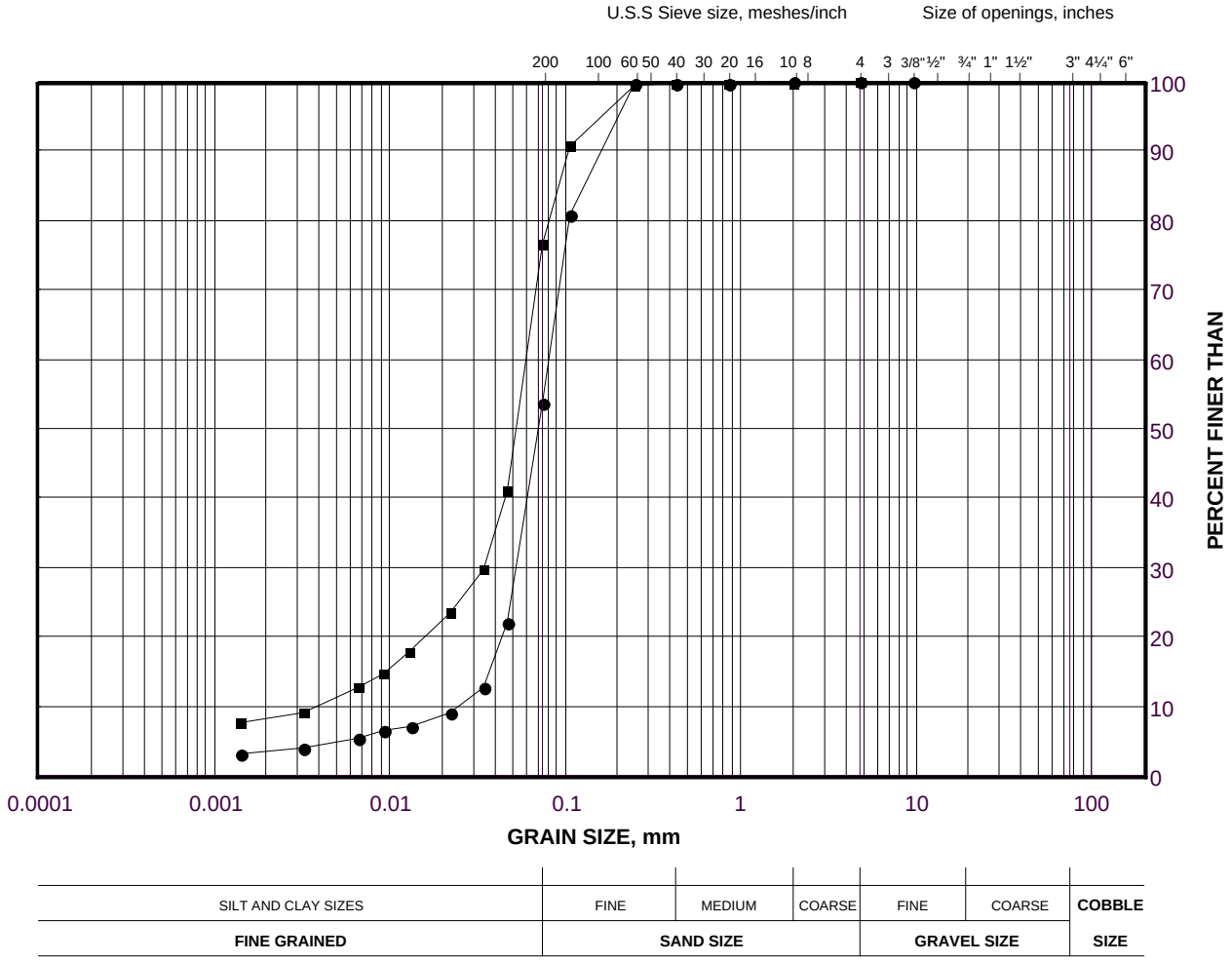
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Silt to Silt and Sand

FIGURE C-4



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OHS-3	5	91.6
■	OHS-3	7	90.1

Project Number: 1662333

Checked By: SMM

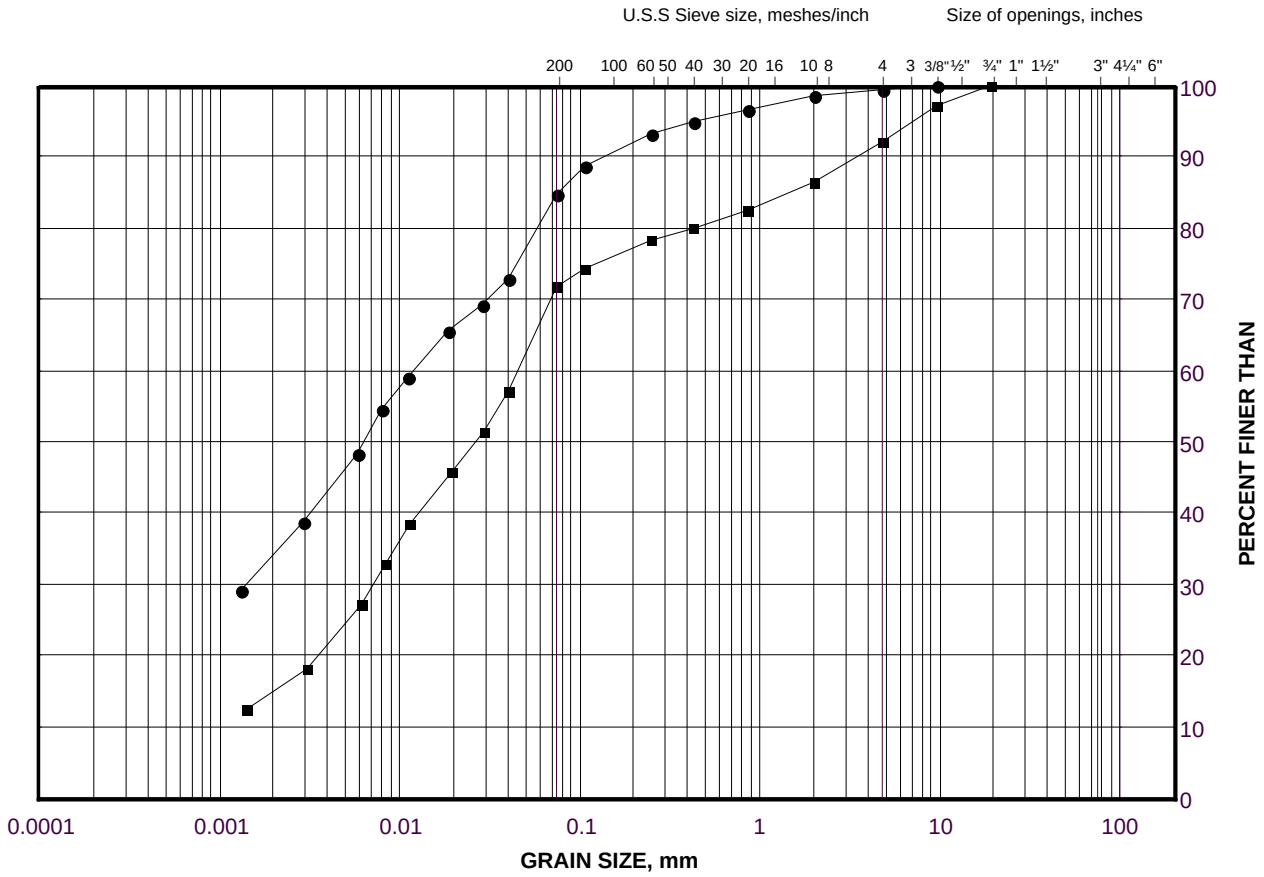
Golder Associates

Date: 12-Nov-18

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE C-5



LEGEND

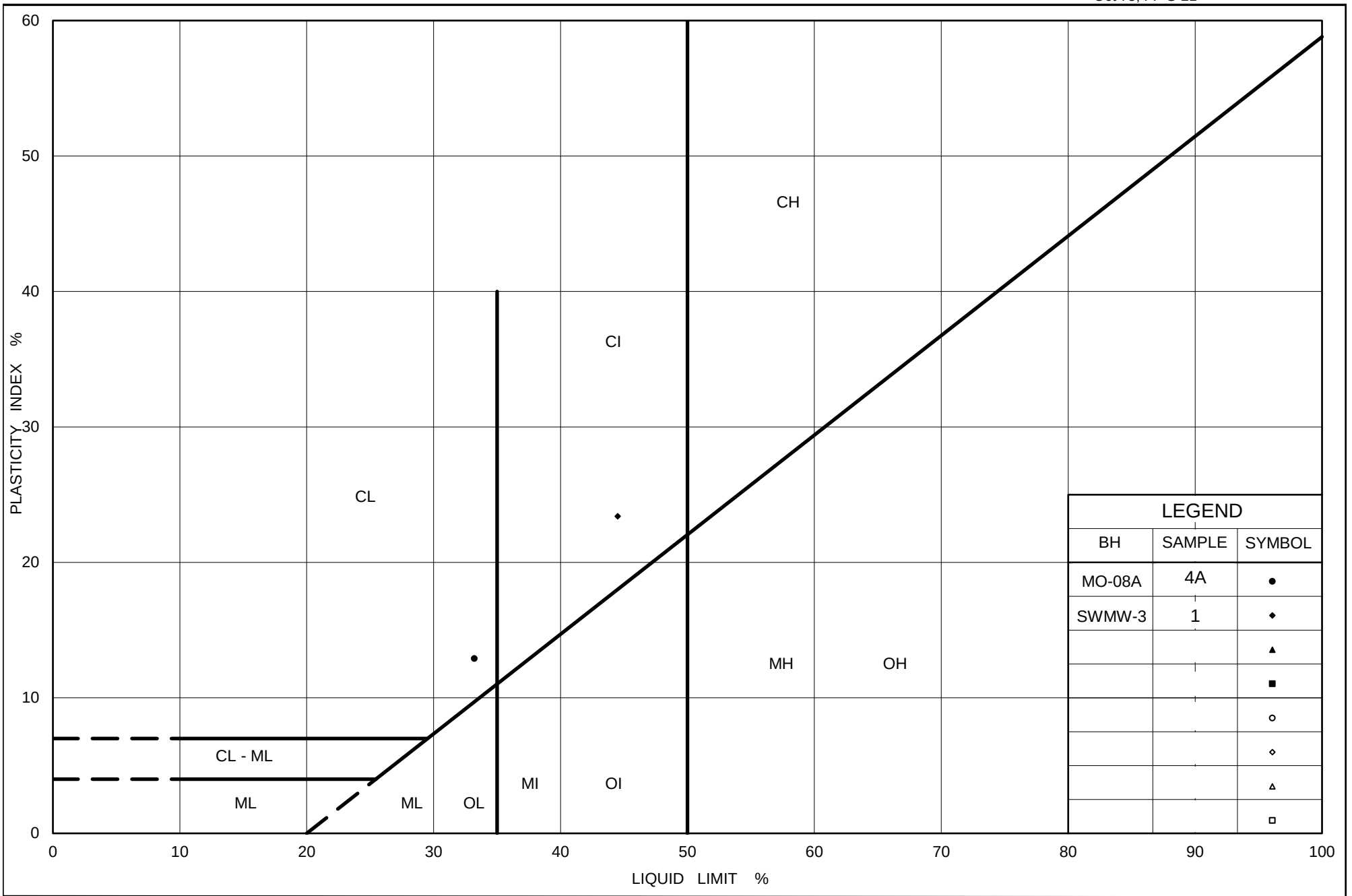
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SWMW-3	1	99.1
■	MO-08A	4A	96.9

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 12-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt to Silty Clay

Figure No. C-6

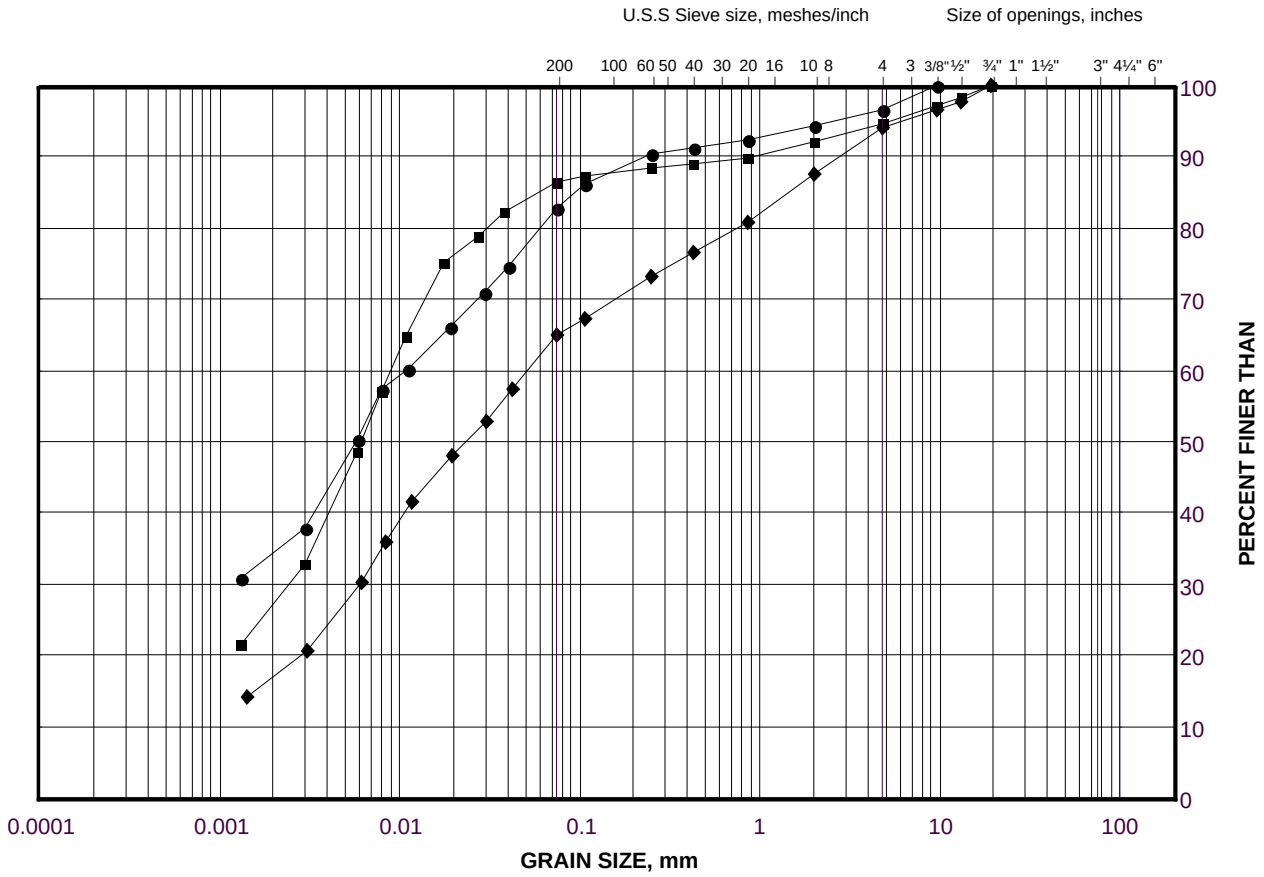
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Silty Clay (Till)

FIGURE C-7



LEGEND

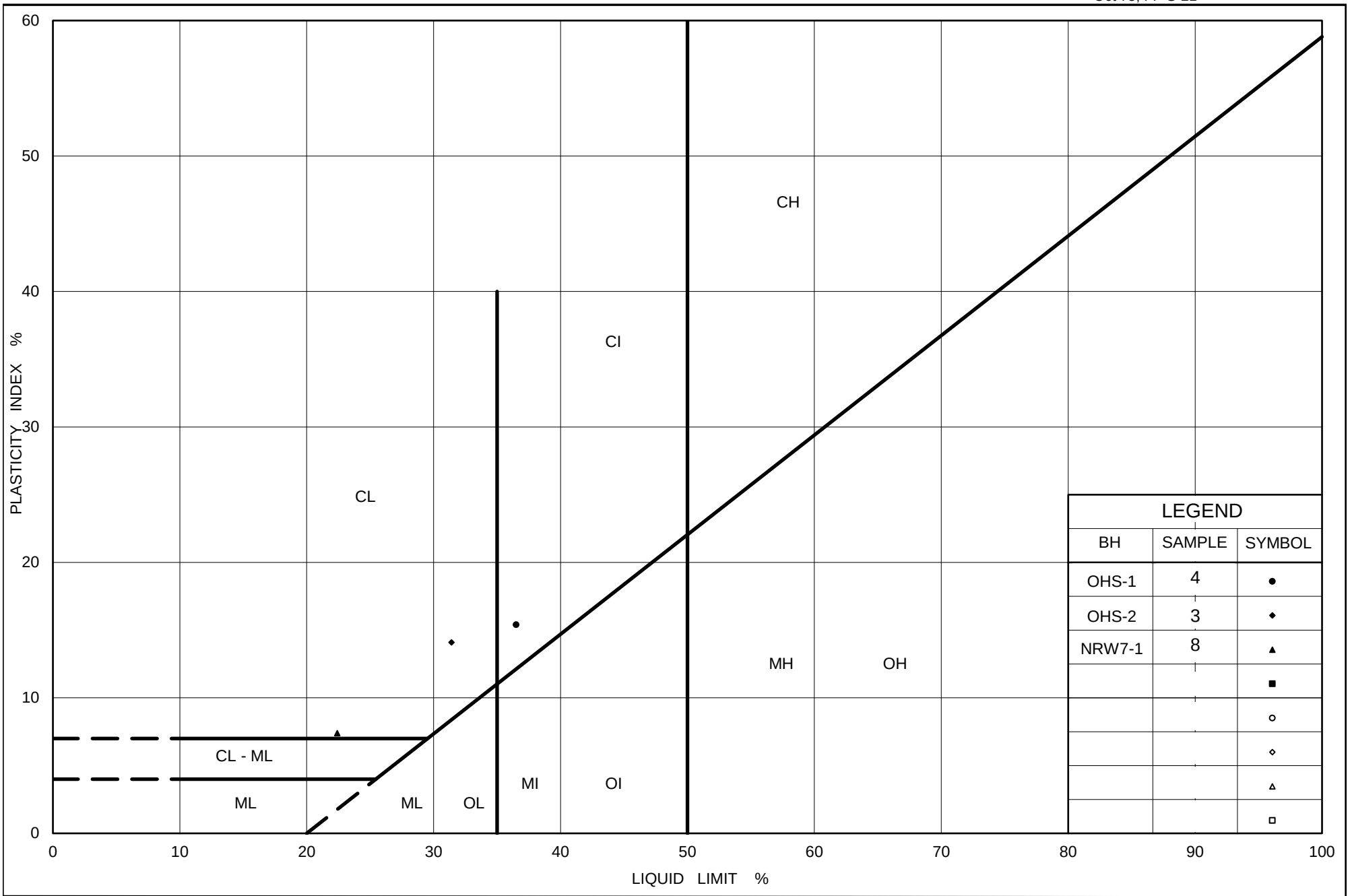
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OHS-2	3	98.8
■	OHS-1	4	99.0
◆	NRW7-1	8	88.5

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 12-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy Clayey Silt to Silty Clay (Till)

Figure No. C-8

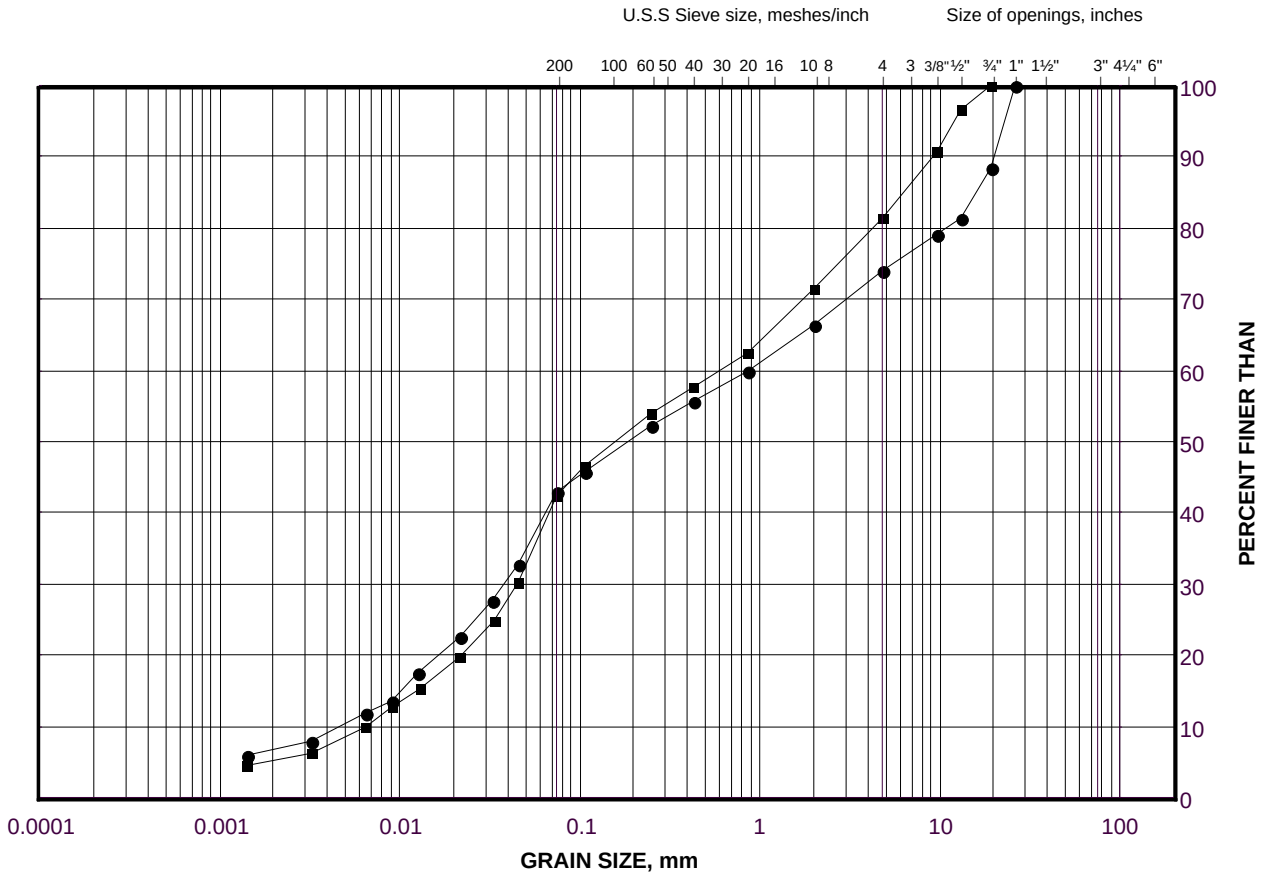
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Silt and Sand to Gravelly Silt and Sand (Till)

FIGURE C-9



LEGEND

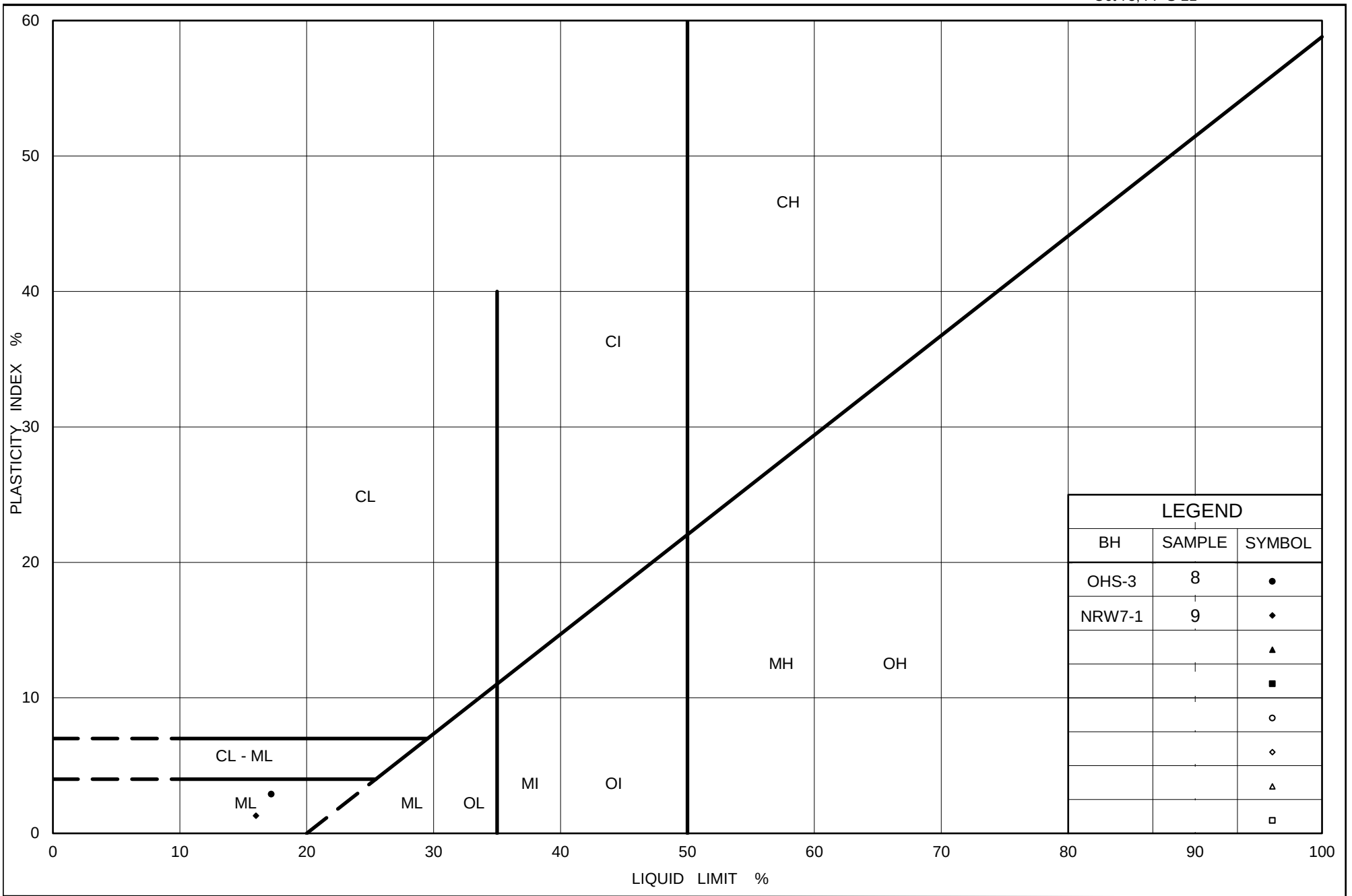
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OHS-3	8	88.6
■	NRW7-1	9	87.3

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 12-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand to Gravelly Silt and Sand (Till)

Figure No. C-10

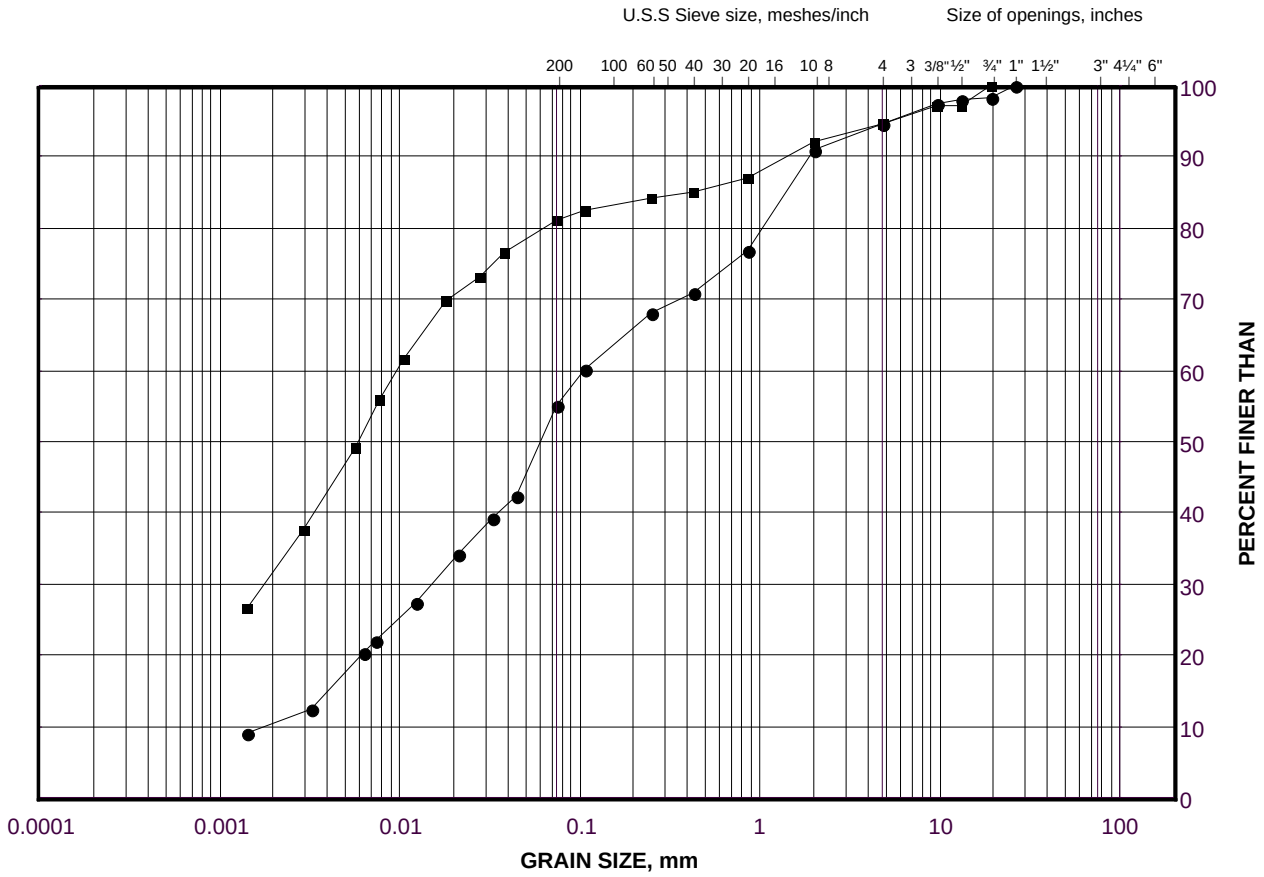
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand to Silty Clay (Residual Soil)

FIGURE C-11



LEGEND

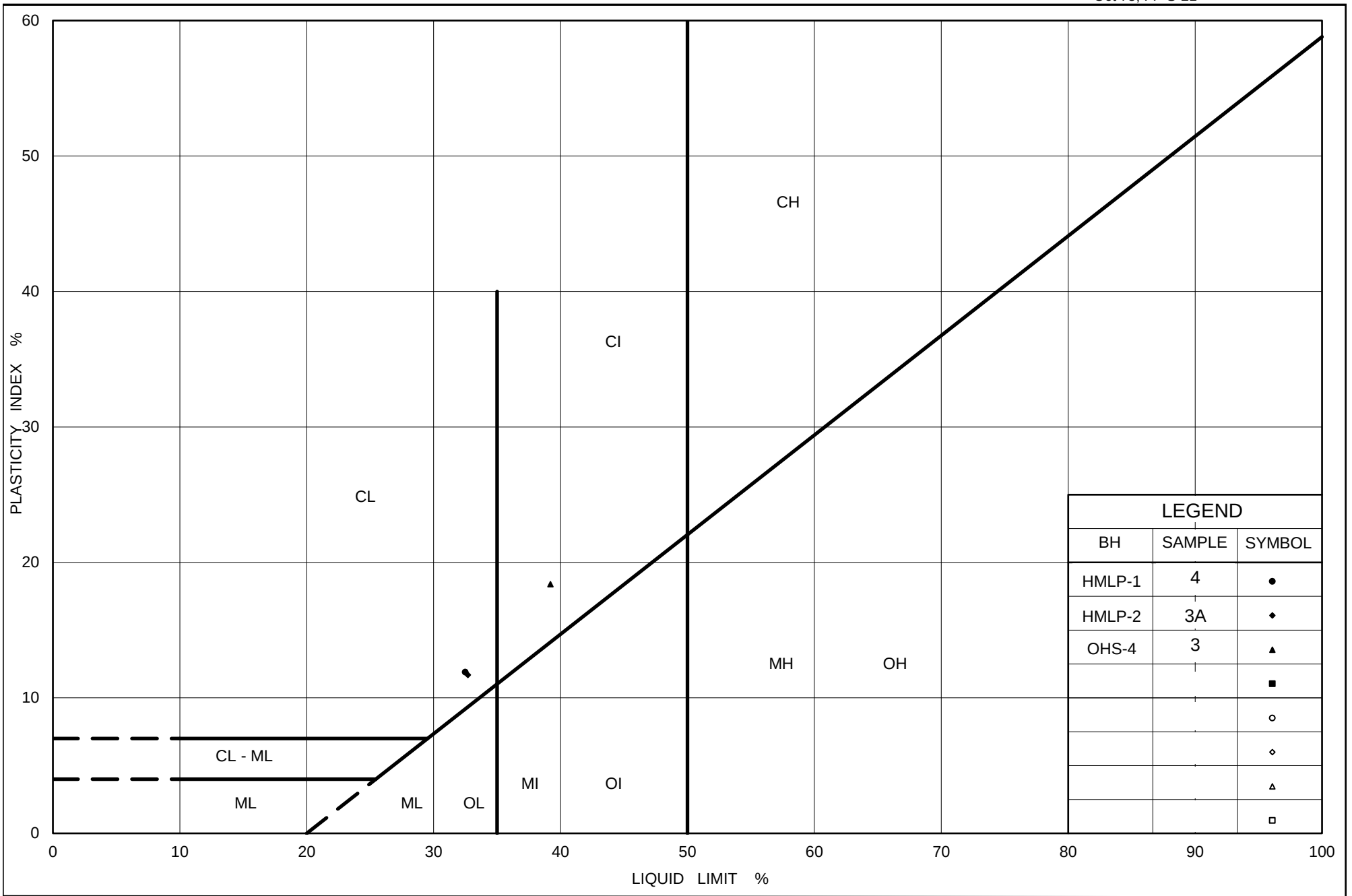
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HMPL-2	2B/2C	97.9
■	OHS-4	3	95.8

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 12-Nov-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt with Sand to Silty Clay(Residual Soil)

Figure No. C-12

Project No. 1662333

Checked By: SMM

Geomechanica Inc.
Suite 900 – 390 Bay St.
Toronto Ontario
Canada M5H 2Y2

August 27, 2018

Mr. David Marmor
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Re: UCS only and UCS + E testing
(Golder Project No. 1662333)

Dear Mr. Marmor:

On July 31, 2018 and August 17, 2018 seven (7) and six (6) HQ-sized core samples were received by Geomechanica Inc. via drop-off by Golder personnel, respectively. These samples were identified as being from boreholes drilled as part of Golder project 1662333. A total of 13 uniaxial compressive strength (UCS) specimens were prepared and tested from these samples. The tangent elastic modulus was measured for 5 of these 13 tests.

Details regarding the steps of specimen preparation and testing along with the test results and specimen photographs before and after testing are presented in the accompanying laboratory report.

Sincerely,

Bryan Tatone Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: bryan.tatone@geomechanica.com

GEOMECHANICA

Rock Laboratory Testing Results

A report submitted to:

David Marmor
Golder Associates Limited
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Prepared by:

Bryan Tatone, PhD, PEng
Omid Mahabadi, PhD, PEng

Geomechanica Inc
#900-390 Bay St
Toronto ON
M5H 2Y2 Canada
Tel: +1-647-478-9767
info@geomechanica.com

August 27, 2018
Project number: 1662333

Abstract

This document summarizes the results of rock laboratory testing of 13 uniaxial compressive strength (UCS) tests. Results, including uniaxial compressive strength (UCS) and Young's modulus (for select samples) along with photographs of samples before and after testing are presented. Additional specimen information is included in an accompaning summary spreadsheet.

In this document:

1 Uniaxial Compressive Strength (UCS) testing

This report summarizes the results of 13 uniaxial compressive strength (UCS) tests. The testing was performed in Geomechanica's rock testing laboratory using a 150 ton (1.3 MN) Forney loading frame equipped with pressure-compensated control valve to maintain an axial displacement rate of approximately 0.15 mm/min for shale and and 0.075 mm/min for limestone samples (Figure 1). This displacement rate was selected to target specimen failure to occur within 2 - 15 minutes.

The specimen preparation and testing procedure included the following:

1. Unwrapping of the core sample, inspecting it for damage, and re-wrapping it in electrical tape to minimize exposure to moisture during subsequent specimen preparation.
2. Diamond cutting of core sample to obtain a cylindrical specimen with an appropriate length (length:diameter = 2:1) and nearly parallel end faces.
3. Diamond grinding of specimen to obtain flat (within ± 0.025 mm) and parallel end faces (within 0.25°).
4. Placement of the specimen into the loading frame, applying a 1 kN axial load, and removing the electrical tape.
5. Axial loading to rupture while continuously recording axial force and axial deformation to determine the peak strength (UCS) and (tangent) Young's modulus (E) mfor select samples.

Figure 1: UCS test setup.

1.1 Results

The results of the tests are summarized in Table 1. The corresponding stress-strain curves for the uniaxial compression tests are presented in Figure 2 and 3. Young's modulus is the tangent modulus, calculated as the slope of the best fit line through ± 300 data points on either side of the point representing 50.0% of the peak strength. Additional specimen information is included in the accompaning summary spreadsheet.

Table 1: Summary of laboratory test results.

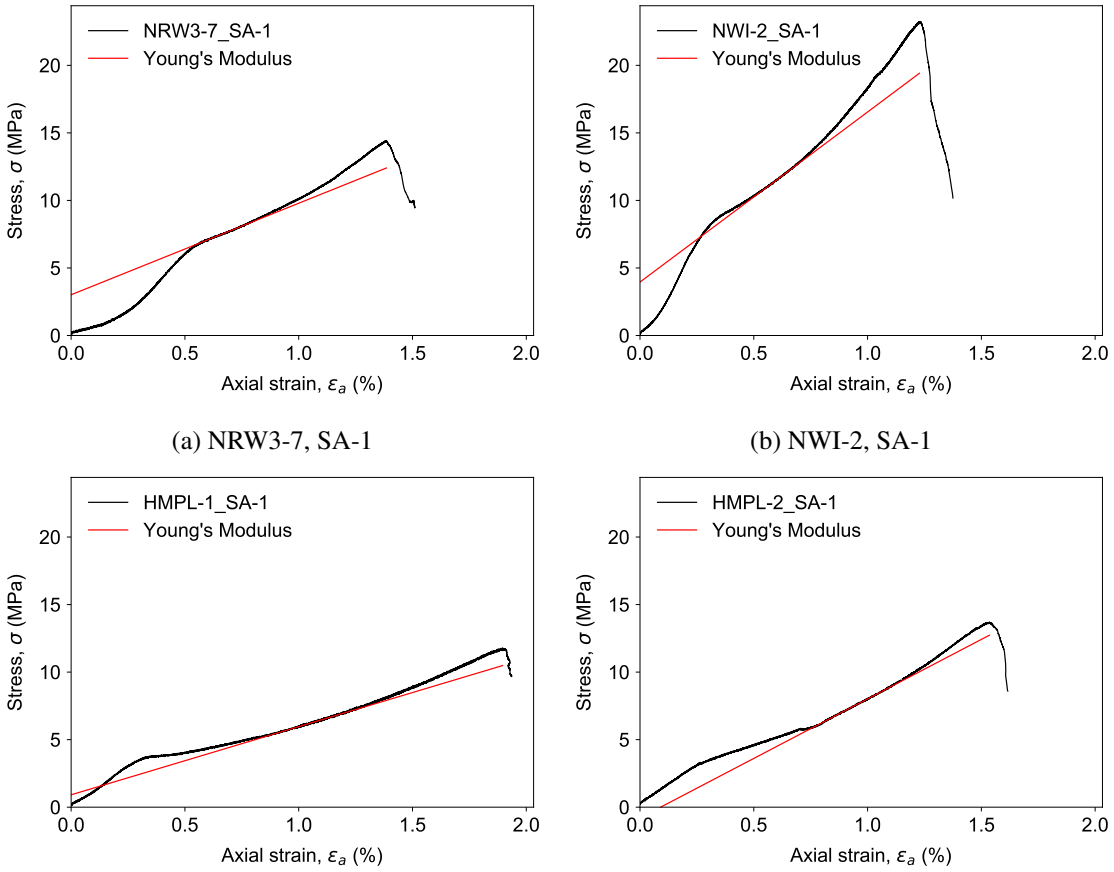
Sample	Depth (m)	Lithology description	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's Modulus E (GPa)	Failure description
NRW3-7, SA-1	9.57 - 9.71	Georgian Bay Formation - Shale	2.596	14.4	0.68	Axial splitting [1, 2]
NWI-2, SA-1	5.06 - 5.31	Georgian Bay Formation - Shale	2.619	23.3	1.26	Inclined shear fracture [2]
NWI-3, SA-1	4.29 - 4.44	Georgian Bay Formation - Shale with several limestone lenses $<$ 5 mm	2.601	16.8	-	Localized crushing [2]
NW5-4, SA-1	5.47 - 5.61	Georgian Bay Formation - Limestone	2.732	196.3	60.84	Inclined shear fracture
OHS-1, SA-1	5.26 - 5.44	Georgian Bay Formation - Shale	2.591	13.0	-	Inclined shear fracture [2]
OHS-2, SA-1	5.38 - 5.49	Georgian Bay Formation - Shale with 2 limestone layers $\approx$5 mm thick	2.449	23.4	-	Hourglass failure [1, 2]
OHS-5, SA-1	6.13 - 6.27	Georgian Bay Formation - Shale	2.603	16.7	-	Axial splitting [2]
AR-2, SA-1	5.92 - 6.12	Georgian Bay Formation - Shale	2.574	9.1	-	Axial splitting [2]
AR-2, SA-2	8.60 - 8.82	Georgian Bay Formation - Shale	2.588	11.5	-	Axial splitting [2]
NW5-1, SA-1	4.29 - 4.45	Georgian Bay Formation - Shale	2.593	13.6	-	Hourglass failure [2]
SWME-4, SA-1	10.40 - 10.54	Georgian Bay Formation - Shale	2.586	13.5	-	Axial splitting [2]
HMPL-1, SA-1	4.81 - 4.96	Georgian Bay Formation - Shale	2.573	11.8	0.50	Localized crushing [2]
HMPL-2, SA-1	3.70 - 3.85	Georgian Bay Formation - Shale	2.594	13.7	0.88	Axial splitting [2]

[1] Specimen Length:Diameter ratio $<$ 2 due to short sample length

[2] Specimen emitted pore water upon loading

1.2 Specimen photographs

Photographs of the specimens before and after testing are presented in Figures 4 to 6.



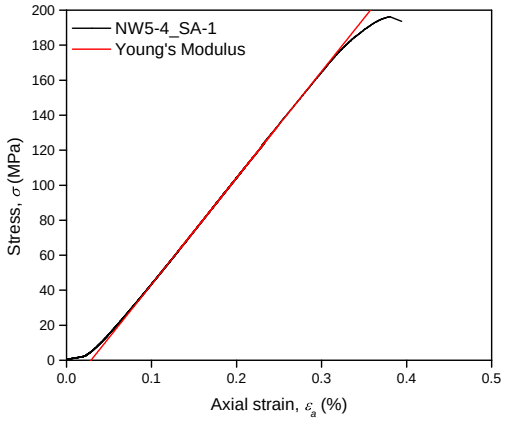
(a) NRW3-7, SA-1

(b) NWI-2, SA-1

(c) HMPL-1, SA-1

(d) HMPL-2, SA-1

Figure 2: Measured stress-strain curves for shale samples.



(a) NRW5-4, SA-1

Figure 3: Measured stress-strain curves for limestone samples.

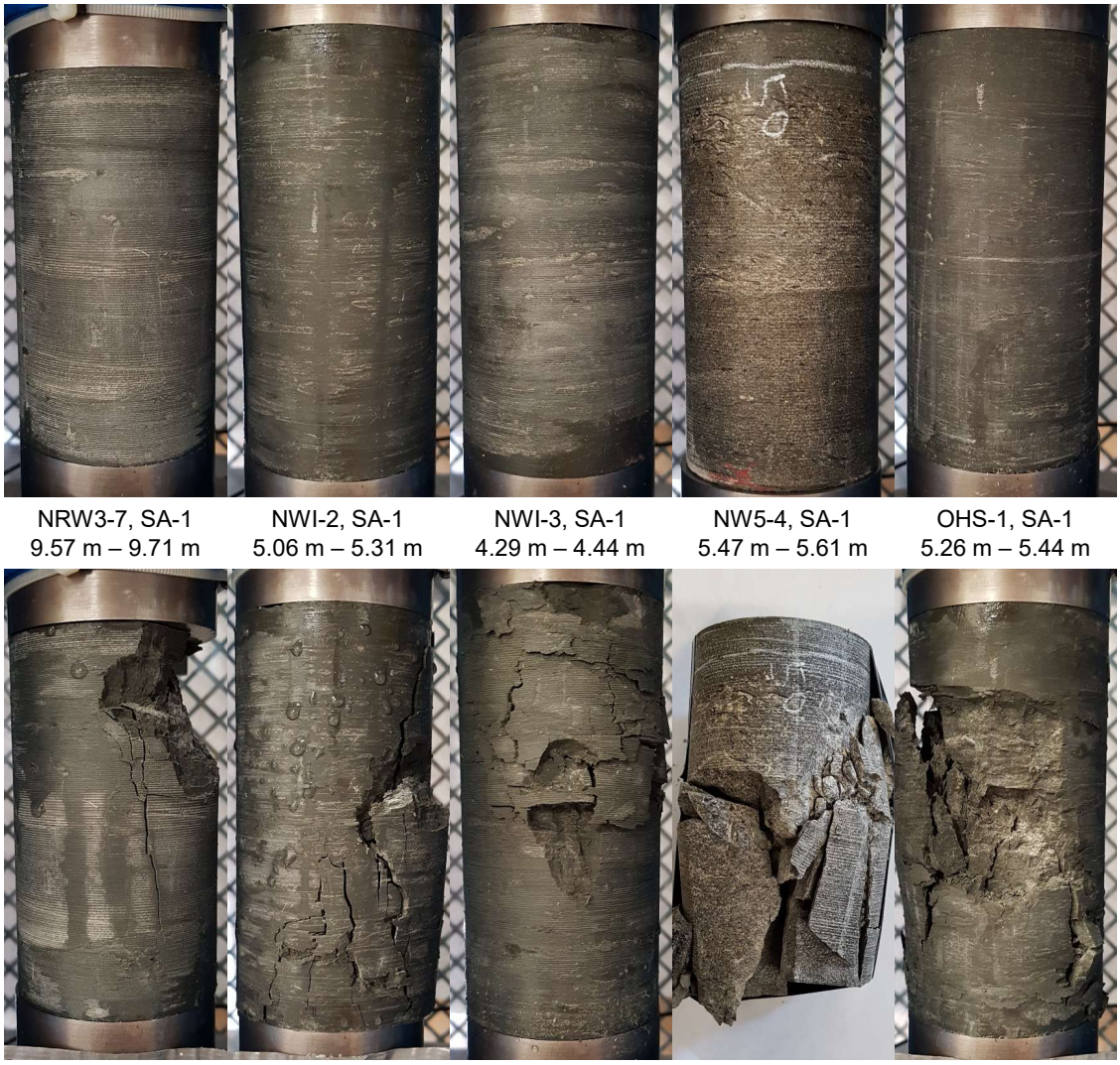


Figure 4: Photographs of specimens before and after testing.

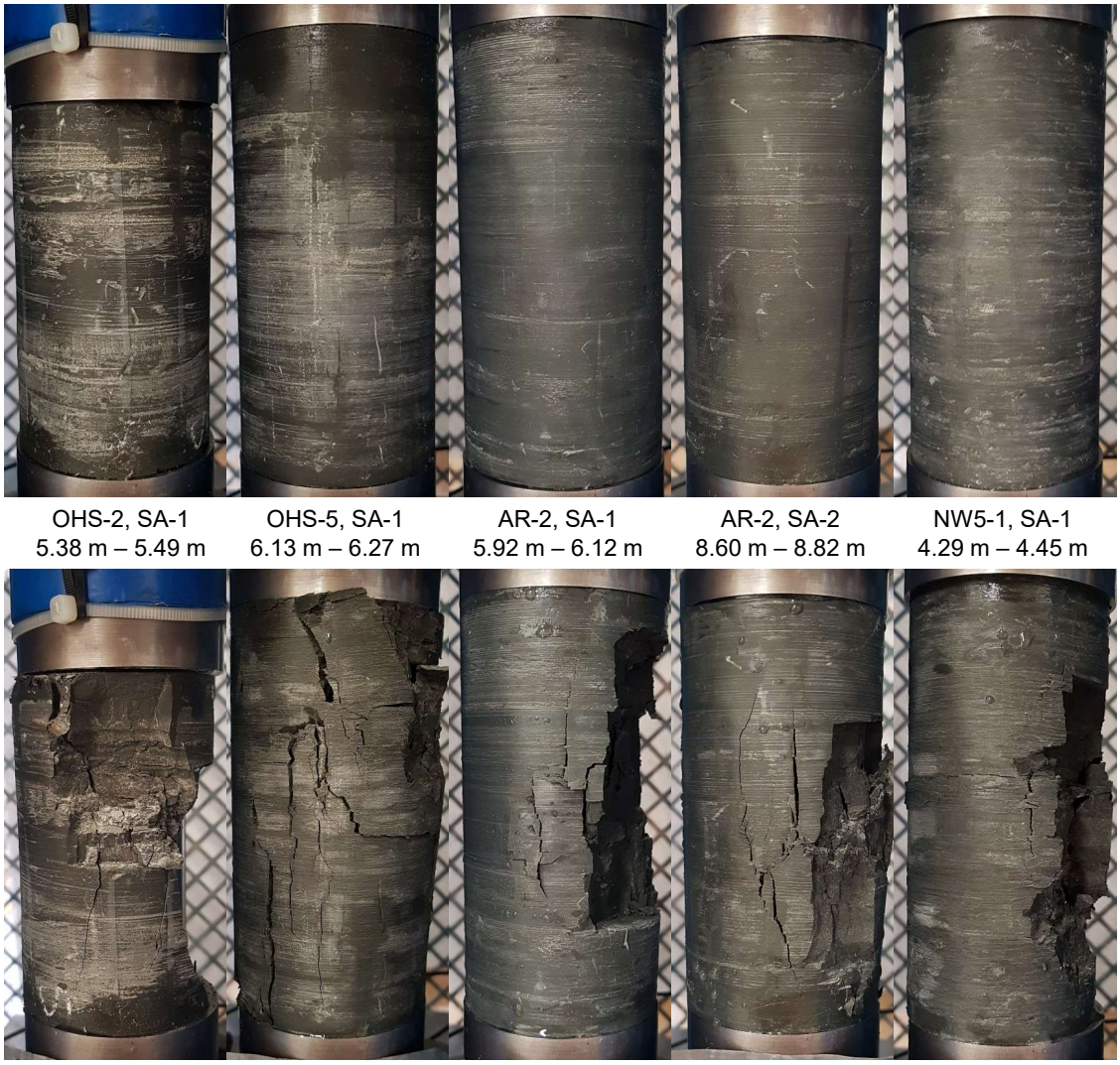


Figure 5: Photographs of failed specimens before and after testing (continued).

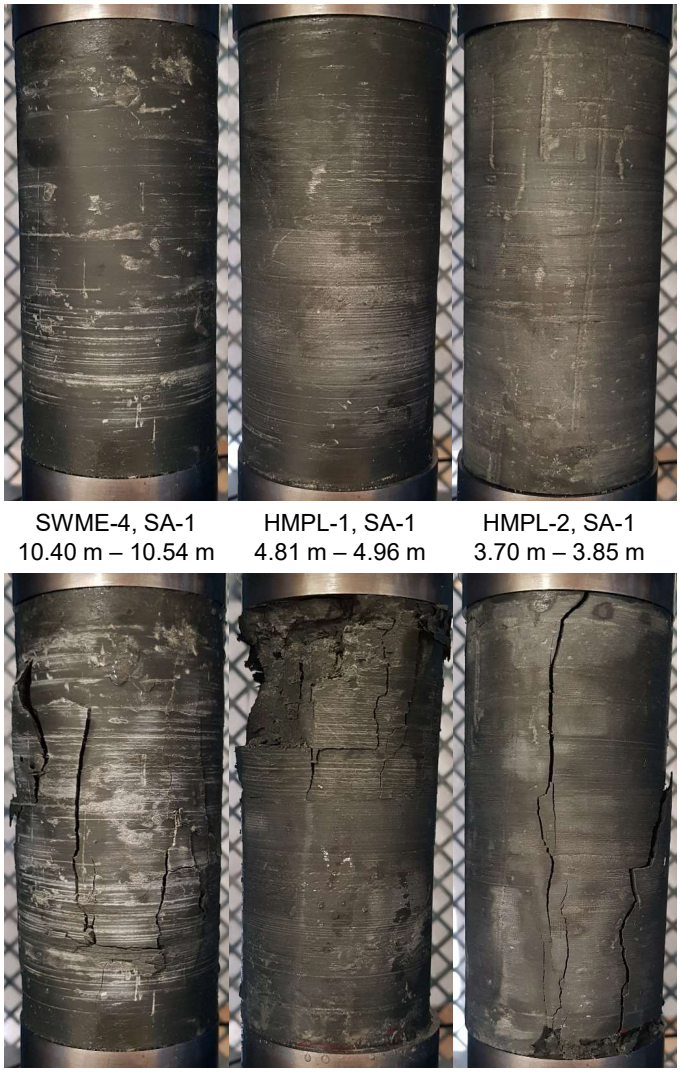


Figure 6: Photographs of failed specimens before and after testing (continued).

golder.com