FOUNDATION INVESTIGATION REPORT

Temporary East Access Road, East of the Credit River, 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:

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Table of Contents

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 in support of the detail design for the widening of the Queen Elizabeth Way (QEW) from west of Mississauga Road to west of Hurontario Street in the City of Mississauga, in the Regional Municipality of Peel, Ontario.

The purpose of this investigation is to establish the subsurface soil, bedrock and groundwater conditions at the location of the proposed temporary East Access Road for the construction of the proposed twinning of the Credit River bridge, by borehole drilling and laboratory testing on selected soil and bedrock 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, and the approved Change Request letters, 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

Based on a preliminary design drawing provided by MH on July 26, 2018, the alignment of the temporary East Access Road will be situated north of the proposed footprint for the twinning of the Credit River bridge (west bound), and extend from Stavebank Road to the east limit of the proposed East Pier (see Drawing 1), adjacent to the Credit River. The current ground surface along the proposed East Access Road is covered with vegetation and trees. In most of the proposed access road footprint, the existing ground surface is covered with sparse vegetation, wood chips and stumps resulting from advanced tree clearing operations in preparation for the widening of the QEW and associated structures. A marsh/swampy area, adjacent to the Credit River, is located directly northwest of west limit of the temporary East Access Road. There are currently buried oil pipelines (Trans-Northern Pipeline) and high voltage electrical transmission overhead lines directly within / across the footprint of the proposed East Access Road and the utilities are to be relocated prior to construction of the access road.

Overall, the existing ground surface on the tableland in the area of the proposed temporary East Access Road gradually slopes down to the crest of the river bank at an inclination ranging from about 5 horizontal to 1 vertical (5H:1V) to 10H:1V, from about Elevation 97 m west of Stavebank Road to about Elevation 88 m at the valley crest. The valley from the tableland to the edge of the river slopes steeply at an inclination of about 1.4H:1V to 3H:1V down to about Elevation 76 m on edge of the East Bank. The Credit River water level was measured to be about Elevation 75 m (September 1986). There is currently a low-lying area situated within the tableland, just north of the proposed East Access Road, which naturally drains down to the river along the western portion of the current East Access Road alignment. According to the design drawings provided by MH, a proposed new Stormwater Management Pond (SWMP) will eventually be located within the footprint of the temporary East Access Road and current low-lying area, and the temporary access road and surrounding topography will be modified to meet the final design grade for the permanent SWMP and associated features.

3.0 INVESTIGATION PROCEDURES

Field work for the foundation investigation was carried out between October 2017 and July 2018, during which time a total of 10 relevant boreholes were carried out as part of the project as follows:

- Boreholes AR-1 and AR-2, advanced on July 30, 2018 as close as possible to the temporary East Access Road alignment taking into consideration access restrictions and requirement for holes to be a minimum 10 m away from the buried oil pipelines owned by Trans-Northern Pipeline Inc. (TNPI).

- Boreholes CRB-4, CRB-5A and CRB-5, advanced between February 13 and 18, 2018 at the east pier for the Credit River bridge and associated east access road;
- Boreholes CRB-6 and CRB-7, advanced between October 17 to 23, 2017 at the east abutment, east access road and east approach for the Credit River bridge;
- Boreholes SWME-1, SWME-3 and SWME-4, which were advanced on July 27 and 31, 2018 for the SWM Dry Pond and east access road.

The locations of the relevant boreholes are shown on Drawing 1. Additional boreholes near the proposed East Access Road that were completed for other foundation components of the QEW bridge widening project are also shown on the drawing for reference only.

The borehole investigation was carried out using track-mounted CME 75 drill rig, supplied and operated by Davis Drilling Ltd. of Milton, Ontario, a CME 55 drill rig supplied and operated by Geo-Environmental Drilling Ltd. of Milton, Ontario and a CME 850 drill rig supplied and operated by Aardvark Drilling Inc. of Guelph, Ontario. The boreholes were advanced using 160 mm to 210 mm outside diameter hollow-stem augers through the overburden, and HW casing and an HQ size core barrel through the bedrock. Soil and/or bedrock samples were typically obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08)[1].

Boreholes were advanced through the overburden and/or bedrock to depths ranging from 5.4 m to 17.2 m below existing ground surface. Bedrock was confirmed by coring for lengths between 3.3 m and 9.5 m in Boreholes AR-2, SWME-4, CRB-4, CRB-5, CRB-5A, CRB-6 and CRB-7.

The groundwater conditions and water levels in the open boreholes were observed during and immediately following drilling operations. A standpipe piezometer was installed in Boreholes SWME-3, CRB-5A and CRB-6 to permit monitoring of the groundwater level at the borehole locations. The standpipe piezometers consist of 50 mm diameter PVC pipe, with a slotted screen within a sand filter pack sealed within the overburden / bedrock interface or upper portion of the bedrock. Above the sand filter pack and piezometer screen, the annulus surrounding the piezometer pipe was backfilled to about 0.5 m below the ground surface with bentonite pellets and finished to ground surface with concrete to set in the protective casing for the standpipe piezometer. All remaining boreholes were backfilled to ground surface 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. Uniaxial compression (UC) strength tests (including core bulk density and Young's Modulus determination) were carried out on selected specimens of the bedrock core samples by Geomechanica Inc. on behalf of Golder.

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

The as-drilled borehole locations and the ground surface elevations were obtained using a GPS (Trimble Geo 7X), having an accuracy of 0.1 m in both the vertical and horizontal directions. 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.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude, °)	Easting (m) (Longitude, °)		
AR-1	4,824,236.4 (43.558012)	295,944.3 (-79.609616)	95.7	9.2
AR-2	4,824,172.2 (43.557434)	295,921.4 (-79.609899)	88.4	11.6 (including 7.0 m bedrock core)
CRB-4	4,824,135.1 (43.557099)	295,902.0 (-79.610138)	79.1	15.3 (including 8.1 m bedrock core)
CRB-5	4,824,128.9 (43.557044)	295,914.2 (-79.609986)	79.2	15.5 (including 8.3 m bedrock core)
CRB-5A	4,824,130.9 (43.557062)	295,910.6 (-79.610032)	79.3	17.2 (including 9.5 m bedrock core)
CRB-6	4,824,196.7 (43.557650)	295,929.5 (-79.609801)	91.7	13.3 (including 8.2 m bedrock core)
CRB-7	4,824,189.6 (43.557590)	295,951.1 (-79.609531)	94.7	16.0 (including 7.5 m bedrock core)
SWME-1	4,824,195.5 (43.557643)	295,896.6 (-79.610206)	89.5	5.5
SWME-3	4,824,227.3 (43.557930)	295,901.0 (-79.610152)	91.9	5.4
SWME-4	4,824,255.4 (43.558183)	295,917.6 (-79.609946)	95.5	13.3 (including 3.3 m of bedrock core)

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].

[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.)

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 detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes, the piezometer installation details and water level readings and the results of the laboratory tests carried out on selected soil and bedrock core samples are presented on the Records of Boreholes and Drillholes provided in Appendix A. Photographs of the recovered bedrock core samples are presented on Figures A-1 to A-8 in Appendix A. The results of the in-situ field tests (i.e. SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. Lists of abbreviations and symbols and lithological and geotechnical rock description terminology are also included in Appendix A to assist in the interpretation of the borehole and drillhole records. The detail results of the geotechnical laboratory testing on soil and bedrock core samples obtained during the investigation are presented in Appendix B.

The stratigraphic boundaries shown on the borehole records and the stratigraphic profile on Drawing 1 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types and soil/bedrock rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the borehole and drillhole records govern any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the proposed temporary East Access Road consist of a layer of topsoil, underlain by fill comprising of sandy silt to silty sand, sand and clayey silt. The fill is underlain by deposits of silt, sandy silt to sand, clayey silt with sand to silty clay and organic clay which is further underlain by a till deposit and residual soil. The native soil deposits are underlain by shale bedrock. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

A layer of topsoil ranging in thickness from about 180 mm to 700 mm was encountered at the ground surface in Boreholes AR-1, AR-2, CRB-7 and SWME-4. SPT “N”-values measured within the topsoil layer range between 3 blows and 9 blows per 0.3 m of penetration, suggesting a soft to stiff consistency.

4.2.2 Fill

A 0.3 m to 4.3 m thick layer of fill consisting of clayey silt with sand / sandy silt to silty sand / sand and gravel was encountered from ground surface in Boreholes SWME-1, SWME-3, CRB-4, CRB-5, CRB-5A and CRB-6, and underlying the topsoil in Boreholes SWME-4, AR-1 and CRB-7. The fill was described as containing variable amounts of organics, brick fragments, and shale and limestone fragments. The depth and elevation of the top and

base of the fill layer, the thickness and the predominant fill type at each borehole location (from east to west) is presented below:

Borehole No.	Top of Layer		Bottom of Layer		Thickness (m)	Fill Type
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)		
SWME-4	0.2	95.3	0.7	94.8	0.5	Silt and Sand
AR-1	0.7	95.0	1.4	94.3	0.7	Sand
SWME-3	0.0	91.9	1.7	90.2	1.7	Sandy Silt to Silty Sand
CRB-6	0.0	91.7	1.7	90.0	1.7	Silty Sand
CRB-7	0.2	94.5	4.5	90.2	4.3	Silt and Sand
SWME-1	0.0	89.5	0.7	88.8	0.7	Sand and Gravel
	0.7	88.8	1.4	88.1	0.7	Silt and Sand
	1.4	88.1	1.7	87.8	0.3	Clayey Silt
CRB-4	0.0	79.1	3.7	75.4	3.7	Clayey Silt with Sand
CRB-5	0.0	79.2	0.7	78.5	0.7	Silty Sand
	0.7	78.5	2.4	76.8	1.7	Clayey Silt with Sand
CRB-5A	0.0	79.3	4.0	75.3	4.0	Clayey Silt with Sand

SPT “N”-values measured within the non-cohesive fill layers range between 4 blows and 21 blows per 0.3 m of penetration, suggesting a loose to compact state of compactness. One SPT “N”-value of 54 blows per 0.3 m of penetration was recorded in Borehole CRB-7 near the base of the fill and the value is likely attributed to the brick fragments that were present within the split-spoon sampler. SPT “N”-values measured within the cohesive fill layers range between 6 blows and 31 blows per 0.3 m of penetration, suggesting a firm to hard consistency.

The results of grain size distribution tests completed on three selected samples of the non-cohesive fill are shown on Figure B-1 in Appendix B.

The results of grain size distribution tests completed on two selected samples of the cohesive fill are shown on Figure B-2 in Appendix B. An Atterberg limits test was carried out on a selected sample of the cohesive fill and measured a liquid limit of about 24 per cent, a plastic limit of about 14 per cent, and a plasticity index of about 10 per cent. The test result, which is plotted on a plasticity chart on Figure B-3 in Appendix B, indicates that the cohesive fill can be classified as a clayey silt of low plasticity.

The natural water content measured on samples of the non-cohesive fill ranges between 4 per cent and 21 per cent. The natural water content measured on samples of the cohesive fill ranges between 6 per cent and 17 per cent.

4.2.3 Sandy Silt to Sand

Underlying the fill in Boreholes SWME-1, SWME-3, SWME-4, AR-1, CRB5, CRB-5A and CRB-7, a non-cohesive deposit ranging in composition from sandy silt to silt and sand to silty sand to sand, trace to some clay, trace gravel, was encountered. The depth and elevation of the surface and base of the non-cohesive layer at each borehole location (from east to west), the thickness and the soil type are presented below:

Borehole No.	Top of Layer		Bottom of Layer		Thickness (m)	Soil Type
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)		
SWME-4	0.7	94.8	3.7	91.8	3.0	Silt and Sand
AR-1	1.4	94.3	5.3	90.4	3.9	Sand to Silt and Sand
SWME-3	1.7	90.2	2.2	89.7	0.5	Sandy Silt
CRB-7	4.5	90.2	6.5	88.2	2.0	Sandy Silt
SWME-1	1.7	87.8	3.0	86.5	1.3	Sand
CRB-5	2.4	76.8	4.7	74.5	2.3	Silty Sand to Silt and Sand
	5.7	73.5	7.2	72.0	1.5	Silty Sand
CRB-5A	4.0	75.3	4.5	74.8	0.5	Silty Sand
	6.4	72.9	7.2	72.1	0.8	

SPT “N”-values measured within the sandy silt to sand deposit range from 0 blows to 63 blows per 0.3 m of penetration, indicating a very loose to very dense compactness condition, but was typically loose to compact.

The results of grain size distribution tests completed on nine selected samples of the sandy silt to sand deposit are shown on Figure B-4 in Appendix B. An Atterberg limits test was attempted on a sample of the sandy silt from Borehole CRB-7; however, it was classified as non-plastic.

The natural water content measured on samples of the sandy silt / silt and sand / silty sand / sand layers ranges between 4 per cent and 28 per cent.

4.2.4 Silt

Underlying the sandy silt deposit in Borehole SWME-3, the clayey silt in Borehole SWME-4 (discussed in Section 4.2.5) and the sand in Borehole AR-1 a deposit of silt, trace to some sand and trace to some clay, was encountered at depths between about 2.2 m and 5.6 m below ground surface (between Elevation 90.4 m and 89.7 m). The thickness of the silt layer ranges from about 1 m to 2 m and the deposit extends to depths between about 3.2 m and 7.6 m below ground surface (between Elevation 88.7 m and 87.9 m).

SPT “N”-values measured within the silt deposit are 16 blows, 19 blows and 56 blows per 0.3 m of penetration, indicating a compact to very dense compactness condition.

The results of the grain size distribution test completed on three selected samples of the silt deposit are shown on Figure B-5 in Appendix B.

The natural water content measured on samples of the silt deposit range from 14 per cent to 17 per cent.

4.2.5 Clayey Silt with Sand to Silty Clay

Underlying the fill in Boreholes CRB-4 and CRB-6, the granular deposits in Borehole SWME-1 and SWME-4, and the silt deposit in Boreholes SWME-3, AR-1 and SWME-4, a deposit consisting of clayey silt with sand to silty clay was encountered. The depth and elevation of the top and bottom of this cohesive deposit at each borehole location (from east to west) and the corresponding thickness and soil type are summarized below.

Borehole No.	Top of Layer		Bottom of Layer		Thickness (m)	Soil Type
	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)		
SWME-4	3.7	91.8	5.6	89.9	1.9	Clayey Silt
	7.6	87.9	8.1	87.4	0.5	Silty Clay
AR-1	7.2	88.5	8.7	87.0	1.5	Clayey Silt
SWME-3	3.2	88.7	3.7	88.2	0.5	Clayey Silt
CRB-6	1.7	90.0	4.4	87.3	2.7	Sandy Clayey Silt
SWME-1	3.0	86.5	3.7	85.8	0.7	Silty Clay
CRB-4	3.7	75.4	6.2	73.0	2.5	Sandy Clayey Silt

SPT “N”-values measured within the cohesive deposit typically range between 2 blows and 13 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency.

The results of the grain size distribution test completed on six selected samples of the sandy clayey silt to silty clay deposit are shown on Figure B-6 in Appendix B.

Atterberg limits tests were carried out on six samples of the cohesive deposit and measured liquid limits ranging from 22 per cent to 42 per cent, plastic limits ranging from 14 per cent to 21 per cent, and plasticity indices ranging from 8 per cent to 21 per cent. These test results, which are plotted on a plasticity chart on Figure B-7 in Appendix B, indicate that the deposit can be classified as a clayey silt of low plasticity to silty clay of intermediate plasticity.

The natural water content measured on samples of the cohesive deposit range from about 14 per cent to 34 per cent.

4.2.6 Organic Clayey Silt with Sand

Underlying the silty sand deposit in Boreholes CRB-5 and CRB-5A, and underlying the cohesive deposit in Borehole CRB-4, a deposit of organic clayey silt with sand, trace gravel, containing sand lenses, wood and shell fragments

was encountered at depths of between about 4.5 m and 6.2 m (between Elevations 74.8 m and 73.0 m) below ground surface. The thickness of the deposit ranges from about 0.8 m to 1.9 m and the deposit extends to depths of between 5.7 m and 7.0 m below ground surface (between Elevations 73.5 m and 72.1 m).

The SPT "N" values measured within the organic deposit range from 1 blow to 7 blows per 0.3 m of penetration, suggesting a very soft to firm consistency.

Three grain size distribution tests were carried out on three selected samples of the organic clayey silt deposit and the results are shown on Figure B-8 in Appendix B. Atterberg limits tests were carried out on three samples of this organic clayey silt deposit and measured liquid limits ranging from about 38 per cent to 46 per cent, plastic limits ranging from about 26 per cent to 36 per cent, and plasticity indices ranging from about 6 per cent to 17 per cent. These test results, which are plotted on the plasticity chart on Figure B-9 in Appendix B, indicate that the deposit consists of organic clayey silt of intermediate plasticity.

Organic content tests completed on two samples from this deposit measured 6 per cent and 7 per cent. The water content measured on samples from the organic deposit range from 41 per cent to 47 per cent.

4.2.7 Silt and Sand / Clayey Silt to Sandy Silty Clay (Till)

Underlying the topsoil in Borehole AR-2 and underlying the cohesive deposit in Boreholes SWME-3 and SWME-4 and underlying the non-cohesive deposit in Borehole CRB-7, a till deposit comprised of silt and sand / clayey silt to sandy silty clay was encountered at depths between about 0.6 m and 8.1 m below ground surface (between Elevation 88.2 m and 87.4 m). The thickness of the till deposit ranges from about 0.6 m to 3.2 m and the deposit extends to depths between about 3.8 m and 9.0 m below ground surface (between Elevation 87.6 m and 84.6 m). The predominantly cohesive till deposit contains trace to some sand and trace to some gravel and in Borehole AR-2, was interlayered with a 1.1 m thick sand and silt till zone at a depth of 1.1 m below ground surface.

SPT "N"-values measured within the cohesive till deposit are between 10 blows and 14 blows per 0.3 m of penetration, suggesting a stiff consistency. Two SPT "N"-values measured within the non-cohesive till were 6 blows and 14 blows per 0.3 m of penetration indicating a loose to compact state of compactness.

Grain size distribution tests carried out on three selected samples of the non-cohesive and cohesive till deposit are shown on Figure B-10 in Appendix B.

Atterberg limits tests were carried out on four samples of the cohesive till deposit and measured liquid limits ranging from about of 23 per cent to 38 per cent, plastic limits ranging from about 14 per cent to 20 per cent, and plasticity indices ranging from about 8 per cent to 18 per cent. These test results, which are plotted on a plasticity chart on Figure B-11 in Appendix B, indicate that the deposit is comprised of clayey silt of low plasticity to a silty clay of intermediate plasticity.

The natural water content measured on samples of the cohesive till deposit range from 12 per cent to 18 per cent and the natural water content measured on a sample of the non-cohesive till deposit was 15 per cent.

4.2.8 Clayey Silt (Residual Soil)

Underlying the cohesive deposit in Boreholes SWME-1, AR-1 and CRB-6, and the till deposit in Boreholes AR-2, SWME-3 and CRB-7 a 0.2 m to 1.0 m thick deposit of residual soil comprised of clayey silt, some sand to sandy, some gravel, and containing trace to some shale fragments was encountered at depths ranging between about 3.7 m and 8.7 m below ground surface (between Elevations 87.6 m and 84.6 m). The cohesive residual soil deposit is interpreted to be derived from weathering of the underlying shale bedrock and extends to the bedrock surface.

SPT “N”-values measured within the residual soil deposit are 28 blows per 0.3 m of penetration and over 50 blows for 0.13 m of penetration, suggesting a very stiff to hard consistency.

The result of a grain size distribution test completed on one selected sample of the residual soil is shown on Figure B-12 in Appendix B. Atterberg limits tests were carried out on three samples of the residual soil and measured liquid limits of about of 23 per cent, plastic limits ranging from about 15 per cent to 16 per cent, and corresponding plasticity indices ranging from about 7 per cent to 8 per cent. These test results, which are plotted on a plasticity chart on Figure B-13 in Appendix B, indicate that the deposit can be classified as a clayey silt of low plasticity.

The natural water content measured on samples of the residual soil ranges between 9 per cent and 14 per cent.

4.2.9 Shale Bedrock

Bedrock was encountered and inferred by split-spoon sampling in Boreholes SWME-1, SWME-3 and AR-1 and confirmed by bedrock coring in Borehole SWME-4, AR-2, CRB-4, CRB-5, CRB-5A, CRB-6 and CRB-7. The depth to bedrock below ground surface and the corresponding bedrock surface elevations at each borehole location (from east to west) are summarized below.

Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
SWME-4	9.0	86.5	1.0 m penetration by augering and split-spoon sampling followed by 3.3 m of bedrock coring.
AR-1	8.9	86.8	0.3 m penetration by augering and split-spoon sampling
SWME-3	4.5	87.4	0.9 m penetration by augering and split-spoon sampling
CRB-6	4.8	86.9	Bedrock cored 8.2 m
CRB-7	8.1	86.6	Bedrock cored 7.5 m
SWME-1	4.7	84.8	0.8 m penetration by augering and split-spoon sampling
AR-2	4.6	83.8	Bedrock cored 7.0 m
CRB-4	7.0	72.1	Bedrock cored 8.1 m
CRB-5	7.2	72.0	Bedrock cored 8.3 m
CRB-5A	7.2	72.1	Bedrock cored 9.5 m

In general, the inferred / confirmed bedrock surface as encountered in the boreholes advanced in the area of the proposed temporary East Access Road varies from about Elevation 72.0 m to 87.4 m.

Based on a review of the bedrock core samples, the bedrock consists of shale of the Georgian Bay Formation. In general, the bedrock samples are described as highly weathered to fresh, thinly bedded, fine grained, faintly to non-porous, weak, grey, with medium strong to strong limestone interbeds at varying intervals, as presented in the drillhole records in Appendix A, and shown on the photographs of the recovered core samples on Figures A-1 to A-8 in in Appendix A. Typically, the upper portion of the bedrock surface is weathered and transitions to slightly weathered to fresh at depth. The degree of weathering of the bedrock samples (e.g. slightly weathered –W2), and

the strength classification of the intact rock mass based on field identification (e.g. weak – R2) are described in accordance with the International Society for Rock Mechanics (ISRM[3]) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples ranges between 0 per cent to 100 per cent, with core run near (typically the upper 1 m) bedrock surface ranging from about 0 per cent to 25 per cent (indicating a rock mass of very poor to poor quality) and core run at depth (typically below about 1 m below bedrock surface) ranging from about 50 per cent to 100 per cent (indicating a rock mass of fair to excellent quality), as classified per Table 3.10 of CFEM (2006)[4]. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered range between 10 and 100 per cent and between 0 per cent and 97 per cent, respectively.

Uniaxial compression (UC) tests (ASTM D7012)[5] were carried out on selected core samples of the shale bedrock and the uniaxial compressive strength (UCS), bulk density and tangent Young's modulus of the intact samples are summarized below and the details are presented in the Rock Laboratory Test Result report(s) from Geomechanica in Appendix B.

Borehole Number	Sample Depth Interval (m)	Sample Elevation Interval (m)	Uniaxial Compressive Strength (UCS) (MPa)	Bulk Density (g/cm^3)	Tangent Young's Modulus (GPa)
SWME-4 (Run #1)	10.4 – 10.5	85.1 to 85.0	13.5	2.59	not tested
AR-2 (Run #2)	5.9 – 6.1	82.5 to 82.3	9.1	2.57	not tested
AR-2 (Run #4)	8.6 – 8.8	79.8 to 79.6	11.5	2.59	not tested
CRB-4 (Run #5)	13.6 – 13.8	65.5 to 65.3	18.6	2.61	0.84
CRB-5 (Run #5)	13.7 – 13.9	65.5 to 65.3	15.5	2.61	0.61
CRB-5A (Run #4)	12.4 – 12.6	66.9 to 66.7	14.2	2.60	0.96
CRB-5A (Run #6)	15.4 – 15.6	63.9 to 63.7	22.7	2.64	0.93
CRB-6 (Run #1)	6.0 - 6.2	85.7 to 85.5	14.6	2.17	0.63
CRB-7 (Run#2)	9.2 – 9.4	85.5 to 85.3	15.5	2.59	0.65
CRB-7 (Run #3)	12.1 – 12.4	82.6 to 82.3	7.4	2.59	1.28

A total of fifteen diametral and fifteen axial point load tests were carried out on shale bedrock core specimens and measured axial and diametral point load strength indices ranging from 0.04 MPa to 2.14 MPa, with an average value of 0.49 MPa. The average point load test index for axial and diametral orientations was 0.66 m MPa and 0.41 MPa, respectively. The results are summarized in Table B-1 in Appendix B.

[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.

[4] Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.

[5] ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

Based on the laboratory UCS tests and also considering the point load strength indices, in accordance with Table 3.5 in CFEM (2006)[4], the shale bedrock is generally classified as weak (R2, 5 MPa < UCS < 25 MPa).

4.2.10 Groundwater Conditions

The overburden samples obtained from the boreholes were generally moist. Boreholes SWME-1, CRB-6, CRB-7 and AR-2 were observed to be open and dry upon completion of drilling and prior to rock coring. Upon completion of drilling overburden in Boreholes SWME-4, AR-1, CRB-4, CRB-5 and CRB-5A the water level in the open boreholes was measured at depths of between 3.7 m and 7.6 m below ground surface (corresponding to Elevations 87.9 m, 92.0 m and 92.0 m about 75.0 m at Boreholes CRB-4, CRB-5 and CRB-5A), upon completion of overburden drilling and prior to rock coring. The depths to the water level observed in the boreholes upon completion of drilling and prior to rock coring is presented below. It is noted that these observations are not necessarily representative of the stabilized groundwater level at the site.

Borehole No.	Ground Surface Elevation (m)	Water Level Depth (m)	Water Elevation (m)	Comment
SWME-4	95.5	7.6	87.9	Upon completion of overburden drilling and prior to rock coring.
AR-1	95.7	3.7	92.0	Upon completion of drilling.
SWME-3	91.9	5.3	86.6	Upon completion of drilling.
CRB-4	79.1	3.8	75.4	Upon completion of overburden drilling and prior to rock coring.
CRB-5	79.2	4.3	74.9	
CRB-5A	79.3	3.6	75.7	

A standpipe piezometer was installed in Boreholes SWME-3, CRB-5A and CRB-6. Details of the stratum that the piezometer screen was sealed into, the recorded water levels and elevations are summarized below.

Borehole No. / Piezometer	Stratum Well Screen Sealed Into	Ground Surface Elevation (m)	Water Level Depth (m)	Water Elevation (m)	Date of Piezometer Reading
SWME-3	Clayey Silt Till, / Clayey Silt Residual Soil / Shale Bedrock	91.9	4.0	87.9	August 14, 2018
			3.8	88.1	November 6, 2018
CRB-6	Shale Bedrock	91.7	5.6	86.0	November 12, 2017
			5.0	86.7	March 12, 2018
			4.9	86.8	April 30, 2018
			4.9	86.8	November 6, 2018

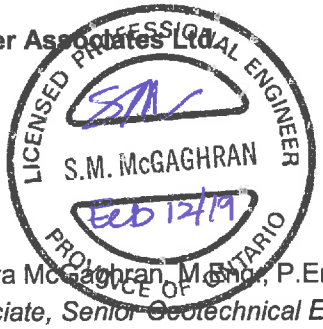
Borehole No. / Piezometer	Stratum Well Screen Sealed Into	Ground Surface Elevation (m)	Water Level Depth (m)	Water Elevation (m)	Date of Piezometer Reading
CRB-5A	Silty Sand/Organic Clayey Silt/Shale Bedrock	79.3	1.6	77.7	March 12, 2018
			4.0	75.3	April 30, 2018
			4.6	74.7	November 6, 2018

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. The groundwater levels may be influenced by the water level in the adjacent Credit River which was measured to be at Elevation 75 m in September 1986. The high-water level for the Credit River is reported to be at Elevation 77.7 m for the 100-year storm.

5.0 CLOSURE

This report was prepared by Ms. Sandra McGaghran, M.Eng., P.Eng., a Geotechnical Engineer and Associate with Golder. Mr. Kevin J. Bentley, P.Eng., an Associate and MTO Foundations Designated Contact with Golder, conducted a quality control audit of the report.

Golder Associates Ltd.

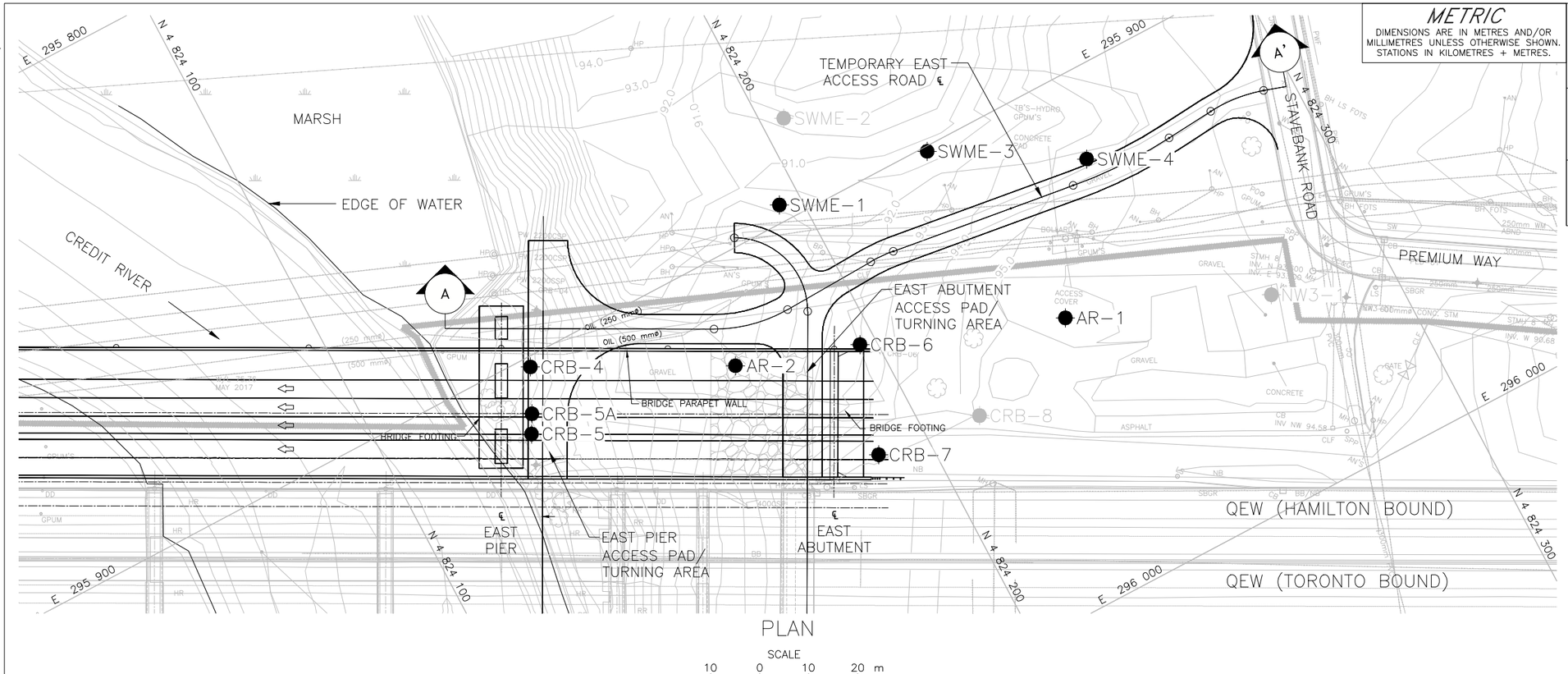


Sandra McGaghran, M.Eng., P.Eng.
Associate, Senior Geotechnical Engineer

Kevin J. Bentley, P.Eng.
Associate, MTO Foundations Designated Contact

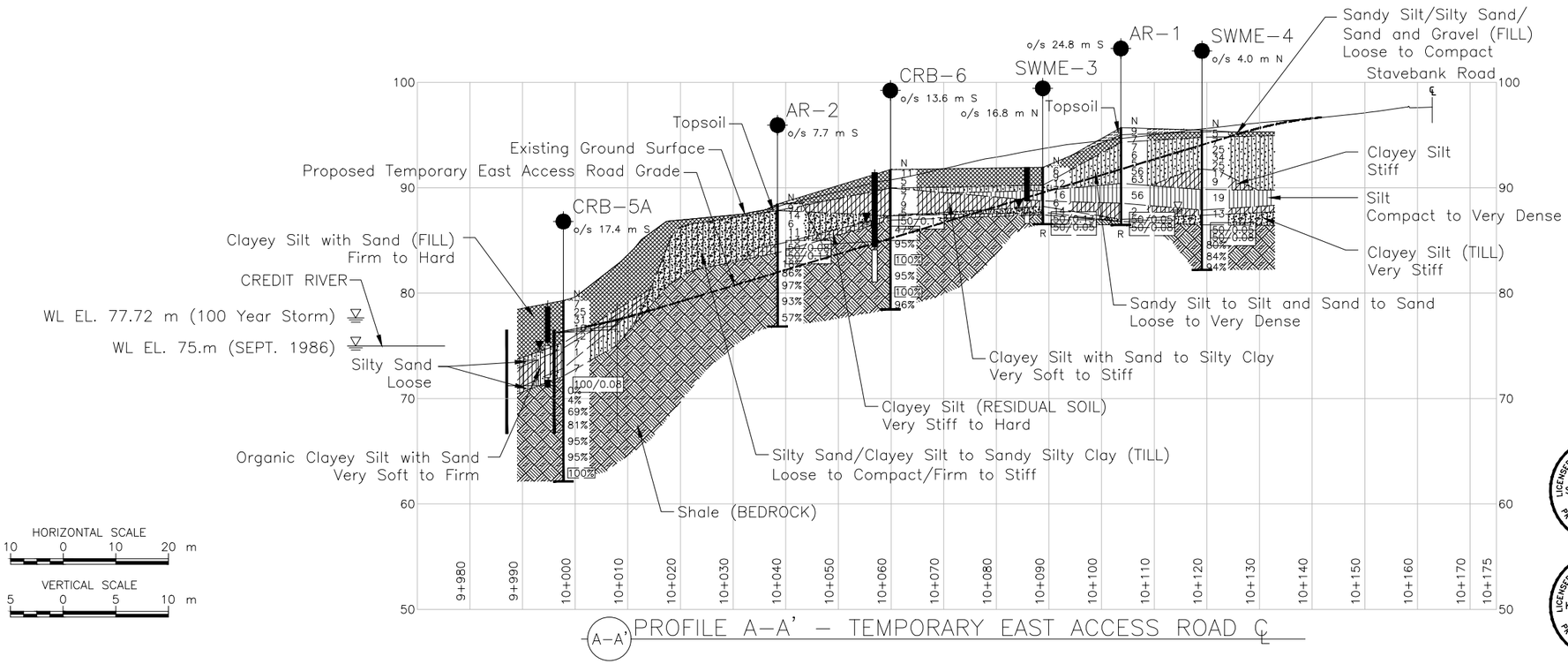
AM//MS/SMM/KJB/rb

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE
10 0 10 20 m



HORIZONTAL SCALE
10 0 10 20 m

VERTICAL SCALE
5 0 5 10 m

A-A' PROFILE A-A' – TEMPORARY EAST ACCESS ROAD ℄

METRIC

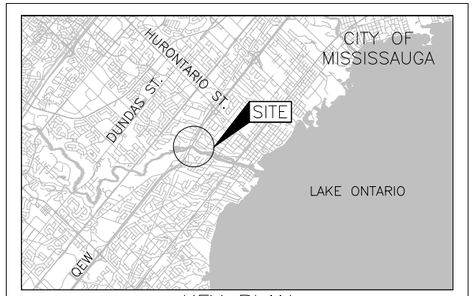
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2019-2016
GWP No. 2002-13-00

SHEET .

QEW WIDENING-MISISSAUGA RD TO HURONTARIO ST
TEMPORARY EAST ACCESS ROAD
BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- R — Split-Spoon Refusal
- WL in piezometer, measured on November 6, 2018
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
AR-1	95.7	4824236.4	295944.2
AR-2	88.4	4824172.2	295921.4
CRB-4	79.1	4824135.1	295902.0
CRB-5	79.2	4824128.9	295914.2
CRB-5A	79.3	4824130.9	295910.6
CRB-6	91.7	4824196.7	295929.5
CRB-7	94.7	4824189.6	295951.1
SWME-1	89.5	4824195.5	295896.6
SWME-3	91.9	4824227.3	295901.0
SWME-4	95.5	4824255.4	295917.6

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.
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file no. X11609340Base.dwg, received April 12, 2018.
General Arrangement plan and profile provided in digital format by Morrison Hershfield, drawing file no. 01.GENERAL ARRANGEMENT (for Golder).dwg, received April 13, 2018.
Utility plan provided in digital format by Morrison Hershfield, drawing file no. X-EX-UTIL-BASE.dwg, received April 17, 2018.
Access Road plan provided in digital format by Morrison Hershfield, drawing file 1160934 – Construction Access Road.dwg, received July 26, 2018.

LICENSED PROFESSIONAL ENGINEER S. McGaghran Feb. 01, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K. J. BENTLEY Feb. 01, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 30M12-437

HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. AM	CHKD. DPM	DATE: 02/01/2019	SITE: .
DRAWN: DD	CHKD. SMM	APPD. KJB	DWG. 1

PLOT DATE: February 1, 2019
FILENAME: S:\Clients\MTO\QEW-Credit_River\99_PROJ\1662333_MM_P&P\40_PROD\0010_Access_Road\1662333-0010-BS-0001.dwg

APPENDIX A

Record of Borehole and Drillhole Sheets 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 AR-1

SHEET 1 OF 1 **METRIC**

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

LOCATION N 4824236.4; E 295944.3 MTM NAD 83 ZONE 10 (LAT. 43.558012; LONG. -79.609616)
BOREHOLE TYPE CME 55, 114 mm I.D., Hollow Stem Augers
DATE July 30, 2018

ORIGINATED BY ACM
COMPILED BY CC
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
95.7	GROUND SURFACE										
0.0	TOPSOIL (700 mm)		1	SS	9						
95.0							95				
0.7	Sand, some silt to silt and sand, trace clay (FILL) Loose Brown Moist		2	SS	7						
94.3							94				
1.4	SAND, some silt SILT and SAND, trace clay Loose to very dense Brown Moist - Oxidation staining from 2.3 m to 3.7 m - Wet from 3.0 m to 3.7 m		3	SS	7				o		0 81 16 3
			4	SS	6		93				
			5	SS	5				o		
			6	SS	56		92		o		0 35 61 4
			7	SS	63		91				
90.4											
5.3	SILT, trace to some sand, trace to some clay Very dense Brown to grey Moist		8	SS	56		90		o		0 11 82 7
88.5							89				
7.2	CLAYEY SILT, trace sand Very soft Grey Moist to wet		9	SS	2		88		o—o		0 1 55 44
87.0			10A	SS	50/0.05						
	Sandy CLAYEY SILT, trace to some gravel, some shale fragments (RESIDUAL SOIL) Hard Grey Moist to wet		10B				87		o—o		7 29 46 18
86.5			11	SS	50/0.08						
9.2	SHALE (BEDROCK) Grey END OF BOREHOLE SPLIT-SPOON REFUSAL										

NOTES:

1. Water level at a depth of approximate 3.7 m below ground surface (Elev. 92.0 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 1/9/19

GOLDER

RECORD OF BOREHOLE No AR-2

SHEET 1 OF 1 **METRIC**

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4824172.2; E 295921.4 MTM NAD 83 ZONE 10 (LAT. 43.557434; LONG. -79.609899) ORIGINATED BY ACM

DIST Central HWY QEW BOREHOLE TYPE CME 75, 114 mm I.D. Hollow Stem Augers, HQ Casing COMPILED BY CC

DATUM Geodetic DATE July 30, 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
88.4	GROUND SURFACE										
0.0 / 87.8	TOPSOIL (600 mm)		1	SS	9		88				
0.6 / 87.3	CLAYEY SILT, some sand, some gravel, trace rootlets, shale fragments (TILL)		2A 2B	SS	14						
1.1	Stiff Brown to grey Moist						87				
86.2	SILT and SAND, trace to some clay, trace to some gravel, clayey silt pockets, shale fragments (TILL)		3	SS	6						6 56 31 7
2.2	Loose to compact Brown Moist		4	SS	11		86				
84.6	Sandy SILTY CLAY, trace to some gravel, trace shale fragments (TILL) Stiff Brown grey with oxidation staining Moist		5	SS	13		85				7 22 44 27
3.8	CLAYEY SILT, some sand, some shale fragments (RESIDUAL SOIL)		6	SS	50/0.08						
83.8	Hard Brown grey Moist		7	SS	50/0.13		84				
4.6	SHALE (BEDROCK) Grey Bedrock cored from a depth of 4.6 m to 11.6 m For bedrock coring details, refer to Record of Drillhole AR-2		1	RC	REC 100%						RQD = 18%
			2	RC	REC 100%		83				RQD = 86%
			3	RC	REC 100%		82				RQD = 97%
			4	RC	REC 100%		81				RQD = 93%
			5	RC	REC 100%		80				RQD = 57%
76.8							79				
11.6	END OF BOREHOLE NOTES: 1. Borehole dry prior to rock coring.						78				
							77				

$+^3, \times^3$: 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 1/9/19

PROJECT: 1662333

RECORD OF DRILLHOLE: AR-2

SHEET 1 OF 1

LOCATION: N 4824172.2 ;E 295921.4

DRILLING DATE: July 30, 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 AR-2		83.87															
5	HQ Core	Moderately to slightly weathered, thinly laminated to medium bedded, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		4.57	1							BD,UN,SM CC, Cl BD,UN,SM CC, Cl BD,PL,SM CC, Cl BD,UN,SM SA, He BD,UN,SM PC, Cl BD,UN,RO SA BD,UN,SM CC, Cl BD,PL,SM SA, He BD,UN,SM CC, Cl BD,UN,RO CC, Cl	2 2 1 2 2 3 2 1 2 3	4 4 4 2 3 2 4 2 4 4	R4 R3 R2 R1	W1 W2 W3 W4 W5 W6		R1 R1	
6					2							BD,PL,RO PC, Cl	1.5	3					UCS = 9.1 MPa
7																			
8					3							BD,UN,SM CL	2	1					
9					4							BD,UN,SM CC, Cl	2	4					UCS = 11.5 MPa
10												BD,CU,SM PC, Cl	2	3					
11					5							BD,UN,SM CC, Cl JN,PL,SM CC, Cl BD,PL,SM CC, Cl BD,PL,SM SA, Co	2 1 1 1	4 4 4 2					
				76.84															
12		END OF DRILLHOLE		11.60															
13																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ACM

CHECKED: AB

GTA-RCK 054 S:\CLIENTS\MTO\CEW-CREDIT_RIVER\02_DATA\GINT\CEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 1/9/19

GOLDER

RECORD OF BOREHOLE No CRB-4

SHEET 1 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824135.1; E 295902.0 MTM NAD 83 ZONE 10 (LAT. 43.557099; LONG. -79.610138)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 55, 159 mm O.D., 70 mm I.D. Hollow Stem Augers (Auto Hammer)

COMPILED BY KN

DATUM Geodetic

DATE February 16, 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
79.1	GROUND SURFACE										
0.0	Clayey silt with sand, trace to some gravel, contains rootlets, contains shale fragments (FILL) Firm to hard Brown, becoming grey at 3.1 m Moist		1	SS	6		79				
			2	SS	13		78				
			3	SS	8		77				
			4	SS	23						7 41 37 15
			5	SS	31		76				
75.4						▽					
3.7	Sandy CLAYEY SILT, some gravel, contains shale fragments Stiff Moist, becoming wet at 4.6 m		6	SS	11		75				14 27 42 17
			7	SS	13		74				
73.0											
6.2	ORGANIC CLAYEY SILT with SAND, trace gravel, contains sand lenses Soft Brown Wet		8	SS	3		73			46 47	2 32 56 10
72.1											
7.0	SHALE (BEDROCK) Grey		1	RC	REC 100%		72				RQD = 0%
	Bedrock cored from a depth of 7.2 m to 15.3 m		9	SS	50/0.10						
	For bedrock coring details, refer to Record of Drillhole CRB-4		2	RC	REC 87%		71				RQD = 53%
			3	RC	REC 97%		70				RQD = 77%
			4	RC	REC 100%		69				RQD = 79%
			5	RC	REC 100%		68				RQD = 86%
			6	RC	REC 100%		67				RQD = 97%
							66				
							65				

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No CRB-4

SHEET 2 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4824135.1; E 295902.0 MTM NAD 83 ZONE 10 (LAT. 43.557099; LONG. -79.610138) ORIGINATED BY JL

DIST Central HWY QEW BOREHOLE TYPE CME 55, 159 mm O.D., 70 mm I.D. Hollow Stem Augers (Auto Hammer) COMPILED BY KN

DATUM Geodetic DATE February 16, 2018 CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
63.8	SHALE (BEDROCK)		6	RC			64				RQD = 97%
15.3	END OF BOREHOLE										
	NOTES:										
	1. Water level encountered during drilling at a depth of about 4.6 m (Elev. 74.5 m) below ground surface.										
	2. Water level measured in open borehole at a depth of about 3.8 m (Elev. 75.4 m) below ground surface prior to rock coring.										

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: CRB-4

SHEET 1 OF 1

LOCATION: N 4824135.1 ;E 295902.0

DRILLING DATE: February 16, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track

DRILLING CONTRACTOR: Geo-Environmental 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 CRB-4		71.88															
	HQ Core	Completely weathered, thinly laminated to medium bedded, brown-grey, very fine to fine grained, faintly porous, extremely weak SHALE (Georgian Bay Formation)		7.22 / 71.58	1														
		Moderately weathered to fresh, thinly to medium bedded, brown-grey, fine grained, faintly porous, very weak to weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		7.52	2							BD,UN,SM SA, CI	2	2					R0 R1 R0 R1 R0 R1 R0
8																			
9																			PLT(D) = 0.04 MPa PLT(A) = 1.02 MPa
		Fresh, thinly to medium bedded, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds			3							JN,PL,SM CL CO,UN,SM IN, CI JN,CU,SM CL BD,UN,SM PC, CI BD,UN,SM IN, CI	1 2 2 2 2	1 6 1 3 6					PLT(A) = 2.14 MPa
10																			
11					4							CO,UN,SM SA, CI JN,CU,SM CL CO,UN,SM IN, CI BD,UN,SM PC, CI CO,UN,SM PC, CI BD,UN,SM IN, CI CO,UN,SM CL	2 2 2 2 2 2 2	2 1 6 3 3 6 1					
12												BD,UN,SM CL	2	1					
13					5							CO,PL,SM CL CO,PL,SM CL CO,UN,SM SA, CI CO,UN,SM CL	1 1 2 2	1 1 2 1					PLT(D) = 0.89 MPa UC = 15.5 MPa
14					6														PLT(D) = 0.08 MPa
15				63.79								BD,UN,SM IN, CI	2	6					PLT(A) = 0.23 MPa
		END OF DRILLHOLE		15.31															
16																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: JL
CHECKED: DM

GTA-RCK 054 S:\CLIENTS\MTO\CEW-CREDIT_RIVER\02_DATA\GINT\CEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 1/9/19

GOLDER

RECORD OF BOREHOLE No CRB-5

SHEET 1 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824128.9; E 295914.2 MTM NAD 83 ZONE 10 (LAT. 43.557044; LONG. -79.609986)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 55, 203 mm O.D., 108 mm I.D. Hollow Stem Augers (Auto Hammer)

COMPILED BY KN

DATUM Geodetic

DATE February 13, 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 / 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
79.2	GROUND SURFACE										
0.0	Silty sand, some gravel, contains rootlets (FILL) Loose Brown		1	SS	6						
78.5											
0.7	Wet										
	Clayey silt with sand, trace to some gravel, contains rootlets / organics. contains clayey silt pockets and shale fragments (FILL) Very stiff Brown and grey Moist/frozen		2	SS	25						
			3	SS	23						
76.8			4A 4B	SS	6						
2.4	Silty SAND to SILT and SAND, trace gravel, trace clay, trace organics, contains clayey silt pockets and rootlets Very loose to loose Brown to grey Moist to wet		5	SS	4						
			6	SS	0	▽				OC= 1.1%	5 60 29 6
74.5			7A 7B	SS	1						
4.7	ORGANIC CLAYEY SILT with SAND, trace gravel Very soft to firm Brown Moist										
73.5			8A 8B	SS	5					OC= 7.1%	1 41 50 8
5.7	Silty SAND, trace to some gravel, trace clay, contains clayey silt pockets, contains wood fragments Loose Grey Wet		9	SS	4						8 68 20 4
72.0			10A								
7.2	SHALE (BEDROCK) Grey Bedrock cored from a depth of 7.2 m to 15.5 m For bedrock coring details, refer to Record of Drillhole CRB-5		10B 1	SS RC	73 REC 53%						RQD = 0%
			2	RC	REC 51%						RQD = 13%
			3	RC	REC 100%						RQD = 99%
			4	RC	REC 100%						RQD = 73%
			5	RC	REC 97%						RQD = 78%
			6	RC	REC 100%						RQD = 99%

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No CRB-5

SHEET 2 OF 2 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
LOCATION N 4824128.9; E 295914.2 MTM NAD 83 ZONE 10 (LAT. 43.557044; LONG. -79.609986)
ORIGINATED BY JL
DIST Central HWY QEW
BOREHOLE TYPE CME 55, 203 mm O.D., 108 mm I.D. Hollow Stem Augers (Auto Hammer)
COMPILED BY KN
DATUM Geodetic
DATE February 13, 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
	--- CONTINUED FROM PREVIOUS PAGE ---										
63.7	SHALE (BEDROCK) Grey		6	RC	REC 100%		64				RQD = 99%
15.5	END OF BOREHOLE										

NOTES:

1. Water level encountered during drilling at a depth of about 3.7 m (Elev. 75.5 m)below ground surface.

2. Water level measured in open borehole at a depth of about 4.3 m (Elev. 74.9 m) below ground surface prior to rock coring.

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: CRB-5

SHEET 1 OF 1

LOCATION: N 4824128.9 ;E 295914.2

DRILLING DATE: February 13, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track

DRILLING CONTRACTOR: Geo-Environmental 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
		Continued from Borehole CRB-5		72.02															
	HQ Core	Highly weathered, thinly laminated to medium bedded, brown to grey, very fine to fine grained, faintly porous, very weak SHALE (Georgian Bay Formation)		7.18	1							BD,UN,SM CC, CI BD,UN,SM CC, CI	2 2	4 4	R4 R3 R2 R1	W1 W2 W3 W4 W5 W6			R0
				71.38															
8		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		7.82	2							BD,UN,RO PC, CI BD,UN,RO PC, CI	3 3	3 3					R1
9												JN,UN,SM SA, CI CO,UN,SM PC, CI	2 2	2 3					PLT(D) = 0.76 MPa PLT(A) = 0.37 MPa
		Slightly weathered to fresh, thinly to medium bedded, grey, fine grained, faintly porous, very weak to weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds			3							JN,PL,SM SA, CI	1	2					PLT(A) = 1.45 MPa R1 R1
10																			R1
																			R1
11					4							CO,UN,SM CL CO,UN,SM SA, CI JN,IR,SM SA, CI	2 2 2	1 2 2					
12												CO,CU,SM PC, CI JN,IR,SM SA, CI CO,UN,SM CC, CI CO,UN,SM CC, CI	2 2 2 2	3 2 4 4					
					5							BD,UN,SM CC, CI BD,UN,SM CC, CI	2 2	4 4					R0
13												BD,UN,SM CL BD,UN,SM CL JN,PL,SM SA, CI CO,UN,SM CC, CI BD,UN,SM IN, CI CO,CU,SM SA, CI JN,IR,SM SA, CI CO,UN,SM SA, CI	2 2 1 2 2 2 2 2	1 1 2 4 6 2 2 2					R1 PLT(D) = 0.07 MPa
14																			UC = 18.6 MPa
					6							BD,UN,SM IN, CI	2	6					PLT(D) = 0.52 MPa PLT(A) = 0.27 MPa
15				63.68															
		END OF DRILLHOLE		15.52															
16																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: JL

CHECKED: DM

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 1/9/19

GOLDER

RECORD OF BOREHOLE No CRB-5A

SHEET 1 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824130.9; E 295910.6 MTM NAD 83 ZONE 10 (LAT. 43.557062; LONG. -79.610032)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 55, 159 mm O.D., 70 mm I.D. Hollow Stem Augers (Auto Hammer)

COMPILED BY KN

DATUM Geodetic

DATE February 15 and 16, 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
79.3	GROUND SURFACE										
0.0	Clayey silt with sand, trace to some gravel, contains organics / rootlets, contains wood fragments. contains shale fragments with limestone (FILL) Firm to hard Brown to grey Moist to wet		1	SS	7		79				
			2	SS	25		78		○		
			3	SS	31				○ —		11 45 34 10
			4	SS	16		77				
			5	SS	12		76		○		
75.3											
4.0	Silty SAND, trace rootlets and wood fragments Loose		6A 6B	SS	7		75		○		
74.8						▽					
4.5	Brown Wet		7	SS	1				○ — ○ 41 43	OC= 5.5%	0 20 62 18
	ORGANIC CLAYEY SILT, some sand, contains sand lenses, wood fragments and shell fragments Very soft to firm Brown Moist to wet						74				
72.9			8A 8B	SS	7		73		○		0 71 24 5
6.4	Silty SAND, trace clay, contains shell fragments and rootlets Loose Grey										
72.1	Wet						72				
7.2	SHALE (BEDROCK) Grey		9	SS	100/0.08						
	Bedrock cored from a depth of 7.7 m to 17.2 m For bedrock coring details, refer to Record of Drillhole CRB-5A		1	RC	REC 100%						RQD = 0%
			2	RC	REC 13%		71				RQD = 4%
			3	RC	REC 100%		70				RQD = 69%
			4	RC	REC 100%		69				RQD = 81%
			5	RC	REC 100%		68				RQD = 95%
			6	RC	REC 100%		67				RQD = 95%
							66				
							65				

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

PROJECT 1662333

RECORD OF BOREHOLE No CRB-5A

SHEET 2 OF 2

METRIC

G.W.P. 2002-13-00 LOCATION N 4824130.9; E 295910.6 MTM NAD 83 ZONE 10 (LAT. 43.557062; LONG. -79.610032) ORIGINATED BY JL

DIST Central HWY QEW BOREHOLE TYPE CME 55, 159 mm O.D., 70 mm I.D. Hollow Stem Augers (Auto Hammer) COMPILED BY KN

DATUM Geodetic DATE February 15 and 16, 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 / 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
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SHALE (BEDROCK) Grey Bedrock cored from a depth of 7.7 m to 17.2 m For bedrock coring details, refer to Record of Drillhole CRB-5A		6	RC	REC 100%		64				RQD = 95%
			7	RC	REC 100%		63				RQD = 100%
62.1 17.2	END OF BOREHOLE										

NOTES:

1. Water level encountered during drilling at a depth of about 4.0 m (Elev. 75.3 m) below ground surface.

2. Water level measured in open borehole at a depth of about 3.6 m (Elev. 75.7 m) below ground surface prior to rock coring.

3. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
12/03/18	1.6	77.7
30/04/18	4.0	75.3
06/11/18	4.6	74.8

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: CRB-5A

SHEET 1 OF 2

LOCATION: N 4824130.9 ;E 295910.6

DRILLING DATE: February 15 and 16, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track

DRILLING CONTRACTOR: Geo-Environmental 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: 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 Borehole CRB-5A		71.58																							
8	HQ Core	Completely to highly weathered, thinly laminated to medium bedded, brown to grey, very fine to fine grained, faintly porous, extremely weak SHALE (Georgian Bay Formation)		7.72	1																						
					2							JN,UN,SM SA	2	2												R1
9				69.75																							
		Fresh, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		9.55																							
10					3							CO,UN,SM SA, CI	2	2													
												JN,PL,SM CC, CI	2	4													
												JN,PL,SM CL	1	1													
												CO,UN,SM PC, CI	2	3													PLT(D) = 0.56 PLT(A) = 0.42
												CO,UN,SM IN, CI	2	6													
												BD,UN,SM CL	2	1													
11					4							JN,CU,SM CL	2	1													
												CO,UN,SM SA, CI	2	2													
												CO,UN,SM SA, CI	2	2													
												CO,UN,SM IN, CI	2	6													
												CO,UN,SM IN, CI	2	6													
												CO,UN,SM IN, CI	2	6													
												JN,PL,SM CL	1	2													
												JN,UN,SM SA, CI	2	2													
12												CO,UN,SM IN, CI	2	6												R1	
												CO,UN,SM PC, CI	2	3													
												BD,UN,SM PC, CI	2	3													
																										R1	
																										R1	UC = 14.2 MPa
13					5							CO,CU,SM SA, CI	2	2												R1	
												JN,UN,SM CL	2	1													
												CO,UN,SM CL	2	1													
												BD,UN,SM IN, CI	2	6													
14																											PLT(D) = 0.43 PLT(A) = 0.07
					6							CO,UN,SM SA, CI	2	2													
15												CO,UN,SM SA, CI	2	2													
												CO,UN,SM CL	2	1													
																											UC = 22.7 MPa
16					7							BD,UN,SM SA, CI	2	2													
		CONTINUED NEXT PAGE																									

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: JL

CHECKED: DM

GTA-RCK 054 S:\CLIENTS\MTO\CEW-CREDIT_RIVER\02_DATA\GINT\CEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 1/9/19

PROJECT: 1662333

RECORD OF DRILLHOLE: CRB-5A

SHEET 2 OF 2

LOCATION: N 4824130.9 ;E 295910.6

DRILLING DATE: February 15 and 16, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track

DRILLING CONTRACTOR: Geo-Environmental 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 PREVIOUS PAGE ---																	
17	HQ Core				7														PLT(D) = 0.82 PLT(A) = 0.24
		END OF DRILLHOLE		62.14 17.16															
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: JL

CHECKED: DM

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GOLDER

RECORD OF BOREHOLE No CRB-6

SHEET 1 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824196.7; E 295929.5 MTM NAD 83 ZONE 10 (LAT. 43.557650; LONG. -79.609801)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers, HQ Casing (Auto Hammer)

COMPILED BY MPL

DATUM Geodetic

DATE October 18-20, 2017

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
91.7	GROUND SURFACE										
0.0	Silty sand, trace to some gravel, trace clay, contains brick fragments (FILL) Loose to compact Brown Moist		1	SS	11		91				
			2	SS	5						7 67 24 2
90.0											
1.7	Sandy CLAYEY SILT, trace to some gravel Firm to stiff brown Moist to wet - Mottled brown-grey below a depth of about 2.3 m		3A 3B	SS	5		90				
			4	SS	7		89				
			5	SS	9						
	- Becoming gravelly at a depth of about 3.7 m - Auger grinding at a depth of about 3.7 m		6	SS	5		88				10 26 44 20
87.3											
4.4	Sandy CLAYEY SILT, containing shale fragments (RESIDUAL SOIL) Hard Grey Moist		7	SS	50/0.13		87				
86.9											
4.8	SHALE (BEDROCK) Grey		1	RC	REC 86%		86				RQD = 47%
	Bedrock cored from a depth of 5.1 m to 13.3 m For bedrock coring details, refer to Record of Drillhole CRB-6		2	RC	REC 100%		85				RQD = 95%
			3	RC	REC 100%		84				RQD = 100%
			4	RC	REC 100%		82				RQD = 95%
			5	RC	REC 100%		80				RQD = 100%
			6	RC	REC 96%		79				RQD = 96%
78.4											
13.3	END OF BOREHOLE										

Continued Next Page

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

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

GOLDER

PROJECT 1662333

RECORD OF BOREHOLE No CRB-6

SHEET 2 OF 2

METRIC

G.W.P. 2002-13-00 LOCATION N 4824196.7; E 295929.5 MTM NAD 83 ZONE 10 (LAT. 43.557650; LONG. -79.609801) ORIGINATED BY JL

DIST Central HWY QEW BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers, HQ Casing (Auto Hammer) COMPILED BY MPL

DATUM Geodetic DATE October 18-20, 2017 CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	w_P w w_L 10 20 30	γ kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTES: 1. Borehole dry prior to rock coring. 2. Water level measured in standpipe piezometer: Date / Depth (m) / Elev. (m) 12/11/17 5.6 86.0 12/03/18 5.0 86.7 30/04/18 4.9 86.8 06/11/18 4.9 86.8										

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

PROJECT: 1662333

RECORD OF DRILLHOLE: CRB-6

SHEET 1 OF 1

LOCATION: N 4824196.7 ;E 295929.5

DRILLING DATE: October 18-20, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track

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	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Borehole CRB-6		86.63															
	HQ Casing	Moderately weathered to fresh, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		5.12															
		Moderately weathered to fresh, thinly laminated to medium bedded, grey, fine grained, slightly porous, weak SHALE (Georgian Bay Formation) with slightly weathered to fresh, thinly bedded, grey, fine grained, non-porous, medium strong, LIMESTONE interbeds.			1							BD,PL,SM CL	1	1				R1	
												BD,PL,RO SA	1.5	2					
												CO,UN,RO CL	3	1				R1	
6												CO,UN,RO CL	3	1					PLT(A) = 0.70 MPa PLT(D) = 0.44 MPa UCS = 14.6 MPa
												BD,PL,SM CL	1	1				R1	
												BD,PL,SM CL	1	1					
												BD,PL,SM CL	1	1					
												CO,UN,RO PC, CI	3	3				R1	
												CO,PL,SM SA	1	2					
7					2							CO,UN,SM CL	2	1					PLT(A) = 0.65 MPa PLT(D) = 0.51 MPa
8												BD,UN,SM CL	2	1					
					3							CO,UN,RO CL	3	1					
9												BD,PL,SM CL	1	1					PLT(A) = 0.61 MPa PLT(D) = 0.15 MPa
												CO,PL,SM PC, CI	1	3					
												BD,PL,SM CL	1	1					
10												BD,PL,SM CL	1	1					
					4														
11												BD,PL,SM CL	1	1					
					5														
12												BD,PL,SM CL	1	1					
					6							CO,UN,SM PC, CI	2	3					
13												BD,IR,RO CL	3	1					
				78.48															
		END OF DRILLHOLE		13.27															
14																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: JL

CHECKED: MPL

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GOLDER

RECORD OF BOREHOLE No CRB-7

SHEET 1 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824189.6; E 295951.1 MTM NAD 83 ZONE 10 (LAT. 43.557590; LONG. -79.609531)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers, HQ Casing (Auto Hammer)

COMPILED BY MPL

DATUM Geodetic

DATE October 23, 2017

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
94.7	GROUND SURFACE										
0.0	TOPSOIL (180mm)										
0.2	Silt and sand, trace gravel, trace clay (FILL) Loose to compact Brown Moist		1	SS	8		94				
			2	SS	9				○		
			3	SS	12		93		○		3 62 33 2
	- Becoming wet at a depth of about 2.6 m		4	SS	19		92				
			5	SS	21				○		
	- Brick fragments at a depth of about 4.0 m		6A 6B	SS	54		91		○		
90.2											
4.5	Sandy SILT, trace clay Compact Brown Wet - Clayey silt layer between 4.6 m to 4.7 m - Becoming grey at a depth of about 4.9 m		7	SS	26		90		○		
			8	SS	25		89		○	NP	0 22 75 3
			9A 9B 9C	SS	17				○		
88.2	- Clayey silt layer between 6.4 m and 6.5 m						88				
6.5	CLAYEY SILT with SAND, trace gravel (TILL) Stiff to hard Grey Moist		10	SS	10				○—○		4 30 47 19
86.9							87				
	Sandy CLAYEY SILT, containing		11	SS	50/0.15				○		
86.6	shale fragments (RESIDUAL										
8.1	SOIL) Hard Grey Moist										
	SHALE (BEDROCK) Grey Bedrock cored from a depth of 8.5 m to 16.0 m		1	RC	REC 79%		86				RQD = 25%
	For bedrock coring details, refer to Record of Drillhole CRB-7		2	RC	REC 100%		85				RQD = 95%
			3	RC	REC 100%		84				RQD = 100%
			4	RC	REC 100%		83				RQD = 89%
			5	RC	REC 100%		82				RQD = 100%
							81				
							80				

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No CRB-7

SHEET 2 OF 2 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
LOCATION N 4824189.6; E 295951.1 MTM NAD 83 ZONE 10 (LAT. 43.557590; LONG. -79.609531)
ORIGINATED BY JL
DIST Central HWY QEW
BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers, HQ Casing (Auto Hammer)
COMPILED BY MPL
DATUM Geodetic
DATE October 23, 2017
CHECKED BY SMM

SOIL PROFILE			SAMPLES			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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SHALE (BEDROCK) Grey		5	RC	REC 100%						RQD = 100%
78.7			6	RC	REC 100%		79				RQD = 100%
16.0	END OF BOREHOLE NOTE: 1. Borehole dry prior to rock coring.										

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: CRB-7

SHEET 1 OF 1

LOCATION: N 4824189.6 ;E 295951.1

DRILLING DATE: October 23, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track

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 CRB-7		86.16															
9	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		8.53	1							BD,PL,SM SO, Cl	1	1					PLT(A) = 0.47 MPa PLT(D) = 0.26 MPa
												BD,PL,SM CL	1	1					UC = 15.5 MPa PLT(A) = 0.56 MPa PLT(D) = 0.42 MPa
10		Slightly weathered to fresh, thinly bedded, grey, fine grained, non-porous, weak to medium strong, SHALE (Georgian Bay Formation) with slightly weathered to fresh, thinly bedded, grey, fine grained, non-porous, medium strong, LIMESTONE interbeds.			2							BD,UN,RO PC, Cl BD,UN,RO PC, Cl BD,PL,RO CL BD,UN,RO CL	3 3 1.5 3	3 3 1 1					
												CO,UN,RO CC, Cl	3	4					
11					3							CO,UN,SM CL	2	1					
												CO,UN,SM CL	2	1					
												BD,UN,RO SA	3	2					
												CO,UN,SM PC, Cl	2	3					
12																			PLT(A) = 0.85 MPa PLT(D) = 0.32 MPa UC = 7.4 MPa
					4							CO,PL,SM CL	1	1					
												BD,UN,RO PC, Cl	3	3					
												BD,UN,RO CL	3	1					
13												BD,UN,RO PC, Cl	3	3					
												BD,UN,RO PC, Cl	3	3					
												BD,UN,RO PC, Cl	3	3					
												BD,UN,RO PC, Cl	3	3					
14												CO,UN,RO PC, Cl	3	3					
					5							CO,UN,RO PC, Cl	3	3					
15												CO,PL,SM CL	1	1					
					6														
16				78.65															
		END OF DRILLHOLE		16.04															
17																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: JL

CHECKED: MPL

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GOLDER

RECORD OF BOREHOLE No CRB-8

SHEET 1 OF 1 **METRIC**

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4824211.5; E 295953.7 MTM NAD 83 ZONE 10 (LAT. 43.557788; LONG. -79.609499) ORIGINATED BY JL

DIST Central HWY QEW BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers (Auto Hammer) COMPILED BY MPL

DATUM Geodetic DATE October 17, 2017 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
94.7	GROUND SURFACE										
0.0 / 0.1	TOPSOIL (80 mm)										
	Sand, some silt, trace clay (FILL) Very loose to compact Brown Moist		1	SS	3		94				
			2	SS	12				○		
93.3						▽	93		○		
1.5	SAND, some silt, trace clay Compact to dense Brown Moist		3	SS	21				○		
			4	SS	44		92		○		0 84 14 2
	- Becoming wet below a depth of about 3.1 m - Clayey silt pockets at a depth of about 3.1 m		5	SS	35				○		
91.0							91				
3.7	SILT, trace to some sand, trace to some clay Slight plasticity Dense to very dense Grey Wet		6	SS	67				○		
			7	SS	32		90		⊕		0 7 85 8
	- Becoming grey and brown at a depth of about 5.6 m						89				
88.3			8A 8B	SS	22				○		
6.4	CLAYEY SILT, some sand Very stiff Grey Wet						88				
87.1											
7.6	Sandy CLAYEY SILT with shale fragments (RESIDUAL SOIL) Hard Grey Moist		9A	SS	50/0.13		87		○		31 27 34 8
86.7 / 8.1 / 86.2			9B 10	SS	50/0.08						
8.5	- Auger grinding at a depth of about 7.6 m SHALE (BEDROCK) Grey END OF BOREHOLE - SPLIT-SPOON REFUSAL										

NOTE:

1. Water level measured at a depth of about 1.5 m (Elev. 93.2 m) below ground surface upon completion of drilling.

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

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GOLDER

RECORD OF BOREHOLE No NW3-1

SHEET 1 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824275.8; E 295959.8 MTM NAD 83 ZONE 10 (LAT. 43.558358; LONG. -79.609422)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers

COMPILED BY MPL

DATUM Geodetic

DATE October 16-17, 2017

CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.5	GROUND SURFACE							
0.0	TOPSOIL (150mm)							
0.2	Silty sand, trace clay (FILL) Loose Brown Moist	1	SS	5		96		
		2	SS	5				0 64 33 3
95.0						95		
1.5	SILT and SAND to silty SAND, trace clay, trace gravel Compact to very dense Brown Moist to wet	3	SS	22				
	- Silt pocket at a depth of about 2.6 m	4	SS	24		94		0 70 28 2
		5	SS	22		93		
	- Becoming wet at a depth of about 3.7 m	6	SS	24	▽			
		7	SS	47		92		
						91		
	- Becoming grey at a depth of about 6.3 m	8	SS	78		90		5 34 59 2
89.3								
7.2	SILTY CLAY, trace to some sand, trace gravel Soft Grey Wet	9	SS	4		89		
87.8								
8.7	Sandy CLAYEY SILT, trace to some gravel (TILL) Stiff Grey Moist to wet	10	SS	12		87		10 29 45 16
86.4								
10.1	Sandy gravelly CLAYEY SILT, some shale fragments (RESIDUAL SOIL) Hard Grey Moist to wet - Tricone grinding at a depth of about 10.1 m	11	SS	64		86		
		12	SS	100/0.08		85		
84.7	- Tricone grinding at a depth of about 11.6 m							
11.8	Shale (BEDROCK) Grey	1	RC	REC 100%		84		RQD = 97%
	Bedrock cored from a depth of 11.8 m to 15.4 m	2	RC	REC 96%				RQD = 90%
	For bedrock coring details, refer to Record of Drillhole NW3-01	3	RC	REC 97%		83		RQD = 97%
						82		

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | UNIT WEIGHT | REMARKS & GRAIN SIZE DISTRIBUTION (%)

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

Continued Next Page

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

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

GOLDER

RECORD OF BOREHOLE No NW3-1

SHEET 2 OF 2

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824275.8; E 295959.8 MTM NAD 83 ZONE 10 (LAT. 43.558358; LONG. -79.609422)

ORIGINATED BY JL

DIST Central HWY QEW

BOREHOLE TYPE CME 850, 210 mm O.D. Hollow Stem Augers

COMPILED BY MPL

DATUM Geodetic

DATE October 16-17, 2017

CHECKED BY SMM

SOIL PROFILE			SAMPLES			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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
81.1			3	RC	REC 97%						RQD = 97%
15.4	END OF BOREHOLE NOTES: 1. Water level measured at a depth of about 4.5 m (Elev. 92.0 m) below ground surface prior to start of rock coring. 2. Water level measured at top of casing (Elev. 96.9 m) following completion of bedrock coring.										

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: NW3-1

SHEET 1 OF 1

LOCATION: N 4824275.8 ;E 295959.8

DRILLING DATE: October 16-17, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 850 Track

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: 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 Borehole NW3-1		84.70																							
12	HQ Core	Slightly weathered to fresh, thinly laminated to medium bedded, grey, very fine to fine grained, faintly to slightly porous, weak, SHALE (Georgian Bay Formation) with slightly weathered to fresh, thinly bedded, grey, fine grained, non-porous, medium, LIMESTONE interbeds.		11.80	1							BD,PL,SM SA	1	2													
												BD,PL,RO CL	1.5	1													
												BD,UN,SM SA	2	2													
												CO,UN,SM CC, Cl	2	4												R1	
												CO,UN,SM CL	2	1													PLT(A) = 0.6 MPa PLT(D) = 0.2 MPa
13					2							BD,IR,SM IN, Ga	2	6												R1	
												CO,PL,SM SA	1	2												R1	
												CO,UN,RO SA	3	2													
												BD,PL,SM SA	1	2													
												BD,PL,SM CL	1	1													PLT(A) = 0.4 MPa PLT(D) = 0.4 MPa
												BD,PL,SM CL	1	1													
												BD,PL,SM CL	1	1													
14	HQ Core				3							BD,PL,SM CL	1	1													
												BD,PL,SM CL	1	1													
												BD,PL,SM CL	1	1													
												BD,PL,SM CL	1	1													PLT(A) = 0.4 MPa PLT(D) = 0.4 MPa
15				81.08																							
		END OF DRILLHOLE		15.42																							
16																											
17																											
18																											
19																											
20																											

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: JL

CHECKED: JC

GTA-RCK 054 S:\CLIENTS\MTO\CEW-CREDIT_RIVER\02_DATA\GINT\CEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 1/9/19

GOLDER

RECORD OF BOREHOLE No SWME-1

SHEET 1 OF 1

METRIC

PROJECT 1662333

G.W.P. 2002-13-00

LOCATION N 4824195.5; E 295896.6 MTM NAD 83 ZONE 10 (LAT. 43.557643; LONG. -79.610206)

ORIGINATED BY ACM

DIST Central HWY QEW

BOREHOLE TYPE CME 55, 210 mm O.D., Hollow Stem Augers

COMPILED BY CC

DATUM Geodetic

DATE July 31, 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 / 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
89.5	GROUND SURFACE							20 40 60 80 100	10 20 30		
0.0 / 88.8	Sand and gravel (FILL) Loose Brown grey Moist		1	SS	7		89				
0.7 / 88.1	Silt and sand, trace clay, trace gravel (FILL) Very loose Brown Moist		2	SS	4				○		1 64 30 5
1.7	Clayey silt, trace to some sand (FILL), oxidation staining Grey Moist		3	SS	7		88				
86.5	SAND, some silt, trace clay, trace rootlets Very loose to loose Brown to dark brown Moist		4	SS	3		87		○		0 77 19 4
3.0	- organics between depths of 2.6 m and 2.9 m		5A 5B	SS	8		86		○ 42		2 13 49 36
85.8	SILTY CLAY, some sand, trace gravel, trace organics Firm to very stiff Grey brown Moist		6	SS	28				○		
3.7 / 84.8	CLAYEY SILT, some gravel, some shale fragments (RESIDUAL SOIL) Hard Grey Moist		7	SS	50/0.10		85				
4.7 / 84.0	SHALE (BEDROCK) Grey		8	SS	50/0.13		84				
5.5	END OF BOREHOLE SPLIT-SPOON REFUSAL										

NOTE:

1. Open borehole dry upon completion of drilling.

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

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

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GOLDER

RECORD OF BOREHOLE No SWME-2

SHEET 1 OF 1

METRIC

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4824204.6; E 295881.3 MTM NAD 83 ZONE 10 (LAT. 43.557725; LONG. -79.610395) ORIGINATED BY ACM

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

DATUM Geodetic DATE July 27, 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
87.4	GROUND SURFACE										
0.0 / 86.9	TOPSOIL (500 mm) Soft		1	SS	3		87				
0.5 / 85.9	CLAYEY SILT with SAND, some gravel Firm Brown Moist - Trace to some rootlets, organics, wood, tree fragments from 0.8 m to 1.4 m		2	SS	7						20 31 34 15
1.5 / 85.2	CLAYEY SILT, trace to some sand, some shale fragments (RESIDUAL SOIL) Hard Brown Moist		3	SS	46		86				
2.2 / 84.3	SHALE (BEDROCK) Grey		4	SS	50/0.15		85				
3.1	END OF BOREHOLE SPLIT-SPOON REFUSAL		5	SS	50/0.08						

NOTE:

1. Open borehole dry upon completion of drilling.

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

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

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GOLDER

RECORD OF BOREHOLE No SWME-3

SHEET 1 OF 1 **METRIC**

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

LOCATION N 4824227.3; E 295901.0 MTM NAD 83 ZONE 10 (LAT. 43.557930; LONG. -79.610152)
BOREHOLE TYPE CME 55, 210 mm O.D., Hollow Stem Augers
DATE July 27, 2018

ORIGINATED BY ACM
COMPILED BY CC
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
91.9	GROUND SURFACE										
0.0	Sandy silt to silty sand to, trace to some clay (FILL) Loose to compact Brown Moist - Some oxidation between depths of 0.6 m and 1.2 m		1	SS	6						
			2	SS	9		91				
90.2			3	SS	12						
1.7	Sandy SILT, trace to some clay Loose Brown		4	SS	7		90		○		0 29 64 7
89.7											
2.2	Moist SILT, some sand, trace to some clay Compact Grey		5	SS	16				○		0 13 79 8
88.7	Moist						89				
3.2	CLAYEY SILT, trace sand Firm		6A 6B	SS	6				○ —— ○		0 2 59 39
88.2											
3.7	Grey Moist CLAYEY SILT, trace gravel, trace sand (TILL)		7A 7B	SS	14		88		○ ○ ——		
87.6	Firm to stiff										
4.5	Grey Moist to wet CLAYEY SILT, some sand, some shale fragments (RESIDUAL SOIL)		8	SS	50/0.13						
86.5			9	SS	50/0.05		87				
5.4	Grey Moist SHALE (BEDROCK) Grey										
	END OF BOREHOLE SPLIT-SPOON REFUSAL										

NOTE:

1. Water level in open borehole at a depth of 5.3 m (Elev. 86.6 m) below ground surface upon completion of drilling.

2. Groundwater level measurements in piezometer:

Date	Depth (m)	Elev. (m)
14/08/18	4.0	87.9
06/11/18	3.8	88.1

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

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

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GOLDER

RECORD OF BOREHOLE No SWME-4

SHEET 1 OF 1

METRIC

PROJECT 1662333

G.W.P. 2002-13-00 LOCATION N 4824255.4; E 295917.6 MTM NAD 83 ZONE 10 (LAT. 43.558183; LONG. -79.609946) ORIGINATED BY ACM

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

DATUM Geodetic DATE July 27, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.5	GROUND SURFACE								
0.0	TOPSOIL								
0.2	Silt and sand, trace to some clay, trace gravel (FILL)		1	SS	5		95		
94.8	Loose								
0.7	Brown Moist - Trace organics and rootlets to 0.6 m		2	SS	7				
	SILT and SAND, trace to some clay, trace gravel Compact Brown to grey at 3.2 m Moist		3	SS	25		94		
	- Pockets of sand present between 1.6 m and 2.1 m		4	SS	34		93		1 50 42 7
	- Clayey silt interlayer between 3.0 m and 3.2 m		5	SS	25		92		
91.8									
3.7	CLAYEY SILT, trace sand, trace gravel, some silt and sand interlayers Stiff Grey Moist		6	SS	17				
			7	SS	9		91		1 13 60 26
89.9							90		
5.6	SILT, trace to some sand, trace to some clay Compact Grey Moist to wet - Pocket of sand from 6.1 m to 6.2 m		8	SS	19		89		0 11 82 7
87.9						▽	88		
7.6	SILTY CLAY Stiff		9A 9B	SS	13				
87.4	Grey								
8.1	Moist CLAYEY SILT, some gravel, trace sand (TILL) Very stiff						87		
86.5	Grey								
9.0	Moist SHALE (BEDROCK) Grey		~~10~~	~~SS~~	~~50/0.05~~		86		
	Bedrock cored from a depth of 10.0 m to 13.3 m.		~~11~~	~~SS~~	~~50/0.08~~				
	For bedrock coring details, refer to Record of Drillhole SWME-4.		1	RC	REC 100%		85		RQD = 80%
			2	RC	REC 100%		84		RQD = 84%
82.2			3	RC	REC 100%		83		RQD = 94%
13.3	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 7.6 m (Elev. 87.9) below ground surface prior to rock coring.								

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: SWME-4

SHEET 1 OF 1

LOCATION: N 4824255.4 ;E 295917.6

DRILLING DATE: July 27, 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: 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 Borehole SWME-4		85.53																							
10	HW Casing	Slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with LIMESTONE interbeds		9.95	1							BD,IR,RO SA	3	2													UCS = 13.5 MPa
												BD,PL,RO CC, CI	1.5	4													
11												CO,UN,RO CC, CI	3	4													
												BD,UN,SM CC, CI	2	4													
												BD,PL,RO PC, CI	1.5	3													
												BD,UN,SM CC, CI	2	4													
	HQ Core				2							CO,PL,SM PC, CI	1	3													
												CO,PL,RO IN, CI	1.5	6													
12												CO,UN,SM IN, CI	2	10													
												BD,PL,SM CC, CI	1	4													
												BD,UN,RO PC, CI	3	3													
13					3							CO,UN,RO CC, CI	3	4													
				82.22																							
		END OF DRILLHOLE		13.26																							
14																											
15																											
16																											
17																											
18																											

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

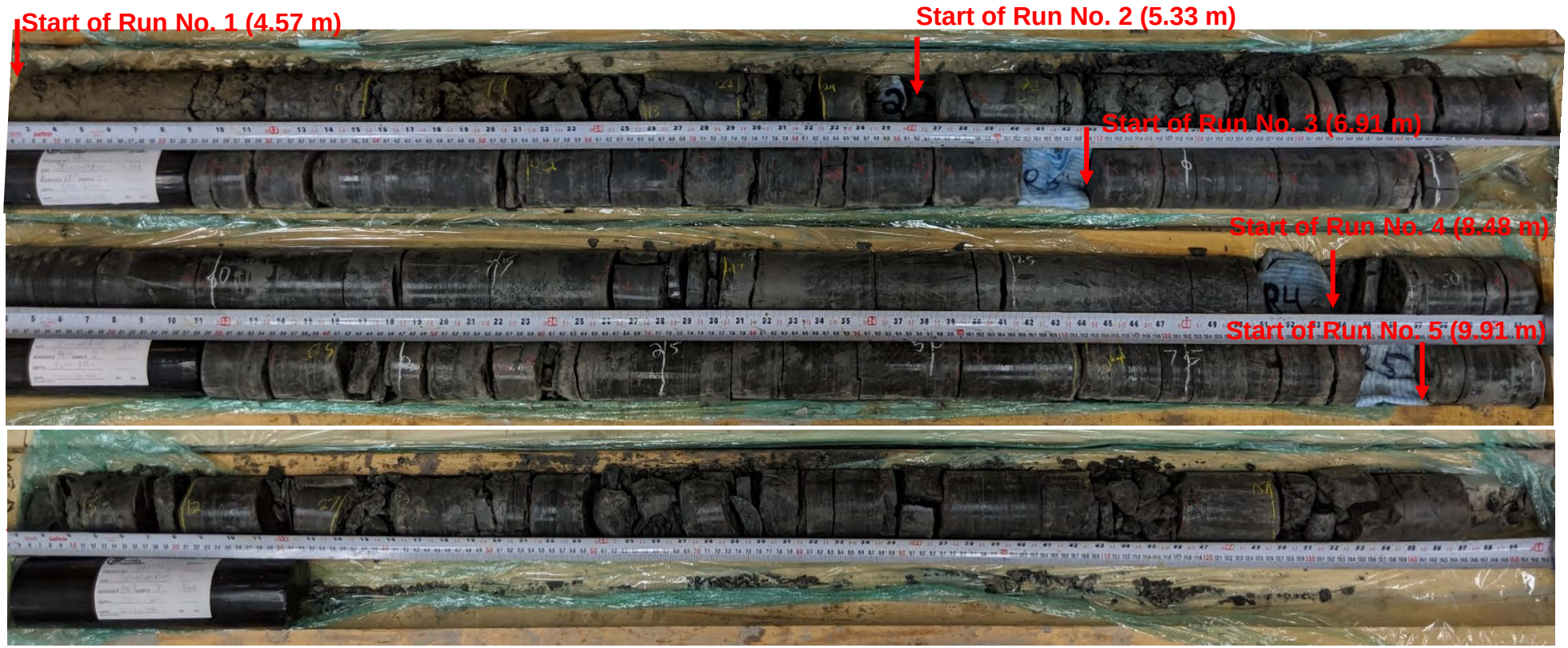
1 : 50

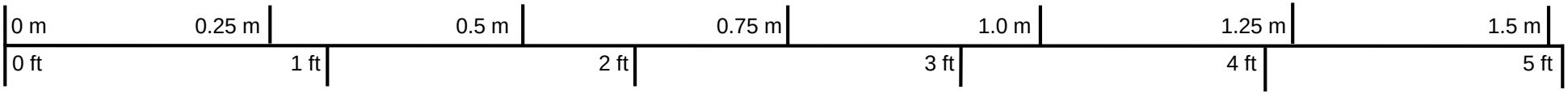
GOLDER

LOGGED: ACM

CHECKED: AB

GTA-RCK 054 S:\CLIENTS\MTO\CEW-CREDIT_RIVER\02_DATA\GINT\CEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 1/9/19





Scale

PROJECT

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

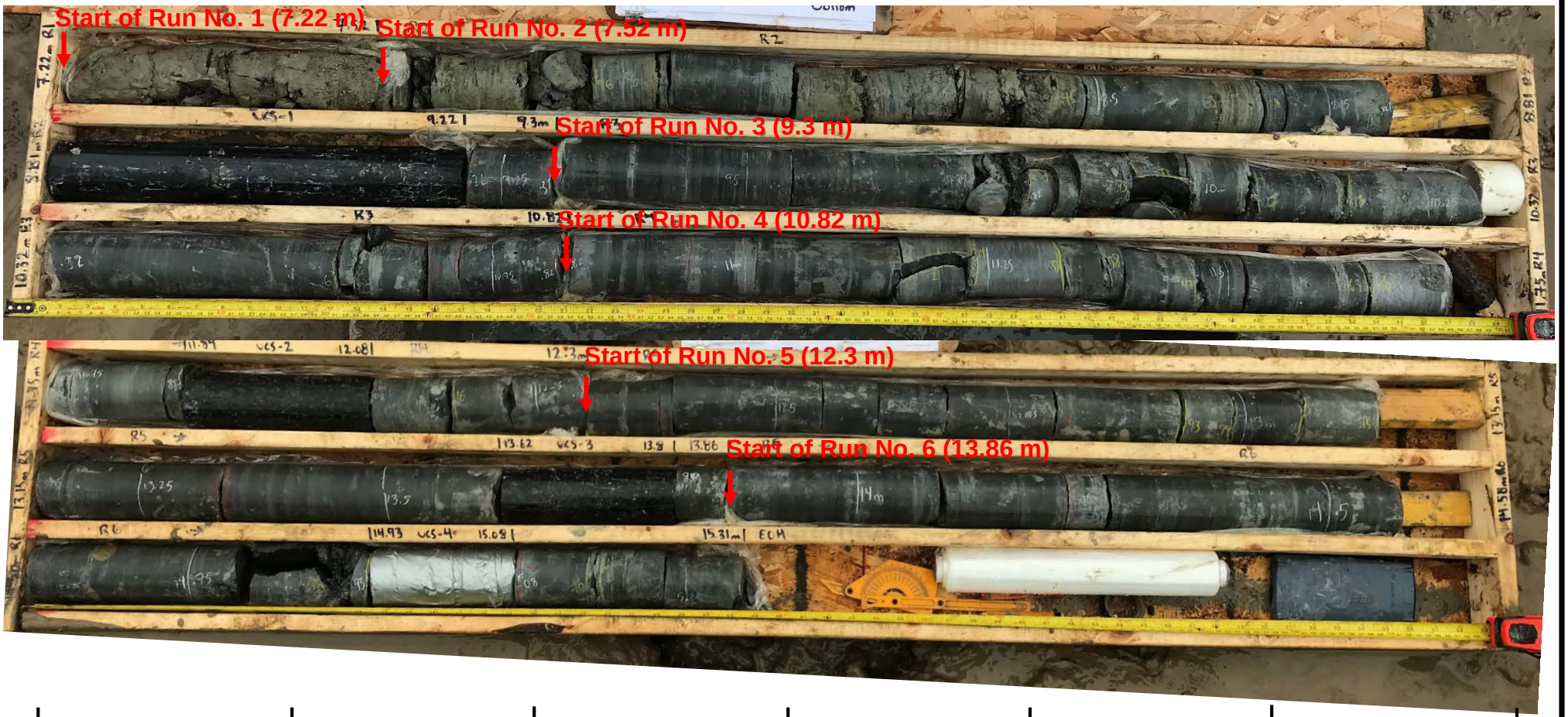
TITLE

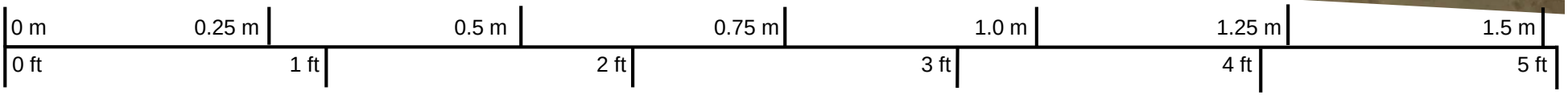
Bedrock Core Photograph
Borehole AR-2 (4.57 m to 11.60 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	SE	20180821	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20181116	**FIGURE A-1**		
REVIEW	JMAC	20181116			

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

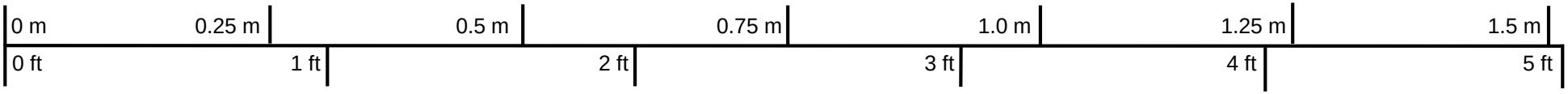
Bedrock Core Photograph
Borehole CRB-4 (7.22 m to 15.31 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	Mar 2018	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	JMAC	11/14/2018			
REVIEW	SMM	11/14/2018			

FIGURE A-2

REVISION DATE: March 7, 2018 BY: JIL Project: 1662333



Scale

PROJECT

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

TITLE

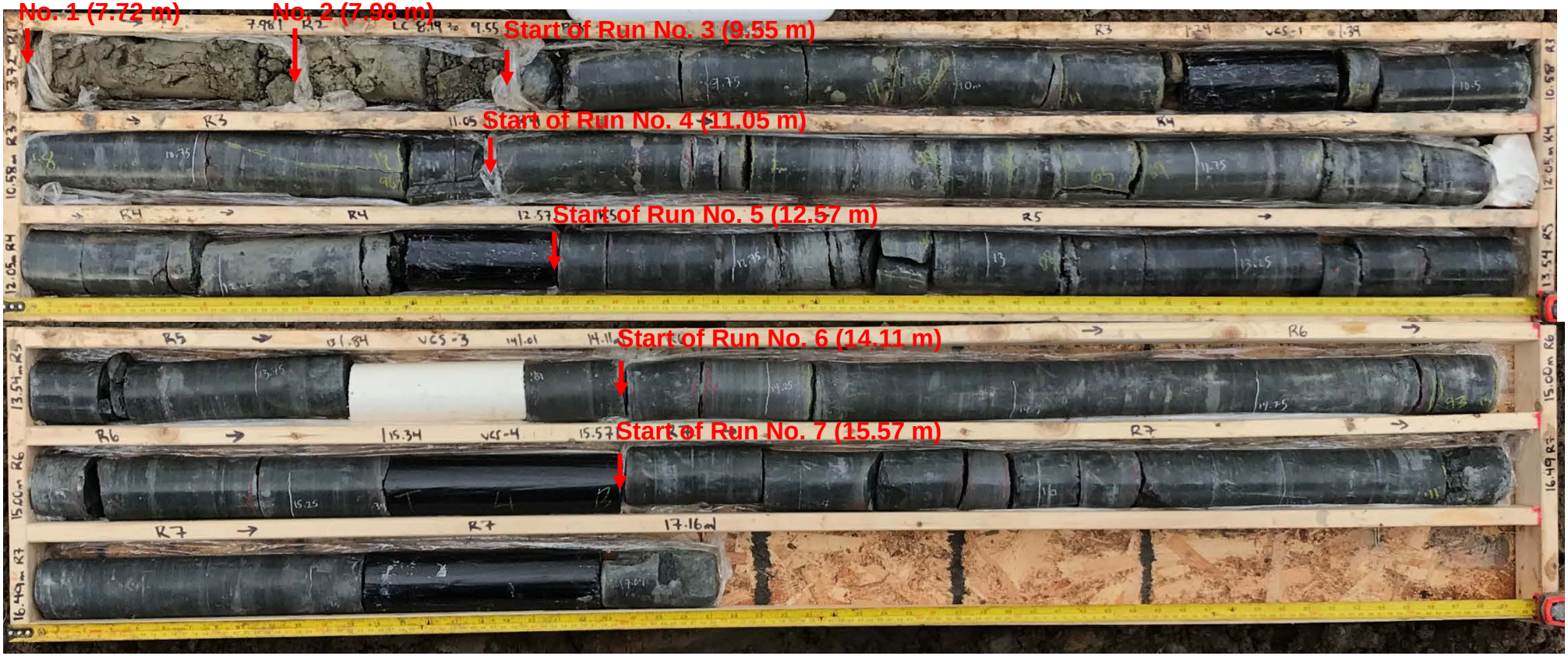
Bedrock Core Photograph
Borehole CRB-5 (7.18 m to 15.52 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	Mar 2018	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	JMAC	11/14/2018			
REVIEW	SMM	11/14/2018			

FIGURE A-3

REVISION DATE: March 7, 2018 BY: JIL Project: 1662333



0 m 0.25 m 0.5 m 0.75 m 1.0 m 1.25 m 1.5 m

0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Scale

PROJECT

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

TITLE

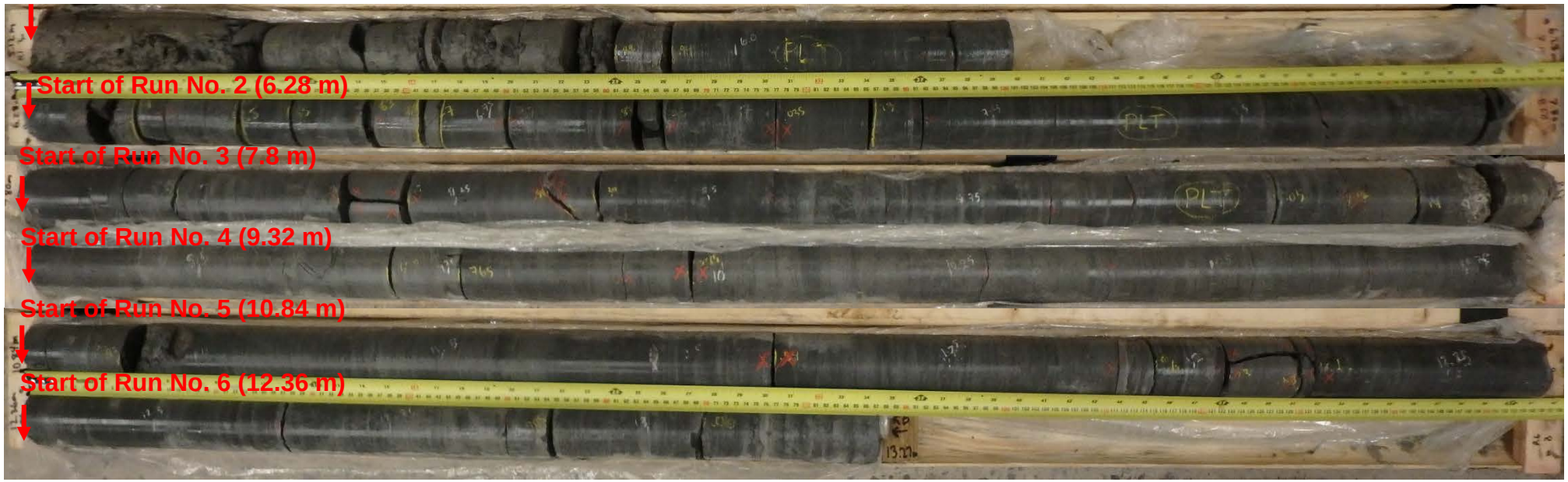
Bedrock Core Photograph
Borehole CRB-5A (7.72 m to 17.16 m)

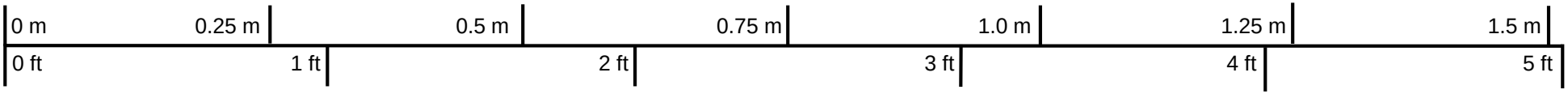
GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	Mar 2018	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	JMAC	11/14/2018			
REVIEW	SMM	11/14/2018			

FIGURE A-4

REVISION DATE: March 7, 2018 BY: JIL Project: 1662333





Scale

PROJECT

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

TITLE

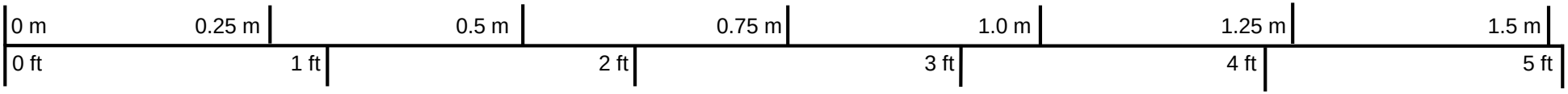
Bedrock Core Photograph
Borehole CRB-6 (5.12 m to 13.27 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	Mar 2018	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	JMAC	11/14/2018			
REVIEW	SMM	11/14/2018			

FIGURE A-5

REVISION DATE: March 7, 2018 BY: JIL Project: 1662333



Scale

PROJECT

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

TITLE

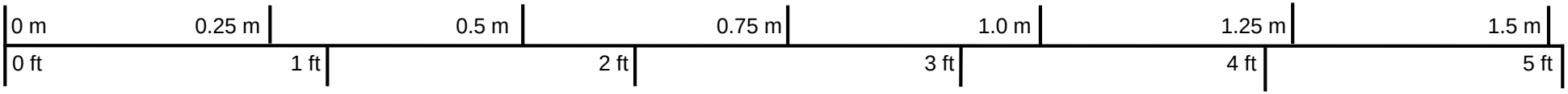
Bedrock Core Photograph
Borehole CRB-7 (8.53 m to 16.04 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	Mar 2018	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	JMAC	11/14/2018			
REVIEW	SMM	11/14/2018			

FIGURE A-6

REVISION DATE: March 7, 2018 BY: JIL Project: 1662333



Scale

PROJECT

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

TITLE

Bedrock Core Photograph
Borehole NW3-1 (11.78 m to 15.42 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	SE	20180821	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	JMAC	11/14/2018	**FIGURE A-7**		
REVIEW	SMM	11/14/2018			

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

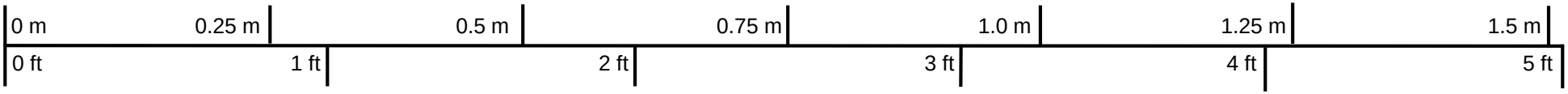
Start of Run No. 1 (9.95 m)

Start of Run No. 2 (11.23 m)

12.75 m

Start of Run No. 3 (12.75m)

13.26 m



Scale

PROJECT	**MTO Assignment 2015-E-0033 QEW Widening Between Mississauga Road and Hurontario Street**
TITLE	**Bedrock Core Photograph Borehole SWME-4 (9.95 m to 13.26 m)**

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JIL	20180307	SCALE	AS SHOWN	VER. 1.
CADD	--		**FIGURE A-8**		
CHECK	SMM	20181116			
REVIEW	JMAC	20181116			

REVISION DATE: March 7, 2018 BY: JIL Project: 1662333

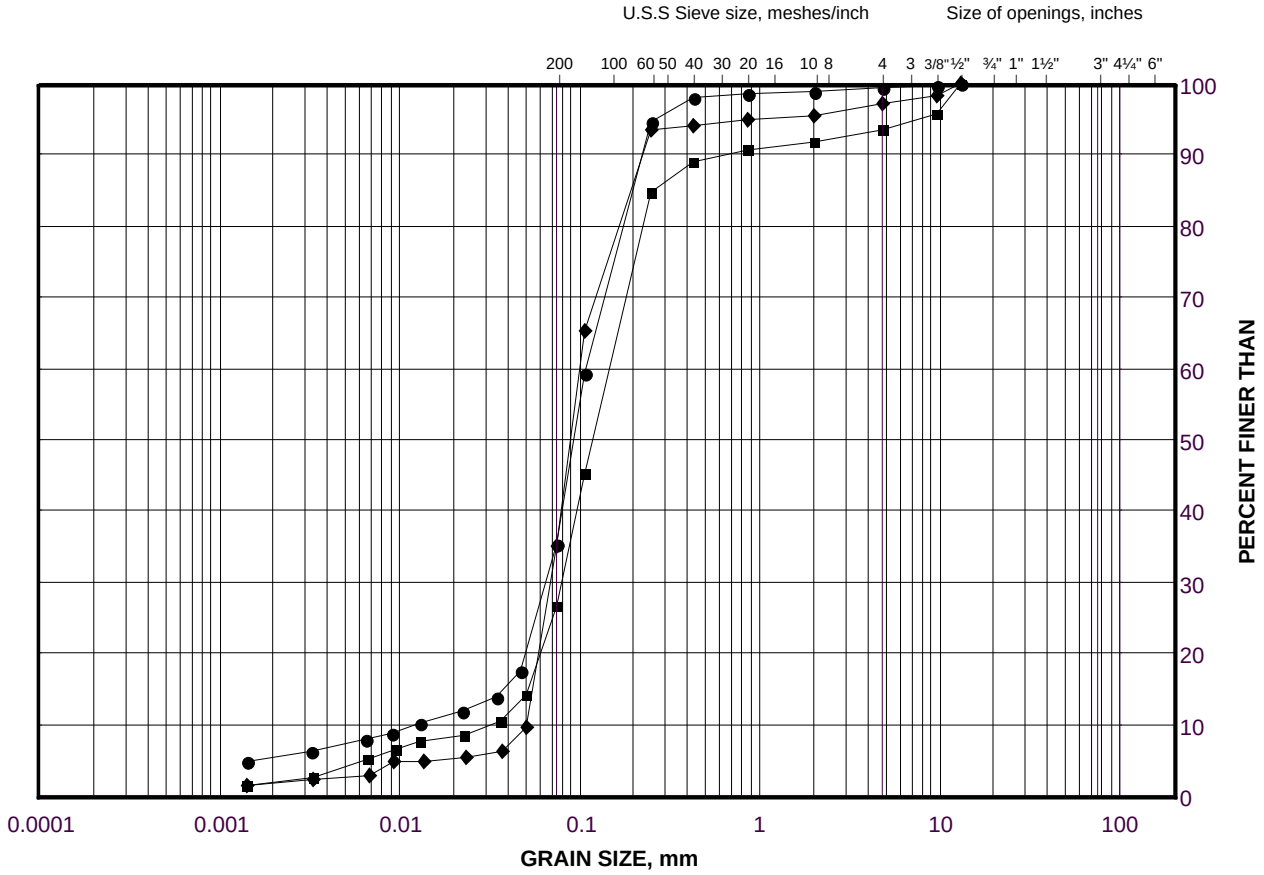
APPENDIX B

Geotechnical Laboratory Test Results (incl. Geomechanica Test Results on Rock)

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand (Fill)

FIGURE B-1



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SWME-1	2	88.4
■	CRB-6	2	90.7
◆	CRB-7	3	92.9

Project Number: 1662333

Checked By: SMM

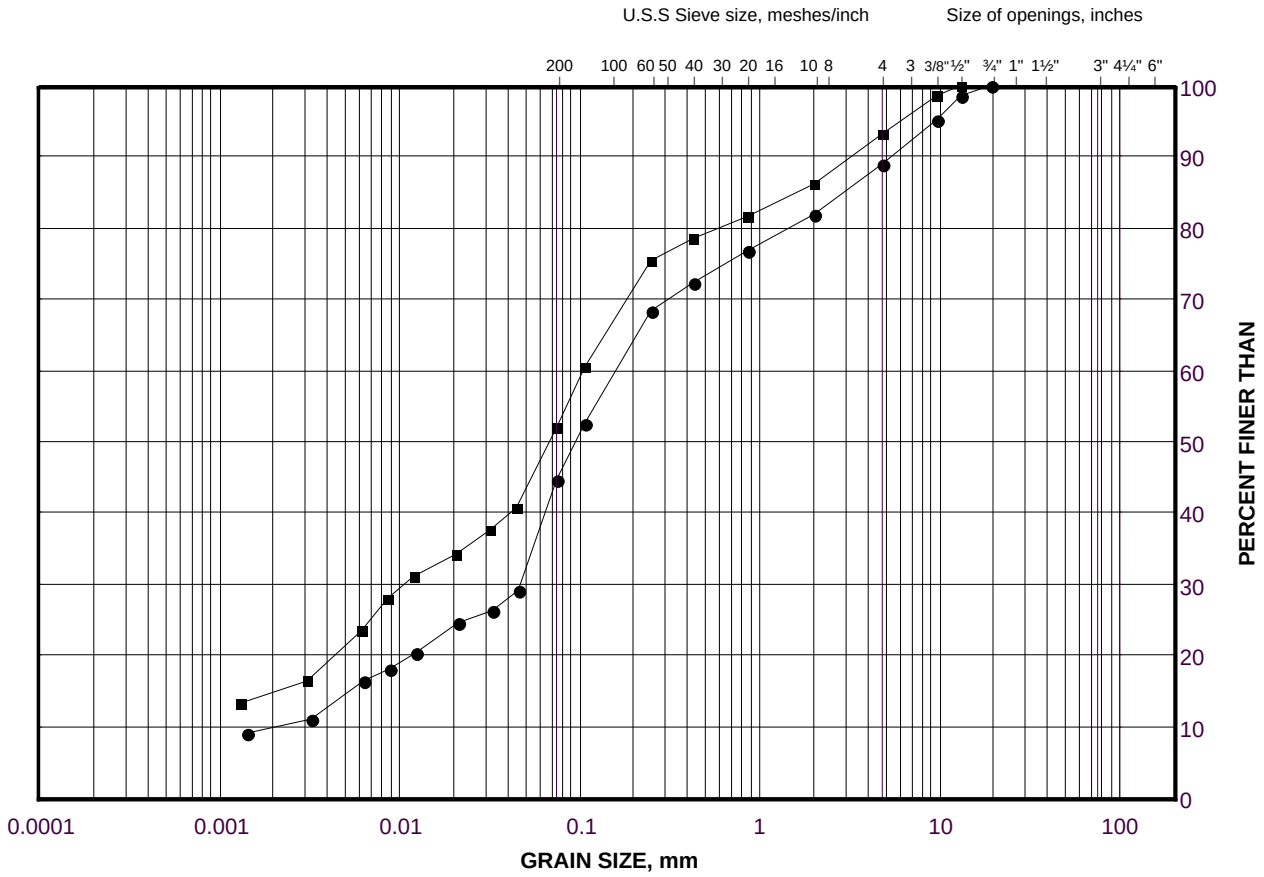
Golder Associates

Date: 10-Dec-18

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE B-2



LEGEND

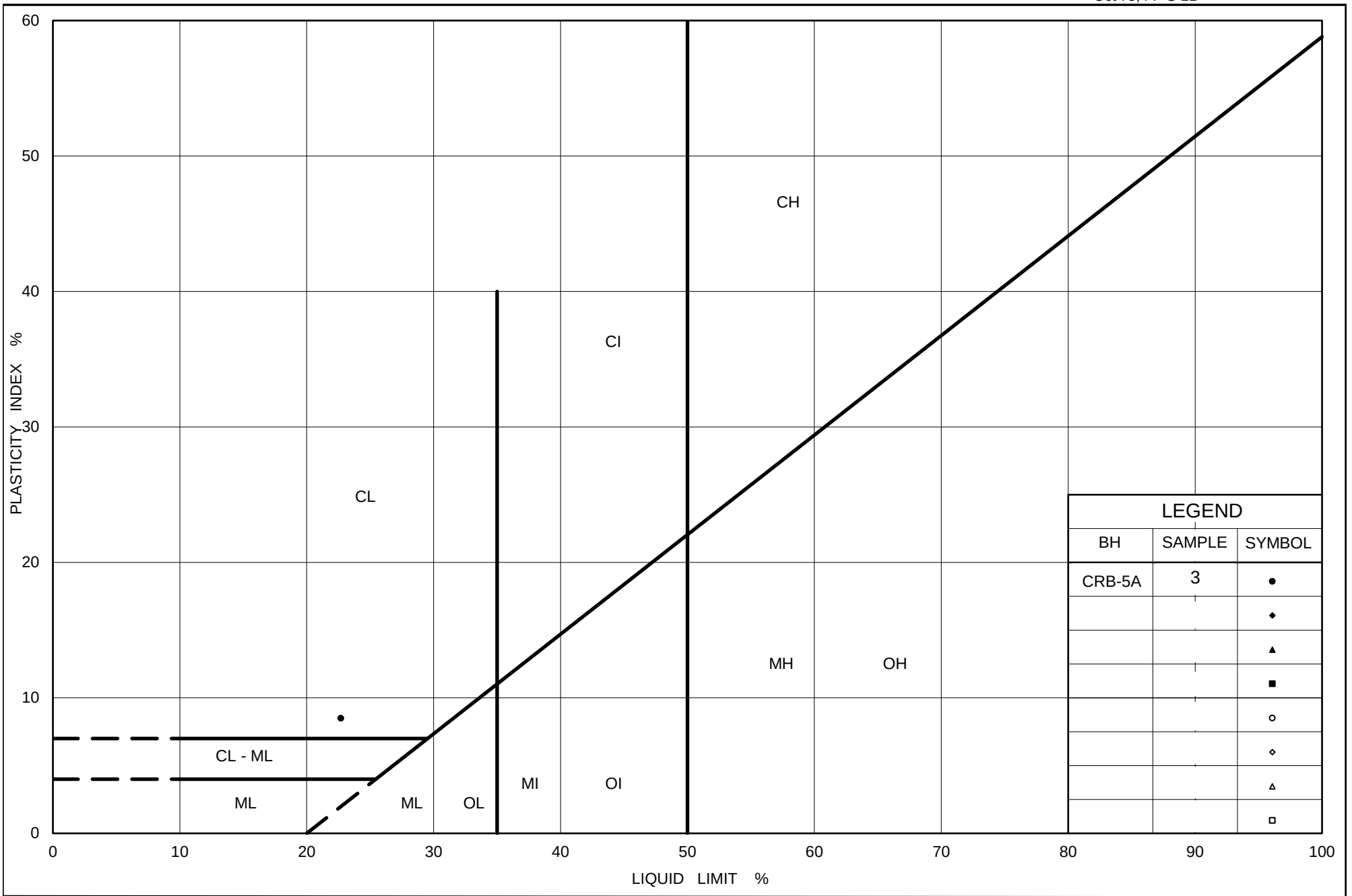
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CRB-5A	3	77.5
■	CRB-4	4	76.5

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 10-Dec-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt with Sand (Fill)

Figure No. B-3

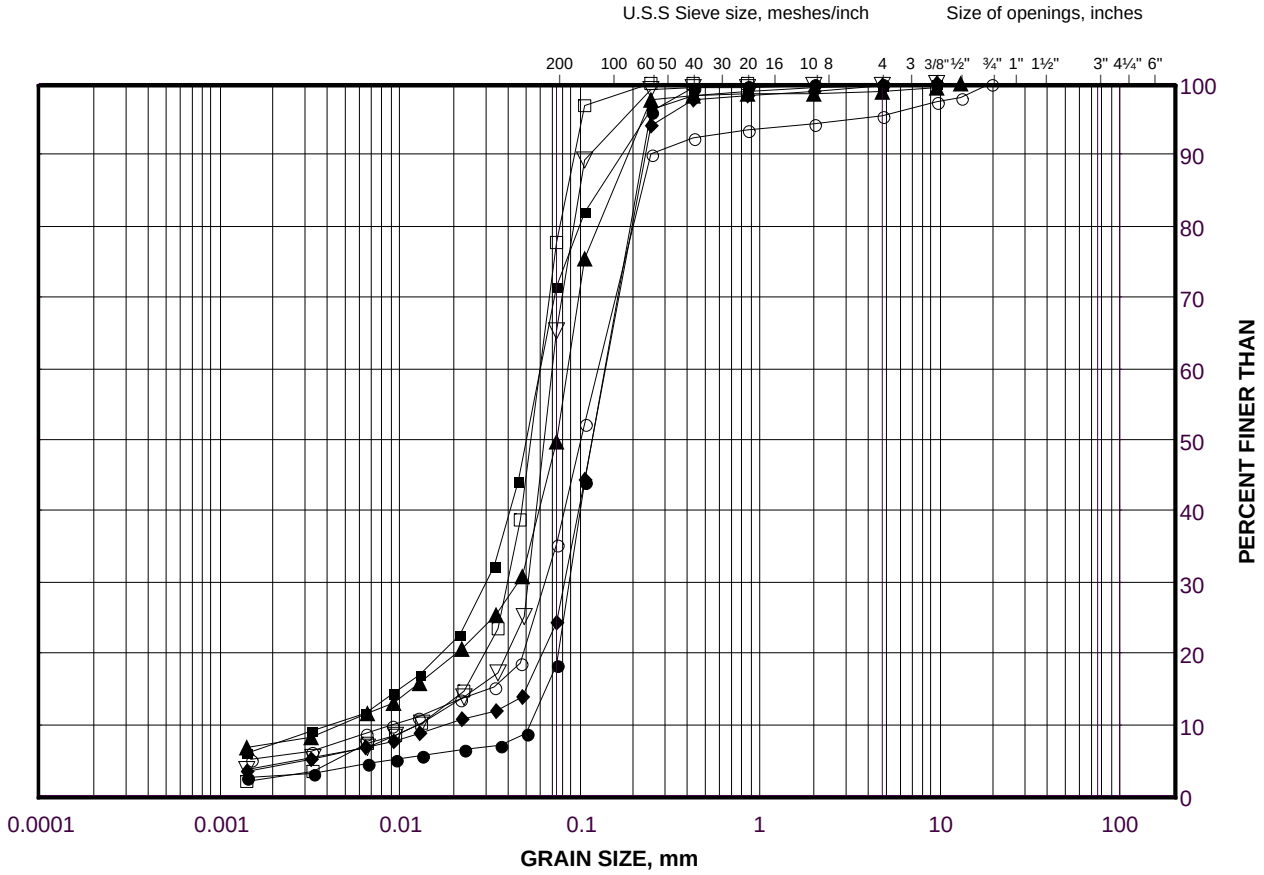
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Silt to Sand

FIGURE B-4A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	AR-1	3	93.9
■	SWME-3	4	89.9
◆	SWME-1	4	86.9
▲	SWME-4	4	92.9
▽	AR-1	6	91.6
❍	CRB-5	6	75.1
□	CRB-7	8	89.1

Project Number: 1662333

Checked By: SMM

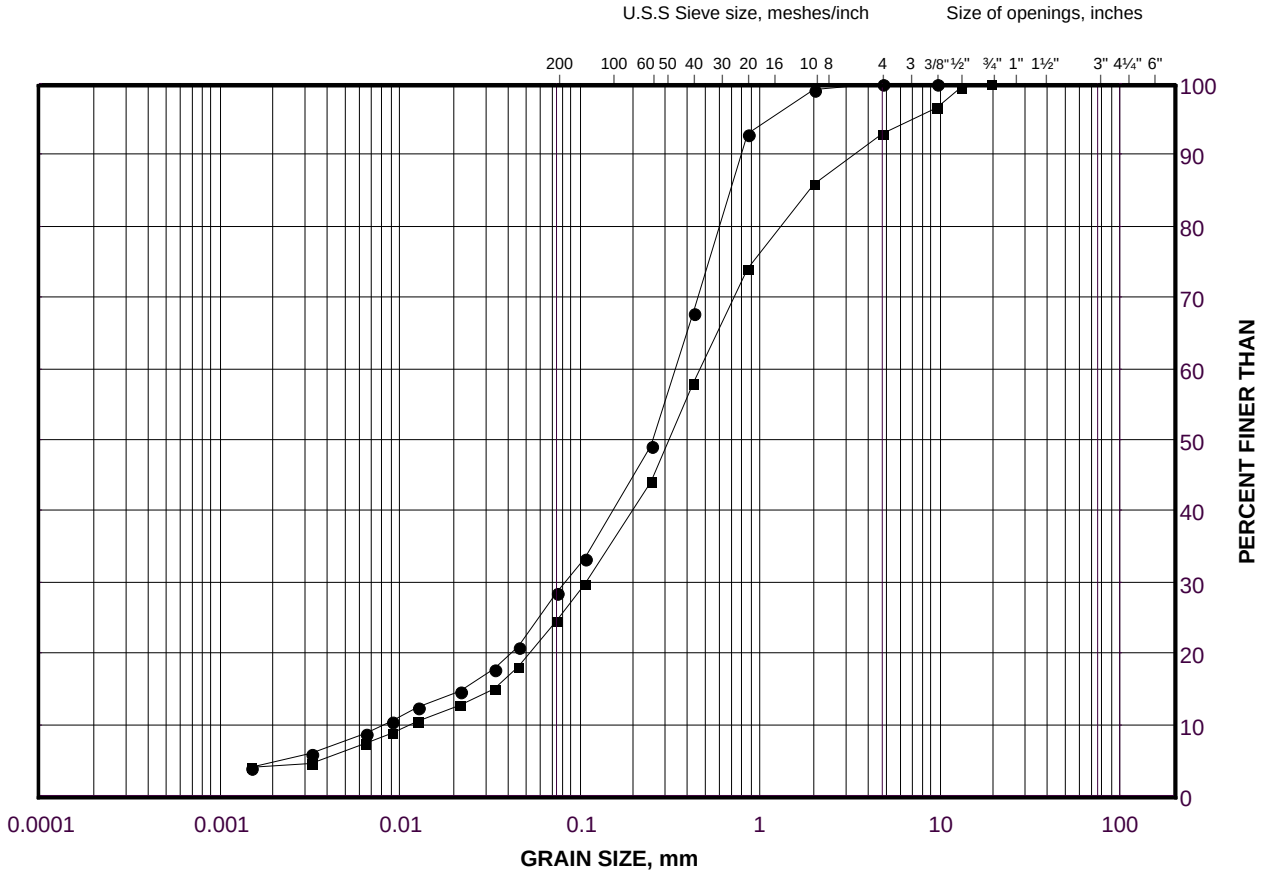
Golder Associates

Date: 10-Dec-18

GRAIN SIZE DISTRIBUTION

Sandy Silt to Sand

FIGURE B-4B



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CRB-5A	8B	72.9
■	CRB-5	9	72.8

Project Number: 1662333

Checked By: SMM

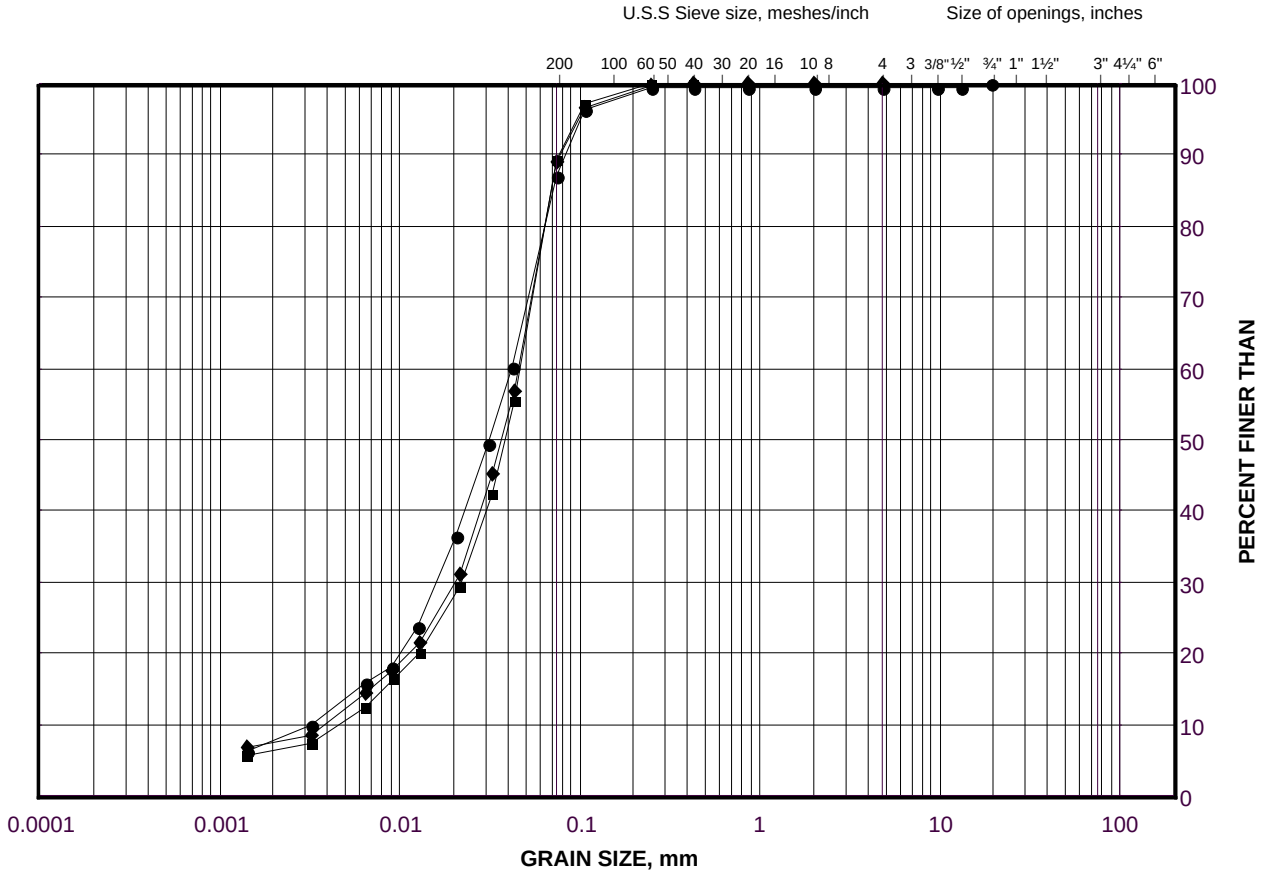
Golder Associates

Date: 10-Dec-18

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B-5



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SWME-3	5	89.3
■	AR-1	8	89.3
◆	SWME-4	8	89.1

Project Number: 1662333

Checked By: _____

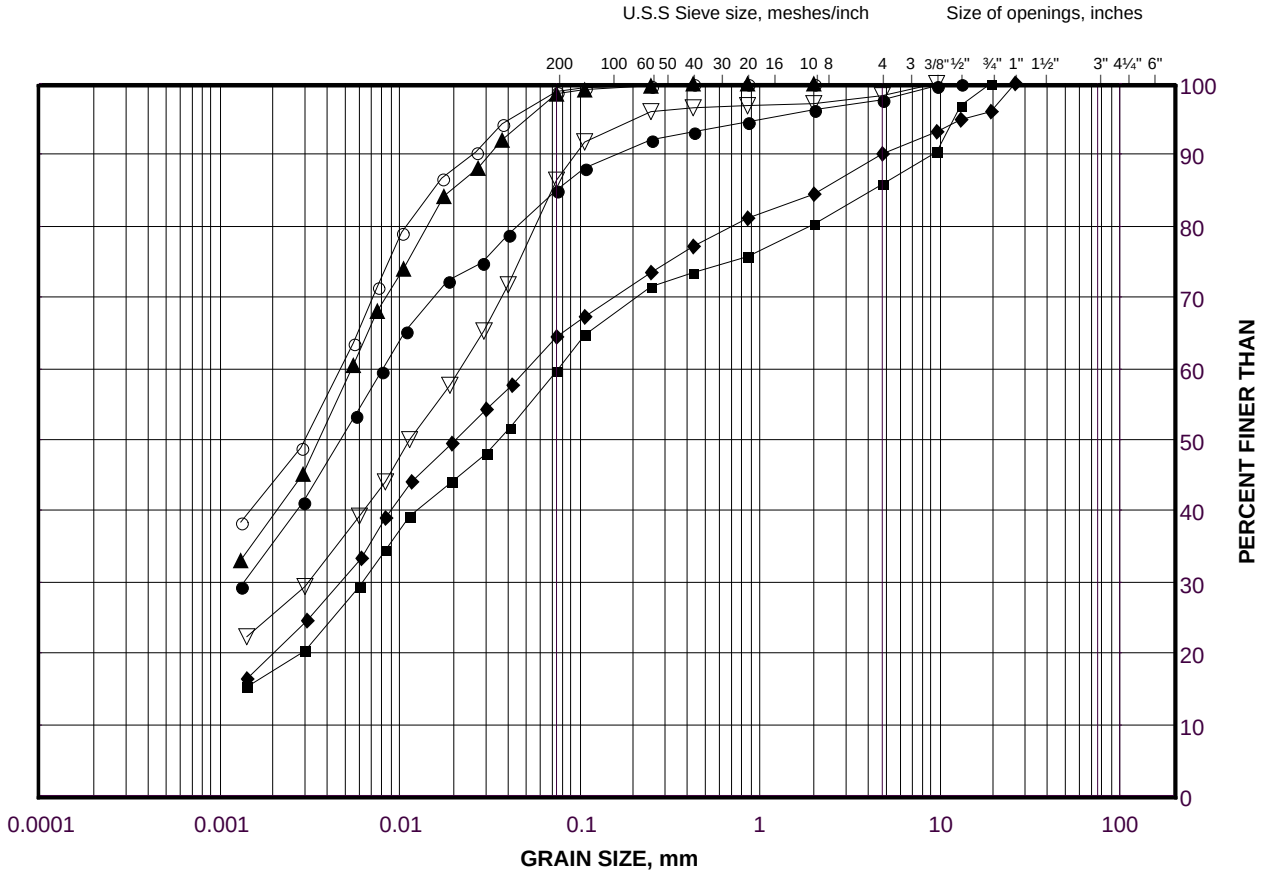
Golder Associates

Date: 10-Dec-18

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Silty Clay

FIGURE B-6



LEGEND

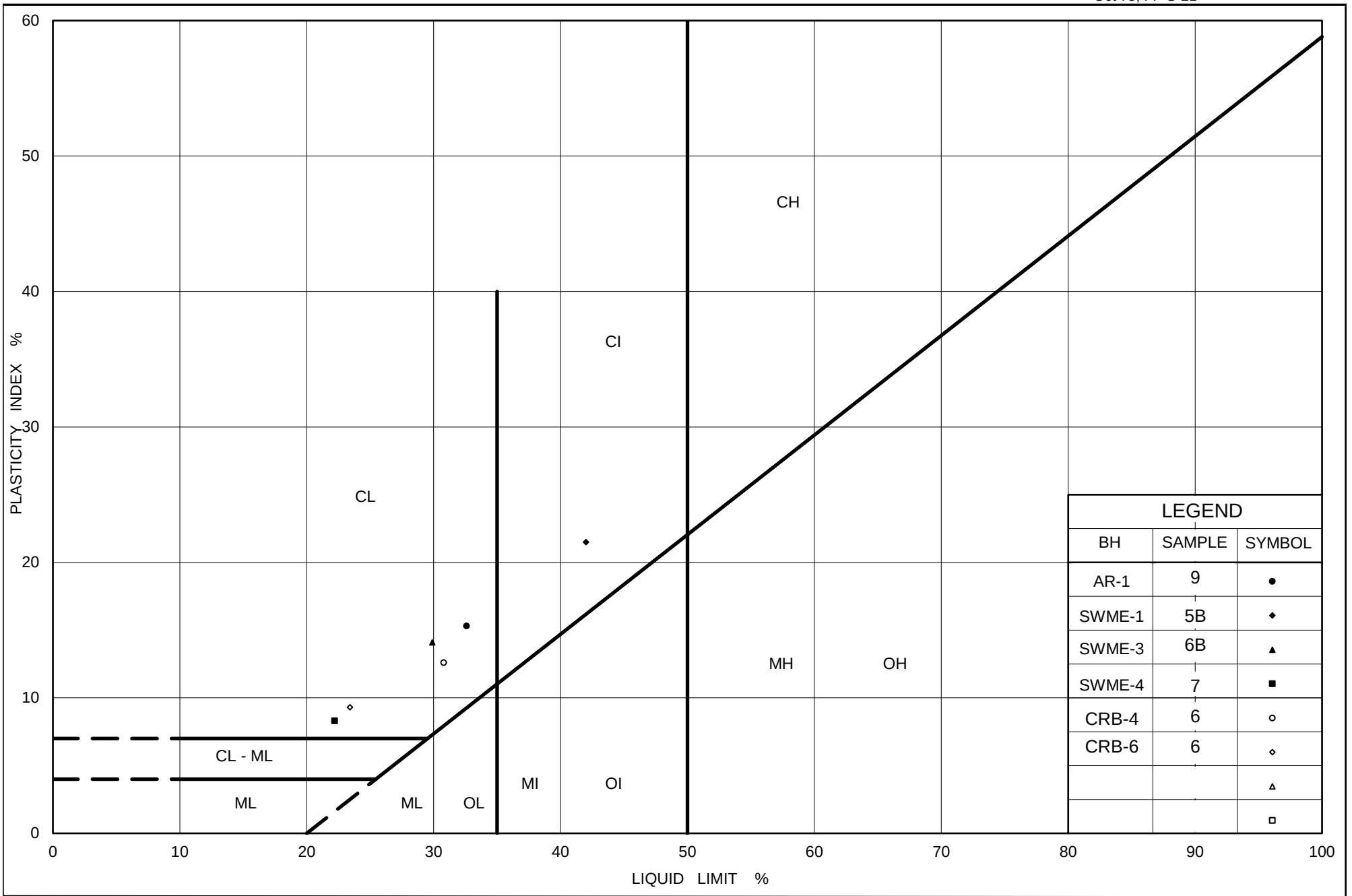
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SWME-1	5B	85.9
■	CRB-4	6	75.0
◆	CRB-6	6	87.6
▲	SWME-3	6B	88.5
▽	SWME-4	7	90.6
❍	AR-1	9	87.8

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 10-Dec-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy Clayey Silt to Silty Clay

Figure No. B-7

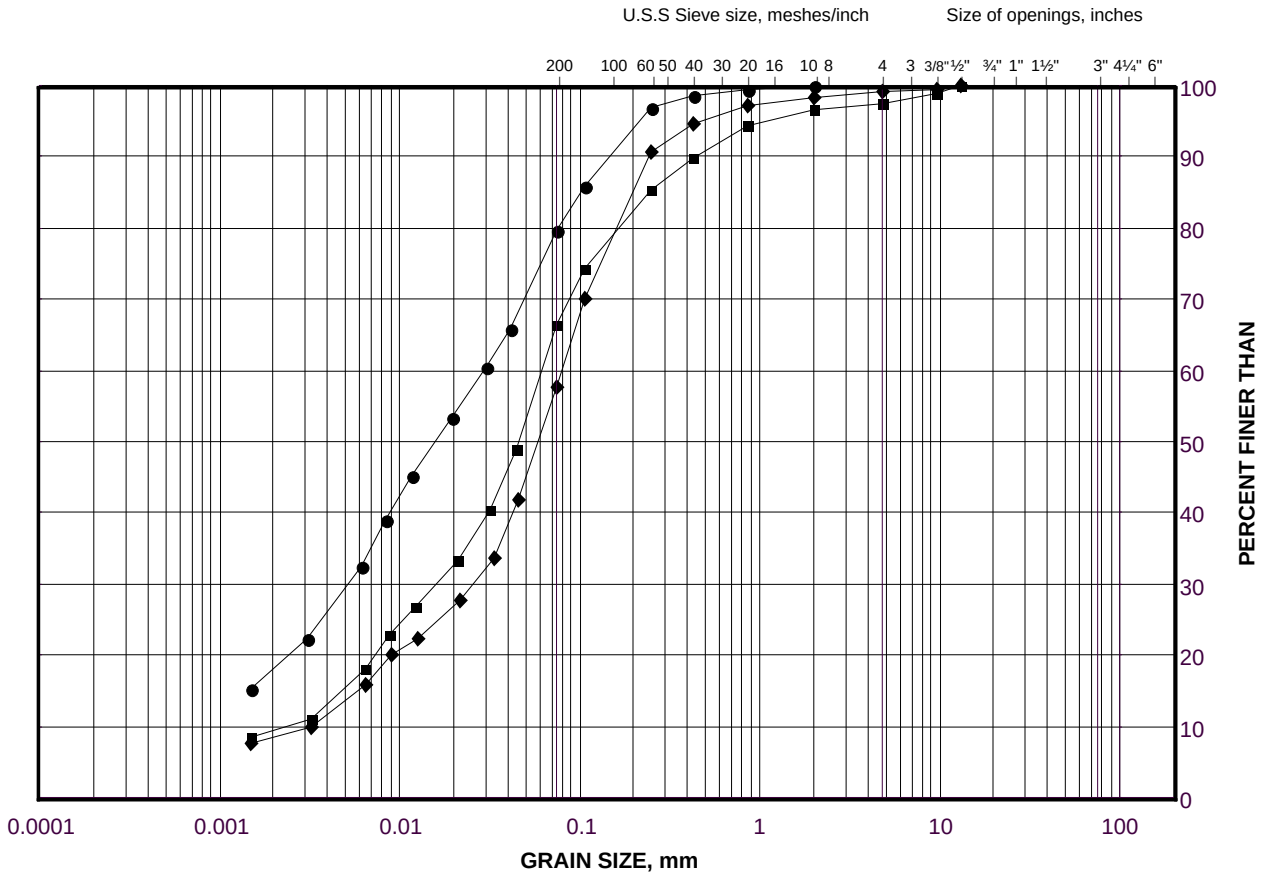
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Organic Clayey Silt

FIGURE B-8



LEGEND

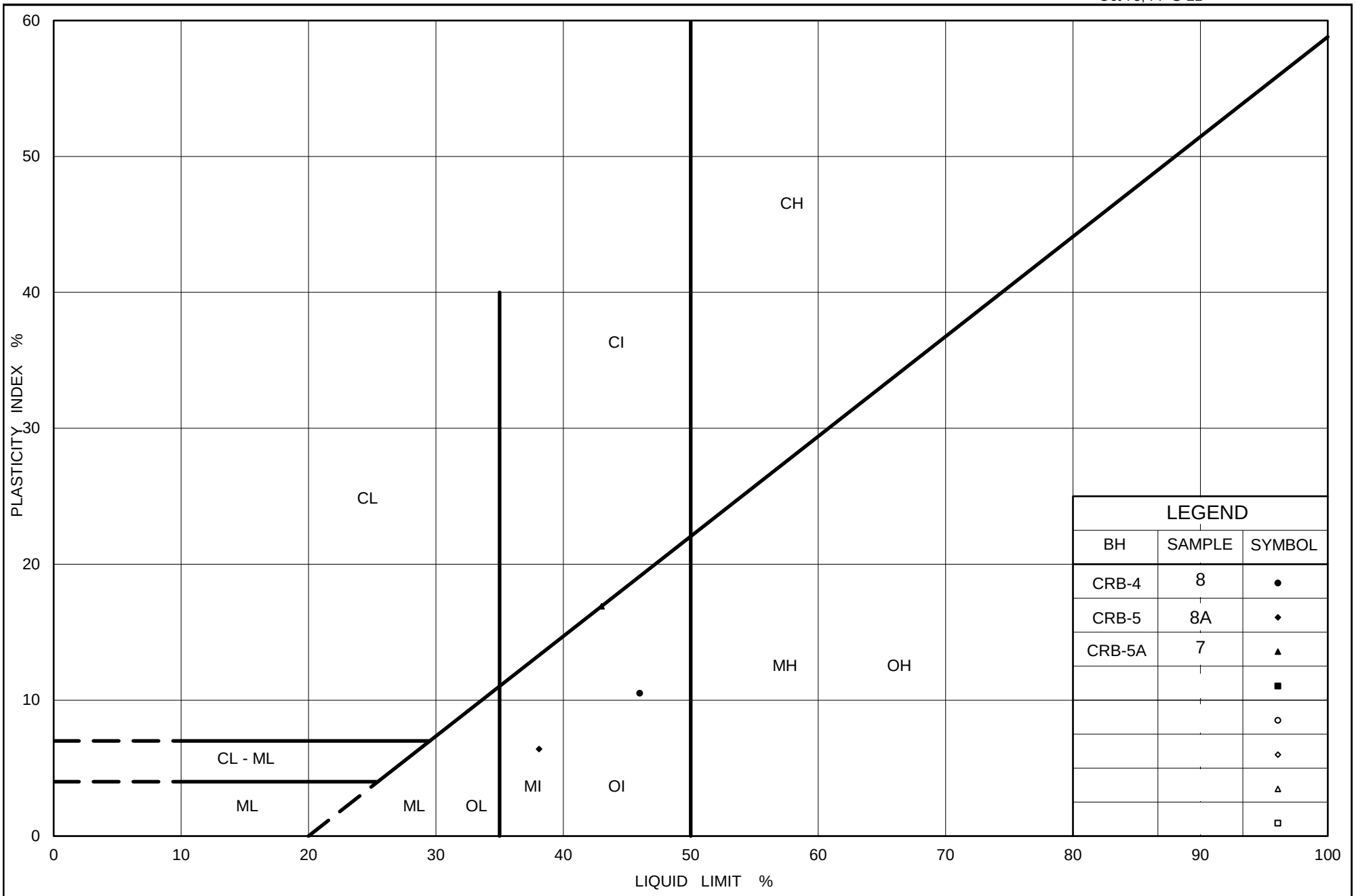
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CRB-5A	7	74.4
■	CRB-4	8	72.8
◆	CRB-5	8A	73.7

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 10-Dec-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Organic Clayey Silt

Figure No. B-9

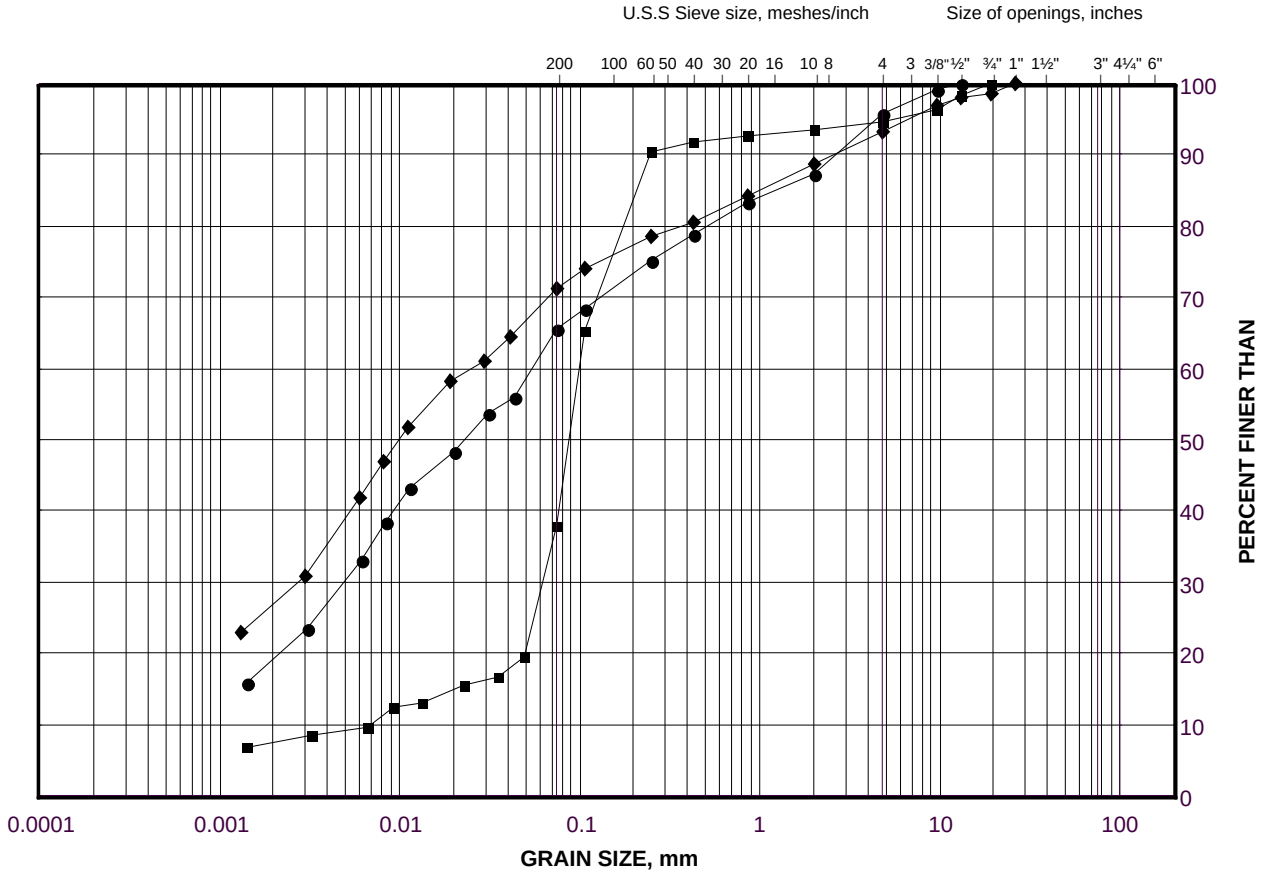
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Silt and Sand/Clayey Silt with Sand to Sandy Silty Clay (Till)

FIGURE B-10



LEGEND

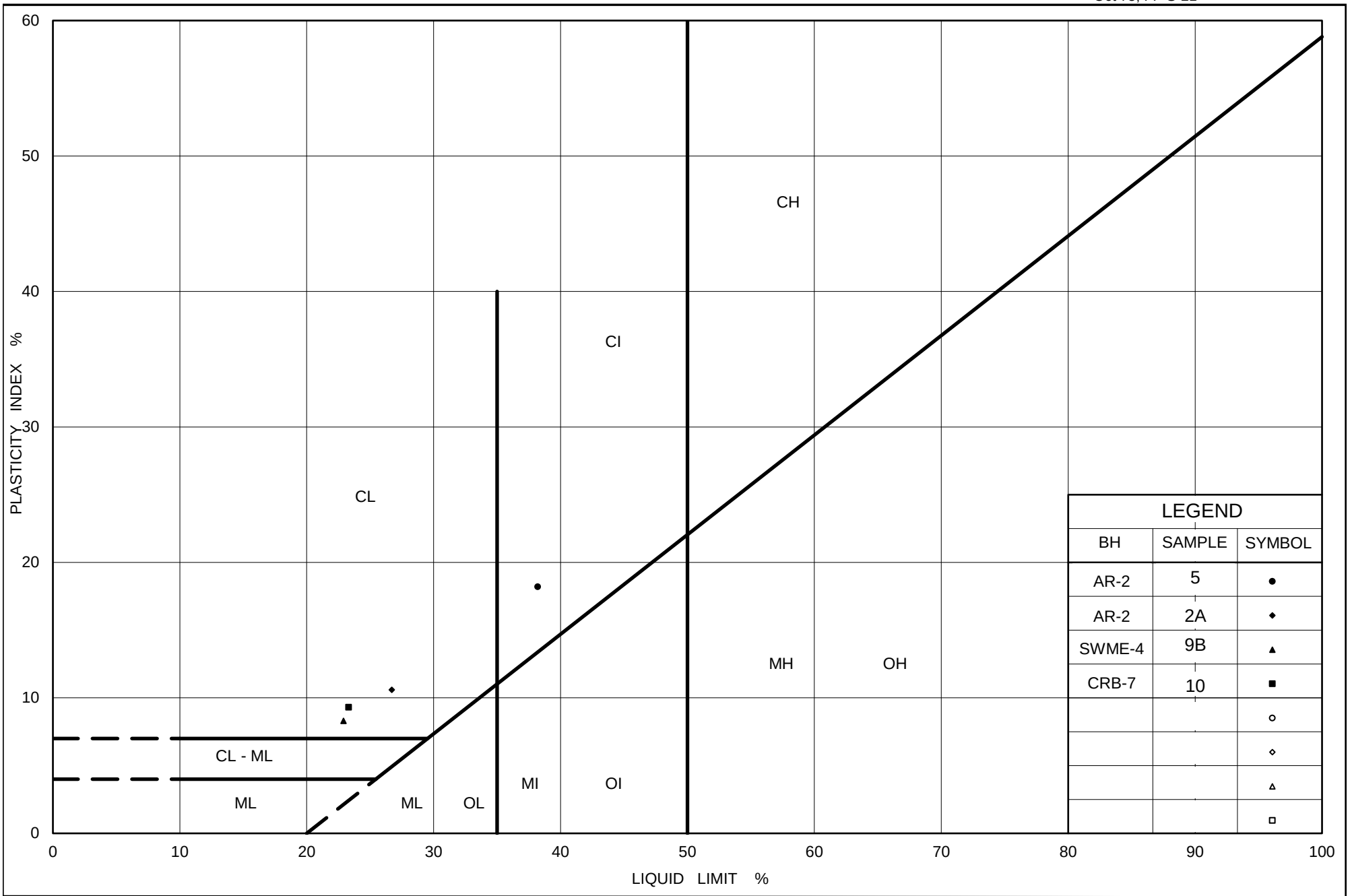
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CRB-7	10	87.5
■	AR-2	3	86.7
◆	AR-2	5	85.1

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 10-Jan-19



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt with Sand to Sandy Silty Clay (Till)

Figure No. B-11

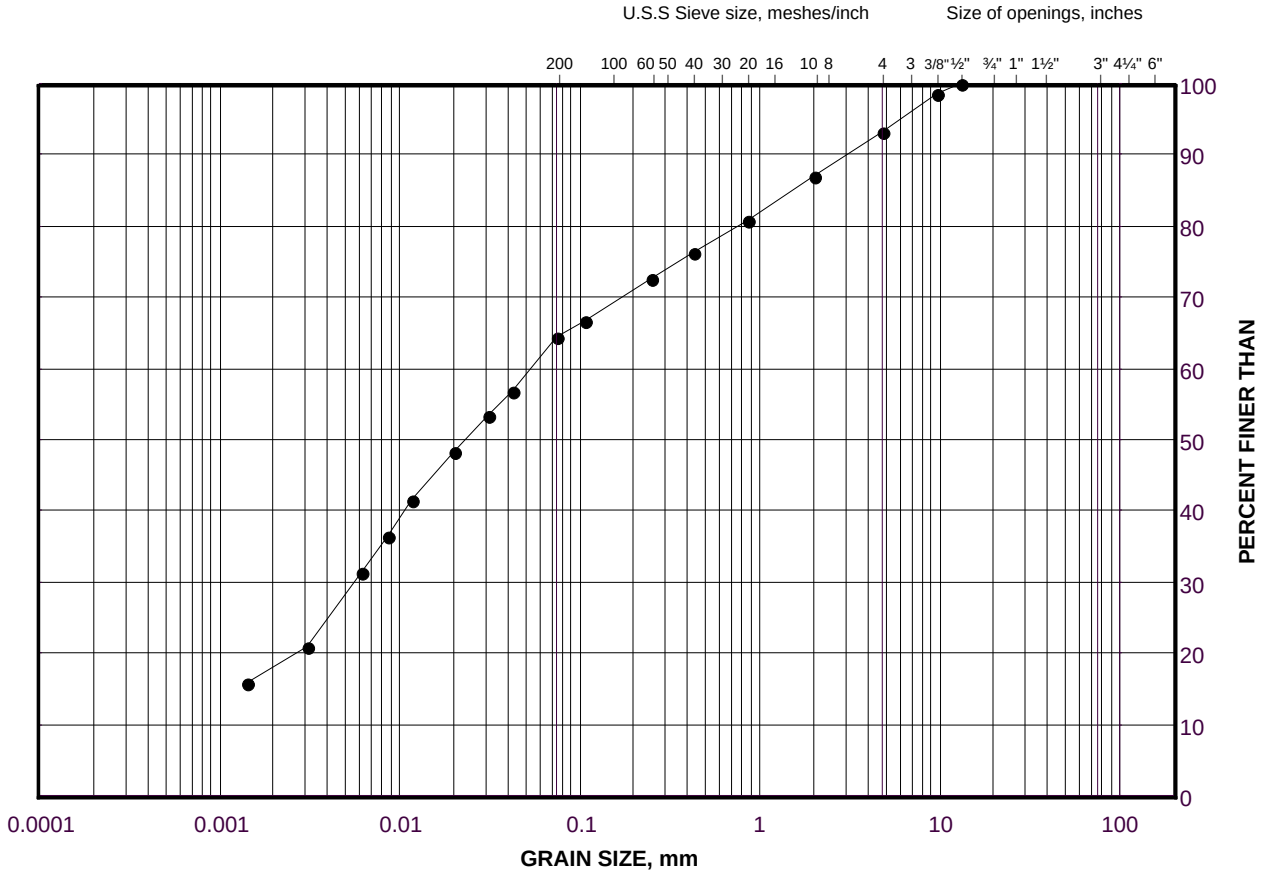
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Clayey Silt (Residual Soil)

FIGURE B-12



LEGEND

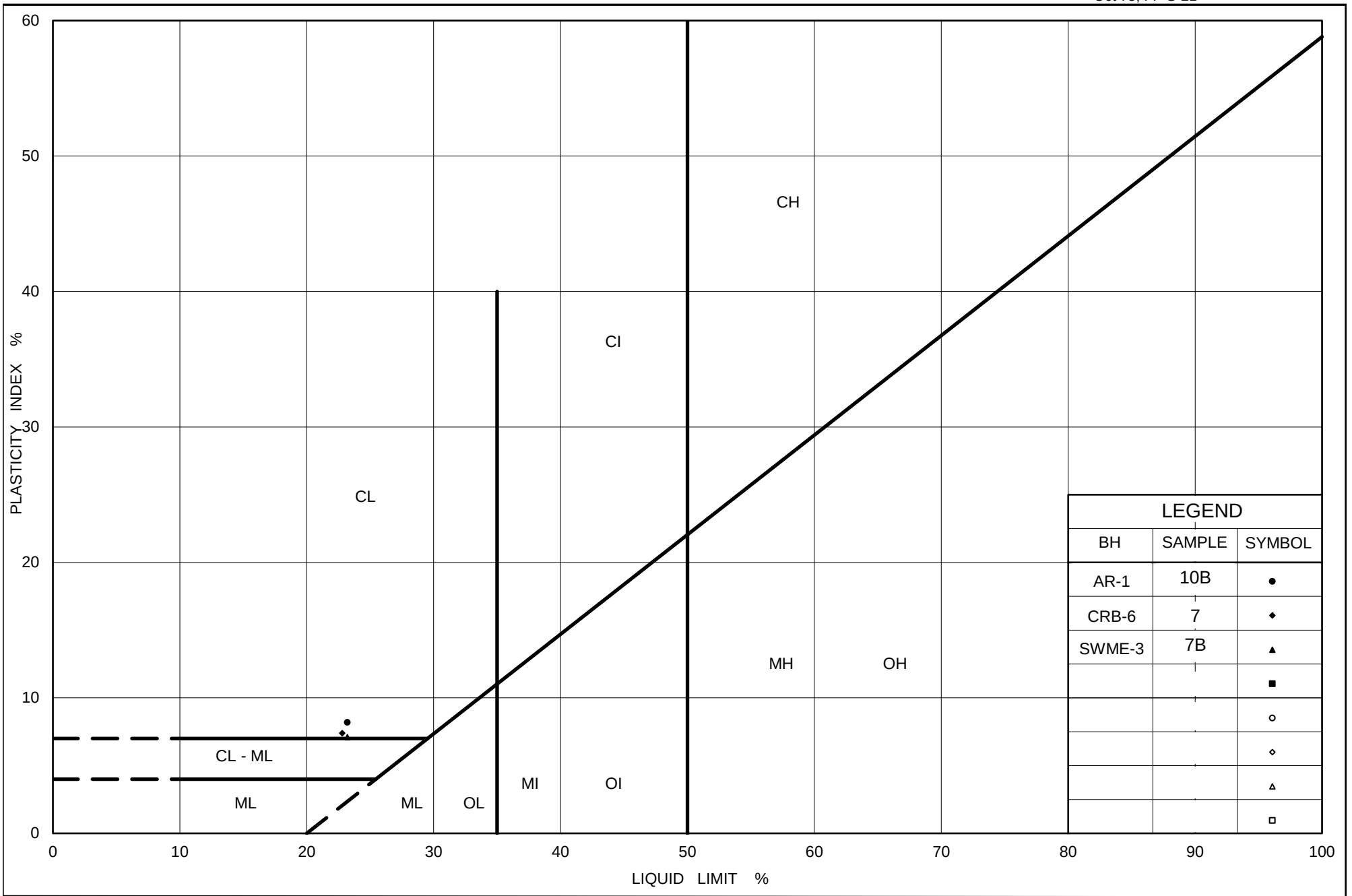
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	AR-1	10B	87.0

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 10-Dec-18



Ministry of Transportation

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PLASTICITY CHART
Sandy Clayey Silt to Clayey Silt (Residual Soil)

Figure No. B-13

Project No. 1662333

Checked By: SMM

Table B-1: Summary of Point Load Test Results

Borehole No.	Sample Depth (m)	Sample Elevation (m)	Orientation	Corrected Is (50 mm) (MPa)
CRB-4	13.5	65.60	Diametral	0.89
CRB-4	9.22	69.88	Diametral	0.04
CRB-4	9.22	69.88	Axial	1.02
CRB-4	9.28	69.82	Axial	2.14
CRB-4	14.93	64.17	Diametral	0.08
CRB-4	14.93	64.17	Axial	0.23
CRB-5	8.95	70.25	Diametral	0.76
CRB-5	9.03	70.17	Axial	0.37
CRB-5	14.48	64.72	Diametral	0.52
CRB-5	14.51	64.69	Axial	0.27
CRB-5	13.31	65.89	Diametral	0.07
CRB-5	9.53	69.67	Axial	1.45
CRB-5A	10.24	69.06	Diametral	0.56
CRB-5A	10.29	69.01	Axial	0.42
CRB-5A	13.84	65.46	Diametral	0.43
CRB-5A	13.89	65.41	Axial	0.07
CRB-5A	16.8	62.50	Diametral	0.82
CRB-5A	17	62.30	Axial	0.24
CRB-6	6.03	85.67	Axial	0.70
CRB-6	6.03	85.67	Diametral	0.44
CRB-6	7.34	84.36	Axial	0.65
CRB-6	7.34	84.36	Diametral	0.51

Borehole No.	Sample Depth (m)	Sample Elevation (m)	Orientation	Corrected Is (50 mm) (MPa)
CRB-6	9.03	82.67	Axial	0.61
CRB-6	9.03	82.67	Diametral	0.15
CRB-7	9.06	85.64	Axial	0.47
CRB-7	9.06	85.64	Diametral	0.26
CRB-7	9.46	85.24	Axial	0.56
CRB-7	9.46	85.24	Diametral	0.42
CRB-7	12.04	82.66	Axial	0.85
CRB-7	12.04	82.66	Diametral	0.32

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

November 22, 2017

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

Re: UCS + E testing
(Golder Project No. 166233)

Dear Mr. Marmor:

On November 3, 2017 four (4) HQ-sized core samples were received by Geomechanica Inc. via courier. These samples were identified as being from boreholes drilled as part of Golder project 166233 (denoted as QEW/Credit River UCS samples). A uniaxial compressive strength (UCS) specimen was prepared and tested from each of these samples (4 tests total).

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,

Giovanni Grasselli Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: giovanni.grasselli@geomechanica.com

GEOMECHANICA

Rock Laboratory Testing Results

A report submitted to:

David Marmor

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

Prepared by:

Bryan Tatone, PhD
Omid Mahabadi, PhD
Giovanni Grasselli, PhD, PEng

Geomechanica Inc
#300-90 Adelaide St W
Toronto ON
M5H 3V9 Canada
Tel: +1-647-478-9767
info@geomechanica.com

November 22, 2017
Project number: 1662333

Abstract

This document summarizes the results of 4 uniaxial compression tests on HQ-sized core samples for Golder Project 1662333. Results including uniaxial compressive strength (UCS) and Young's modulus along with photographs of samples before and after testing are presented.

In this document:

1 Overview

This report summarizes the results of laboratory testing of 4 uniaxial compression tests on HQ-sized core samples for Golder Project 1662333. The tests were performed in Geomechanica's laboratory in Oakville, Ontario, Canada using a 1.3 MN capacity Forney compression testing machine (Figure 1). The specimens were loaded with a nearly constant axial displacement rate of 0.150 mm/min.The specimen preparation and testing procedure included the following:

1. Unwrapping of the core samples, inspecting them for damage, and re-wrapping them in electrical tape to minimize disturbance during subsequent specimen preparation.
2. Diamond cutting of core samples to obtain cylindrical specimens with an appropriate length (length:diameter = 2:1) and nearly parallel end faces.
3. Surface grinding of specimens to obtain flat (within ± 0.025 mm) and parallel end faces (within 0.25°).
4. Placing each specimen into the loading frame, applying a 0.5-1.0 kN axial load, removing the electrical tape, and subsequently increasing the axial load gradually to cause rupture while continuously recording axial force and axial deformation to determine peak strength (UCS) and (tangent) Young's modulus.

Figure 1: UCS Test setup.

2 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. The 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% of the peak strength.

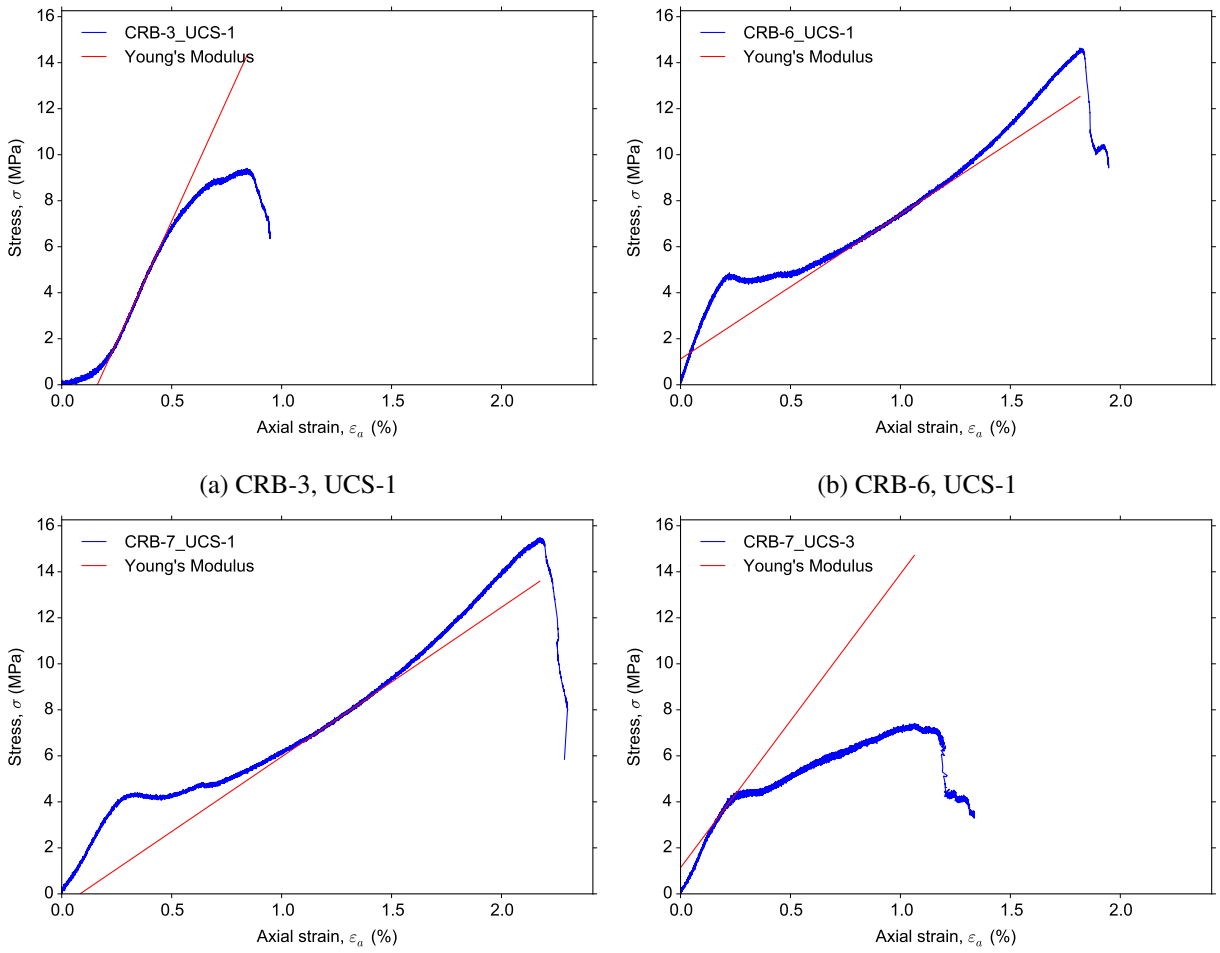
Table 1: Summary of laboratory test results.

Sample	Depth (m)	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's Modulus E (GPa)	Notes
CRB-3, UCS-1	11.44 - 11.66	2.61	9.4	2.10	[1]
CRB-6, UCS-1	6.06 - 6.17	2.17	14.6	0.63	[1,2]
CRB-7, UCS-1	9.21 - 9.369	2.59	15.5	0.65	[1,2]
CRB-7, UCS-3	12.11 - 12.36	2.59	7.4	1.28	
Mean		2.49	11.7	1.2	
Standard Deviation		0.18	3.4	0.6	

[1] Specimen emitted fresh pore water upon loading
[2] length:diameter ratio $< 2{:}1$.

2.1 Specimen photographs

Photographs of the specimens before and after testing are presented in Figure 3.



(a) CRB-3, UCS-1

(b) CRB-6, UCS-1

(c) CRB-7, UCS-1

(d) CRB-7, UCS-3

Figure 2: Measured stress-strain curves.

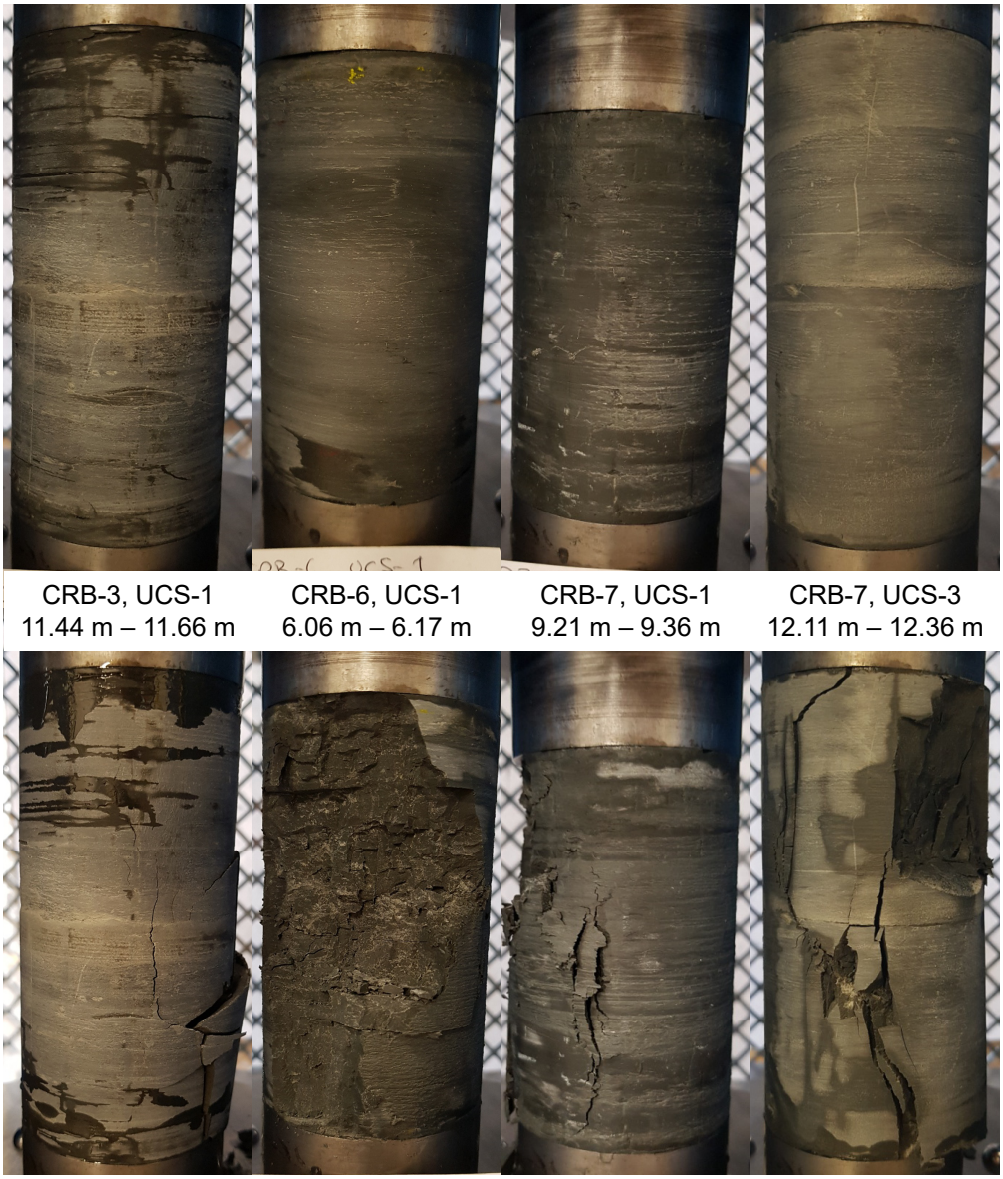


Figure 3: Photographs of specimens prior to testing.

GEOMECHANICA

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

April 09, 2018

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

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

Dear Mr. Marmor:

On March 27, 2018 three (3) NQ-sized and eight (8) HQ-sized core samples were received by Geomechanica Inc. via drop-off by Golder personnel. These samples were identified as being from boreholes drilled as part of Golder project. A uniaxial compressive strength (UCS) specimen was prepared and tested from each of these samples (11 tests total).

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 Ltd.
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

April 9, 2018
Project number: 1662333

Abstract

This document summarizes the results of 11 uniaxial compression tests on a combination of NQ and HQ core samples. Results, including uniaxial compressive strength (UCS) and Young's modulus, along with photographs of test specimens before and after testing are presented.

In this document:

1 Overview

This report summarizes the results of 11 uniaxial compression tests. The specimen preparation and testing procedure included the following:

1. Unwrapping of the core samples, inspecting them for damage, and re-wrapping them in electrical tape to minimize disturbance during subsequent specimen preparation.
2. Diamond cutting of core samples to obtain cylindrical specimens with an appropriate length (length:diameter = 2:1) and nearly parallel end faces.
3. Surface grinding of specimens to obtain flat (within ± 0.025 mm) and parallel end faces (within $0.25°$).
4. Placing each specimen into the loading frame, applying a 0.5-1.0 kN axial load, removing the electrical tape, and axial loading at a constant displacement rate to rupture while continuously recording axial force and axial deformation to determine the peak strength (UCS) and (tangent) Young's modulus (E).

2 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 1 to Figure 2. The 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.

Table 1: Summary of laboratory test results.

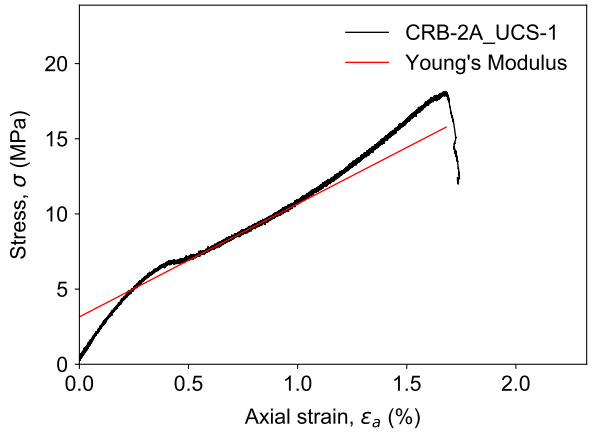
Sample	Rock type	Depth (m)	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's Modulus E (GPa)	Notes
CRB-2A, UCS-1	Shale	4.31 - 4.46	2.59	18.2	0.75	1, 2
CRB-2A, UCS-2	Shale	4.92 - 5.15	2.60	17.1	0.76	1
CRB-3C, UCS-3	Limestone	7.87 - 7.98	2.61	114.1	22.91	2, 3
CRB-2, UCS-2	Shale	7.75 - 7.92	2.58	11.2	0.83	1
CRB-2, UCS-3	Shale	11.37 - 11.52	2.61	13.0	2.19	3
CRB-3A, UCS-3	Shale	10.19 - 10.33	2.60	8.9	0.48	1, 4 - 2 limestone layers 5-10 mm thick
CRB-3A, UCS-5	Shale	12.99 - 13.28	2.62	16.9	0.67	1
CRB-4, UCS-3	Shale	13.62 - 13.80	2.61	18.6	0.84	1
CRB-5, UCS-2	Shale	13.68 - 13.95	2.61	15.5	0.61	1
CRB-5A, UCS-2	Shale	12.43 - 12.57	2.60	14.2	0.96	1
CRB-5A, UCS-4	Shale	15.34 - 15.57	2.64	22.7	0.93	1

[1] Upon loading specimen emitted pore water

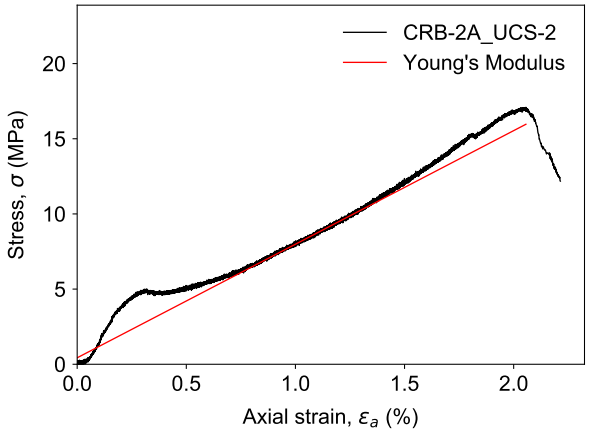
[2] Irregular diameter > 0.5 mm

[3] Length:Diameter ratio less than 2

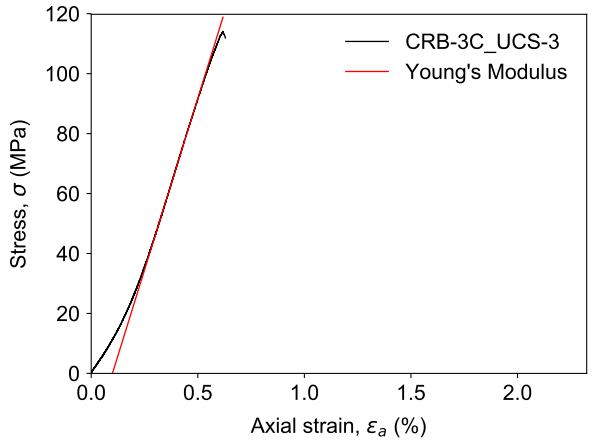
[4] Inter-bedded limestone and shale



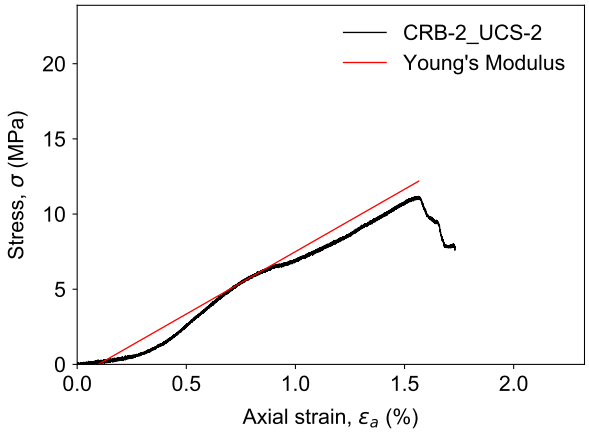
(a) CRB-2A, UCS-1



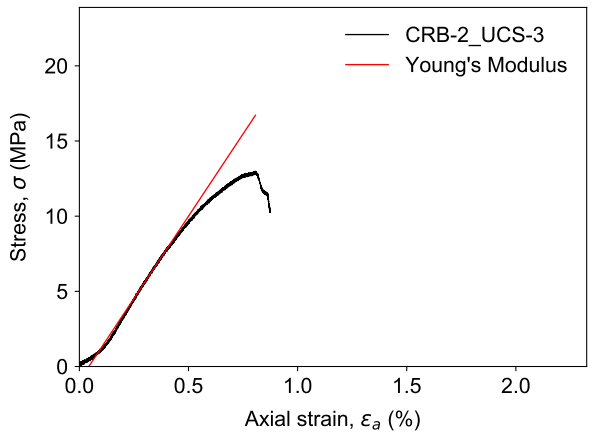
(b) CRB-2A, UCS-2



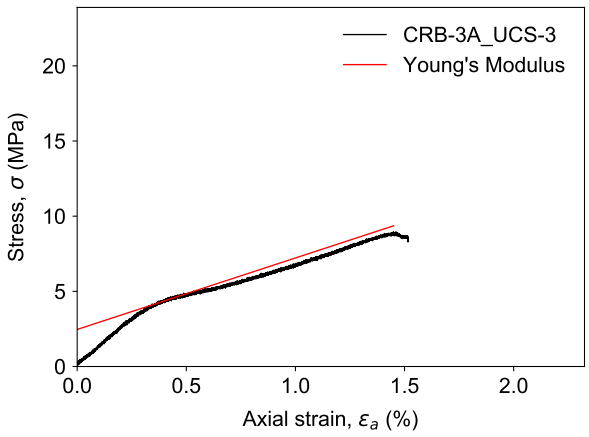
(c) CRB-3C, UCS-3



(d) CRB-2, UCS-2

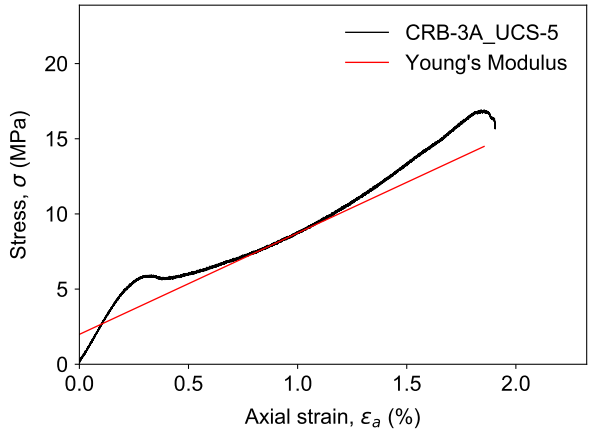


(e) CRB-2, UCS-3

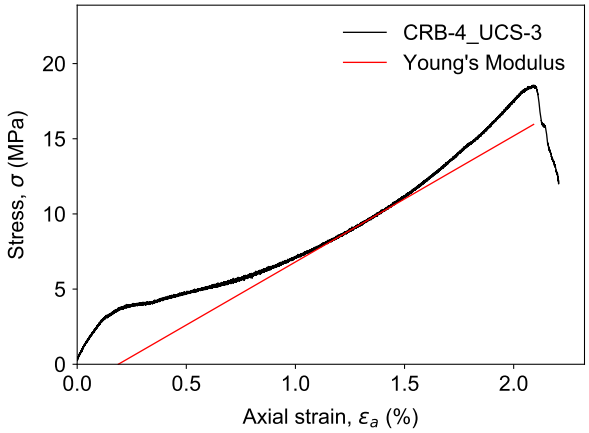


(f) CRB-3A, UCS-3

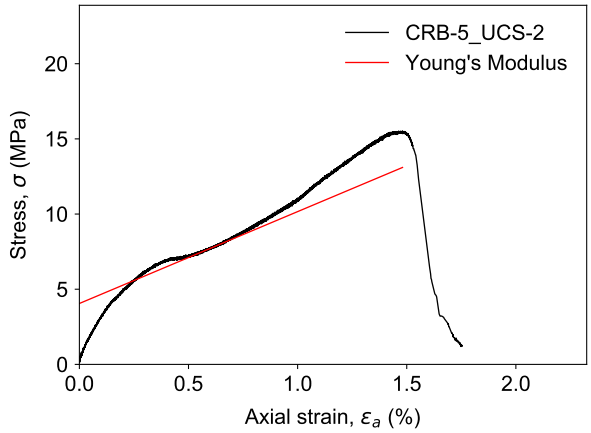
Figure 1: Measured stress-strain curves.



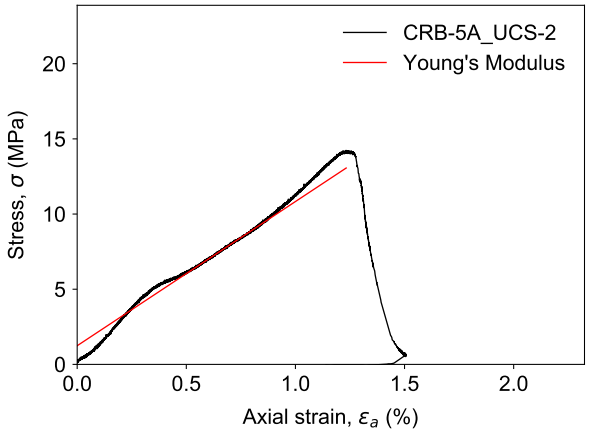
(a) CRB-3A, UCS-5



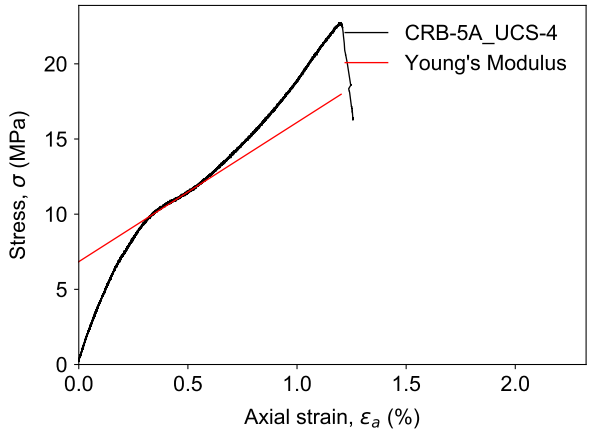
(b) CRB-4, UCS-3



(c) CRB-5, UCS-2



(d) CRB-5A, UCS-2



(e) CRB-5A, UCS-4

Figure 2: Measured stress-strain curves.

2.1 Specimen photographs

Photographs of the specimens before and after testing are presented in Figure 3 and Figure 4

Figure 3: Photographs of specimens prior to testing.

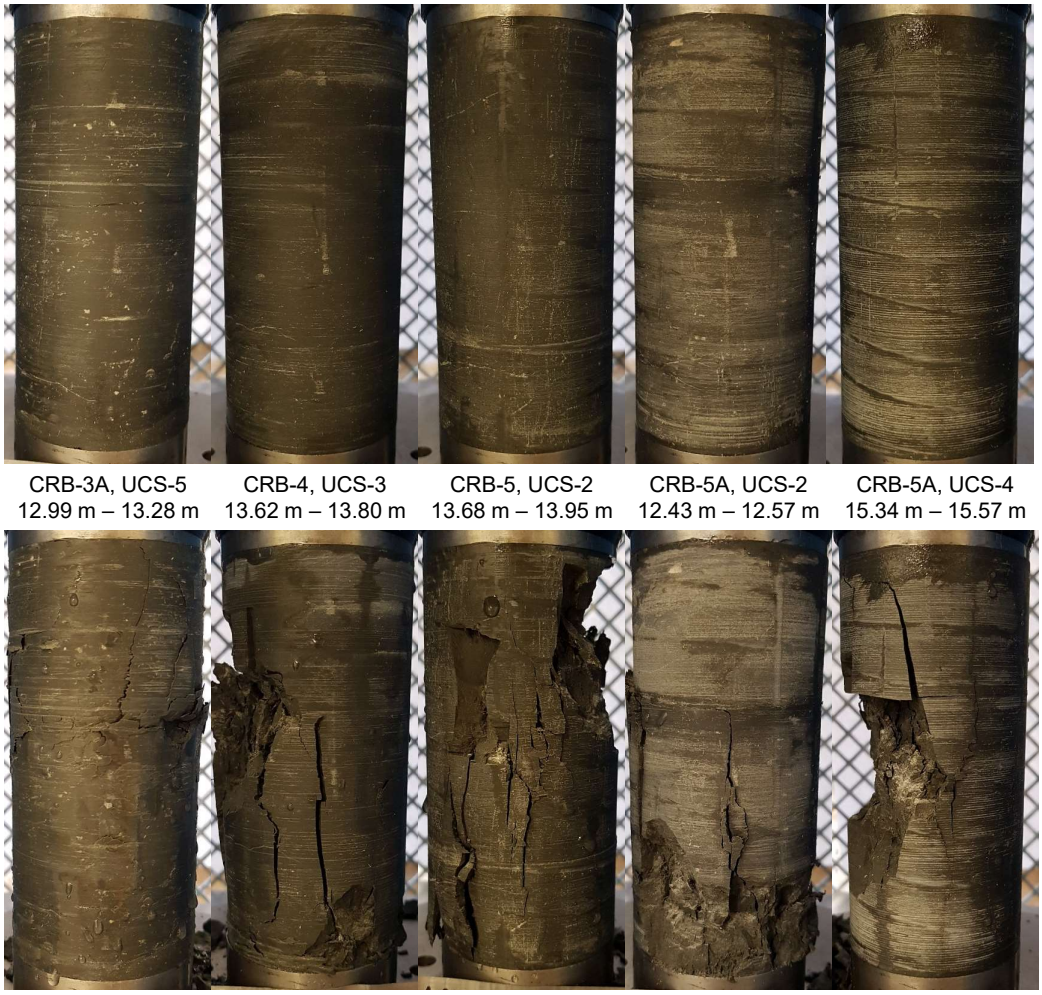


Figure 4: Photographs of failed specimens after testing.

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
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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.

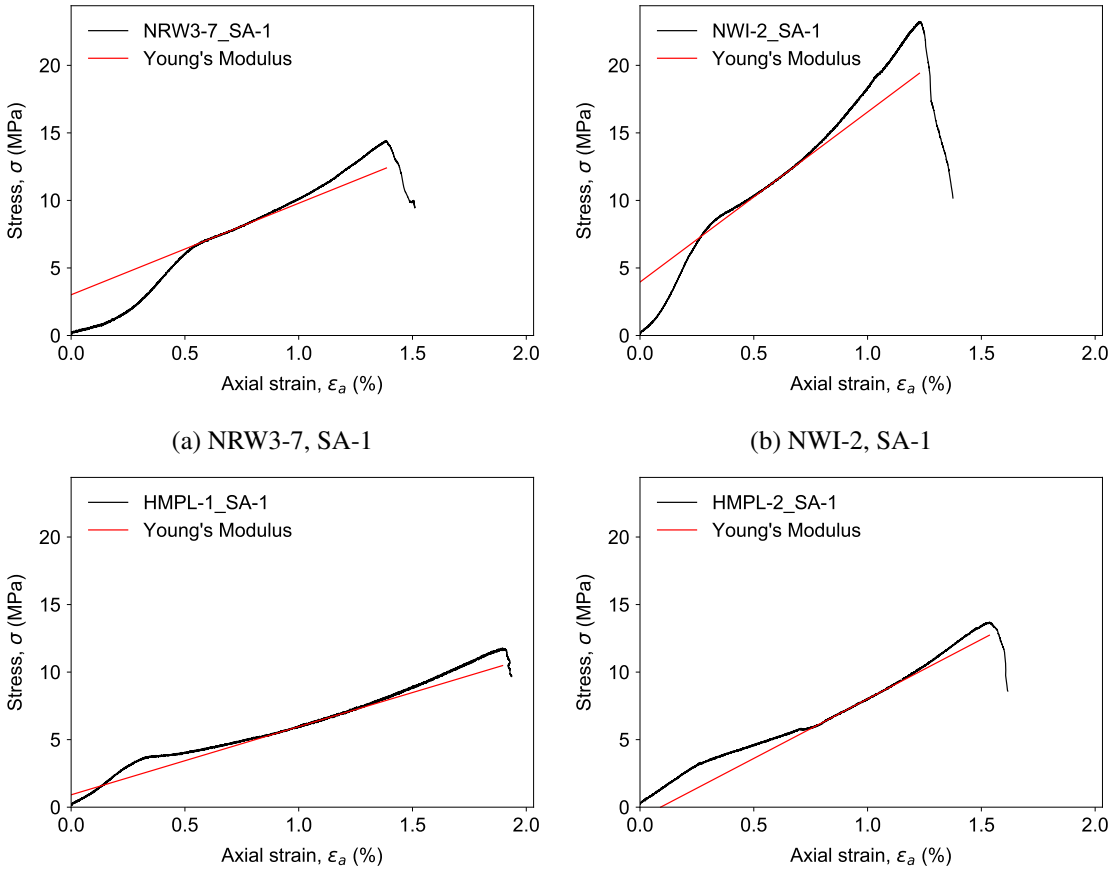
Sample	Depth (m)	Lithology description	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's Modulus E (GPa)	Failure description
NRW3-7, SA-1	9.57 - 9.71	Georgian Bay Formation - Shale	2.596	14.4	0.68	Axial splitting [1, 2]
NWI-2, SA-1	5.06 - 5.31	Georgian Bay Formation - Shale	2.619	23.3	1.26	Inclined shear fracture [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.



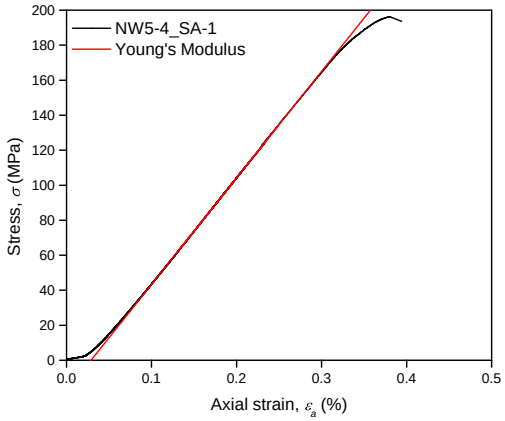
(a) NRW3-7, SA-1

(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.

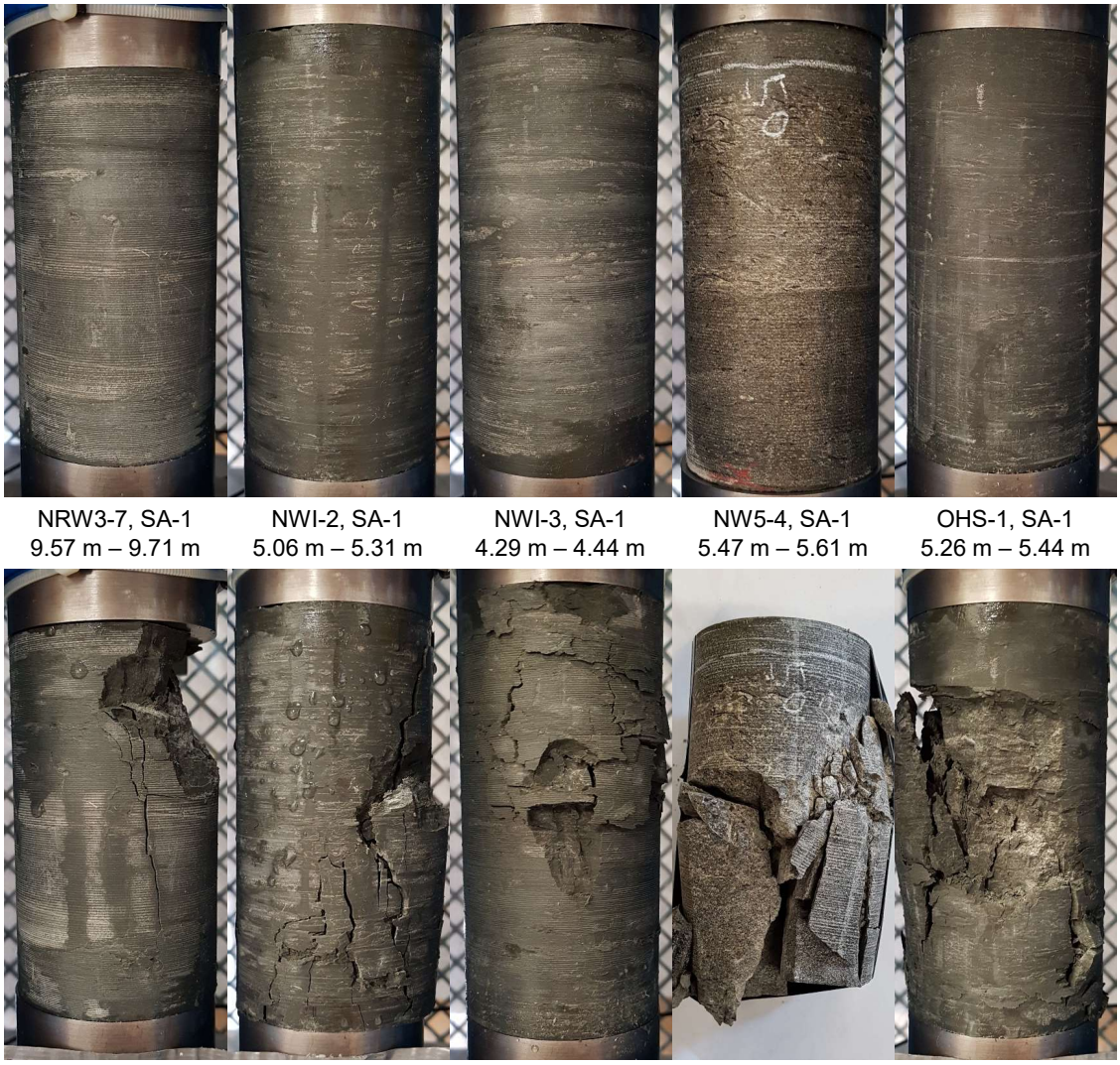


Figure 4: Photographs of specimens before and after testing.

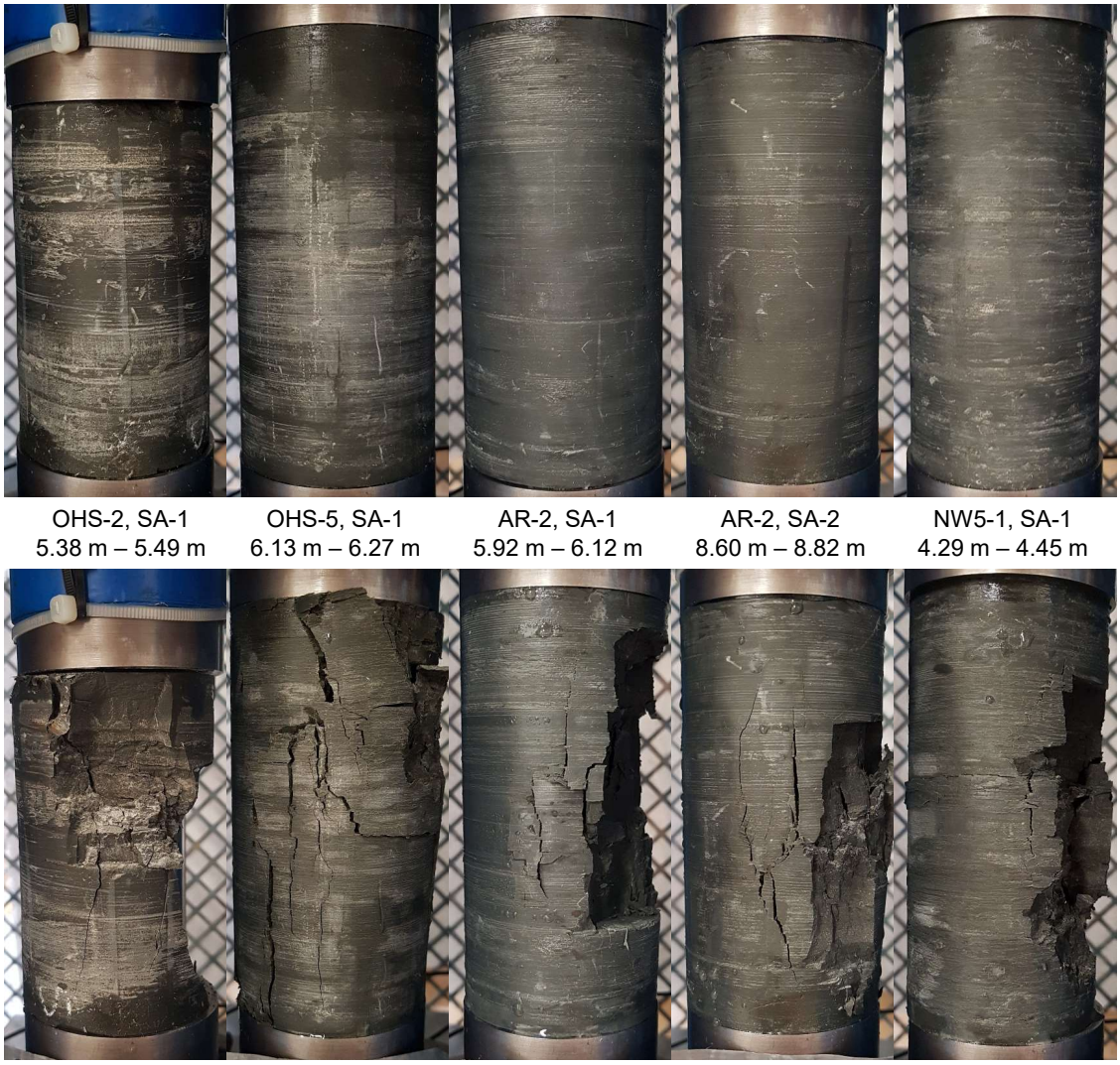


Figure 5: Photographs of failed specimens before and after testing (continued).

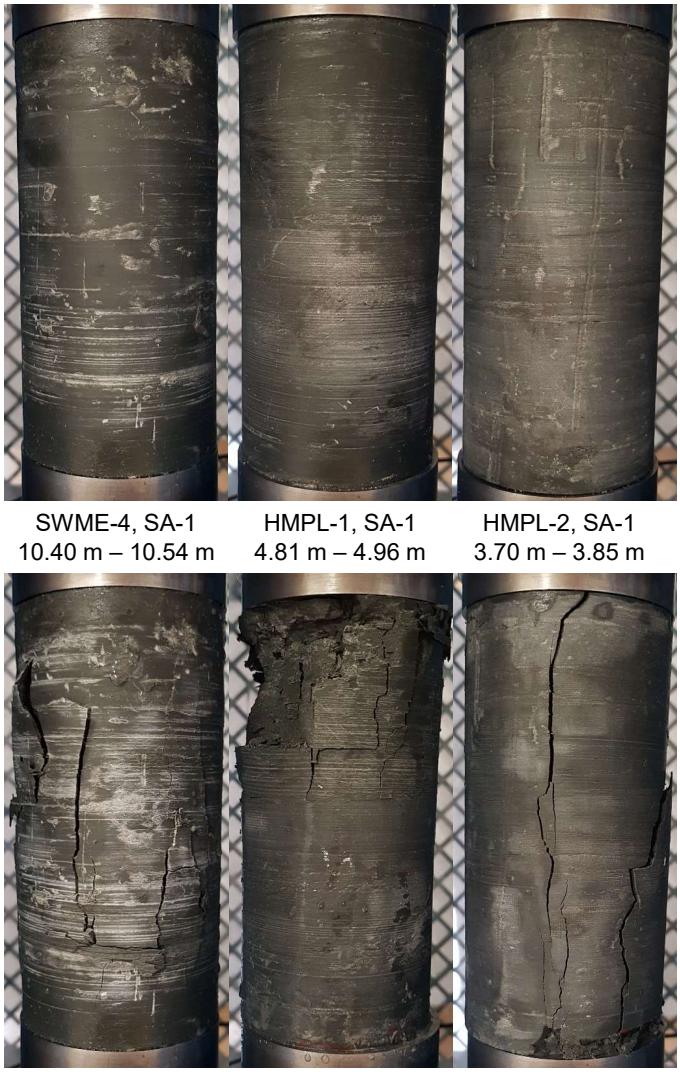


Figure 6: Photographs of failed specimens before and after testing (continued).

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