



May 23, 2018

FOUNDATION INVESTIGATION REPORT

**Queen Elizabeth Way (QEW)-Mississauga Road
Overpass Replacement, Structure Site No.24-196
QEW Widening from West of Mississauga Road to West
of Hurontario Street, Mississauga, Ministry of
Transportation, Ontario, GWP 2002-13-00**

Submitted to:

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REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed replacement and widening of the Queen Elizabeth Way (QEW) Overpass at Mississauga Road in support of the widening of the 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 and bedrock conditions at the proposed replacement structure location, including the associated approach embankments, by borehole drilling, rock coring, and laboratory testing on selected soil and rock core samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated July 2016, which forms part of the Consultant's Assignment Number (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

At this site the QEW is generally oriented in a northeast-southwest direction; for the purpose of this report the QEW is described as being in an east-west orientation. The existing QEW-Mississauga Road Overpass is located approximately 4.1 km east of the QEW-Erin Mills Interchange and approximately 2.1 km west of the QEW - Hurontario Street Interchange and approximately 500 m west of the west bank of the Credit River. Street Interchange, approximately 500 m west of the west bank of the Credit River.

The existing overpass is an approximately 17.3 long and 35.6 m wide single span bridge, with abutments supported on spread footings founded on bedrock at about Elevation 91.6 m. At the time of overpass construction, the surface grade at Mississauga Road was lowered, to allow for the QEW to pass over the roadway, and therefore the heights of the approach embankments is minimal. The natural ground surface, in the immediate vicinity of the overpass is about Elevation 95 m and the grade of the QEW is between about Elevations 99.4 m and 99.8 m. The Mississauga Road grade under the QEW is at about Elevation 93 m.

Land use in the northeast, northwest, southeast and southwest quadrant of the interchange is primarily residential with scattered light commercial development. A golf course is located to the north of QEW and the Credit River and the Credit River valley are located to the east of Mississauga Road.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

In September 2011, a preliminary foundation investigation for the Mississauga Road Overpass replacement was carried out at the site by Thurber Engineering Ltd. (Thurber) during which time a total of two boreholes, designated as Boreholes MR11-01 and MR11-02, were advanced. The results of the Thurber investigation are contained in their report titled "Foundation Investigation and Design Report, Preliminary Design and Environmental



Assessment, QEW Mississauga Road Overpass, Mississauga Ontario" File No. 19-1351-174, dated May 14, 2012 (GEOCRE 30M12-342).

The locations of the boreholes advanced by Thurber are shown on Drawing 1, and the borehole records and the summary of the laboratory testing results from this investigation are presented in Appendix A. The borehole locations in MTM NAD 83 Zone 10 coordinates, ground surface elevations in Geodetic Datum and the drilled depths as taken from the borehole records are as follows:

Borehole No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
MR11-01	4,823,600.3	295,564.2	94.3	3.1
MR11-02	4,823,601.1	295,645.2	93.3	7.7

3.2 Current Investigation

The field work for the current foundation investigation was carried out between August 22 and September 7, 2017 and between December 19 and 21, 2017 during which time twelve sampled boreholes (designated as Boreholes MO-01 to MO-12) were advanced in the area of the structure, at the locations shown on Drawing 1. A cluster of borings was advanced in the area of Boreholes MO-01 and MO-08 (Boreholes are designated as MO-01A to MO-01C and MO-08A to MO-08B) to confirm the depth to bedrock and provide confirmation of subsurface conditions at the locations of the primary boreholes. The Record of Borehole/Drillhole sheets for the current investigation are presented in Appendix B.

The field borehole investigation was carried out using a truck-mounted CME 75 or CME 55 drill rig, supplied and operated by Aardvark Drilling Inc., of Guelph, Ontario, a track-mounted CME 55 drill rig, supplied and operated by Geo-Environmental Drilling Inc., of Acton, Ontario, and using portable drilling equipment supplied and operated by Walker Drilling Ltd., of Utopia, Ontario. The boreholes were advanced through the overburden using 203 mm outer-diameter hollow stem augers and 'HQ' casing in the boreholes advanced by a drill rig and continuous split spoon sampling in the boreholes advanced by the portable drilling equipment (Boreholes MO-01A to MO-01C, MO-08A and MO-08B). In the boreholes where continuous sampling was not carried out, soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08)¹. Core samples of the bedrock in select boreholes were obtained using an 'HQ' size rock core barrel and coring techniques.

The boreholes were typically advanced to sampler refusal and bedrock was confirmed by either split spoon sampling or rock coring. The boreholes were advanced to depths of about 1.2 m and 7.0 m below existing ground surface, including coring of bedrock for core lengths of between 3.0 m and 4.7 m in select boreholes. Photographs of the recovered bedrock core samples are provided in Appendix C.

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



The water levels in the open boreholes and field moisture content of the recovered soil samples were observed during the drilling operations and are noted on the Record of Borehole sheets in Appendix B. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903, Wells (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 and cared for the soil and bedrock core samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our 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. The results of the laboratory testing for the current investigation are included in Appendix C. Unconfined compression (UC) tests (including assessment of Young's modulus, Poisson's ratio, and core density) were carried out on selected specimens of the bedrock core samples by Geomechanica Inc. on behalf of Golder. The results of the laboratory testing for the current investigation are included in Appendix C.

Selected bedrock core samples were submitted to Maxxam Analytics (Maxxam), a Standards Council of Canada (SCC) accredited laboratory of Mississauga, Ontario for chemical analysis. The samples of bedrock core, specifically collected from Boreholes MO-10 and MO-11 advanced at the west and east abutments, respectively, were crushed and homogenized by Maxxam prior to testing, and analyzed for a suite of corrosivity parameters, including conductivity, resistivity, soluble chloride, soluble sulphate and pH. The results of the chemical analyses are presented in Appendix C.

The as-drilled borehole locations and the ground surface elevations were obtained using a GPS (Trimble XH 3.5G), having an accuracy of 0.1 m in the vertical and 0.1 m in the horizontal directions. The locations given in 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 (Latitude, °)	Easting (Longitude, °)		
MO-01A	4,823,580.0 (43.552090)	295,566.4 (-79.614279)	98.9	1.5
MO-01B	4,823,579.3 (43.552084)	295,565.7 (-79.614288)	98.9	1.2
MO-01C	4,823,581.1 (43.552100)	295,567.5 (-79.614265)	99.2	1.2
MO-02	4,823,572.9 (43.552027)	295,595.8 (-79.613914)	99.8	3.3
MO-03	4,823,599.6 (43.552266)	295,570.4 (-79.614229)	94.0	4.3*
MO-04	4,823,583.9 (43.552126)	295,593.2 (-79.613947)	99.7	6.6*
MO-05	4,823,585.1 (43.552136)	295,623.8 (-79.613568)	99.6	7.0*



Borehole No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude, °)	Easting (Longitude, °)		
MO-06	4,823,610.0 (43.552360)	295,581.0 (-79.614098)	93.6	4.7*
MO-07	4,823,616.9 (43.552423)	295,622.5 (-79.613584)	99.4	6.3*
MO-08A	4,823,630.5 (43.552545)	295,614.5 (-79.613684)	98.9	2.2
MO-08B	4,823,632.0 (43.552559)	295,615.8 (-79.613668)	98.9	2.1
MO-09	4,823,634.3 (43.552580)	295,652.9 (-79.613208)	99.2	3.1
MO-10	4,823,597.7 (43.552249)	295,592.3 (-79.613959)	93.1	5.8*
MO-11	4,823,604.7 (43.552313)	295,610.1 (-79.613738)	92.9	5.7*
MO-12	4,823,592.2 (43.552201)	295,628.5 (-79.613511)	92.9	5.7*

* includes bedrock core between 3.0 m and 4.7 m length

As noted in Section 3.1, the current investigation was supplemented with previous boreholes advanced by Thurber. While the Thurber report does not reference the coordinate system of the borehole locations, it is inferred that they are referenced to the MTM NAD 83 coordinate system based on the plotted position relative to that reference system. The northing and eastings of the boreholes, advanced during the previous investigation and this current investigation are shown in plan and tabulated on Drawing 1.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

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

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

The bedrock of the Georgian Bay Formation that underlies the study area consists mainly of blue-grey shale, containing siltstone, sandstone and limestone interbeds. Outcrops of this formation are commonly found along

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.)



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 advanced during the previous and current investigations and the results of the laboratory tests carried out on selected soil and bedrock core samples are presented on the Record of Borehole and Drillhole sheets provided in Appendices A and B, respectively. The results of the in situ field tests (i.e. SPT "N" values) as presented on the Record of Borehole sheets of the current investigation and in sub sections of Section 4.2 are uncorrected. The geotechnical laboratory testing plots for samples from the current investigation are contained in Appendix C.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profiles on Drawings 1 and 2 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 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 record of Borehole and Drillhole sheets governs any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawings 1 and 2 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the replacement overpass consist of a layer of asphalt and concrete in places, or topsoil, underlain by a deposit of granular fill associated with the construction of the existing highway and Mississauga Road. The fill is underlain in some locations by a deposit of residual soil comprised of clayey silt or sandy clayey silt. The fill deposits and/or the native deposits are underlain by shale bedrock.

A detailed description of the subsurface conditions encountered in the boreholes from the previous and current investigations are provided in the following sections.

4.2.1 Asphalt/Concrete

Boreholes MO-02, MO-04, MO-05, MO-07 and MO-09 were advanced through the QEW highway surface and encountered a layer of asphalt varying in thickness from about 130 mm to 250 mm. Underlying the asphalt a layer of concrete was encountered in Boreholes MO-02, MO-05, MO-07 and MO-09, ranging in thickness from about 150 mm to 280 mm.

Boreholes MO-03, MO-06, MO-10 to MO-12, MR11-01 and MR11-02 were advanced through the Mississauga Road surface and encountered a layer of asphalt varying in thickness from about 100 mm to 250 mm.

4.2.2 Topsoil

The MO-01 and MO-08 series of boreholes were advanced north of the existing QEW highway surface and encountered a layer of topsoil at ground surface varying in thickness from about 75 mm to 180 mm.

4.2.3 Non-Cohesive Fill

A 0.5 m to 3.3 m thick layer of non-cohesive fill was encountered underlying the asphalt and concrete (where present) or topsoil or cohesive fill (where present) in all the boreholes advanced at the site. The fill is variable in composition and generally consists of silty sand to gravelly sand to sand and gravel. The surface of the fill deposit was encountered between about Elevations 99.4 m and 93.5 m and extends to depths of between about 0.6 m and 3.6 m below ground surface.



The SPT “N” values measured within the non-cohesive fill range from 5 blows to 63 blows per 0.3 m of penetration with one value of 100 blows for 0.13 m of penetration, indicating that the fill layer has a loose to very dense relative density.

Grain size distribution tests were carried out on two samples of the fill material sampled in the boreholes from the previous investigation and the results are presented on the borehole records included in Appendix A. Grain size distribution tests were carried out on thirteen selected samples of the non-cohesive fill recovered during the current investigation and the results are shown on Figures C1A and C1B in Appendix C. One Atterberg limits test was carried out on a sample of the non-cohesive fill from Borehole MO-08B and confirmed that the fill is non-plastic.

The water content measured on samples of the non-cohesive fill ranges between about 3 per cent and 24 per cent.

4.2.4 Cohesive Fill

A 0.2 m to 0.9 m thick layer of cohesive fill was encountered underlying the topsoil in Borehole MO-08B, underlying the non-cohesive fill in Borehole MO-09, and within the non-cohesive fill layer in Borehole MO-02. The fill is variable in composition and generally consists of clayey silt trace sand to clayey silt with sand and contains trace to some gravel and trace rootlets. The surface of the fill deposit was encountered between about Elevations 98.8 m and 97.9 m and extends to depths of between about 0.6 m and 2.2 m below ground surface.

The SPT “N” values measured within the cohesive fill are 9 blows and 25 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

A grain size distribution test was carried out on a selected sample of the cohesive fill recovered from Borehole MO-09 and the result is shown on Figure C2 in Appendix C. Atterberg limits tests were carried out on two samples of the cohesive fill and measured liquid limits of 31 per cent and 33 per cent, plastic limits of 16 per cent, and plasticity indices of 15 per cent and 17 per cent. These results, which are plotted on a plasticity chart on Figure C3 in Appendix C indicate that the samples tested can be classified as clayey silt of low plasticity.

The water content measured on samples of the cohesive fill ranges between about 14 per cent and 24 per cent.

4.2.5 Clayey Silt

In Boreholes MO-01A to MO-01C, MO-08A and MO-08B a 0.4 m to 0.9 m thick deposit of clayey silt trace to some sand, trace to some gravel, was encountered underlying the fill deposit at depths between 0.6 m and 1.4 m below ground surface (between Elevations 98.6 m and 97.5 m).

The SPT “N” values measured within the clayey silt deposit range between 20 blows and 77 blows per 0.3 m of penetration and 100 blows for 0.25 m of penetration, suggesting that the cohesive deposit has a very stiff to hard consistency.

A grain size distribution test was carried out on a selected sample of the clayey silt deposit from Borehole MO-08A and the result is shown on Figure C4 in Appendix C. Atterberg limits tests were carried out on three samples of this deposit and measured liquid limits between 32 per cent and 33 per cent, plastic limits between 19 per cent and 20 per cent, and plasticity indices between 12 per cent and 13 per cent. These results are shown on Figure C5 in Appendix C and indicate that the deposit consists of clayey silt of low plasticity.

The natural water content measured on samples of the cohesive deposit are between 11 per cent and 21 per cent.



4.2.6 Residual Soil

In Boreholes MO-02, MO-04, MO-05, MO-07 and MO-09 a 0.2 m to 1.6 m thick deposit of residual soil was encountered underlying the fill deposits at depths between 1.8 m and 3.6 m below ground surface (between Elevations 97.8 m and 96.0 m).

The SPT “N” values measured within the residual soil deposit range between 36 blows and 66 blows per 0.3 m of penetration and up to 100 blows for 0.1 m of penetration, suggesting a hard consistency.

The deposit consists of clayey silt with sand to sandy, some gravel to gravelly and contains trace to some shale fragments, derived from weathering of the underlying shale bedrock. Grain size distribution tests were carried out on three selected samples of the clayey silt residual soil deposit and the results are shown on Figure C6 in Appendix C. Atterberg limits tests were carried out on three samples of this deposit and measured liquid limits between 31 per cent and 33 per cent, plastic limits between 20 per cent and 21 per cent, and plasticity indices between 11 per cent and 13 per cent. These results are shown on Figure C7 in Appendix C and indicate that the deposit consists of clayey silt of low plasticity.

The water content measured on samples of the residual soil deposit range between 4 per cent and 13 per cent.

4.2.7 Bedrock

Bedrock was encountered and core samples were recovered in Boreholes MO-03 to MO-07, MO-10 to MO-12, MR11-01 and MR11-02, and the bedrock surface was inferred from augering and/or split-spoon sampling in Boreholes MO-01A to MO-01C, MO-02, MO-08A, MO-08B and MO-09. The depths to bedrock below ground surface, and the corresponding bedrock surface elevation are summarized below.

Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Comments
MO-01A	1.2	97.7	Split Spoon Sample
MO-01B	1.1	97.8	Split Spoon Sample
MO-01C	1.1	98.1	Split Spoon Sample
MO-02	3.3	96.5	Auger Refusal
MO-03	1.0	93.0	Bedrock Cored
MO-04	3.5	96.2	Bedrock Cored
MO-05	3.8	95.9	Bedrock Cored
MO-06	1.6	92.0	Bedrock Cored
MO-07	3.0	96.4	Bedrock Cored
MO-08A	2.2	96.8	Split Spoon Sample
MO-08B	1.8	97.1	Split Spoon Sample
MO-09	3.0	96.2	Split Spoon Sample
MO-10	0.9	92.2	Bedrock Cored
MO-11	0.7	92.2	Bedrock Cored
MO-12	0.9	92.0	Bedrock Cored
MR11-01	1.1	93.3	Bedrock Cored
MR11-02	2.8	90.5	Bedrock Cored



In general, the bedrock surface as encountered or inferred in the area of the proposed bridge replacement slopes gently down towards the south, with the exception of the Mississauga Road alignment which was constructed in a bedrock cut.

Based on a review of the bedrock core samples from the current investigation and descriptions of the bedrock from the previous investigation, the bedrock consists of shale of the Georgian Bay Formation. In general, the bedrock samples are described as moderately to slightly weathered to fresh, thinly to medium bedded, fine grained, faintly porous, very weak to weak, grey, with medium strong limestone interbeds at varying intervals of depth, as presented in the borehole records from the previous investigation in Appendix A and the Record of Drillhole sheets from the current investigation in Appendix B, and shown on the photographs of the recovered core samples on Figures C8 to C15 in Appendix C. The degree of weathering of the bedrock samples (i.e. fresh to moderately weathered – W1 to W3), and the strength classification of the intact rock mass based on field identification (i.e. strong to very strong – R4 to R5) 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 from about 29 per cent to 100 per cent, and is generally greater than 50 per cent, indicating a rock mass of poor to excellent quality, and generally fair to excellent quality, as per Table 3.10 of CFEM (2006)⁴. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 67 per cent and 100 per cent and between 45 per cent and 100 per cent, respectively.

Unconfined compression uniaxial compressive strengths (UCS) obtained from the UC tests (ASTM D7012)⁵ carried out on selected core samples of the shale bedrock and the results are summarised below and the details are presented on the Rock Laboratory Test Result reports from Geomechanica in Appendix C.

Borehole No.	Sample Depth (m)	UCS (MPa)	Bulk Density (g/cm ³)	Young's Modulus (GPa)
MO-03	3.94 – 4.09	14.8	2.58	2.20
MO-04	6.21 – 6.37	6.4	2.56	0.24
MO-05*	6.08 – 6.16	39.2	2.60	6.53
MO-10	2.68 – 2.83	19.6	2.60	0.86
MO-11	3.66 – 3.79	18.3	2.59	0.97
MO-12	4.15 – 4.27	17.3	2.60	1.00

Note: *Specimen included 60 mm thick limestone layer at bottom.

Twenty-four axial and eleven diametral point Load tests were carried out on 35 samples of the shale bedrock, and the results are summarized below:

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



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Borehole No.	Sample Depth (m)	Sample Elevation (m)	Orientation	Axial $I_{s(50mm)}$ (MPa)
M0-3	3.35	90.65	Axial	1.84*
M0-3	3.59	90.41	Axial	3.4*
M0-3	3.62	90.38	Axial	1.73
M0-4	5.70	93	Diametral	0.42
M0-4	5.73	92.97	Axial	0.57
M0-4	6.43	93.27	Diametral	0.27
M0-4	6.47	93.23	Axial	1.85*
M0-5	5.68	94.02	Axial	1.38
M0-5	5.97	93.73	Axial	1.56
M0-5	5.87	93.83	Axial	1.62
M0-6	3.40	89.75	Axial	2.14*
M0-6	4.34	89.36	Axial	1.67
M0-6	4.36	89.34	Axial	1.62
M0-7	4.98	94.42	Axial	1.32
M0-7	5.52	93.88	Axial	1.42
M0-7	6.02	93.38	Axial	0.85
MO-10	1.94	91.16	Diametral	0.07
MO-10	2.06	91.04	Axial	0.45
MO-10	2.46	90.64	Axial	0.52
MO-10	2.46	90.64	Diametral	0.62
MO-10	2.59	90.51	Axial	0.36
MO-10	2.89	90.21	Diametral	0.57
MO-10	4.17	88.93	Diametral	0.22
MO-10	4.21	88.89	Axial	0.43
MO-11	1.37	91.53	Axial	6.52*
MO-11	2.25	90.65	Diametral	0.34
MO-11	2.31	90.59	Axial	1.08
MO-11	3.79	89.11	Diametral	0.33
MO-11	3.86	89.04	Axial	0.56
MO-12	2.33	90.57	Diametral	0.38
MO-12	2.33	90.57	Axial	0.46
MO-12	2.47	90.43	Diametral	0.56
MO-12	2.47	90.43	Axial	0.74
MO-12	3.99	88.91	Diametral	0.50
MO-12	3.99	88.91	Axial	0.70

*test carried out on limestone interlayer



The estimated uniaxial compressive strength (UCS) values for each sample tested for point load strength are based on a relationship between Is_{50} and UCS which is given by a correlation factor (C) in accordance with ASTM D573108 (*Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification*), which may vary depending on the size of the core sample and the strength of the rock. For this site, the UCS values are based on an estimated average correlation factor (C) of 13.6 calculated from the average Is_{50} , and ignoring the tests carried out on limestone layers, compared to the average of the UCS test results.

Based on the laboratory UCS and point load tests, in accordance with Table 3.5 in CFEM (2006)⁴, the shale bedrock is generally classified as very weak (R1, 1 MPa < UCS < 5 MPa) to weak (R2, 5 MPa < UCS < 25 MPa) and the limestone interlayers are classified as medium strong (R3, 25 MPa < UCS < 50 MPa) to strong (R4, 50 MPa < UCS < 100 MPa).

4.2.8 Groundwater Conditions

The overburden samples obtained from the borehole investigations were generally moist. The boreholes were observed to be dry upon completion of soil drilling and prior to rock coring and the water level on completion of rock coring varied between about 4.8 m and 5.7 m below ground surface (between Elevations 94.7 m and 93.8 m). The water levels recorded in the piezometers during the 2011 subsurface investigation, about one month after installation is presented below.

Borehole	Stratum Sealed Into	Water Level Depth (m)	Water Elevation (m)	Date
MR11-02	Sand Fill / Bedrock Interface	2.3	91.0	September 30, 2011

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.

4.2.9 Analytical Testing Results

As discussed in Section 3.2 two samples of crushed and homogenized shale bedrock core were submitted for analysis of parameters used to assess the potential corrosivity of the site bedrock to steel and concrete. The following summarizes the results of the testing:

Parameter	Borehole MO-10 Run 1 (1.65 m to 1.78 m)	Borehole MO-11 Run 2 (1.79 m to 1.89 m)
pH	8.33	8.22
Resistivity (ohm-cm)	1,500	1,800
Electrical Conductivity (umho/cm)	647	566
Chlorides (ug/g)	120	99
Soluble Sulphates (ug/g)	130	150



5.0 CLOSURE

This report was prepared by Mr. Matthew Kelly, P.Eng., a geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., MTO Foundations Designated Contact for Golder and Senior Consultant conducted a technical and quality control review of the report.

GOLDER ASSOCIATES LTD.



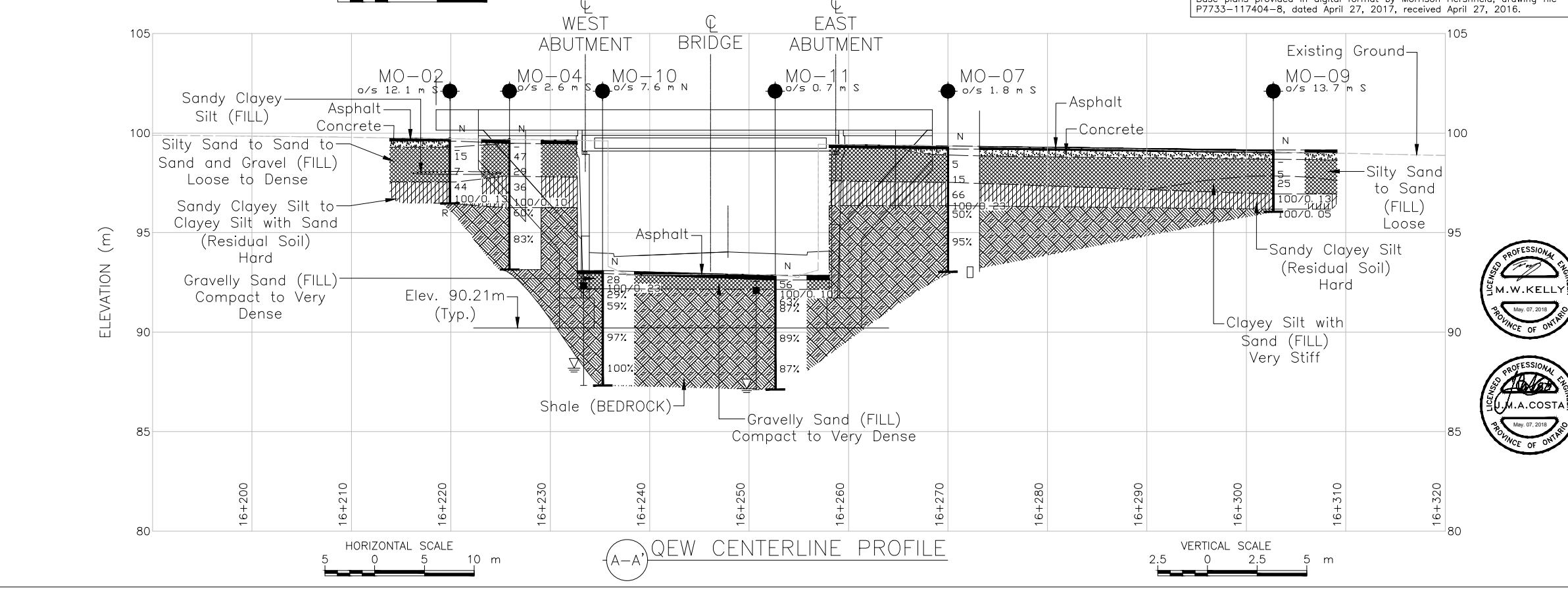
Matthew Kelly, P.Eng.
Geotechnical Engineer



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

MWK/ARV/JMAC/GDS/SMM/sm/rb

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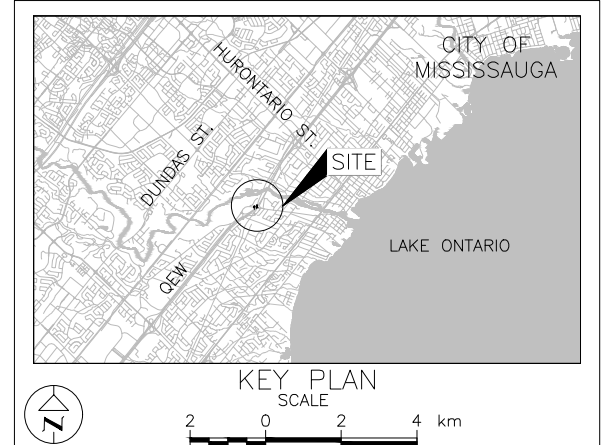


METRIC
 ONS ARE IN METRES AND/OR
 ES UNLESS OTHERWISE SHOW
 S IN KILOMETRES + METRES





CONT No.
GWP No.2002-13-00



QEW MISSISSAUGA ROAD OVERPASS
BOREHOLE LOCATIONS AND SOIL SRATA



LEGEND

- | | |
|---|--|
|  | Borehole |
|  | 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 | Refusal |
|  | WL upon completion of drilling |

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)			
No.	ELEVATION (m)	NORTHING	EASTING
MO-01A	98.9	4823580.0	295566.4
MO-01B	98.9	4823579.3	295565.7
MO-01C	99.2	4823581.1	295567.5
MO-02	99.8	4823572.9	295595.8
MO-03	94.0	4823599.6	295570.4
MO-04	99.7	4823583.9	295593.2
MO-05	99.6	4823585.1	295623.8
MO-06	93.6	4823610.0	295581.0
MO-07	99.4	4823616.9	295622.5
MO-08A	98.9	4823630.5	295614.5
MO-08B	98.9	4823632.0	295615.8
MO-09	99.2	4823634.3	295652.9
MO-10	93.1	4823597.7	295592.3
MO-11	92.9	4823604.7	295610.1
MO-12	92.9	4823592.2	295628.5
MR11-01	94.3	4823600.3	295564.2
MR11-02	93.3	4823601.1	295645.2

-	-	-	-	-
NO.	DATE	BY	REVISION	
Geocres No. 30M12-418				
HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL	
SUBM'D. JIL	CHKD. SM	DATE: 5/7/2018	SITE: 24-196	
DRAWN: SMD	CHKD. MWK	APPD. JMCA	DWG. 01	

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

CONT No.
GWP No.2002-13-00

QEW – MISSISSAUGA ROAD OVERPASS
SOIL STRATA

SHEET



LEGEND

Borehole

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)

WL in piezometer, measured on Sept. 30, 2011

WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)			
No.	ELEVATION (m)	NORTHING	EASTING
MO-01A	98.9	4823580.0	295566.4
MO-01B	98.9	4823579.3	295565.7
MO-01C	99.2	4823581.1	295567.5
MO-03	94.0	4823599.6	295570.4
MO-04	99.7	4823583.9	295593.2
MO-05	99.6	4823585.1	295623.8
MO-06	93.6	4823610.0	295581.0
MO-07	99.4	4823616.9	295622.5
MO-08A	98.9	4823630.5	295614.5
MO-08B	98.9	4823632.0	295615.8
MO-10	93.1	4823597.7	295592.3
MO-11	92.9	4823604.7	295610.1
MO-12	92.9	4823592.2	295628.5
MR11-01	94.3	4823600.3	295564.2
MR11-02	93.3	4823601.1	295645.2



NOTES

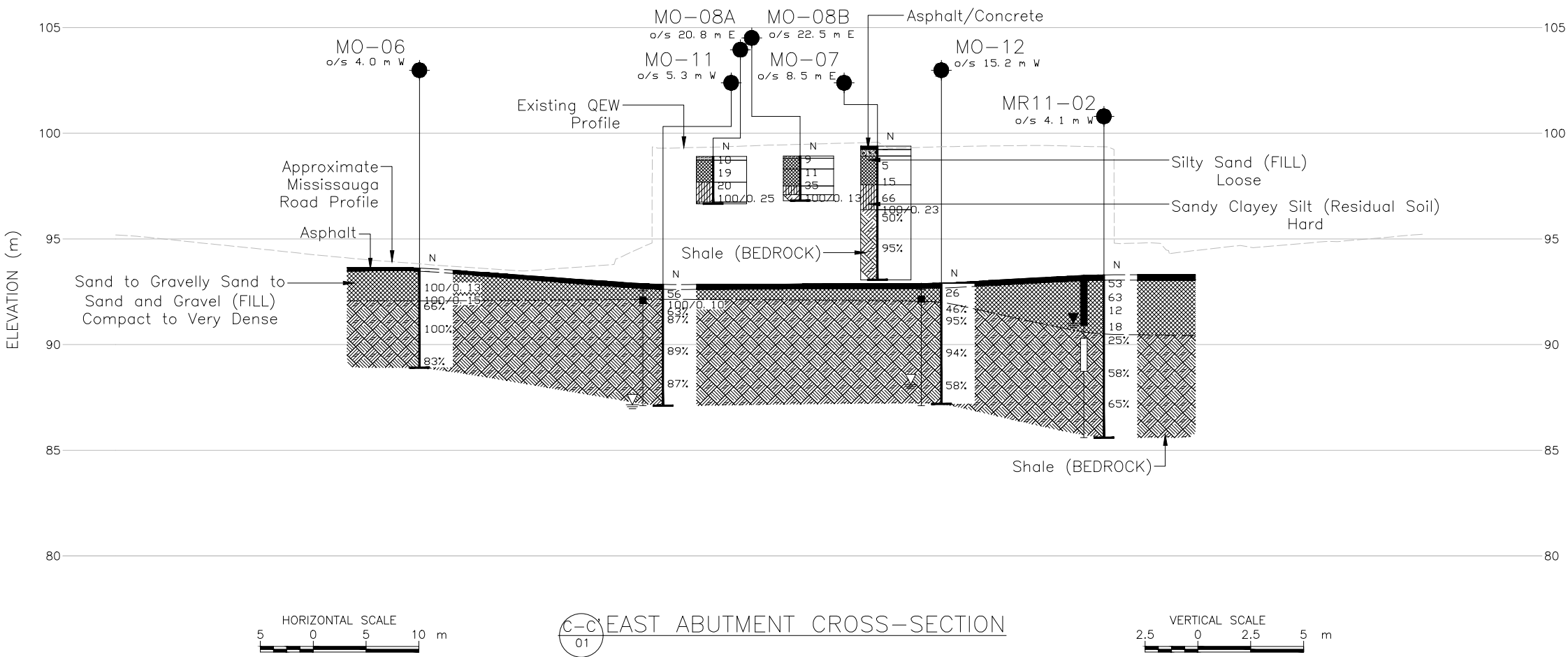
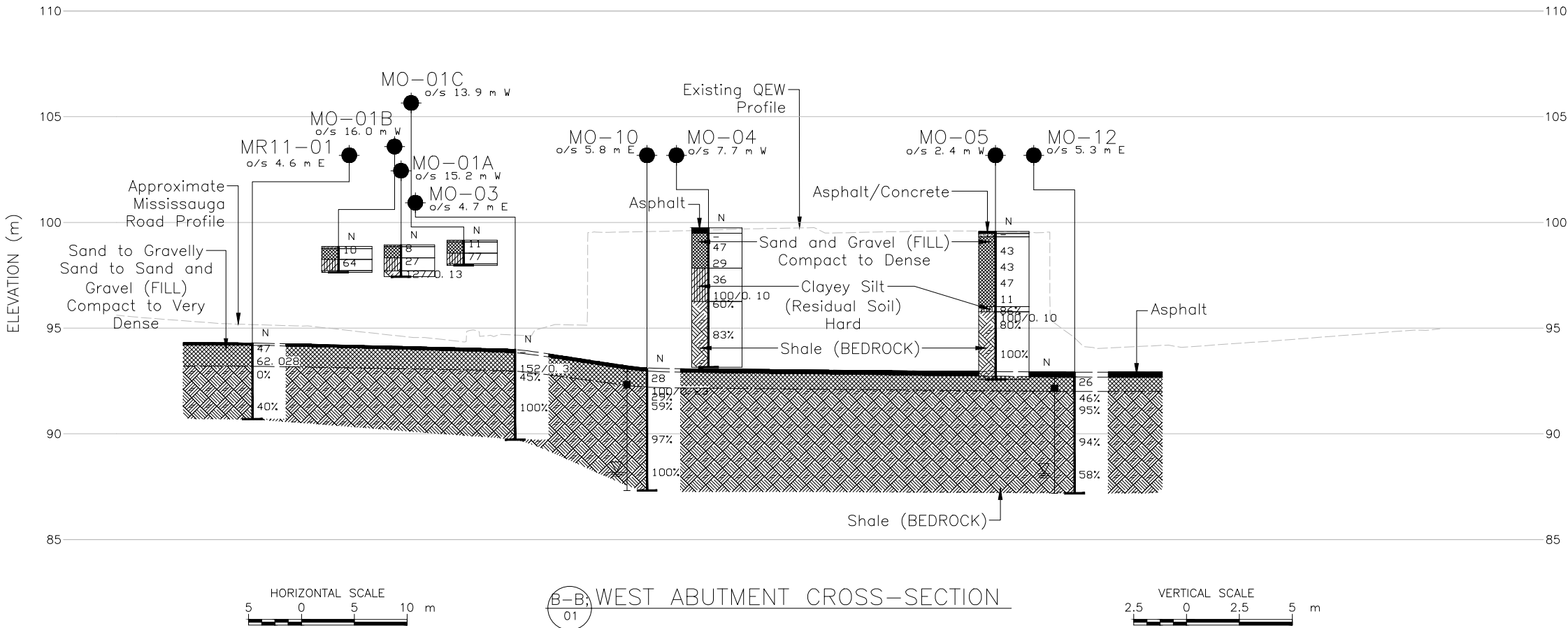
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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 P7733-117404-8, dated April 27, 2017, received April 27, 2016.

NO.	DATE	BY	REVISION
Geocres No. 30M12-418			
HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. JIL	CHKD. SM	DATE: 5/7/2018	SITE: 24-196
DRAWN: SMD	CHKD. MWK	APPD. JMAC	DWG. 02





APPENDIX A

Record of Boreholes - Previous Investigation (GEOCRES No. 30M12-342)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

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

 Water Level






C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
	HIGHLY ORGANIC SOILS		Pt
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.				
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No MR11-01

1 OF 1

METRIC

W.P. W.O. 08-20008 LOCATION N 4 823 600.3 E 295 564.2 QEW Mississauga Road Overpass ORIGINATED BY DA
 HWY QEW BOREHOLE TYPE Solid Stem Augers/NQ Core Barrel COMPILED BY AN
 DATUM Geodetic DATE 2011.09.17 - 2011.09.17 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
94.3								20	40	60	80	100			
0.0	ASPHALT: (100mm)		1	AS											
0.1	SAND, some gravel, some silt, trace clay		1	SS	47		94								17 62 16 5
	Dense														
	Brown														
	Moist														
93.3	(FILL)		2	SS	62/										
1.1	Some limestone fragments				0.28										
92.8	SHALE, weathered, grey						93								
1.5	END OF SPT SAMPLING AT 1.2m. AUGER TO 1.5m AND START CORING. FOR ROCK DETAILS PLEASE REFER TO MR11-01R.														

RECORD OF BOREHOLE MR11-01R

PROJECT : QEW Mississauga Rd. Overpass
LOCATION : Mississauga, ON
STARTED : September 17, 2011
COMPLETED : September 17, 2011

Project No. W.O. 08-20008


INCLINATION: Vertical AZIMUTH:

SHEET 1 OF 1
DATUM Geodetic

[illegible]

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

 DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : DA
CHECKED : MEF

METRIC

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE MR11-02R

PROJECT : QEW Mississauga Rd. Overpass
 LOCATION : Mississauga, ON
 STARTED : September 17, 2011
 COMPLETED : September 17, 2011

Project No. W.O. 08-20008

INCLINATION: Vertical AZIMUTH:

SHEET 1 OF 1
 DATUM Geodetic

DEPTH SCALE (metres)	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	SYMBOLIC LOG														FIELD/LABORATORY TESTING RESULTS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
					ELEV.		RUN No.	PENETRATION RATE (mm/min)	FLUSH % RETURN	FR-FRACTURE CL-CLEAVAGE SH-SHEAR VN-VEIN				F-FAULT J-JOINT P-POLISHED S-SLICKENSIDED				SM-SMOOTH R-ROUGH ST-STEPPED PL-PLANAR				FL-FLEXURED UE-UNEVEN W-WAVY C-CURVED				Unconfined Compressive Strength (MPa)	25 75	● Point Load Test Diametral ▲ Point Load Test Axial ■ Laboratory UCS Test																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
					DEPTH (m)	RECOVERY				R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY k, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
												TOTAL CORE %	SOLID CORE %	DIP wrt Core Axis	TYPE AND SURFACE DESCRIPTION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
 WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
 WATER LEVEL (date)

LOGGED : DA
 CHECKED : MEF



APPENDIX B

Record of Borehole and Record of Drillhole Sheets - Current Investigation



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
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal 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

(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 = $\tan \delta$
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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² 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

Density Index	N
Relative Density	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	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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

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° 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	

PROJECT		RECORD OF BOREHOLE				No MO-01A		SHEET 1 OF 1		METRIC				
G.W.P. 2002-13-00		LOCATION				N 4823580.0; E 295566.4 MTM NAD ZONE 10 (LAT. 43.552090; LONG. -79.614279)		ORIGINATED BY AJ						
DIST Central HWY QEW		BOREHOLE TYPE				64 mm O.D. 51 mm I.D. Split Spoon Sampler		COMPILED BY JL						
DATUM Geodetic		DATE				December 20, 2017		CHECKED BY GDS						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
98.9	GROUND SURFACE													
0.0	TOPSOIL (75 mm)		1A											
98.3	Silty gravelly sand, some clay (FILL)		1B	SS	8									29 34 25 12
0.6	Loose Brown Moist		2	SS	27									
97.7	CLAYEY SILT, trace to some sand													
97.4	Very stiff Brown to grey Moist		3	SS	27/0.13									
1.5	SHALE (BEDROCK)													
	Grey													
	END OF BOREHOLE													
NOTE: 1. Borehole dry upon completion of drilling.														

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PROJECT		RECORD OF BOREHOLE				No MO-01B		SHEET 1 OF 1		METRIC							
G.W.P. 2002-13-00		LOCATION				N 4823579.3; E 295565.7 MTM NAD ZONE 10 (LAT. 43.552084; LONG. -79.614288)		ORIGINATED BY AJ									
DIST Central HWY QEW		BOREHOLE TYPE				64 mm O.D. 51 mm I.D. Split Spoon Sampler		COMPILED BY JL									
DATUM Geodetic		DATE				December 20, 2017		CHECKED BY GDS									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
98.9	GROUND SURFACE																
0.0	TOPSOIL (100 mm)		1A		10												
0.1	Gravelly sand, trace clay, some silt to silty (FILL)		1B	SS													28 54 14 4
98.3	Loose Grey Moist		2A	SS	64												
0.6																	
97.8	CLAYEY SILT, trace to some sand		2B														
1.2	Hard Brown to grey Moist																
	SHALE (BEDROCK)																
	Grey																
	END OF BOREHOLE																
NOTE: 1. Borehole dry upon completion of drilling.																	

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PROJECT		RECORD OF BOREHOLE				No MO-01C		SHEET 1 OF 1		METRIC							
G.W.P. 2002-13-00		LOCATION				N 4823581.1; E 295567.5 MTM NAD		ZONE 10 (LAT. 43.552100; LONG. -79.614265)		ORIGINATED BY AJ							
DIST Central HWY QEW		BOREHOLE TYPE				64 mm O.D. 51 mm I.D. Split Spoon Sampler				COMPILED BY JL							
DATUM Geodetic		DATE				December 20, 2017				CHECKED BY GDS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
99.2	GROUND SURFACE																
0.0	TOPSOIL (75 mm)		1A	SS	11												
98.6	Sand, trace clay, some silt to silty, some gravel, trace organics (FILL)		1B	SS													
0.6	Compact Grey Moist		2A	SS	77												
98.1			2B														
1.2	CLAYEY SILT, trace to some sand Hard Brown Moist SHALE (BEDROCK) Grey END OF BOREHOLE																
NOTE: 1. Borehole dry upon completion of drilling.																	

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PROJECT 1662333		RECORD OF BOREHOLE No MO-02				SHEET 1 OF 1		METRIC						
G.W.P. 2002-13-00		LOCATION N 4823572.9; E 295595.8 MTM NAD 83 ZONE 10 (LAT. 43.552027; LONG. -79.613914)				ORIGINATED BY FC								
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers				COMPILED BY KN								
DATUM Geodetic		DATE August 24, 2017				CHECKED BY SMM								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
99.8	GROUND SURFACE													
0.0	ASPHALT (150 mm)													
99.3	CONCRETE (300 mm)													
0.5	Silty sand, trace to some gravel, trace to some clay (FILL) Compact Grey to brown Moist		1	AS	-									
			2	SS	15									4 68 23 5
98.1	Sandy clayey silt, some gravel (FILL) Mottled brown Moist		3A 3B 3C	SS	7									
97.6	Sand, trace clay, some silt (FILL) Loose Brown Moist		4	SS	44									19 27 43 11
96.5	Sandy CLAYEY SILT, some gravel, some shale fragments (RESIDUAL SOIL) Hard Brown Moist		5	SS	100/0.13									
3.3	END OF BOREHOLE - AUGER REFUSAL													
NOTE: 1. Borehole dry upon completion of drilling.														

PROJECT		1662333		RECORD OF BOREHOLE		No MO-03		SHEET 1 OF 1		METRIC							
G.W.P.		2002-13-00		LOCATION		N 4823599.6; E 295570.4 MTM NAD 83 ZONE 10 (LAT. 43.552266; LONG. -79.614229)		ORIGINATED BY		FC							
DIST		Central		HWY		QEW		BOREHOLE TYPE		CME 55, 203 mm O.D. Hollow Stem Augers, NW Casing							
COMPILED BY		KN		DATE		August 24, 2017		CHECKED BY		SMM							
DATUM		Geodetic		BOREHOLE TYPE		CME 55, 203 mm O.D. Hollow Stem Augers, NW Casing		COMPILED BY		KN							
DATE		August 24, 2017		CHECKED BY		SMM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
94.0	GROUND SURFACE																
0.0	ASPHALT (150 mm)																
0.2	Sand and gravel, trace to some fines (FILL) Brown Moist		1	AS	-												45 45 (10)
93.0			2A	SS	152/0.3												
1.0	SHALE (BEDROCK) Grey		2B														
	Bedrock cored from a depth of 1.2 m to 4.3 m																
	For bedrock coring details, refer to Record of Drillhole MO-03																
			1	RC	REC 88%												RQD = 45%
			2	RC	REC 100%												RQD = 100%
89.7	END OF BOREHOLE																
4.3	NOTES: 1. Borehole dry prior to rock coring.																

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[illegible] BROKEN CORE CLAY SEAM Limestone

■ LOST CORE



PROJECT 1662333		RECORD OF BOREHOLE No MO-04		SHEET 1 OF 1		METRIC											
G.W.P. 2002-13-00		LOCATION N 4823583.9; E 295593.2 MTM NAD 83 ZONE 10 (LAT. 43.552126; LONG. -79.613947)		ORIGINATED BY FC													
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers, HQ Casing		COMPILED BY KN													
DATUM Geodetic		DATE September 7, 2017		CHECKED BY SMM													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30	20 40 60 80 100	20 40 60 80 100			
99.7	GROUND SURFACE																
0.0	ASPHALT (250 mm)																
0.3	Sand and gravel, trace to some silt, trace clay (FILL) Compact to dense Brown Moist		1	AS	-		99										32 60 6 2
			2	SS	47												
97.8			3A	SS	29		98										
1.9	CLAYEY SILT with SAND, some gravel, some shale fragments (RESIDUAL SOIL) Hard Brown to grey Moist		3B														
			4	SS	36		97										20 38 35 7
			5	SS	100/0.10												
96.2			6	SS	100/0.10												
3.5	SHALE (BEDROCK) Grey						96										
	Bedrock cored from a depth of 3.5 m to 6.6 m		1	RC	REC 87%		95										RQD = 60%
	For bedrock coring details, refer to Record of Drillhole MO-04		2	RC	REC 95%		94										RQD = 83%
93.1	END OF BOREHOLE																
6.6	NOTES: 1. Borehole dry prior to rock coring.																

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PROJECT 1662333		RECORD OF BOREHOLE No MO-05				SHEET 1 OF 1		METRIC								
G.W.P. 2002-13-00		LOCATION N 4823585.1; E 295623.8 MTM NAD 83 ZONE 10 (LAT. 43.552136; LONG. -79.613568)				ORIGINATED BY FC										
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers, HQ Casing				COMPILED BY KN										
DATUM Geodetic		DATE August 22, 2017				CHECKED BY SMM										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
99.6	GROUND SURFACE															
0.0	ASPHALT (100 mm)															
0.3	CONCRETE (150 mm)		1	AS	-											
	Sand and gravel, trace to some silt, trace clay (FILL) Compact to dense Brown Moist		2	SS	43											
			3	SS	43											
			4	SS	47											40 50 8 2
			5A 5B	SS	11											39 35 19 7
96.0	Sandy CLAYEY SILT, some shale fragments (RESIDUAL SOIL) Brown-grey Moist		6	SS	100/10 10											
3.8	SHALE (BEDROCK) Grey		1	RC	REC 100%											RQD = 86%
	Bedrock cored from a depth of 3.9 m to 6.4 m		2	RC	REC 100%											RQD = 80%
	For bedrock coring details, refer to Record of Drillhole MO-05		3	RC	REC 100%											RQD = 100%
93.2	END OF BOREHOLE															
6.4	NOTE: 1. Borehole dry prior to rock coring.															

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PROJECT: 1662333

RECORD OF DRILLHOLE: MO-05

SHEET 1 OF 1

LOCATION: N 4823585.1 ;E 295623.8

DRILLING DATE: August 22, 2017

DATUM: Geodetic


INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75

DRILLING CONTRACTOR: Aardvark Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	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.													FEATURES	R0/R1 ZONES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
						RECOVERY		R.Q.D. %	FRACT. INDEX PER Meter	DISCONTINUITY DATA						ROCK STRENGTH INDEX					WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
						TOTAL CORE % 80 40 20	SOLID CORE % 80 40 20			TYPE AND SURFACE DESCRIPTION	Jr	Ja	R3	R2	R1	W1	W2	W3			W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
4	HQ Casing	Continued from Borehole MO-05 Slightly weathered to fresh, thinly to medium bedded, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation), with slightly weathered to fresh, thinly bedded, grey, fine grained, non-porous, medium strong, LIMESTONE interbeds		95.70 3.90	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															</

FEATURES LEGEND

 BROKEN CORE

 CLAY SEAM

 LIMESTONE

 LOST CORE

DEPTH SCALE

1 : 50



LOGGED: FC

CHECKED: AC

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PROJECT 1662333		RECORD OF BOREHOLE No MO-06				SHEET 1 OF 1		METRIC									
G.W.P. 2002-13-00		LOCATION N 4823610.0; E 295581.0 MTM NAD 83 ZONE 10 (LAT. 43.552360; LONG. -79.614098)				ORIGINATED BY FC											
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers, HQ Casing				COMPILED BY KN											
DATUM Geodetic		DATE August 24, 2017				CHECKED BY SMM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
93.6	GROUND SURFACE																
0.0	ASPHALT (150 mm)																
0.2	Sand and gravel, trace to some silt, trace clay (FILL) Very dense Brown Moist		1	AS	-												32 55 10 3
92.0			2	SS	100/0.13												
1.6	SHALE (BEDROCK) Grey		3	SS	100/0.15												
	Bedrock cored from a depth of 1.7 m to 4.7 m		1	RC	REC 93%												RQD = 66%
	For bedrock coring details, refer to Record of Drillhole MO-06																
			2	RC	REC 100%												RQD = 100%
88.9			3	RC	REC 100%												RQD = 83%
4.7	END OF BOREHOLE																
	NOTE: 1. Borehole dry prior to rock coring.																

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[illegible]

FEATURES LEGEND



BROKEN CORE



CLAY SEAM



LIMESTONE



LOST CORE

DEPTH SCALE

1 : 50



GOLDER

LOGGED: FC

CHECKED: AC


PROJECT 1662333		RECORD OF BOREHOLE No MO-07				SHEET 1 OF 1		METRIC								
G.W.P. 2002-13-00		LOCATION N 4823616.9; E 295622.5 MTM NAD 83 ZONE 10 (LAT. 43.552423; LONG. -79.613584)				ORIGINATED BY FC										
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers, HQ Casing				COMPILED BY KN										
DATUM Geodetic		DATE August 30, 2017				CHECKED BY SMM										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
99.4	GROUND SURFACE															
0.0	ASPHALT (150 mm)															
98.9	CONCRETE (300 mm)		1	AS	-											
0.5	Silty sand, trace clay (FILL) Loose Brown Moist		2	SS	5											0 68 28 4
97.6	- Clayey silt, containing organics from a depth of about 1.3 m to 1.4 m		3A	SS	15											
1.8	Sandy CLAYEY SILT, some gravel, some shale fragments (RESIDUAL SOIL) Hard Brown Moist		3B													13 29 43 15
96.4	SHALE (BEDROCK) Grey		4	SS	66											
3.0	Bedrock cored from a depth of 3.3 m to 6.3 m For bedrock coring details, refer to Record of Drillhole MO-07		5	SS	100/0.23											
			1	RC	REC 78%											RQD = 50%
			2	RC	REC 100%											RQD = 95%
93.1	END OF BOREHOLE															
6.3	NOTE: 1. Borehole dry prior to rock coring.															

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

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Aardvark Drilling

[illegible] BROKEN CORE CLAY SEAM Limestone

■ LOST CORE

DEPTH SCALE

1 : 50



GOLDER

LOGGED: FC

CHECKED: AC

GTA-RCK 054 \\GOLDER.GDS\GAL\MISSAUGA\S\MCLIENTS\MTQEW-CREDIT RIVER\02 DATA\INTQEW-CREDIT RIVER.GPJ GAL-MISS.GDT 5/7/18

PROJECT		1662333		RECORD OF BOREHOLE No MO-08A		SHEET 1 OF 1		METRIC							
G.W.P.		2002-13-00		LOCATION		N 4823630.5; E 295614.5 MTM NAD 83 ZONE 10 (LAT. 43.552545; LONG. -79.613684)		ORIGINATED BY							
DIST		Central		HWY		QEW		BOREHOLE TYPE							
64 mm O.D. 51 mm I.D. Split Spoon Sampler		COMPILED BY		DM		DATE		December 21, 2017							
DATUM		Geodetic		CHECKED BY		GDS									
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	γ	GR SA SI CL	
98.9	GROUND SURFACE														
0.0	TOPSOIL (180 mm)		1A		10										
0.2	Silty sand, trace gravel, some organics (FILL) Compact Brown Moist to wet		1B	SS											
97.7			2	SS	19										
1.2	CLAYEY SILT, trace to some sand, trace to some gravel Very stiff to hard Grey to brown Moist		3A	SS	20										
			3B												
96.8			4A	SS	100/0.25										
			4B												
2.2	SHALE (BEDROCK) Grey END OF BOREHOLE														
NOTE: 1. Borehole dry upon completion of drilling.															

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

PROJECT		1662333		RECORD OF BOREHOLE		No MO-08B		SHEET 1 OF 1		METRIC							
G.W.P.		2002-13-00		LOCATION		N 4823632.0; E 295615.8 MTM NAD 83 ZONE 10 (LAT. 43.552559; LONG. -79.613668)		ORIGINATED BY		JL							
DIST		Central HWY QE		BOREHOLE TYPE		64 mm O.D. 51 mm I.D. Split Spoon Sampler		COMPILED BY		DM							
DATUM		Geodetic		DATE		December 21, 2017		CHECKED BY		GDS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
98.9	GROUND SURFACE																
0.0	TOPSOIL (100 mm)																
98.3	Clayey silt, trace sand, trace gravel, some rootlets (FILL)		1	SS	9												
0.6	Stiff																
	Brown to black		2	SS	11												
	Moist																
97.5	Silty sand, trace to some clay, trace gravel, some rootlets (FILL)		3A	SS	35												
1.4	Compact																
97.1	Brown		3B	SS													
	Moist to wet																
96.8	CLAYEY SILT		4	SS	100/0.13												
2.1	Hard																
	Brown to grey																
	Moist																
	SHALE (BEDROCK)																
	Grey																
	END OF BOREHOLE																
NOTE: 1. Borehole dry upon completion of drilling.																	

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

PROJECT 1662333		RECORD OF BOREHOLE No MO-09		SHEET 1 OF 1		METRIC													
G.W.P. 2002-13-00		LOCATION N 4823634.3; E 295652.9 MTM NAD 83 ZONE 10 (LAT. 43.552580; LONG. -79.613208)		ORIGINATED BY FC															
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers, HQ Casing		COMPILED BY KN															
DATUM Geodetic		DATE August 29, 2017		CHECKED BY SMM															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ			GR SA SI CL		
99.2	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30									
0.0	ASPHALT (130 mm)						99												
98.7	CONCRETE (280 mm)																		
0.5	Sand, some silt, trace clay (FILL) Brown Moist		1	AS	-														
97.9			2A	SS	5		98										0 86 12 2		
1.3	Clayey silt with sand, some gravel, trace rootlets (FILL) Very stiff Black to brown Moist		3	SS	25												18 35 30 17		
97.0							97												
2.2	Sandy CLAYEY SILT, some shale fragments (RESIDUAL SOIL) Hard Brown Moist		4	SS	100/0.13														
96.2			5	SS	100/0.05														
3.1	SHALE (BEDROCK) Grey END OF BOREHOLE - AUGER REFUSAL																		
NOTE: 1. Borehole dry upon completion of drilling.																			

PROJECT 1662333		RECORD OF BOREHOLE No MO-10				SHEET 1 OF 1		METRIC									
G.W.P. 2002-13-00		LOCATION N 4823597.7; E 295592.3 MTM NAD 83 ZONE 10 (LAT. 43.552249; LONG. -79.613959)				ORIGINATED BY JL											
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers				COMPILED BY DM											
DATUM Geodetic		DATE December 20, 2017				CHECKED BY GDS											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
93.1	GROUND SURFACE																
0.0	ASPHALT (150 mm)																
0.2	Gravelly sand, trace clay, trace to some silt (FILL) Compact Brown Moist		1	SS	28												26 60 11 3
92.2	SHALE (BEDROCK) Grey		2	SS	100/0.23												
1.1	Bedrock cored from a depth of 1.1 m to 5.8 m. For bedrock coring details, refer to Record of Drillhole MO-10		1	RC	REC 67%												RQD = 29%
			2	RC	REC 97%												RQD = 59%
			3	RC	REC 100%												RQD = 97%
			4	RC	REC 100%												RQD = 100%
87.3	END OF BOREHOLE																
5.8	NOTES: 1. Borehole dry prior to rock coring. 2. Water level measured at a depth of about 4.9 m below ground surface following completion of rock coring.																

PROJECT: 1662333

RECORD OF DRILLHOLE: MO-10

SHEET 1 OF 1

LOCATION: N 4823597.7 ;E 295592.3

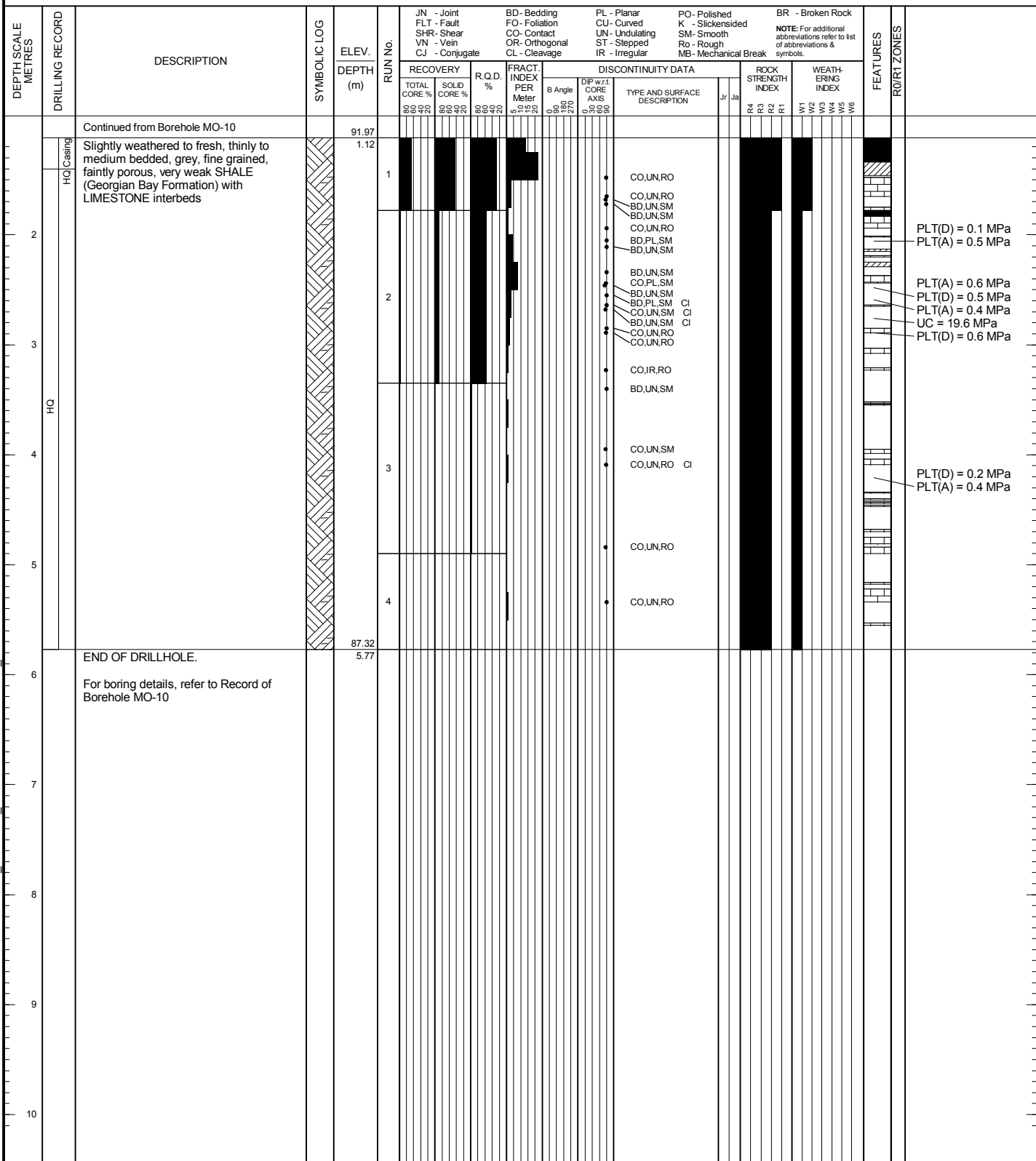
DRILLING DATE: December 20, 2017

DATUM: Geodetic


INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75

DRILLING CONTRACTOR: Geo-Environmental Drilling




FEATURES LEGEND

 BROKEN CORE

 CLAY SEAM

 LIMESTONE

 LOST CORE

DEPTH SCALE

1 : 50



LOGGED: JL

CHECKED: ML/AK

GTA-RCK 054 \\GOLDER.GDS\GALMISSAUGA\SIMCLIENTS\MTQ\QEW-CREDIT_RIVER\02_DATA\GINTQEW-GDT_5/7/18

PROJECT 1662333		RECORD OF BOREHOLE No MO-11				SHEET 1 OF 1		METRIC									
G.W.P. 2002-13-00		LOCATION N 4823604.7; E 295610.1 MTM NAD 83 ZONE 10 (LAT. 43.552313; LONG. -79.613738)				ORIGINATED BY JL											
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers				COMPILED BY DM											
DATUM Geodetic		DATE December 19, 2017				CHECKED BY GDS											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
92.9	GROUND SURFACE																
0.0	ASPHALT (230 mm)																
0.2	Gravelly sand, trace clay, trace to some silt (FILL)		1A	SS	56												29 56 11 4
92.2	Very dense Brown Moist SHALE (BEDROCK)		1B	SS	100/0.10												
0.7	Grey		2	SS	100/0.10												RQD = 63%
	Bedrock cored from a depth of 1.1 m to 5.7 m.		1	RC	REC 100%												
	For bedrock coring details, refer to Record of Drillhole MO-11.		2	RC	REC 100%												RQD = 87%
			3	RC	REC 100%												RQD = 89%
			4	RC	REC 100%												RQD = 87%
87.2	END OF BOREHOLE																
5.7	NOTES: 1. Borehole dry prior to rock coring. 2. Water level measured at a depth of 5.7 m below ground surface following completion of rock coring.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Geo-Environmental Drilling

[illegible]

FEATURES LEGEND



BROKEN CORE



CLAY SEAM



LIMESTONE



LOST CORE

DEPTH SCALE

1 : 50



GOLDER

LOGGED: JL

CHECKED: ML/AK

GTA-RCK 054 \\GOLDER.GDS\GAL\MISSISSAUGA\SIM\CLIENTS\IMTO\QEW-CREDIT_RIVER\GPJ GAL-MISS.GDT 5/7/18

PROJECT 1662333		RECORD OF BOREHOLE No MO-12				SHEET 1 OF 1		METRIC									
G.W.P. 2002-13-00		LOCATION N 4823592.2; E 295628.5 MTM NAD 83 ZONE 10 (LAT. 43.552201; LONG. -79.613511)				ORIGINATED BY JL											
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 203 mm O.D. Hollow Stem Augers				COMPILED BY DM											
DATUM Geodetic		DATE December 19, 2017				CHECKED BY GDS											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
92.9	GROUND SURFACE																
0.0	ASPHALT																
0.2	Gravelly sand to sand and gravel, trace fines (FILL) Compact Brown Moist		1	SS	26												
92.0	SHALE (BEDROCK) Grey		1	RC	REC 100%												RQD = 46%
0.9	Bedrock cored from a depth of 1.2 m to 5.7 m. For bedrock coring details, refer to Record of Drillhole MO-12.		2	RC	REC 100%												RQD = 95%
			3	RC	REC 100%												RQD = 94%
			4	RC	REC 100%												RQD = 58%
87.2	END OF BOREHOLE																
5.7	NOTES: 1. Borehole dry prior to rock coring. 2. Water level measured at a depth of 4.8 m below ground surface following completion of rock coring.																

PROJECT: 1662333

RECORD OF DRILLHOLE: MO-12

SHEET 1 OF 1

LOCATION: N 4823592.2 ;E 295628.5

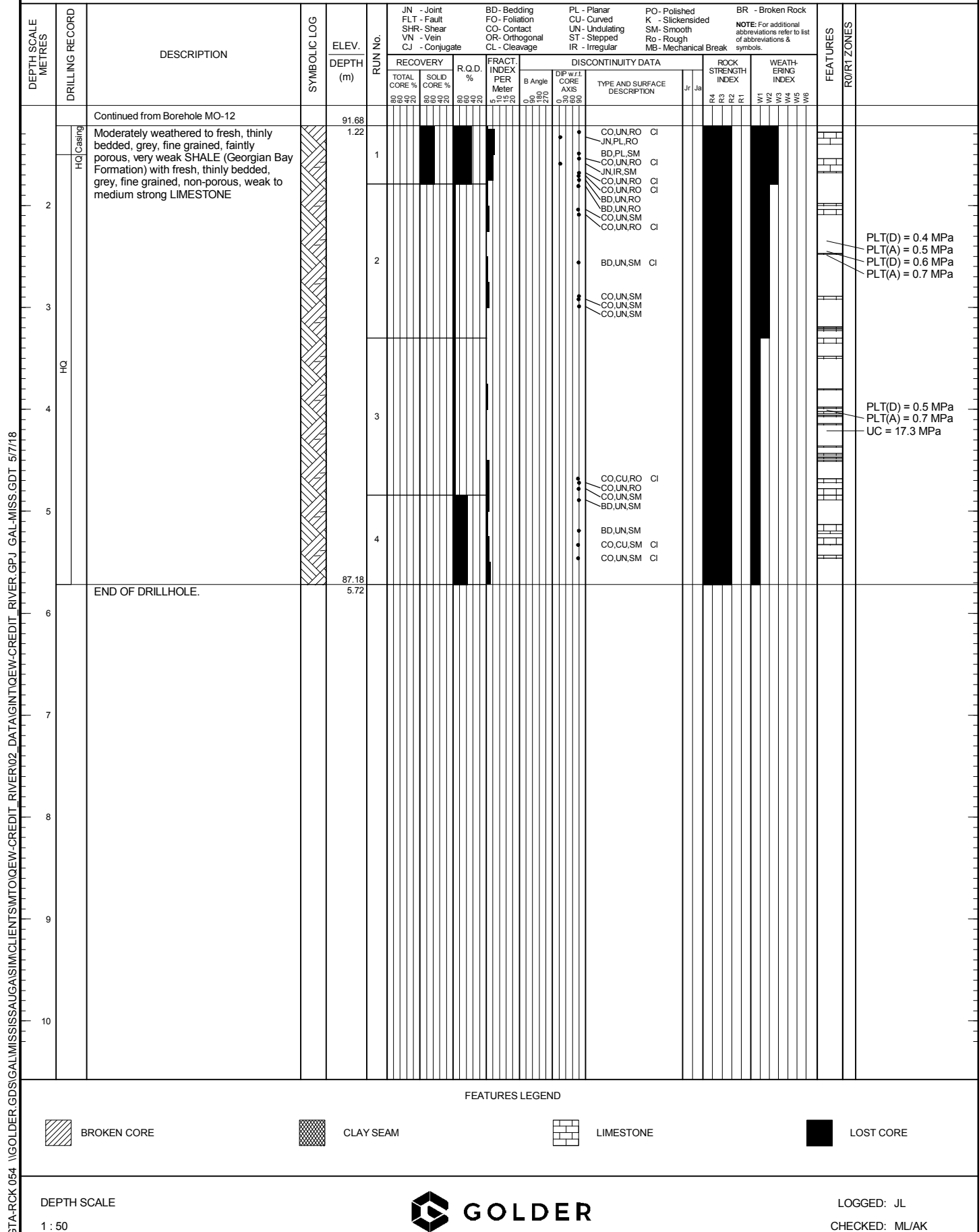
DRILLING DATE: December 19, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75

DRILLING CONTRACTOR: Geo-Environmental Drilling



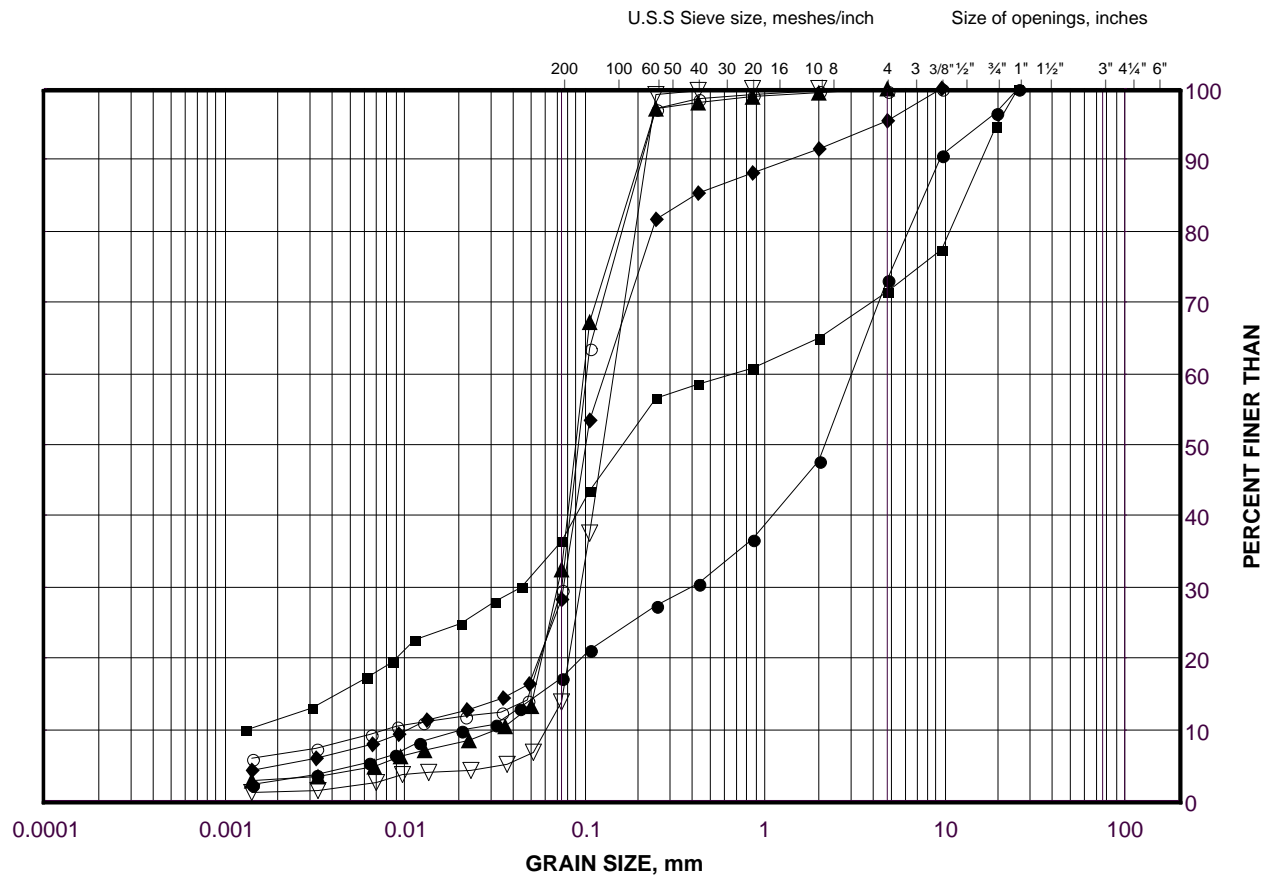


APPENDIX C

Geotechnical Laboratory Test Results, Bedrock Core Photographs and Analytical Test Results

Silty Sand to Gravelly Sand (Fill)

FIGURE C1A



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	MO-01B	1B	98.6
■	MO-01A	1B	98.6
◆	MO-02	2	98.7
▲	MO-07	2	98.3
▽	MO-09	2A	98.0
○	MO-08B	3A	97.6

Project Number: 1662333

Checked By: MWK

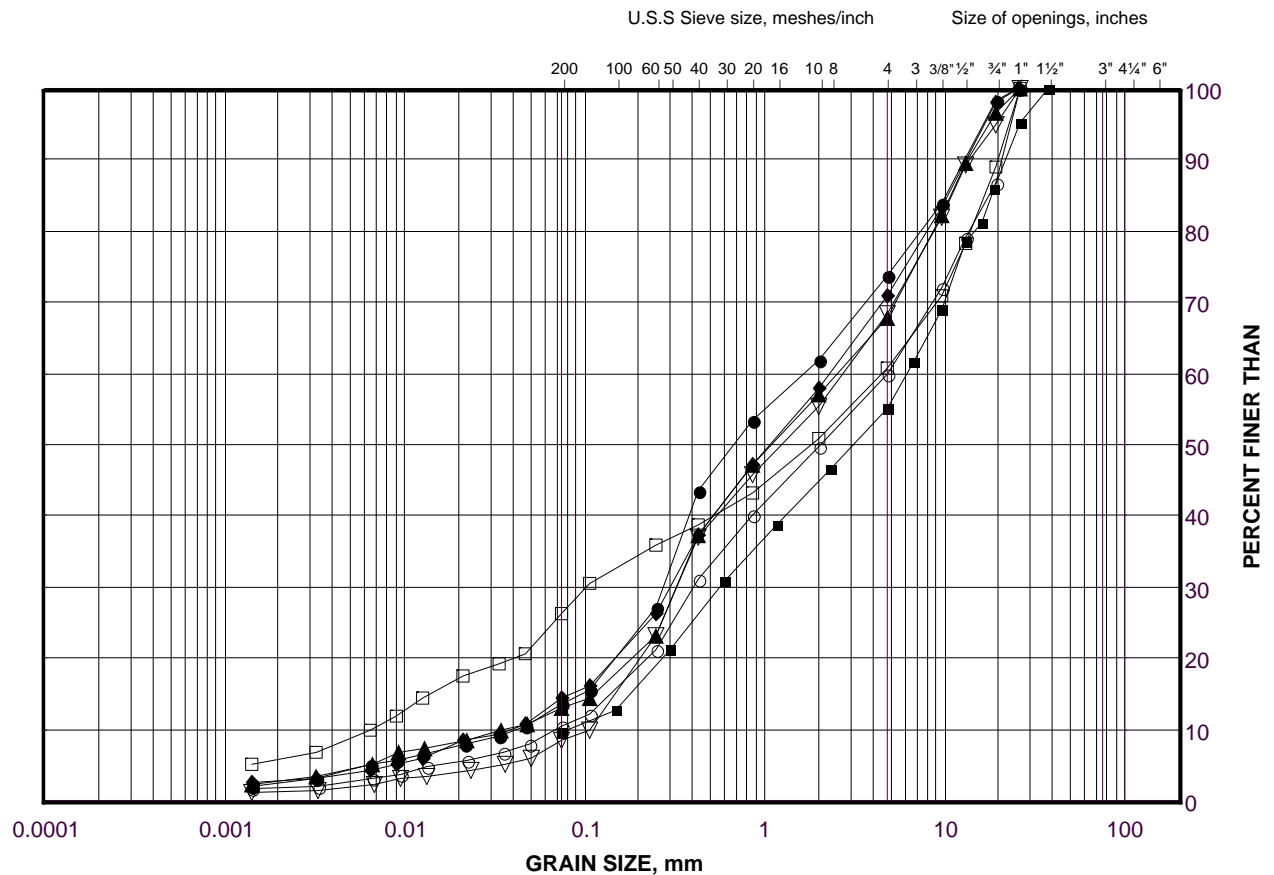
Golder Associates

Date: 01-Feb-18

GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sand and Gravel (Fill)

FIGURE C1B



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	MO-10	1	92.6
■	MO-03	1	93.6
◆	MO-11	1A	92.3
▲	MO-06	2	92.7
▽	MO-04	2	98.6
○	MO-05	4	97.1
□	MO-05	5B	96.1

Project Number: 1662333

Checked By: MWK

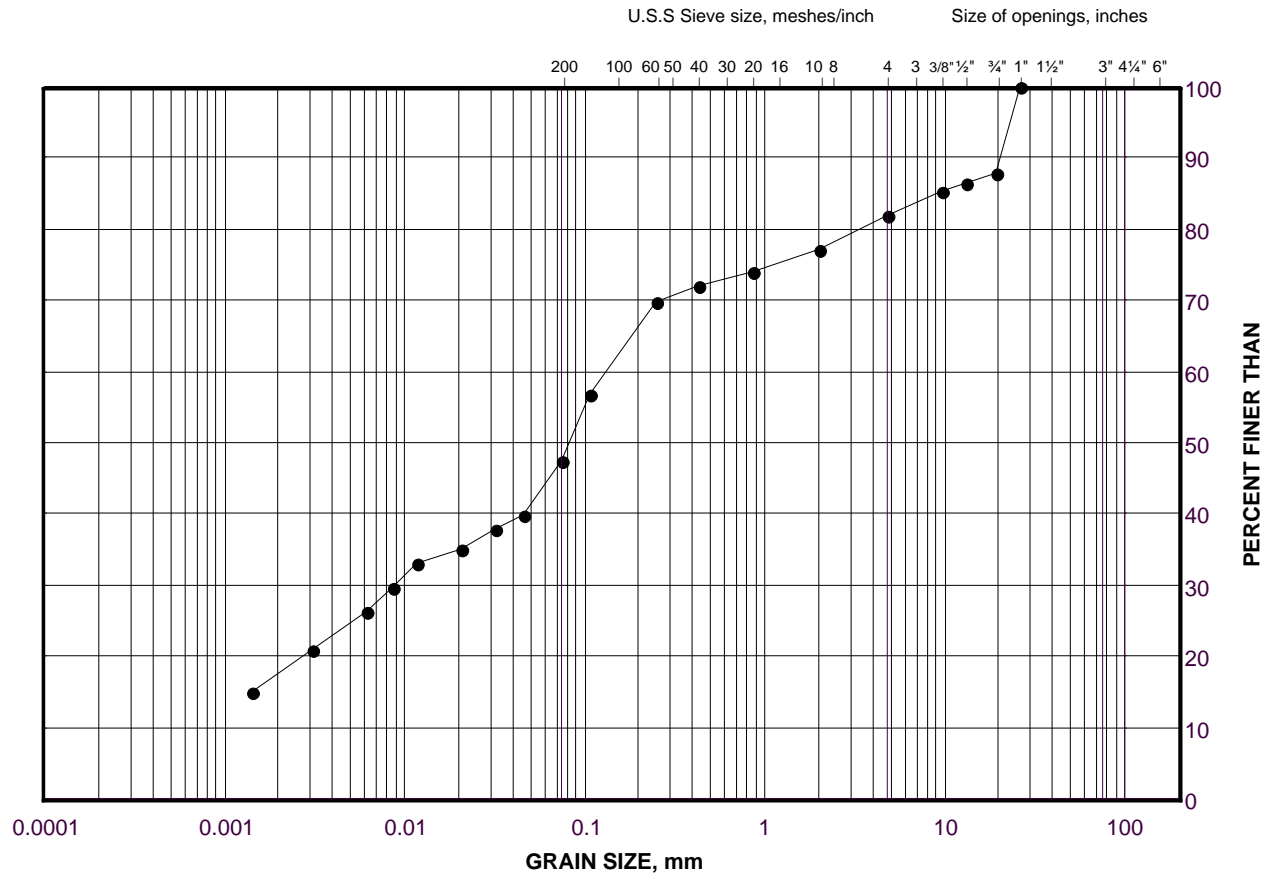
Golder Associates

Date: 01-Feb-18

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (Fill)

FIGURE C2



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

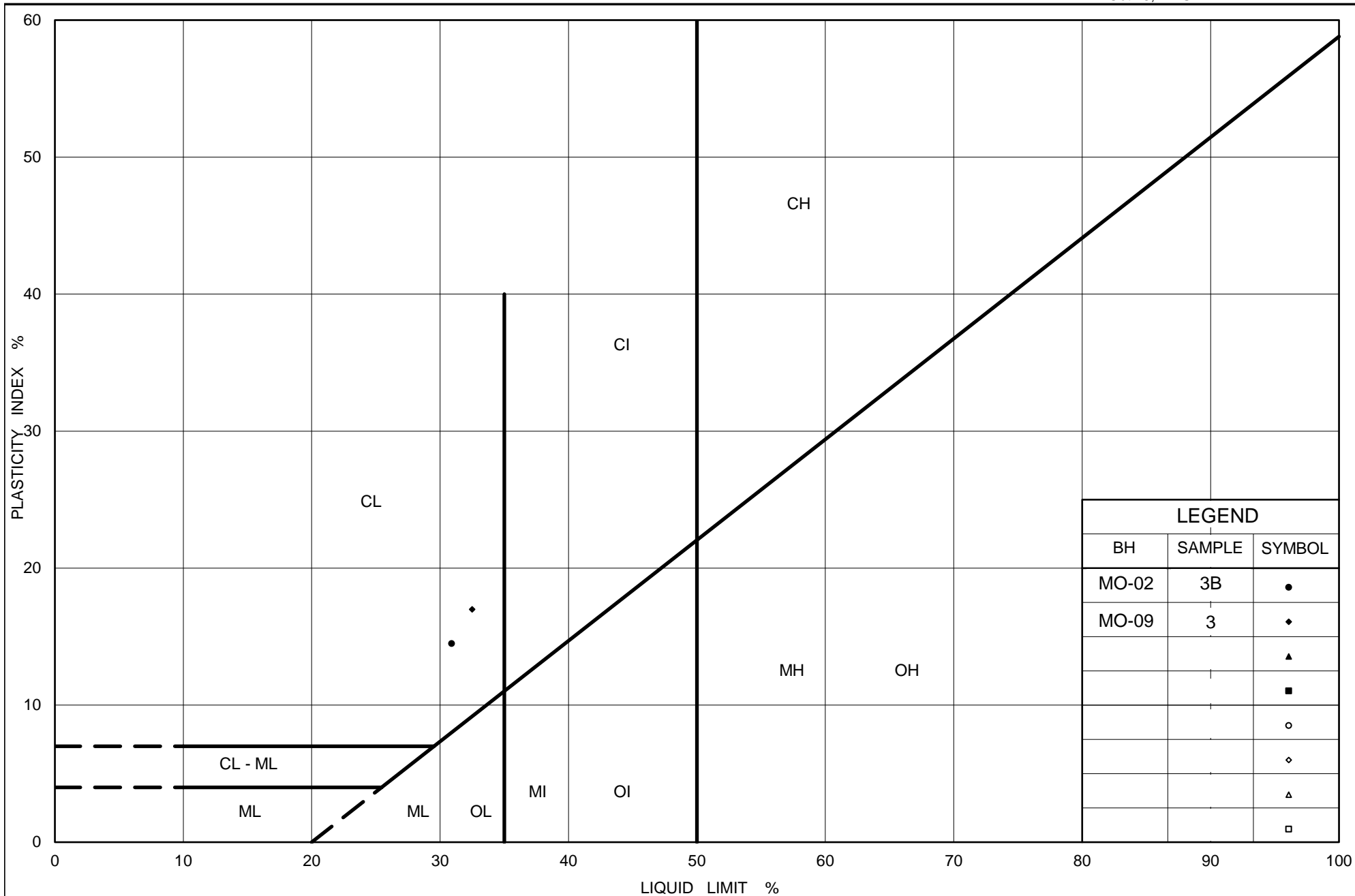
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	MO-09	3	97.4

Project Number: 1662333

Checked By: MWK

Golder Associates

Date: 01-Feb-18



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PLASTICITY CHART Clayey Silt (Fill)

Figure No. C3

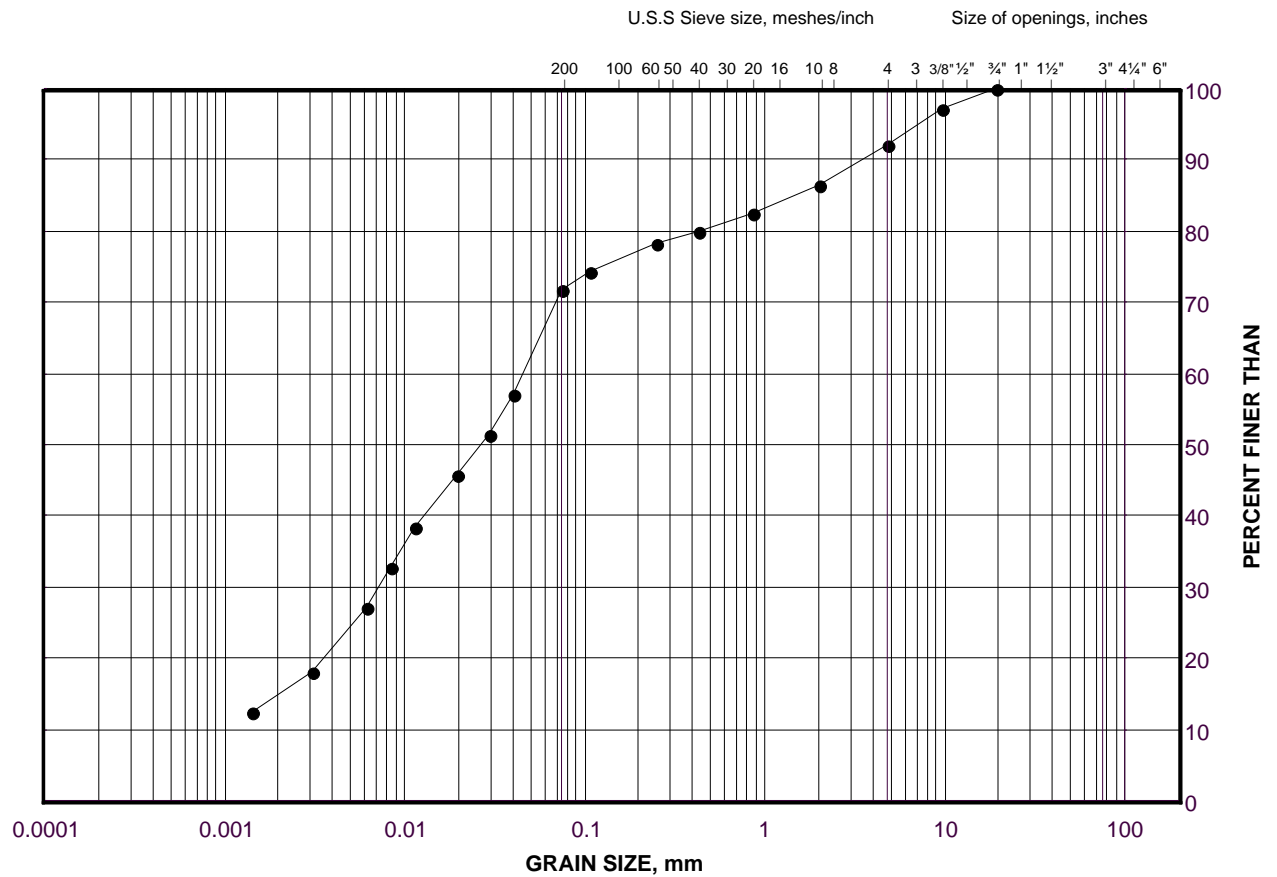
Project No. 1662333

Checked By: MWK

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE C4



LEGEND

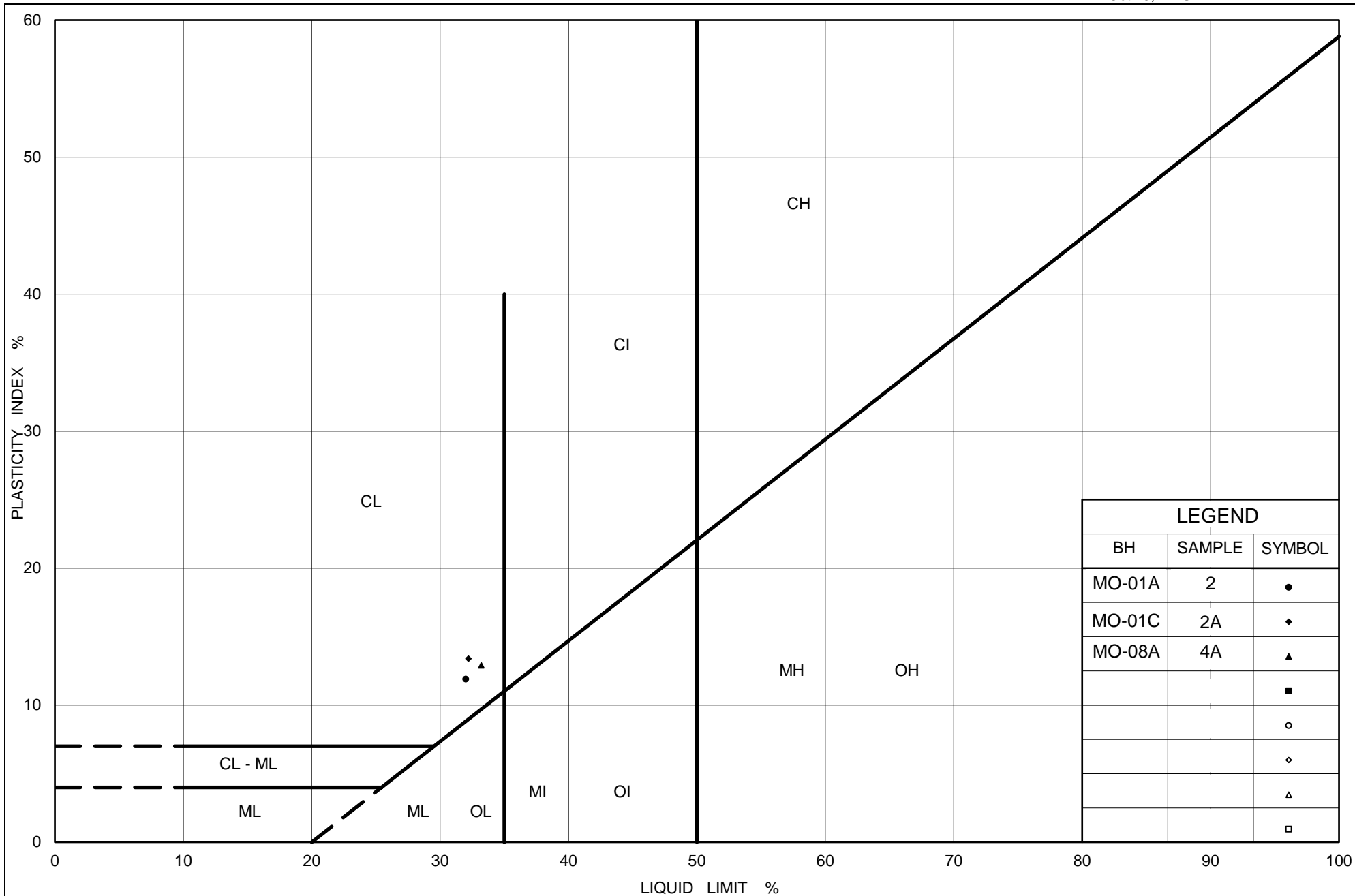
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	MO-08A	4A	96.9

Project Number: 1662333

Checked By: MWK

Golder Associates

Date: 01-Feb-18



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Figure No. C5

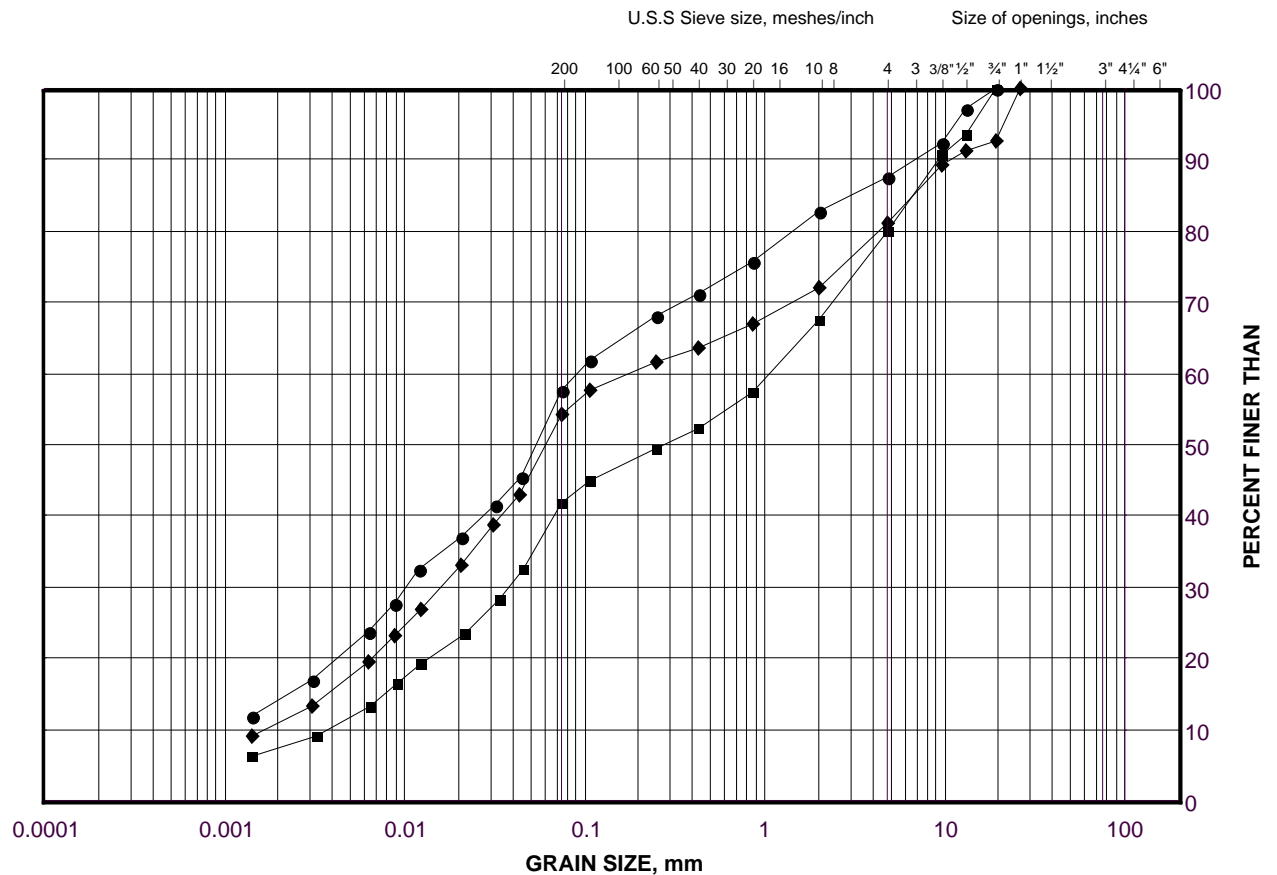
Project No. 1662333

Checked By: MWK

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Clayey Silt with Sand (Residual Soil)

FIGURE C6



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

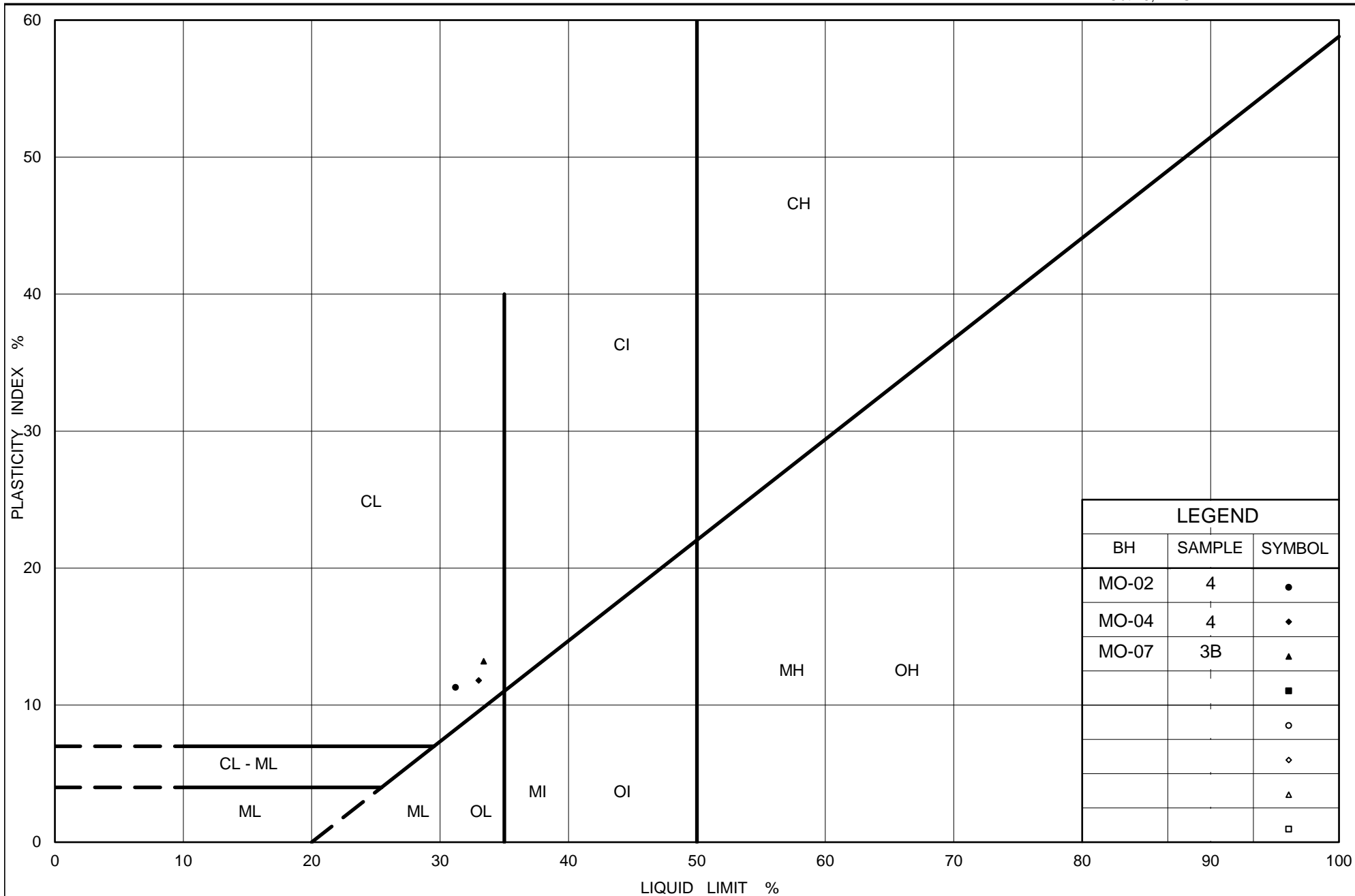
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	MO-07	3B	97.4
■	MO-04	4	97.1
◆	MO-02	4	97.2

Project Number: 1662333

Checked By: MWK

Golder Associates

Date: 01-Feb-18



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt (Residual Soil)

Figure No. C7

Project No. 1662333

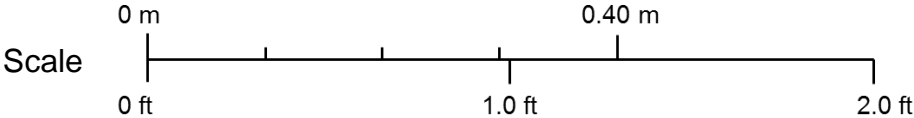
Checked By: MWK

Start of Run No. 1 (1.22 m)




Box 1: 1.22 m to 4.28 m

Start of Run No. 2 (2.76 m)



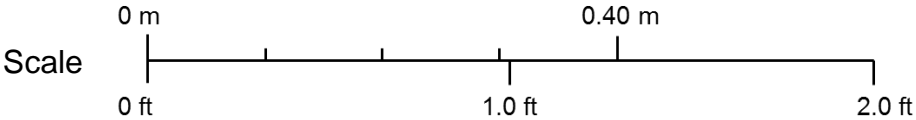
PROJECT	MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street				
	TITLE Bedrock Core Photographs Borehole MO-03 (1.22 m to 4.28 m)				


	PROJECT No. 1662333		FILE No. ----		
	DESIGN	MWK	1/31/18	SCALE	NTS
	CADD	--		FIGURE C8	
	CHECK				
	REVIEW	JMAC	2/01/18		

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



Box 1: 3.53 m to 6.59 m



PROJECT					
MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street					
TITLE					
Bedrock Core Photographs Borehole MO-04 (3.53 m to 6.59 m)					
			PROJECT No. 1662333		
			FILE No. ----		
			DESIGN	MWK	1/31/18
			CADD	--	
			CHECK		
			REVIEW	JMAC	2/01/18
			SCALE	NTS	REV.
			FIGURE C9		

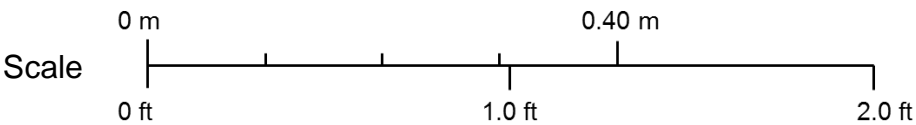
Start of Run No. 1 (3.90 m)

Start of Run No. 2 (4.27 m)



Box 1: 3.90 m to 6.38 m

Start of Run No. 3 (5.80 m)



PROJECT MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street

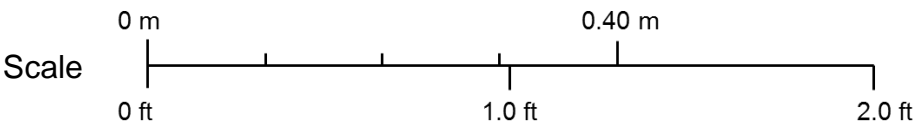
TITLE **Bedrock Core Photographs**
Borehole MO-05 (3.90 m to 6.38m)




PROJECT No. 1662333			FILE No. ----		
DESIGN	MWK	1/31/18	SCALE	NTS	REV.
CADD	--		FIGURE C10		
CHECK					
REVIEW	JMAC	2/01/18			

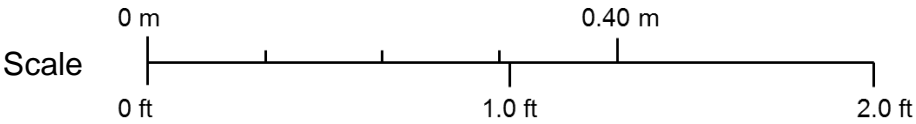
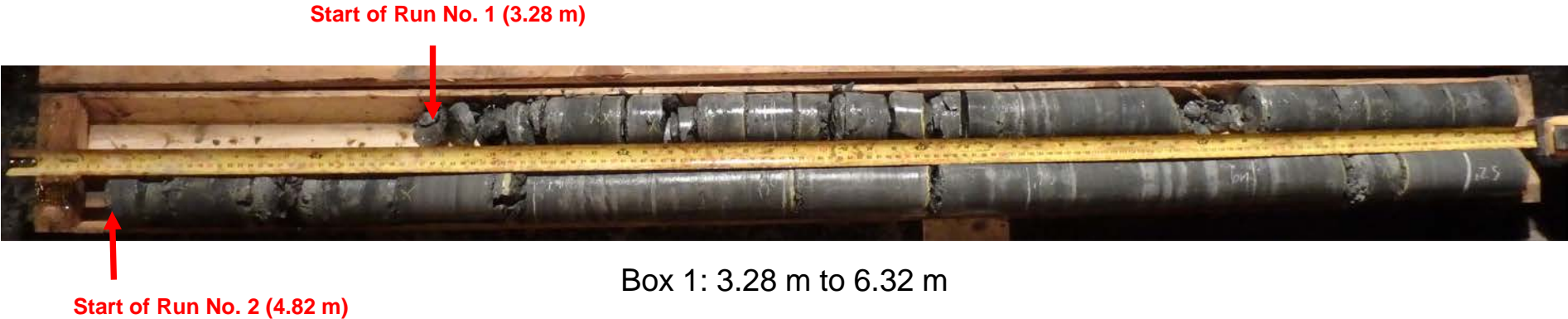



Box 1: 1.67 m to 4.71 m



PROJECT MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street					
TITLE Bedrock Core Photographs Borehole MO-06 (1.67 m to 4.71m)					
	PROJECT No. 1662333			FILE No. ----	
	DESIGN	MWK	1/31/18	SCALE	NTS
	CADD	--		FIGURE C11	
	CHECK				
	REVIEW	JMAC	2/01/18		

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



PROJECT MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street					
TITLE Bedrock Core Photographs Borehole MO-07 (3.28 m to 6.32 m)					
	PROJECT No. 1662333			FILE No. ----	
	DESIGN	MWK	1/31/18	SCALE	NTS
	CADD	--		FIGURE C12	
	CHECK				
	REVIEW	JMAC	2/01/18		

Start of Run No. 1 (1.12 m)

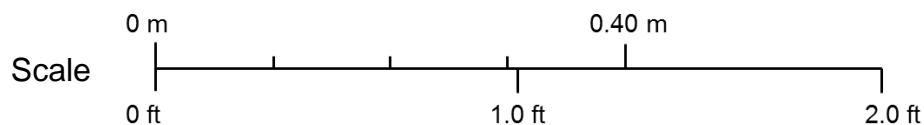
Start of Run No. 2 (1.78 m)



Start of Run No. 3 (3.35 m)

Start of Run No. 4 (4.90 m)

Box 1: 1.12 m to 5.77 m

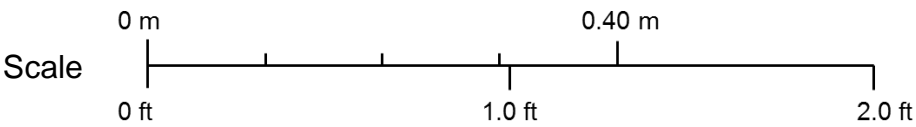
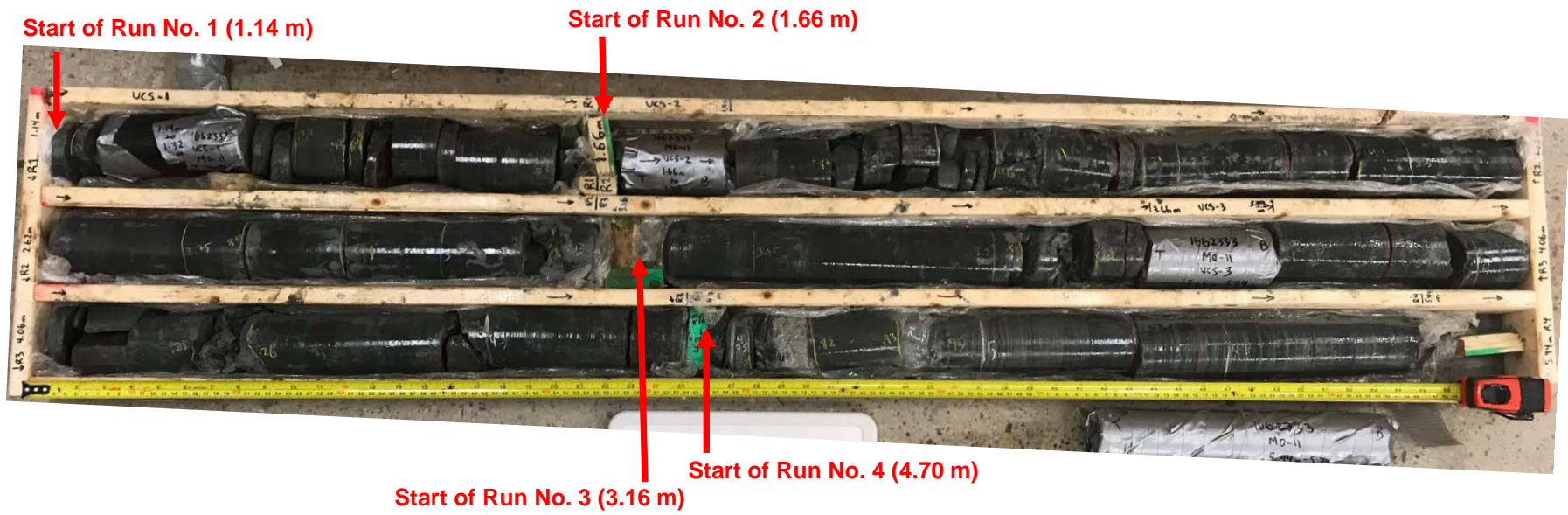



PROJECT MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street

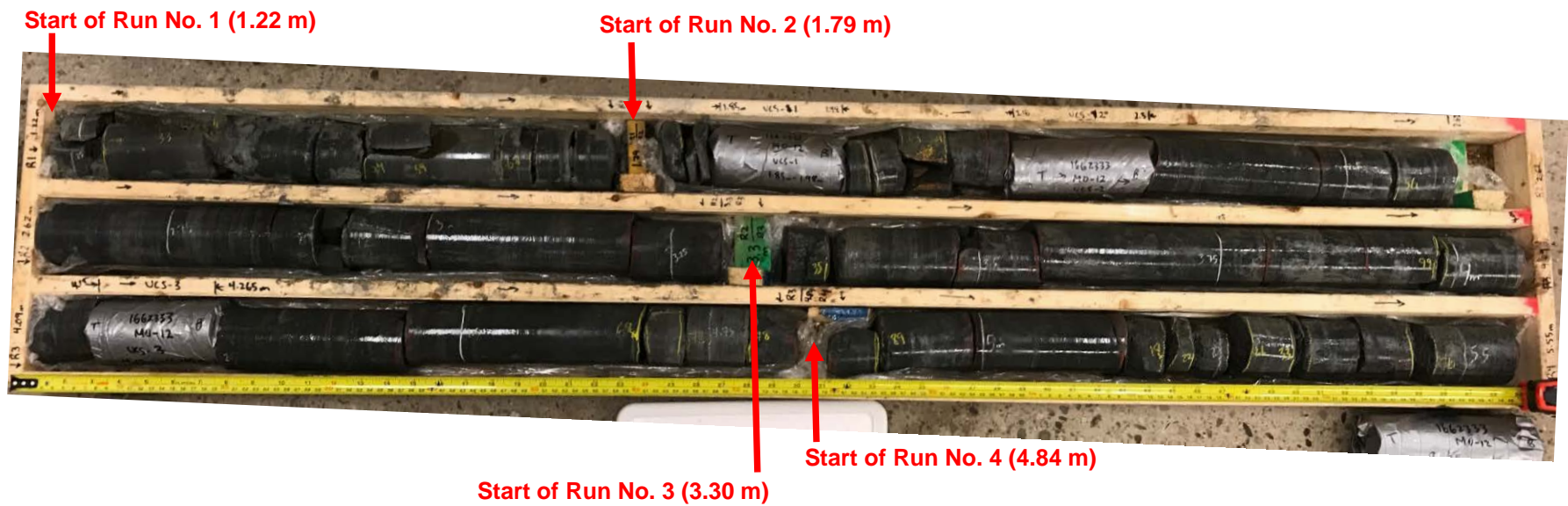
TITLE **Bedrock Core Photographs**
Borehole MO-10 (1.12 m to 5.77 m)



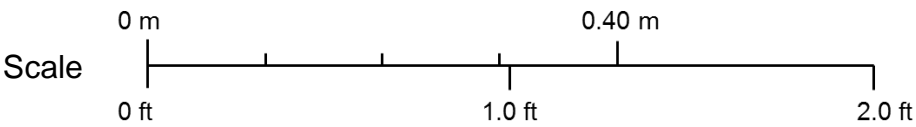
PROJECT No. 1662333			FILE No. ----		
DESIGN	MWK	1/31/18	SCALE	NTS	REV.
CADD	--		FIGURE C13		
CHECK					
REVIEW	JMAC	2/01/18			




PROJECT					
MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street					
TITLE					
Bedrock Core Photographs Borehole MO-11 (1.14 m to 5.74 m)					
	PROJECT No. 1662333			FILE No. ----	
	DESIGN	MWK	1/31/18	SCALE	NTS
	CADD	--		FIGURE C14	
	CHECK				
	REVIEW	JMAC	2/01/18		
			REV.		



Box 1: 1.22 m to 5.72 m



PROJECT MTO Assignment 2015-E-0033: Detail Design for the widening/rehab/realignment of QEW Between Mississauga Road and Hurontario Street					
TITLE Bedrock Core Photographs Borehole MO-12 (1.22 m to 5.72 m)					
	PROJECT No. 1662333			FILE No. ----	
	DESIGN	MWK	1/31/18	SCALE	NTS
	CADD	--		FIGURE C15	
	CHECK				
	REVIEW	JMAC	2/01/18		
			REV.		

October 23, 2017

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

Re: UCS testing
(Golder Project No. 166233)

Dear Mr. Zalucki:

On September 25, 2017 three (3) HQ-sized core samples were received by Geomechanica Inc. via dropoff. These samples were identified as being from boreholes drilled as part of Golder project 166233. A uniaxial compressive strength (UCS) specimen was prepared tested from each of these samples (3 tests total).

Details regarding the steps of specimen preparation and testing along with the test results and photographs of the test specimens 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

Rock Laboratory Testing Results

A report submitted to:

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

October 23, 2017

Project number: 1662333

Abstract

This document summarizes the results of 3 uniaxial compression strength testson 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	1
2	Results	2

1 Overview

This report summarizes the results of laboratory testing of 3 uniaxial compression strength testson 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. Placement of the specimen into the loading frame, applying a 0.5-1.0 kN axial load, removing the electrical tape, and positioning a radial strain sensor at the mid-height of the specimen.
5. Axial loading to rupture while continuously recording axial force, axial deformation, and radial deformation to determine peak strength (UCS), (tangent) Young's modulus (E), and Poisson's ratio (ν).



Figure 1: Uniaxial Compressive Strength (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. 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	Depth (m)	Bulk density ρ (g/cm ³)	UCS (MPa)	Young's Modulus E (GPa)	Notes
M05-1	6.08 - 6.16	2.60	39.2	6.53	See ¹
M03-1	3.94 - 4.09	2.58	14.8	2.20	See ²
M04-1	6.21 - 6.37	2.56	6.4	0.24	See ³
Mean		2.58	20.1	3.0	
Standard Deviation		0.02	13.9	2.6	

¹ Failure partially along healed fracture, bottom 60 mm of specimen limestone, length:diameter ratio < 2:1.

² Specimen very weathered, inter-bedded limestone and shale, length:diameter ratio < 2:1.

³ Specimen separated along weak plane prior to testing, halves tightly re-fit and tested; specimen emitted water upon loading.

2.1 Specimen photographs

Photographs of the specimens prior to and after testing are presented in Figure 3

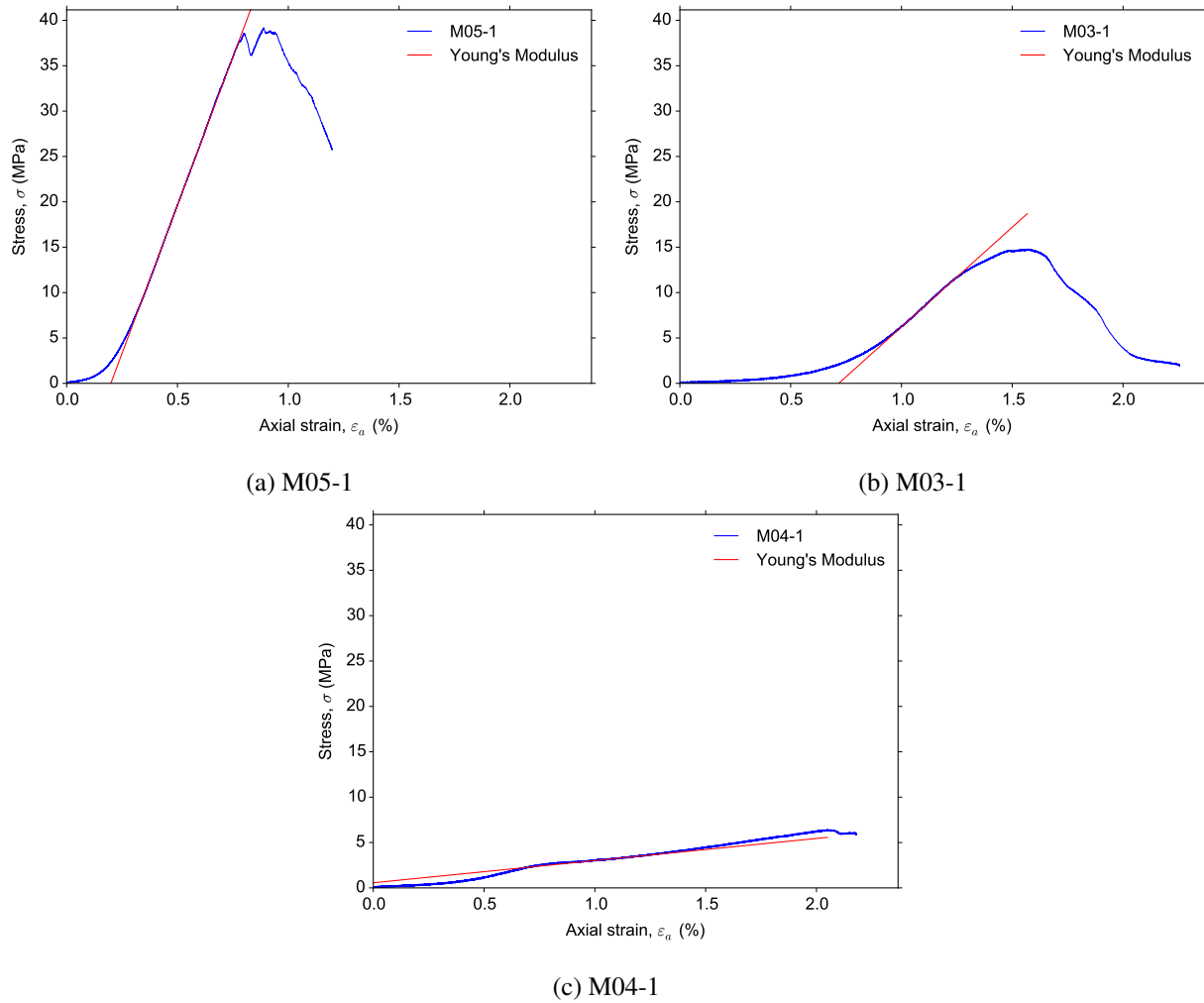


Figure 2: Measured stress-strain curves.

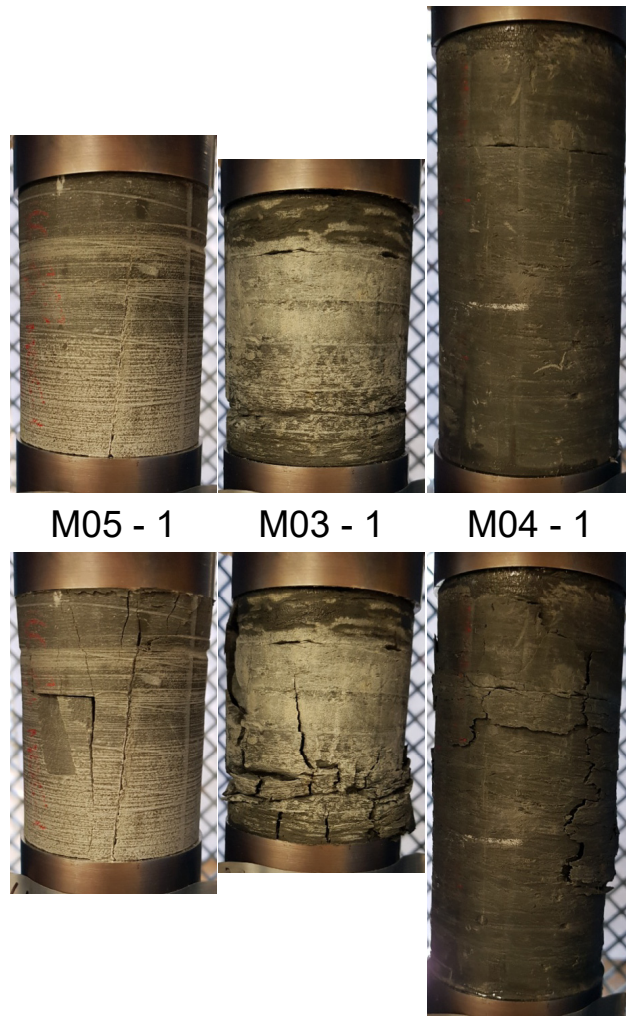


Figure 3: Photographs of specimens prior to testing.

January 03, 2018

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 25, 2017 one (1) HQ-sized core sample was received by Geomechanica Inc. via drop-off by Golder personnel. On December 22, 2017 an additional three (3) 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 166233 (denoted as QEW South Ped. Bridge and QEW and Mississauga Road 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

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

January 3, 2018

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	1
2	Results	2

1 Overview

This report summarizes the results 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. 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.

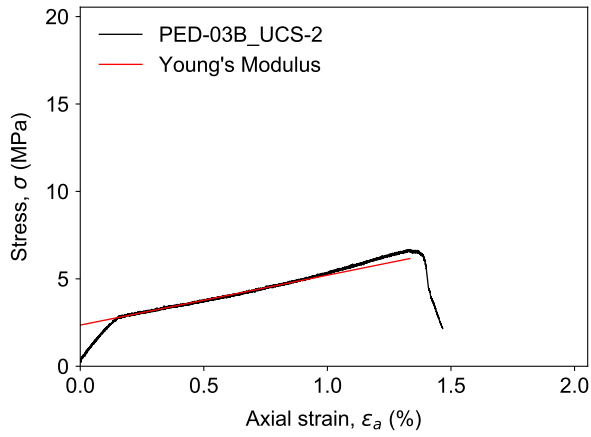
Table 1: Summary of laboratory test results.

Sample	Depth (m)	Bulk density ρ (g/cm ³)	UCS (MPa)	Young's Modulus E (GPa)	Notes
PED-03B, UCS-2	16.03 - 16.27	2.57	6.7	0.29	1
MO-10, UCS-2	2.68 - 2.83	2.60	19.6	0.86	1
MO-12, UCS-2	4.15 - 4.27	2.60	17.3	1.00	1,2
MO-11, UCS-3	3.66 - 3.79	2.59	18.3	0.97	1,2,3 - 2 layers 8 - 20 mm thick
Mean		2.59	15.5	0.8	
Standard Deviation		0.02	5.1	0.3	

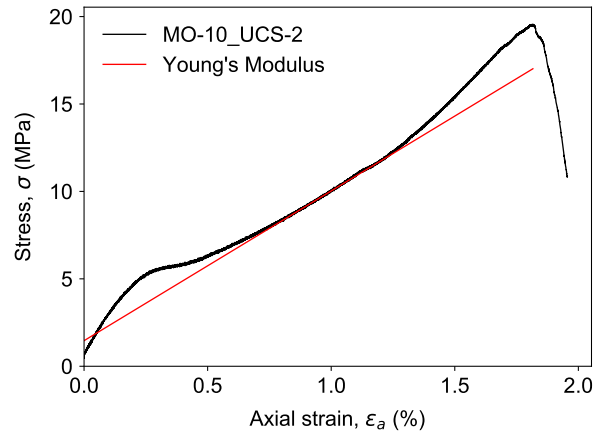
¹ Specimen emitted fresh pore water upon loading
² Length:diameter ratio < 2:1
³ Contains limestone layers

2.1 Specimen photographs

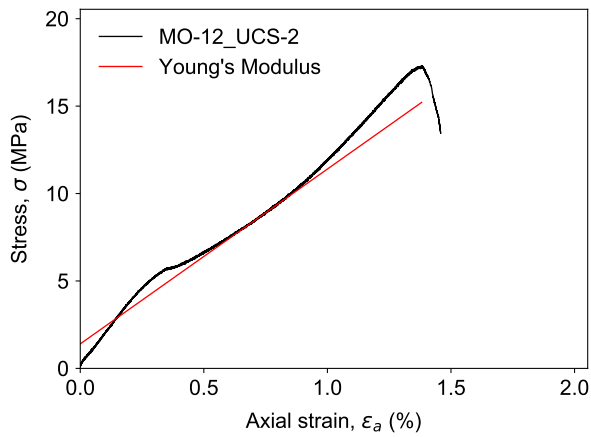
Photographs of the specimens before and after testing are presented in Figure 3.



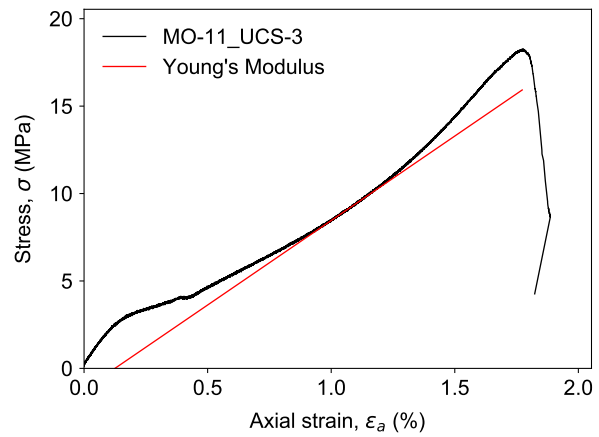
(a) PED-03B, UCS-2



(b) MO-10, UCS-2



(c) MO-12, UCS-2



(d) MO-11, UCS-3

Figure 2: Measured stress-strain curves.

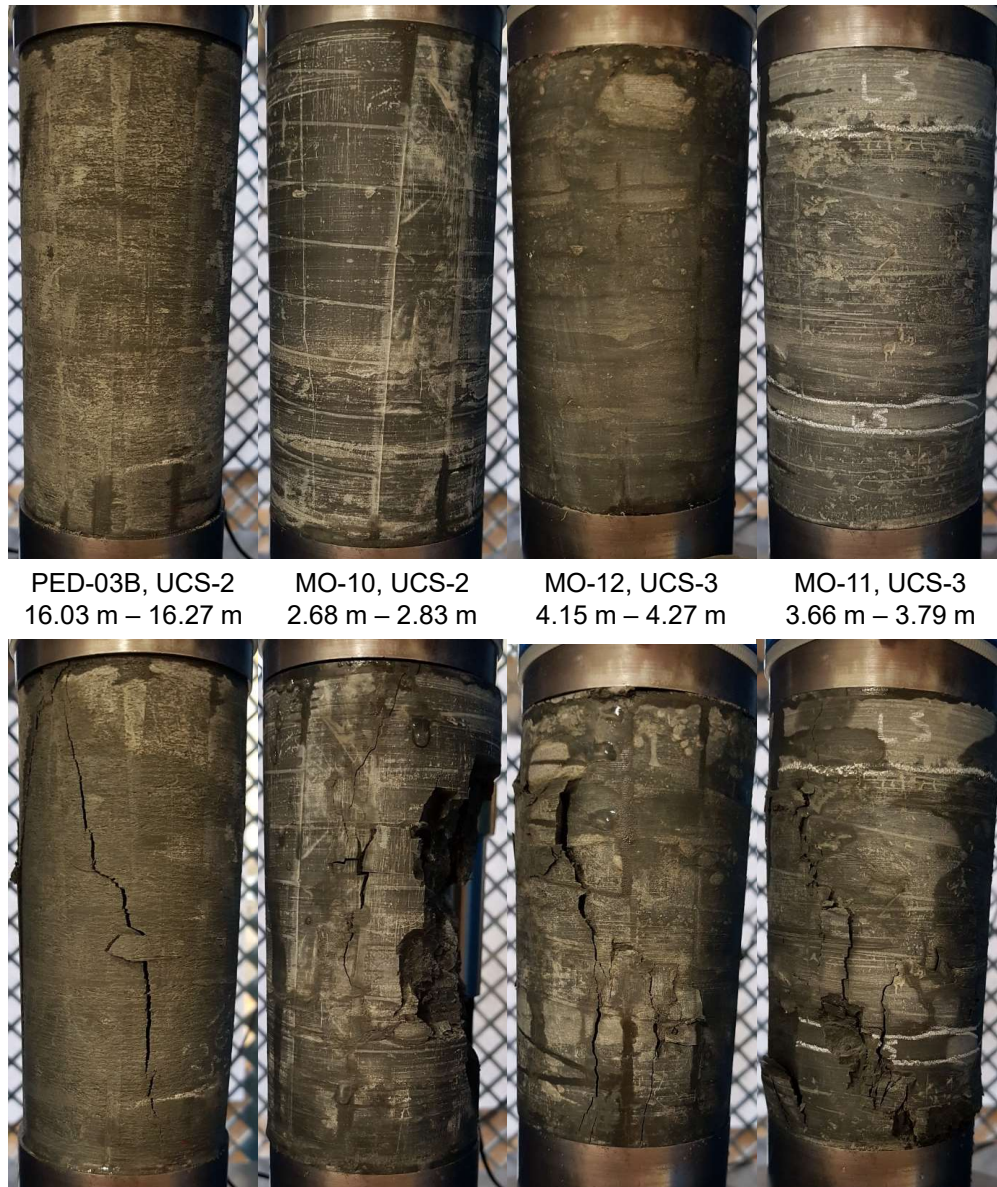


Figure 3: Photographs of specimens prior to testing.

Your Project #: 1662333
Site Location: MISSISSAUGA RD/QEW
Your C.O.C. #: 60265

Attention: Jeremy Lebow

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2018/01/17
Report #: R4940243
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B806888

Received: 2018/01/11, 09:32

Sample Matrix: ROCK
Samples Received: 2

Analyses	Date		Date		Laboratory Method	Reference
	Quantity	Extracted	Analyzed			
Chloride (20:1 extract)	2	N/A	2018/01/17		CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2018/01/16		CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2018/01/15	2018/01/15		CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2018/01/11	2018/01/16		CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	2	N/A	2018/01/17		CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 1662333
Site Location: MISSISSAUGA RD/QEW
Your C.O.C. #: 60265

Attention: Jeremy Lebow

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2018/01/17
Report #: R4940243
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B806888
Received: 2018/01/11, 09:32

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF ROCK

Maxxam ID		FWV272	FWV273		FWV273		
Sampling Date		2017/12/20	2017/12/19		2017/12/19		
COC Number		60265	60265		60265		
	UNITS	MO-10	MO-11	QC Batch	MO-11 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	1500	1800	5348800			
Inorganics							
Soluble (20:1) Chloride (Cl)	ug/g	120	99	5353048	98	20	5353048
Conductivity	umho/cm	647	566	5354646	569	2	5354646
Available (CaCl2) pH	pH	8.33	8.22	5352490			
Soluble (20:1) Sulphate (SO4)	ug/g	130	150	5353049	150	20	5353049
RDL = Reportable Detection Limit							
QC Batch = Quality Control Batch							
Lab-Dup = Laboratory Initiated Duplicate							

TEST SUMMARY

Maxxam ID: FWV272
Sample ID: MO-10
Matrix: ROCK

Collected: 2017/12/20
Shipped:
Received: 2018/01/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5353048	N/A	2018/01/17	Deonarine Ramnarine
Conductivity	AT	5354646	N/A	2018/01/16	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5352490	2018/01/15	2018/01/15	Tahir Anwar
Resistivity of Soil		5348800	2018/01/16	2018/01/16	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5353049	N/A	2018/01/17	Alina Dobreanu

Maxxam ID: FWV273
Sample ID: MO-11
Matrix: ROCK

Collected: 2017/12/19
Shipped:
Received: 2018/01/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5353048	N/A	2018/01/17	Deonarine Ramnarine
Conductivity	AT	5354646	N/A	2018/01/16	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5352490	2018/01/15	2018/01/15	Tahir Anwar
Resistivity of Soil		5348800	2018/01/16	2018/01/16	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5353049	N/A	2018/01/17	Alina Dobreanu

Maxxam ID: FWV273 Dup
Sample ID: MO-11
Matrix: ROCK

Collected: 2017/12/19
Shipped:
Received: 2018/01/11

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5353048	N/A	2018/01/17	Deonarine Ramnarine
Conductivity	AT	5354646	N/A	2018/01/16	Neil Dassanayake
Sulphate (20:1 Extract)	KONE/EC	5353049	N/A	2018/01/17	Alina Dobreanu

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	1.3°C
-----------	-------

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1662333
Site Location: MISSISSAUGA RD/QEW
Sampler Initials: JL

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5352490	Available (CaCl ₂) pH	2018/01/15			100	97 - 103			1.0	N/A
5353048	Soluble (20:1) Chloride (Cl)	2018/01/17	NC	70 - 130	110	70 - 130	<20	ug/g	0.98	35
5353049	Soluble (20:1) Sulphate (SO ₄)	2018/01/17	NC	70 - 130	109	70 - 130	<20	ug/g	1.4	35
5354646	Conductivity	2018/01/16			100	90 - 110	<2	umho/cm	0.53	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required	
Company Name: <u>Golder Associates Ltd.</u>		Company Name: <u>Golder</u>		Quotation #: _____		<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses	
Contact Name: <u>David Marmor</u>		Contact Name: <u>Jeremy Lebow</u>		P.O. #/ AFE#: _____		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
Address: <u>100-6925 Century Ave.</u> <u>Mississauga, ON L5N 7K2</u>		Address: _____		Project #: <u>1062333</u>		Rush TAT (Surcharges will be applied)	
Phone: <u>905-567-4444</u> Fax: <u>905-567-6561</u>		Phone: _____ Fax: _____		Site Location: <u>Mississauga Rd / QEW</u>		<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days	
Email: <u>David.Marmor@golder.com</u>		Email: <u>invoice email + jlebow@golder.com</u>		Site #: _____		Date Required: _____	
Sampled By: _____		Sampled By: <u>Jeremy Lebow</u>		Rush Confirmation #: _____			

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153		Other Regulations		Analysis Requested										LABORATORY USE ONLY				
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> Med/ Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCS F2 - F4	VOCs	REG 153 METALS & INORGANICS	REFER TO BACK OF COC	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	CEROSIVITY PACKAGE	HOLD- DO NOT ANALYZE	CUSTODY SEAL Y / N <u>(Y)</u>		COOLER TEMPERATURES
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Coarse	<input type="checkbox"/> MISA	<input type="checkbox"/> Storm Sewer Bylaw												Present	Intact	
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/ Other		<input type="checkbox"/> PWQO	Region _____														
<input type="checkbox"/> Table _____			<input type="checkbox"/> Other (Specify) _____															
FOR RSC (PLEASE CIRCLE) Y / <u>(N)</u>				<input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED)														
Include Criteria on Certificate of Analysis: <u>(Y)</u> / N																		
SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM																		
SAMPLE IDENTIFICATION		DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX														
1	<u>MO-10</u>	<u>2017/12/20</u>	<u>am</u>	<u>Rock</u>	<u>1</u>	<u>2</u>												
2	<u>MO-11</u>	<u>2017/12/19</u>	<u>am</u>	<u>Rock</u>	<u>1</u>	<u>2</u>												
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
<u>Jeremy Lebow</u>	<u>2018/01/11</u>	<u>09:30</u>	<u>[Signature]</u>	<u>2018/01/11</u>	<u>09:32</u>

11-Jan-18 09:32
 Ema Gitej

B806888
 PS4 ENV-1265

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

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Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

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Canada
T: +1 (905) 567 4444

