

Foundation Investigation Report

Culvert Replacement / Extensions and Temporary Protection Systems for Rehabilitation of Frenchman's Creek Culverts, QEW from 1.4 km North of Bowen Road Interchange Southerly to Gilmore Road Interchange, Niagara Region, Ontario, GWP 2116-16-00

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for Assignment 2016-E-0029-008, GWP 2116-16-00. This assignment involves the detailed design for the Queen Elizabeth Way (QEW) realignment and associated grade raise, including replacement of the twin structures carrying the QEW over the CP/CN railways and associated approach embankment retaining walls, realignment/reconstruction of the four ramps at the QEW/Bowen Road Interchange, extension of existing twin CSP culverts at the realigned QEW/Bowen Road Interchange, replacement of the existing culvert at Station 14+268 with a new culvert at Station 14+273 beneath the QEW and rehabilitation of two structural culverts at Frenchman's Creek (Structure Nos. 34-454/C and 34-455/C).

This report addresses the results of the foundation investigation for the detail design of the following components of this assignment:

- Replacement of existing concrete box culvert located at Station 14+268 with new culvert at Station 14+273 (QEW centreline chainage) below the QEW (Toronto Bound and Fort Erie Bound);
- Extension of the twin corrugated steel pipe (CSP) culverts under the QEW / Bowen Road N-EW and EW-S ramps;
- Temporary protection systems that are required to expose and rehabilitate two structural culverts along Frenchman's Creek (Structure Nos. 34-455/C and 34-454/C). Structure 34-455/C crosses below the QEW and the QEW/Gilmore Road W-N and W-S ramps and Structure 34-454/C crosses below Gilmore Road and the QEW/Gilmore Road W-N Ramp.

The purpose of this foundation investigation report is to establish the subsurface soil, bedrock and groundwater conditions at the culvert sites by borehole drilling and in situ and laboratory testing on selected soil / bedrock samples.

The Terms of Reference (TOR) for the foundation engineering services are outlined in MTO's Work Order No. 2016-E-0029-008 dated March 2018 which forms part of the Consultant's Assignment for the Central Region Retainer under Assignment No. 2016-E-0029-008.

2.0 SITE DESCRIPTION

The culvert sites are located less than 5 km northwest of the Town of Fort Erie, Ontario (see Key Plan on Drawing 1). In general, the QEW road grade rises from the north limit of the project to the south reaching a high point at the CN / CP structure crossings. South of the CN / CP structures, the road grade descends to a low point near the existing culverts crossing below the QEW / Bowen Road N-EW Ramp and EW-S Ramp and then rises again slightly to the south and flattens south of Bowen Road. Bowen Road and the associated bridge structure that crosses over the QEW was under construction during the foundation field investigation conducted in September 2018.

Frenchman's Creek is located at the QEW / Gilmore Road Interchange (see Key Plan on Drawing 3). Gilmore Road crosses over the QEW diagonally at this location. The surrounding area is generally flat and open with light brush cover to the south of Gilmore Road.

A more detailed description of each culvert site is provided in the following sections.

2.1 Station 14+273 (QEW) Concrete Box Culvert

The existing non-structural concrete box culvert north of Station 14+268 conveys surface water beneath the QEW from the west side (near the start of the QEW/Bowen Road N-EW off-ramp) to the east side (see Drawing 1). The existing culvert consists of a concrete box structure with a span of 1.8 m and a height of 0.9 m oriented in the north-south direction and is about 57 m long. The QEW consists of an asphalt road surface with two lanes of traffic in both Toronto bound and Fort Erie bound directions and is surrounded by residential farm lands. The Canadian Pacific (CP) and Canadian National (CN) railways intersect the QEW about 200 m north-west of the culvert location.

Based on AECOM contract drawings dated March 2019, the existing culvert is located at about Station 14+268 and will be replaced by a non-structural concrete box culvert about 68 m long at Station 14+273, with a span of 2.4 m and a height of 1.5 m. Based on contract drawings provided by AECOM dated March 2019, the proposed invert elevation at the culvert inlet and outlet is about Elevation 180.3 m and Elevation 180.0 m, respectively.

The existing grade of the QEW above the proposed culvert location is at about Elevation 184.0 m and will be raised to about Elevation 187.0 m as part of the realignment of the QEW mainline over the CN and CP railways.

2.2 Twin CSP Culvert below QEW / Bowen Road Ramps

The existing non-structural twin CSP culvert conveys surface water beneath the existing Bowen Road N-EW off-ramp and EW-S on-ramp south of the QEW (see Drawing 1). The existing culvert consists of twin 800 mm CSP structures about 70 m long and oriented in the north-south direction.

The N-EW off-ramp and EW-S on-ramp consist of an asphalt road surface and a single lane of traffic. The proposed culvert extensions at this site are to accommodate the ramp reconfiguration associated with the realignment of the QEW over the CN and CP railways. Based on the contract drawings provided by AECOM dated March 2019, the existing twin culverts will be extended by about 30 m to the north, extending beneath the proposed realigned N-EW ramp, and about 40 m on the south side, beneath the proposed realigned EW-S ramp. A portion of the existing twin culverts is to be removed and an open channel will extend and connect to the new twin culverts on the south side. Based on an Contract Drawings from AECOM dated March 2019, the proposed invert elevation of the culvert extension below the new N-EW ramp at the inlet (i.e. connection to existing culverts) and outlet is about Elevation 183.03 m and Elevation 182.67 m, respectively. The proposed invert elevation for the new culvert below the EW-S ramp at the inlet and outlet is about Elevation 183.5 m and Elevation 183.35 m, respectively.

The existing grade of the Bowen Road N-EW and EW-S ramps is at about Elevation 184 m and 185 m, and both will be raised to about Elevation 186 to 186.5 m, respectively, as part of the ramp reconfiguration.

2.3 Frenchman's Creek Culverts (34-454/C and 34-455/C)

The Frenchman's Creek culverts (Structure Nos. 34-454/C and 34-455/C) convey surface water in a north-east to south-west direction beneath the QEW, Gilmore Road, and associated ramps (see Drawing 3). Culvert 34-454/C is about 94.5 m long and is located beneath Gilmore Road, the QEW / Gilmore Road W-N on-ramp and the S-EW off-ramp. Culvert 34-455/C is about 69.5 m long and is located beneath the QEW, the QEW / Gilmore Road W-N on-ramp and the W-S on-ramp.

Based on the Contract drawings provided by AECOM dated March 2019, the existing culverts at Structure No. 34-454/C and 34-455/C consist of rigid frame concrete structures supported on open footings with spans and heights of about 6.7 m by 2.1 m each. The approximate footing founding elevations at Structure No. 34-454/C and 34-455/C are about Elevation 182.9 m and Elevation 182.2 m, respectively (assuming the top of footing is at about Elevation 183.4 m).

The existing road grade above Structure No. 34-454/C and 34-455/C varies from Elevation 189.6 m to Elevation 187.4 m, with corresponding variable depths of cover up to 3.6 m and 1.4 m, respectively.

According to the design drawings, these culverts are to be structurally repaired / rehabilitated near the culvert ends. As a result, temporary protections systems are required perpendicular to the culvert alignment in order to remove the cover soils and expose the existing concrete while maintaining traffic on the adjacent roadways.

3.0 INVESTIGATION PROCEDURES

The field work for the current investigation was carried out between September 4, 2018 and February 8, 2019 during which time a total of thirteen boreholes (designated as Boreholes C1-1 to C1-3, C2-1, C2-2, C3-1, C3-2, C4-1, C4-3, C6-1, C6-3, C7-1, and C7-2) were advanced at the culvert sites. The borehole locations, relative to each culvert, are shown on Drawings 1 and 3 and summarized in the table below.

Culvert Location		Borehole ID	Ground Surface Elevation (m)	Termination Depth (m)	Location
Sta. 14+273 (QEW) Concrete Box Culvert		C1-1	183.7	13.4	Centre of QEW
		C1-2	181.8	4.1	West (inlet) side of QEW
		C1-3	184.1	10.1	East (outlet) side of QEW
Twin CSP Culverts at QEW / Bowen Road Ramps		C2-1	183.8	8.1	East side of extension
		C2-2	183.2	4.6	West side of extension
		C3-1	183.9	3.2	Northeast side of new culverts (extension)
		C3-2	183.9	3.2	Southwest side of new culverts (extension)
Frenchman's Creek Culverts	34-454/C	C4-1	187.9	7.5	Northeast side
		C4-3	187.8	7.9	Northwest side
	34-455/C	C6-1	186.4	7.9	Northeast side
		C6-3	186.5	7.9	Northwest side
		C7-1	186.6	9.1	Southwest side
		C7-2	185.0	7.8	Southeast side

The investigation was carried out using truck-mounted CME 75 and track-mounted CME 55 drill rigs, supplied and operated by Geo Environmental Drilling of Milton, Ontario, and truck-mounted CME 75 and track-mounted CME 45 drill rigs supplied and operated by OGS Drilling Inc. of Almonte, Ontario. The boreholes were advanced through the overburden using 150 mm to 210 mm outer diameter hollow stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using nominal 50 mm outside diameter (35 mm inside diameter) split-spoon samplers

driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure¹. Considering the inside diameter of the split-spoon samplers, soil particles larger than 35 mm cannot be retrieved.

The groundwater conditions were noted in the open boreholes upon completion of drilling. Boreholes C1-2, C1-3, C4-3, and C6-3 were instrumented with standpipe piezometers screened in the upper portion of the dolomitic limestone bedrock. An additional well (designated as SC4-3) was installed within the shallow overburden about 1 m away from Borehole C4-3. The installed piezometers consist of a 50 mm diameter PVC pipe, with a 1.5 m to 3 m slotted screen sealed within a filter sand pack positioned near the bottom of the borehole. The annulus surrounding the piezometer pipe above the filter sand pack was backfilled to the ground surface with bentonite pellets. All other boreholes were backfilled upon completion of drilling in accordance with Ontario Regulation 903 (as amended).

The field work was observed by a member of Golder's engineering staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined the samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination. Classification testing (i.e., water content, Atterberg limits and grain size distribution) was carried out on selected soil samples, in accordance with MTO and/or ASTM Standards, as appropriate.

Where bedrock was inferred to be encountered within the boreholes, the bedrock was typically confirmed by coring with HQ-size equipment. Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD), weathering and strength indices, discontinuity characteristics (type, shape and surface roughness) and classification data of the retrieved rock core samples were generally recorded in the field on the drillhole log based on visual observations. The bedrock was sequentially photographed, packed and transported to Golder's Mississauga laboratory for further visual examination and laboratory testing (i.e. point load testing). Bedrock core photographs are included on Figures B-8 to B-20 in Appendix B. The degree of weathering of the bedrock core samples and the strength classification of the intact rock mass based on field identification are described in accordance with Table B.3 and Table B.6, respectively, of the International Society of Rock Mechanics (ISRM, 1985) standard classification system.

Two soil samples and two rock samples were submitted to Maxxam Analytics of Mississauga, Ontario for analytical testing of a suite of corrosivity parameters including pH, sulphate, chloride, resistivity and electrical conductivity.

A base plan containing topographic data was provided to Golder by AECOM. The as-drilled borehole locations and elevations were surveyed by Callon-Dietz and superimposed on the base plan. The borehole locations are positioned relative to MTM NAD 83 (Zone 10) CSRS CBNV6-2010.0 northing and easting coordinates, together with latitude and longitude, and the ground surface elevations are referenced to Geodetic datum. The borehole locations as provided on the borehole / drillhole records and shown on Drawings 1 to 3, ground surface elevations and drilled depths are summarized below.

¹ American Society for Testing and Materials (ASTM) D1586-11 – Standard Test Method for Standard Penetration Tests and Split-Barrel Sampling of Soils.

Culvert	Borehole ID	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole Depth (Cored Bedrock Length)
		Northing, m (Latitude, °)	Easting, m (Longitude, °)		
Sta. 14+273 (QEW) Concrete Box Culvert	C1-1	4,755,249.3 (42.935891)	346,719.3 (-78.986399)	183.7	13.4 (4.7)
	C1-2	4,755,217.3 (42.935603)	346,711.3 (-78.986498)	181.8	4.1 (3.3)
	C1-3	4,755,255.7 (42.935947)	346,753.3 (-78.985981)	184.1	10.1 (1.5)
Twin CSP Culverts at QEW / Bowen Road Ramps	C2-1	4,755,139.8 (42.934901)	346,780.7 (-78.985653)	183.8	8.1 (4.5)
	C2-2	4,755,139.4 (42.934899)	346,766.3 (-78.985831)	183.2	4.6 (3.4)
	C3-1	4,755,081.7 (42.934375)	346,836.0 (-78.984980)	183.9	3.2 (3.2)
	C3-2	4,755,062.9 (42.934206)	346,839.2 (-78.984942)	183.9	3.2 (3.2)
Frenchman's Creek, No. 34-454/C	C4-1	4,753,420.2 (42.919322)	348,541.5 (-78.964214)	187.9	7.5 (3.1)
	C4-3	4,753,442.4 (42.919524)	348,521.2 (-78.964462)	187.8	7.9 (3.5)
	*SC4-3	4,753,443.3 (42.919531)	348,520.8 (-78.964467)	187.8	4.0
Frenchman's Creek, No. 34-455/C	C6-1	4,753,273.7 (42.918013)	348,378.3 (-78.966226)	186.4	7.9 (3.3)
	C6-3	4,753,288.7 (42.918149)	348,358.0 (-78.966473)	186.5	7.9 (3.1)
	C7-1	4,753,256.6 (42.917862)	348,327.5 (-78.966848)	186.6	9.1 (3.2)
	C7-2	4,753,242.8 (42.917740)	348,296.4 (-78.967231)	185.0	7.8 (3.1)

*shallow standpipe piezometer only – no borehole information

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of the QEW is located in the Clay Plains within the Haldimand Clay Plain physiographic region, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984)². The Beaches and Limestone Plains, also within the Haldimand Clay Plain physiographic region, are located in close proximity to the site.

Generally, this section of Haldimand Clay Plain, located in the farthest southeast reach of the Niagara peninsula consists of fine-textured glaciolustrine deposits of silt and clay with minor amounts of sand and gravel. These deposits range from massive to well-laminated layers. This area of the clay plains can be considered a separate subregion, characterized by levelness and poor drainage.

Underlying the overburden in this area is dolomitic limestone and dolostone of the Bois Blanc and Salina formations, specifically the Bertie member of the Salina formation. The limestone and dolostone units are typically characterized as medium strong to extremely strong, grey, crystalline and slightly argillaceous.

4.2 Subsurface Conditions

The subsurface soil and groundwater conditions as encountered in the boreholes advanced during the investigation, including groundwater level readings, are presented on the record of borehole and drillhole sheets provided in Appendix A. The results of the geotechnical laboratory testing are given on the record of borehole and drillhole sheets provided in Appendix A and the geotechnical laboratory test figures in Appendix B. The bedrock core photographs are provided in Appendix B. The summary results of the analytical testing are presented in Section 4.4 and the detailed analytical laboratory test report is provided in Appendix C.

The results of the in situ field tests (i.e. SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile and cross-sections on Drawing 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. The interpreted stratigraphic profile along the sections shown on Drawing 2 are simplifications of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes exists and is to be expected.

4.2.1 Station 14+273 (QEW) Concrete Box Culvert

Three boreholes (designated as Boreholes C1-1 to C1-3) were advanced near the existing and proposed culvert location as shown on Drawing 1. In general, the subsurface conditions consist of a surficial asphalt underlain by non-cohesive and cohesive fill. The fill layers are underlain by clayey silt and silt and sand deposits followed by dolomitic limestone bedrock.

A more detailed description of the subsurface conditions encountered in the boreholes advanced during the field investigation is provided in the following sections.

4.2.1.1 Asphalt

Boreholes C1-1 and C1-3 were advanced through the QEW and encountered approximately 200 mm and 300 mm of asphalt, respectively, at ground surface.

² Chapman, L.J. and Putnam, D.F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Ontario Geological Survey, Special Volume 2, third Edition. Accompanied by Map P.2715, Scale 1:600,000.

4.2.1.2 *Fill*

Approximately 0.7 m of non-cohesive fill, consisting of sand to silty sand and gravel to sand and gravel, was encountered below the asphalt in Boreholes C1-1 and C1-3. The non-cohesive fill is underlain by approximately 2.1 m and 2.7 m of cohesive fill in Boreholes C1-1 and C1-3. Borehole C1-2 was advanced in the ditch adjacent to the QEW and encountered approximately 0.4 m of cohesive fill at ground surface. The cohesive fill consists of sandy clayey silt, trace gravel, to clayey silt with sand, trace to some gravel. The cohesive fill contains organics in Borehole C1-2. The non-cohesive and cohesive fill extends to depths ranging from 0.4 m to 3.7 m below ground surface in Boreholes C1-1 to C1-3 (corresponding to Elevations 180.4 m to 180.7 m).

The SPT “N”-values measured within the non-cohesive fill are 9 blows per 0.3 m of penetration and 50 blows per 0.25 m of penetration, indicating a loose to very dense state of compactness. The SPT “N”-values measured within the cohesive fill range from 4 blows to 24 blows per 0.3 m of penetration, suggesting a soft to very stiff, but typically stiff consistency.

The results of grain size distribution testing carried on two samples of cohesive fill are shown on Figure B-1 in Appendix B.

The natural water content measured on samples of the cohesive fill range from about 13 per cent to 19 per cent.

Atterberg limits testing was carried out on three samples of the cohesive fill and measured liquid limits ranging from about 27 per cent to 35 per cent, and plastic limits of about 14 per cent, corresponding to plasticity indices of about 11 per cent to 20 per cent. The Atterberg limits test results are shown on Figure B-2 in Appendix B and indicate the material is a clayey silt of low plasticity.

4.2.1.3 *Silt and Sand*

An approximately 0.7 m thick non-cohesive deposit consisting of silt and sand with some clay was encountered below the fill layer in Borehole C1-1 (at approximate El. 180.7 m).

The SPT “N”-value measured within the non-cohesive deposit is 17 blows per 0.3 m of penetration, indicating the soil layer is compact.

The results of grain size distribution testing carried on one sample of the non-cohesive deposit is shown on Figure B-3 in Appendix B.

The natural water content measured on a sample of the silt and sand deposit is about 12 per cent.

4.2.1.4 *Clayey Silt*

A 3.9 m thick clayey silt deposit was encountered below the fill layers in Borehole C1-3 and a 0.4 m thick clayey silt deposit was encountered below the silt and sand deposit in Borehole C1-1. This deposit consists of clayey silt, some sand to sandy, trace gravel. The surface of the cohesive deposit was encountered at a depth of 3.7 m below ground surface (Elevation 180.0 m and 180.4 m at Borehole C1-1 and C1-3 respectively).

The SPT “N”-values measured within the cohesive deposit range from 8 blows to 71 blows per 0.3 m of penetration, suggesting a firm to hard consistency.

The results of grain size distribution testing carried on a sample of the cohesive deposit is shown on Figure B-4 in Appendix B.

The natural water content measured on samples of the cohesive deposit range from about 13 per cent to 21 per cent.

Atterberg limits testing was carried out on a sample of the cohesive deposit and measured a liquid limit of about 28 per cent, a plastic limit of about 13 per cent, corresponding to a plasticity index of about 15 per cent. The Atterberg limits test results are shown on Figure B-5 in Appendix B and indicate the material is a clayey silt of low plasticity.

4.2.1.5 Dolomitic Limestone Bedrock

Dolomitic limestone bedrock was encountered below the cohesive fill in Borehole C1-2 and below the cohesive deposit in Boreholes C1-1 and C1-3. Bedrock fragments were collected in split-spoon samples in all three boreholes (C1-1 to C1-3) and bedrock was confirmed by coring in all boreholes for lengths ranging between 1.5 m and 4.7 m. The bedrock surface was inferred to be encountered at depths ranging between 0.4 m and 4.1 m below ground surface (Elevations 179.6 m to 181.4 m) based on continuous grinding of the augers and limited penetration / recovery of rock fragments (inferred to be highly weathered bedrock with zones of residual soil) from split-spoon samples. An attempt to core the bedrock from a depth of 4.5 m to 5.9 m in C1-1 resulted in limited core recovery and suggests the rock is highly weathered and contains zones of residual soil. A grain size distribution test was carried out on a sample of the rock fragments collected from a split-spoon sample at a depth of 7.5 m in C1-1, and is shown on Figure B-7 in Appendix B. The natural water content measured on a sample of the bedrock is about 14 per cent. The SPT "N"-values measured within the inferred bedrock deposit in Boreholes C1-1 to C1-3 range from 20 blows to 100 blows for 0.03 m of penetration.

Bedrock was cored and confirmed below depths of 8.7 m, 0.8 m, and 8.6 m below ground surface in Boreholes C1-1, C1-2, and C1-3 respectively. Bedrock core photographs for Boreholes C1-1 to C1-3 are provided on Figures B-8 to B-10 in Appendix B.

Based on bedrock core samples retrieved, the bedrock is described as highly to slightly weathered (W4 to W2), medium to thickly bedded, grey, fine-grained, slightly porous, medium strong dolomitic limestone of the Bois Blanc Formation. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of the core samples recovered range between 8 per cent to 94 per cent and between 0 per cent to 94 per cent, respectively. The Rock Quality Designation (RQD) measured on the core samples ranges from 0 per cent to 84 per cent, indicative of a rock mass of very poor to good quality, as per Table 3.10 of CFEM, 2006.

Laboratory axial and diametric Point Load Strength Tests (PLT) were completed by Golder on selected bedrock samples obtained from cores collected from Boreholes C1-1 to C1-3 and the results are shown on the drillhole records and included in Appendix B. The calculated PLT index for a sample tested in the axial orientation is 0.91 MPa and for two samples tested in the diametric orientation are 0.15 MPa and 0.73 MPa.

4.2.2 Twin CSP Culvert at QEW / Bowen Road Ramps

Four boreholes (designated as Boreholes C2-1, C2-2, C3-1 and C3-2) were advanced near the twin CSP culvert in the vicinity of QEW / Bowen Road N-EW and EW-S ramps. At the time of the investigation, the new QEW / Bowen Road underpass was being constructed. In general, the subsurface conditions at the proposed culvert extension beneath the proposed N-EW ramp reconfiguration consist of a surficial layer of cohesive fill at ground surface, underlain by dolomitic limestone bedrock. The subsurface conditions at the proposed new culverts (i.e. culvert extension) beneath the proposed EW-S ramp reconfiguration consist of dolomitic limestone bedrock at ground surface.

A more detailed description of the subsurface conditions encountered in the boreholes advanced during the field investigation at this site is provided in the following sections.

4.2.2.1 Asphalt

Borehole C2-1 was advanced through the QEW / Bowen Road N-EW off ramp and encountered approximately 200 mm asphalt at ground surface.

4.2.2.2 Fill

Below the asphalt in Borehole C2-1 and at ground surface in Borehole C2-2 (located on the shoulder of the off ramp), a deposit of fill was encountered. Approximately 0.6 m of non-cohesive fill, consisting of sand to sand and gravel, was encountered below the asphalt in Borehole C2-1 and approximately 0.8 m of cohesive fill consisting of clayey silt with sand, trace gravel, was encountered at ground surface in Borehole C2-2. The cohesive fill contains organics and rootlets. The fill extends to Elevation 183.0 m and 182.4 m in Boreholes C2-1 and C2-2 respectively.

An SPT “N”-value was measured within the cohesive fill and is 9 blows per 0.3 m of penetration, suggesting a stiff consistency. An SPT “N”-value measured within the non-cohesive fill is 100 blows per 0.05 m of penetration, indicating a very dense compactness, however, this high “N”-value could be due to the spilt-spoon bouncing on rock fragments / bedrock that was encountered directly below the fill layer.

The results of grain size distribution testing carried on a sample of clayey silt with sand fill is shown on Figure B-1 in Appendix B.

The natural water content measured on a sample of the cohesive fill is about 17 per cent.

Atterberg limits testing was carried out on a sample of the cohesive fill and measured a liquid limit of about 26 per cent and a plastic limit of about 16 per cent, corresponding to a plasticity index of about 10 per cent. The Atterberg limits test result is shown on Figure B-2 in Appendix B and indicates the material is a clayey silt of low plasticity.

4.2.2.3 Dolomitic Limestone Bedrock

Dolomitic limestone bedrock was encountered at ground surface in Boreholes C3-1 and C3-2, and below the fill layers in Boreholes C2-1 and C2-2. Bedrock fragments were encountered in the split-spoon samples collected in Borehole C2-1 and bedrock was cored in all of the boreholes at this site (C2-1, C2-2, C3-1 and C3-2) for lengths ranging between 3.2 m and 4.5 m. The bedrock surface was inferred to be encountered at depths ranging between 0.4 m and 4.1 m below ground surface (Elevations 179.6 m to 181.4 m) based on continuous grinding of the augers and limited penetration / recovery of rock fragments (inferred to be highly weathered bedrock with zones of residual soil) from split-spoon samples.

The bedrock surface was inferred to be encountered at a depth of 0.8 m below ground surface (Elevation 183.0 m and 182.4 m in Boreholes C2-1 and C2-2, respectively) based on limited split-spoon penetration / recovery of rock fragments (inferred to be highly to slightly weathered). Bedrock was confirmed by coring from depths of 3.6 m to 8.1 m in Borehole C2-1 and 1.2 m to 4.6 m in Borehole C2-2. Bedrock was encountered at ground surface (Elevation 183.9 m) and confirmed by coring to a depth of 3.2 m at Boreholes C3-1 and C3-2. Bedrock core photographs for Boreholes C2-1, C2-2, C3-1 and C3-2 are provided in Appendix B on Figures B-11 to B-14.

The natural water content measured on two samples of the bedrock are about 2 per cent and 4 per cent. The SPT “N”-values measured within the inferred bedrock deposit range from 100 blows for 0.03 m of penetration to 100 blows for 0.1 m of penetration.

Based on bedrock core samples retrieved, the bedrock is described as highly weathered to fresh (W4 to W1), medium to thickly bedded, grey, fine-grained, slightly porous, medium strong dolomitic limestone of the Bois Blanc Formation. The TCR and SCR of the core samples recovered range from between 20 per cent to 100 per cent and between 0 per cent to 100 per cent, respectively. The RQD ranges from 0 per cent to 96 per cent, indicative of a rock mass of very poor to excellent quality, as per Table 3.10 of CFEM (2006).

Axial and diametric PLTs were completed by Golder on bedrock samples obtained from Boreholes C2-1, C2-2, C3-1 and C3-2 and results are shown on the drillhole records and included in Appendix B. The calculated PLT index results for two samples tested in the axial orientation are 2.25 MPa and 4.97 MPa and the results for samples tested in the diametric orientation range from 0.13 MPa to 1.52 MPa.

4.2.3 Frenchman's Creek Culverts (34-454/C and 34-455/C)

Six boreholes (designated as Boreholes C4-1, C4-3, C6-1, C6-3, C7-1 and C7-2) were advanced near the limits of the culvert ends requiring rehabilitation along Frenchman's Creek. In general, the subsurface conditions consist of surficial asphalt or topsoil underlain by non-cohesive and cohesive fill. The fill layers are underlain by a clayey silt to clayey silt with sand deposit, which in turn is underlain by dolomitic limestone bedrock.

A more detailed description of the subsurface conditions encountered in the boreholes advanced during the field investigation is provided in the following sections.

4.2.3.1 Asphalt / Topsoil

Boreholes C6-1 and C6-3 were advanced through the W-N ramp from Gilmore Road to QEW and encountered an approximately 230 mm and 100 mm thick asphalt layer, respectively, at ground surface.

Borehole C7-1 and C7-2 were advanced in the grassy area adjacent to the QEW / Gilmore Road W-S ramp and encountered an approximately 130 mm and 80 mm thick topsoil layer, respectively, at ground surface.

4.2.3.2 Fill

Fill was encountered at ground surface in Boreholes C4-1 and C4-3 (advanced through the shoulder of the Gilmore Road / Petit Road / QEW-Gilmore Road S-E/W ramp intersection), below the asphalt in Boreholes C6-1 and C6-3, and below the topsoil in Borehole C7-1.

The fill transitioned from a non-cohesive to cohesive material with depth. The non-cohesive fill typically consisted of sand and gravel, trace to some silt, and was generally 0.7 m to 2 m thick (extending to approximate El. 184.2 m to 187.1 m). Below the granular fill, a cohesive deposit of fill was encountered and typically consisted of clayey silt to silty clay, containing trace organics including wood pieces and topsoil. The cohesive fill layer generally ranged from 1.0 m to 1.6 m thick (extending to approximate 183.1 m to 185.7 m). In Borehole C7-1, thin interlayers of non-cohesive and cohesive fill were encountered directly below the topsoil before transitioning to a predominant cohesive fill layer.

The SPT "N"-values measured within the non-cohesive fill range from 6 blows to 35 blows per 0.3 m of penetration, indicating a loose to dense state of compactness. The SPT "N"-values measured within the cohesive fill range from 2 blows to 20 blows per 0.3 m of penetration, suggesting a very soft to very stiff consistency.

The results of grain size distribution testing carried on two samples of non-cohesive fill are shown on Figure B-7 in Appendix B. The results of grain size distribution testing carried on a sample of cohesive fill is shown on Figure B-1 in Appendix B.

The natural water content measured on samples of the non-cohesive fill range from about 2 per cent to 7 per cent and the cohesive fill range from about 17 per cent to 32 per cent.

Atterberg limits testing was carried out on a sample of the cohesive fill and measured a liquid limit of about 52 per cent and a plastic limit of about 21 per cent, corresponding to a plasticity index of about 31 per cent. The Atterberg limits test results is shown on Figure B-2 in Appendix B and indicates the material is a silty clay of high plasticity.

4.2.3.3 Clayey Silt to Silty Clay

A 1.3 m to 3.3 m thick native cohesive deposit was encountered below the topsoil in Borehole C7-2 and below the fill layers in Boreholes C4-1, C4-3, C6-1, C6-3 and C7-1. This native cohesive deposit consists of clayey silt to clayey silt with sand to silty clay. The surface of the cohesive deposit was encountered at depths ranging from 0.1 m to 3.4 m (approximate Elevations 183.1 m to 184.4 m at Structure No. 34-455/C, and Elevations 185.7 m and 185.5 m at Structure No. 34-454/C).

The typical SPT “N”-values measured within the cohesive deposit range from 8 blows to 23 blows per 0.3 m of penetration, suggesting a firm to stiff consistency. Two higher SPT “N”-values of 78 blows and 100 blows for 0.2 m of penetration were measured in Borehole C4-1 and C7-2, and may be attributable to rock fragments / broken rock as the surface of the bedrock was located directly below the sampled clay layer at these locations.

The results of grain size distribution testing carried on six samples of the cohesive deposit are shown on Figure B-4 in Appendix B.

The natural water content measured on samples of the cohesive deposit range from about 9 per cent to 18 per cent.

Atterberg limits testing was carried out on six samples of the cohesive deposit and measured liquid limits ranging from about 22 per cent to 34 per cent, plastic limits ranging from about 13 per cent to 16 per cent, and plasticity indices ranging from about 9 per cent to 17 per cent. The Atterberg limits test results are shown on Figure B-5 in Appendix B and indicate the material is clayey silt of low plasticity.

4.2.3.4 Dolomitic Limestone Bedrock

Dolomitic limestone bedrock was encountered below the cohesive deposit in all boreholes (C4-1, C4-3, C6-1, C6-3, C7-1 and C7-2) advanced at the site. A 0.5 m thick layer of sand and gravel was encountered between the cohesive deposit and underlying bedrock in Borehole C7-2, the sand and gravel deposit was grey in color and resembled residual soil or highly weathered bedrock. The SPT “N”-value measured within this sand and gravel layer is 100 blows for 0.13 m of penetration, indicating a very dense relative compactness.

Bedrock fragments were encountered in the tips of the split-spoon samples in Boreholes C6-1, C6-3 and C7-2 and bedrock was cored in all boreholes for lengths ranging between 3.1 m and 3.5 m.

The bedrock surface was encountered at depths ranging from 4.4 m to 5.5 m below ground surface (Elevations 180.3 m to 183.5 m). Bedrock core photographs for Boreholes C4-1, C4-3, C6-1, C6-3, C7-1 and C7-2 are provided on Figures B-15 to B-20 in Appendix B.

Based on the bedrock core samples retrieved, the bedrock is described as moderately weathered to fresh (W3 to W1), medium to thickly bedded, grey, fine-grained, slightly porous, medium strong dolomitic limestone of the Bois Blanc Formation. The TCR and SCR of the core samples recovered range from between 88 per cent to 100 per cent and between 82 per cent to 100 per cent, respectively. The RQD values range from between 66 per cent to 100 per cent, indicative of a rock mass of fair to excellent quality, as per Table 3.10 of CFEM, 2006.

Axial and diametric PLTs were completed by Golder on bedrock samples obtained from Boreholes C4-1, C4-3, C6-1, C6-3, C7-1 and C7-2 and results are included on the drillhole records and in Appendix B. The calculated PLT index results for samples tested in the axial orientation range from 3.25 MPa to 7.16 MPa and for samples tested in the diametric orientation range from 2.30MPa to 7.19 MPa, confirming that the bedrock is strong to very strong according to Table 3.5 of CFEM (2006).

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured during and upon completion of drilling operations. It should be noted that the groundwater level (or lack thereof) measured in open boreholes does not represent stabilized groundwater conditions as water may not have stabilized in the hole prior to coring operations and/or water levels would have been impacted by the use of drilling mud and circulation water used in the drilling and rock coring operations. Boreholes C1-2, C1-3, C4-3, and C6-3 were instrumented with standpipe piezometers screened in the dolomitic limestone bedrock. An additional piezometer (designated SC4-3) was advanced adjacent to borehole C4-3 and was screened in the overburden. The groundwater level recorded in the open boreholes and in the standpipe piezometers are shown on the borehole records in Appendix A and are summarized below.

Culvert	Borehole / Piezometer No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
Sta. 14+273 (QEW) Concrete Box Culvert	C1-1	183.7	Dry 7.2	- 176.5	Sept 4, 18 Sept 4, 18	prior to rock coring after rock coring
	C1-2	181.8	3.9	177.9	Jan 13, 19	standpipe piezometer
			3.2	178.6	Feb 8, 19	
			3.8	178.0	Feb 22, 19	
	C1-3	184.1	3.2	180.9	Feb 8, 19	standpipe piezometer
			5.9	178.2	Feb 22, 19	
Twin CSP Culverts at QEW / Bowen Road Ramps	C2-1	183.8	Dry	-	Sept 5, 18	prior to rock coring
	C2-2	183.2	Dry	-	Jan 13, 19	prior to rock coring
	C3-1	183.9	0	183.9	Sept 24, 18	prior to rock coring
	C3-2	183.9	0	183.9	Sept 24, 18	prior to rock coring
Frenchman's Creek, Structure No. 34-454/C	C4-1	187.9	Dry	-	Dec 19, 18	prior to rock coring
	C4-3	187.8	3.4	184.4	Feb 8, 19	standpipe piezometer
			3.4	184.4	Feb 22, 19	
Frenchman's Creek, Structure No 34-455/C	SC4-3	187.8	3.5	184.3	Feb 22, 19	standpipe piezometer
	C6-1	186.4	2.1	184.3	Dec 18, 18	prior to rock coring
	C6-3	186.5	1.4	185.1	Feb 8, 19	standpipe piezometer
	C7-1	186.6	Dry 1.0	- 185.6	Sept 27, 18 Sept 27, 18	prior to rock coring after rock coring
			2.3	182.7	Sept 7, 18	prior to rock coring

The groundwater level observations at this site will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation. The water level in Frenchman's Creek is shown on the Contract Drawings to be at about Elevation 184.2 m to 184.3 m in the vicinity of the culverts; thus groundwater levels will also be subject to water level fluctuations within Frenchman's Creek.

4.4 Analytical Testing Results

A total of four samples, two soil samples and two rock cores, were submitted for analysis of parameters used to assess the potential for corrosivity of steel and deterioration of concrete at the site. The results of the analytical testing are summarized below, and the detailed analytical laboratory test report is included in Appendix C.

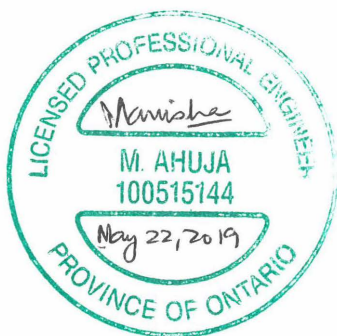
Culvert Site	Borehole / Sample No.	Soil / Bedrock Type	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Soluble Chlorides (µg/g)	Soluble Sulphates (µg/g)
Station 14+273 (QEW) Concrete Box Culvert	C1-1 / 1	Fill	8.06	2000	504	150	110
Twin CSP culvert extensions at QEW / Bowen Road Ramps	C2-1 / 1	Dolomitic Limestone	8.22	3800	260	53	<20*
	C3-1 / 1	Dolomitic Limestone	7.94	5600	179	23	<20*
Frenchman's Creek Culverts	C7-1 / 5	Clayey Silt	7.92	1200	858	330	270

* Reportable Detection Limit

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Darcy Hansen, EIT., a geotechnical engineer-in-training, and was reviewed by Ms. Manisha Ahuja, P.E., P.Eng., a geotechnical engineer with Golder. Mr. Kevin Bentley, P.Eng., an Associate and MTO Foundations Designated Contact for Golder, conducted an independent technical and quality control review of the report.

Golder Associates Ltd.



Manisha Ahuja, P.Eng., P.E. (OH)
Geotechnical Engineer

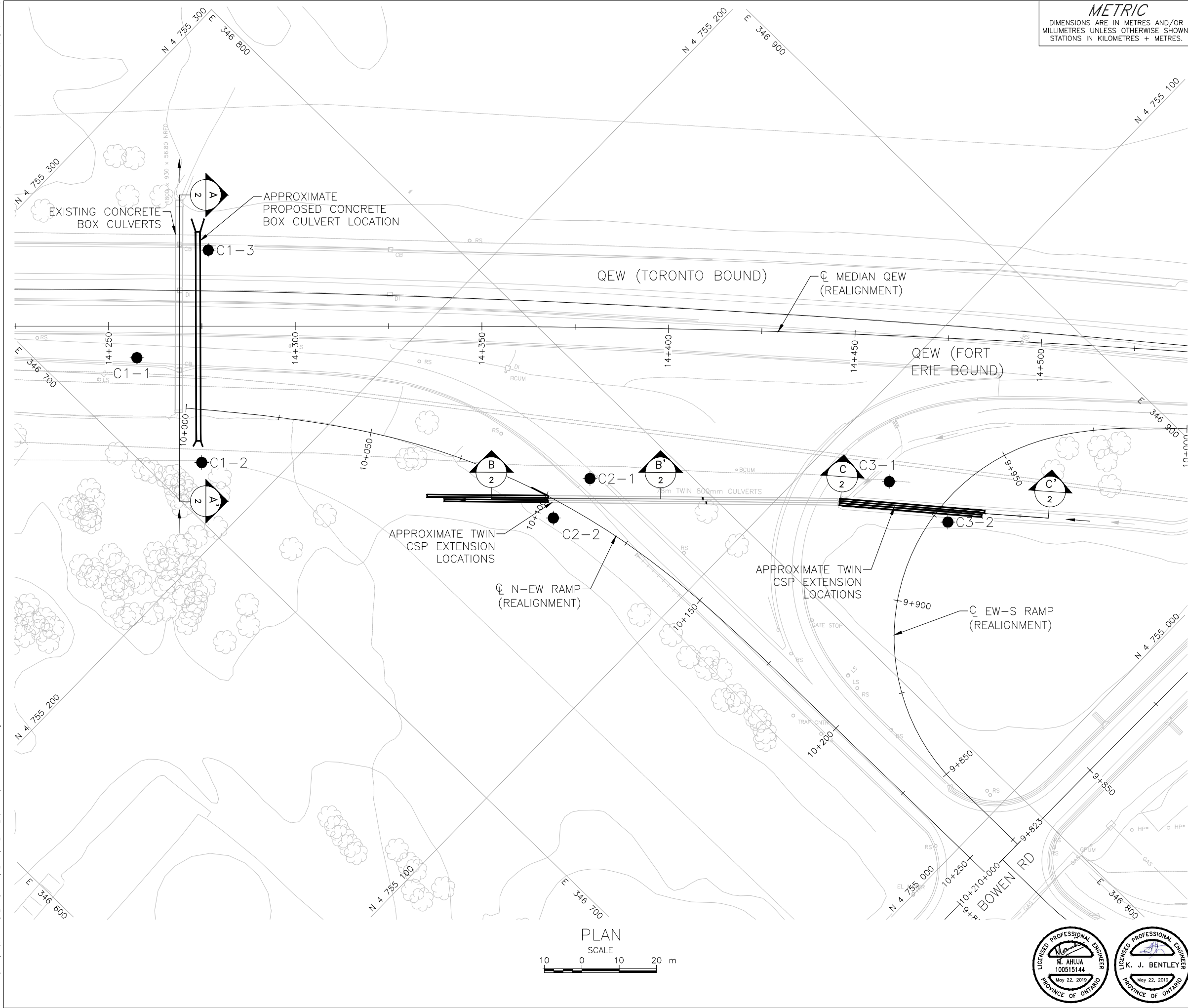


Kevin J. Bentley, P.Eng.
Associate, MTO Foundations Designated Contact

DH/MA/KJB/rb

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[https://golderassociates.sharepoint.com/sites/15994g/6. deliverables/wo 008 - qew-bertie detailed design/fnds/4. culverts and temporary protections/4. final/1671430 w08 fir 2019may22 culverts and tps.docx](https://golderassociates.sharepoint.com/sites/15994g/6.%20deliverables/wo%20008-%20qew-bertie%20detailed%20design/fnds/4.%20culverts%20and%20temporary%20protections/4.%20final/1671430%20w08%20fir%202019may22%20culverts%20and%20tps.docx)



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

CONT No. 2019-2003
GWP No. 2116-16-00

QEW
CULVERT REPLACEMENT/EXTENSIONS
BOREHOLE LOCATION PLAN

SHEET



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

Borehole - Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C1-1	183.7	4755249.3	346719.3
C1-2	181.8	4755217.3	346711.3
C1-3	184.1	4755255.7	346753.2
C2-1	183.8	4755139.8	346780.7
C2-2	183.2	4755139.4	346766.3
C3-1	183.9	4755081.7	346836.0
C3-2	183.9	4755062.9	346839.2

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

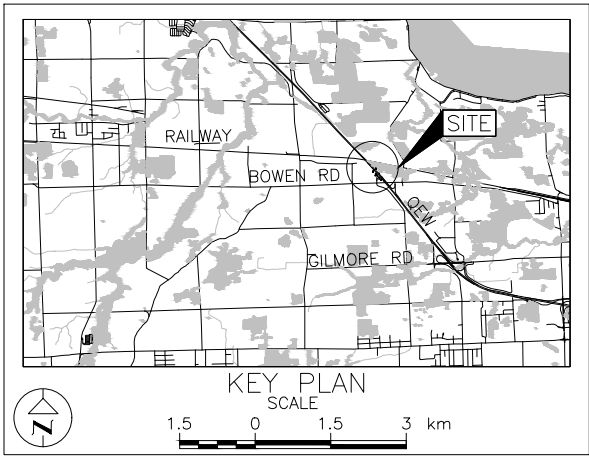
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NO.	DATE	BY	REVISION
Geocres No. 30L15-17			
HWY. QEW		PROJECT NO. 1671430	
SUBM'D. NK	CHKD. DH	DATE: 05/22/2019	SITE:
DRAWN: SW	CHKD. MA	APPD. KJB	DWG. 1

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

CONT No. 2019-2003 GWP No. 2116-16-00		
QEW CULVERT REPLACEMENT/EXTENSIONS		SHEET
SOIL STRATA		



LEGEND	
	Borehole - Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
	Seal
	Piezometer
	WL upon completion of drilling
	WL in piezometer, measured on FEB 22, 2019

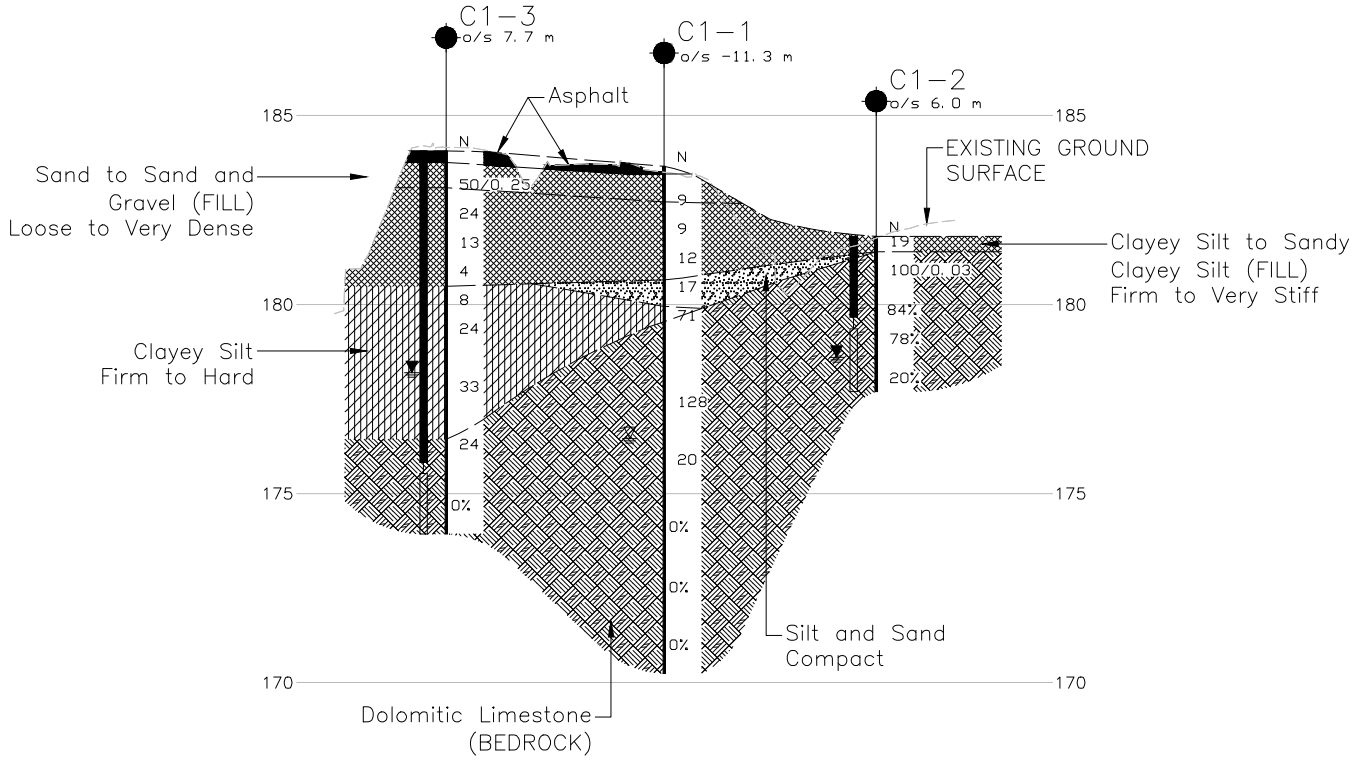
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C1-1	183.7	4755249.3	346719.3
C1-2	181.8	4755217.3	346711.3
C1-3	184.1	4755255.7	346753.2
C2-1	183.8	4755139.8	346780.7
C2-2	183.2	4755139.4	346766.3
C3-1	183.9	4755081.7	346836.0
C3-2	183.9	4755062.9	346839.2

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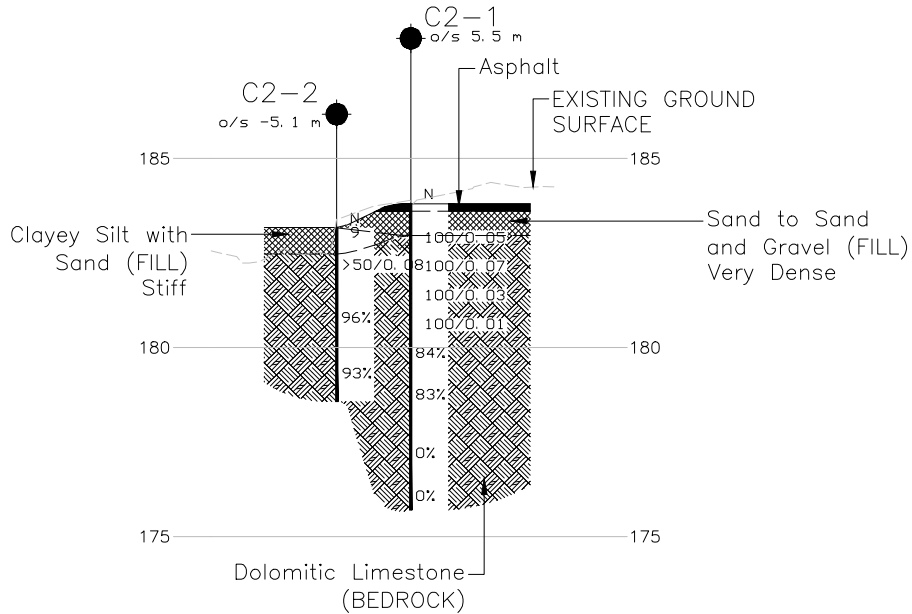
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE
Base plans provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Berti Alignments_2019Jan03mw.dwg, received January 08, 2018.
Proposed Culverts provided in digital format by Aecom, drawing file no. X-60581660-C-CNCP-QEW-DES_ADDENDUM.dwg, received May 7, 2019.

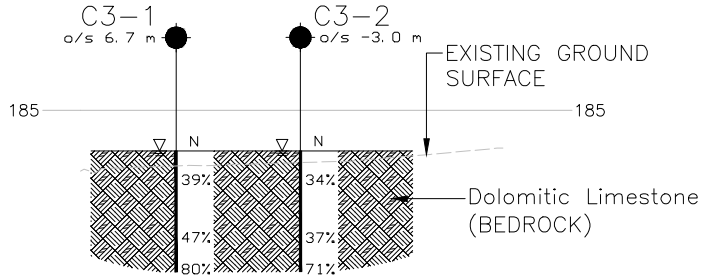
NO.	DATE	BY	REVISION
Geocres No. 30L15-17			
HWY. QEW	PROJECT NO. 1671430		DIST. CENTRAL
SUBM'D. NK	CHKD. DH	DATE: 05/22/2019	SITE:
DRAWN: SW	CHKD. MA	APPD. KJB	DWG. 2



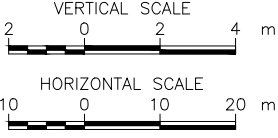
PROFILE A-A'

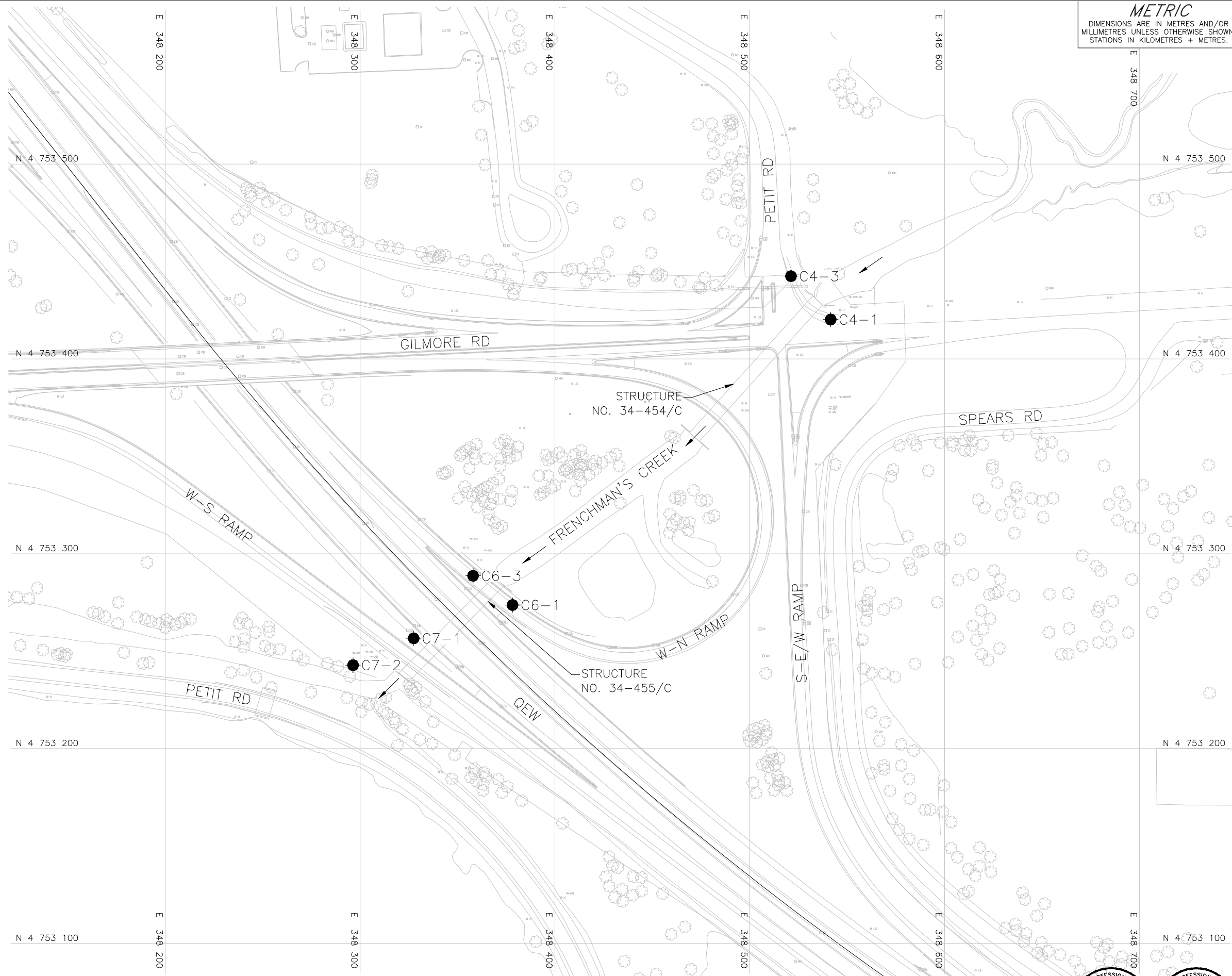


PROFILE B-B'



PROFILE C-C'

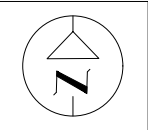




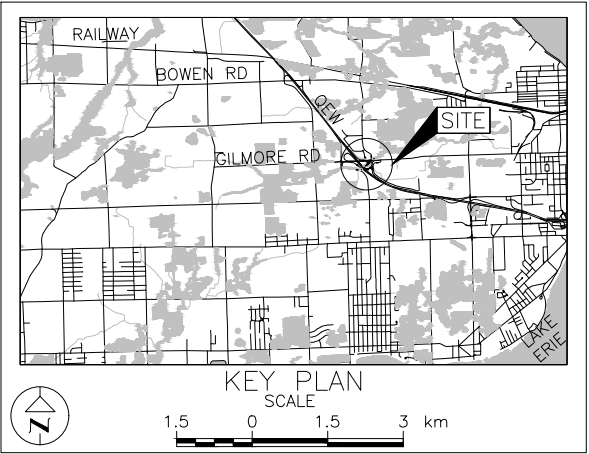
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STATIONS IN KILOMETRES + METRES.

CONT No. 2019-2003
GWP No. 2116-16-00

QEW
TEMPORARY PROTECTION SYSTEMS
BOREHOLE LOCATION PLAN



SHEET



LEGEND

Borehole – Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C4-1	187.9	4753420.2	348541.5
C4-3	187.8	4753442.4	348521.2
C6-1	186.4	4753273.7	348378.3
C6-3	186.5	4753288.7	348358.0
C7-1	186.6	4753256.6	348327.5
C7-2	185.0	4753242.8	348296.4

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

REFERENCE
Base plans provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Bertie Alignments_2019Jan03mw.dwg, received January 08, 2018.



Geocres No. 30L15-17			
NO.	DATE	BY	REVISION
HWY. QEW PROJECT NO. 1671430 DIST. .			
SUBM'D. NK	CHKD. DH	DATE: 05/22/2019	SITE: .
DRAWN: SW	CHKD. MA	APPD. KJB	DWG. 3

APPENDIX A

Record of Boreholes and Drillholes

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 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

Compactness	N
Condition	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

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

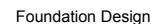
JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT		1671430 W08		RECORD OF BOREHOLE No C1-1		SHEET 1 OF 2		METRIC						
G.W.P.		2116-16-00		LOCATION		N 4755249.3; E 346719.3 MTM NAD 83 ZONE 10 (LAT. 42.935891; LONG. -78.986398)		ORIGINATED BY JK						
DIST		Central HWY QEW		BOREHOLE TYPE		203 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN/KN						
DATUM		Geodetic		DATE		September 4, 2018		CHECKED BY NK						
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						
183.7	GROUND SURFACE													
0.0	ASPHALT (200 mm)													
0.2	Sand and gravel (FILL) Brown													
182.9														
0.9	Sand (FILL) Loose Brown-red Moist		1A	SS	9									
			1B											
	Sandy clayey silt, trace gravel (FILL) Stiff Brown-grey Moist		2	SS	9									
			3	SS	12									
180.7														
3.0	SILT and SAND, some clay, trace gravel Compact Brown Moist		4	SS	17									2 40 44 14
180.0														
3.7	Sandy CLAYEY SILT, trace gravel Hard Brown Moist		5A	SS	71									
179.6			5B											
4.1	Dolomitic Limestone (BEDROCK)													
	- Augers grinding below a depth of 4.3 m													
	- Auger refusal at 4.5 m													
	- Cored from 4.5 m to 5.9 m													
			6	SS	128									
	- Auger grinding between depths of 6.9 m and 7.0 m, and at 8.2 m													
			7	SS	20									30 52 15 3
	- Auger refusal at 8.7 m													
	- Augered to 8.7 m		1	RC	REC 22%									RQD = 0%
	Bedrock cored from 8.7 m to 13.4 m.													
	For rock details refer to Record of Drillhole C1-1.		2	RC	REC 8%									RQD = 0%
			3	RC	REC 10%									RQD = 0%
170.3														
13.4	END OF BOREHOLE													
NOTES:														
1. Open borehole dry prior to rock coring.														

Continued Next Page

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

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

GTA-MTO 001 S:\CLIENTS\IMTO\QEW-BERTIE\02_DATA\GIN\QEW-BERTIE.GPJ GAL-GTA.GDT 05/22/19

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C1-1

SHEET 1 OF 1

LOCATION: N 4755249.34 ;E 346719.27

DRILLING DATE: September 4, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																	FEATURES	PIEZOMETER
				ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA				WEATH- ERING INDEX	Diametral Point Load Index (MPa)					
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon							
																		000000 000				

DEPTH SCALE

1 : 50



LOGGED: KN/JK

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02 DATA\INT\QEW-BERTIE.GPJ GAL-MISS GDT 19-5-22

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

PROJECT: 1671430 W08F

RECORD OF DRILLHOLE: C1-2

SHEET 1 OF 1

LOCATION: N 4755217.33 ;E 346711.26

DRILLING DATE: January 10, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45 Truck mounted Drill Rig

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY												FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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1	Rotary Diamond Drill HQ Core	Continued from Record of Borehole C1-2 Slightly to highly weathered, medium to thickly bedded, grey, fine grained, slightly porous, medium strong, DOLOMITIC LIMESTONE (Bois Blanc Formation)		181.01 0.79	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: LK/SK

CHECKED: NK

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PROJECT 1671430 W08		RECORD OF BOREHOLE No C1-3				SHEET 1 OF 1				METRIC					
G.W.P. 2116-16-00		LOCATION N 4755255.7; E 346753.3 MTM NAD 83 ZONE 10 (LAT. 42.935947; LONG. -78.985981)				ORIGINATED BY LK									
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME45 Track/CME75 Truck mounted Drill Rigs				COMPILED BY EN									
DATUM Geodetic		DATE January 26, 2019				CHECKED BY NK									
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							
184.1	GROUND SURFACE							20 40 60 80 100							
183.8	ASPHALT (300 mm)														
0.3	Sand and gravel to silty sand and gravel (FILL)		1	AS											
183.3	Grey to dark grey		2	SS	50/0.25										
1.0	Sand and gravel, trace silt to silty (FILL)						183								
	Very dense														
	Grey														
	Dry														
	Sandy clayey silt, trace gravel (FILL)		3	SS	24		182								
	Soft to very stiff														
	Mottled grey brown		4	SS	13										1 26 49 24
	Moist														
			5	SS	4		181								
180.4															
3.7	CLAYEY SILT, some sand, trace gravel														
	Firm to hard		6	SS	8		180								
	Mottled grey-brown														
	Moist to wet														
	- Auger increased resistance between 5.3 m and 5.5 m		7	SS	24		179								2 17 49 32
			8	SS	33		178								
							177								
176.5															
7.6	Dolomitic Limestone (BEDROCK)														
	Bedrock cored from 8.6 m to 10.1 m.		9	SS	24		176								
	For rock coring details refer to Record of Drillhole C1-3.														
			1	RC	REC 39%		175								RQD = 0%
174.0															
10.1	END OF BOREHOLE						174								
NOTE: 1. Water level in borehole at a depth of 7.5 m (Elev. 176.6 m) below ground surface prior to rock coring. 2. Water level in standpipe piezometer Date Depth (m) Elev. (m) Feb. 08, 2019 3.2 180.9 Feb. 22, 2019 5.9 178.2															

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C1-3

SHEET 1 OF 1

LOCATION: N 4755255.74 ;E 346753.25

DRILLING DATE: January 26, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
					DEPTH (m)	ELEV.			RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA						WEATH- ERING INDEX		Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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9	Rotary Diamond Drill HQ Core	Continued from Record of Borehole C1-3		175.45																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: NK

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PROJECT		1671430 W08		RECORD OF BOREHOLE No C2-1		SHEET 1 OF 1		METRIC								
G.W.P.		2116-16-00		LOCATION		N 4755139.8; E 346780.7 MTM NAD 83 ZONE 10 (LAT. 42.934901; LONG. -78.985653)		ORIGINATED BY JK								
DIST		Central HWY QEW		BOREHOLE TYPE		152 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig		COMPILED BY EN/KN								
DATUM		Geodetic		DATE		September 5, 2018		CHECKED BY NK								
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
183.8	GROUND SURFACE															
0.0	ASPHALT (200 mm)															
0.2	Sand to sand and gravel (FILL) Brown to brown-grey below 0.5 m Very dense Moist															
183.0	Dolomitic Limestone (BEDROCK)		1A	SS	100/0.05	183										
0.8	Bedrock cored from 3.6 m to 8.1 m. For rock coring details refer to Record of Drillhole C2-1.		1B													
			2	SS	100/0.05	182										
			3	SS	100/0.05	181										
			4	SS	100/0.1	180										
			1	RC	REC 100%	179										RQD = 84%
			2	RC	REC 92%	178										RQD = 83%
			3	RC	REC 20%	177										RQD = 0%
			4	RC	REC 47%	176										RQD = 0%
175.7	END OF BOREHOLE															
8.1	NOTES: 1. Open borehole dry prior to rock coring. 2. Borehole caved to 7.6 m below ground surface on removal of casing. 3. Variable weathered bedrock inferred from limited split-spoon recovery between 0.8 m and 3.6 m.															

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C2-1

SHEET 1 OF 1

LOCATION: N 4755139.78 ;E 346780.68

DRILLING DATE: September 5, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY												FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA	WEATH- ERING INDEX	Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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DEPTH SCALE


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**GOLDER**

LOGGED: KN/JK

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02_DATA\GINT\QEW-BERTIE.GPJ GAL-MISS GDT 19-5-22

PROJECT		1671430 W08		RECORD OF BOREHOLE No C2-2		SHEET 1 OF 2		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4755139.4; E 346766.3 MTM NAD 83 ZONE 10 (LAT. 42.934899; LONG. -78.985831)		ORIGINATED BY LK							
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY JMP							
DATUM		Geodetic		DATE		January 13, 2019		CHECKED BY NK							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
183.2 0.0	GROUND SURFACE Clayey silt with sand, trace gravel with organics and roots (FILL) Stiff Brown Moist		1	SS	9		183							4 34 46 16	
182.4 0.8	Dolomitic Limestone (BEDROCK) Bedrock cored from 1.2 m to 4.6 m. For rock coring details refer to Record of Drillhole C2-2.		2	SS	50/0.04		182								
			1	RC	REC 96%		181								RQD = 96%
			2	RC	REC 95%		180								RQD = 93%
178.6 4.6	END OF BOREHOLE NOTE: 1. Open borehole dry on completion of drilling and prior to rock coring.						179								


GTA-MTO 001 S:\CLIENTS\MTQ\QEW-BERTIE02_DATAGINT\QEW-BERTIE.GPJ GAL-GTA.GDT 05/22/19

SHEET 2 OF 2

DATUM: Geodetic

DRILLING CONTRACTOR: OGS

CHECKED: NK

PROJECT <u>1671430 WO8</u>		RECORD OF BOREHOLE No C3-1				SHEET 1 OF 1		METRIC									
G.W.P. <u>2116-16-00</u>		LOCATION <u>N 4755081.7; E 346836.0 MTM NAD 83 ZONE 10 (LAT. 42.934375; LONG. -78.984981)</u>				ORIGINATED BY <u>MA/KN</u>											
DIST <u>Central</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>HQ3 Core, CME 55 Track-Mounted Drill Rig</u>				COMPILED BY _____											
DATUM <u>Geodetic</u>		DATE <u>September 24, 2018</u>				CHECKED BY <u>NK</u>											
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									WATER CONTENT (%)
183.9 0.0	GROUND SURFACE Dolomitic Limestone (BEDROCK) Bedrock cored from 0 m to 3.2 m. For rock coring details refer to Record of Drillhole C3-1.		1	RC	REC 100%											183	
			2	RC	REC 100%											182	
180.7 3.2	END OF BOREHOLE		3	RC	REC 100%											181	

GTA-MTO 001 S:\CLIENTS\MTQ\QEW-BERTIE02_DATAGINT\QEW-BERTIE.GPJ GAL-GTA.GDT 05/22/19

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C3-1

SHEET 1 OF 1

LOCATION: N 4755081.69 ;E 346835.97

DRILLING DATE: September 24, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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DEPTH SCALE

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LOGGED: MA/KN

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02 DATA\INT\QEW-BERTIE.GPJ GAL-MISS.GDT 19-5-22

PROJECT		1671430 WO8		RECORD OF BOREHOLE No C3-2		SHEET 1 OF 1		METRIC										
G.W.P.		2116-16-00		LOCATION		N 4755062.9; E 346839.2 MTM NAD 83 ZONE 10 (LAT. 42.934206; LONG. -78.984842)		ORIGINATED BY										
DIST		Central HWY QEW		BOREHOLE TYPE		HQ3 Core, CME 55 Track-Mounted Drill Rig		COMPILED BY										
DATUM		Geodetic		DATE		December 24, 2018		CHECKED BY										
								NK										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
183.9	GROUND SURFACE							20	40	60	80	100						
0.0	Dolomitic Limestone (BEDROCK)																	
	Bedrock cored from 0 m to 3.2 m.																	
	For rock coring details refer to Record of Drillhole C3-2.																	
			1	RC	REC 100%		183											RQD = 34%
			2	RC	REC 98%		182											RQD = 37%
			3	RC	REC 71%		181											RQD = 71%
180.7	END OF BOREHOLE																	
3.2	NOTE: 1. Surface water level at ground surface (Elev. 183.9 m) prior to coring. 2. Water level at ground surface prior to coring.																	

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C3-2

SHEET 1 OF 1

LOCATION: N 4755062.89 ;E 346839.16

DRILLING DATE: September 24, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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DEPTH SCALE

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LOGGED: MA/EN

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02 DATA\GINT\QEW-BERTIE.GPJ GAL-MISS GDT 19-5-22

PROJECT		1671430 W08		RECORD OF BOREHOLE No C4-1		SHEET 1 OF 1		METRIC										
G.W.P.		2116-16-00		LOCATION		N 4753420.2; E 348541.5 MTM NAD 83 ZONE 10 (LAT. 42.919322; LONG. -78.964214)		ORIGINATED BY SE										
DIST		Central HWY QEW		BOREHOLE TYPE		152 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig		COMPILED BY KN/EN										
DATUM		Geodetic		DATE		December 19, 2018		CHECKED BY NK										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
187.9 0.0	GROUND SURFACE Sand and gravel, trace to some silt, trace clay (FILL) Compact Grey Moist		1	SS	18													GR SA SI CL
186.7 1.2	Sandy clayey silt, some gravel (FILL) Firm Brown Moist		2	SS	13													
185.7 2.2	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace gravel Stiff to hard Brown to brown-grey Moist		3	SS	6													
185.7 2.2	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace gravel Stiff to hard Brown to brown-grey Moist		4	SS	8												4 23 45 28	
185.7 2.2			5	SS	14													
185.7 2.2			6	SS	78/0.20													
183.5 4.4			Dolomitic Limestone (BEDROCK) Bedrock cored from 4.4 m to 7.5 m. For rock coring details refer to Record of Drillhole C4-1.	1	RC	REC 100%												RQD = 94%
183.5 4.4	Dolomitic Limestone (BEDROCK) Bedrock cored from 4.4 m to 7.5 m. For rock coring details refer to Record of Drillhole C4-1.		2	RC	REC 100%												RQD = 100%	
183.5 4.4			3	RC	REC 88%												RQD = 88%	
180.4 7.5			END OF BOREHOLE NOTE: 1. Borehole dry prior to start of rock coring.															

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C4-1

SHEET 1 OF 1

LOCATION: N 4753420.21 ;E 348541.53

DRILLING DATE: December 19, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																		FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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DEPTH SCALE

1 : 50



LOGGED: SE/KG

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02 DATA\GINT\QEW-BERTIE.GPJ GAL-MISS GDT 19-5-22

PROJECT		1671430 W08		RECORD OF BOREHOLE No C4-3		SHEET 1 OF 1		METRIC											
G.W.P.		2116-16-00		LOCATION		N 4753442.4; E 348521.2 MTM NAD 83 ZONE 10 (LAT. 42.919524; LONG. -78.964462)		ORIGINATED BY SE											
DIST		Central HWY QEW		BOREHOLE TYPE		152 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig		COMPILED BY KN/EN											
DATUM		Geodetic		DATE		December 20, 2018		CHECKED BY NK											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40
187.8	GROUND SURFACE																		
0.0	Sand and gravel, trace silt, some clay (FILL) Compact Grey Moist		1	SS	17														
187.1																			
0.7	Silty clay, trace to some sand, trace gravel (FILL) Stiff to very stiff Brown Moist		2	SS	20														
			3	SS	8														
185.5																			
2.3	CLAYEY SILT, trace to some sand, trace gravel Very stiff Brown Moist		4	SS	21														
			5	SS	21														
			6	SS	15														
183.4																			
4.4	Dolomitic Limestone (BEDROCK)		1	RC	REC 100%														
	Bedrock cored from 4.4 m to 7.9 m.																		
	For rock coring details refer to Record of Drillhole C4-3.		2	RC	REC 100%														
			3	RC	REC 100%														
180.0	END OF BOREHOLE																		
7.9	NOTES: 1. Borehole dry prior to start of rock coring. 2. Water level in standpipe piezometer Date Depth (m) Elev. (m) Feb. 08/19 3.4 184.4 Feb. 22/19 3.4 184.4																		

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C4-3

SHEET 1 OF 1

LOCATION: N 4753442.44 ;E 348521.17

DRILLING DATE: December 20, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS D.D. C.R.S.	DISCONTINUITY DATA					WEATH- ERING INDEX								Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon	W1	W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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		Continued from Record of Borehole C4-3		183.41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													

DEPTH SCALE

1 : 50



LOGGED: SE/KG

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02 DATA\GINT\QEW-BERTIE.GPJ GAL-MISS GDT 19-5-22

PROJECT		RECORD OF BOREHOLE		No SC4-3		SHEET 1 OF 1		METRIC									
G.W.P. 2116-16-00		LOCATION		N 4753442.3; E 348520.8 MTM NAD 83 ZONE 10 (LAT. 42.919523; LONG. -78.964467)		ORIGINATED BY CC											
DIST Central HWY QEW		BOREHOLE TYPE		152 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN											
DATUM Geodetic		DATE		February 8, 2019		CHECKED BY NK											
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									
187.8	GROUND SURFACE							20	40	60	80	100					
0.0	Sand and gravel, trace silt, some clay (FILL) Compact Grey Moist																
187.1																	
0.7	Clay, trace to some sand, trace gravel (FILL) Stiff to very stiff Brown Moist																
185.5																	
2.3	CLAYEY SILT, trace to some sand, trace gravel Very stiff Brown Moist																
183.8																	
4.0	END OF BOREHOLE																
	NOTE: 1. Water level measured in standpipe piezometer at a depth of 3.5 m below ground surface (Elev. 184.3 m) on February 22, 2019.																

PROJECT		1671430 W08		RECORD OF BOREHOLE No C6-1		SHEET 1 OF 1		METRIC									
G.W.P.		2116-16-00		LOCATION		N 4753273.7; E 348378.3 MTM NAD 83 ZONE 10 (LAT. 42.918013; LONG. -78.966226)		ORIGINATED BY									
DIST		Central HWY QEW		BOREHOLE TYPE		152 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig		COMPILED BY									
DATUM		Geodetic		DATE		December 18, 2018		CHECKED BY									
								NK									
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									
186.4	GROUND SURFACE																
0.0	ASPHALT (230 mm)																
0.2	Sand and gravel, trace silt, trace clay (FILL) Loose to dense Grey to grey-brown Moist		1	SS	35		186										
			2	SS	6												
			3	SS	9		185										
184.2	Clayey silt, trace gravel, trace wood pieces (FILL) Very soft to soft Reddish brown Wet		4	SS	2		184										
183.1	CLAYEY SILT, trace sand to sandy, trace gravel to gravelly Very stiff to hard Reddish brown Wet		5	SS	18		183										
181.8	Dolomitic Limestone (BEDROCK)		6	SS	58/0.15		182										
4.7	Bedrock cored from 4.7 m to 7.9 m. For rock coring details refer to Record of Drillhole C6-1.		1	RC	REC 100%												24 25 35 16 RQD = 100%
			2	RC	REC 100%		181										RQD = 89%
			3	RC	REC 100%		180										RQD = 97%
178.5	END OF BOREHOLE						179										
7.9	NOTE: 1. Water level in borehole at 2.1 m (Elev. 184.3 m) depth below ground surface prior to start of rock coring.																

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

[illegible]

CHECKED: NK

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PROJECT		1671430 W08		RECORD OF BOREHOLE No C6-3				SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION				N 4753288.7; E 348358.0 MTM NAD 83 ZONE 10 (LAT. 42.918149; LONG. -78.966473)		ORIGINATED BY							
DIST		Central HWY QEW		BOREHOLE TYPE				152 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig		COMPILED BY							
DATUM		Geodetic		DATE				December 18, 2018		CHECKED BY							
										NK							
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									
186.5	GROUND SURFACE						20	40	60	80	100						
0.0	ASPHALT (100 mm)		1	SS	17												
185.6	Sand and gravel, some silt (FILL) Compact Grey Moist		2	SS	13												
0.9	Clayey silt, trace to some sand, trace gravel (FILL) Stiff Reddish brown to brown Moist		3	SS	12												
184.3	CLAYEY SILT, trace to some sand to CLAYEY SILT with SAND, trace gravel Very stiff Reddish brown to brown Moist		4	SS	20												
2.2			5	SS	20												
			6	SS	20												
181.9	Dolomitic Limestone (BEDROCK)		7	SS	50/0.08												
4.7	Bedrock cored from 4.8 m to 7.9 m. For rock coring details refer to Record of Drillhole C6-3.		1	RC	REC 100%												RQD = 88%
			2	RC	REC 96%												RQD = 96%
178.6	END OF BOREHOLE																
7.9	NOTE: 1. Borehole dry prior to start of rock coring. 2. Water level in standpipe piezometer Date Depth (m) Elev. (m) Feb. 08/19 1.4 185.1 3. Flush mount casing installed on road surface.																

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C6-3

SHEET 1 OF 1

LOCATION: N 4753288.68 ;E 348358.01


DRILLING DATE: December 19, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																		FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION						Jr	Ja	Jzon	W1	W2	W3				W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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5	Rotary Diamond Drill HQ Core	Continued from Record of Borehole C6-3		181.70 4.80	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

DEPTH SCALE

1 : 50



LOGGED: SE/LG

CHECKED: NK

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PROJECT		1671430 W08		RECORD OF BOREHOLE No C7-1		SHEET 1 OF 1		METRIC									
G.W.P.		2116-16-00		LOCATION		N 4753256.6; E 348327.5 MTM NAD 83 ZONE 10 (LAT. 42.917862; LONG. -78.966848)		ORIGINATED BY JK									
DIST		Central HWY QEW		BOREHOLE TYPE		203 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig		COMPILED BY EN/KN									
DATUM		Geodetic		DATE		September 27, 2018		CHECKED BY NK									
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									
186.6	GROUND SURFACE																
0.0	TOPSOIL (130 mm)																
0.3	Clayey silt, trace sand, trace gravel (FILL)																
185.9	Brown																
0.7	Sand and gravel, some silt (FILL)																
	Brown																
	Clayey silt, trace sand, trace gravel, trace topsoil (FILL)		1	SS	7												
	Firm to stiff																
	Brown																
	Moist		2	SS	8												
184.4																	
2.2	CLAYEY SILT, trace to some sand, trace gravel																
	Stiff to very stiff		3	SS	15												
	Brown																
	Moist		4	SS	21												
			5	SS	17												
			6	SS	17												
181.1																	
5.5	Dolomitic Limestone (BEDROCK)																
	Bedrock cored between 6.0 m and 9.1 m.																
	For rock coring details refer to Record of Drillhole C7-1.																
	- Auger refusal at a depth of 6.0 m		1	RC	REC 100%												RQD = 100%
			2	RC	REC 100%												RQD = 94%
177.5																	
9.1	END OF BOREHOLE																
	NOTES:																
	1. Open borehole dry prior to rock coring.																
	2. Water level at a depth of 1.0 m (Elev. 185.6 m) below ground surface upon removal of casing.																

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C7-1

SHEET 1 OF 1

LOCATION: N 4753256.59 ;E 348327.54

DRILLING DATE: September 27, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 Track-Mounted

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS DIP CORR	DISCONTINUITY DATA				WEATH- ERING INDEX	Diametral Point Load Index (MPa)					
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon							
							88 88															

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: MA/EN

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02_DATA\GINT\QEW-BERTIE.GPJ GAL-MISS GDT 19-5-22

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

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C7-2

SHEET 1 OF 1

LOCATION: N 4753242.84 ;E 348296.40

DRILLING DATE: September 27, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY															FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS D.D. C.R.D.S.	DISCONTINUITY DATA			WEATH- ERING INDEX						Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon	W1	W2	W3	W4	W5				W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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5	Rotary Diamond Drill HQ Core	Continued from Record of Borehole C7-2		180.28	1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			</

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: MA

CHECKED: NK

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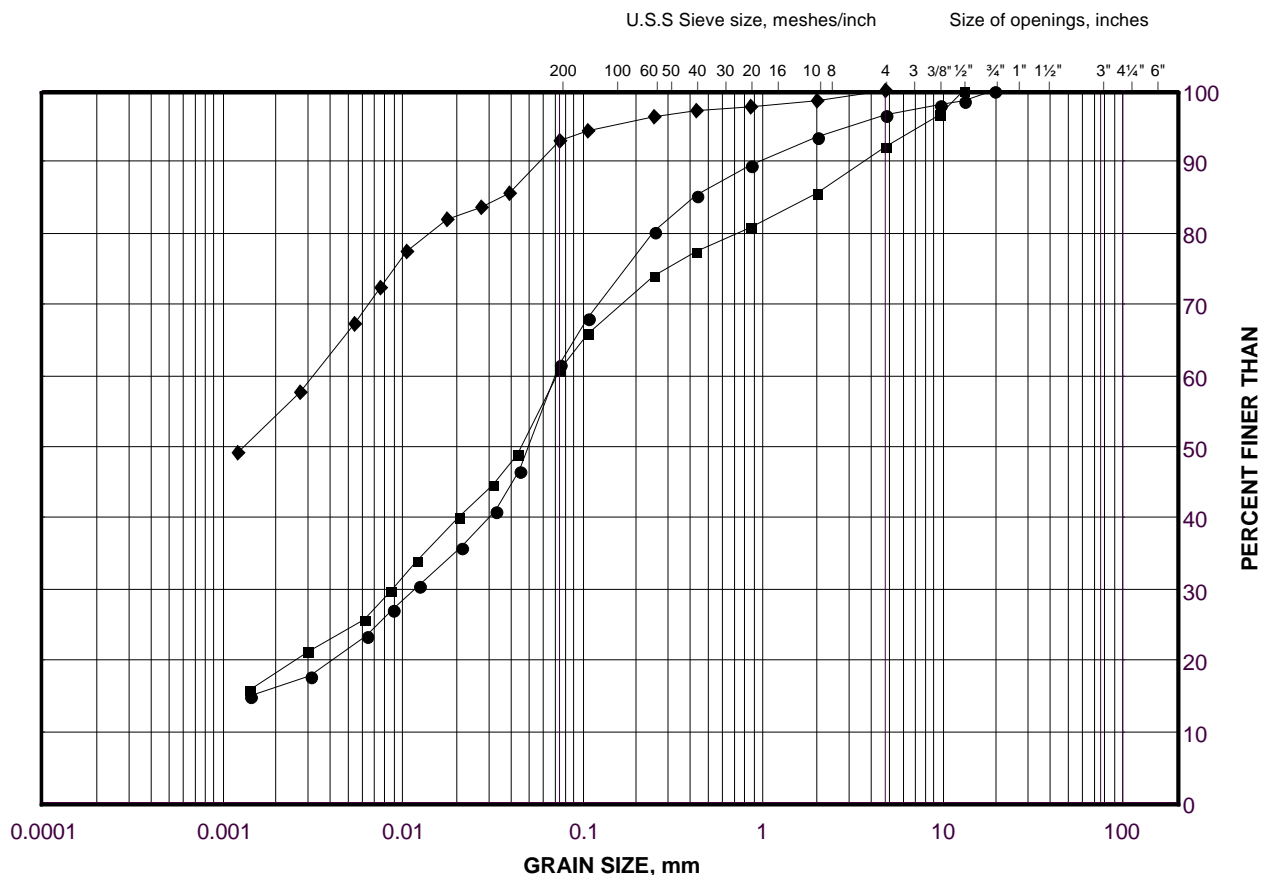
APPENDIX B

**Geotechnical Laboratory Test
Results and Bedrock Core
Photographs**

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand to Silty Clay (Fill)

FIGURE B-1



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

LEGEND

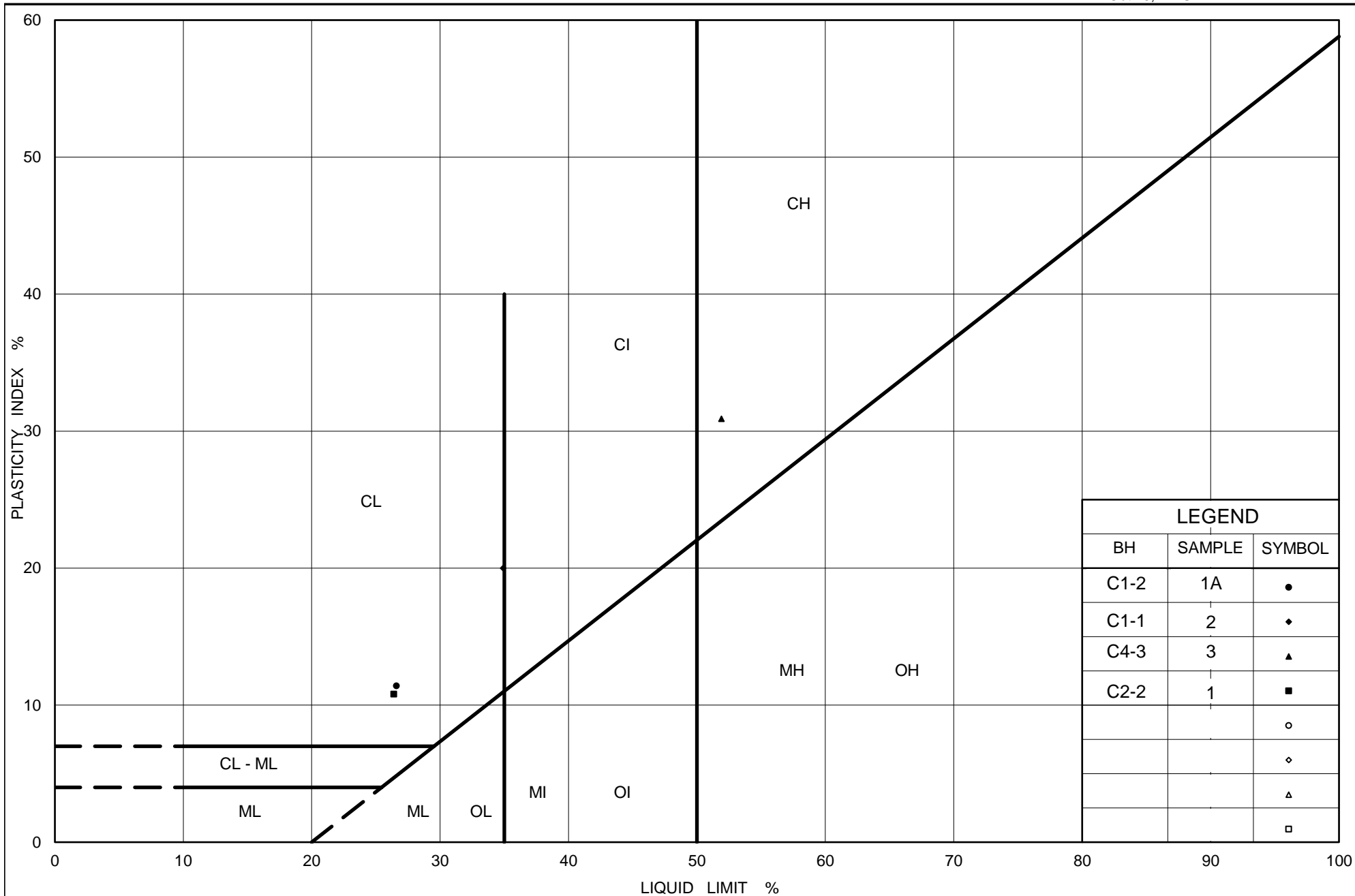
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C2-2	1	182.9
■	C1-2	1A	181.5
◆	C4-3	3	186.0

Project Number: 1671430

Checked By: DH

Golder Associates

Date: 25-Mar-19



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt to Clayey Silt with Sand to Silty Clay (Fill)

Figure No. B-2

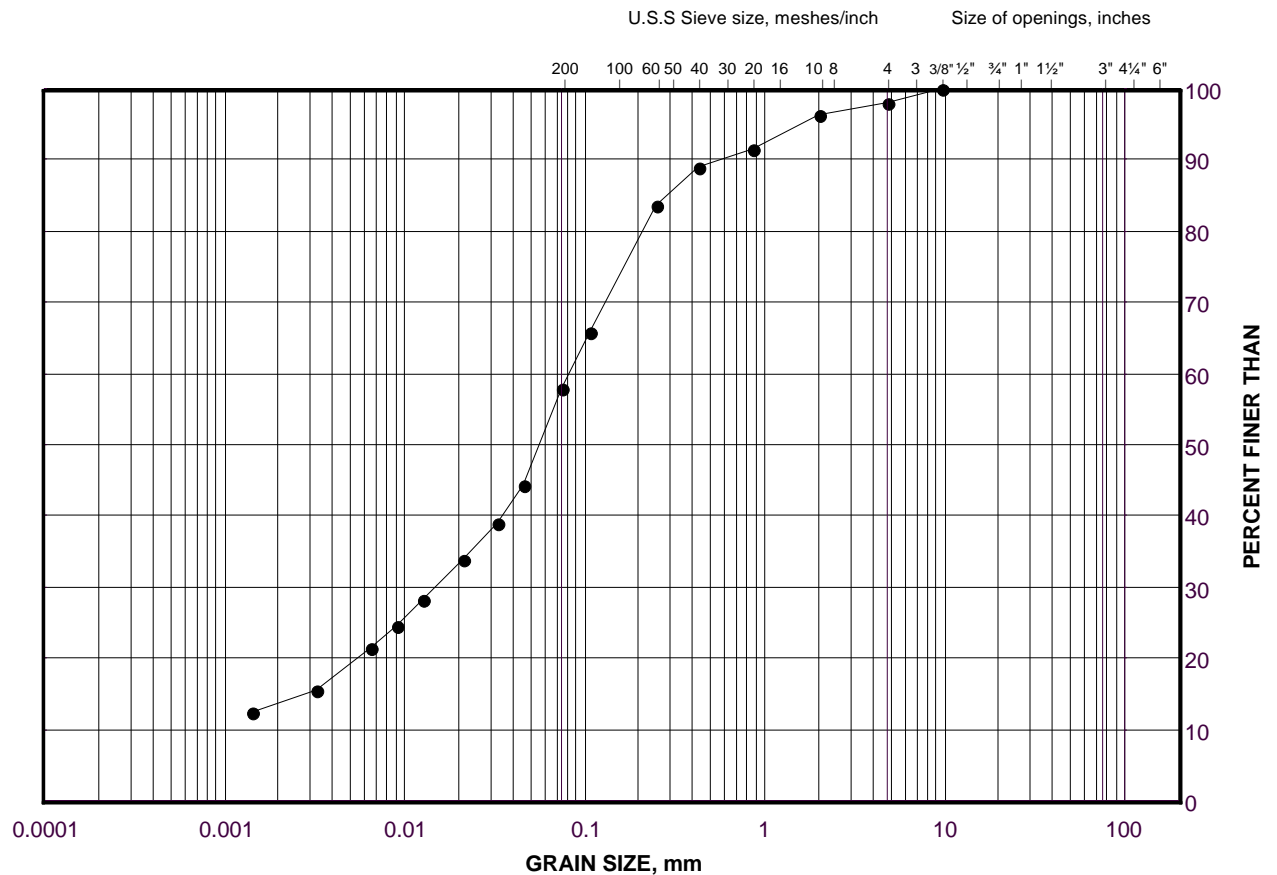
Project No. 1671430

Checked By: DH

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B-3



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	C1-1	4	180.3

Project Number: 1671430

Checked By: _____ DH

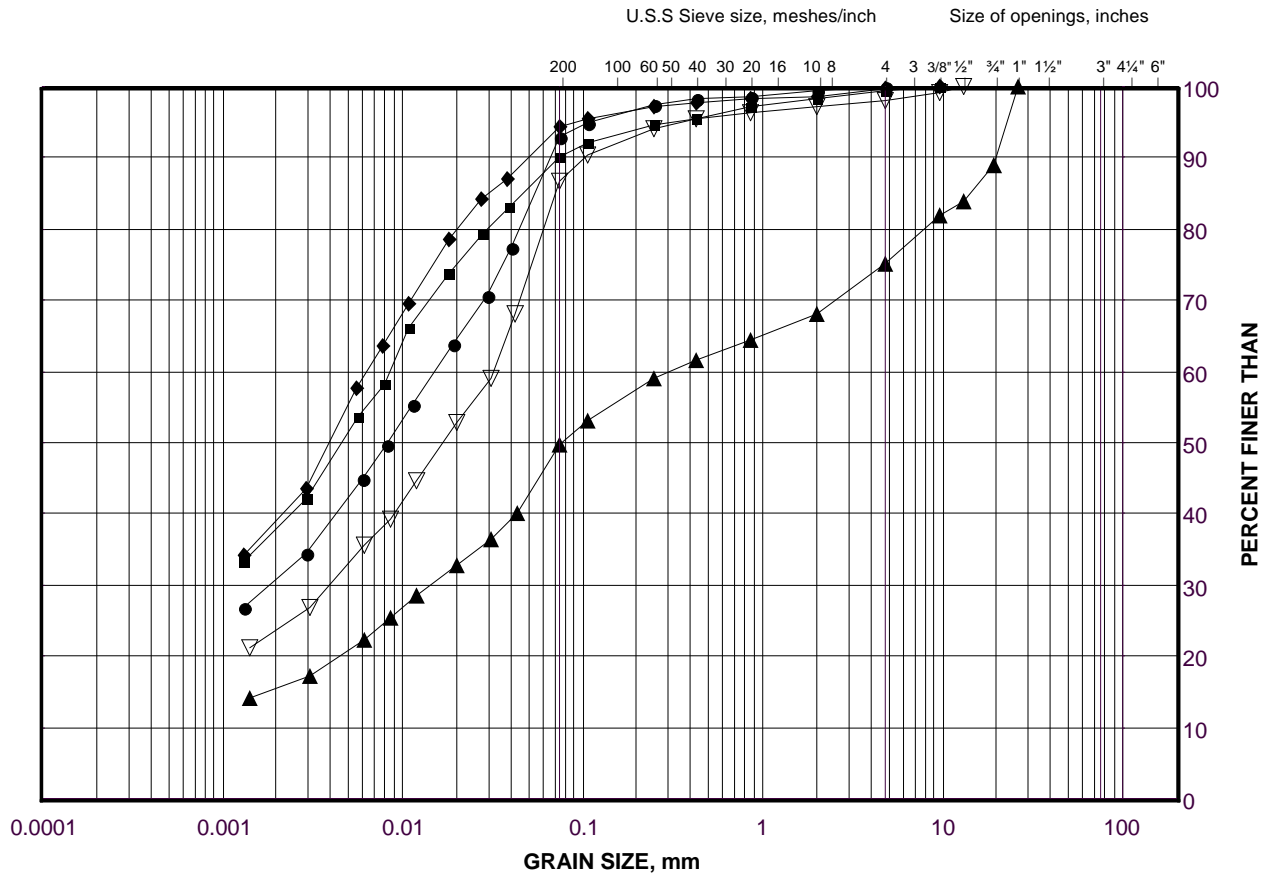
Golder Associates

Date: 02-May-19

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand

FIGURE B-4A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C7-2	2	183.2
■	C6-3	5	183.1
◆	C4-3	5	184.4
▲	C6-1	6	181.8
▽	C7-1	6	181.7

Project Number: 1671430

Checked By: _____ DH _____

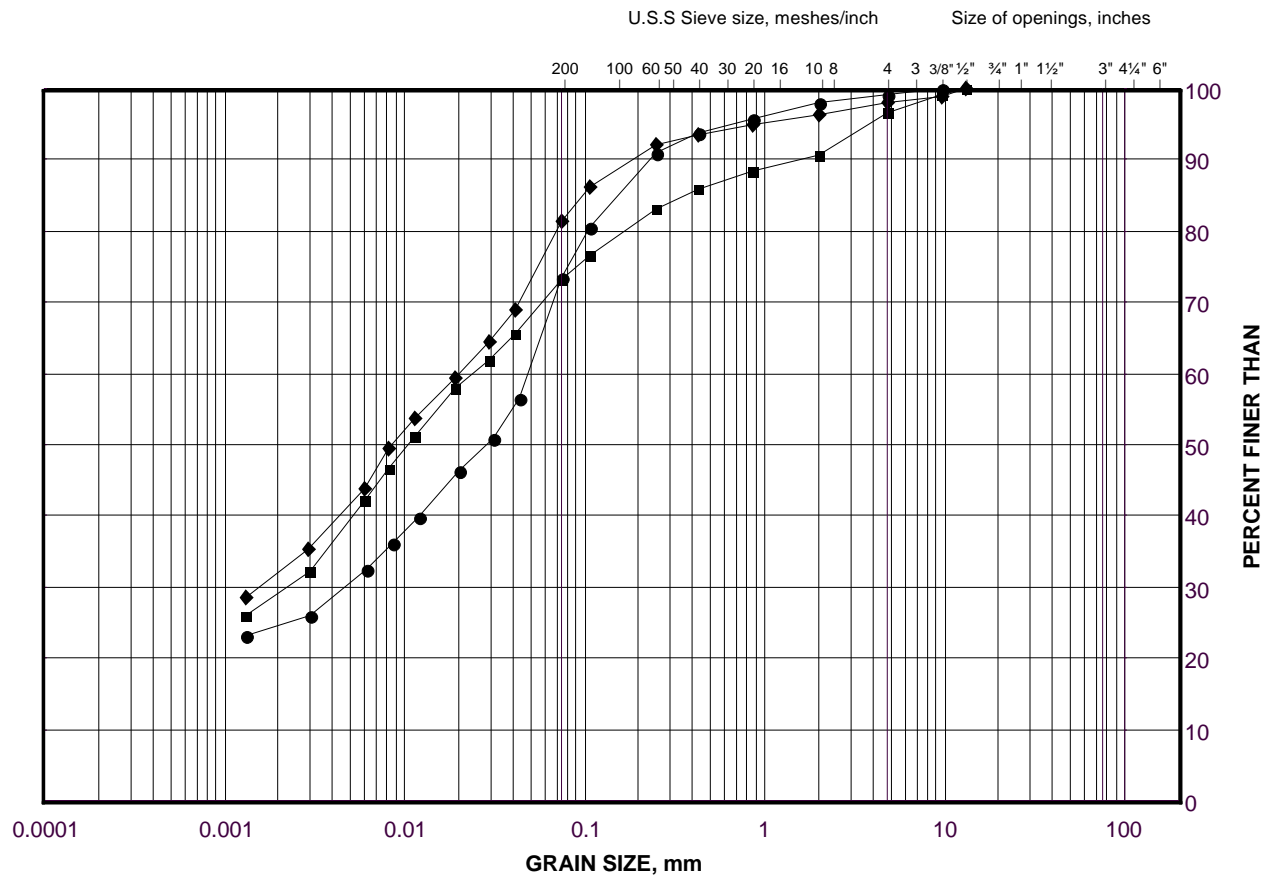
Golder Associates

Date: 05-Apr-19

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand

FIGURE B-4B



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

LEGEND

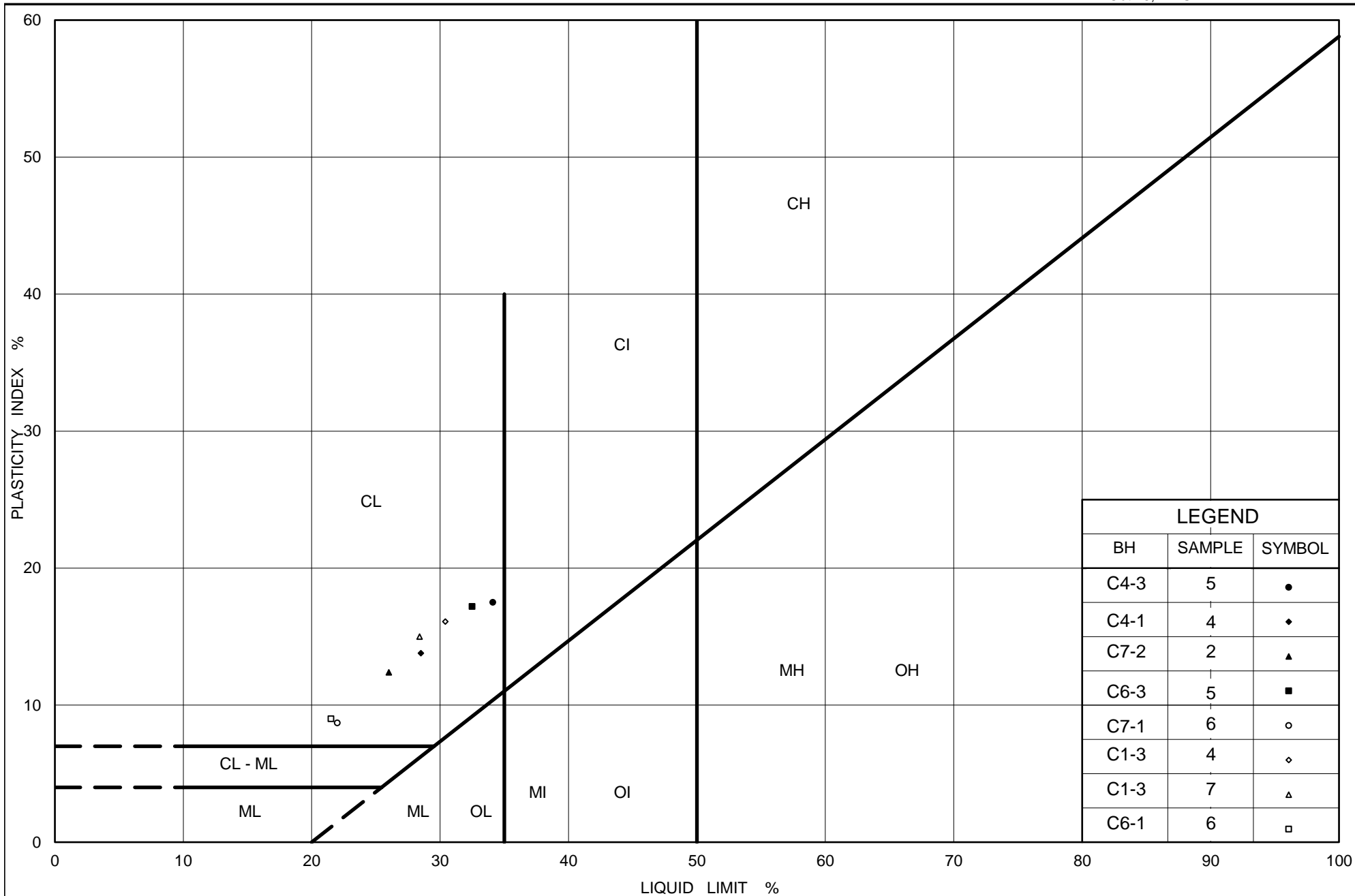
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C1-3	4	181.5
■	C4-1	4	185.3
◆	C1-3	7	179.2

Project Number: 1671430

Checked By: _____ DH _____

Golder Associates

Date: 05-Apr-19



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt to Clayey Silt with Sand

Figure No. B-5

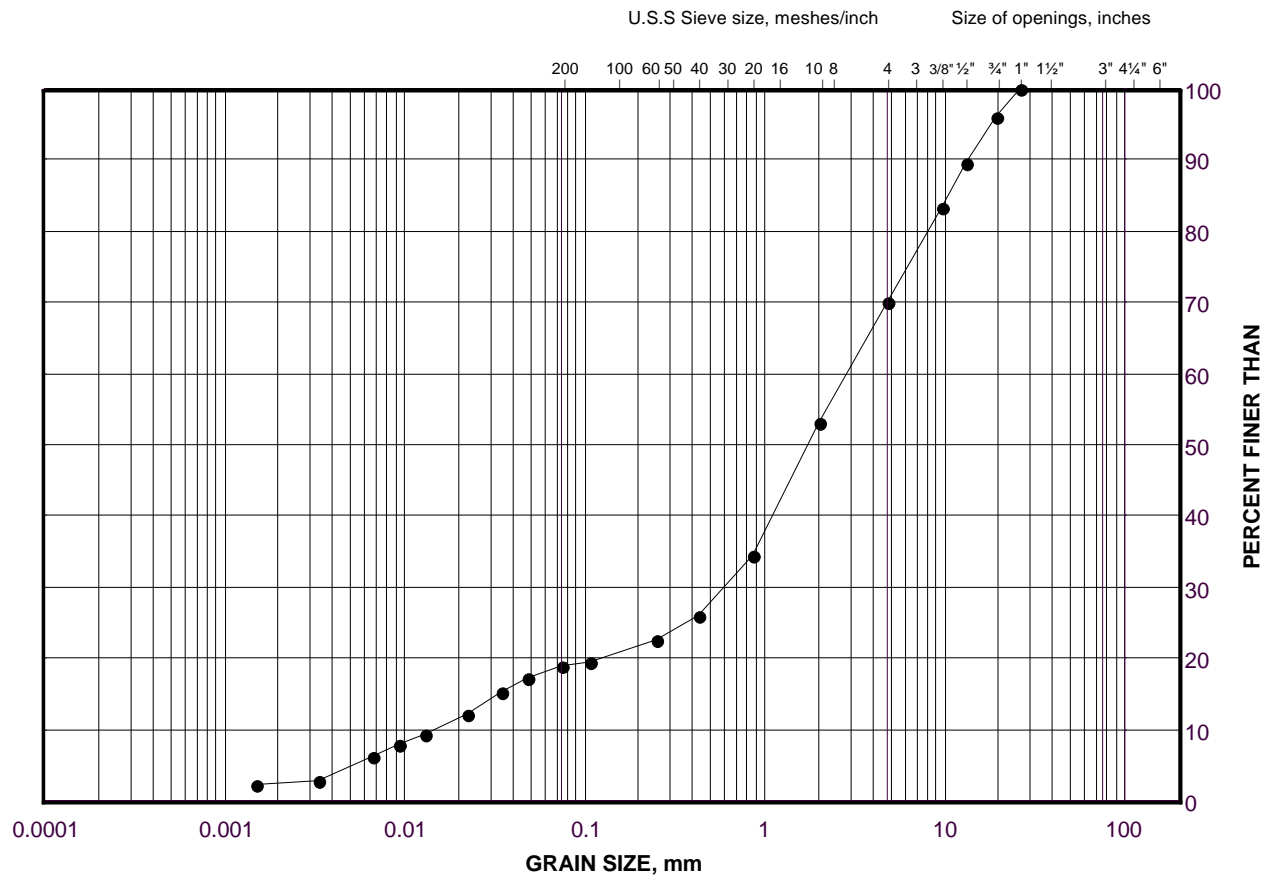
Project No. 1671430

Checked By: DH

GRAIN SIZE DISTRIBUTION

Bedrock Fragments

FIGURE B-6



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	C1-1	7	175.8

Project Number: 1671430

Checked By: _____ DH

Golder Associates

Date: 02-May-19

Sand and Gravel (Fill)

U.S.S Sieve size, meshes/inch

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	U.S.S Sieve Size (meshes/inch)	Opening Size (inches)	Percent Finer Than (Circular Markers)	Percent Finer Than (Square Markers)
0.075	20	0.075	5	4
0.15	10	0.15	10	8
0.3	60	0.3	15	12
0.6	30	0.6	25	18
1.18	16	1.18	35	25
2.5	8	2.5	45	35
4.75	4	4.75	65	50
7.5	3	7.5	80	65
10	20	10	90	75
15	10	15	95	80
20	8	20	100	85

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

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C4-1	1	187.6
■	C6-1	2	185.3

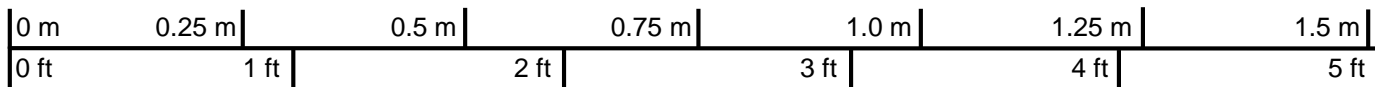
Date: 25-Mar-19

8.7 m Run 1 10.4 m



10.4 m Run 2 11.9 m

11.9 m Run 3 13.4 m



Scale

PROJECT
CULVERT REPLACEMENT, EXTENSION AND REHABILITATION
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00

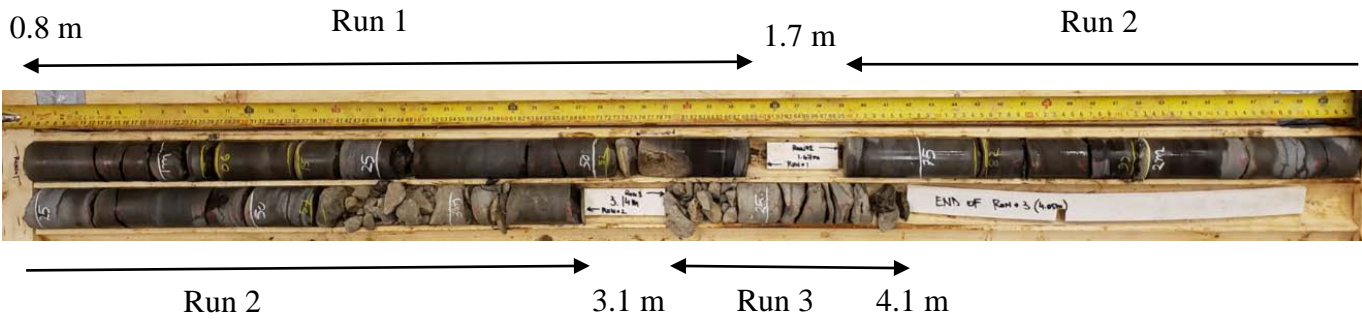
CLIENT
AECOM / MINISTRY OF TRANSPORTATION

TITLE
BEDROCK CORE PHOTOGRAPHS – BOREHOLE C1-1




PROJECT NO. 1671430		PHASE 8000 (W08)	
DESIGNED	DH		REV. A
PREPARED	DH		
REVIEWED	MA		
APPROVED	KB		

Figure B-8



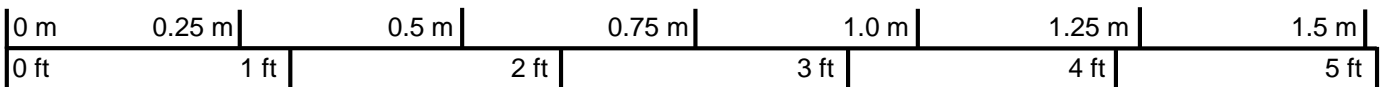
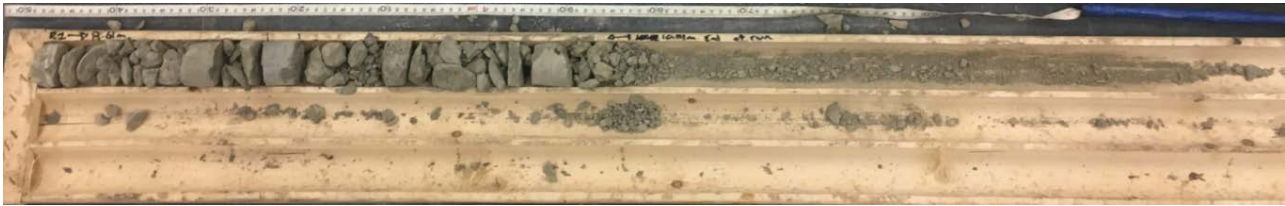
Scale

PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C1-2			
 GOLDER	PROJECT NO.	1671430	PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	
Figure B-9			

8.6 m

Run 1

10.1 m



Scale

PROJECT

**CULVERT REPLACEMENT, EXTENSION AND REHABILITATION
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00**

CLIENT

AECOM / MINISTRY OF TRANSPORTATION

TITLE

BEDROCK CORE PHOTOGRAPHS – BOREHOLE C1-3



GOLDER

PROJECT NO. **1671430** PHASE **8000 (W08)**

DESIGNED DH

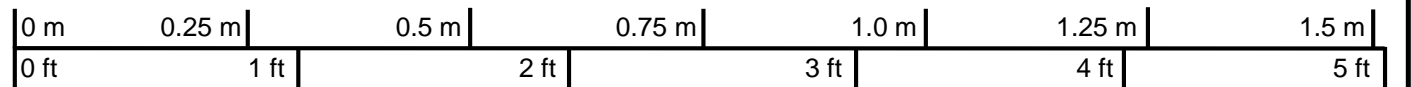
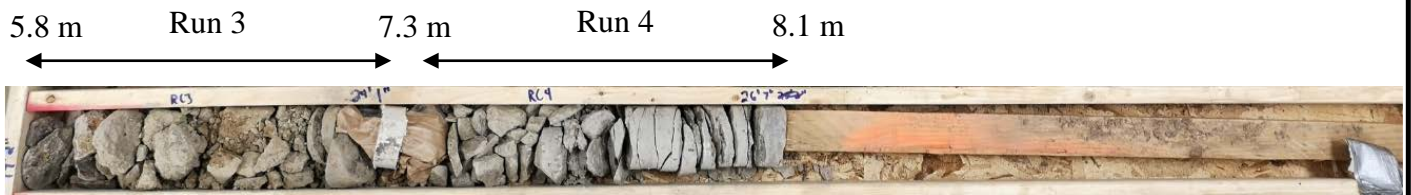
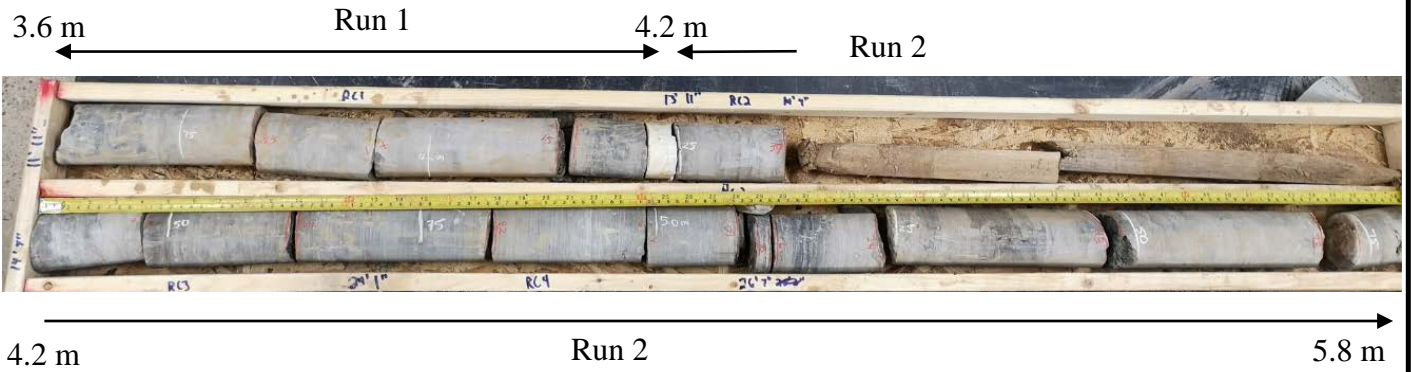
REV. **A**

PREPARED DH


REVIEWED MA

APPROVED KB

Figure B-10



Scale

PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C2-1			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	
Figure B-11			

1.2 m

Run 1

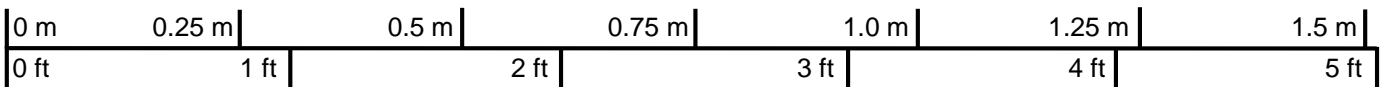


3.0 m

Run 2

Run 2

4.6 m



Scale


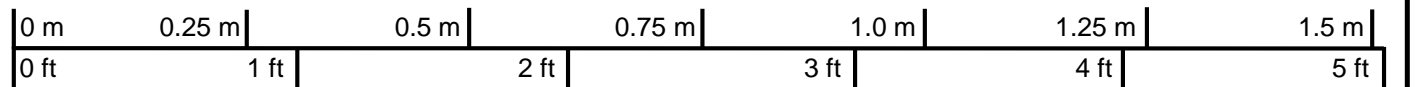
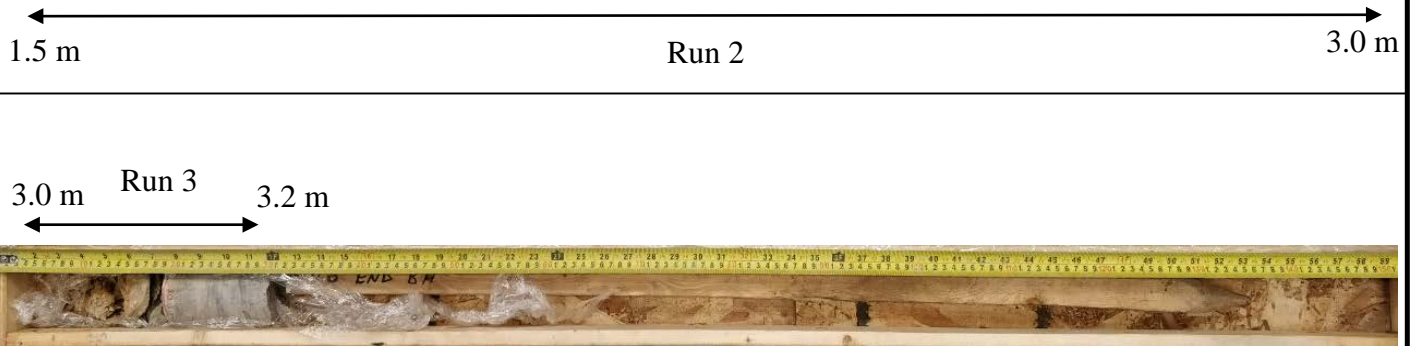
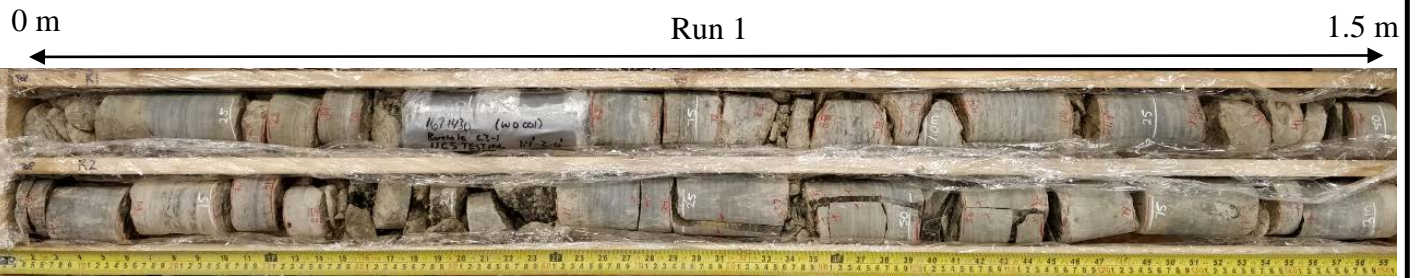
PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C2-2			
 GOLDER	PROJECT NO.	1671430	PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	

Figure B-12



Scale


PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C3-1			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	

Figure B-13

0 m Run 1 1.5 m



1.5 m Run 2 3.0 m




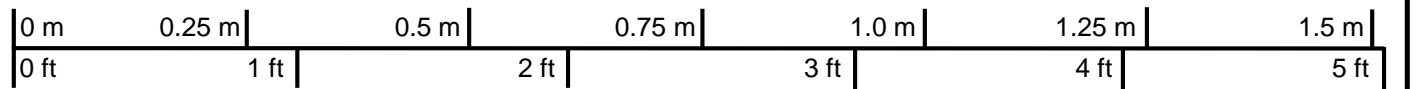
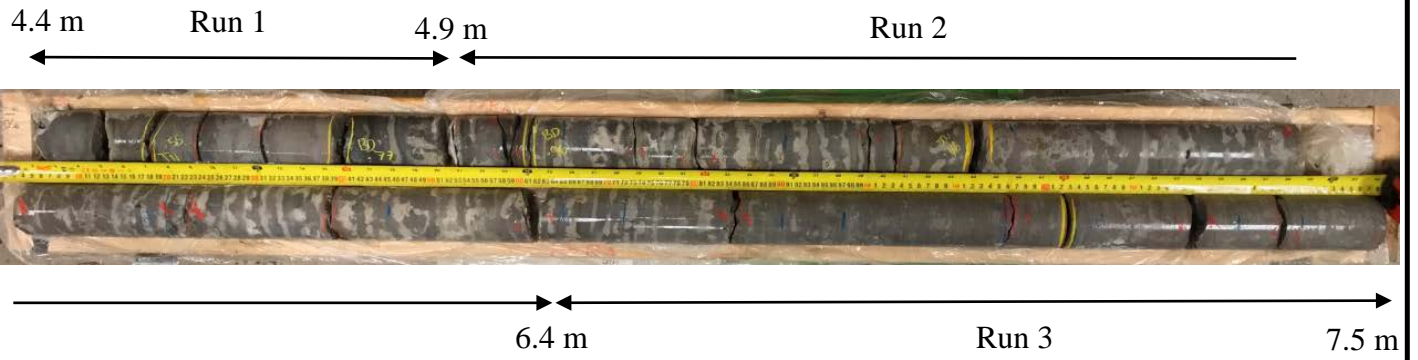
3.0 m Run 3 3.2 m




0 m 0.25 m 0.5 m 0.75 m 1.0 m 1.25 m 1.5 m
0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Scale

PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C3-2			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	
Figure B-14			



Scale

PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C4-1			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	
Figure B-15			

4.4 m Run 1 4.9 m Run 2



6.4 m Run 3

7.9 m



0 m 0.25 m 0.5 m 0.75 m 1.0 m 1.25 m 1.5 m
0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Scale

PROJECT
CULVERT REPLACEMENT, EXTENSION AND REHABILITATION
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00

CLIENT
AECOM / MINISTRY OF TRANSPORTATION

TITLE
BEDROCK CORE PHOTOGRAPHS – BOREHOLE C4-3



PROJECT NO.	1671430	PHASE	8000 (W08)
DESIGNED	DH	REV.	A
PREPARED	DH		
REVIEWED	MA		
APPROVED	KB		

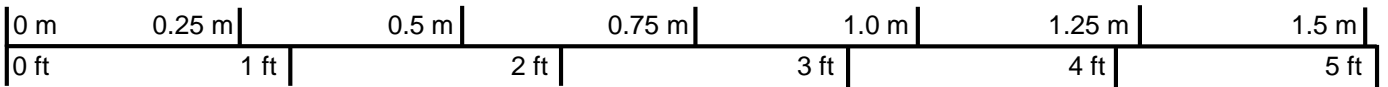
Figure B-16

4.7 m Run 1 4.9 m Run 2




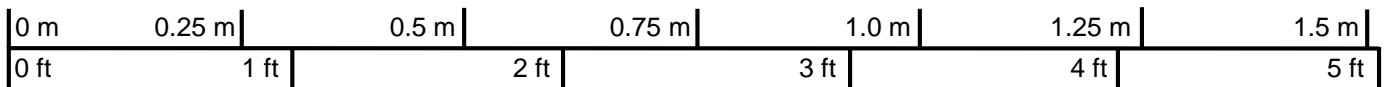
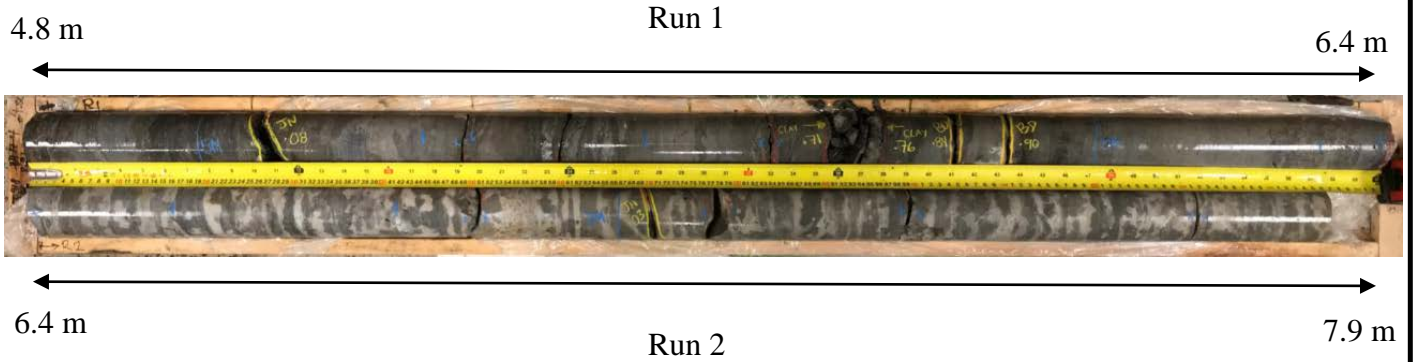
6.4 m Run 3

Run 3 7.9 m




Scale

PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C6-1			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	
Figure B-17			



Scale

PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C6-3			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	
Figure B-18			

6.0 m

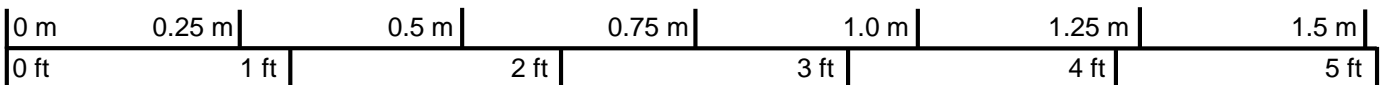
Run 1



7.5 m

Run 2

9.1 m



Scale


PROJECT CULVERT REPLACEMENT, EXTENSION AND REHABILITATION QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM / MINISTRY OF TRANSPORTATION			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C7-1			
 GOLDER	PROJECT NO. 1671430		PHASE 8000 (W08)
	DESIGNED	DH	REV. A
	PREPARED	DH	
	REVIEWED	MA	
	APPROVED	KB	

Figure B-19

4.7 m

Run 1

6.0 m



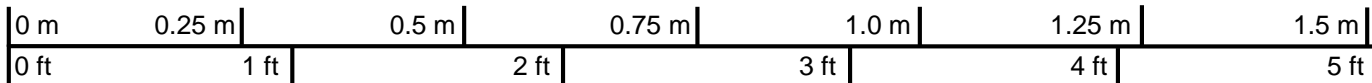
6.0 m

Run 2

Run 3

7.5 m

7.8 m



Scale

PROJECT

CULVERT REPLACEMENT, EXTENSION AND REHABILITATION
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00

CLIENT

AECOM / MINISTRY OF TRANSPORTATION

TITLE

BEDROCK CORE PHOTOGRAPHS – BOREHOLE C7-2



GOLDER

PROJECT NO. 1671430 PHASE 8000 (W08)

DESIGNED DH

PREPARED DH

REVIEWED MA

APPROVED KB

REV. A

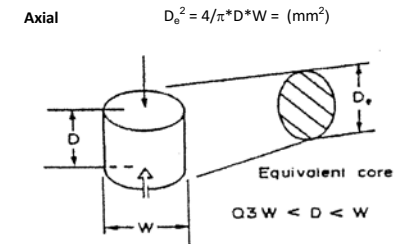
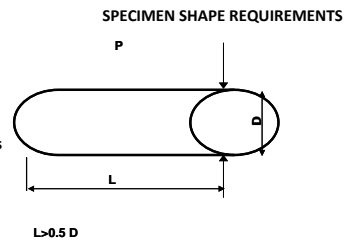
Figure B-20

POINT LOAD STRENGTH TEST (ISRM, 1985)
Summary of Point Load Test Results on Rock Samples

Borehole	Rock type	Depth (top)	W	D	Gauge Reading	Load P	D_e^2	$I_s = P/D_e^2$	$F = (D_e/50)^{0.45}$	$I_{s(50)}$	Type	Valid Test
		m	mm	mm	MPa	MN	mm ²	MPa		MPa		
C1-3	Bois Blanc Limestone	8.80	48	45.00	2.52	0.00244	2750.2	0.89	1.022	0.91	A	Y
C3-1	Bois Blanc Limestone	1.19	110	63.50	0.88	0.00085	4032.3	0.21	1.114	0.24	D	Y
C3-1	Bois Blanc Limestone	2.92	120	63.50	5.70	0.00551	4032.3	1.37	1.114	1.52	D	Y
C3-1	Bois Blanc Limestone	0.34	64	40.00	15.78	0.01526	3259.5	4.68	1.062	4.97	A	Y
C3-2	Bois Blanc Limestone	1.32	64	55.00	9.14	0.00884	4481.8	1.97	1.140	2.25	A	Y
C3-2	Bois Blanc Limestone	1.63	90	63.50	1.02	0.00099	4032.3	0.24	1.114	0.27	D	Y
C3-2	Bois Blanc Limestone	2.79	100	63.50	1.44	0.00139	4032.3	0.35	1.114	0.38	D	Y
C4-1	Bois Blanc Limestone	6.94	64	55.00	13.22	0.01278	4481.8	2.85	1.140	3.25	A	Y
C4-1	Bois Blanc Limestone	5.38	85	63.50	14.62	0.01414	4032.3	3.51	1.114	3.90	D	Y
C4-3	Bois Blanc Limestone	4.88	64	50.00	27.04	0.02615	4074.4	6.42	1.116	7.16	A	Y
C4-3	Bois Blanc Limestone	7.06	64	55.00	16.54	0.01599	4481.8	3.57	1.140	4.07	A	Y
C4-3	Bois Blanc Limestone	6.37	110	63.50	8.62	0.00834	4032.3	2.07	1.114	2.30	D	Y
C6-1	Bois Blanc Limestone	7.88	64	58.00	23.94	0.02315	4726.3	4.90	1.154	5.65	A	Y
C6-1	Bois Blanc Limestone	5.71	70	63.50	13.28	0.01284	4032.3	3.18	1.114	3.55	D	Y
C6-1	Bois Blanc Limestone	6.97	100	63.50	26.92	0.02603	4032.3	6.46	1.114	7.19	D	Y
C6-3	Bois Blanc Limestone	5.84	64	60.00	14.12	0.01365	4889.2	2.79	1.163	3.25	A	Y
C6-3	Bois Blanc Limestone	7.03	75	63.50	10.72	0.01037	4032.3	2.57	1.114	2.86	D	Y
C6-3	Bois Blanc Limestone	4.94	110	63.50	14.74	0.01425	4032.3	3.53	1.114	3.94	D	Y
C7-1	Bois Blanc Limestone	6.17	64	63.00	26.66	0.02578	5133.7	5.02	1.176	5.90	A	Y
C7-1	Bois Blanc Limestone	8.01	90	63.50	11.24	0.01087	4032.3	2.70	1.114	3.00	D	Y
C7-1	Bois Blanc Limestone	7.30	100	63.50	24.70	0.02388	4032.3	5.92	1.114	6.60	D	Y
C7-2	Bois Blanc Limestone	5.89	64	63.00	27.52	0.02661	5133.7	5.18	1.176	6.09	A	Y
C7-2	Bois Blanc Limestone	4.75	100	63.50	16.88	0.01632	4032.3	4.05	1.114	4.51	D	Y
C7-2	Bois Blanc Limestone	7.24	90	63.50	17.52	0.01694	4032.3	4.20	1.114	4.68	D	Y

$I_{s(50)}$ = Size Corrected Point Load Strength	F = Size Correction Factor
$I_{s(50)} = F * I_s$	$F = (D_e/50)^{0.45}$
I_s = Uncorrected Point Load Strength	D_e = equivalent core diameter (mm)
$I_s = P/D_e^2$	$D_e^2 = D^2 \text{ (mm}^2\text{)}$
Ram Area = 9.67E-04 m ²	

D = diametral
A = axial
b = block
l = irregular lump
\\ = parallel
p = perpendicular to planes of weakness



APPENDIX C

Analytical Test Results

Your Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Your C.O.C. #: 674002-02-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522878
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6738

Received: 2018/12/06, 12:29

Sample Matrix: ROCK
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	2	N/A	2018/12/12	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2018/12/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2018/12/12	2018/12/12	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2018/12/11	2018/12/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	2	N/A	2018/12/12	CAM SOP-00464	EPA 375.4 m

Sample Matrix: Soil
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	7	N/A	2018/12/12	CAM SOP-00463	EPA 325.2 m
Conductivity	7	N/A	2018/12/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	7	2018/12/12	2018/12/12	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	7	2018/12/11	2018/12/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	7	N/A	2018/12/12	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. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

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. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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

Your Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Your C.O.C. #: 674002-02-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522878
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6738

Received: 2018/12/06, 12:29

Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied 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.

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.

SOIL CORROSIVITY PACKAGE (ROCK)

Maxxam ID		IMF770	IMF771		
Sampling Date		2018/09/05	2018/09/24		
COC Number		674002-02-01	674002-02-01		
	UNITS	C2-1	C3-1	RDL	QC Batch
Calculated Parameters					
Resistivity	ohm-cm	3800	5600		5882461
Inorganics					
Soluble (20:1) Chloride (Cl-)	ug/g	53	23	20	5883825
Conductivity	umho/cm	260	179	2	5883994
Available (CaCl2) pH	pH	8.22	7.94		5883840
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	20	5883826
RDL = Reportable Detection Limit					
QC Batch = Quality Control Batch					

SOIL CORROSIVITY PACKAGE (SOIL)

Maxxam ID		IMF764	IMF765	IMF766	IMF767	IMF768		
Sampling Date		2018/09/21	2018/09/19	2018/09/19	2018/09/19	2018/09/21		
COC Number		674002-02-01	674002-02-01	674002-02-01	674002-02-01	674002-02-01		
	UNITS	RW4A_SA3	RW5_SA8	RW7_SA5B	RW9_SA6	RW-10_SA7	RDL	QC Batch

Calculated Parameters								
Resistivity	ohm-cm	610	2100	3300	1600	710		5882461
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	810	200	95	340	660	20	5883825
Conductivity	umho/cm	1640	483	302	623	1400	2	5883994
Available (CaCl2) pH	pH	8.02	7.71	7.84	7.87	7.89		5883840
Soluble (20:1) Sulphate (SO4)	ug/g	120	81	<20	39	88	20	5883826
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								

Maxxam ID		IMF768			IMF769	IMF772			IMF772	
Sampling Date		2018/09/21			2018/09/04	2018/09/27			2018/09/27	
COC Number		674002-02-01			674002-02-01	674002-02-01			674002-02-01	
	UNITS	RW-10_SA7 Lab-Dup	RDL	QC Batch	C1-1_AS1	C7-1 SA5	RDL	QC Batch	C7-1 SA5 Lab-Dup	QC Batch

Calculated Parameters										
Resistivity	ohm-cm				2000	1200		5882461		
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g	650	20	5883825	150	330	20	5883825		
Conductivity	umho/cm	1390	2	5883994	504	858	2	5883994		
Available (CaCl2) pH	pH				8.06	7.92		5883840	8.02	5883840
Soluble (20:1) Sulphate (SO4)	ug/g				110	270	20	5883826		
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										
Lab-Dup = Laboratory Initiated Duplicate										

TEST SUMMARY

Maxxam ID: IMF764
Sample ID: RW4A_SA3
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF765
Sample ID: RW5_SA8
Matrix: Soil

Collected: 2018/09/19
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF766
Sample ID: RW7_SA5B
Matrix: Soil

Collected: 2018/09/19
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF767
Sample ID: RW9_SA6
Matrix: Soil

Collected: 2018/09/19
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF768
Sample ID: RW-10_SA7
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva

TEST SUMMARY

Maxxam ID: IMF768
Sample ID: RW-10_SA7
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF768 Dup
Sample ID: RW-10_SA7
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva

Maxxam ID: IMF769
Sample ID: C1-1_AS1
Matrix: Soil

Collected: 2018/09/04
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF770
Sample ID: C2-1
Matrix: ROCK

Collected: 2018/09/05
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF771
Sample ID: C3-1
Matrix: ROCK

Collected: 2018/09/24
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam Job #: B8W6738
Report Date: 2018/12/12

Golder Associates Ltd
Client Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Sampler Initials: JK

TEST SUMMARY

Maxxam ID: IMF772
Sample ID: C7-1 SA5
Matrix: Soil

Collected: 2018/09/27
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF772 Dup
Sample ID: C7-1 SA5
Matrix: Soil

Collected: 2018/09/27
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas

GENERAL COMMENTS

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

Package 1	5.3°C
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Conductivity Analysis: Analysis was performed past sample holding time. This may increase the variability associated with these results.

Sample IMF770 [C2-1] : Rock sample submitted, sample preparation completed by the lab as per client request.

Sample IMF771 [C3-1] : Rock sample submitted, sample preparation completed by the lab as per client request.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Sampler Initials: JK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5883825	Soluble (20:1) Chloride (Cl ⁻)	2018/12/12	NC	70 - 130	102	70 - 130	<20	ug/g	1.9	35
5883826	Soluble (20:1) Sulphate (SO ₄)	2018/12/12	NC	70 - 130	103	70 - 130	<20	ug/g	24	35
5883840	Available (CaCl ₂) pH	2018/12/12			101	97 - 103			1.3	N/A
5883994	Conductivity	2018/12/12			103	90 - 110	<2	umho/cm	0.65	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).



Brad Newman, 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.

		Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campbell Road, Mississauga, Ontario Canada L5N 2L8 Tel: (905) 817-5700 Toll-free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca				CHAIN OF CUSTODY RECORD		Page of			
IMMEDIATE Company Name: #1326 Golder Associates Ltd Attention: Accounts Payable Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 Tel: (905) 567-4444 Fax: (905) 567-6561 Email: AP_CustomerService@golder.com		REPORT TO: Company Name: <u>N. Kol Kochmarov</u> Attention: <u>N. Kol Kochmarov</u> Address: <u>905 567 6100 x2134</u> Tel: <u>905 567 6100 x2134</u> Fax: <u>905 567 6100 x2134</u> Email: <u>nkol.kochmarov@golder.com</u>		PROJECT INFORMATION: Quotation #: <u>B8W638</u> P.O. #: <u>08-111-0039/147</u> Project: <u>QEW Bette - Detailed Design</u> Project Name: <u>QEW Bette - Detailed Design</u> Site #: <u>JK/MA/EN</u> Sampled By: <u>JK/MA/EN</u>		Laboratory Use Only: Maxxam Job #: <u>674002</u> Bottle Order #: <u>674002</u> COC #: <u>674002-02-01</u> Project Manager: <u>Ema Gitej</u>					
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY						ANALYSIS REQUESTED (PLEASE BE SPECIFIC) Field Filtered (please circle): Metals / Hg / Cr VI O Reg 153 VOCs by HS & F1-F4 4-hydroxy-4-methyl-2-pentanone by SVOC Open Scan Corrosivity Package (pH, Sulphate, Chloride, resistivity, conductivity)		Turnaround Time (TAT) Required: Please provide advance notice for rush projects Regular (Standard) TAT: (will be applied if Rush TAT is not specified): Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details. Job Specific Rush TAT (if applies to entire submission) Date Required: _____ Time Required: _____ Rush Confirmation Number: _____ (call lab for #)			
Include Criteria on Certificate of Analysis (Y/N)?						Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____		Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA Municipality _____ <input type="checkbox"/> PWGO <input type="checkbox"/> Other _____		Special Instructions	
Sample Chain of Custody						# of Bottles		Comments			
Sample Barcode Label		Sample (Location) Identification		Date Sampled	Time Sampled	Matrix	06-Dec-18 12:29 Ema Gitej B8W6738 URE ENV-1116		Standard Corrosivity Package		
1		RW4A-SA3		Sept. 21, 18	AM	SOIL	<input checked="" type="checkbox"/>		1		
2		RW5-SA8		Sept. 19, 18	PM	SOIL	<input checked="" type="checkbox"/>		1		
3		RW7-SASB		Sept. 19, 18	AM	SOIL	<input checked="" type="checkbox"/>		1		
4		RW9-SA6		Sept. 19, 18	AM	SOIL	<input checked="" type="checkbox"/>		1		
5		RW-10-SA7		Sept. 21, 18	PM	SOIL	<input checked="" type="checkbox"/>		1		
6		C1-1-AS1		Sept. 4, 18	AM	SOIL	<input checked="" type="checkbox"/>		1		
7		C2-1		Sept. 5, 18	PM	ROCK	<input checked="" type="checkbox"/>		1		
8		C3-1		Sept. 24, 18	PM	ROCK	<input checked="" type="checkbox"/>		1		
9		C7-1 SAS		Sept. 27	AM	SOIL	<input checked="" type="checkbox"/>		1		
10							<input type="checkbox"/>				
* RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)		Time		RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)		Time	
		18/12/06		12:15				12:29		2018/12/06	
# jars used and not submitted		Laboratory Use Only		Time Sensitive		Temperature (°C) on Reel		Custody Seal		Yes	
						8/3/5		Present		No	
								Intact		Yes	
										No	
* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.						* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.					
** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WWP-CONTENT/UPLOADS/ONTARIO-COC.PDF.						SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM					
White: Maxxa Yellow: Client						White: Maxxa Yellow: Client					



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