Foundation Investigation and Design Report

Temporary Protection Systems Along Dixie Road
QEW Improvements from East of Cawthra Road to The East Mall, Cities of Mississauga and Etobicoke, Ontario
MTO GWP 2102-13-00

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FOUNDATION INVESTIGATION REPORT
TEMPORARY PROTECTION SYSTEMS ALONG DIXIE ROAD
QEW WIDENING FROM EAST OF CAWTHRA ROAD TO THE EAST MALL
CITIES OF MISSISSAUGA AND ETOBICOKE
MTO GWP 2102-13-00

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 the widening of Queen Elizabeth Way (QEW) from Cawthra Road in Mississauga to the East Mall in Etobicoke, Ontario. The purpose of this report is to assess the subsurface and groundwater conditions in the vicinity of proposed temporary protection systems at three locations along or near Dixie Road, as described in Section 2.0.

2.0 SITE DESCRIPTION

Within the project limits, the QEW is generally oriented in a northeast-southwest direction; for the purpose of this report the QEW is described as oriented in an east-west direction, and Dixie Road in a north-south direction. The protection system site locations are shown on Drawing 1 and described below from north to south.

- **Area 1 – North Service Road West of Dixie Road:** A proposed protection system will be placed along the west side of existing Dixie Road where the realigned North Service Road will cut into the existing Dixie Road embankment. The existing grade along the centreline of the new North Service Road alignment is at about Elevation 107 m to 110 m in this area, and the new North Service Road subgrade is proposed to be at approximately Elevation 105.5 m to 107 m (rising northeastward), with the finished roadway grade at approximately Elevation 106 m to 107.5 m. Residential buildings are located to the north and west of this area.
- **Area 2 – South of Dixie Road Underpass:** A temporary protection system is proposed to be located between the existing and new alignments of Dixie Road, immediately south of the south abutment for the existing and new underpass structures, along the west edge of the proposed Dixie Road N-E Ramp that will connect the southbound lane of Dixie Road to QEW eastbound. The surrounding area consists of residential buildings to the east, and the Dixie Outlet Mall to the west of the area.
- **Area 3 – Dixie Road and Rometown Drive Intersection:** The intersection of Dixie Road and Rometown Drive is slated for rehabilitation to accommodate the realignment of Dixie Road. A proposed temporary protection system is situated at the northwest quadrant of this intersection, along the west edge of the Dixie Road southbound lanes. The surrounding area consists of the Dixie Outlet Mall to the west and residential building to the east of the site.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigations

3.1.1 2014 Investigation (GEOCRES Report No. 30M11-251)

From August 2014 to July 2015, a foundation investigation was carried out by Thurber Engineering Ltd. (Thurber) for the QEW/Dixie Road Interchange Structure during which time Borehole DR14-01 was drilled near the proposed temporary protection system south of QEW at the proposed N-E Ramp. The results of the Thurber investigation are contained in their report titled, "Preliminary Foundation Investigation and Design Report, QEW/DIXIE Road Interchange Structure, Mississauga, Ontario, G.W.P. 09-20003, Site No. 24-193", dated July 13, 2015 (GEOCRES Report No 30M11-251). While this report does not reference the coordinate system of the borehole location, it is inferred to be referenced to the MTM NAD 83 (Zone 10) coordinate system based on the plotted position relative to that reference system. The location of Borehole DR14-01 is summarized in the table below along with the geographic coordinates, ground surface elevation (referenced to Geodetic Datum) and the borehole termination depth. This borehole is shown on Drawing 1 and the borehole record and figures showing the relevant laboratory test results are presented in Appendix A.

Borehole No.	Location	Location (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (Latitude, °)	Easting (Longitude, °)		
DR14-01	Proposed Dixie Road alignment south of QEW	4,828,505.1 (43.596469)	299,295.5 (-79.568179)	106.5	7.9

3.1.2 2016 and 2017 Investigation (GEOCRES Report No. 30M11-280)

Between October 2016 and June 2017, a foundation investigation was carried out by Golder for the proposed installation of noise barrier walls. Four of these boreholes, designated as Boreholes NW3-7, NW4-1, NW4-2, and NW6-1, were drilled in the vicinity of the proposed protection systems. The results of the investigation are contained in the report titled, "Foundation Investigation Report, Noise Barrier Walls, QEW Widening from East of Cawthra Road to the East Mall, Cities of Mississauga and Etobicoke, Ministry of Transportation, Ontario, GWP 2102-13-00 & 2432-13-00" dated May 29, 2018 (GEOCRES 30M11-280). The locations of the relevant boreholes from this investigation are shown on Drawing 1 and summarized in the table below along with the geographic coordinates, ground surface elevations and the borehole termination depths. The locations are positioned relative to North American Datum 1983 (NAD83CSRS), Modified Transverse Mercator (MTM) northing and easting coordinates, Zone 10, and the ground surface elevations are referenced to Geodetic datum.

Borehole No.	Location	MTM NAD 83 ZONE 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (Latitude, °)	Easting (Longitude, °)		
NW3-7	Along realigned North Service Road	4,828,492.9 (43.596348)	299,182.1 (-79.569580)	105.8	4.7
NW4-1		4,828,595.5 (43.597273)	299,115.9 (-79.570402)	107.5	4.7
NW4-2		4,828,628.9 (43.597573)	299,093.7 (-79.570676)	107.7	4.7
NW6-1	Proposed Dixie Road alignment south of QEW	4,828,501.2 (43.596434)	299,323.7 (-79.567830)	106.0	3.5

3.1.3 2018 Investigation (GEOCRES Report No. 30M11-272)

Between September 2016 and January 2018, a foundation investigation was carried out by Golder during which time eleven boreholes were drilled for the QEW-Dixie Road underpass replacement. Three of the eleven boreholes, designated as Boreholes DO-1, DO-2, and DO-5, were drilled near the proposed temporary protection systems. The results of this investigation are contained in the report titled, "Foundation Investigation and Design Report, QEW-Dixie Road Underpass Replacement Structure Site No. 24-193, QEW Widening from East of Cawthra Road to The East Mall, Cities of Mississauga and Etobicoke, Ministry of Transportation, Ontario, GWP 2102-13-00 &

2432-13-00", dated January 10, 2018 (GEOCRES No 30M11-272). The locations of the relevant boreholes are shown on Drawing 1 and summarized in the table below along with the geographic coordinates, ground surface elevations and the borehole termination depths. The locations are positioned relative to North American Datum 1983 (NAD83CSRS), Modified Transverse Mercator (MTM) northing and easting coordinates, Zone 10, and the ground surface elevations are referenced to Geodetic datum.

Borehole No.	Location	MTM NAD 83 ZONE 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (Latitude, °)	Easting (Longitude, °)		
DO-1	Proposed Dixie Road alignment, north of QEW	4,828,582.4 (43.597155)	299,214.9 (-79.569175)	107.3	3.3
DO-2		4,828,567.2 (43.597019)	299,225.4 (-79.569044)	107.0	9.8
DO-5	Proposed Dixie Road alignment, south of QEW	4,828,517.1 (43.596569)	299,294.2 (-79.568192)	106.4	4.7

3.2 2021 Investigation

The field work for this foundation investigation was carried out on July 27, 2021, during which time two boreholes, designated as Borehole TPS-1 and TPS-2, were advanced at the approximate locations shown on Drawing 1.

The boreholes were advanced using a CME-75 truck-mounted drill rig, supplied and operated by Davis Drilling of Milton, Ontario. Soil samples were generally obtained at 0.75 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by automatic hammer in accordance with Standard Penetration Test (SPT) procedures. The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions.

The groundwater conditions and water levels in the open boreholes were observed during and immediately following the drilling operations. Both boreholes were backfilled with bentonite in accordance with Ontario Regulation 903 Wells (as amended), and the ground surface was restored to near original condition as practical using cold-patch asphalt and quick-set concrete, as applicable.

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, arranged for the clearance of underground services, supervised the drilling and sampling operations, logged the boreholes, and examined and took custody of the soil samples. The soil samples were identified in the field, placed in labelled containers, and transported to Golder's Mississauga geotechnical laboratory for further visual examination and geotechnical laboratory testing. Classification testing (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.

The as-drilled borehole locations and the ground surface elevations at the borehole locations were obtained using a GPS Trimble GEO 7X having an accuracy of approximately 0.1 m in the vertical and horizontal directions. The locations given on the borehole records and shown on Drawing 1 are relative to MTM NAD 83 (Zone 10) CSRS CGVD28 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, geographic coordinates, ground surface elevations and depths advanced prior to termination are summarized below.

Borehole No.:	Location	MTM NAD 83 ZONE 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (Latitude, °)	Easting (Longitude, °)		
TPS-1	Dixie Road and Rometown Drive	4,828,296.3 (43.594590)	299,468.7 (-79.566032)	103.6	5.4
TPS-2		4,828,280.0 (43.594444)	299,487.3 (-79.565801)	103.8	4.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITION

4.1 Regional Geography

The project area is located within the Iroquois Plain physiographic region, as delineated in The Physiography of Southern Ontario (Chapman and Putman, 1984)[1] .

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

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

4.2 Subsurface Conditions

The borehole records and laboratory testing summary figures from the 2014 to 2018 investigations are presented in Appendix A. The borehole records from the current (2021) investigation are presented in Appendix B, while the geotechnical and analytical laboratory test results from Golder's 2016-2018 and current investigations are presented in Appendix C.

The results of in situ tests (i.e., SPT "N" values) as presented on the borehole records and within this report are uncorrected. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and observation of drilling progress. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond the boreholes will exist and is to be expected.

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

In general, the subsurface conditions in the vicinity of the proposed temporary protection systems consist of topsoil and asphalt underlain by non-cohesive fill material that is generally underlain by silty sand to sand, glacial till and residual soil which are underlain by shale bedrock. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

It should be noted that post-investigation construction activities may have modified the subsurface conditions from those shown on the borehole records from previous investigations.

4.2.1 Topsoil

Approximately 100 mm to 300 mm of topsoil was encountered at ground surface in Boreholes DO-1, DO-2, NW4-1, NW4-2, NW6-1, and TPS-2, which were drilled outside of existing roadways.

Materials designated as topsoil were classified solely based on visual and textural evidence. Testing or organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.2.2 Asphalt and Concrete

Approximately 70 mm to 200 mm of asphalt was encountered at the pavement surface in Boreholes DO-5, DR14-01, NW3-7 and TPS-1, and underlying the topsoil in Borehole TPS-2 near the Rometown Drive intersection.

An approximately 80 mm thick layer of granular fill was encountered underlying the asphalt in Borehole DO-5, followed by an approximately 230 mm thick layer of concrete; this borehole is located on the south side of QEW along the proposed Dixie Road alignment.

4.2.3 SILTY SAND (SM) to SAND (SP) to SAND (SP) and GRAVEL (FILL)

Layers of non-cohesive fill about 0.3 to 1.1 m thick and consisting of silty sand to sand to sand and gravel were encountered underlying the topsoil and asphalt in Boreholes DR14-01, DO-1, NW-3-7 and TPS-1. The top of the fill layers was encountered at depths ranging from 0.1 m to 0.3 m below ground surface (between Elevations 107.0 m and 103.5 m).

The depths and elevations of the surface of the fill and the corresponding overall thicknesses are summarized below for each of the three proposed protection system areas.

Site	Borehole No.	Top of Fill		Thickness (m)
		Depth (m)	Elevation (m)	
Area 1 North of QEW	DO-1	0.3	107.0	1.1
	NW3-7	0.2	105.6	0.3
Area 2 South of QEW	DR14-01	0.1	106.4	0.6
Area 3 Dixie/Rometown	TPS-1	0.1	103.5	0.7

The SPT "N"-values measured within the non-cohesive fill layer range from 17 to 26 blows per 0.3 m of penetration, indicating that the fill materials are compact.

The water contents measured on samples of the non-cohesive fill range from about 8% to 10%.

4.2.4 SANDY SILT (ML) to SILTY SAND (SM) to SAND (SP)

A deposit of non-cohesive soil ranging from sandy silt to silty sand to sand was encountered in all the boreholes shown on Drawing 1, underlying the topsoil in Boreholes DO-2, NW4-1, NW4-2 and NW6-1, underlying the pavement structure in Boreholes DO-5 and TPS-2, and underlying the non-cohesive fill material in Boreholes DR14-01, DO-1, NW3-7 and TPS-1. The top of sandy silt to silty sand to sand deposit was encountered at depths ranging from 0.2 m to 1.4 m below the ground surface (between Elevations 107.5 m and 102.8 m) with thicknesses ranging from 1.2 m to 3.1 m.

The depths and elevations of the sandy silt to silty sand to sand deposit and the corresponding thicknesses are summarized in the table below.

Site	Borehole No.	Top of Deposit		Thickness (m)
		Depth (m)	Elevation (m)	
Area 1 North of QEW	DO-1	1.4	105.9	1.7
	DO-2	0.2	106.8	3.1
	NW3-7	0.5	105.3	1.8
	NW4-1	0.1	107.4	2.2
	NW4-2	0.2	107.5	2.5
Area 2 South of QEW	DR14-01	0.7	105.8	2.9
	DO-5	0.5	105.9	2.6
	NW6-1	0.2	105.8	2.3
Area 3 Dixie/Rometown Intersection	TPS-1 (including interlayer)	0.8	102.8	1.8
	TPS-2	0.3	103.5	2.4

The SPT "N" values measured in the sandy silt to silty sand to sand deposit generally range from the weight of sampling hammer to 53 blows per 0.3 m of penetration. The SPT "N" values indicate that the sandy silt to silty sand to sand strata are very loose to very dense.

Grain size distribution testing was carried out on eight samples of the sandy silt to silty sand to sand deposit. One of the results is shown on Figure A1 in Appendix A, and seven of the results are shown on Figure C1 in Appendix C. The water contents on the selected samples of the deposit ranged from 4% to 25%.

4.2.4.1 Sandy CLAYEY SILT Interlayer

A 0.2 m thick interlayer of sandy clayey silt was encountered within the silty sand deposit in Borehole TPS-1 at a depth of 2.0 m below ground surface (at Elevation 101.6 m). Similar cohesive interlayers should be expected elsewhere in the sandy silt to silty sand to sand deposit, and where present these cohesive layers may cause groundwater to be locally "perched" above such layers.

Atterberg limits testing was carried out on one sample of the sandy clayey silt interlayer and the results are presented in Figure C2 in Appendix C. An Atterberg limits test measured a liquid limit of about 23%, a plastic limit of about 15%, and a corresponding plasticity index of approximately 8%, indicating that the fines portion of the sandy clayey silt interlayer has low plasticity. The water content measured on one sample of the sandy clayey silt interlayer is about 13%.

4.2.5 Sandy CLAYEY SILT to Gravelly SILTY SAND TILL

Layers of glacial till about 0.3 to 0.7 m thick were encountered below the sandy silt to sand deposit in Boreholes NW6-1, TPS-1 and TPS-2. The cohesive portion of the glacial till deposit ranges from sandy clayey silt to clayey silt, trace to some gravel containing shale fragments, while the non-cohesive portion of the glacial till is comprised of gravelly silty sand.

The depths and elevations of the glacial till deposit and the corresponding thicknesses are summarized in the table below.

Site	Borehole No.	Top of Deposit		Thickness (m)
		Depth (m)	Elevation (m)	
Area 2 South of QEW	NW6-1	2.5	103.5	0.7
Area 3 Dixie/Rometown	TPS-1	2.6	101.0	0.5
	TPS-2	2.7	101.1	0.3

The SPT “N”-values measured within the cohesive portions of the till deposit range from 14 blows per 0.3 m of penetration to 50 blows per 0.13 m of penetration, suggesting a stiff to hard consistency and noting that the higher SPT N”-values may also reflect the presence of the underlying bedrock. The SPT “N”-values measured within the non-cohesive portions of the till deposit range from the weight of the sampling hammer to 54 blows per 0.25 m of penetration; however, the lowest SPT “N” value (weight of hammer, in Borehole NW6-1) is interpreted to be associated with groundwater disturbance in the overlying sand and gravelly silty sand till, while the highest SPT “N” value (over 50 blows per 0.3 m of penetration) is associated with the underlying shale bedrock. The non-cohesive glacial till deposit is therefore interpreted to be generally compact.

Grain size distribution testing was carried out on three samples of the deposit and the results are presented on Figure C3 in Appendix C. Atterberg limits testing was carried out on three samples of the cohesive portion of the glacial till deposit and the results are presented in Figure C4 in Appendix C. The Atterberg limits test measured liquid limits ranging from about 16% to 31%, plastic limits ranging from about 12% to 16%, and plasticity indices ranging from about 4% to 15%, indicating that the fines portion of the sandy clayey silt and gravelly silty sand till deposit has low plasticity. The water content measured on select samples of the glacial till deposit range from about 13% to 17%.

4.2.6 Clayey Silt Residual Soil

Approximately 0.1 m to 0.7 m of residual soil was encountered underlying the silty sand to sand deposit in Boreholes DO-1, DO-2, DO-5, NW4-1, NW4-2, and TPS-2. The residual soil consists of clayey silt containing gravel and shale fragments. The residual soil was encountered at depths ranging from of 2.3 m to 3.3 m below ground surface (between Elevation 105.2 m to 100.8 m). The depths and elevations of the residual soil and the corresponding thicknesses at each of the applicable sites are summarized in the table below.

Site	Borehole No.	Top of Deposit		Thickness (m)
		Depth (m)	Elevation (m)	
Area 1 North of QEW	DO-1	3.1	104.2	0.1
	DO-2	3.3	103.7	0.01
	NW4-1	2.3	105.2	0.3
	NW4-2	2.7	105.0	0.2
Area 2 South of QEW	DO-5	3.1	103.3	0.3
Area 3 Dixie/Rometown	TPS-2	3.0	100.8	0.7

The SPT "N"-values measured within the residual soil range from 12 blows per 0.3 m of penetration to 50 blows per 0.1 m of penetration, suggesting a stiff to hard consistency.

Atterberg limits testing was carried out on one sample of the clayey silt residual soil deposit and measured a liquid limit of about 29%, a plastic limit of about 18%, corresponding to a plasticity index of about 11%; the results, as presented on Figure C5 in Appendix C, indicate that the fines portion of the deposit is a clayey silt of low plasticity. The water content measured on a sample of the residual soil was about 14%.

4.2.7 Shale Bedrock

Bedrock was sampled in all boreholes by split-spoon and the bedrock was confirmed by rock coring in Borehole DR14-01 and DO-2.

The depths to bedrock below ground surface, as determined from coring and inferred from augering and split-spoon sampling, and the corresponding bedrock surface elevations at each of the three sites are summarized below.

Site	Borehole No.	Top of Bedrock		Comment
		Depth (m)	Elevation (m)	
Area 1 North of QEW	DO-1	3.2	104.1	0.1 m auger penetration
	DO-2	3.3	103.7	0.1 m auger penetration 6.2 m bedrock cored
	NW3-7	2.3	103.5	2.4 m auger penetration
	NW4-1	2.6	104.9	2.1 m auger penetration
	NW4-2	2.9	104.8	1.8 m auger penetration
Area 2 South of QEW	DR14-01	3.6	102.9	0.7 m auger penetration 3.6 m bedrock cored
	DO-5	3.4	103.0	1.3 m auger penetration
	NW6-1	3.2	102.8	0.3 m auger penetration

Site	Borehole No.	Top of Bedrock		Comment
		Depth (m)	Elevation (m)	
Area 3 Dixie/Rometown	TPS-1	3.1	100.5	2.3 m auger penetration
	TPS-2	3.7	100.1	1.0 m auger penetration

In general, the bedrock surface as encountered or inferred in the boreholes is relatively flat at each of the three protection system areas with bedrock at a higher elevation on the north side of QEW, declining southward. Variation in the bedrock surface should be expected between borehole locations and at the other foundation elements.

The bedrock consists of grey shale of the Georgian Bay formation, which contains limestone and siltstone interbeds at various intervals. The recovered bedrock samples are generally described as highly to slightly weathered, thinly to very thinly laminated, very fine to fine grained, non-porous, weak to medium strong, grey shale with clay seams and limestone interbeds ranging from 10 mm to 130 mm. The bedrock details are presented in the borehole and drillhole records from the 2014 and 2018 investigations in Appendix A. Photographs of the recovered bedrock core samples at Borehole DR14-01 can be found in Photograph 1 in Appendix A. The degree of weathering of the bedrock samples (i.e., slightly to highly weathered – W2 to W4), and strength classification of the intact rock mass based on field indication (i.e., weak to medium strong – R2 to R3) are described in accordance with the International Society for Rock Mechanics (ISRM)[2] standard classification system.

The Rock Quality Designation (RQD) measured on the core samples obtained from the past investigations generally range from about 29% to 91%, indicating a rock mass of poor to excellent quality as per Table 3.10 of CFEM (2006)[3], except in Run 1 in Borehole DR14-01 which had a measured RQD of 0%, indicating a rock mass of very poor quality. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered from the previous investigations are between 94% and 100% and between 62% and 98%, respectively.

An Unconfined Compression (UC) Test was carried out on a selected core sample of the shale bedrock in Borehole DO-2 as part of the previous 2018 Golder investigation. The uniaxial compressive strength (UCS), bulk density and tangent Young's modulus of the intact sample is summarized below, and the details are presented in the Rock Laboratory Test Results report from Geomechanica in Appendix A. Results from Borehole DR14-01 from the previous 2014 investigation are also included in the table below, and the associated point load test sheet can also be found in Appendix A.

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

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

Borehole No.	Sample Depth Interval (m)	Sample Elevation Interval (m)	Uniaxial Compressive Strength (UCS) (MPa)	Bulk Density (g/cm³)	Tangent Young's Modulus (GPa)
DO-2	9.12 – 9.27	97.88 – 97.73	13.1	2.59	1.01
DR14-01	5.8	100.7	22.4	-	-
	6.0	100.5	17.4	-	-
	7.3	99.2	30.8	-	-
	7.9	98.6	11.9	-	-

Based on the laboratory UCS test results, in accordance with Table 3.5 in CFEM (2006), the shale bedrock is generally classified as weak (R2, 5 MPa < UCS < 25 MPa) to medium strong (R3, 25 MPa < UCS < 50 MPa).

4.3 Groundwater Conditions

The overburden samples obtained from the current and previous investigations were generally moist becoming wet with depth. The depth to the water level observed in the boreholes upon completion of drilling and prior to rock coring varied from about 1.8 m to 4.4 m (between Elevation 105.5 m and 103.1 m), although some boreholes were dry; however, these observations are not necessarily representative of the stabilized groundwater level at the site.

Based on the observed moisture condition of recovered soil samples and the water level observed during and/or on completion of drilling (and prior to rock coring), the estimated groundwater levels at the borehole locations are summarized below.

Site	Borehole No.	Estimated Groundwater Level		Comment
		Depth (m)	Elevation (m)	
Area 1 North of QEW	DO-1	1.8	105.5	Based on sample moisture conditions and water level in open borehole on completion
	DO-2	2.3	104.7	Based on sample moisture conditions during drilling
	NW3-7	1.8	104.0	Based on sample moisture conditions during drilling
	NW4-1	2.3	105.2	Based on sample moisture conditions during drilling
	NW4-2	2.3	105.4	Based on sample moisture conditions during drilling

Site	Borehole No.	Estimated Groundwater Level		Comment
		Depth (m)	Elevation (m)	
Area 2 South of QEW	DR14-01	3.5	103.0	Measured in piezometer in October 2014; however, this piezometer is sealed within the bedrock and may not be representative of the water level associated with the sandy silt to sand deposit, nor the current groundwater level
	DO-5	2.3	104.1	Based on sample moisture conditions during drilling
	NW6-1	1.8	104.2	Based on water level in open borehole on completion of drilling
Area 3 Dixie/Rometown	TPS-1	2.2	101.4	Based on colour transition from brown to grey
	TPS-2	1.8	102.0	Based on sample moisture conditions during drilling

The groundwater level in the area will be subject to seasonal fluctuations and precipitation events and should be expected to be higher during wet periods of the year. In addition to the groundwater levels suggested by the above observations, perched groundwater conditions should be expected above cohesive deposits, including above cohesive interlayers that are distributed randomly within the predominant sandy silt to silty sand to sand deposit across the site.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Ankaren Maheswaran, EIT and Ms. Katelyn Nero, P.Eng. and reviewed by Mr. Michael Beadle, P.Eng. Ms. Lisa Coyne, P.Eng., an MTO Foundations Designated Contact for Golder, conducted an independent technical and quality control review of this report.

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Principal, MTO Foundations Designated Contact

AK/KNN/MEB/LCC/ml

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PART B

FOUNDATION DESIGN REPORT
TEMPORARY PROTECTION SYSTEMS ALONG DIXIE ROAD
QEW WIDENING FROM EAST OF CAWTHRA ROAD TO THE EAST MALL
CITIES OF MISSISSAUGA AND ETOBICOKE
MTO GWP 2102-13-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical engineering parameters and general design considerations for temporary protection systems required at three locations associated with realignment of Dixie Road and North Service Road as part of the QEW improvements from east of Cawthra Road to The East Mall in Mississauga and Etobicoke, Ontario.

The Foundation Design Report, discussion and recommendations are intended for the use of MTO and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation Report) of this report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

The temporary protection system areas are summarized below, together with the approximately length and anticipated maximum depth of excavation in these areas.

Temporary Protection System Location	Relevant Boreholes	Approximate Length of Protection System (m)	Approximate Maximum Depth of Excavation (m)
Area 1 North of QEW	DO-1 DO-2 NW3-7 NW4-1	70	4.5
Area 2 South of QEW	NW6-1 NW6-2 DO-5 DR14-01	45	1.5
Area 3 Dixie/Rometown Intersection	TPS-1 TPS-2	30	1.5

6.2 Excavations and Groundwater Control

The proposed excavations for roadway realignment and grading will require removal of the pavement structure, topsoil, existing non-cohesive (silty sand to sand to sand and gravel) fill and portions of the silty sand to sand deposit. All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The fills are classified as Type 3 soils above the groundwater level and Type 4 soils below the groundwater table. Temporary excavations (i.e., those which are open for a relatively short period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V) in Type 3 soils and 3H:1V in Type 4 soils unless these soils are effectively dewatered. Depending upon the construction procedures adopted by the contractor, perched groundwater seepage conditions and weather conditions at the time of construction, some local flattening of the slopes may be required, particularly in looser/softer zones or where localized seepage is encountered (such as near the interface of cohesive and non-cohesive materials).

As summarized in Section 4.3, the groundwater level in Area 1 is expected to be at approximately Elevation 105 m to 105.5 m, that in Area 2 at approximately Elevation 104 m to 104.5 m, and that in Area 3 at approximately Elevation 102 m. Excavations for the roadway realignment and reconstruction are expected to extend near to and potentially below the groundwater table in Area 1, and near but likely above the groundwater table in Areas 2 and 3. However, perched groundwater conditions may be present in the non-cohesive layers above cohesive soils including interlayers within the sandy silt to sand deposit. In addition, the groundwater level in the area is subject to seasonal fluctuations and precipitation events and should be expected to be higher during wet periods of the year.

Excavations that extend below the groundwater level will require groundwater control to minimize loss of soil particles through the protection systems, and to ensure appropriate subgrade conditions for placement of new embankment fill or pavement structure materials. Dewatering operations should be carried out in accordance with OPSS.PROV 517 (*Dewatering*).

6.3 Temporary Protection Systems

The protection systems should be designed and constructed in accordance with OPSS.PROV 539 *(Temporary Protection Systems).* The lateral movement of the protection systems should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any adjacent utilities can tolerate this magnitude of deformation. If the utilities cannot tolerate these movements, a “stiffer” protection system will be required to limit deflections, or the utilities can be isolated and supported independently.

Temporary protection systems could consist of soldier piles and lagging or steel sheet piles, depending on the lateral support systems being contemplated (struts, anchors, walers, etc.) and the required embedment depth of the system. However, the temporary protection system used at these sites must be suitable for installation where cobbles and boulders may be present (such as for the glacially-derived till deposit and the residual soil), which may require that measures be taken to remove/break up boulders and cobbles prior to the installation of temporary protection system elements. The feasibility of a sheet pile system will depend on the depth of excavation, the depth of penetration of the system and the means of lateral support. It is anticipated that installation of sheet piles through the glacial till, residual soils and shale will be difficult and not necessarily successful without pre-augering or pre-excavating. In this case, a soldier pile and lagging wall system would be preferable as the soldier piles can be installed in pre-drilled holes. Given the overlying non-cohesive soils, the pre-drilled holes would need to be advanced with temporary liners.

The sheet piles or soldier piles will need to extend/be socketed to a sufficient depth to provide the necessary passive resistance for the retained soil height, plus any surcharge loads behind the protection system. Lateral support to the sheet pile wall or soldier pile wall could be provided in the form of rakers or temporary anchors, if and as required.

While the selection and design of the protection system will be the responsibility of the contractor, the following geotechnical parameters are provided to MTO for information purposes associated with contractor submittals.

Temporary Protection System Area	Soil Type	Unit Weight	Internal Angle of Friction	Undrained Shear Strength	Coefficient of Lateral Earth Pressure		
		(kN/m^3)	(°)	(kPa)	Active, K_a	At Rest, K_o	Passive, K_p
Area 1 North of QEW	Compact sand and gravel fill	19	28	-	0.36	0.53	2.77
	Loose to compact silty sand to sand	20	30	-	0.33	0.50	3.00
	Hard clayey silt to clayey silt with gravel (residual soil)	22	32	200	0.31	0.47	3.25
Area 2 South of QEW	Compact sand to sand and gravel fill	19	28	-	0.36	0.53	2.77
	Very loose to very dense silty sand to sand	20	28	-	0.36	0.53	2.77
	Very dense silty sand till	22	30	-	0.33	0.50	3.00
	Hard clayey silt (residual soil)	22	32	200	0.31	0.47	3.25
Area 3 Dixie/Rometown Intersection	Compact sand fill	19	28	-	0.36	0.53	2.77
	Loose to compact sandy silt to sand	20	30	-	0.33	0.50	3.00
	Stiff to very stiff clayey silt till	20	32	150	0.31	0.47	3.25
	Very dense silty sand till	22	32	-	0.31	0.47	3.25
	Stiff clayey silt (residual soil)	22	32	20	0.31	0.47	3.25

Notes:

1. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficients need to be adjusted accordingly.
2. The total passive resistance below the base of the excavation (i.e., within the shored excavation and / or adjacent to the temporary protection system, may be calculated based on the value of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6:16 of the CHBDC (2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

Perched water may be present in the fill or sandy silt to silty sand deposit, atop cohesive soil deposits or interlayers. Where groundwater is present, it will be necessary to control seepage and include measures to mitigate loss of soil particles through lagging boards if a soldier pile and lagging system is employed.

6.4 Obstructions

Cobbles and/or boulders may be encountered within the glacial till deposits and shale and/or limestone fragments may be encountered within the residual soil deposits, which may affect the selection and installation of the temporary protection systems. It is recommended that a Notice to Contractor be included in the Contract Documents to warn the Contractor of the possible presence of cobbles, boulders and/or bedrock fragments within the overburden soils; a Notice to Contractor is provided in Appendix D.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Katelyn Nero, E.I.T. and reviewed by Mr. Michael Beadle, P. Eng. Ms. Lisa Coyne, P. Eng., an MTO Foundations Designated Contact for Golder, conducted an independent technical and quality control review of this report.

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Principal, MTO Foundations Designated Contact

AK/KNN/MEB/LCC/ml

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

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

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Ontario Occupational Health and Safety Act

Ontario Regulation 903 Wells (as amended)

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 517 Construction Specification for Dewatering

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

Ontario Provincial Standard Drawings (OPSD)

OPSD 3090.101 Foundation, Frost Penetration Depths for Southern Ontario

DRAWINGS

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

CONT No. 2021-2127
WP No. 2102-13-00

SHEET

QEW-CAWTHRA TO EAST MALL WIDENING
TEMPORARY PROTECTION SYSTEMS ALONG DIXIE ROAD

BOREHOLE LOCATIONS

GOLDER
MEMBER OF WSP

PLAN
SCALE
30 0 30 60 m

KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Golder Investigation (MTO GEOCRES No. 30M11-272 and 30M11-280)
- Borehole– Thurber Investigation (MTO GEOCRES No. 30M11-251)
- Proposed Alignment of Temporary Protection System

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
TPS-2	103.8	4828280.0	299487.3
TPS-1	103.6	4828296.3	299468.7
NW6-1	106.0	4828501.2	299323.7
NW4-2	107.6	4828628.9	299093.7
NW4-1	107.5	4828595.5	299115.9
NW3-7	105.8	4828492.8	299182.1
DR14-01	106.5	4828505.1	299295.5
DO-5	106.4	4828517.1	299294.2
DO-2	107.0	4828567.2	299225.4
DO-1	107.3	4828582.4	299214.9

NOTES

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

REFERENCE

Proposed temporary protection plan provided in digital format by AECOM, file no. 08_QEW_DixieIC_temp roadway protection.dwg, received August 24, 2021.
Sanitary and Watermain plans provided in digital format by AECOM, drawing file nos. QEW_DixieIC_UTL_PROP_SANITARY.dwg and QEW_DixieIC_UTL_PROP_WATERMAIN.dwg, received March 16, 2021.
Design plans provided in digital format by AECOM, drawing file nos. QEW_Dixie_Cont1_plan.dwg and QEW_Dixie_Cont2_plan.dwg, received July 21, 2017.
Existing ground contours provided in digital format by AECOM, drawing file no. QEW_DixieIC_Contours3D.dwg, received Nov. 08, 2016, contour interval 0.5 m.
Base plans provided in digital format by AECOM, drawing file nos. QEW_DixieIC_base.dwg and QEW_DixieIC_plan.dwg, dated July 20, 2016, received Dec. 06, 2016.
Key plan base data – MNRF LIO, obtained 2015.

LICENSED PROFESSIONAL ENGINEER M.E. BEADLE Jan. 18, 2022 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Jan. 18, 2022 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M11-319

HWY. QEW		PROJECT NO. 1530382	DIST.
SUBM'D. KN	CHKD. KN	DATE: 01/18/2022	SITE:
DRAWN: DD	CHKD. MEB	APPD. LCC	DWG. 1

PLOT DATE: January 18, 2022
FILENAME: S:\Clients\MTO\QEW-Dixie\99_PROJ\1530382\40_PROD\0044_TPS_Along_Dixie_Rd\1530382-0044-BG-0001.dwg

APPENDIX A

Previous Investigations

2014 Investigation – MTO GEOCRES No. 30M11-251

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

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

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery:(SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation:(RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

UNIFIED SOILS CLASSIFICATION

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No DR 14-01

METRIC

W.P. 09-20003	LOCATION Dixie Rd. Underpass N 4 828 505.1 E 299 295.5	ORIGINATED BY SLL
HWY QEW	BOREHOLE TYPE Hollow Stem Augers/NQ Coring	COMPILED BY AN
DATUM Geodetic	DATE 2014.08.08 - 2014.08.08	CHECKED BY MW

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT (kN/m³) / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.5	GROUND SURFACE						
0.0	**ASPHALT:** (113mm)						
0.1	**SAND**, trace gravel, trace silt, occasional cobbles Brown Moist (FILL)	1	GS		106		
105.8 / 0.7	Silty **SAND**, trace clay, trace gravel, trace rootlets Loose to Dense Brown Moist	2	SS	9			
		3	SS	10	105		5 67 25 3
		4	SS	34	104		
		5	SS	53	103		
102.9 / 3.6	**SHALE**, highly to moderately weathered, fine grained, thinly bedded, grey, weak to medium strong, with strong limestone interbeds: **(Georgian Bay Formation)** Highly broken zone (125mm) at 4.2m	1	RUN		102	FI: 12, 12, 12	RUN #1 TCR=94% SCR=83% RQD=0%
	Highly broken zone (75mm) at 5.5m	2	RUN		101	9, 13, 5, 6	RUN #2 TCR=100% SCR=95% RQD=29% UCS=22.4MPa UCS=17.4 MPa
98.6	Thin clay seam (less then 25mm) from 6.8m to 7.0m	3	RUN		100, 99	5, 8, 5, 10, 7	RUN #3 TCR=100% SCR=96% RQD=28% UCS=30.8MPa UCS=11.9 MPa
7.9	END OF BOREHOLE AT 7.9m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Sep 29, 14	3.8	102.7
Oct 27, 14	3.5	103.0

Column headings also shown: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60.

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

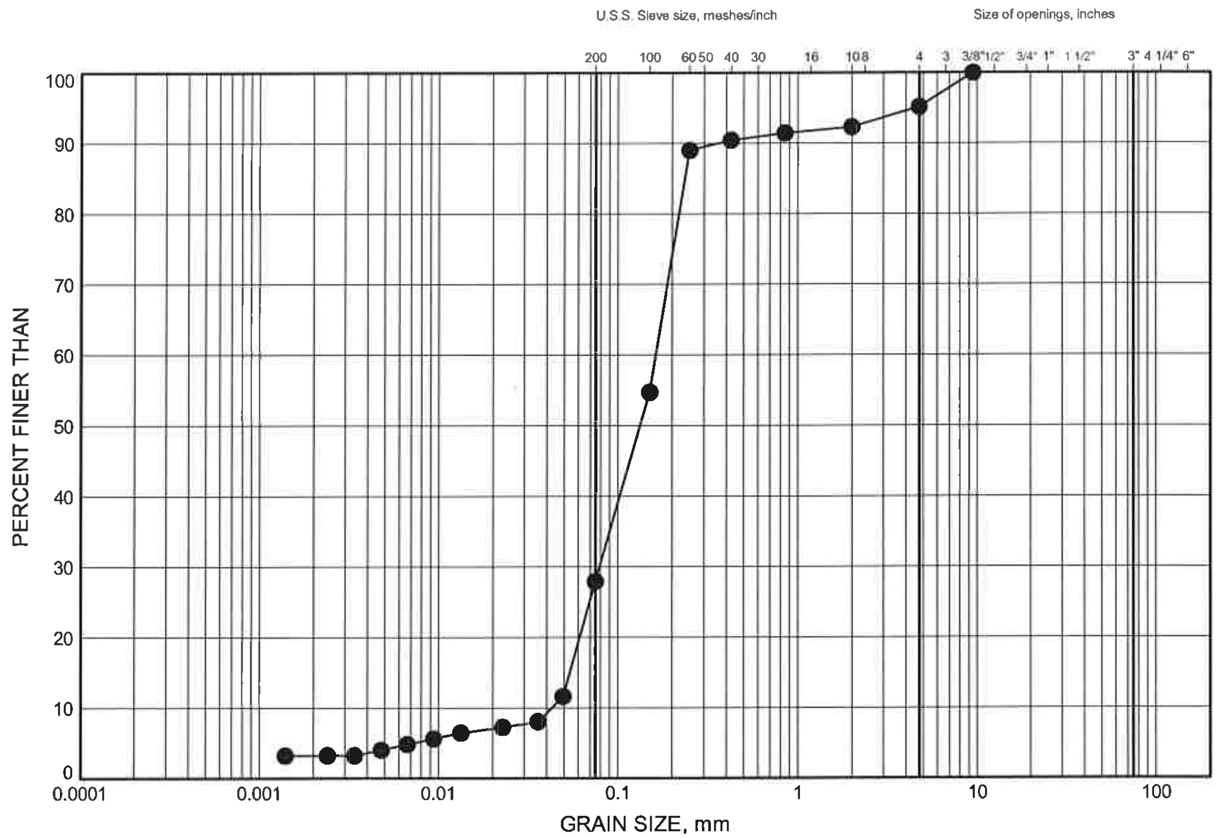
THURBER

QEW Cawthra Road

GRAIN SIZE DISTRIBUTION

FIGURE A1

SILTY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	DR 14-01	1.83	104.67

Date December 2014

W.P. 09-20003

THURBER

Prep'd AN

Chkd. AP

Appendix C

Point load Test Results and Rock Core Photographs

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No :	19-1351-219	**Client :**	MMM Group
		Date Drilled :	08-Aug-14
Project Name :	QEW CAWTHRA ROAD	**Date Tested :**	08-Aug-14
Core Size :	NQ **BH No :** DR14-01	**Tester :**	GAZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	2	5.8	A	3.0	47.1	54.3	22.4	Shale	Weak
2	2	6.0	A	2.2	47.0	50.2	17.4	Shale	Weak
3	3	7.3	A	4.0	47.0	51.2	30.8	Shale	Medium Strong
4	3	7.9	D	1.2	46.9	long	11.9	Shale	Weak
5									
6									
7									
8									
9									
10									
11									
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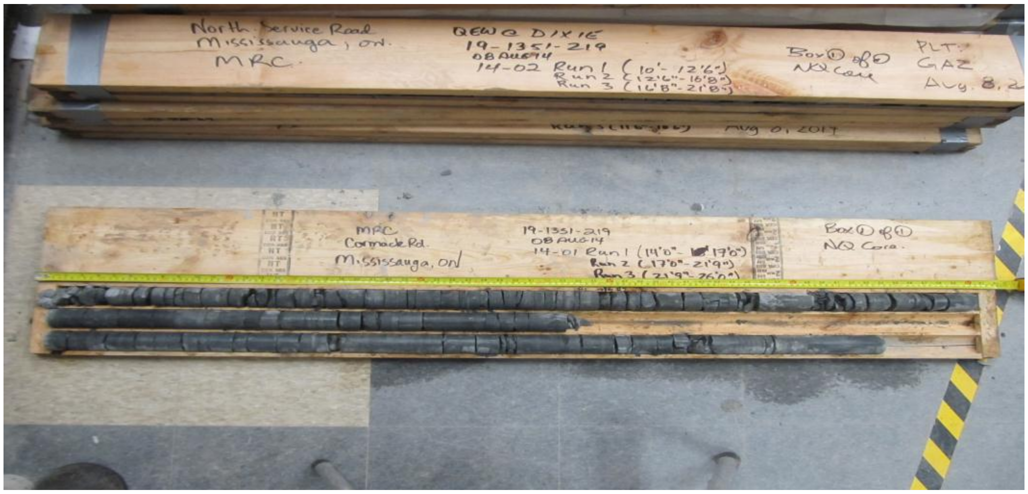
35									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

Last Modified: August 15, 2013



Photograph 1. Rock cores recovered from Borehole DR14-01

Photograph 2. Rock cores recovered from Borehole DR14-02

2016-2017 Investigation –
MTO GEOCRES No. 30M11-280

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils
Consistency

	c_u, s_u **kPa**	**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	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

GOLDER

RECORD OF BOREHOLE No NW3-7

SHEET 1 OF 1

METRIC

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00

LOCATION N 4828492.9; E 299182.1 MTM NAD 83 ZONE 10 (LAT. 43.596348; LONG. -79.569580)

ORIGINATED BY PKS

DIST Central HWY QEW

BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Augers

COMPILED BY ACK

DATUM Geodetic

DATE October 6, 2016

CHECKED BY SMM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
105.8	GROUND SURFACE							
0.0	ASPHALT (150 mm)							
0.2	Sand and gravel (FILL) Brown Moist							
105.3 / 0.5	Silty SAND Compact Brown Moist	1	SS	16		105		
	- Wet below a depth of 1.8 m	2	SS	23		104	~22	0 77 23 0
103.5 / 2.3	SHALE (BEDROCK)	3	SS	100/0.15				
		4	SS	100/0.15		103		
		5	SS	100/0.10		102		
101.1		6	SS	100/0.08				
4.7	END OF BOREHOLE							

NOTE:

1. Open borehole dry upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No NW4-1

SHEET 1 OF 1 **METRIC**

PROJECT 1530382
G.W.P. 2102-13-00; 2432-13-00
LOCATION N 4828595.5; E 299115.9 MTM NAD 83 ZONE 10 (LAT. 43.597273; LONG. -79.570402)
ORIGINATED BY PKS
DIST Central HWY QEW
BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Augers
COMPILED BY ACK
DATUM Geodetic
DATE October 6, 2016
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.5	GROUND SURFACE										
0.0	Sandy TOPSOIL										
0.1	SAND, trace to some silt, trace clay Compact Brown Moist to wet below 2.3 m depth		1	SS	10		107				
			2	SS	12				○		0 87 10 3
			3	SS	30		106				
105.2 2.3	CLAYEY SILT, some sand, trace to some gravel, some shale fragments (RESIDUAL SOIL) Hard Grey Moist		4	SS	100		105				
104.9 2.6	SHALE (BEDROCK)		5	SS	100/0.15		104				
			6	SS	100/0.15	∇	103				
102.8			7	SS	100/0.15						
4.7	END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 4.4 m below ground surface (Elev. 103.1 m) upon completion of drilling.										

Plot scales: DCPT 20 40 60 80 100; Shear strength: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; Water content 10 20 30.

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No NW4-2

SHEET 1 OF 1 **METRIC**

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00 LOCATION N 4828628.9; E 299093.7 MTM NAD 83 ZONE 10 (LAT. 43.597573; LONG. -79.570676) ORIGINATED BY PKS

DIST Central HWY QEW BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Augers COMPILED BY ACK

DATUM Geodetic DATE October 6, 2016 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
107.7	GROUND SURFACE											
0.0	TOPSOIL											
0.2	SAND, trace to some silt, trace clay Very loose to compact Brown to grey Moist to wet below 2.3 m depth	1	SS	8		107						
		2	SS	8		106						
		3	SS	3			o		0	87	11	2
105.0		4	SS	26		105	o					
2.9	CLAYEY SILT, some shale fragments (RESIDUAL SOIL) Very stiff Grey Moist SHALE (BEDROCK)	5	SS	100/0.20		104						
		6	SS	100/0.13	∇							
103.0 / 4.7	END OF BOREHOLE	7	SS	100/0.10		103						

NOTE:

1. Water level in open borehole at a depth of 4.1 m below ground surface (Elev. 103.6 m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

GOLDER

PROJECT 1530382

RECORD OF BOREHOLE No NW6-1 SHEET 1 OF 1 **METRIC**

G.W.P. 2102-13-00; 2432-13-00 LOCATION N 4828501.2; E 299323.7 MTM NAD 83 ZONE 10 (LAT. 43.596434; LONG. -79.567830) ORIGINATED BY ML

DIST Central HWY QEW BOREHOLE TYPE 150 mm O.D. Solid Stem Augers COMPILED BY AZ

DATUM Geodetic DATE June 28, 2017 CHECKED BY GDS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.0	GROUND SURFACE							
0.0	TOPSOIL							
0.2	SAND, trace to some silt, trace clay, some gravel Very loose Brown Moist to wet	1	SS	3				
		2	SS	2		105		
		3	SS	WH	∇	104		
103.5 / 2.5	Gravelly Silty SAND, clayey silt pockets (TILL) Grey Wet	4A / 4B	SS	WH				
		5A	SS	54/0.25		103		32 48 17 3
102.8	SHALE (BEDROCK)	5B						
102.5 / 3.5	END OF BOREHOLE							

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; STRAT PLOT.

NOTE:

1. Water level in open borehole at a depth of about 1.8 m below ground surface (Elev. 104.2 m) upon completion of drilling.

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

2018 Investigation – MTO GEOCRES No. 30M11-272

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1 $\tau = c' + \sigma' \tan\phi'$
2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

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

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

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

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

III. SOIL DESCRIPTION

(a) Non-Cohesive Soils

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

(b) Cohesive Soils

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (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) 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 90º angle is horizontal.

Description and Notes

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

Abbreviations

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

Golder Associates

RECORD OF BOREHOLE No DO-1

SHEET 1 OF 1 **METRIC**

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00

LOCATION N 4828582.4; E 299214.9 MTM NAD 83 ZONE 10 (LAT. 43.597155; LONG. -79.569175)

ORIGINATED BY KG

DIST Central HWY QEW

BOREHOLE TYPE CME 55, 150 mm O.D. Solid Stem Augers

COMPILED BY

DATUM Geodetic

DATE June 15,2017

CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
107.3	GROUND SURFACE										
0.0	TOPSOIL										
107.0 / 0.3	Sand and gravel (FILL) Compact Grey Moist	1	SS	21		107					
		2	SS	17			~10				
105.9 / 1.4	SAND, trace to some silt Compact Brown Moist to wet - Becoming wet below 1.8 m	3	SS	27	▽	106					
		4	SS	14		105	~21	0	89	11	0
104.2 / 3.3	CLAYEY SILT with GRAVEL, some shale fragments (RESIDUAL SOIL) Hard Grey Moist	5	SS	50/0.10		104					
	SHALE (BEDROCK)										
	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev. 105.5 m) upon completion of overburden drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

Foundation Design

RECORD OF BOREHOLE No DO-2

SHEET 1 OF 2 **METRIC**

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00 LOCATION N 4828567.2; E 299225.4 MTM NAD 83 ZONE 10 (LAT. 43.597019; LONG. -79.569044) ORIGINATED BY KG

DIST Central HWY QEW BOREHOLE TYPE CME 75, 150 mm O.D. Solid Stem Augers COMPILED BY

DATUM Geodetic DATE June 15,2017 CHECKED BY MWK

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.0	GROUND SURFACE						
0.0 / 106.8	TOPSOIL						
0.2	Silty SAND to SAND, some silt, trace rootlets, Loose to compact, Brown, Moist	1	SS	4			
		2	SS	7		~10	
		3	SS	15		~22	
	- Becoming wet below 2.3 m	4	SS	16	Water level (▽) at approx. El. 104.8	~21	0 85 13 2
		5	SS	50/0.13			
103.7 / 3.3	CLAYEY SILT with GRAVEL (RESIDUAL SOIL), Hard, Grey, Moist	6	SS	50/0.15			
	SHALE (BEDROCK). Bedrock cored from depths of 3.6 m to 9.8 m. For bedrock coring details refer to Record of Drillhole DO-2.	1	RC	REC 92%			RQD = 62%
		2	RC	REC 100%			RQD = 87%
		3	RC	REC 100%			RQD = 91%
		4	RC	REC 100%			RQD = 75%
97.2 / 9.8	END OF BOREHOLE						

Elevation scale: 106, 105, 104, 103, 102, 101, 100, 99, 98

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No DO-2

SHEET 2 OF 2

METRIC

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00

LOCATION N 4828567.2; E 299225.4 MTM NAD 83 ZONE 10 (LAT. 43.597019; LONG. -79.569044)

ORIGINATED BY KG

DIST Central HWY QEW

BOREHOLE TYPE CME 75, 150 mm O.D. Solid Stem Augers

COMPILED BY

DATUM Geodetic

DATE June 15,2017

CHECKED BY MWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTE: 1. Water level in open borehole at a depth of 2.3 m below ground surface (Elev. 104.7 m) upon completion of overburden drilling.										

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

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

GTA-MTO 001 S:\CLIENTS\MTO\QEW-DIXIE\02_DATA\GINT\QEW-DIXIE.GPJ GAL-GTA.GDT 01/10/18 GPK

RECORD OF DRILLHOLE: DO-2

PROJECT: 1530382

SHEET 1 OF 1

LOCATION: N 4828567.2 ;E 299225.4

DRILLING DATE: June 15,2017

DATUM: Geodetic

DRILL RIG: CME 75 (Truck Mounted)

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: Davis Drilling Ltd.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate; BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage; PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular; PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break; BR - Broken Rock

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

Column headings: DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DEPTH (m) | RUN No. | RECOVERY (TOTAL CORE % 80 60 40 20; SOLID CORE % 80 60 40 20) | R.Q.D. % 80 60 40 20 | FRACT. INDEX PER Meter 5 10 15 20 | DISCONTINUITY DATA (B Angle 0 90 180 270; DIP w.r.t. CORE AXIS 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jr; Ja) | ROCK STRENGTH INDEX R4 R3 R2 R1 | WEATHERING INDEX W1 W2 W3 W4 W5 W6 | FEATURES | R0/R1 ZONES | NOTES WATER LEVELS INSTRUMENTATION

Drilling record: Rotary Drill, NQ Core

Description	Elev. / Depth (m)
Continued from Record of Borehole DO-2	103.39
Highly weathered, thinly to very thinly laminated, grey, very fine to fine grained, non-porous, weak SHALE with limestone interbeds (Georgian Bay Formation)	3.63
Moderately weathered, thinly to very thinly laminated, grey, very fine to fine grained, non-porous, weak SHALE with limestone interbeds (Georgian Bay Formation) - For broken cores, clay seams, limestone layers and lost cores refer to features column and legend	102.52 / 4.50
Slightly weathered, thinly to very thinly laminated, grey, very fine to fine grained, non-porous, weak SHALE with limestone interbeds (Georgian Bay Formation)	100.24 / 6.78
END OF DRILLHOLE	97.22 / 9.80

Run No.: 1, 2, 3, 4

Depth scale: 4, 5, 6, 7, 8, 9, 10, 11, 12

Type and Surface Description	Jr	Ja
BD,PL,SM	1	1
BD,UN,RO	2	1
BD,UN,RO PC, Sa+Si	2	4
BD,UN,RO	8	1
CO,UN,SM	2	1
CO,UN,RO PC, Br	3	1
CO,UN,SM	2	1
BD,ST,SM	2	1
CO,UN,RO	3	1
BD,UN,SM	2	1
SN,UN,SM	2	1
CO,UN,RO	3	1
BD,UN,SM	2	1
BD,UN,RO	3	1
CO,UN,RO	2	1
CO,UN,RO PC, Cl	3	4
BD,UN,SM PC, Br	2	4
CO,UN,RO PC, Cl	3	4
CO,UN,RO PC, Cl	3	4
CO,UN,RO PC, Cl	3	4
CO,UN,RO PC, Cl+Br	3	4
BD,PL,SM	1	1
BD,PL,SM	1	1
CO,UN,RO PC, Br	3	4
BD,UN,RO PC, Cl	3	4

R0/R1 Zones: R1

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED:

CHECKED:

Golder Associates

RECORD OF BOREHOLE No DO-5

SHEET 1 OF 1 **METRIC**

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00

LOCATION N 4828517.1; E 299294.2 MTM NAD 83 ZONE 10 (LAT. 43.596569; LONG. -79.568192)

ORIGINATED BY PKS

DIST Central HWY QEW

BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Augers

COMPILED BY ACK

DATUM Geodetic

DATE October 13, 2016

CHECKED BY SMM

ELEV / DEPTH (m)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.4	GROUND SURFACE							
0.0	ASPHALT (200 mm)							
106.2	Sand and gravel (FILL), Brown, Moist							
105.9 / 0.5	CONCRETE (230 mm)							
	SAND, some silt, trace clay; Loose to compact; Brown; Moist to wet below 2.3 m depth	1	SS	7				
		2	SS	6		w ≈ 14		0 79 18 3
		3	SS	30		w ≈ 25		
103.4 / 3.1	CLAYEY SILT, some sand, trace gravel, trace shale fragments (RESIDUAL SOIL); Hard; Grey; Wet	4	SS	108		w ≈ 14; WP ≈ 18, WL ≈ 29		
103.1 / 3.4	SHALE (BEDROCK)	5	SS	100/0.13				
		6	SS	100/0.13				
101.7 / 4.7	END OF BOREHOLE							

NOTE:

1. Open borehole dry upon completion of drilling.

Elevation scale: 106, 105, 104, 103, 102

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30

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

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

July 18, 2016

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

Re: UCS Testing of shale sample - Golder Associates Project No. 1530382

Dear Ms. McGaghran:

On July 12, 2017 one (1) HQ-sized core samples were received by Geomechanica Inc. via drop-off. These samples were identified as shale from a drilling investigation for Golder project 1530382 in Mississauga, Ontario. One (1) uniaxial compressive strength (UCS) test specimen was prepared and tested.

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

Sincerely,

Giovanni Grasselli Ph.D., P. Eng.

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

Rock Laboratory Testing Results

A report submitted to:

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

Prepared by:

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

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

July 18, 2017
Project number: 1530382

Abstract

This document summarizes the results of Uniaxial Compressive Strength (UCS) testing of 1 rock core sample for Golder Associates Ltd. (Golder Project No. 1530382). The results, including the tabulated values of the UCS, bulk density, and elastic modulus along with photos of the test specimen before and after testing, are presented herein.

In this document:

1 Uniaxial Compressive Strength (UCS) Testing

1.1 Introduction

This section summarizes the results of UCS testing of a core sample of shale received by Geomechanica from Golder Associates Ltd. (Golder Project No. 1530382). The test was performed in Geomechanica's rock testing laboratory in Oakville, Ontario using a 150 ton Forney loading frame equipped with pressure-compensated control valve to maintain an axial strain rate of approximately 1.5×10^{-5} s^{-1} (Figure 1). The specimen preparation and testing procedure included the following:

1. Unwrapping of the core sample, inspecting it for damage, and re-wrapping it in electrical tape to maintain the moisture content, avoid damage during handling, and minimize exposure to moisture during specimen preparation.

2. Diamond cutting of the core sample to length such that a cylindrical specimen with a length:diameter ratio of approximately 2:1 and nearly parallel end faces was obtained.

3. Surface grinding the specimens to obtain flat (within ± 0.025 mm) and parallel end faces (within 0.25°).

4. Loading the specimen into a stiff hydraulic loading frame and applying a small axial load of 0.5 kN to allow removal of the electrical tape and subsequently loading the specimen to rupture while recording axial force and axial deformation to determine the peak strength (UCS) and (tangent) Young's modulus (E).

1.2 Results

The results of UCS testing are summarized in Table 1. The corresponding stress-strain curve is shown in Figure 2. The Young's modulus value presented in Table 1 represents the tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 50% of the UCS, unless noted otherwise.

Table 1: Summary of UCS test results.

Borehole	Depth	Bulk density, ρ (g/cm^3)	UCS (MPa)	Elastic modulus, E (GPa)
BH-DO-2	9.13 - 9.27	2.59	13.1	1.01

1.3 Specimen photographs

Photographs of the test specimen before and after testing are shown in Figure 3.

Figure 1: Equipment setup for measuring Uniaxial Compression Strength (UCS).

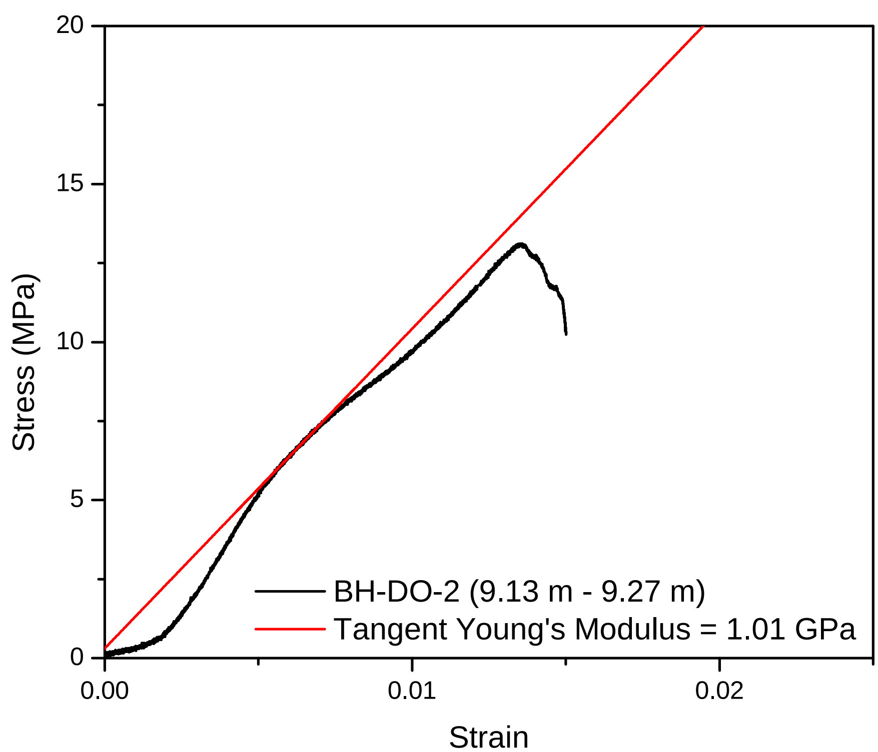


Figure 2: Measured stress-strain curve.

Figure 3: Photographs of UCS test specimen before and after testing. Note that the sub-horizontal lineations visible on the specimen are from the electrical tape used to protect the sample. That is, they do not reflect natural rock structure.

APPENDIX B

2021 Investigation – Borehole Records

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

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

Dynamic Cone Penetration Resistance (DCPT); 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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , 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, Gs)
DS	direct shear test
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

1. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
2. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	< 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	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 $\gamma = \rho \cdot g$ (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 = $(w_l - w_p)$
NP	non-plastic
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
$C_{\alpha(e)}$	secondary compression index
C_α	rate of secondary compression
$C_{\alpha(\varepsilon)}$	modified 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
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
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 or q'	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

GOLDER MEMBER OF WSP

Foundation Design

RECORD OF BOREHOLE No TPS-1

SHEET 1 OF 1 **METRIC**

PROJECT 1530382
G.W.P. 2102-13-00; 2432-13-00
LOCATION N 4828296.3; E 299468.7 MTM NAD 83 ZONE 10 (LAT. 43.594590; LONG. -79.566032)
ORIGINATED BY ML/KN
DIST Central HWY QEW
BOREHOLE TYPE CME 75 truck, 150 mm OD Hollow Stem Augers (Auto Hammer)
COMPILED BY ML/KN
DATUM Geodetic
DATE July 27, 2021
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	Natural Moisture Content w (%)	GR	SA	SI	CL
103.6	GROUND SURFACE								
0.0	ASPHALT (70 mm)								
0.1	SAND (SP), some gravel (FILL) Compact Brown Moist	1	SS	26					
102.8 / 0.8	SILTY SAND (SM) Compact Brown Moist	2	SS	13	~15	0	59	37	4
		3A	SS	25					
101.6	Sandy CLAYEY SILT (CL) Very stiff Brown Moist	3B / 3C			~12 (wp–wL bar ~13–20)				
101.4 / 2.2	SILTY SAND (SP), some fines Compact Grey Moist	4A	SS	14	~12				
101.0 / 2.6	Sandy CLAYEY SILT (CL) to CLAYEY SILT (CL) trace gravel (TILL) Stiff to hard Grey Moist	4B			~14 (wp–wL bar ~14–25)				
100.5 / 3.1	Inferred slightly weathered to fresh SHALE (BEDROCK) Grey	5A / 5B	SS	50/0.13	~11	2	32	51	15
		6	SS	50/0.13					
		7	SS	50/0.10					
98.2 / 5.4	END OF BOREHOLE	8	SS	50/0.07					

Elevation scale: 103, 102, 101, 100, 99

NOTES:

1. Auger and split-spoon refusal at a depth of 5.4 m below ground surface (Elev. 98.2 m).

2. Borehole dry upon completion of drilling.

3. Borehole caved to a depth of 5 m below ground surface (Elev. 98.6 m) upon removal of augers.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

RECORD OF BOREHOLE No TPS-2

SHEET 1 OF 1 **METRIC**

PROJECT 1530382

G.W.P. 2102-13-00; 2432-13-00 LOCATION N 4828280.0; E 299487.3 MTM NAD 83 ZONE 10 (LAT. 43.594444; LONG. -79.565801) ORIGINATED BY ML/KN

DIST Central HWY QEW BOREHOLE TYPE CME 75 truck, 150 mm OD Hollow Stem Augers (Auto Hammer) COMPILED BY ML/KN

DATUM Geodetic DATE July 27, 2021 CHECKED BY LCC

ELEV / DEPTH (m)	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.8	GROUND SURFACE						
0.0	TOPSOIL (150 mm)						
	ASPHALT (130 mm)						
0.3	Sandy SILT (ML), contains rootlets; Loose to compact; Brown; Moist	1	SS	12			
		2	SS	8		w ≈ 9 %	
	- Wet below a depth of 1.8 m (Elev. 102.0 m)	3	SS	20		w ≈ 21 %	0 45 53 2
		4A	SS	23			
101.1 / 2.7	CLAYEY SILT (CL), some sand, trace gravel (TILL); Very stiff; Grey; Moist	4B				w_P ≈ 13, w ≈ 14, w_L ≈ 29 %	1 11 50 38
100.8 / 3.0	CLAYEY SILT (CL), some gravel, contains shale fragments (RESIDUAL SOIL); Stiff; Grey; Moist	5	SS	12			
100.1 / 3.7	Inferred slightly weathered SHALE; Grey	6	SS	50/0.13			
99.1 / 4.7	END OF BOREHOLE	7	SS	50/0.10			

NOTES:

1. Auger and split-spoon refusal at a depth of 4.7 m below ground surface (Elevation 98.7 m).

2. Borehole dry upon completion of drilling.

3. Borehole caved to a depth of 4.3 m below ground surface (Elev. 99.1 m) upon removal of augers.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³. Elevation scale 103, 102, 101, 100.

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

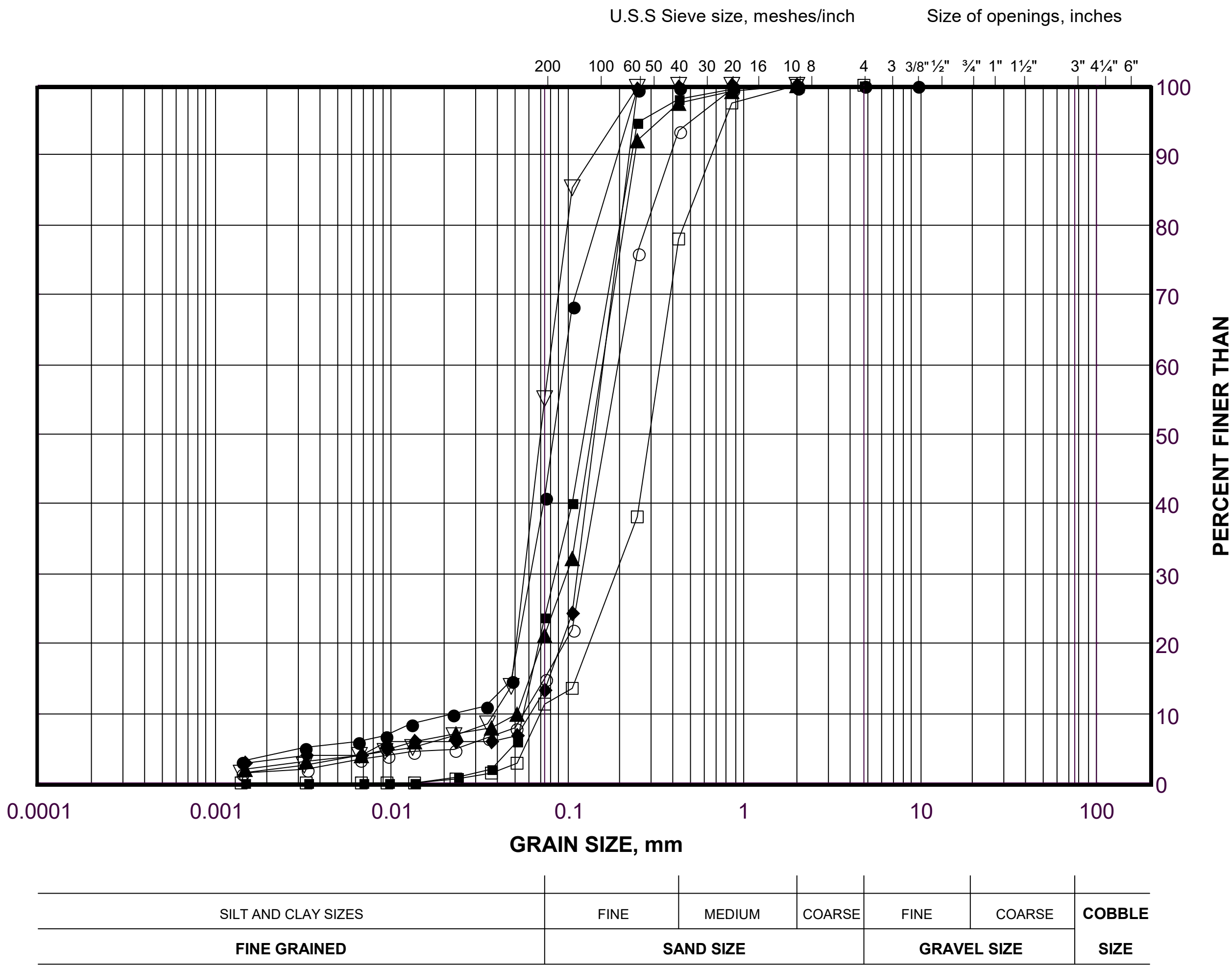
APPENDIX C

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

FIGURE C1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	TPS-1	2	102.8
■	NW3-7	2	104.0
◆	NW4-1	2	106.4
▲	DO -5	2	104.6
▽	TPS-2	3	102.3
○	DO-2	4	104.4
□	DO-1	4	104.7

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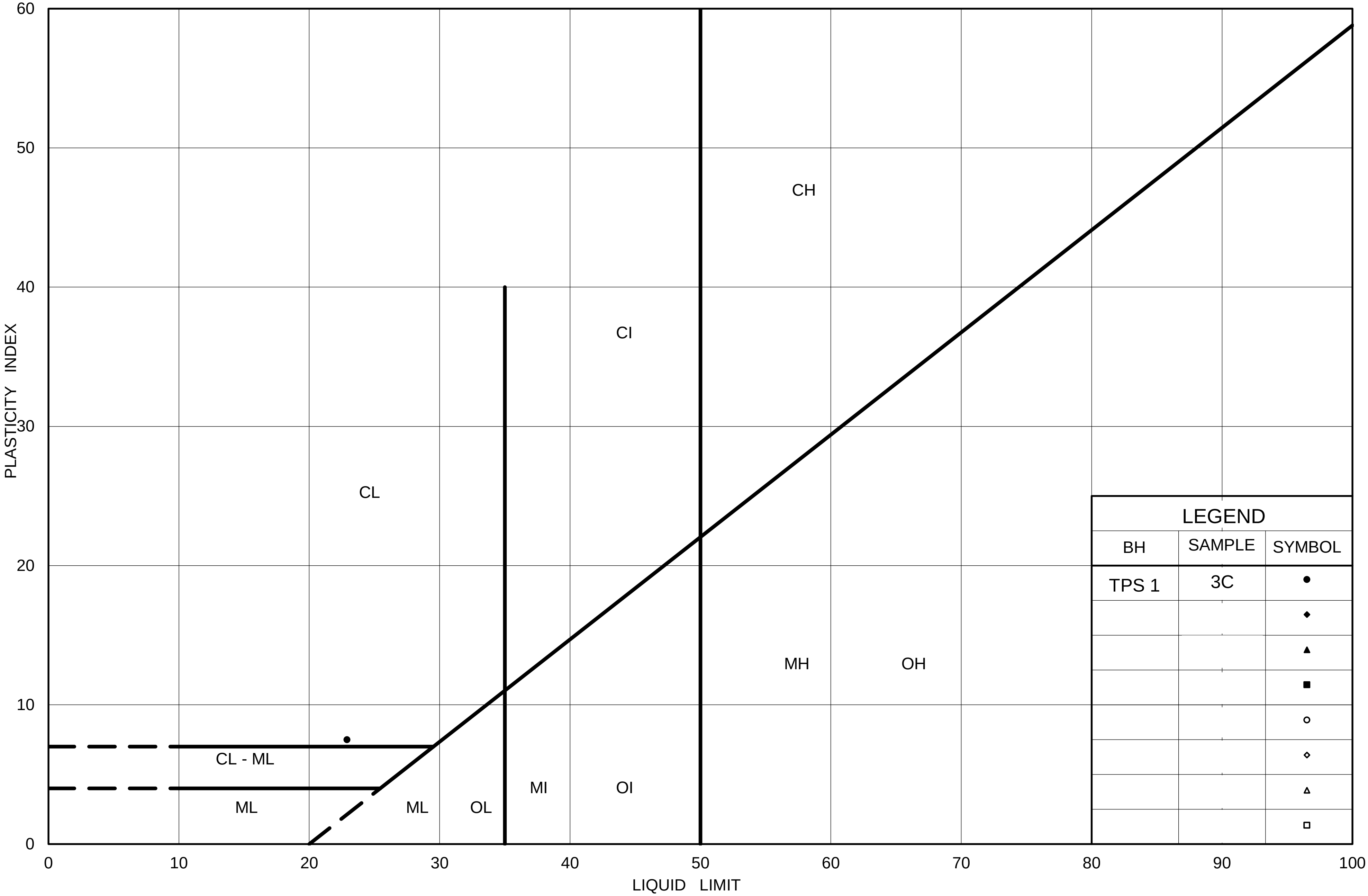
Checked By: LCC

Golder Associates

Date: 23-Sep-21

Oct 75, FF-S-21



Ministry of Transportation

Ontario

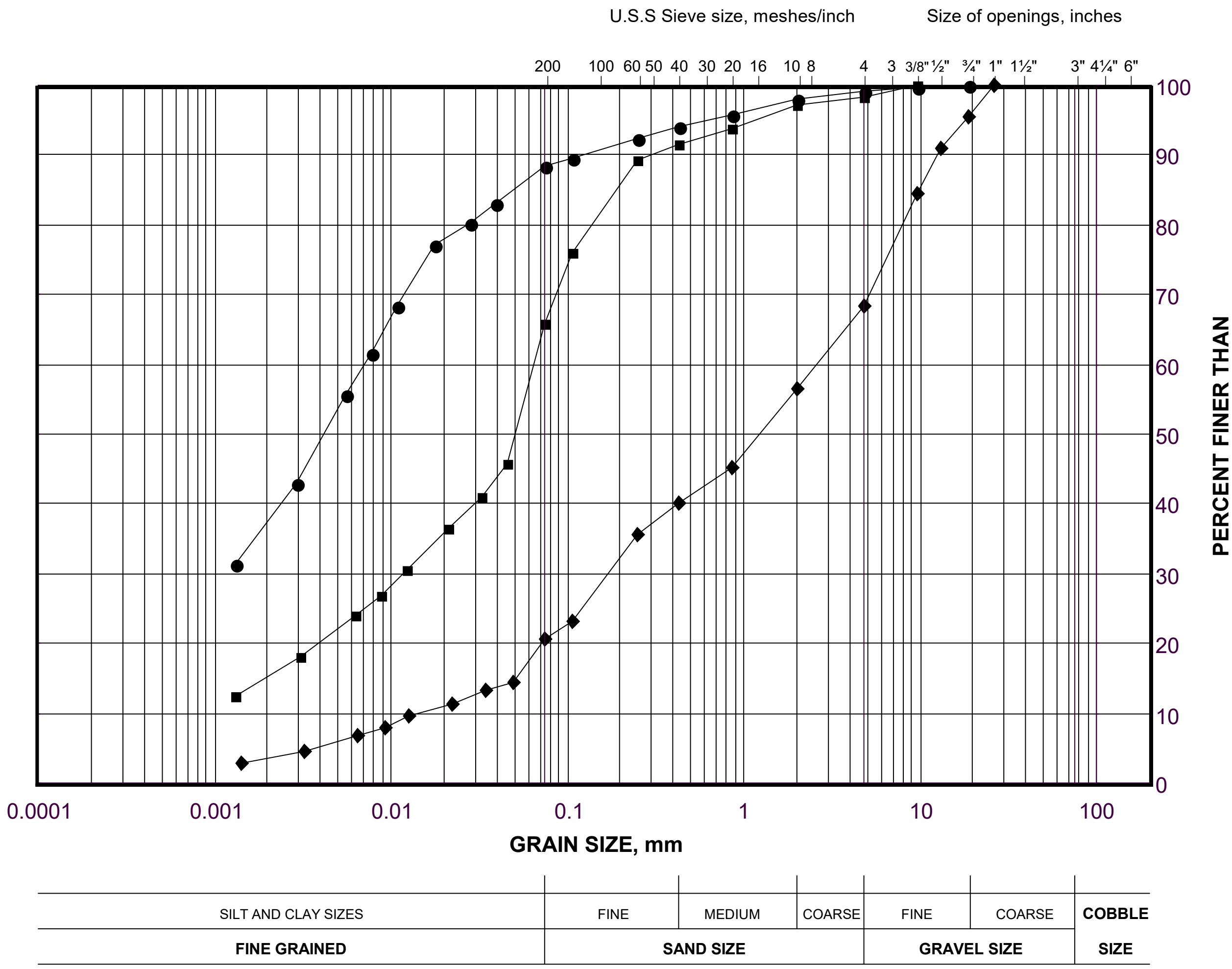
PLASTICITY CHART
Sandy Clayey Silt Interlayer

Figure No. C2

Project No. 1530382

Checked By: LCC

GRAIN SIZE DISTRIBUTION Glacial Till	FIGURE C3



LEGEND

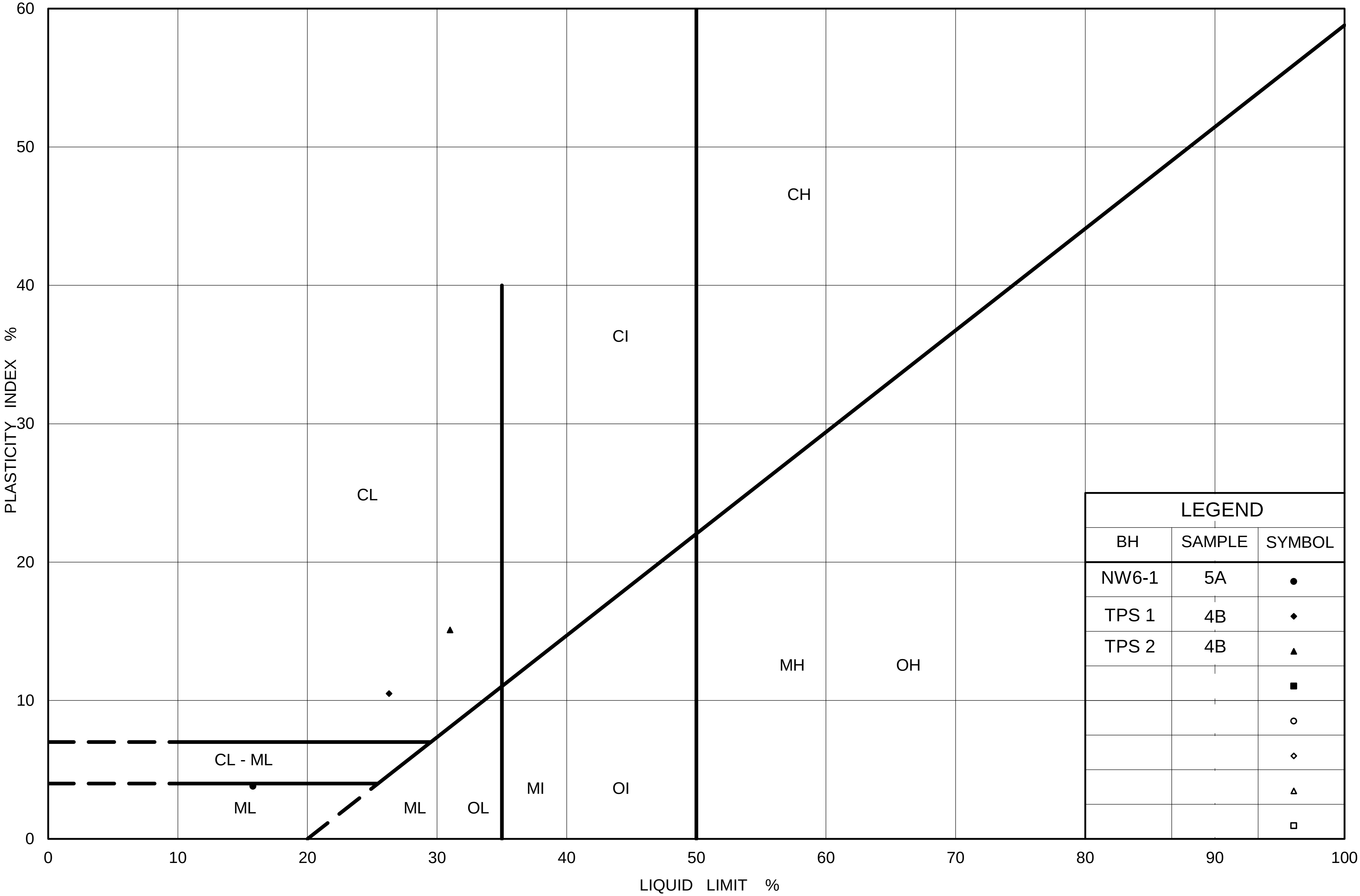
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	TPS-2	4B	101.1
■	TPS-1	5A	100.6
◆	NW6-1	5A	102.9

Project Number: 1530382

Checked By: LCC

Golder Associates

Date: 23-Sep-21



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Ontario

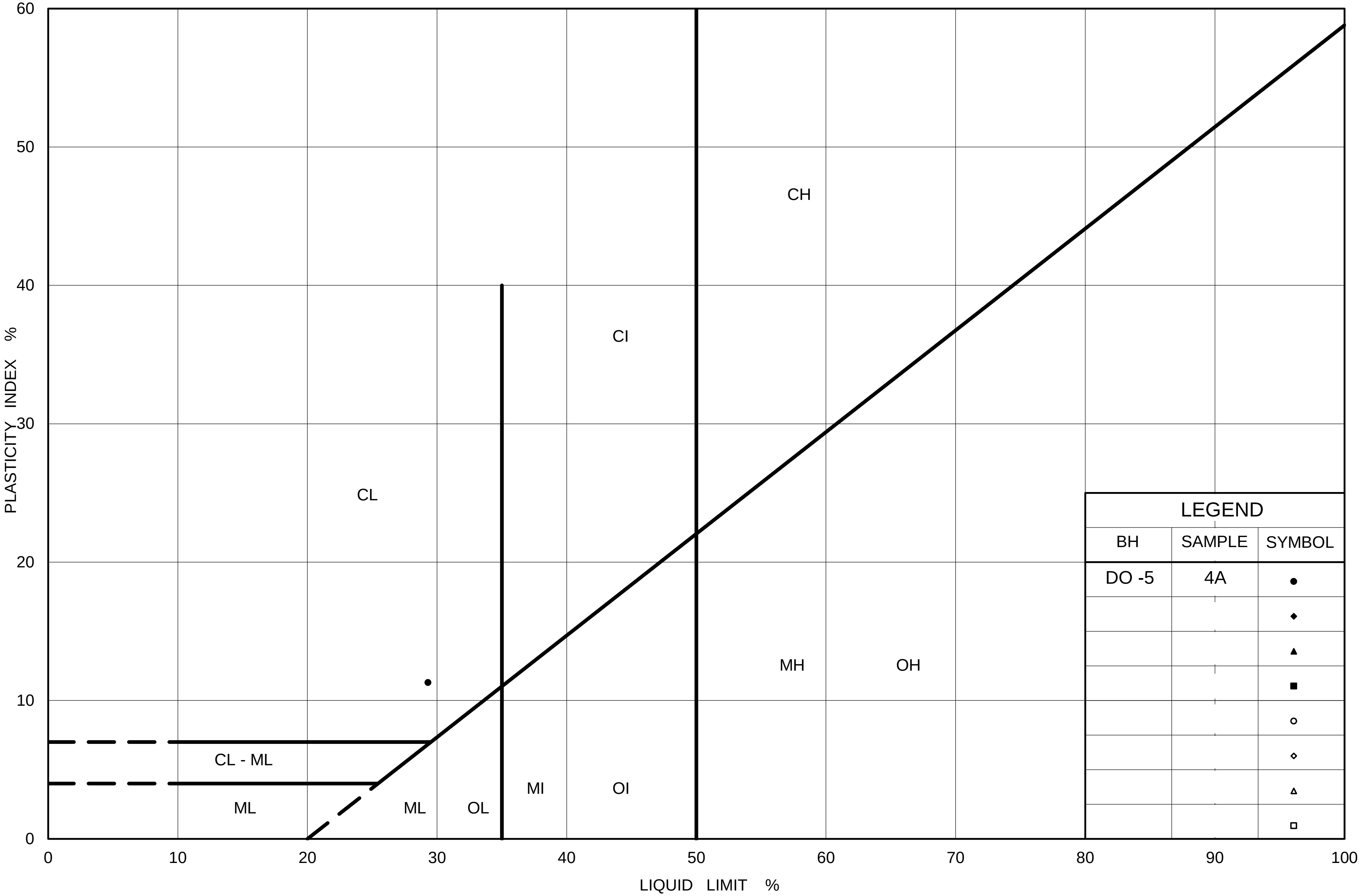
PLASTICITY CHART
Glacial Till

Figure No. C4

Project No. 1530382

Checked By: LCC

Oct 75, FF-S-21



Ministry of Transportation Ontario	**PLASTICITY CHART** Clayey Silt (Residual Soil)	Figure No. C5 Project No. 1530382 Checked By: LCC

APPENDIX D

Non-Standard Special Provisions

OBSTRUCTIONS – Item No.

Notice to Contractor

The Contactor shall be alerted to the potential presence of shale fragments, cobbles and boulders within the native soil deposits including the residual soil overlying the shale bedrock. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for excavations and installation of temporary protection systems.

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