Foundation Investigation and Design Report

Sign Supports at Bridge 29 Site No. 37-822/1&2, Structure Rehabilitation at Highway 401 / Highway 427, City of Toronto, Ontario, G.W.P. 2032-11-00

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CITY OF TORONTO, ONTARIO
G.W.P. 2032-11-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed rehabilitation of the existing structures listed below.

- Site No. 37-819 (Bridge 25): Eglinton Avenue East - Highway 401 West Collector Ramp over Highway 401
- Site No. 37-822/1&2 (Bridge 29): Renforth Drive N/S over Highway 401
- Site No. 37-827 (Bridge 70): Eglinton Avenue East - Highway 427 North Ramp over Highway 401

This report summarizes the foundation investigation carried out to support the proposed overhead sign (OHS) supports at Site No. 37-822/1&2 (Bridge 29) Renforth Drive over Highway 401 at the location shown on the Key Plan on Drawing 1. The Terms of Reference for the foundation engineering services are outlined Golder's change request letter dated December 18, 2018 which forms part of the Consultant's Assignment for the Structure Rehabilitation at Highway 401/Highway 427, Assignment No. 2015-E-0026.

2.0 SITE DESCRIPTION

Site No. 37-822/1&2 (the Renforth Drive Underpass), is located approximately 800 m west of Site Nos. 37-827 and 37-819. The Renforth Drive underpass is bordered by industrial/commercial lands (including the Toronto Pearson International Airport) to the north and commercial land / residential housing to the south. The Renforth Drive road grade is at approximately Elevation 163 m and the surrounding area is at approximately the same level. Highway 401 appears to have been constructed primarily in cut and the highway surface is at about Elevation 156 m.

3.0 INVESTIGATION PROCEDURES

The field work for the current investigation was carried out on December 2 and 16, 2018 during which time two boreholes (designated as Boreholes TP-05 and TP-06) were advanced within the approaches of Site No. 37-822/1&2 (Bridge 29) near the proposed overhead sign locations. The approximate locations of the boreholes are shown on Drawing 1.

Boreholes TP-05 and TP-06 were advanced using 152 mm outer diameter hollow-stem augers and a CME-55 truck mount drill rig, both supplied and operated by Geo-Environmental Drilling Ltd. of Milton, Ontario. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)[1]

Boreholes TP-05 and TP-06 were advanced on the south and north approaches of Site No. 37-822/1&2 to a depth of 9.4 m and 9.3 m, respectively, below the roadway surface. Traffic protection consisted of single lane closures, consistent with MTO's Book 7 Ontario Traffic Manual, Temporary Conditions, requirements.

[1] ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. All boreholes were backfilled in accordance with Ontario Regulation 903, Wells (as amended), and sealed at the roadway surface with cold patch asphalt upon completion.

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 relative to on site features, directed the sampling and in situ testing operations, logged the boreholes and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual review and geotechnical laboratory testing on selected samples, consisting of natural moisture content, Atterberg limits and grain size distribution conducted in accordance with MTO and / or ASTM Standards as applicable. One soil sample obtained from each of Boreholes TP-05 and TP-06, using appropriate sampling protocols, was submitted to a specialist analytical laboratory under chain of custody procedures for testing of conductivity / resistivity, pH chemical analysis of sulphate and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and corrosion to steel.

The boreholes were measured on-site relative to the existing structures and site features and the ground surface elevations were provided by AECOM. The borehole locations provided on the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including geographic (Latitude / Longitude) coordinates, the ground surface elevations and borehole drilled depths are summarized below.

Borehole No.	MTM NAD83 (Geographic)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude)	Easting (m) (Longitude)		
TP-05	4,836,436.2 (43.667844)	297,491.7 (-79.590627)	161.7	9.4
TP-06	4,836,634.6 (43.669629)	297,406.2 (-79.591690)	161.4	9.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 401 is located within the Till Plains of the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2].

The Peel Plain physiographic region covers the central portions of the Regional Municipalities of York, Peel and Halton. The general topography of this region consists of level to gently rolling terrain, sloping gradually southward toward Lake Ontario. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till, which is mapped in this area as the Halton Till, typically consists of clayey silt to silty clay, with occasional sand to silt zones. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial

[2] 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.

meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay. The study area, in the western portion of the Peel Plain, is underlain by grey shale of the Georgian Bay Formation.

4.2 General Overview of Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes of the current investigation, and the results of the in situ and laboratory tests are provided on the Record of Borehole Sheets in Appendix A. The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4 are uncorrected. The results of the geotechnical laboratory testing on soil samples are presented on the laboratory test figures in Appendix B.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected, however, the factual data presented on the borehole records governs any interpretation of the site conditions.

In general, the subsurface conditions at this site consist of asphalt and concrete associated with the Renforth Drive pavement structure, underlain by fill. The fill material is underlain by non-cohesive deposits of silt, gravelly silty sand, and sand and gravel. A silty clay deposit was encountered at one borehole location underlying the non-cohesive deposit and shale bedrock was encountered below the till / non-cohesive deposits in both boreholes.

4.2.1 Asphalt

An approximately 70 mm and 90 mm thick layer of asphalt pavement was encountered at ground surface in Boreholes TP-05 and TP-06, respectively.

4.2.2 Concrete

An approximately 230 mm and 160 mm thick layer of concrete was encountered underlying the asphalt pavement in Boreholes TP-05 and TP-06, respectively.

4.2.3 Fill

A 1.2 m thick layer of fill material was encountered underlying the concrete in Boreholes TP-05 and TP-06. The fill material is comprised of silty sand in Borehole TP-05 and clayey silt in Borehole TP-06. The base of the fill layer extends to Elevations 160.2 m and 159.9 m in Boreholes TP-05 and TP-06, respectively. Clay pockets were encountered within the silty sand fill in Borehole TP-05 between depths of 0.8 m and 1.4 m.

The Standard Penetration Test (SPT) “N”-value measured within the silty sand fill layer is 17 blows per 0.3 m of penetration, indicating a compact level of compactness. The SPT “N”-value measured within the clayey silt fill layer is 9 blows per 0.3 m of penetration, suggesting a stiff consistency.

4.2.4 Silt

A 3.2 m thick deposit of silt was encountered underlying the silty sand fill layer in Borehole TP-05 at a depth of 1.5 m, corresponding to Elevation 160.2 m.

The SPT "N"-values measured within the silt deposit range from 31 blows to 69 blows per 0.3 m of penetration, indicating a dense to very dense level of compactness.

A grain size distribution was carried out on two samples of the silt deposit and the results are shown on Figure B1 in Appendix B. The natural water content measured on three selected samples of the silt deposit range between about 11 per cent and 25 per cent.

4.2.5 Gravelly Silty Sand to Sand and Gravel

A 4.0 m thick deposit of gravelly silty sand to sand and gravel was encountered underlying the silt deposit in Borehole TP-05. The deposit grades from a gravelly silty sand to a sand and gravel with depth, with the surface of the gravelly silty sand deposit encountered at Elevation 157.0 m, and the surface of the sand and gravel deposit encountered at Elevation 154.5 m. Cobbles / boulders are inferred to be present within the gravelly silty sand to sand and gravel deposit due to auger grinding at depths below about 5 m, with auger refusal encountered at a depth of about 6.0 m. As a result, Borehole TP-05 was backfilled and relocated about 3 m to the south and re-drilled to 6 m where sampling operations were resumed to greater depth to termination of the borehole.

The SPT "N"-values measured within the gravelly silty sand to sand and gravel deposit range from 61 blows to 86 blows per 0.3 m of penetration, indicating a very dense level of compactness.

A grain size distribution was carried out on one sample of the gravelly silty sand deposit and the result is shown on Figure B2 in Appendix B. The natural water content measured on two selected samples of the gravelly silty sand to sand and gravel deposit is about 6 per cent and 7 per cent.

4.2.6 Sand

A 5.7 m thick deposit of sand was encountered underlying the clayey silt fill in Borehole TP-06 at a depth of 1.5 m, corresponding to Elevation 159.9 m. A 0.3 m thick layer of gravelly clayey silt was encountered at a depth of 4.2 m within the sand deposit. Cobbles / boulders are inferred to be present within the sand deposit due to effective split-spoon refusal at various sampling intervals below about 2.5 m below ground surface and auger grinding at a depth of about 7.0 m.

The SPT "N"-values measured within the sand deposit range from 45 blows per 0.3 m of penetration to 165 blows per 0.28 m of penetration, indicating a dense to very dense level of compactness.

A grain size distribution test was carried out on two samples of the sand deposit and the results are shown on Figure B3 in Appendix B. Atterberg limits testing was carried out on one selected sample of the sand deposit and indicates non-plastic conditions. The natural water content measured on four selected samples of the sand deposit range between about 3 per cent and 10 per cent. The natural water content measured on one selected sample of the gravelly clayey silt layer is about 9 per cent.

4.2.7 Silty Clay (Till)

A 1.5 m thick silty clay till deposit was encountered underlying the sand deposit in Borehole TP-06 at a depth of 7.2 m, corresponding to Elevation 154.2 m. Shale fragments were encountered within the silty clay deposit. Although not encountered during drilling operations, cobbles/boulders are known to be present within the glacial till soils in this local region and should be anticipated to be present within this till deposit.

The SPT "N"-value measured within the silty clay till deposit is 50 blows per 0.3 m of penetration, suggesting a hard consistency.

A grain size distribution was carried out on one sample of the silty clay till deposit and the result is shown on Figure B4 in Appendix B. Atterberg limits testing was carried out on one selected sample of the silty clay till deposit and measured a liquid limit of 36 per cent, a plastic limit of 22 per cent, and a plasticity index of 14 per cent. The result, which is plotted on a plasticity chart on Figure B5 in Appendix B, indicates that the deposit is a silty clay of intermediate plasticity. The natural water content measured on one selected sample of the silty clay till deposit is about 11 per cent.

4.2.8 Shale

Shale bedrock was encountered underlying the sand and gravel deposit in Borehole TP-05 at a depth of 8.7 m (Elevation 153.0 m) and underlying the silty clay till deposit in Borehole TP-06 at a depth of 8.7 m (Elevation 152.7 m). The shale was confirmed from limited recovery of split-spoon samples. The shale is inferred to be weathered within the upper portion.

4.2.9 Groundwater Conditions

The groundwater level in the open boreholes was measured upon completion of drilling operations. The groundwater level recorded is provided on the borehole records in Appendix A and is summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
TP-05	161.7	7.9	153.8	December 16, 2018	Open borehole (borehole caved to 8.2m)
TP-06	161.4	4.6	156.8	December 2, 2018	Open borehole (borehole caved to 5.8m)

The groundwater level observations at this site are not considered to represent long-term stabilized groundwater conditions. Groundwater levels will be subject to seasonal fluctuations and precipitation events; the water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.3 Analytical Testing Results

Two soil samples were submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and deterioration of concrete. Detailed analytical test results are included in Appendix C and the test results are summarized below.

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (umho/cm)	Chlorides (ug/g)	Soluble Sulphates (ug/g)
TP-05 / 4	8.14	490	2,050	1,200	44
TP-06 / 6	7.97	1,100	950	490	36

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Nikol Kochmanová, P.Eng. Mr. Jorge Costa, P.Eng., a MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent technical review of this report. Mr. Kevin Bentley, P.Eng., a MTO Foundations Designated Contact and Associated with Golder performed an independent quality control review of this report.

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PART B

FOUNDATION DESIGN REPORT
SIGN SUPPORTS AT BRIDGE 29 SITE NO. 37-822 / 1&2
STRUCTURE REHABILITATION AT HIGHWAY 401 / HIGHWAY 427
CITY OF TORONTO, ONTARIO
G.W.P. 2032-11-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation recommendations for the design of the cantilevered sign support foundations at Site No. 37-822/1&2 (Bridge 29) Renforth Drive over Highway 401 (see Drawing 1). These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at Renforth Drive. The interpretation and recommendations presented in this report are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and carry out detail design of the OHS support foundation.

The foundation investigation report, discussion and recommendations are intended for the use of the Ministry of Transportation, Ontario (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. Contractors must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the 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 should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Frost Penetration

As per Ontario Provincial Standard Drawing (OPSD) 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*), the frost penetration depth in the area is interpreted to be 1.2 m.

6.3 Design of Sign Support Foundations

Caisson foundations for sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual* (MTO, 2015). The *Sign Support Manual* includes standard caisson foundation designs for each sign type as follows:

- **Cantilever Signs:** Cantilever Static Sign Supports, Section 3 and Standard Drawings SS118-3, SS118-4 and SS118-5.

In the standard caisson foundation design, the caisson is extended 5 m to 6.5 m below the design frost depth (i.e. 1.2 m as per OPSD 3090.101 - *Foundation Frost Penetration Depths for Southern Ontario*) resulting in a total length of 6.2 to 7.7 m below final grade depending on the sign class and corresponding caisson diameter. The standard sign foundation designs presented in the MTO's Sign Support Manual have been developed based on the minimum soil conditions given below.

- **Case 1 (Non-Cohesive Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials looser or softer than those of Case 1 or Case 2 are present. The standard foundation design is also not applicable where bedrock is encountered within the standard foundation depth. For such subsurface conditions, a site-specific design is required.

Based on the review of the borehole information, the subsurface conditions at the proposed sign locations have been compared to the standard design requirements to assess whether a standard or site-specific design is required. The standard sign foundation design may be applied to both signs as proposed at locations Sta. 9+896 (Sign 1) and Sta. 10+086 (Sign 2) as shown on Drawing 1.

6.3.1 Site-Specific Caisson Foundation Design in Soil

A site-specific caisson foundation design may be carried out by the structural engineer to optimize the standard foundation design using the equations provided below and geotechnical design parameters given in Table 1 following the text of this report.

The resistance to lateral loading of caissons may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction (k_h in kPa/m) is determined based on the equations given below:

For cohesionless soils:

$$k_h = \frac{n_h z}{B}$$

where

n_h is the constant of horizontal subgrade reaction (kPa/m);

z is the depth (m); and

B is the caisson diameter (m)

For cohesive soils:

$$k_h = \frac{67 S_u}{B}$$

where

S_u is the undrained shear strength of the soil (kPa); and
B is the caisson diameter (m)

The above equations and recommended parameters in Table 1 may be used to analyse the interaction between a caisson and the surrounding soil (i.e. for serviceability limit state design) provided that lateral displacements within the soil do not exceed about 10 mm. If deflections exceed 10 mm, a non-linear analysis method should be used to model the behaviour of the soil (e.g. p-y curves). The upper 1.2 m of soil resistance should not be included in the design to account for frost action.

The spring constant, K, for structural analysis may be obtained by the expression, K = k_h x L x B (kN/m), where k_h is the coefficient of horizontal subgrade reaction (kPa/m), B is the buried caisson diameter (m) and L is the length (m) of the caisson segment used in the analysis.

The lateral pressures obtained from the structural analysis must not exceed the ultimate lateral geotechnical resistance or the factored structural flexural shear resistance and/or bending moment of the buried concrete pole / caisson. The ultimate resistance should be checked by the structural engineer and the ultimate lateral geotechnical resistance can be checked using the conventional Broms' equation, based on the stratigraphy and geotechnical design parameters given in Table 1.

Alternatively, the unfactored lateral geotechnical resistance can be calculated using passive lateral earth pressure, P_p (kPa) as defined below, distributed along the length of the caisson based on the stratigraphy and geotechnical design parameters given in Table 1.

$P_p = K_p \gamma d_w$ above the groundwater table (kPa), and

$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w)$ below the groundwater table (kPa)

where K_p is the passive earth pressure coefficient;

γ is the bulk unit weight (kN/m^3);

γ is the effective unit weight below the groundwater level (kN/m^3);

d is the depth below the ground surface (m); and

d_w is the depth to the groundwater level (m).

The unfactored lateral resistance, p_{ult} (kN) for non-cohesive soils should be calculated assuming an equivalent width equal to three times the caisson diameter, and an equivalent length equal to six times the caisson diameter (Section C6.8.7.1 of CHBDC (2006)), as outlined below:

$p_{ult} = P_p A_e$ (kN)

where A_e is the equivalent area equal to $3D \cdot 6D = 18D^2$ (m^2)

D is the caisson diameter (m)

Where an undrained shear strength, S_u, is provided for a cohesive soil layer in Table 1, the undrained capacity of the caisson should also be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson within the cohesive soil should be calculated assuming an internal angle of friction, Φ' = 0 degrees, and an unfactored passive lateral pressure distribution varying from 2 S_u at ground surface and increase linearly to 9 S_u at and below a depth equivalent to three caisson diameters, acting over the actual width of the caisson (Section C6.8.7.1 of CHBDC (2006)), as outlined below.

$p_{ult} = P_p A_e$ (kN)

where P_p is equal to 2 S_u at ground surface to 9 S_u at and below a depth equivalent to 3D (kPa)

A_e is the equivalent area equal to L x D (m^2)

L is the caisson length (m)

D is the caisson diameter (m)

In accordance with CHBDC (2014), the product of the consequence factor, Ψ, and the geotechnical resistance factor, ϕ_{gu} should be applied to this unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (p_{ULS}) as shown below.

$p_{ULS} = p_{ult} \cdot \Psi \cdot \phi_{gu}$ (kN)

where $\Psi = 1$ (typical consequence factor as per Table 6.1 in CHBDC (2014))

ϕ_{gu} = 0.5 (passive resistance factor for typical degree of understanding, as per Table 6.2 in CHBDC (2014))

Based on the drawings provided by AECOM, the sign support foundations will be constructed in areas of relatively flat ground, however, in the event that the foundations are located on an embankment slope or within about 2 caisson diameters of the crest of the slope in the direction of loading, there would be unbalanced earth pressures around the foundation due to it being located within sloping ground (assumed 2H:1V embankment). For this case, the passive earth pressure coefficient ($K_{p2:1}$), to be used in the foundation design is also included in Table 1.

6.4 Corrosion Assessment and Protection

Soil corrosivity may affect the concrete foundations and reinforcing steel and other concrete elements buried in the soil. The long-term performance and durability of the foundations are directly related to their respective corrosion resistance. Generally, the corrosivity of a structure depends on the soil resistivity, hydrogen ion concentration, salt (chloride and sulphate) concentrations and redox potential. The analytical results for the samples submitted for testing are presented in Section 4.3 and included in Appendix C.

6.4.1 Potential for Sulphate Attack

The analytical test results were compared to CSA Standard, CAN/CSA-A23.1-14 Table 3 *("Additional requirements for concrete subjected to sulphate attack")* for potential sulphate attack on concrete. The sulphate concentrations measured in the soil samples are less than 0.1 per cent, which is below the exposure class of “Moderate”. Therefore, based on the test results of the single soil sample from each borehole at the OHS locations the effects of sulphates from within the existing native deposits around the foundations may not need to be considered.

6.4.2 Potential for Corrosion

The soil has a pH of 7.9 and 8.1 and a resistivity of about 490 ohm-cm and 1,100 ohm-cm for the samples tested at the respective sign locations. According to the Gravity Pipe Design Guidelines (MTO, 2014), the pH is not considered detrimental to concrete durability. However, the resistivity measured in soil samples is less than 2,000 ohm-cm, which indicates that the soil corrosiveness is “Severe” (R < 2,000 ohm-cm), as per Table 3.2 of the Gravity Pipe Design Guideline (MTO, 2014). Based on these results some level of protection would be appropriate depending on the foundation design and materials specified. Further, given that the OHS foundations are located adjacent to the roadway shoulder and will be exposed to de-icing salt, consideration should be given to selection of a “C” type exposure class as defined by CSA A23.1 Table 1.

The sign support foundations should be designed with due consideration given to Table 7.1 of the Gravity Pipe Design Guidelines (MTO, 2014). It is ultimately up to the designer to determine the appropriate exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 “Durability Requirements” are followed.

6.5 Construction Considerations

6.5.1 Control of Soil and Groundwater

The water-bearing cohesionless soils at this site should be expected to run or flow into the caisson hole during or after drilling of the caisson foundations for the overhead signs. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and concrete placement. This could include the use of temporary or permanent caisson liners, and/or the use of drilling mud. Foundations for the overhead sign supports should be constructed consistent with OPSS.PROV 915 (*Sign Support Structures*). It is recommended that a Non-

Standard Special Provision (NSSP) be included in the Contract Documents to warn the contractor of this condition; such an NSSP is provided in Appendix D.

6.5.2 Obstructions

The fill soils, silt to sand, gravelly silty sand to sand and gravel, and silty clay deposits potentially contain obstructions such as cobbles, and/or boulders and the till deposit contains shale fragments. The depth at which potential obstructions, as inferred from auger grinding during field investigation and/or auger refusal, are anticipated to be encountered are described in the Foundation Investigation Report (Part A of this report) and associated Record of Boreholes. It is recommended that a Notice to Contractor be included in the Contract Documents to alert the Contractor of the presence of obstructions such as cobbles and/or boulders within the overburden soils; an example is provided in Appendix D.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng. Mr. Jorge Costa, P.Eng., a MTO Foundations Designated Contact and Senior Consultant for Golder, conducted a technical review of this report. Mr. Kevin Bentley, P.Eng., a MTO Foundations Designated Contact and Associate with Golder conducted an independent quality control review of this report.

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OPSS 915 Construction Specification for Sign Support Structures

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TABLE 1
GEOTECHNICAL DESIGN PARAMETERS FOR SIGN SUPPORT FOUNDATIONS

Overhead Sign ID (Location)	Reference Borehole	Ground Surface Elevation at Reference Borehole (m)	Estimated Ground Surface Elevation at OHS Location (m)	Standard or Site-Specific Foundation Design	Stratum	Depth Relative to Proposed Ground Surface (m)[1]	Elevation (m)	Groundwater Elevation (m)	Design Parameters[2, 3]							
									S_u (kPa)	Φ'	n_h (kPa/m)	γ (kN/m^3)	γ' (kN/m^3)	K_p	$K_{p2:1}$	f_{horiz} (kPa)
Cantilever Sign 1 (Sta. 9+896)	TP-05	161.7	161.6	Standard	Asphalt and Concrete	0 - 0.3	161.7 - 161.4	153.8	--	--	--	--	--	--	--	--
					Compact silty sand (fill)	0.3 - 1.5	161.4 - 160.2		--	30	4,000	19	9	3.0	1.1	--
					Dense to very dense silt	1.5 - 4.7	160.2 - 157.0		--	33	10,000	20	10	3.4	1.3	--
					Very dense gravelly silty sand	4.7 - 7.2	157.0 - 154.5		--	35	10,000	20	10	3.7	1.4	
					Very dense sand and gravel	7.2 - 8.7	154.5 - 153.0		--	35	15,000	21	11	3.7	1.4	
					Weathered Shale Bedrock	Below 8.7	Below 153.0		--	40	--	23	23	4.6	1.7	600
Cantilever Sign 2 (Sta. 10+086)	TP-06	161.6	161.4	Standard	Asphalt and Concrete	0 - 0.3	161.4 - 161.1	156.8	--	--	--	--	--	--	--	--
					Stiff clayey silt (fill)	0.3 - 1.5	161.1 - 159.9		60	30	--	19	9	3.0	1.1	--
					Dense to very dense sand	1.5 - 7.2	159.9 - 154.2		--	34	10,000	20	10	3.5	1.3	--
					Hard silty clay (till)	7.2 - 8.7	154.2 - 152.7		200	32	--	20	10	3.3	1.2	
					Weathered Shale Bedrock	Below 8.7	Below 152.7		--	40	--	23	23	4.6	1.7	600

NOTES:

1. Depths are given at the existing or proposed sign support locations relative to the estimated proposed ground surface following construction, including any grade raises or regrading. Although Su, ϕ' and Kp parameters are given for the full depth of the soil, the passive resistance in the upper 1.2 m should be neglected to account for frost action.

2. Design parameters:
   - s_u = undrained shear strength (kPa);
   - φ' = effective friction angle (degrees);
   - n_h = the constant of horizontal subgrade reaction (kPa/m)
   - γ = bulk unit weight (kN/m3);
   - γ' = effective unit weight below the groundwater level (kN/m3);
   - K_p = passive earth pressure coefficient; and
   - $K_{p2:1}$ = passive earth pressure coefficient for 2H:1V sloping ground surface.
   - f_{horiz} = factored lateral geotechnical resistance of sound rock at Ultimate Limit States (kPa).

3. Where both undrained shear strength and effective friction angle parameters are provided for cohesive materials, the structural assessment should be completed for both undrained and drained conditions, and the selected design should be based on the more conservative approach.

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

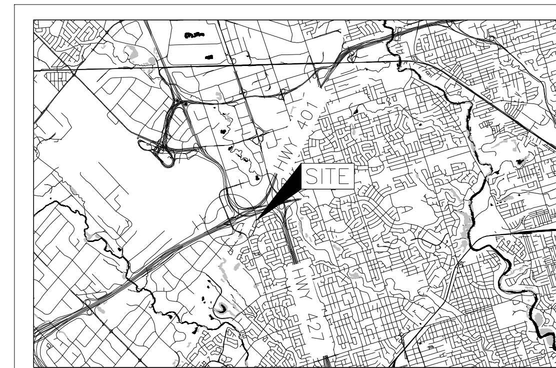
CONT No.
GWP No. 2032-11-00

HIGHWAY 401/427 INTERCHANGE
SIGN SUPPORTS – SITE NO. 37-822/1 AND 2

BOREHOLE LOCATIONS

SHEET

GOLDER

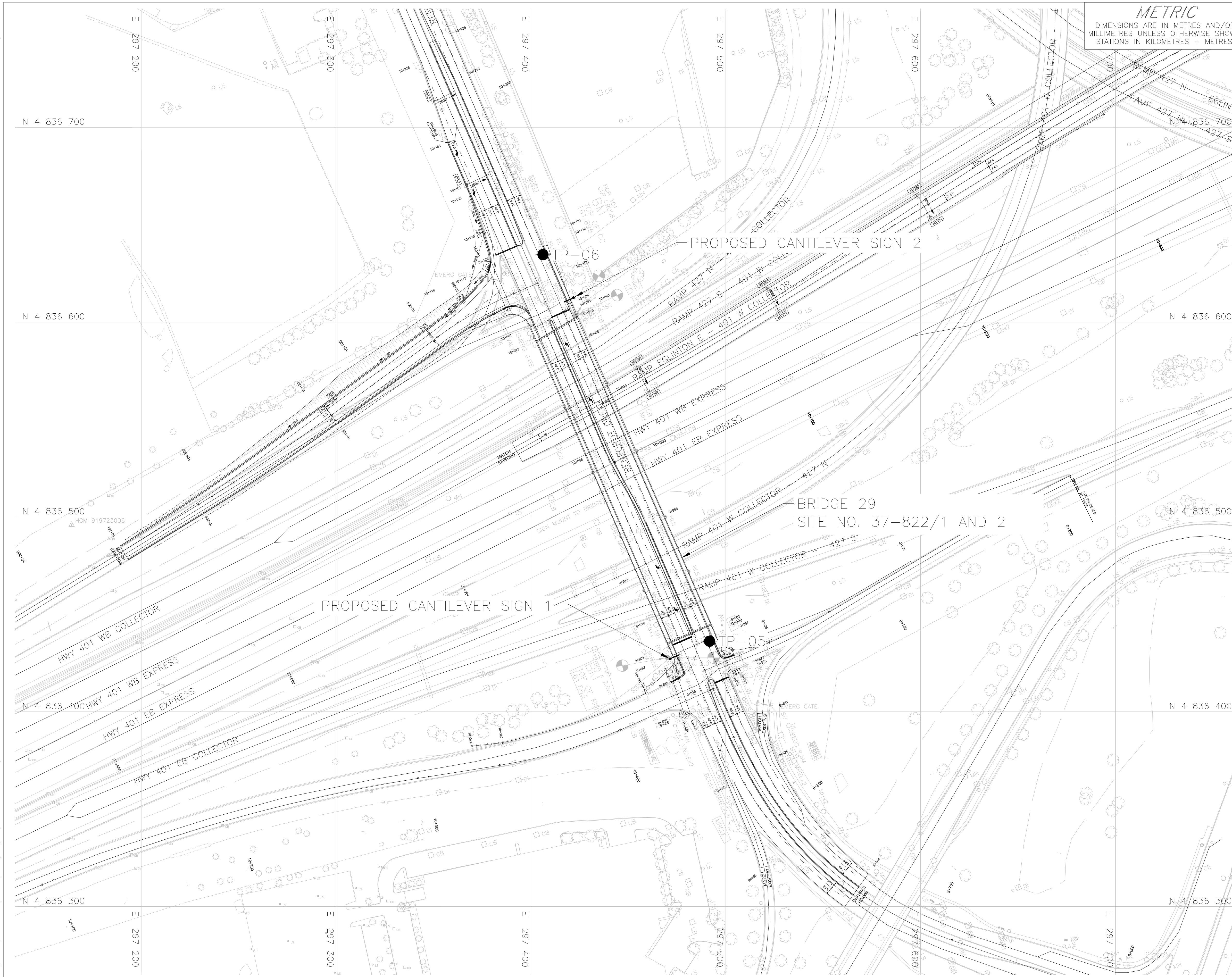


KEY PLAN
SCALE
2 0 2 4 km

LEGEND

● Borehole – Current Investigation

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)			
No.	ELEVATION	NORTHING	EASTING
TP-05	161.7	4836436.2	297491.7
TP-06	161.4	4836634.6	297406.2



PLAN
SCALE
20 0 20 40 m

N. KOCHMAN
100117863
Feb. 11, 2019
LICENSED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

K. J. BENTLEY
Feb. 11, 2019
LICENSED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

NOTES

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

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

REFERENCE

Base plans provided in digital format by AECOM, drawing file nos. Hwy401_base_C1.dwg, Hwy401_KM_alignment_C1.dwg and 401KM_NC_C1.dwg, received November 05, 2018.
Sign support plan provided in digital format by AECOM, drawing file no 401KM_PMK_C1.dwg, received February 05, 2019.

NO.	DATE	BY	REVISION

Geocres No. 30M11-286

HWY. 401		PROJECT NO. 1665765	DIST.
SUBM'D. CC	CHKD. CC	DATE: 02/11/2019	SITE: 37-822
DRAWN: DD	CHKD. NK	APPD. KJB/JMAC	DWG. 1

PLOT DATE: February 12, 2019
FILENAME: S:\Clients\MTO\Hwy_401\99_PROJ\1665765_Aecom\40_PROD\0005_Sign_Supports\1665765-0005-BG-0001.dwg

APPENDIX A

Borehole Records

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 $= \tan\delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils

Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No TP-05

SHEET 1 OF 1

METRIC

PROJECT 1665765

G.W.P. 2032-11-00

DIST Central HWY 401

DATUM Geodetic

LOCATION N 4836436.2; E 297491.7 MTM NAD 83 ZONE 10 (LAT. 43.667844; LONG. -79.590627)

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig

DATE December 16, 2018

ORIGINATED BY EN

COMPILED BY EN

CHECKED BY NK

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (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	NUMBER	TYPE	"N" VALUES	GROUND WATER	GR SA SI CL
161.7	GROUND SURFACE					
0.0	ASPHALT (70 mm)					
	CONCRETE (230 mm)					
0.3	Silty sand, some gravel (FILL) Compact Brown Moist - Clay pockets from 0.8 m to 1.4 m	1	SS	17		
160.2 / 1.5	SILT, trace sand, trace clay Dense to very dense Brown Moist becoming wet below 3.7 m	2	SS	31		0 2 94 4
		3	SS	63		
		4	SS	69		
		5	SS	45		0 0 97 3
157.0 / 4.7	Gravelly silty SAND Very dense Brown Moist - Auger grinding at 5.0 m	6A 6B	SS	61		
	- Auger refusal encountered at a depth of 6.0 m; borehole was moved 3.0 m to the south	7	SS	86		23 47 24 6
154.5 / 7.2	SAND and GRAVEL, some silt Very dense Brown-grey Moist	8	SS	63	∇	
153.0 / 8.7	SHALE, weathered (BEDROCK) Grey	9	SS	100/0.13		
152.3 / 9.4	END OF BOREHOLE					

Elevation scale: 161, 160, 159, 158, 157, 156, 155, 154, 153

NOTES:

1. Auger refusal was encountered at a depth of 6.0 m and borehole was moved 3.0 m to the south and drilling operations continued.

2. Borehole dry on completion of drilling.

3. Borehole caved to 8.2 m on removal of augers.

4. Water level in open borehole at a depth of 7.9 m below ground surface (Elev. 153.8 m) on removal of augers.

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_401\02_DATA\GINT\HWY_401.GPJ GAL-GTA.GDT 01/23/19

GOLDER

RECORD OF BOREHOLE No TP-06

SHEET 1 OF 1 **METRIC**

PROJECT 1665765
G.W.P. 2032-11-00
DIST Central HWY 401
DATUM Geodetic
LOCATION N 4836634.6; E 297406.2 MTM NAD 83 ZONE 10 (LAT. 43.669629; LONG. -79.591690)
BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers, CME 55 Truck Mounted Drill Rig
DATE December 2, 2018
ORIGINATED BY EN
COMPILED BY EN
CHECKED BY NK

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
161.4	GROUND SURFACE										
0.0	ASPHALT (90 mm)										
0.3	CONCRETE (160 mm)										
	Clayey silt, some sand, trace gravel (FILL) Stiff Brown Moist	1	SS	9							
159.9 / 1.5	SAND, some gravel, trace to some silt, trace clay Dense to very dense Brown Moist	2	SS	45		○	NP	18	67	12	3
		3	SS	100/0.23							
		4	SS	122		○					
		5A	SS	99		○					
157.2 / 156.9 / 4.5	Gravelly CLAYEY SILT, some sand Hard Grey	5B			∇	○					
	SAND, some gravel, trace to some silt, trace clay Very dense Grey Wet	6	SS	67		○		13	74	10	3
		7	SS	165/0.28							
154.2	- Auger grinding at 7.0 m depth										
7.2	SILTY CLAY, some sand, trace gravel, contains trace shale fragments (TILL) Hard Grey	8	SS	50		○ (Wp–WL bar)		3	16	59	22
152.7 / 8.7	SHALE, weathered (BEDROCK) Grey Moist										
152.1	- Auger grinding at 8.8 m	9	SS	100/0.03							
9.3	END OF BOREHOLE										

NOTES:

1. Water level at a depth of 9.0 m below ground surface (Elev. 152.4 m) inside augers on completion of drilling.

2. Borehole caved to 5.8 m on removal of auger.

3.. Water level at a depth of 4.6 m below ground surface (Elev. 156.8 m) after removal of augers.

Elevation scale: 161, 160, 159, 158, 157, 156, 155, 154, 153

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

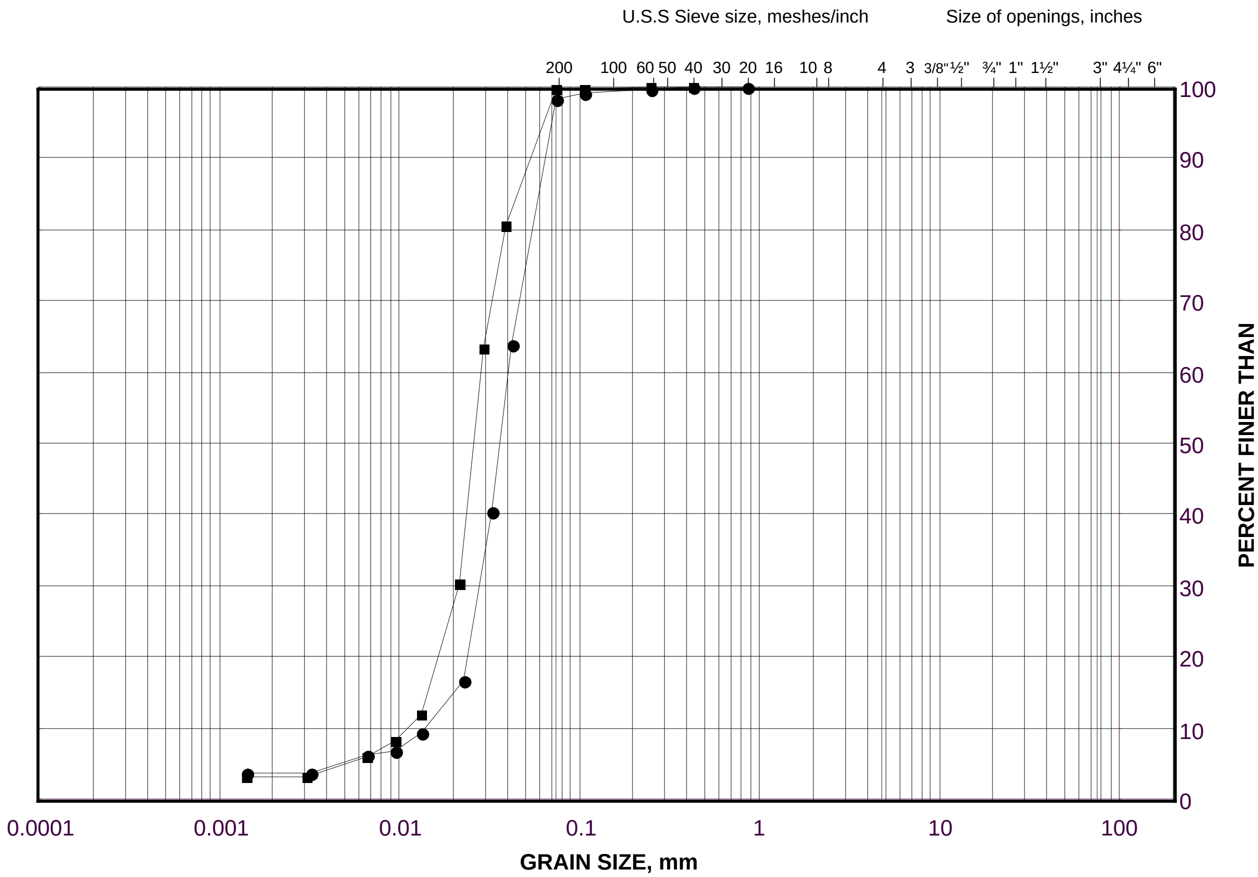
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B1



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

LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-05	2	159.9
■	TP-05	5	157.6

Project Number: 1665765

Checked By: NK

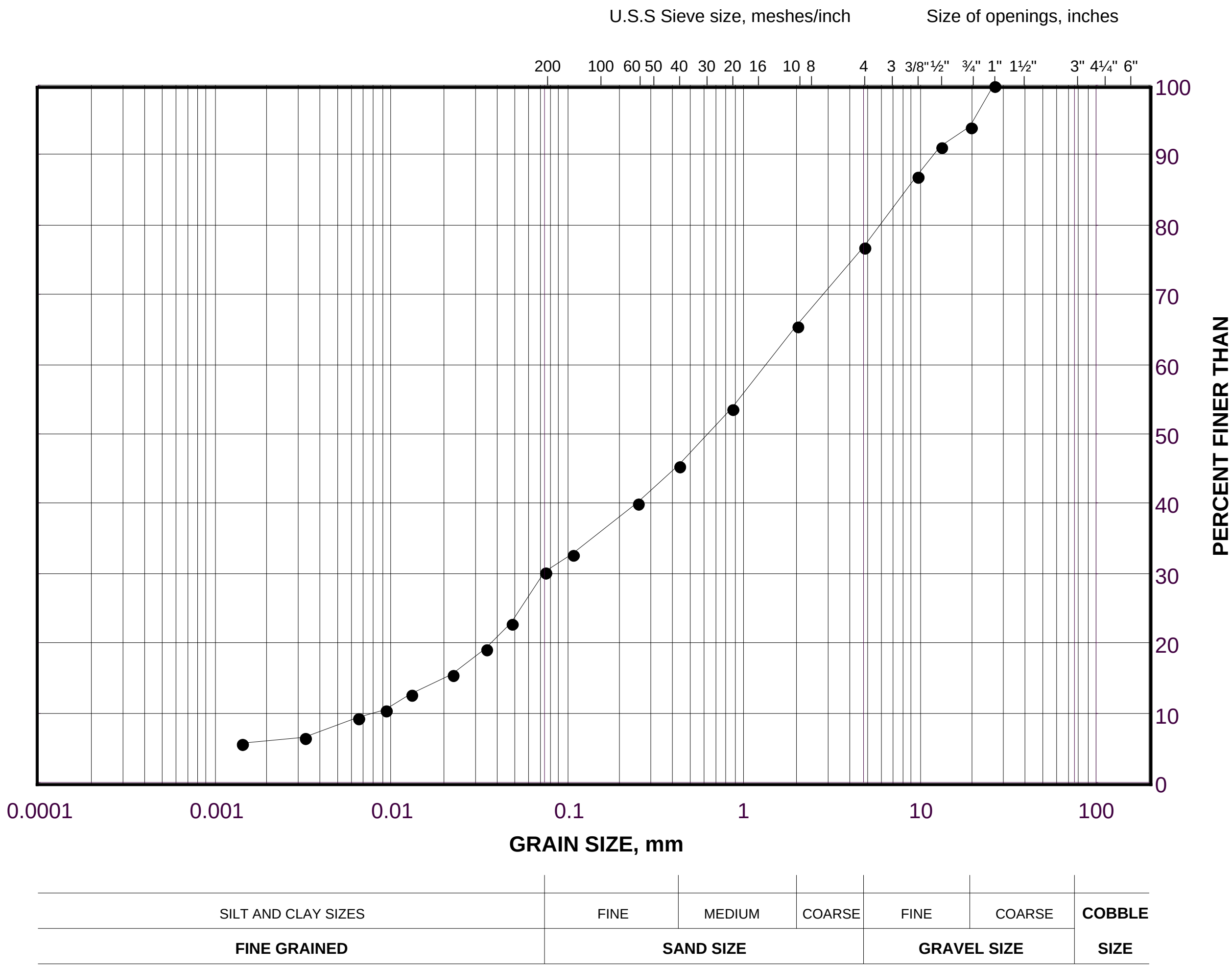
Golder Associates

Date: 16-Jan-19

GRAIN SIZE DISTRIBUTION

Gravelly Silty Sand

FIGURE B2



LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-05	7	155.3

Project Number: 1665765

Checked By: NK

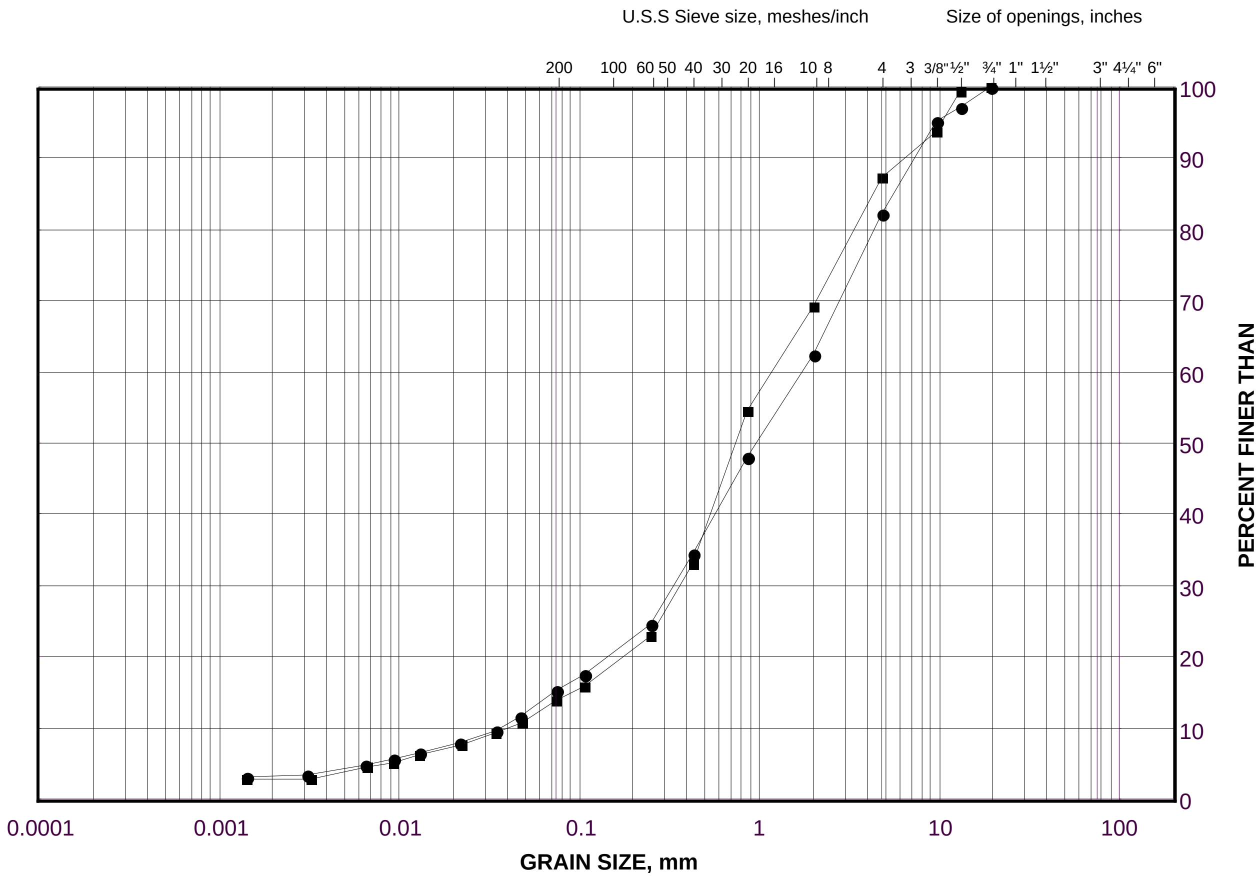
Golder Associates

Date: 16-Jan-19

GRAIN SIZE DISTRIBUTION

Sand

FIGURE B3



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

LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-06	2	159.6
■	TP-06	6	156.5

Project Number: 1665765

Checked By: NK

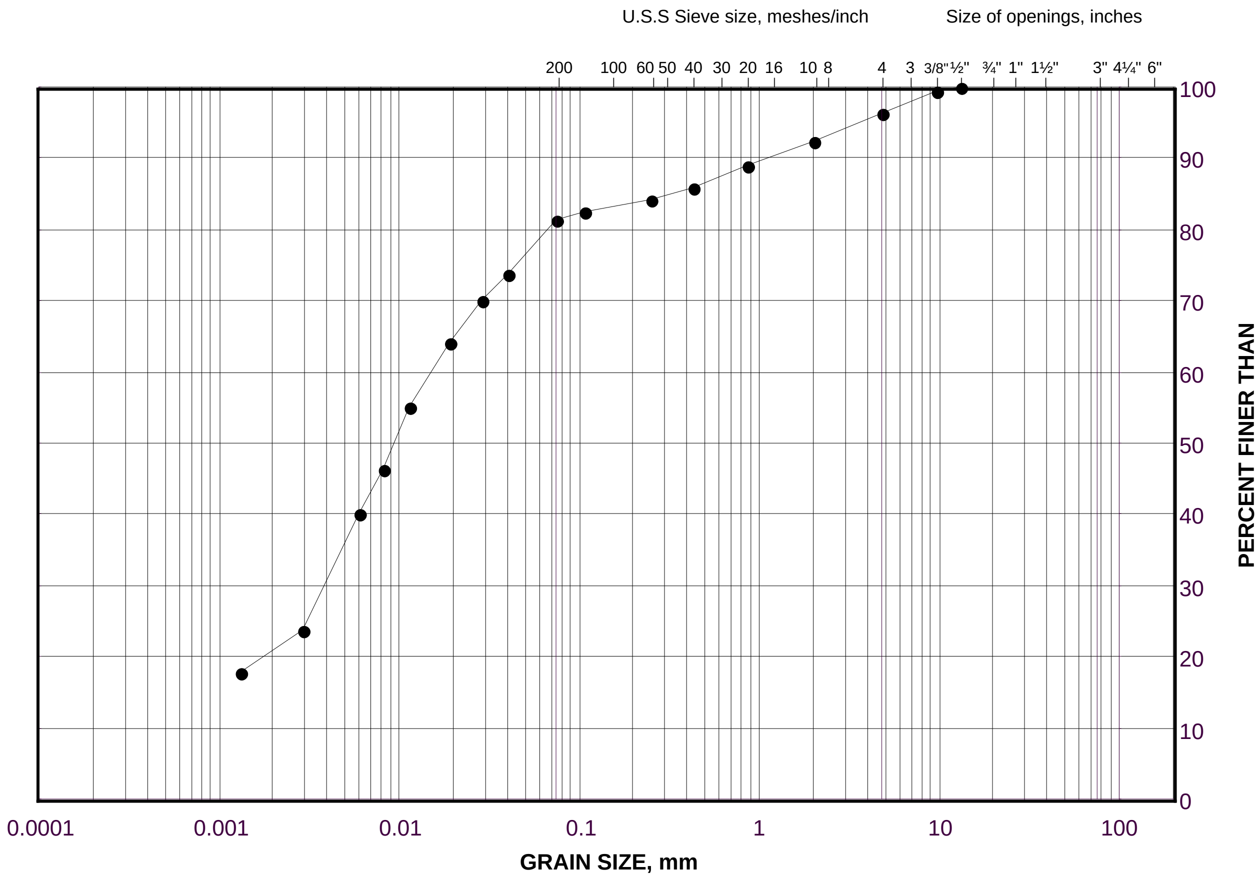
Golder Associates

Date: 16-Jan-19

GRAIN SIZE DISTRIBUTION

Silty Clay (Till)

FIGURE B4



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

LEGEND

SYMBOL	Test Pit	SAMPLE	ELEVATION(m)
●	TP-06	8	153.5

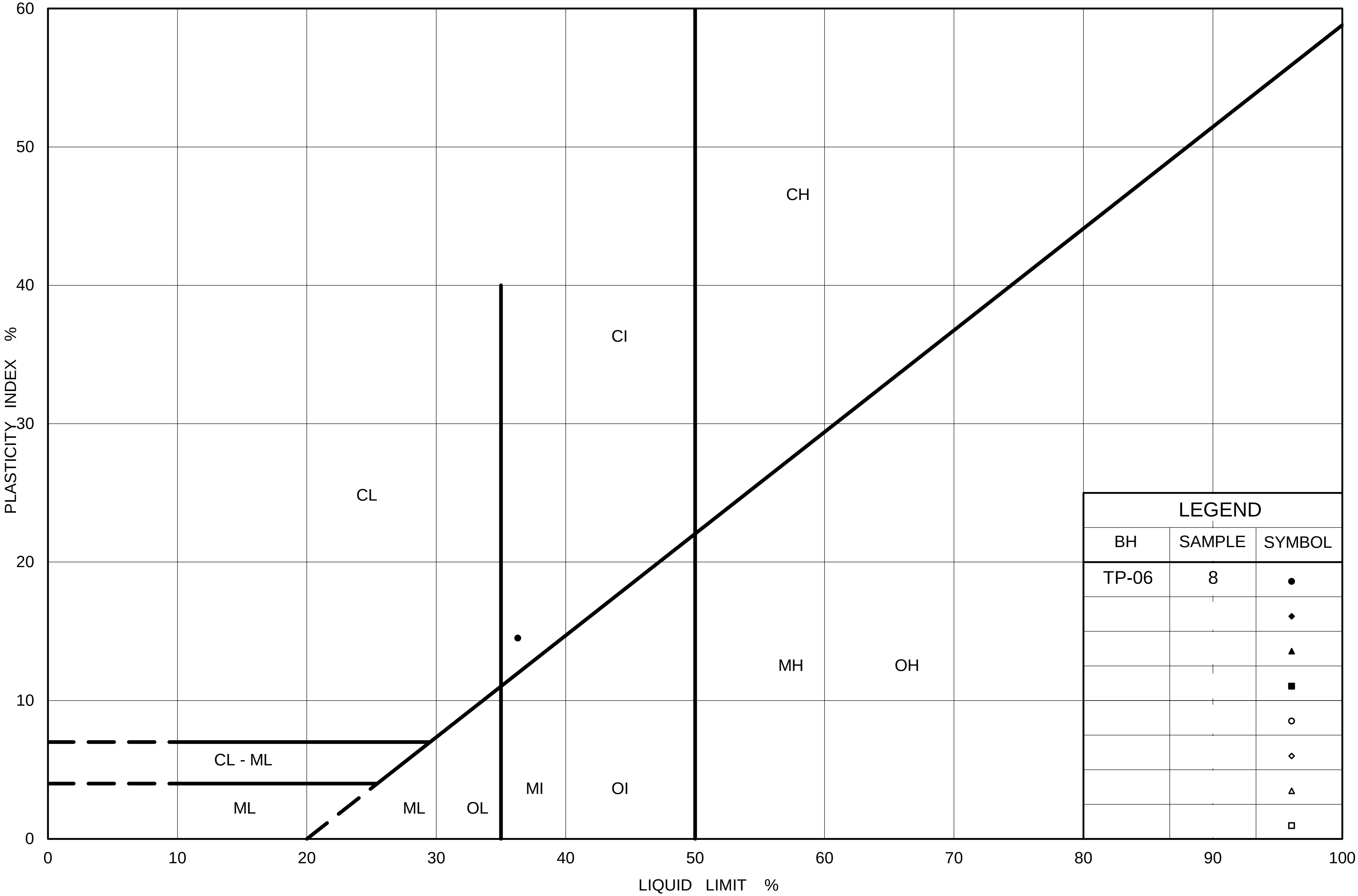
Project Number: 1665765

Checked By: NK

Golder Associates

Date: 16-Jan-19

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay (Till)

Figure No. B5

Project No. 1665765

Checked By: NK

APPENDIX C

Analytical Chemical Test Results

Maxxam
A Bureau Veritas Group Company

Your Project #: 1665765
Site Location: HWY401/427
Your C.O.C. #: 700485-02-01

Attention: Nikol Kochmanova

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

Report Date: 2019/01/18
Report #: R5562434
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B913251
Received: 2019/01/16, 15:46

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	2	N/A	2019/01/18	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2019/01/17	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2019/01/17	2019/01/17	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2019/01/16	2019/01/17	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	2	N/A	2019/01/18	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Your Project #: 1665765
Site Location: HWY401/427
Your C.O.C. #: 700485-02-01

Attention: Nikol Kochmanova

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

Report Date: 2019/01/18
Report #: R5562434
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B913251
Received: 2019/01/16, 15:46

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B913251
Report Date: 2019/01/18

Golder Associates Ltd
Client Project #: 1665765
Site Location: HWY401/427
Sampler Initials: EN

RESULTS OF ANALYSES OF SOIL

Maxxam ID		ITR174		ITR175		
Sampling Date		2018/12/16		2018/12/02		
COC Number		700485-02-01		700485-02-01		
	UNITS	**TP05 SA4**	**RDL**	**TP06 SA6**	**RDL**	**QC Batch**
Calculated Parameters						
Resistivity	ohm-cm	490		1100		5931501
Inorganics						
Soluble (20:1) Chloride (Cl-)	ug/g	1200	40	490	20	5932736
Conductivity	umho/cm	2050	2	950	2	5933030
Available (CaCl2) pH	pH	8.14		7.97		5932730
Soluble (20:1) Sulphate (SO4)	ug/g	44	20	36	20	5932712

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B913251
Report Date: 2019/01/18

Golder Associates Ltd
Client Project #: 1665765
Site Location: HWY401/427
Sampler Initials: EN

TEST SUMMARY

Maxxam ID: ITR174
Sample ID: TP05 SA4
Matrix: Soil

Collected: 2018/12/16
Shipped:
Received: 2019/01/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5932736	N/A	2019/01/18	Deonarine Ramnarine
Conductivity	AT	5933030	N/A	2019/01/17	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5932730	2019/01/17	2019/01/17	Gnana Thomas
Resistivity of Soil		5931501	2019/01/17	2019/01/17	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5932712	N/A	2019/01/18	Alina Dobreanu

Maxxam ID: ITR175
Sample ID: TP06 SA6
Matrix: Soil

Collected: 2018/12/02
Shipped:
Received: 2019/01/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5932736	N/A	2019/01/18	Deonarine Ramnarine
Conductivity	AT	5933030	N/A	2019/01/17	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5932730	2019/01/17	2019/01/17	Gnana Thomas
Resistivity of Soil		5931501	2019/01/17	2019/01/17	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5932712	N/A	2019/01/18	Alina Dobreanu

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GENERAL COMMENTS

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

Package 1	11.0°C

Conducitivity Analysis: Analysis was performed past sample holding time. This may increase the variability associated with these results.

Results relate only to the items tested.

Maxxam Job #: B913251
Report Date: 2019/01/18

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1665765
Site Location: HWY401/427
Sampler Initials: EN

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5932712	Soluble (20:1) Sulphate (SO4)	2019/01/18	116	70 - 130	107	70 - 130	<20	ug/g	NC	35
5932730	Available (CaCl2) pH	2019/01/17			100	97 - 103			1.6	N/A
5932736	Soluble (20:1) Chloride (Cl-)	2019/01/18	107	70 - 130	105	70 - 130	<20	ug/g	0.20	35
5933030	Conductivity	2019/01/17			103	90 - 110	<2	umho/cm	1.9	10

N/A = Not Applicable

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

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

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

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

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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Maxxam Job #: B913251
Report Date: 2019/01/18

Golder Associates Ltd
Client Project #: 1665765
Site Location: HWY401/427
Sampler Initials: EN

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

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

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16-Jan-19 15:46
Ema Gitej
B913251
MAF ENV-920
C#700485-02-01

Page of

Bottle Order #: 700485
Project Manager: Ema Gitej

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name	#1326 Golder Associates Ltd	Company Name		Quotation #	B80683
Attention	Accounts Payable	Attention	Nikol Kochmanová	P.O. #	
Address	6925 Century Ave Suite 100	Address		Project	1665765
	Mississauga ON L5N 7K2			Project Name	Hwy 401/427
Tel	(905) 567-4444 Fax (905) 567-6561	Tel	Fax	Site #	
Email	AP_CustomerService@golder.com	Email	nikol_kochmanova@golder.com	Sampled By	EN

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

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ___ ☐ PWQO ☐ Other ___

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; Corrosivity pkg (pH, Cl, SO4, EC/Resistivity)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☐
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Jan 18, 19 Time Required: 3:00PM ☑
Rush Confirmation Number: ___ (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered / Metals / Hg / Cr VI	Corrosivity pkg	# of Bottles	Comments
1		TP05 SA4	Dec16,'18	PM	Soil		✓	1	
2		TP06 SA6	Dec2,'18	PM	Soil		✓	1	
3									
4									
5									
6									
7									
8									
9									
10									

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
[signature] Eric Naylor	Jan 16/19	4:00PM	[signature] TRUSHNA PATEL	2019/01/16	15:46	

Laboratory Use Only: Time Sensitive; Temperature (°C) on Receipt: 11/11/11 Ice

Custody Seal	Yes	No
Present		✓
Intact		✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX D

Non-Standard Special Provisions

DEEP FOUNDATIONS - Item No.

Non-Standard Special Provision

Where OPSS 903 is called up by OPSS 915, OPSS 903 is amended by the following. Where conflict occurs, this NSSP shall take precedence.

The Contractor shall construct sign support foundations in conformance with the design and at the locations indicated in the Contract Documents.

The Contractor shall construct the sign support foundations against undisturbed bases and sides of excavations. The bases of caisson excavations shall be cleaned of loosened and/or softened materials prior to pouring concrete for the foundation. The construction methods and techniques shall be the responsibility of the contactor, but consideration could be given to using temporary liners or placement of concrete by tremie methods where conditions warrant.

The contractor is advised that variable subsurface conditions may be encountered at the caisson locations for the two cantilever overhead signs. For bidding purposes, the Contractor shall assume that the overburden has zones of non-cohesive soil and contains cobbles and boulders, as inferred from drilling / sampling operations, and that the groundwater levels are within about 4.5 m below the ground surface. The Contractor is advised that non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head. As a lower priority than the above-noted instruction, the Contractor shall assume that the subsurface conditions at sign (including conventional overhead type) foundation locations are generally similar to the closest of the boreholes, as illustrated in the Foundation Investigation Report.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

OBSTRUCTIONS – Item No.

Notice to Contractor

The Contractor shall be alerted to the presence of obstructions including shale fragments, cobbles and boulders within the fill soils and the native silt, sand, gravelly silty sand to sand and gravel, silty clay and glacially derived till deposits. Details of the depths at which obstructions were encountered (as inferred from auger grinding during borehole investigation) are detailed in the Foundation Investigation Report and associated Record of Boreholes at each overhead sign location. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for excavations and construction of overhead sign foundations.

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