



February 21, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

High Mast Light Poles Highway 401/Holt Road Interchange Reconfiguration Clarington, Ontario G.W.P. 2101-08-00

Submitted to:
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REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
3.0 INVESTIGATION PROCEDURES	1
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	3
4.1 Regional Geology	3
4.2 Subsurface Conditions.....	3
4.2.1 Topsoil	4
4.2.2 Asphalt.....	4
4.2.3 Sand Fill	4
4.2.4 Clayey Silt Fill	4
4.2.5 Silty Sand.....	5
4.2.6 Clayey Silt (Till)	5
4.2.7 Silt and Sand (Till).....	5
4.3 Groundwater Conditions	6
5.0 CLOSURE.....	6

PART B – FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS.....	7
6.1 General.....	7
6.2 Design of High Mast Light Pole Foundations.....	7
6.3 Construction Considerations.....	7
6.3.1 Control of Soil and Groundwater.....	7
6.3.2 Obstructions During Caisson Installation	8
7.0 CLOSURE.....	8

REFERENCES

TABLES

Table 1	Geotechnical Design Parameters for High Mast Light Pole Foundations
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FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

DRAWINGS

Drawing 1 Borehole Locations

APPENDIX A Borehole Records

Lists of Abbreviations and Symbols

Record of Boreholes:

13-1, 13-2, 13-3, 13-4, 13-11, 13-15, 13-16, 13-19, 13-20, 13-23, 13-46, 13-50

APPENDIX B Laboratory Test Results

Figure B1 Grain Size Distribution Test Results – Clayey Silt (Fill)

Figure B2 Plasticity Chart – Clayey Silt (Fill)

Figure B3 Grain Size Distribution Test Results – Clayey Silt (Till)

Figure B4 Plasticity Chart – Clayey Silt (Till)

Figure B5 Grain Size Distribution Test Results –Silt and Sand (Till)

APPENDIX C Non-Standard Special Provisions



PART A

**FOUNDATION INVESTIGATION REPORT
HIGH MAST LIGHT POLES
HIGHWAY 401/HOLT ROAD INTERCHANGE RECONFIGURATION
CLARINGTON, ONTARIO
G.W.P. 2101-08-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the Highway 401/Holt Road Interchange reconfiguration in the Town of Clarington, Regional Municipality of Durham, Ontario.

This report addresses the results of the detail subsurface investigation carried out for the High Mast Light (HML) Pole foundations.

The Terms of Reference for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 2008-E-0059 dated March 2009 and associated clarifications, and in Section 6.8 of the URS *Technical Proposal* for this assignment. The Scope of Work for the HML foundation investigation is summarised in Golder's Scope Change Letter dated January 31, 2014.

2.0 SITE DESCRIPTION

The existing Highway 401/Holt Road Interchange is located near the entrance to the Darlington Nuclear Power Plant, approximately 10 km east of Oshawa, Ontario.

Based on the drawings of the proposed new Highway 401/Holt Road Interchange provided by URS (Drawing No. 2013-10-24-Hwy401-HoltRd_profile and 2013-10-24-Hwy401-HoltRd_plan), the existing Holt Road will be realigned and a new bridge structure with associated interchange ramps will be constructed about 30 m to the east of the existing underpass bridge. Further, it is understood that the South Service Road will be realigned to the south as part of the interchange reconfiguration, to accommodate the future Highway 407 East Durham Link that connects to Highway 401 immediately to the west of the site.

In general, the terrain in the area of the proposed new interchange is relatively flat to gently rolling, with the natural ground surface within the limits of the project ranging between about Elevations 111 m and 116 m.

The proposed HML poles are located at the roundabouts immediately north and south of the proposed Holt Road bridge structure, at the intersection of Holt Road and the interchange ramps, as shown on Drawing 1, and summarised below.

- HML 1 – Holt Road roundabout south of Highway 401 at about Station 10+091, and
- HML 2 – Holt Road roundabout north of Highway 401 at about Station 9+795.

3.0 INVESTIGATION PROCEDURES

As part of the foundation investigation for the interchange reconfiguration (Golder 2013 (a) and (b)) fifty one (51) boreholes (Boreholes HR-1, HR-2, 13-1 to 13-21 and 13-23 to 13-50) were advanced on November 22, 2012 and between May 27 and August 22, 2013 to investigate the subsurface conditions at the proposed bridge structure, high fill embankments and deep cut areas. The boreholes from this investigation located in the area of the proposed HML poles have been used in this report, namely Boreholes 13-1 to 13-4, 13-11, 13-15, 13-16, 13-19, 13-20, 13-23, 13-46 and 13-50, and specifically the boreholes which are closest to the proposed HML Poles, Boreholes 13-2, 13-11 and 13-19.



FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

The boreholes were drilled by conventional track and truck mounted drill rigs supplied and operated by KC Drilling Ltd. of Innisfil, Ontario and Strong Soil Search Inc. of Claremont, Ontario. The boreholes were advanced through the overburden using 108 mm, 120 mm and 150 mm solid stem augers. In general, samples of the overburden soils were obtained at intervals of depth ranging from 0.75 m to 1.5 m using a 50 mm outer diameter (O.D.) split-spoon sampler operated by an automatic hammer on the drill rigs, performed in accordance with Standard Penetration Testing (SPT) procedures, as specified in ASTM Method D1586.

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations, and monitored in a piezometer installed in one of the boreholes, and are described on the Record of Borehole sheets in Appendix A. It should be noted that groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations in precipitation and on local soil permeability. All boreholes were abandoned by backfilling to the ground surface with bentonite upon completion in accordance with Ontario Regulation 903 (as amended).

The three boreholes specific to the HML Pole locations were advanced to depths between 4.6 m and 7.7 m below existing ground surface, generally penetrating below ground surface to a depth equivalent to the proposed height of the embankment fill and a minimum of 2 m into "refusal" material (SPT N-values > 100 blows per 0.3 m of penetration).

The proposed centreline of each roadway and ramp alignment was staked at 50 m intervals in the field by URS prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the centreline alignment and were subsequently converted into MTM NAD 83 coordinates using the base drawing provided by URS in AutoCAD format. Borehole elevations were surveyed by a member of our technical staff in reference to the surveyed ground surface elevations at the centreline median. The locations of the closest borehole(s) to the proposed HML poles shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.

Summary of Borehole Locations and Elevations

HML Pole Designation	Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
HML 1	13-2	4860647.0	367303.2	116.3	7.7
HML 2	13-11	4860938.7	367308.4	109.7	4.7
	13-19	4860918.3	367294.0	110.0	4.6

Prepared by: MWK, Checked by KJB

The field work was observed by members of our engineering and technical staff who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further detailed visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples. The results of the laboratory



FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

classification testing are summarized on the Record of Borehole sheets and are included in Appendix B for the three specific boreholes drilled closest to the HML Pole locations.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 401 is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)¹ and *Urban Geology of Canadian Cities* (Karrow and White, 1998)². The Iroquois Plain extends around the western shores of Lake Ontario. The Plain is comprised of the flat to undulating lakebed and beaches of the former glacial Lake Iroquois, which occupied this area during the last glacial recession.

The surficial soils in this area of the Iroquois Plain are typically comprised of glaciolacustrine clays, silts and sands to gravelly sands, which are underlain by an extensive till deposit that is mapped in this area as the Bowmanville Till. Within the area approximately bounded by Holt Road and Morgan's Road, the surficial glaciolacustrine deposits are absent or of limited thickness and the Bowmanville Till unit is frequently present immediately below the ground surface. Between these limits, an extensive surficial deposit of clayey silt to silty clay is present over the Bowmanville Till (Karrow and White, 1998). More recent alluvial deposits of gravel, sand, silt and/or clay are present in the valleys associated with Bowmanville Creek, Soper Creek, Wilmot Creek and Graham Creek.

The overburden soils are underlain by limestone bedrock of the Lindsay Formation, Simcoe Group (Geological Survey of Canada, 1997).³

4.2 Subsurface Conditions

The borehole locations and ground surface elevations are shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A. The results of geotechnical laboratory testing on samples from pertinent boreholes are also presented on Figures B1 to B5 contained in Appendix B.

The stratigraphic boundaries shown on the borehole records are inferred from observations of drilling progress and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the borehole locations.

The description of the subsurface conditions encountered at the site in the following sections is based on the three (3) boreholes advanced as part of the high fill and deep cut investigation that are closest in proximity to the HML Pole locations (Boreholes 13-2, 13-11 and 13-19). The subsurface conditions encountered in these boreholes are generally consistent with the subsurface conditions encountered in the other boreholes advanced in the general vicinity of the HML pole locations as shown on Drawing 1 and presented on the Record of Borehole sheets included in Appendix A.

¹ Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

² Karrow, P. F., and White, O. L., 1998. *Urban Geology of Canadian Cities*. Geological Association of Canada Special Paper No. 42. St. John's, Nfld.

³ Ontario Geological Society, 1991. *Geology of Ontario*. Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.



FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

In summary, the subsurface conditions encountered at the site consist of a surficial layer of asphalt underlain by a fill deposit comprised of sand, some gravel, to clayey silt or a topsoil layer underlain by a silty sand deposit. The silty sand and fill deposits are underlain by a very dense/hard silt and sand to clayey silt till deposit.

A more detailed description of the subsurface conditions encountered in the three boreholes is provided in the following sections. The subsurface conditions for each specific HML pole location can be inferred from the closest borehole.

4.2.1 Topsoil

A 0.3 m and 0.4 m thick deposit of topsoil was encountered immediately below ground surface in Boreholes 13-11 and 13-19.

One Standard Penetration Test (SPT) "N" value measured within the topsoil deposit is 23 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The natural water content measured on one sample of the topsoil is 14 per cent.

4.2.2 Asphalt

An approximately 0.15 m thick layer of asphalt was encountered in Borehole 13-2 at ground surface.

4.2.3 Sand Fill

A fill deposit comprised of sand, some gravel, trace silt was encountered below the asphalt in Boreholes 13-2. The surface of the granular fill deposit was encountered at Elevation 116.1 m and the deposit is 0.6 m thick.

The natural water content measured on one sample of the granular fill is 3 per cent.

4.2.4 Clayey Silt Fill

A deposit of sandy clayey silt to clayey silt fill was encountered below the sand fill in Borehole 13-2. The cohesive fill deposit also contains trace to some gravel, trace organics and rootlets. The surface of the cohesive fill deposit was encountered at Elevation 115.5 m and the deposit is 4.8 m thick.

The measured SPT "N"-values within this deposit range from 23 blows to 106 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

The results of grain size distribution tests completed on two selected samples of the clayey silt fill are shown on Figure B1 in Appendix B.

Atterberg limits testing conducted on one selected sample of the clayey silt fill measured a plastic limit of about 13 per cent, a liquid limit of about 20 per cent and a plasticity index of about 7 per cent. This test result, which is plotted on a plasticity chart on Figure B2 in Appendix B, indicates that the fill consists of clayey silt of low plasticity.

The natural water content measured on two selected samples of the clayey silt fill deposit is about 13 per cent and 15 per cent.



4.2.5 Silty Sand

A granular deposit comprised of silty sand, trace gravel, trace clay was encountered underlying the topsoil in Borehole 13-19. The surface of the silty sand deposit was encountered at a depth of 0.3 m below ground surface (Elevation 109.7 m), and the deposit is 1.2 m thick.

The measured SPT “N”-values within this deposit are 16 blows and 73 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The natural water content measured on one selected sample of the silty sand deposit is about 11 per cent.

4.2.6 Clayey Silt (Till)

A deposit of clayey silt till was encountered below the fill in Borehole 13-2, and below the topsoil in Borehole 13-11. The surface of the clayey silt till was encountered at depths of 5.6 m and 0.4 m below ground surface, corresponding to Elevations 110.7 m and 109.3 m in the respective boreholes. The thickness of this till deposit is about 2.1 m and 4.3 m in the respective boreholes and was not fully penetrated.

The measured SPT “N”-values within this deposit range from 50 blows per 0.13 m of penetration to 50 blows per 0.05 m of penetration, suggesting a hard consistency.

The till deposit consists of clayey silt with sand, trace to some gravel. The presence of cobbles and boulders within this deposit was inferred from grinding of the augers as noted on the Record of Borehole sheets. The results of grain size distribution tests completed on three selected samples of the clayey silt till are shown on Figure B3 in Appendix B.

Atterberg limits testing was conducted on two selected samples of the clayey silt till and measured plastic limits of 9 per cent and 10 per cent, liquid limits of about 15 per cent and plasticity indices of about 5 per cent and 6 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B4 in Appendix B and indicate that the material is a clayey silt of low plasticity.

The natural water content measured on samples of the clayey silt till deposit ranges from about 5 per cent to 9 per cent.

4.2.7 Silt and Sand (Till)

A deposit of silt and sand till was encountered underlying the silty sand deposit in Borehole 13-19. The surface of the silt and sand till deposit was encountered at a depth of 1.5 m below ground surface, at Elevation 108.5 m, and the borehole was terminated within this till deposit at a depth of 4.6 m below ground surface corresponding to Elevation 105.4 m.

The measured SPT “N”-values within this deposit range from 50 blows per 0.1 m of penetration to 50 blows per 0.05 m of penetration, indicating a very dense relative density.

The glacial till deposit consists of silt and sand, some clay, trace to some gravel. The presence of cobbles and boulders within this deposit was inferred from grinding of the augers as noted on the Record of Borehole sheet. The results of grain size distribution tests completed on two selected samples of the silt and sand till are shown on Figure B5 in Appendix B.



FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

The natural water content measured on three samples of the silt and sand till deposit ranges from about 4 per cent to 7 per cent.

4.3 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets in Appendix A of this report. The water level in Borehole 13-2 was measured at a depth of 7.3 m below ground surface corresponding to Elevation 109.0 m in Borehole 13-2; Boreholes 13-11 and 13-19 were dry upon completion of drilling.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Matthew Kelly, P.Eng. and reviewed by Mr. Jorge Costa, P.Eng., a Principal with and Designated MTO Foundations Contact for Golder.

GOLDER ASSOCIATES LTD.



Matthew Kelly, P.Eng.
Geotechnical Engineer



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

MWK/JMAC/sm

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PART B

**FOUNDATION DESIGN REPORT
HIGH MAST LIGHT POLES
HIGHWAY 401/HOLT ROAD INTERCHANGE RECONFIGURATION
CLARINGTON, ONTARIO
G.W.P. 2101-08-00**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides geotechnical recommendations for the design of the high mast light (HML) pole foundations. The recommendations are based on interpretation of the factual data obtained from boreholes advanced in the general area of the HML Poles. The interpretation and recommendations contained in this report are intended to provide the designers with sufficient information to carry out detail design of the HML pole foundations. 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.

Available subsurface information pertinent to the design of the HML Pole foundations was obtained from one borehole located approximately 10 m south of HML1 and two boreholes located approximately 85 m to 100 m east of HML 2. Golder has reviewed the topography and subsurface conditions for other boreholes in the general area of each proposed HML pole and confirms that the conditions are relatively consistent in the area and therefore relevant to the proposed HML pole locations.

6.2 Design of High Mast Light Pole Foundations

Two new HML pole foundations are required for the proposed reconfiguration of the Highway 401/Holt Road interchange. The foundations should consist of a single caisson at each HML Pole location designed using the geotechnical parameters provided in Table 1 following the text of this report.

Caisson foundations for HML poles should be designed in accordance with the requirements in MTO's *Guidelines for the Design of High Mast Pole Foundations* (MTO, 2004), based on the interpolated stratigraphy between the boreholes and the HML Pole locations and geotechnical design parameters given in Table 1. In the design of the foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action (OPSD 3090.101).

It has been assumed that the recommendations provided in Golder's Foundation Design Report (Golder, 2013(b)) for the High Fill and Deep Cut sections of the roadway in the general vicinity of the HML pole foundations will be followed, in that any near surface loose/soft, organic, or existing fill soils that do not form part of an existing roadway embankment, will be removed prior to construction and suitable earth fill will be used for embankment construction. However, the thickness of the fill through which the caisson foundations will extend should be taken as one-half (1/2) of the actual thickness of the fill deposit in the design of the caisson embedment depth.

6.3 Construction Considerations

6.3.1 Control of Soil and Groundwater

Running or flowing of water-bearing cohesionless soil strata and/or fill material could occur during caisson construction. Temporary or permanent caisson liners may be required to support the soils during construction and placement of concrete by tremie methods may be required near the bottom of the caissons to keep the hole open and minimize disturbance to the caisson base. It is recommended that a Non-Standard Special Provision



FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

(NSSP) be included in the Contract Documents to warn the Contractor of this condition; such an NSSP is provided in Appendix C.

6.3.2 Obstructions During Caisson Installation

The soils at this site are glacially derived and as such should be expected to contain cobbles and boulders, which could affect the installation of caisson foundations. The presence of cobbles and boulders was inferred from auger grinding in the very dense silt and sand till/hard clayey silt till as noted on the Record of Borehole sheets. It is recommended that an NSSP be included in the Contract Documents to warn the Contractor of the possible presence of cobbles and/or boulders within the overburden soils and an example NSSP is presented in Appendix C.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Matthew Kelly, P.Eng. and reviewed by Mr. Jorge Costa, P.Eng., a Principal with and Designated MTO Foundations Contact for Golder.

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Designated MTO Foundations Contact, Principal

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Ontario Provincial Standard Drawings (OPSD)

OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario

TABLE 1
GEOTECHNICAL DESIGN PARAMETERS FOR HIGH MAST LIGHT POLE FOUNDATIONS
HIGHWAY 401/Holt Road Interchange Reconfiguration, G.W.P. 2101-08-00

Pole No.	Approximate Holt Road Station	Nearest Relavant Borehole	Ground Surface Elevation at Reference Borehole (m)	Proposed Ground Surface Elevation at HML Pole Location (m)	Stratum*	Depth Below Proposed Ground Surface at HML Pole Location (m) ¹	Elevation (m)	Estimated Groundwater Elevation (m)	Design Parameters ^{2,3}					
									S _u (kPa)	Φ'	γ (kN/m ³)	γ' (kN/m ³)	K _p	n _h (kPa/m)
HML 1	10+091	13-2	116.3	118.5	Earth Fill (Assumed - Existing/New)	7.8	118.5 - 110.7	109.0	50	28	19	9	2.8	1800
					Hard clayey silt till	Below 7.8	Below 110.7		200	34	21	11	3.5	10000
HML 2	9+795	13-11 / 13-19	109.7 / 110.0	114.2	Earth Fill (Assumed - Existing/New)	0 - 4.9	114.2 - 109.3	109.3	50	28	19	9	2.8	1800
					Compact to very dense silty sand	4.9 - 5.7	109.3 - 108.5		-	32	20	10	3.3	4400
					Very dense silt and sand till/hard clayey silt with sand till	Below 5.7	Below 108.5		-	34	21	11	3.5	10000

*Assumes existing topsoil will be removed

NOTES:

1. Depths are given at the proposed HML pole locations relative to the estimated proposed Holt Road ground surface shown on the profile drawings provided in the 90% Contract Drawings.
The actual ground surface elevation at the HML locations should be used and the stratum depths adjusted accordingly. 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

φ'

γ

γ'

K_p

n_h

= undrained shear strength (kPa);

= effective friction angle (degrees);

= bulk unit weight (kN/m³);

= effective unit weight below the groundwater level (kN/m³);

= passive earth pressure coefficient.

= Coefficient of horizontal subgrade reaction
3. Where both undrained shear strength and effective friction angle parameters are provided, the structural assessment should be completed for both cohesive soil and cohesionless soil cases, and the selected design should be based on the more conservative result.

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

CONT No.
GWP No. 2101-08-00

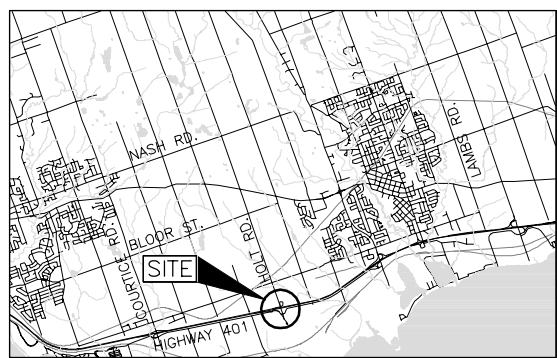
HIGHWAY 401/HOLT ROAD INTERCHANGE
HIGH MAST LIGHT POLES
BOREHOLE LOCATIONS



SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE

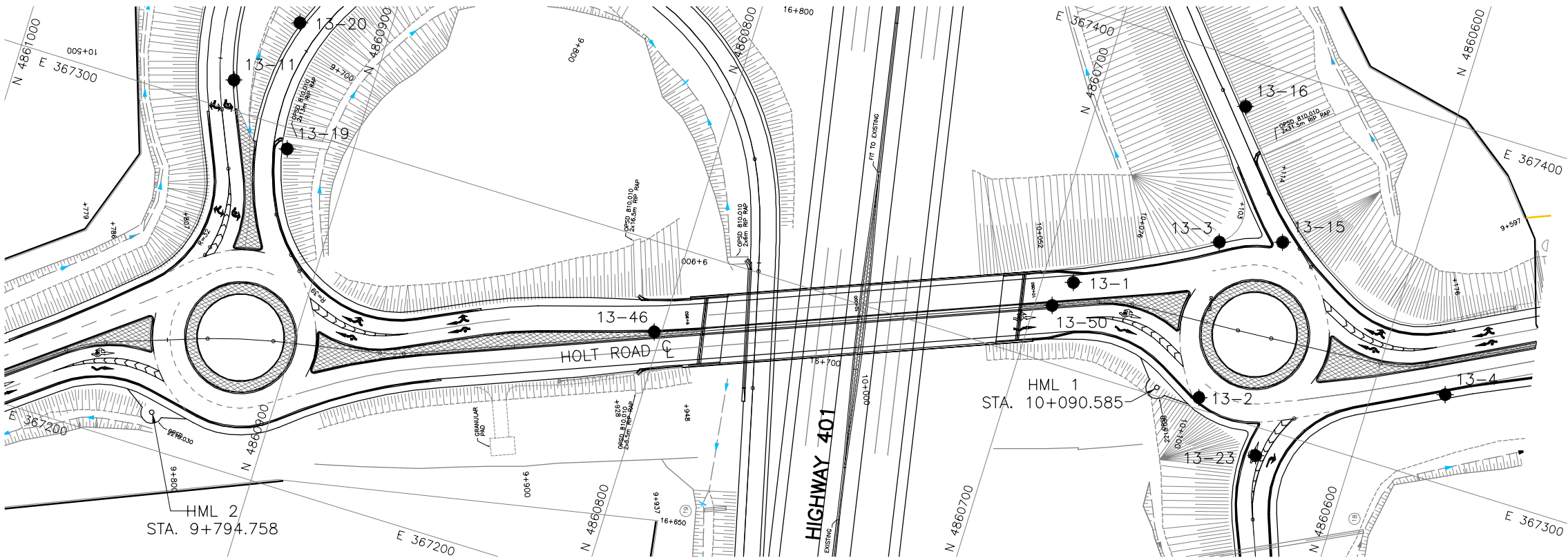
2 0 2 4 km



LEGEND



Borehole - Current Investigation



PLAN

SCALE
15 0 15 30 m

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 complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plan provided in digital format by URS, drawing file no. HoltRd_hmlp to golder.dwg, received January 21, 2014

NO.	DATE	BY	REVISION
Geocres No. 30M15-165			
HWY. 401		PROJECT NO. 09-1111-0019	DIST.
SUBM'D. MWK	CHKD. MWK	DATE: Feb. 2014	SITE:
DRAWN: JFC	CHKD. KJB	APPD. JMAC	DWG. 1



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
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

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

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

PROJECT 09-1111-0019		RECORD OF BOREHOLE No 13-1		SHEET 1 OF 1		METRIC	
G.W.P. 2101-08-00		LOCATION N 4860691.2 ; E 367324.1		ORIGINATED BY JLC			
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM			
DATUM Geodetic		DATE May 27, 2013		CHECKED BY MWK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _p	W	W _L						
111.0	GROUND SURFACE																				
0.0	TOPSOIL		1	SS	3																
110.6																					
110.2	Clayey silt, some sand, trace gravel (FILL) Brown Moist		2	SS	34																
0.8	CLAYEY SILT with SAND to some sand, trace to some gravel, inferred cobbles throughout (TILL) Hard Brown to grey Moist		3	SS	50/0.13													3 15 49 33			
			4	SS	50/0.13													12 39 37 12			
			5	SS	50/0.08																
			6	SS	50/0.08																
			7	SS	50/0.08																
			8	SS	50/0.08																
			9	SS	50/0.05																
			10	SS	50/0.05																
101.8	END OF BOREHOLE																				
9.2	NOTES: 1. Water level at a depth of 6.1 m below ground surface (Elev. 104.9 m) upon completion of drilling. 2. Borehole caved to a depth of 6.1 m below ground surface (Elev. 104.9 m) upon completion of drill																				

GTA-MTO 001 09-1111-0019.GPJ GAL-GTA.GDT 2/7/14

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

PROJECT		RECORD OF BOREHOLE		No 13-2		SHEET 1 OF 1		METRIC								
G.W.P. 09-1111-0019		LOCATION		N 4860647.0 ; E 367303.2		ORIGINATED BY		JLC								
DIST		HWY 401		BOREHOLE TYPE		120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY								
DATUM		Geodetic		DATE		May 30, 2013		CHECKED BY								
								MWK								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
116.3	GROUND SURFACE															
0.0	ASPHALT (150 mm)															
0.2	Sand, some gravel, trace silt (FILL)		1	AS	-											
115.5	Brown Moist		2	SS	37											
0.8	Sandy clayey silt to clayey silt, some sand, trace to some gravel, trace organics and containing rootlets (FILL)		3	SS	36											
	Very stiff to hard		4	SS	33											
	Brown to grey Moist		5	SS	106											
			6	SS	28											
			7	SS	23											
110.7																
5.6	CLAYEY SILT with SAND trace to some gravel, inferred cobbles throughout (TILL)		8	SS	100/0.10											
	Hard Grey Wet															
108.6																
7.7	END OF BOREHOLE		9	SS	100/0.08											
NOTES:																
1. Water level at a depth of 7.3 m below ground surface (Elev. 109.0 m) during drilling.																
2. Borehole caved at a depth of 7.6 m below ground surface (Elev. 108.7 m) upon completion of drilling.																

PROJECT 09-1111-0019		RECORD OF BOREHOLE No 13-3		SHEET 1 OF 1		METRIC	
G.W.P. 2101-08-00		LOCATION N 4860654.6 ; E 367347.6		ORIGINATED BY JLC			
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM			
DATUM Geodetic		DATE May 28, 2013		CHECKED BY MWK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE							
110.9	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL		1	SS	16											
110.6																
0.3	Clayey silt, some sand, trace to some gravel (FILL) Very stiff Brown Moist		2	SS	21											
110.1																
0.8	CLAYEY SILT with SAND, trace to some gravel, inferred cobbles and boulders at 4.6 m depth (TILL) Very stiff to hard Brown to grey Moist		3	SS	64											
			4	SS	50/0.13											
			5	SS	50/0.10											
			6	SS	50/0.08											
			7	SS	50/0.02											
	Augers grinding on inferred cobbles and boulders		8	SS	50/0.02											
			9	SS	50/0.10											
103.2																
7.7																

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

PROJECT		RECORD OF BOREHOLE No 13-4		SHEET 1 OF 1		METRIC											
G.W.P. 09-1111-0019		LOCATION N 4860579.7 ; E 367324.9		ORIGINATED BY JLC													
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM													
DATUM Geodetic		DATE May 27, 2013		CHECKED BY MWK													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30					
113.5	GROUND SURFACE																
0.0	TOPSOIL																
113.1			1	SS	27		113										
0.4	CLAYEY SILT with SAND trace gravel, inferred cobbles and boulders (TILL) Hard Brown to grey Moist		2	SS	50/0.15	▽	112										16 38 34 12
			3	SS	50/0.08		111										9 43 38 10
	Augers grinding on inferred cobbles and boulders between depths of 2.13 m and 4.6 m		4	SS	50/0.08		110										
			5	SS	50/0.08		109										
	Augers grinding on inferred cobbles and boulders at a depth of 3.8 m		6	SS	50/0.08												
108.9	END OF BOREHOLE		7	SS	50/0.08												
4.7	NOTES: 1. Water level at a depth of 0.9 m below ground surface (Elev. 112.6 m) during drilling. 2. Borehole caved to a depth of 3.4 m below ground surface (Elev. 110.1 m) upon completion of drilling.																

PROJECT <u>09-1111-0019</u>		RECORD OF BOREHOLE No 13-11		SHEET 1 OF 1		METRIC	
G.W.P. <u>2101-08-00</u>		LOCATION <u>N 4860938.7 ; E 367308.4</u>		ORIGINATED BY <u>JLC</u>			
DIST <u> </u> HWY <u>401</u>		BOREHOLE TYPE <u>108 mm O.D. Continuous Flight Solid Stem Power Auger</u>		COMPILED BY <u>BM</u>			
DATUM <u>Geodetic</u>		DATE <u>June 4, 2013</u>		CHECKED BY <u>MWK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						w _p	w	w _L		GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT		RECORD OF BOREHOLE No 13-15		SHEET 1 OF 1		METRIC																		
G.W.P. 09-1111-0019		LOCATION N 4860637.2 ; E 367352.9		ORIGINATED BY JLC																				
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM																				
DATUM Geodetic		DATE May 31, 2013		CHECKED BY MWK																				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																			
111.1	GROUND SURFACE																							
0.0	TOPSOIL		1	SS	18																			
110.7																								
0.4	Sandy clayey silt, trace gravel (FILL) Very stiff Brown Moist		2	SS	28																			
109.7																								
1.4	CLAYEY SILT with SAND trace to some gravel, inferred cobbles and boulders at 4.6 m depth (TILL) Hard Brown to grey Moist		3	SS	50																			
			4	SS	50/13																			
			5	SS	50/10																			
			6	SS	50/10																			
			7	SS	50/10																			
	Augers grinding on inferred cobbles and boulders		8	SS	50/10																			
			9	SS	50/10																			
103.4	END OF BOREHOLE																							
7.7	NOTES: 1. Water level at a depth of 4.0 m below ground surface (Elev. 107.1 m) upon completion of drilling. 2. Borehole caved to a depth of 7.2 m below ground surface (Elev. 103.9 m) upon completion of drill																							

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

GT-A-MTO 001 09-1111-0019.GPJ GAL-GTA.GDT 2/7/14

PROJECT		RECORD OF BOREHOLE		No 13-19		SHEET 1 OF 1		METRIC									
G.W.P. 09-1111-0019		LOCATION		N 4860918.3 ; E 367294.0		ORIGINATED BY		JLC									
DIST _____ HWY 401		BOREHOLE TYPE		108 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY		BM									
DATUM Geodetic		DATE		June 4, 2013		CHECKED BY		MWK									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
110.0	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL							20	40	60	80	100					
0.3	Silty SAND, trace gravel, trace clay Compact to very dense Brown Moist		1	SS	16												
			2	SS	73												
108.5			3	SS	50/0.08												
1.5	SILT and SAND, some clay, trace to some gravel, inferred cobbles and boulders at 4.0 m and 4.3 m depth (TILL) Very dense Brown Moist		4	SS	50/0.08												
			5	SS	50/0.10												
			6	SS	50/0.05												
			7	SS	50/0.05												
105.4	Auger grinding on inferred cobbles and boulders																
4.6	END OF BOREHOLE																
	NOTE: 1. Open borehole was dry upon completion of drilling.																

PROJECT		RECORD OF BOREHOLE No 13-20		SHEET 1 OF 1		METRIC											
G.W.P. 09-1111-0019		LOCATION N 4860925.5 ; E 367329.7		ORIGINATED BY JLC													
DIST _____ HWY 401		BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM													
DATUM Geodetic		DATE May 31, 2013		CHECKED BY MWK													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30					
109.1	GROUND SURFACE																
0.0	TOPSOIL																
0.2	Silty SAND, some gravel, trace clay, containing rootlets		1	SS	21		109										
108.4	Compact Brown Moist		2	SS	39		108										
0.7	SILT and SAND, trace to some clay, trace to some gravel (TILL) Dense to very dense Brown Moist		3	SS	50/0.13		107										
			4	SS	50/0.08		106										
			5	SS	50/0.08		105										
			6	SS	50/0.08		104										
			7	SS	50/0.13		103										
102.9	END OF BOREHOLE		8	SS	50/0.13												
6.2	NOTE: 1. Open borehole was dry upon completion of drilling.																

PROJECT		RECORD OF BOREHOLE No 13-23		SHEET 1 OF 1		METRIC								
G.W.P. 09-1111-0019		LOCATION N 4860626.5 ; E 367292.1		ORIGINATED BY JLC										
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM										
DATUM Geodetic		DATE May 30, 2013		CHECKED BY MWK										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		W _p	W			W _L
113.2	GROUND SURFACE						20 40 60 80 100							
0.0	TOPSOIL						20 40 60 80 100							
112.7	Firm Dark brown Moist		1	SS	8									
0.5	CLAYEY SILT with SAND trace to some gravel, inferred cobbles and boulders throughout (TILL) Hard Brown to grey Moist		2	SS	36									
			3	SS	100/0.13									20 47 22 11
			4	SS	100/0.08									
			5	SS	100/0.10									3 43 37 17
			6	SS	100/0.05									
			7	SS	100/0.05									
			8	SS	100/0.05									
107.1	END OF BOREHOLE													
6.2	NOTE: 1. Water level in open borehole at a depth of 4.9 m below ground surface (Elev. 108.3 m) upon completion of drilling.													

PROJECT 09-1111-0019		RECORD OF BOREHOLE No 13-46		SHEET 1 OF 1		METRIC	
G.W.P. 2101-08-00		LOCATION N 4860802.0 ; E 367275.0		ORIGINATED BY JLC			
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM			
DATUM Geodetic		DATE June 11, 2013		CHECKED BY MWK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
114.1	GROUND SURFACE																
0.0	TOPSOIL		1	SS	19												
113.5	Compact Dark brown Moist																
0.6	Sand and silt, some gravel, some clay, trace organics (FILL) Compact to very dense Grey to black Moist		2	SS	87												
			3	SS	29												
			4	SS	24												
	Pockets of wood fibres/rootlets below Elev. 111.0 m		5	SS	37										16 38 32 14		
			6	SS	36												
109.7	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Brown to grey Moist		7	SS	97										10 39 36 15		
4.4	Auger grinding on possible cobbles and boulders below 5.1 m depth		8	SS	50/0.03												
			9	SS	50/0.03												
105.8	SAND and SILT, trace to some gravel, some clay (TILL) Very dense Grey Moist		10	SS	50/0.03												
8.3																	
104.9	END OF BOREHOLE																
9.2	NOTES: 1. Borehole caved at a depth of 8.7 m below ground surface (Elev. 105.4 m) upon completion of drilling. 2. Water level in caved borehole at a depth of 6.2 m below ground surface (Elev. 107.9 m) upon completion of drilling. 3. Water level measurements in Piezometer: Date Depth (m) Elev. (m) 09/10/13 3.9 110.2																

GTA-MTO 001 09-1111-0019.GPJ GAL-GTA.GDT 2/7/14

PROJECT 09-1111-0019		RECORD OF BOREHOLE No 13-50		SHEET 1 OF 1		METRIC	
G.W.P. 2101-08-00		LOCATION N 4860695.0 ; E 367316.0		ORIGINATED BY JLC			
DIST _____ HWY 401		BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger		COMPILED BY BM			
DATUM Geodetic		DATE May 27, 2013		CHECKED BY MWK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20 40 60 80 100	W _p W W _L							
111.0	GROUND SURFACE																
0.0	TOPSOIL		1	SS	8												
110.6	Loose Brown Moist																
110.2	Clayey silt, some sand, trace gravel, trace organics (FILL) Dark brown Moist		2	SS	47		110			○				5 37 41 17			
0.8	CLAYEY SILT with SAND, trace to some gravel, occasional silt seams (TILL) Hard Brown to grey Moist		3	SS	50/0.13		109			○				2 39 44 15			
			4	SS	50/0.10		108			○							
			5	SS	50/0.08		107			○				10 42 35 13			
			6	SS	50/0.06		106			○							
			7	SS	50/0.03		105			○	H						
			8	SS	50/0.05		104			○	H						
			9	SS	50/0.08		103			○							
			10	SS	50/0.08		102			○							
101.8	END OF BOREHOLE																
9.2	NOTES: 1. Water level at a depth of 5.5 m below ground surface (Elev. 105.5 m) during drilling. 2. Borehole caved to a depth of 6.1 m below ground surface (Elev. 104.9 m) upon completion of drilling.																

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

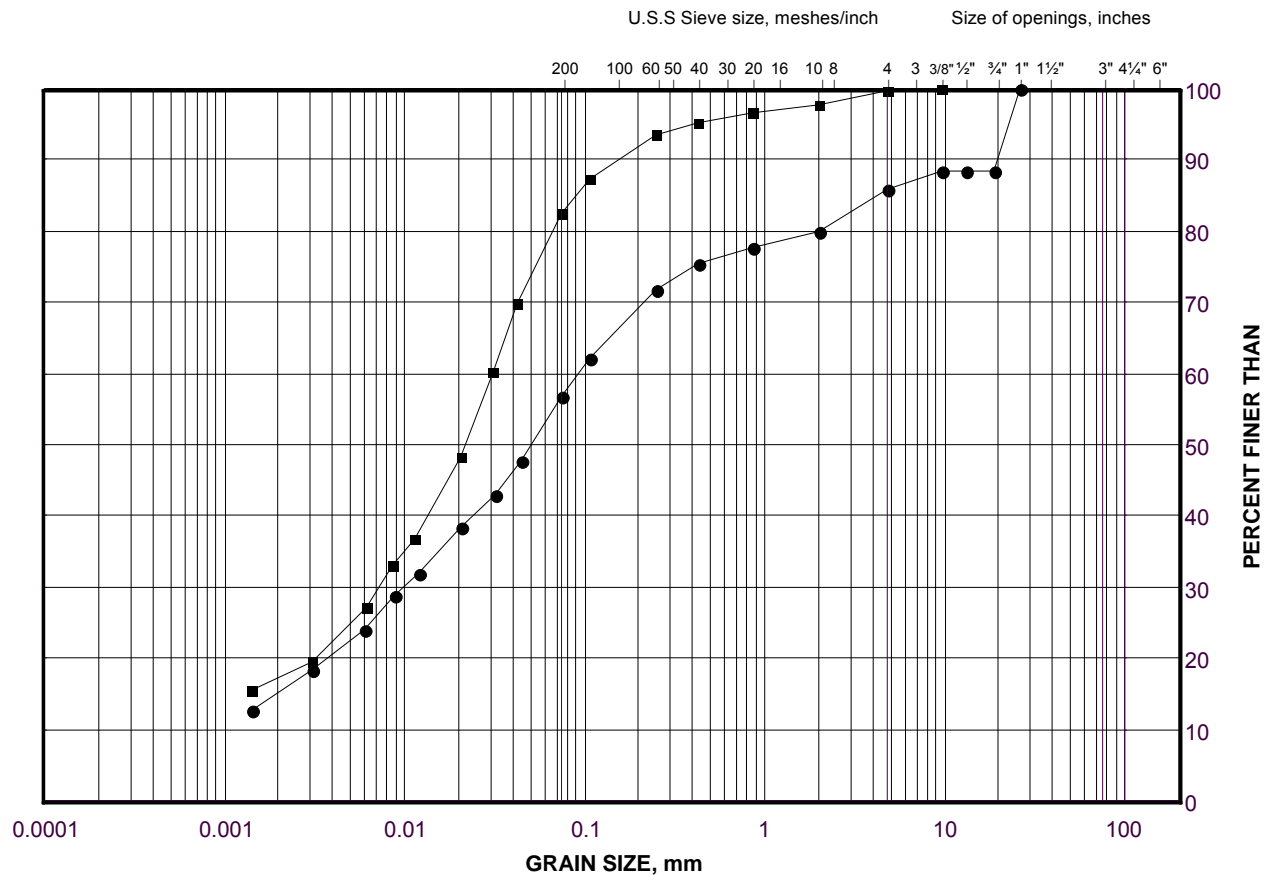


APPENDIX B

Laboratory Test Results

Clayey Silt (Fill)

FIGURE B1



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

LEGEND

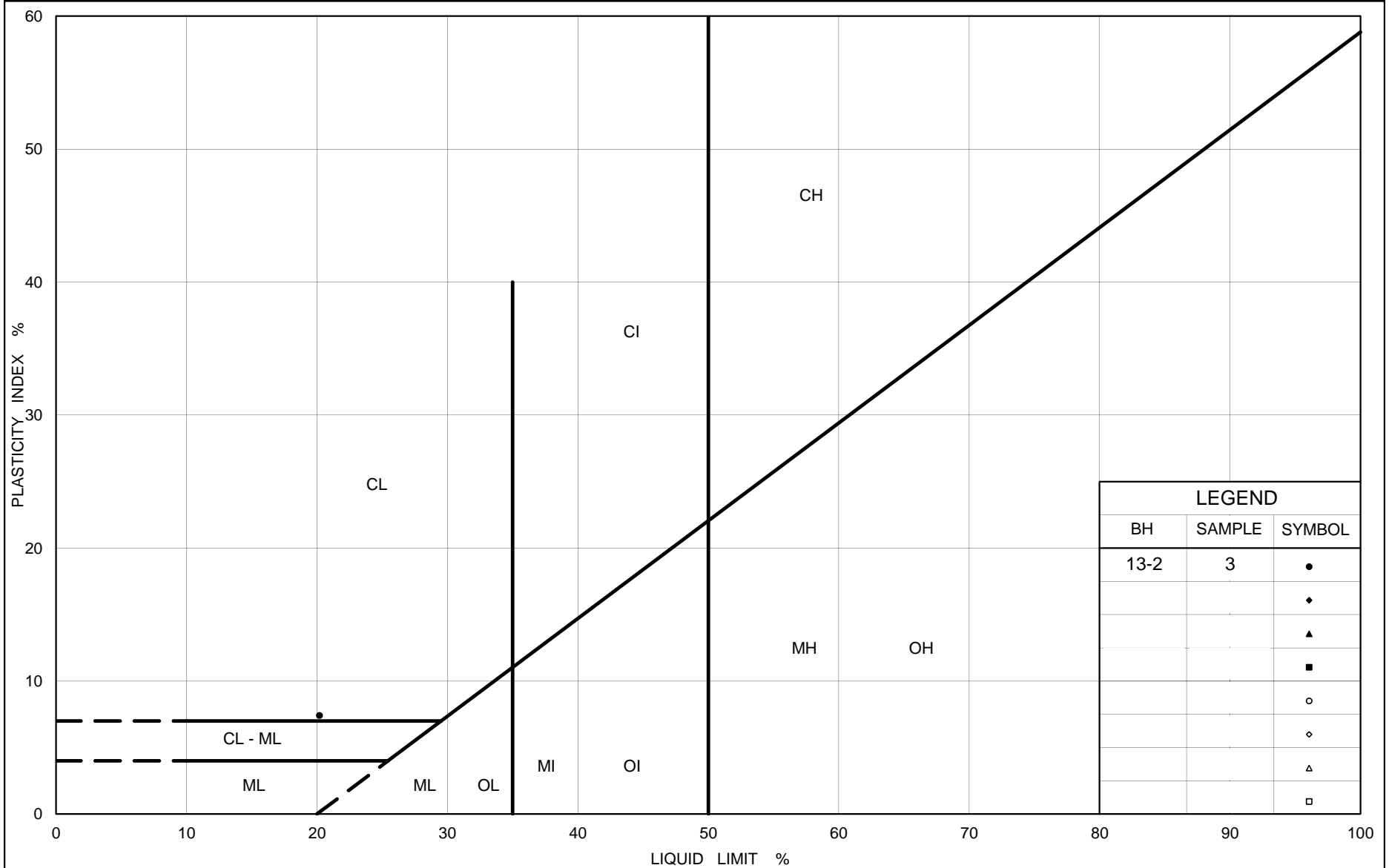
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-2	3	114.5
■	13-2	5	113.0

Project Number: 09-1111-0019

Checked By: _____

Golder Associates

Date: 05-Feb-14



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt (Fill)

Figure No. B2

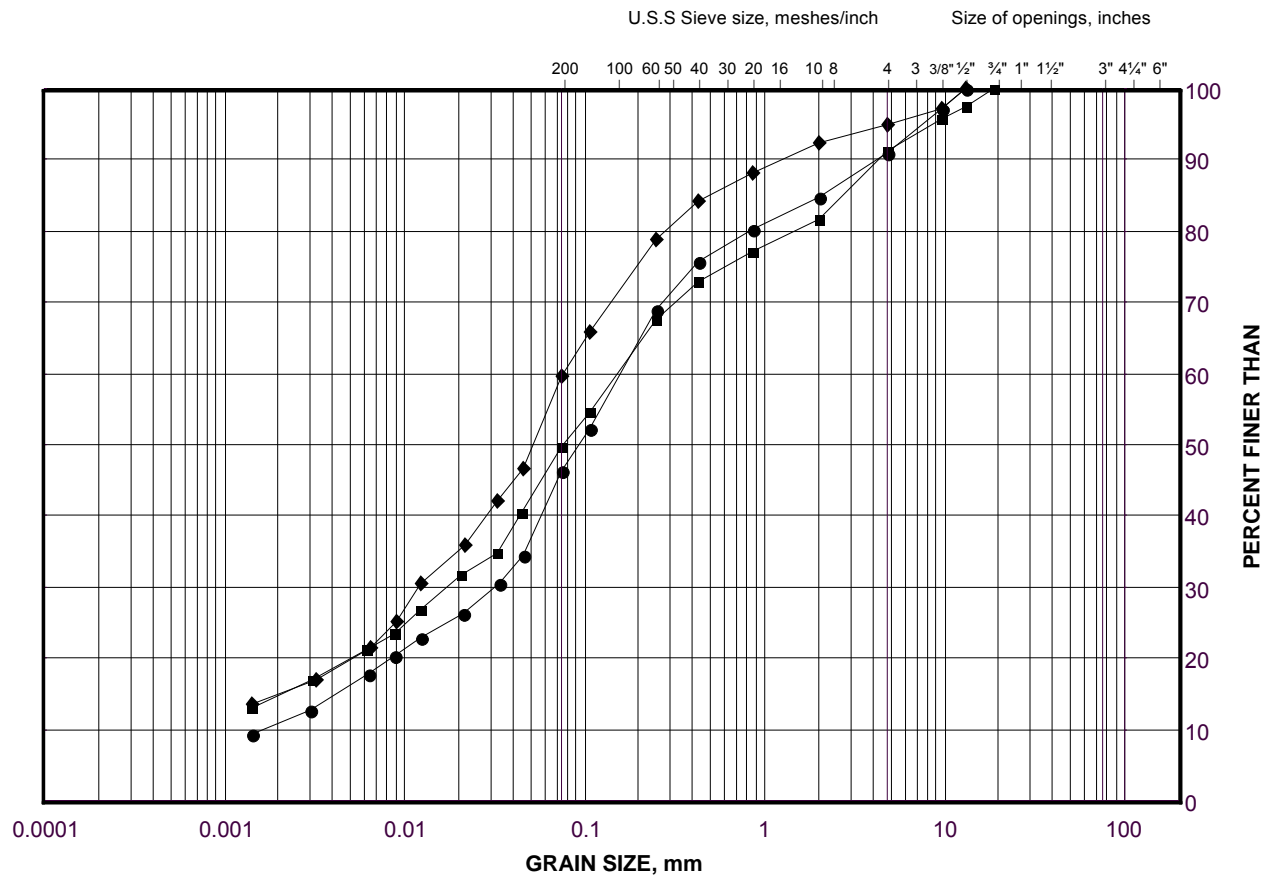
Project No. 09-1111-0019

Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt (Till)

FIGURE B3



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

LEGEND

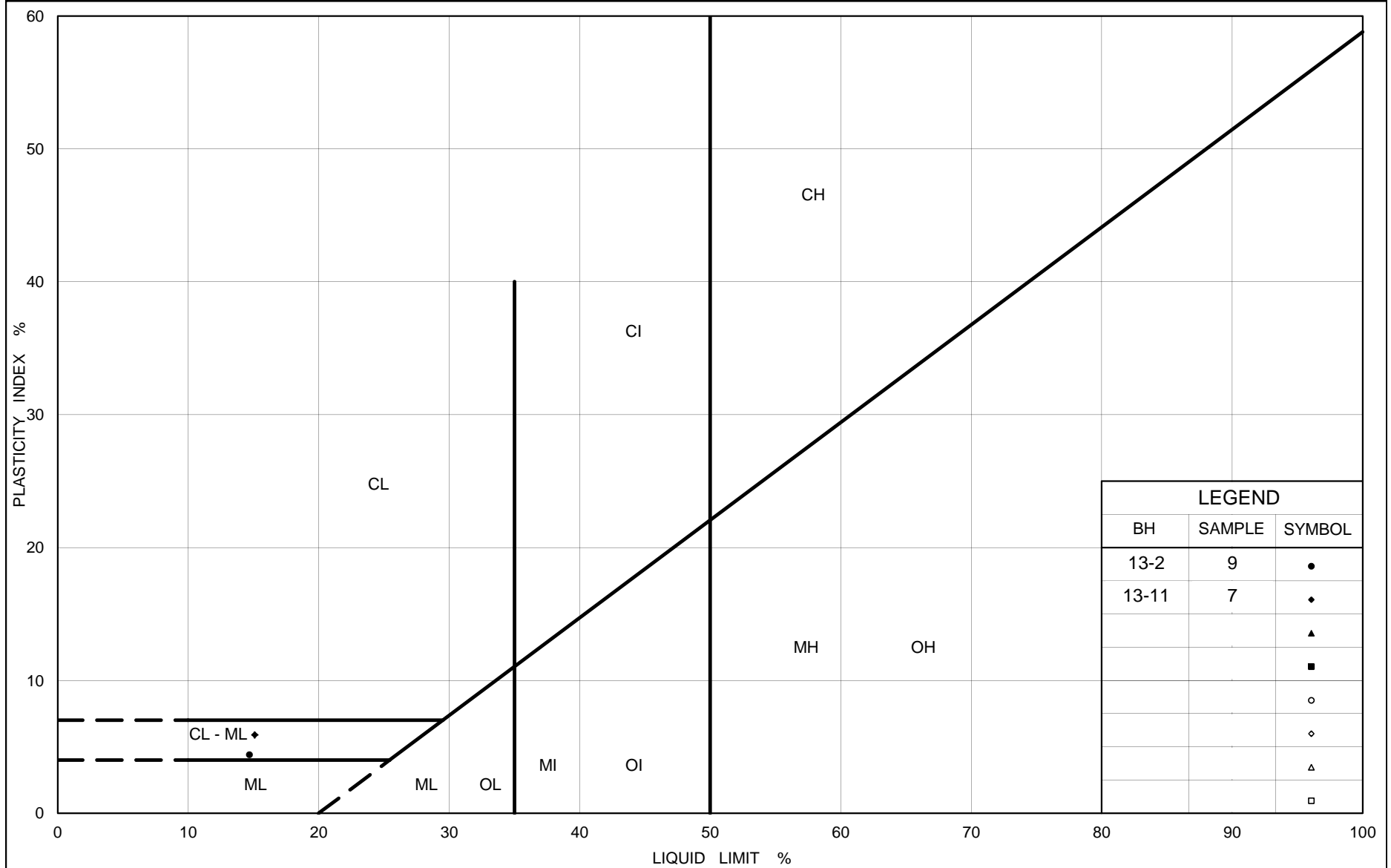
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-11	4	107.4
■	13-11	7	105.2
◆	13-2	8	110.1

Project Number: 09-1111-0019

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Date: 05-Feb-14



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt (Till)

Figure No. B4

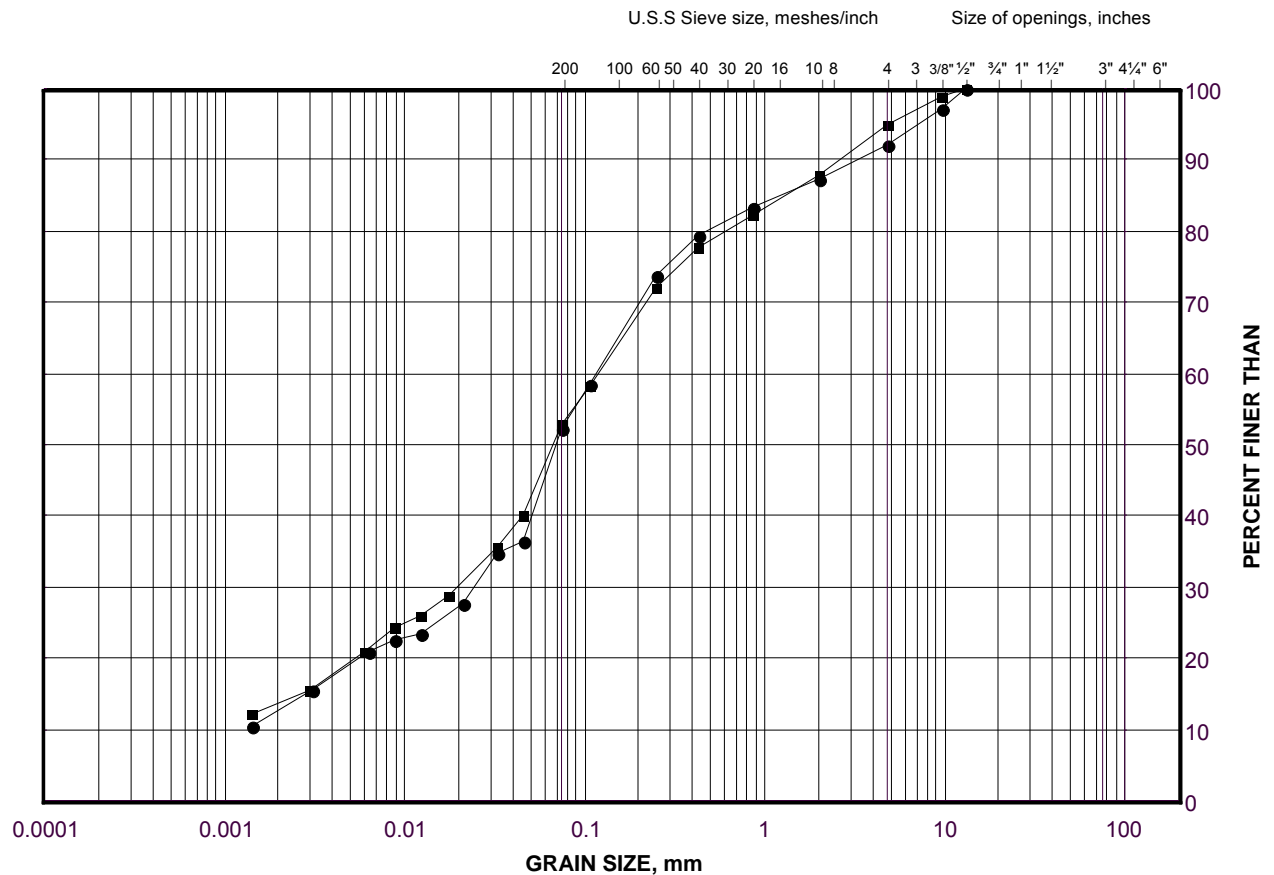
Project No. 09-1111-0019

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GRAIN SIZE DISTRIBUTION TEST RESULTS

Silt and Sand (Till)

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-19	5	106.9
■	13-19	7	105.4

Project Number: 09-1111-0019

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Date: 05-Feb-14



APPENDIX C

Non-Standard Special Provisions



FOUNDATION REPORT - HIGH MAST LIGHT POLES HIGHWAY 401/HOLT ROAD INTERCHANGE

CAISSON FOUNDATIONS FOR HML POLES - Item No.

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 HML pole foundations in conformance with the design and at the locations indicated in the Contract Documents.

The Contractor shall construct the HML pole foundations against undisturbed bases and sides of caisson excavations. The base of each caisson excavation 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 Contractor, but consideration should be given to using temporary liners or tremie concreting techniques where conditions warrant.

The Contractor is advised that variable subsurface conditions may be encountered at HML pole caisson locations where included in the Contract. For bidding purposes, the Contractor shall assume that the overburden has zones of fill, non-cohesive soil, cobbles and boulders may be encountered, and the groundwater levels are near the ground surface. The Contractor is advised that non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head. The Contractor may assume that the subsurface conditions at HML pole caisson locations are generally similar to those of the closest borehole(s), as described in the Foundation Investigation Report.

Augering for caissons for the HML pole foundations may extend into the very dense/hard till soils and the presence of cobbles and boulders should be expected. Appropriate construction procedures and equipment will be required to penetrate into the till soils.

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

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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