



**FOUNDATION INVESTIGATION REPORT**

**Highway 65, Station 17+077, Township of James  
Culvert Replacement  
Ministry of Transportation, Ontario  
GWP 5204-14-00**

Submitted to:

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GEOCRES NO: 41P-77

LAT: 47.717213  
LONG: -80.306919



## Distribution List

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Maxxam Analytical Laboratory Test Report

**PART A**  
**FOUNDATION INVESTIGATION REPORT**  
**HIGHWAY 65, STA 17+077, TOWNSHIP OF JAMES**  
**CULVERT REPLACEMENT**  
**MINISTRY OF TRANSPORTATION, ONTARIO**  
**GWP 5204-14-00**

## 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 related to the replacement of the culvert on Highway 65 at Station 17+077, approximately 2.4 km southeast of the intersection with Highway 560, in the Township of James, Ontario. The Key Plan of the general location of this section of Highway 65 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at the culvert replacement site by borehole drilling with laboratory testing carried out on selected soil samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated February 2018, and the subsequent clarifications/addenda, which forms part of the Consultant's Assignment Number 5017-E-0039 for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project dated November 2018.

## 2.0 SITE DESCRIPTION

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and therefore may differ from magnetic north shown on Drawing 1. For the purpose of this report, Highway 65 is oriented in a west-east direction with the culvert positioned perpendicular to the highway generally in a north-south orientation. At the culvert location the creek flows in a north-south direction.

The existing culvert consists of a 1.4 m diameter 29 m long Corrugated Steel Pipe (CSP). The culvert inlet (north end) and outlet (south end) inverts are approximately Elevations 283.7 m and 283.1 m, respectively. In general, the topography in the vicinity of the culvert consists of relatively flat terrain, with the Montreal River flowing easterly about 80 m south/southwest of Highway 65. At the culvert location, the highway grade is at approximately Elevation 288.0 m and the embankment is approximately 4.6 m high relative to the culvert invert. The ground surface conditions at select locations in the culvert area are shown on Photographs 1 to 4.

## 3.0 INVESTIGATION PROCEDURES

Field work for this subsurface investigation was carried out between October 11 and October 17, 2018, during which time five boreholes (Boreholes C8-1 to C8-5) were advanced at approximate locations shown on Drawing 1. Three boreholes were advanced through the roadway embankment and two boreholes were advanced near the toes of the highway embankment slopes adjacent to the culvert inlet/outlet ends using a track mounted CME-55LC drill rig supplied and operated by George Downing Estate Drilling of Grenville-Sur-La-Rouge, Quebec. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

The boreholes were advanced using 108 mm I.D. Hollow Stem Augers and NW casing with wash boring techniques. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). The groundwater level inside the augers/casing was observed during the drilling operations. The boreholes were backfilled using the native sand soil cuttings upon completion of drilling, consistent with Ontario Regulation 903 (as amended) considering the consistent subsurface soil conditions at the

site. The roadway surface at the boreholes drilled through Highway 65 were capped at ground surface using cold patch asphalt.

Field work was supervised on a full-time basis by a member of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, and Atterberg limits was carried out on selected soil samples. The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable.

The as-drilled borehole locations were measured relative to highway chainages/stations marked on the pavement by a member of our technical staff to an accuracy of 0.1 m and converted into northing/easting coordinates on the plan drawing. The ground surface elevation at the borehole locations as surveyed by Golder relative to the highway and culvert centreline to an accuracy of 0.1 m, with the elevation of the roadway centreline provided by AECOM. The MTM NAD83-CSRS CBN v6-2010.0 (Zone 12) northing and easting coordinates, geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

Borehole Number	MTM NAD 83 Northing (m) [Latitude]	MTM NAD 83 Easting (m) [Longitude]	Ground Surface Elevation (m)	Borehole Depth (m)
C8-1	5286683.5 (47.717171)	356811.5 (-80.306745)	288.0	15.9
C8-2	5286692.4 (47.717252)	356791.6 (-80.307011)	287.8	15.9
C8-3	5286683.8 (47.717174)	356800.4 (-80.306893)	287.9	20.4
C8-4	5286701.3 (47.717331)	356805.1 (-80.306829)	284.9	9.8
C8-5	5286668.6 (47.717037)	356794.0 (-80.306981)	284.8	9.8

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)<sup>1</sup> mapping, the subsoils in the vicinity of the culvert site are located within a glaciolacustrine plain, consisting of clay and sand.

Based on geological mapping (MNDM)<sup>2</sup>, the site is underlain by mafic and related intrusive rocks generally consisting of diabase sills and diabase dikes.

<sup>1</sup> Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41PNE

<sup>2</sup> Ontario Ministry of Northern Development and Mines. Bedrock Geology of Ontario, East-Central Sheet. Map 2543

## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the summary results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in-situ field tests (i.e., SPT 'N' values) as presented on the Record of Borehole sheets and discussed in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile shown on Drawing 1 are inferred 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, however, the factual data presented on the record of borehole governs any interpretation of the site conditions. A summary description of the soil deposits and groundwater conditions encountered in the boreholes is provided below. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

### 4.2.1 Asphalt/Fill

An approximately 50 mm to 100 mm thick layer of asphalt (pavement) was encountered in the roadway Boreholes C8-1 to C8-3 between Elevations 288.0 and 287.8 m. A 3.1 m to 3.6 m thick layer of embankment fill consisting of sand and gravel, sand, or sandy silt was encountered below the asphalt in Boreholes C8-1 to C8-3. In Borehole C8-4, a 0.8 m thick layer of sandy silt was encountered from ground surface at Elevation 284.9 m.

The SPT "N"-values measured within the fill range between 4 blows and 100 blows per 0.3 m of penetration, indicating a very loose to very dense compactness condition.

Grain size distribution analysis was carried out on two samples of the fill and the results are presented on Figure B-1 in Appendix B. The natural moisture content measured on two samples of the fill were 4 and 5 per cent.

### 4.2.2 Topsoil / Peat

In Borehole C8-4, a 0.6 m thick layer of amorphous peat was encountered below the fill at Elevation 284.1 m and in Borehole C8-5, a 0.1 m thick layer of topsoil was encountered from ground surface at Elevation 284.8 m.

One SPT "N"-value measured within the peat is 6 blows per 0.3 m of penetration, indicating a firm consistency.

### 4.2.3 Silt to Silt and Sand

A non-cohesive deposit of silt with clay pockets/layers to silt and sand was encountered in Boreholes C8-1 and C8-3 to C8-5 between Elevations 284.8 m and 283.5 m. The thickness of the deposit ranges between 1.1 m and 3.7 m.

The SPT "N"-values measured within the deposit range from 1 blow to 15 blows per 0.3 m of penetration, indicating that the deposit has a very loose to compact compactness condition.

Grain size distribution analysis was carried out on eight samples of the deposit and the results are presented on Figure B-2 in Appendix B. Atterberg limits tests was carried out on five samples of the deposit: two samples were determined to be non-plastic and three samples yielded liquid limits ranging from 21 per cent to 26 per cent, plastic limits ranging between 17 per cent and 20 per cent and plasticity indices ranging between 4 per cent and 7 per cent. The results of the three Atterberg limit tests are presented on Figure B-3 in Appendix B and together with the two non-plastic results indicate the overall deposit is comprised of clayey silt - silt of slight plasticity to silt. The natural moisture content measured on samples of the deposit ranged from 19 per cent to 27 per cent.

#### 4.2.4 Sand

A sand deposit was encountered in Boreholes C8-1 to C8-5, between Elevations 284.6 m and 281.0 m. Boreholes C8-1 to C8-5 were terminated within the sand deposit, penetration into the deposit for thicknesses between 6.0 m and 14.8 m.

The SPT "N"-values measured within the sand deposit range from 1 blow to 36 blows per 0.3 m of penetration indicating that the deposit has a very loose to dense compactness condition.

Grain size distribution analysis was carried out on ten samples of the deposit, the results are presented on Figure B-4 in Appendix B. The natural moisture content measured on samples of the deposit range from 8 per cent to 28 per cent.

### 4.3 Groundwater Conditions

The unstabilized groundwater levels relative to ground surface measured inside the casing or auger upon completion of drilling are summarized below. The creek water level near the culvert outlet, as surveyed by Golder on October 11, 2018, was about at Elevation 283.1 m. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
C8-1	7.0	281.0
C8-2	6.6	281.2
C8-3	7.3	280.6
C8-4	4.6	280.3
C8-5	4.1	280.7

## 4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a soil sample recovered from Borehole C8-3. The soil sample was submitted to Maxxam Analytics of Sudbury, Ontario for corrosivity testing. The analytical laboratory test results are summarized below, and the detailed analytical laboratory test report is included in Appendix B.

Borehole No.	Sample No.	Depth (m)	Parameters				
			Resistivity (ohm/cm)	Electrical Conductivity ( $\mu\text{mho/cm}$ )	Soluble Sulphate (SO <sub>4</sub> ) Content ( $\mu\text{g/g}$ )	Chloride (Cl) Content ( $\mu\text{g/g}$ )	pH
C8-3	3	1.5 – 2.1	3,300	302	<20 <sup>1</sup>	71	7.81

Note:

1. The sulphate concentration is below the reportable detection limit of 20  $\mu\text{g/g}$ .

## 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Tibor Berecz, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Tibor Berecz, and Mr. André Bom, P.Eng., provided a technical review of the report. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of this report.

# Signature Page

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TB/AB/JMAC/sb

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[https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2\\_reporting/fr01-jam-108/3\\_final/1896349-r-reva-aecom-jam-108-hwy-65-fir-17jun\\_2019.docx](https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2_reporting/fr01-jam-108/3_final/1896349-r-reva-aecom-jam-108-hwy-65-fir-17jun_2019.docx)

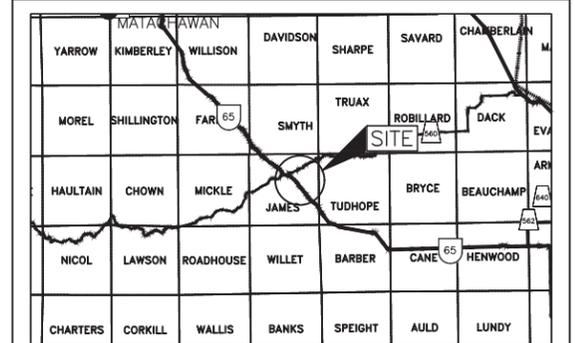
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. GWP No. 5204-14-00



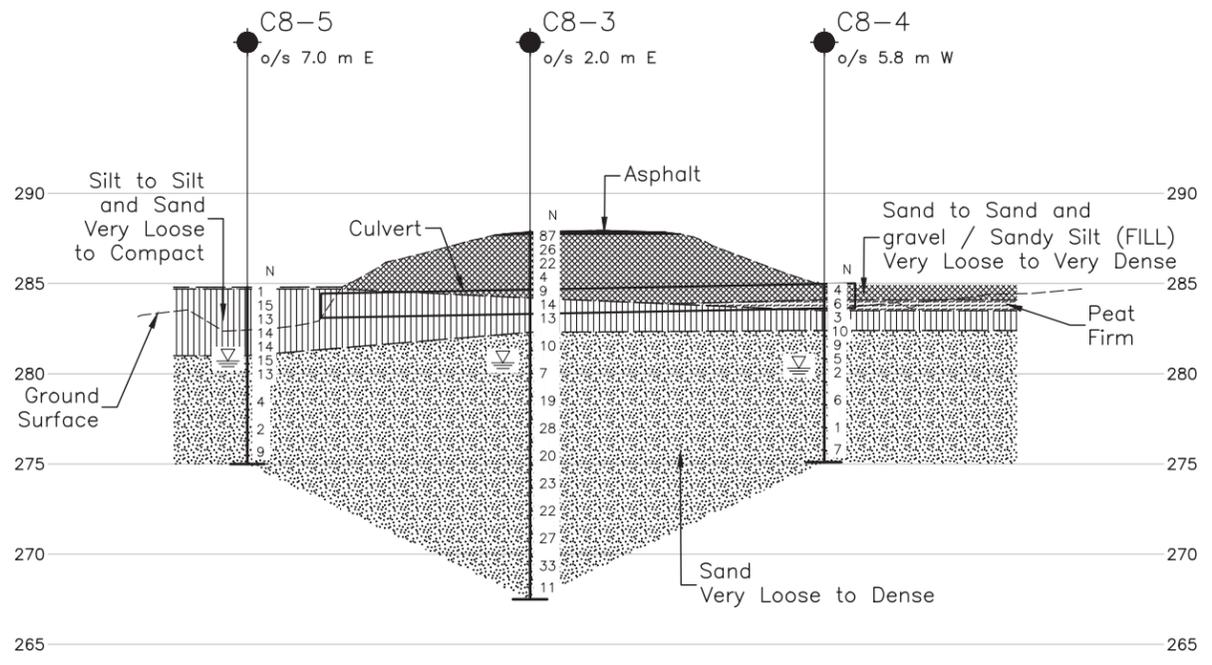
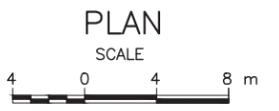
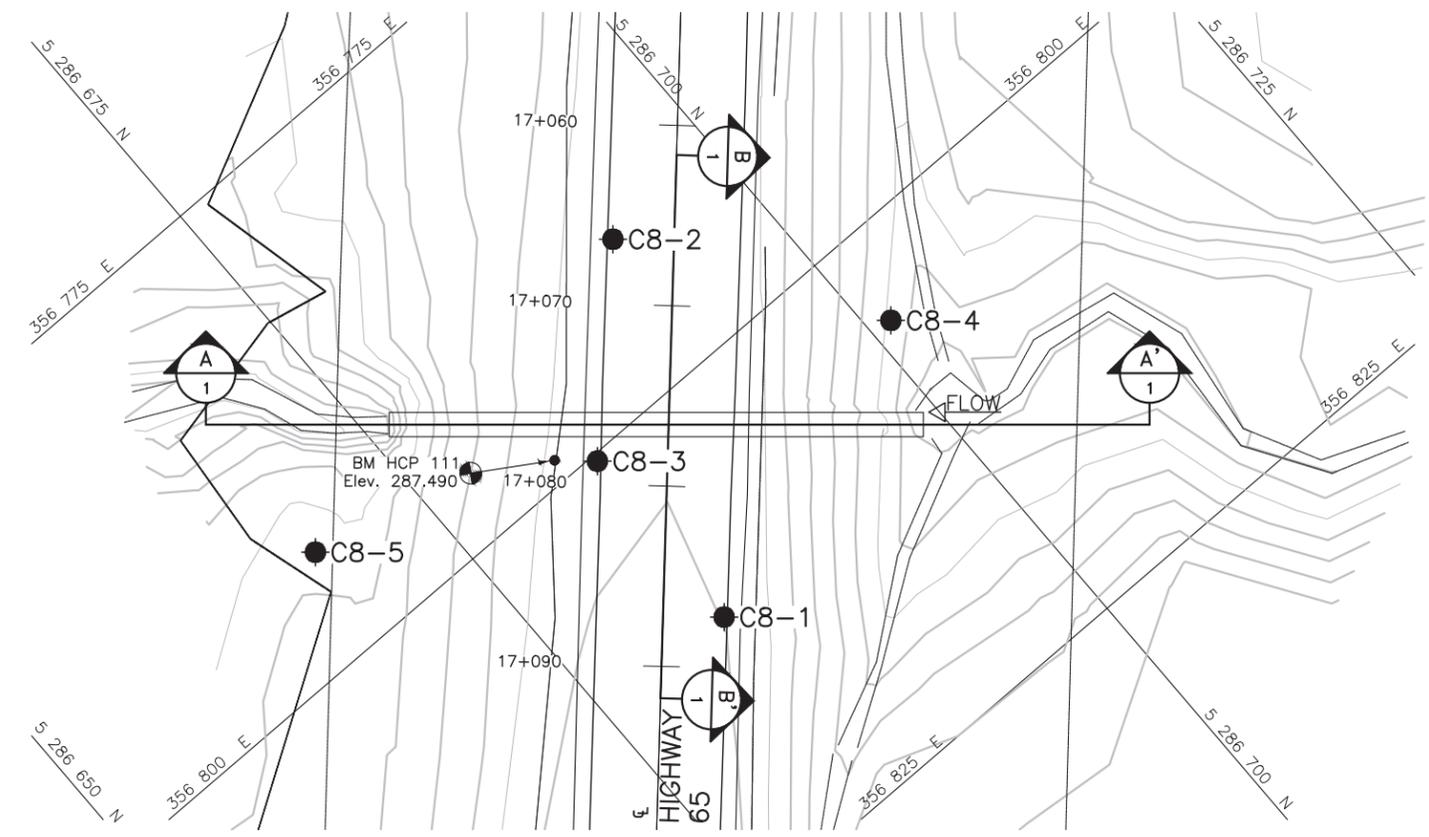
HIGHWAY 65  
STATION 17+077  
TOWNSHIP OF JAMES CULVERT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

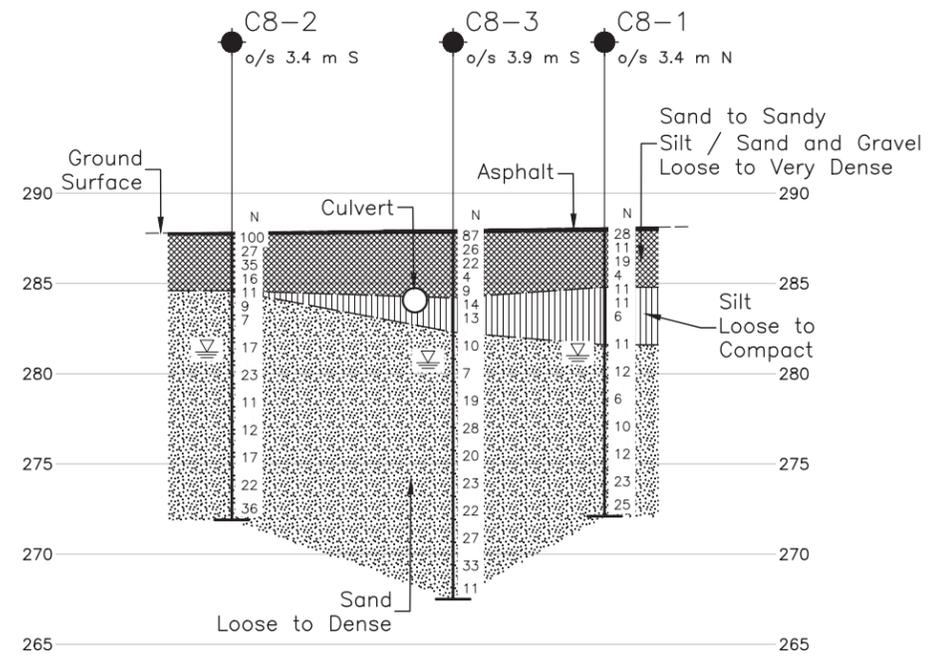


**LEGEND**

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ∇ WL upon completion of drilling



**A-A'**  
1  
HORIZONTAL SCALE  
VERTICAL SCALE



**B-B'**  
1  
HORIZONTAL SCALE  
VERTICAL SCALE

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
C8-1	288.0	5286683.5	356811.5
C8-2	287.8	5286692.4	356791.6
C8-3	287.9	5286683.8	356800.4
C8-4	284.9	5286701.3	356805.1
C8-5	284.8	5286668.6	356794.0

**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. B065JAM.dwg, received MAR 15, 2019.

NO.	DATE	BY	REVISION

Geocres No. 41P-77

HWY. 65	PROJECT NO. 1896349	DIST. .
SUBM'D. GM	CHKD. TB	DATE: 5/21/2019
DRAWN: TR	CHKD. AB	APPD. JMAC
		SITE: .
		DWG. 1



**Photograph 1: Borehole C8-3, Facing South (October 2018)**



**Photograph 2: Borehole C8-2, Facing North (October 2018)**



**Photograph 3: Borehole C8-4, Facing South (October 2018)**



**Photograph 4: Borehole C8-5, Facing South (October 2018)**

**APPENDIX A**

**Record of Boreholes**

## LIST OF SYMBOLS

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

### I. GENERAL

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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  $\rho$ . Unit weight symbol is  $\gamma$  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
$C_{\alpha}$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

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

Notes: 1  
2

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

## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

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

#### Dynamic Cone Penetration Resistance; $N_d$ :

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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.

### 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

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

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

#### (b) Cohesive Soils

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

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

PROJECT <u>1896349</u>	<b>RECORD OF BOREHOLE No C8-1</b>	1 OF 2 <b>METRIC</b>
G.W.P. <u>5204-14-00</u>	LOCATION <u>N 5286683.5; E 356811.5 NAD83 MTM ZONE 12 (LAT. 47.717171; LONG. -80.306745)</u>	ORIGINATED BY <u>TB/GM</u>
DIST <u>                    </u> HWY <u>65</u>	BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring</u>	COMPILED BY <u>TB</u>
DATUM <u>GEODETIC</u>	DATE <u>October 17, 2018</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
288.0	PAVEMENT SURFACE																
0.0	ASPHALT (65mm)																
287.4	Sand and gravel, 100 mm thick asphalt layer at 0.3 m depth. (FILL)		1	SS	28												
0.6	Compact Brown Moist																
	Sandy silt to sand, trace to some gravel (FILL)		2	SS	11		287										
	Loose to compact																
	Brown to grey Moist		3	SS	19		286										
			4	SS	4		285										
284.8																	
3.2	SILT with clay pockets/layers, trace to some sand		5	SS	11												0 8 70 22
	Loose to compact																
	Brown Moist		6	SS	11		284										NP 0 26 70 4
			7	SS	6		283										0 17 65 18
							282										
281.6			A														
6.4	SAND, trace silt, trace gravel		8	SS	11		281										
	Loose to compact																
	Brown to grey Moist to wet																
							280										2 95 (3)
			9	SS	12		279										
			10	SS	6		278										
			11	SS	10		277										

SUD-MTO 001 S:\CLIENTS\MT\Hwy65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

Continued Next Page

 +<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT <u>1896349</u>	<b>RECORD OF BOREHOLE No C8-1</b>	2 OF 2	<b>METRIC</b>
G.W.P. <u>5204-14-00</u>	LOCATION <u>N 5286683.5; E 356811.5 NAD83 MTM ZONE 12 (LAT. 47.717171; LONG. -80.306745)</u>	ORIGINATED BY <u>TB/GM</u>	
DIST <u>                    </u> HWY <u>65</u>	BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring</u>	COMPILED BY <u>TB</u>	
DATUM <u>GEODETIC</u>	DATE <u>October 17, 2018</u>	CHECKED BY <u>AB</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	SHEAR STRENGTH kPa			20	40	60
272.1	SAND, trace silt, trace gravel Loose to compact Brown to grey Moist to wet  --- CONTINUED FROM PREVIOUS PAGE ---		12	SS	12																		
275																							
274			13	SS	23																		
273																							
272.1 15.9	END OF BOREHOLE																						
	Note:  1. Water level at a depth of 7.0 m below ground surface (Elev. 281.0 m) upon completion of drilling.																						

SUD-MTO 001 S:\CLIENTS\MT\HWHY65866\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



PROJECT <u>1896349</u>	<b>RECORD OF BOREHOLE No C8-2</b>	2 OF 2	<b>METRIC</b>
G.W.P. <u>5204-14-00</u>	LOCATION <u>N 5286692.4; E 356791.6 NAD83 MTM ZONE 12 (LAT. 47.717252; LONG. -80.307011)</u>	ORIGINATED BY <u>TB</u>	
DIST <u>        </u> HWY <u>65</u>	BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring</u>	COMPILED BY <u>TB</u>	
DATUM <u>GEODETIC</u>	DATE <u>October 11, 2018</u>	CHECKED BY <u>AB</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---					20 40 60 80 100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	WATER CONTENT (%)					
271.9	SAND, trace silt, trace gravel Loose to dense Brown to grey Moist to wet		12	SS	17									○		
275																
274			13	SS	22											
273																
272			14	SS	36											
271.9 15.9	END OF BOREHOLE															
	Note:  1. Water level at a depth of 6.6 m below ground surface (Elev. 281.2m) upon completion of drilling.															

SUD-MTO 001 S:\CLIENTS\MT\HWHY65866\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



PROJECT <u>1896349</u>	<b>RECORD OF BOREHOLE No C8-3</b>	2 OF 2 <b>METRIC</b>
G.W.P. <u>5204-14-00</u>	LOCATION <u>N 5286683.8; E 356800.4 NAD83 MTM ZONE 12 (LAT. 47.717174; LONG. -80.306893)</u>	ORIGINATED BY <u>TB</u>
DIST <u>        </u> HWY <u>65</u>	BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring</u>	COMPILED BY <u>TB</u>
DATUM <u>GEODETIC</u>	DATE <u>October 11, 2018</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
						20	40	60	80	100	20	40	60	kN/m <sup>3</sup>	GR SA SI CL		
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SAND, trace silt, trace gravel Loose to dense Brown to grey Moist to wet		12	SS	20												
			275														
			274	13	SS	23							o				0 97 (3)
			273														
			272	14	SS	22											
			271	15	SS	27											
			270														
			269	16	SS	33											
			268														
267.5 20.4			END OF BOREHOLE														
	Note: 1. Water level at a depth of 7.3 m below ground surface (Elev. 280.6 m) upon completion of drilling.																

SUD-MTO 001 S:\CLIENTS\MT01\HWY65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

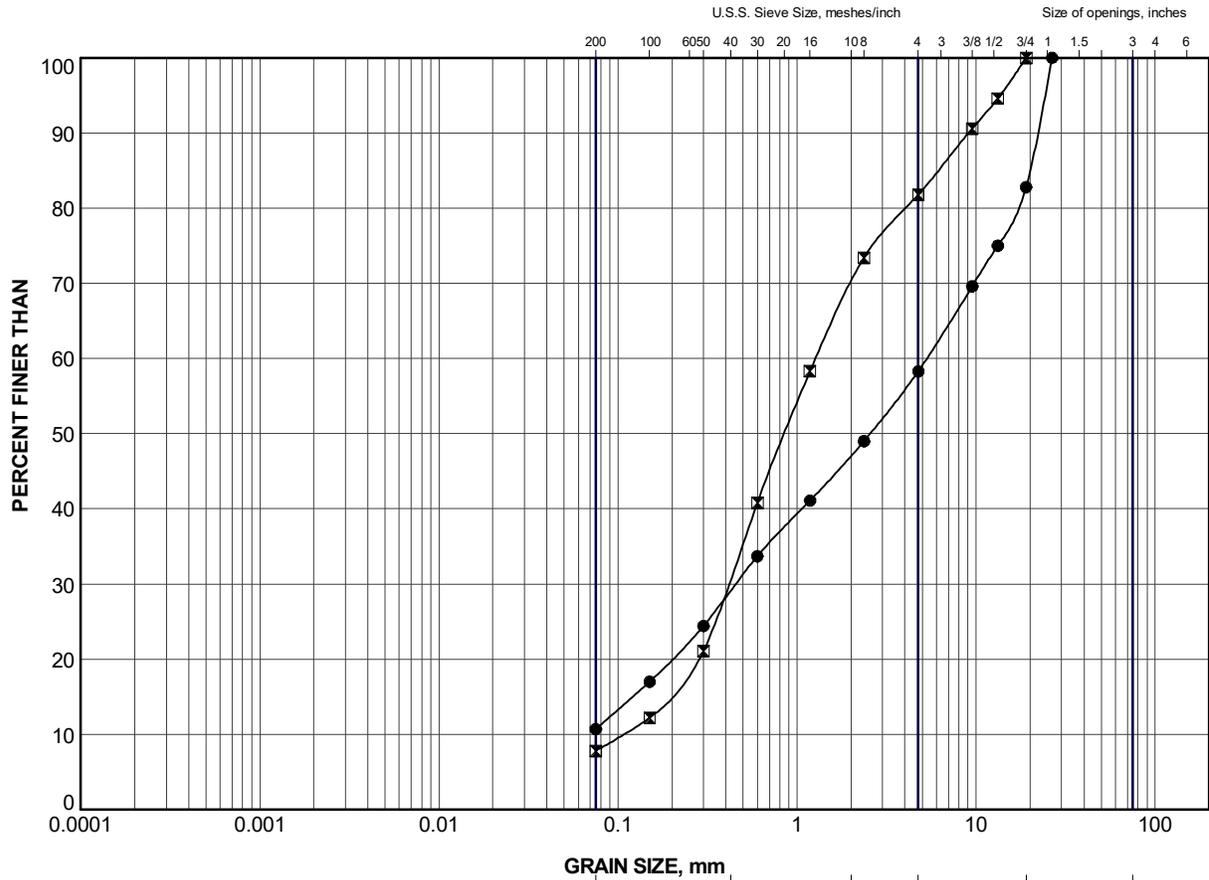
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE





**APPENDIX B**

# Laboratory Test Results

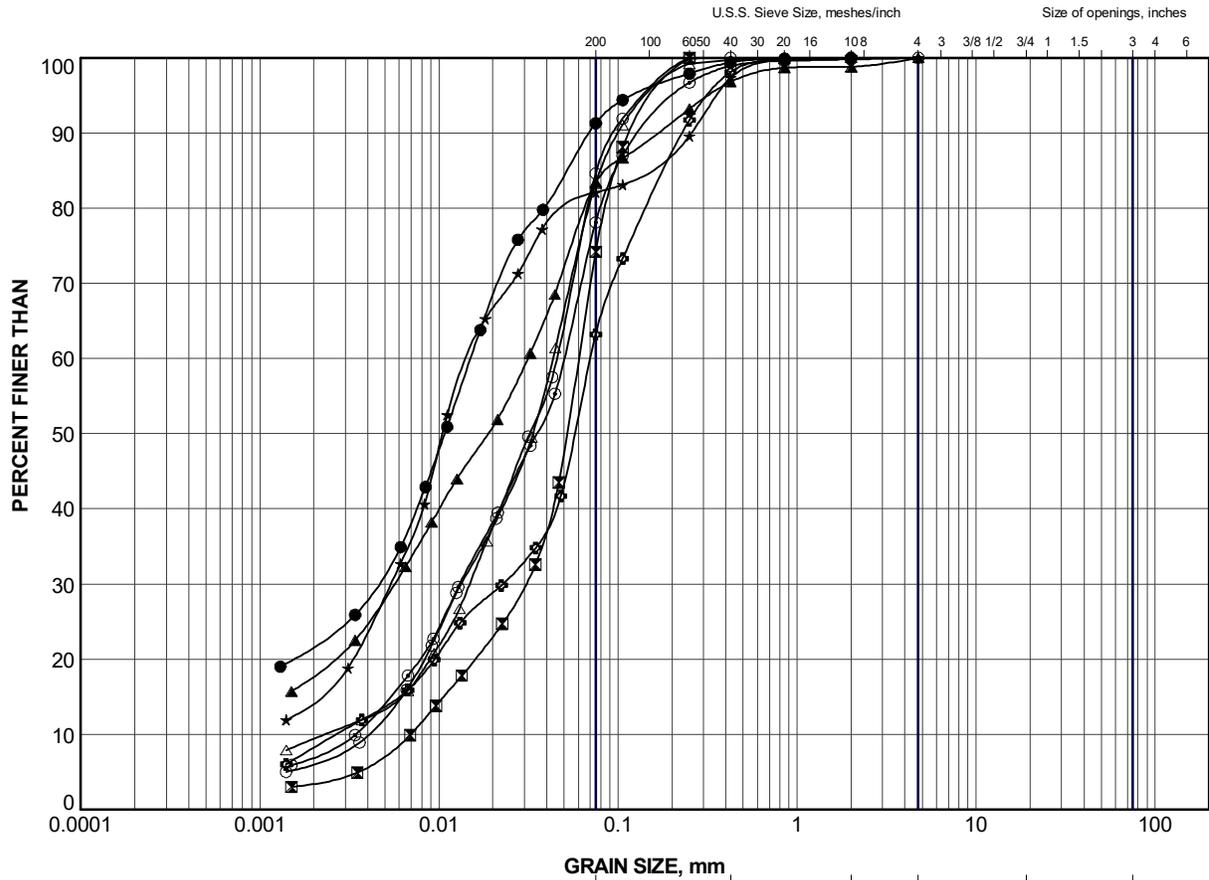


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-2	4	285.2
■	C8-3	5	284.6

PROJECT	HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT				
TITLE	<b>GRAIN SIZE DISTRIBUTION</b> SAND / SAND and GRAVEL (FILL)				
 <b>GOLDER</b> SUDBURY, ONTARIO	PROJECT No.	1896349	FILE No.	1896349.GPJ	
	DRAWN	TR	Apr 2019	SCALE	N/A
	CHECK	AB	Apr 2019	REV.	
	APPR	JMAC	Apr 2019	<b>FIGURE B-1</b>	



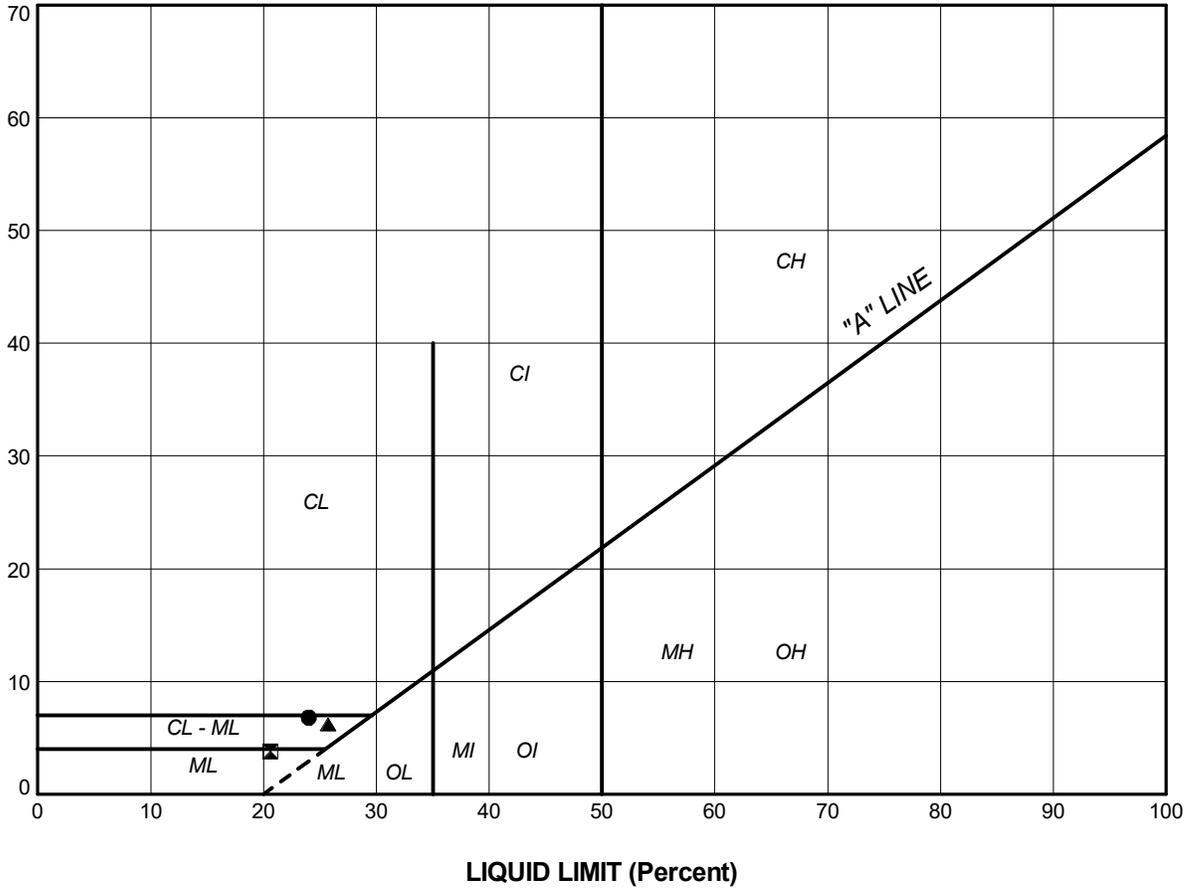
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-1	5	284.6
⊠	C8-1	6	283.9
▲	C8-1	7	283.1
★	C8-3	6	283.8
⊙	C8-3	7	283.0
⊕	C8-4	3	283.1
○	C8-5	3	283.0
△	C8-5	5	281.5

PROJECT						HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT					
TITLE						<b>GRAIN SIZE DISTRIBUTION</b> SILT with CLAY POCKETS / LAYERS to SILT and SAND					
PROJECT No.			1896349			FILE No.			1896349.GPJ		
DRAWN	TR	Apr 2019	SCALE	N/A	REV.	<b>FIGURE B-2</b>					
CHECK	AB	Apr 2019									
APPR	JMAC	Apr 2019									
 <b>GOLDER</b> SUDBURY, ONTARIO											

PLASTICITY INDEX (Percent)



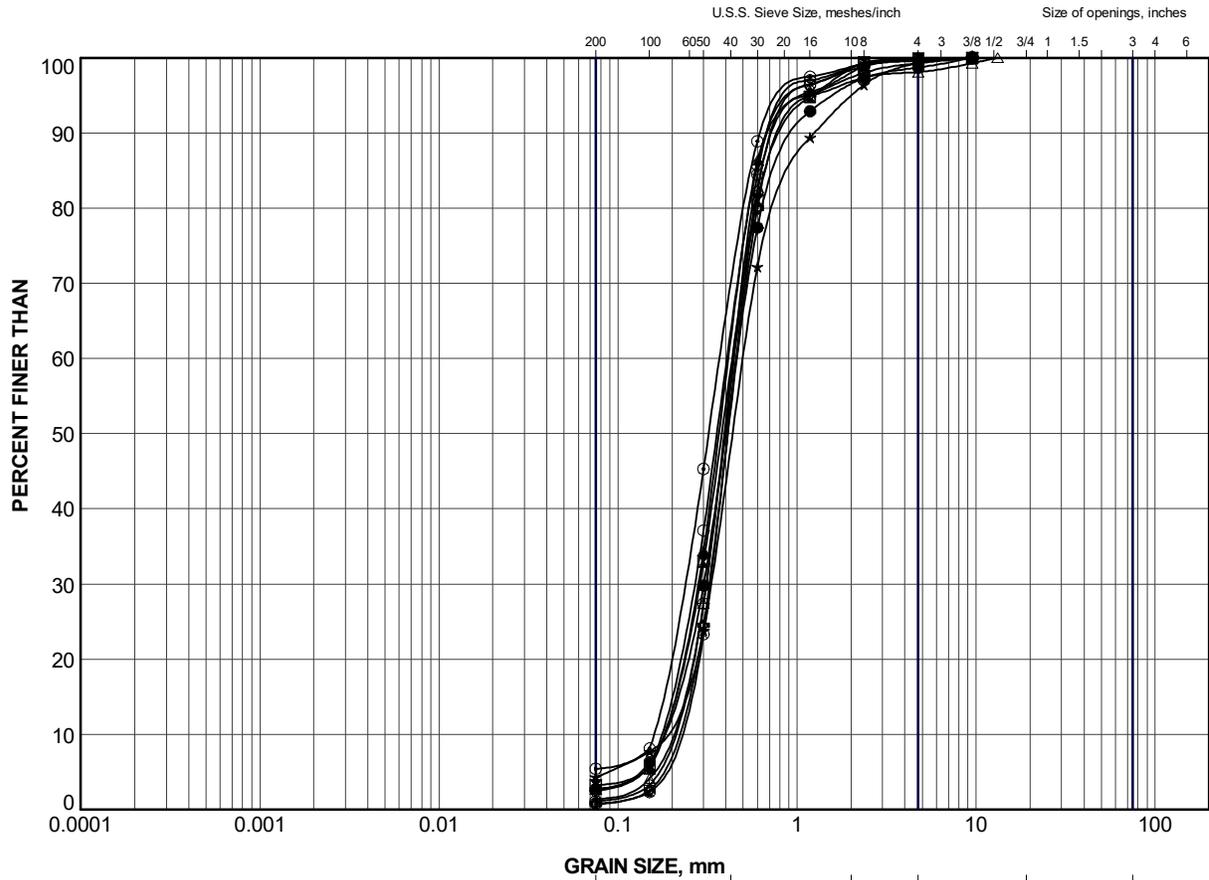
**SOIL TYPE**  
 C = Clay  
 M = Silt  
 O = Organic

**PLASTICITY**  
 L = Low  
 I = Intermediate  
 H = High

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C8-1	5	24.0	17.2	6.8
⊠	C8-1	7	20.6	16.8	3.8
▲	C8-3	6	25.7	19.5	6.2

PROJECT					HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT				
TITLE					<b>PLASTICITY CHART</b> SILT with CLAY POCKETS / LAYERS				
PROJECT No.			1896349		FILE No.			1896349.GPJ	
DRAWN		TR	Apr 2019		SCALE		N/A	REV.	
CHECK		AB	Apr 2019		<b>FIGURE B-3</b>				
APPR		JMAC	Apr 2019						
 <b>GOLDER</b> SUDBURY, ONTARIO									



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

**LEGEND**

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-1	9	280.1
⊠	C8-1	12	275.5
▲	C8-2	6	283.7
★	C8-2	9	279.9
⊙	C8-2	12	275.3
⊕	C8-3	10	278.5
○	C8-3	13	273.9
△	C8-4	5	281.6
⊗	C8-4	8	278.5
⊕	C8-5	8	278.4

PROJECT						HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT					
TITLE						<b>GRAIN SIZE DISTRIBUTION</b> SAND					
PROJECT No.			1896349			FILE No.			1896349.GPJ		
DRAWN		TR		Apr 2019		SCALE		N/A		REV.	
CHECK		AB		Apr 2019		<b>FIGURE</b>		<b>B-4</b>			
APPR		JMAC		Apr 2019							
<b>GOLDER</b> SUDBURY, ONTARIO											

SUD-MTO GSD GLDR\_LDN.GDT

**RESULTS OF ANALYSES OF SOIL**

<b>Maxxam ID</b>		IBQ378	IBQ379			IBQ379			IBQ380		
<b>Sampling Date</b>		2018/10/18 08:42	2018/10/11 09:58			2018/10/11 09:58			2018/10/12 09:34		
<b>COC Number</b>		35870	35870			35870			35870		
	<b>UNITS</b>	<b>C2-3 SA# 4A</b>	<b>C8-3 SA# 3</b>	<b>RDL</b>	<b>QC Batch</b>	<b>C8-3 SA# 3 Lab-Dup</b>	<b>RDL</b>	<b>QC Batch</b>	<b>C9-3 SA# 3</b>	<b>RDL</b>	<b>QC Batch</b>

<b>Calculated Parameters</b>											
Resistivity	ohm-cm	2300	3300		5794629				2500		5794629
<b>Inorganics</b>											
Soluble (20:1) Chloride (Cl-)	ug/g	150	71	20	5799805	77	20	5799805	170	20	5799805
Conductivity	umho/cm	429	302	2	5797627				396	2	5797627
Available (CaCl2) pH	pH	7.74	7.81		5796193				7.76		5796193
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	20	5799807	<20	20	5799807	<20	20	5799807
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate											

<b>Maxxam ID</b>		IBQ380			IBQ381		
<b>Sampling Date</b>		2018/10/12 09:34			2018/10/13 09:21		
<b>COC Number</b>		35870			35870		
	<b>UNITS</b>	<b>C9-3 SA# 3 Lab-Dup</b>	<b>RDL</b>	<b>QC Batch</b>	<b>C19-3 SA# 3</b>	<b>RDL</b>	<b>QC Batch</b>

<b>Calculated Parameters</b>							
Resistivity	ohm-cm				10000		5794629
<b>Inorganics</b>							
Soluble (20:1) Chloride (Cl-)	ug/g				21	20	5799805
Conductivity	umho/cm	397	2	5797627	99	2	5797627
Available (CaCl2) pH	pH				6.22		5796193
Soluble (20:1) Sulphate (SO4)	ug/g				<20	20	5799807
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate							



**[golder.com](http://golder.com)**