



## FOUNDATION INVESTIGATION REPORT

# Highway 65, Station 14+480, Township of Barber Culvert Replacement Ministry of Transportation, Ontario GWP 5204-14-00

Submitted to:

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1896349-R06

August 6, 2019

GEOCRES NO: 41P-81

LAT: 47.660009

LONG: -80.182193



## Distribution List

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Maxxam Analytical Laboratory Test Report

**PART A**

FOUNDATION INVESTIGATION REPORT  
HIGHWAY 65, STA 14+480, TOWNSHIP OF BARBER  
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 under Highway 65 at Station 14+480, approximately 1.1 km west of the Highway 65 intersection with Barber Cane Township Road, in the Township of Barber, 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 exploration 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 services 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 his 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 north-south, perpendicular to the highway. At the culvert location the creek flows in a north-south direction.

The existing culvert consists of a 1.2 m diameter, 24 m long Corrugated Steel Pipe (CSP). The culvert inlet (north end) and outlet (south end) inverts are approximately Elevations 288.4 m and 288.1 m, respectively. In general, the topography in the vicinity of the culvert consists of relatively flat terrain, with the Montreal River flowing easterly about 1.9 km south of Highway 65. At the culvert location, the highway grade is approximately Elevation 291.3 m and the embankments are approximately 3.2 m high relative to the culvert invert. The ground surface conditions at select locations in the culvert area are shown on Photographs 1 to 3.

## 3.0 INVESTIGATION PROCEDURES

Field work for this subsurface exploration was carried out between November 17 and 24, 2018 and on January 22, 2019, during which time three boreholes (Boreholes C27-1 to C27-3) were advanced at approximate locations shown on Drawing 1. One borehole was advanced through the roadway embankment using a track mounted CME-55LC drilling rig supplied and operated by George Downing Estate Drilling of Grenville-Sur-La-Rouge, Quebec. Two boreholes were advanced near the toes of the highway embankment slopes adjacent to the culvert inlet/outlet using a portable tripod drilling rig supplied and operated by George Downing Estate Drilling and Landcore Drilling from Sudbury, Ontario. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

Borehole C27-1 was advanced using 108 mm I.D. Hollow Stem Augers and NW casing with wash boring techniques and Boreholes C27-1 and C27-2 were advanced with 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 a full weight automatic hammer (Borehole C27-1) or half weight hammer (Boreholes C27-2 and C27-3) in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586).

The SPT “N”-values obtained using the half weight hammer were adjusted to the inferred values that would have been obtained using a standard weight (63.6 kg) hammer. The groundwater level inside the augers/casing was observed during the drilling operations. The boreholes were backfilled in accordance with Ontario Regulation 903. The roadway surface at the borehole drilled through Highway 65 was sealed 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 and converted into northing/easting coordinates on the plan drawing. The ground surface elevations at the borehole locations were surveyed relative to the highway and culvert centreline, 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)
C27-1	5280426.0 (47.660063)	366224.1 (-80.182178)	291.3	20.4
C27-2	5280436.1 (47.660154)	366220.2 (-80.182228)	289.4	9.8
C27-3	5280407.8 (47.659901)	366222.6 (-80.182201)	289.4	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 culvert site is located within a glaciolacustrine plain and the subsoils reportedly consist of clay and sand.

Based on geological mapping (MNDM)<sup>2</sup>, the site is underlain by siltstone, argillite, sandstone and conglomerate.

<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

A layer of asphalt (pavement) approximately 100 mm thick was encountered in roadway Borehole C27-1 at Elevation 291.3 m. Underlying the surface asphalt, the borehole penetrated a 180 mm thick layer of sand and gravel fill, a further 100 mm thick layer of asphalt, and a 2.7 m thick layer of embankment fill comprised of a layer of sand and gravel (0.2 m thick), sand (1.7 m thick) and silt (0.8 m thick).

The SPT “N”-values measured within the sand and the silt layers of fill range between 8 blows and 32 blows per 0.3 m of penetration, indicating a loose to dense compactness condition.

### 4.2.2 Peat

An approximately 0.8 m thick layer of black fibrous peat was encountered in Borehole C27-2 at ground surface, at Elevation 289.4 m.

One SPT “N”-value measured within the fibrous peat is 1 blow per 0.3 m of penetration, indicating a very soft consistency.

### 4.2.3 Clayey Silt

An approximately 0.8 m thick deposit of clayey silt, containing trace organics, was encountered in Borehole C27-3 at ground surface, at Elevation 289.4 m.

One SPT “N”-value measured with the clayey silt deposit is 2 blows per 0.3 m of penetration, indicating a very soft consistency.

### 4.2.4 Silty Sand

An approximately 0.7 m thick deposit of silty sand, containing trace organics, was encountered in Borehole C27-2 below the fibrous peat, at Elevation 288.6 m.

One SPT “N”-value measured with the silty sand deposit is 6 blows per 0.3 m of penetration, indicating a loose compactness condition.

#### 4.2.5 Silt

A non-cohesive deposit of silt with clay layers/seams/laminations was encountered in Boreholes C27-1, C27-2 and C27-3 between Elevations 288.6 m and 287.9 m. The upper approximately 0.7 m thick zone of the deposit contains trace organics/wood in Borehole C27-3. The overall thickness of the deposit is 13.4 m in Borehole C27-1 where it was fully penetrated. The deposit was not fully penetrated in Boreholes C27-2 and C27-3 after exploring the deposit for 8.3 m and 9.0 m, respectively.

The SPT “N”-values measured within the silt deposit range from 5 blows to 22 blows per 0.3 m of penetration, indicating a loose to compact compactness condition.

Grain size distribution analysis was carried out on ten samples of the silt deposit and the results are presented on Figure B-1 in Appendix B. Atterberg limits tests was carried out on seven silt samples of the deposit: five samples were determined to be non-plastic; and two samples yielded liquid limits of about 21 per cent, plastic limits of about 16 per cent and 17 per cent and plasticity indices of about 4 per cent and 5 per cent. The results of the two Atterberg limit tests are presented on Figure B-2 in Appendix B and together with the six non-plastic results indicate the overall deposit is comprised of silt to silt of slight plasticity. The natural moisture content measured on samples of the deposit ranges from 22 per cent to 30 per cent.

#### 4.2.6 Silty Sand and Gravel (Till)

A silty sand and gravel till deposit was encountered in Borehole C27-1, at Elevation 274.8 m. Cobbles are inferred within the deposit from grinding of the augers. Borehole C27-1 was terminated within the silty sand and gravel till deposit after penetrating 3.9 m into the deposit.

The SPT “N”-values measured within the silty sand and gravel till deposit range from 33 blows to 42 blows per 0.3 m of penetration indicating a dense compactness condition.

### 4.3 Groundwater Conditions

The unstabilized groundwater levels relative to ground surface, measured in the augers/casing upon completion of drilling, are summarized below. The top of the frozen creek surface at the culvert outlet, as surveyed by Golder on November 24, 2018, was about Elevation 289.4 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)
C27-1	2.3	289.0
C27-2	0.0	289.4
C27-3	0.1	289.3

## 4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a soil sample recovered from immediately below the embankment fill in Borehole C27-1. The soil sample was submitted to Maxxam Analytics of Sudbury, Ontario for testing a suite of parameters associated with potential corrosion to steel and deterioration of concrete. 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) (Elev. m)	Parameters					
			Resistivity (ohm-cm)	Electrical Conductivity (µmho-cm)	Soluble Sulphate (SO <sub>4</sub> ) Content (µg-g)	Sulphide Content (µg-g)	Chloride Content (µg-g)	pH
C27-1	5	3.1 – 3.7 288.2 – 287.6	2000	508	<20 <sup>1</sup>	<0.55	250	7.54

Note:

1. The sulphate concentration is below the reportable detection limit of 20 µg/g.

## 5.0 CLOSURE

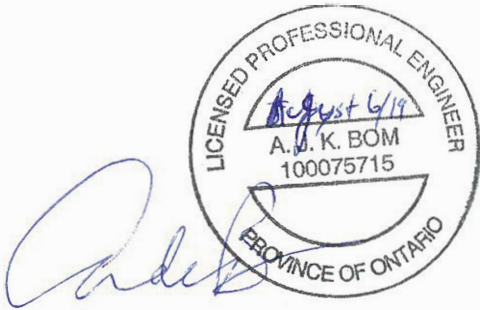
The field drilling program was carried out under the supervision of Mr. Mat Riopelle, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Michael Bentley, and Mr. André Bom, P.Eng. provided a technical review of the report. Mr. Jorge Costa, P.Eng.,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

## Signature Page

### Golder Associates Ltd.



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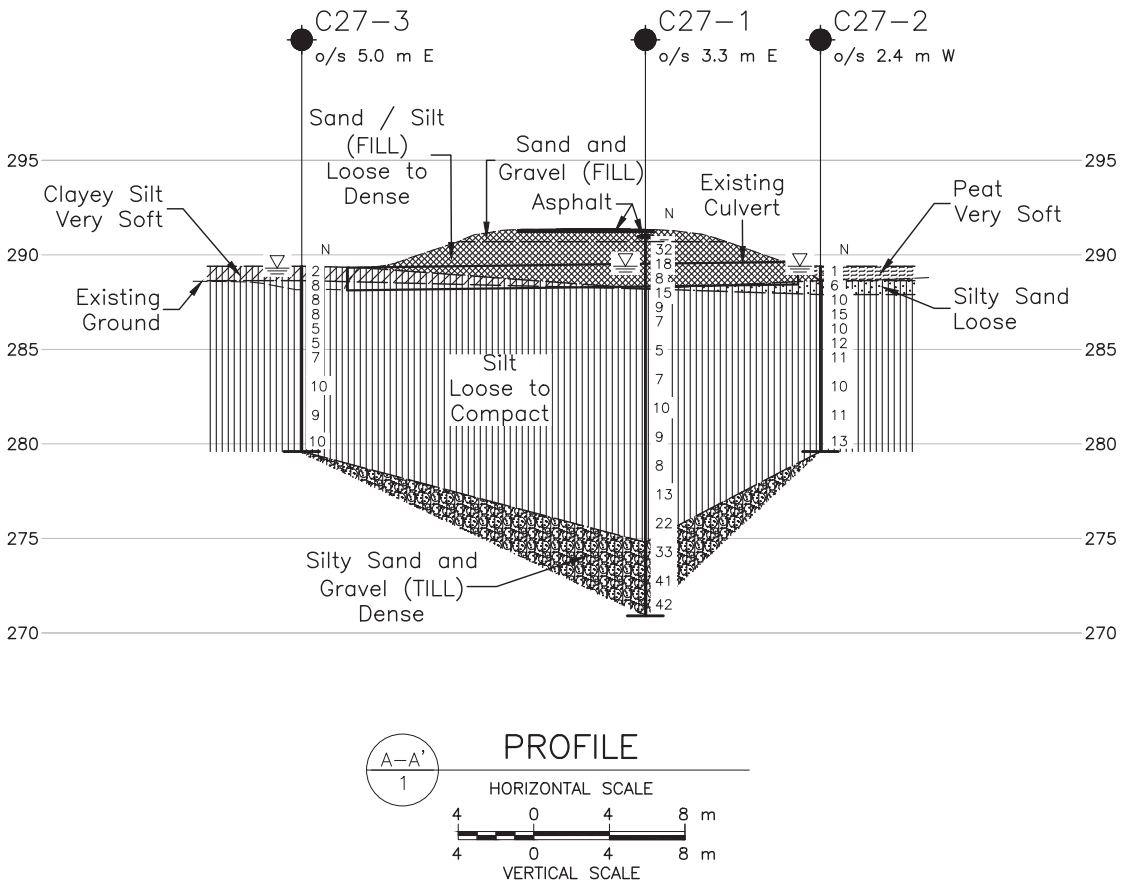
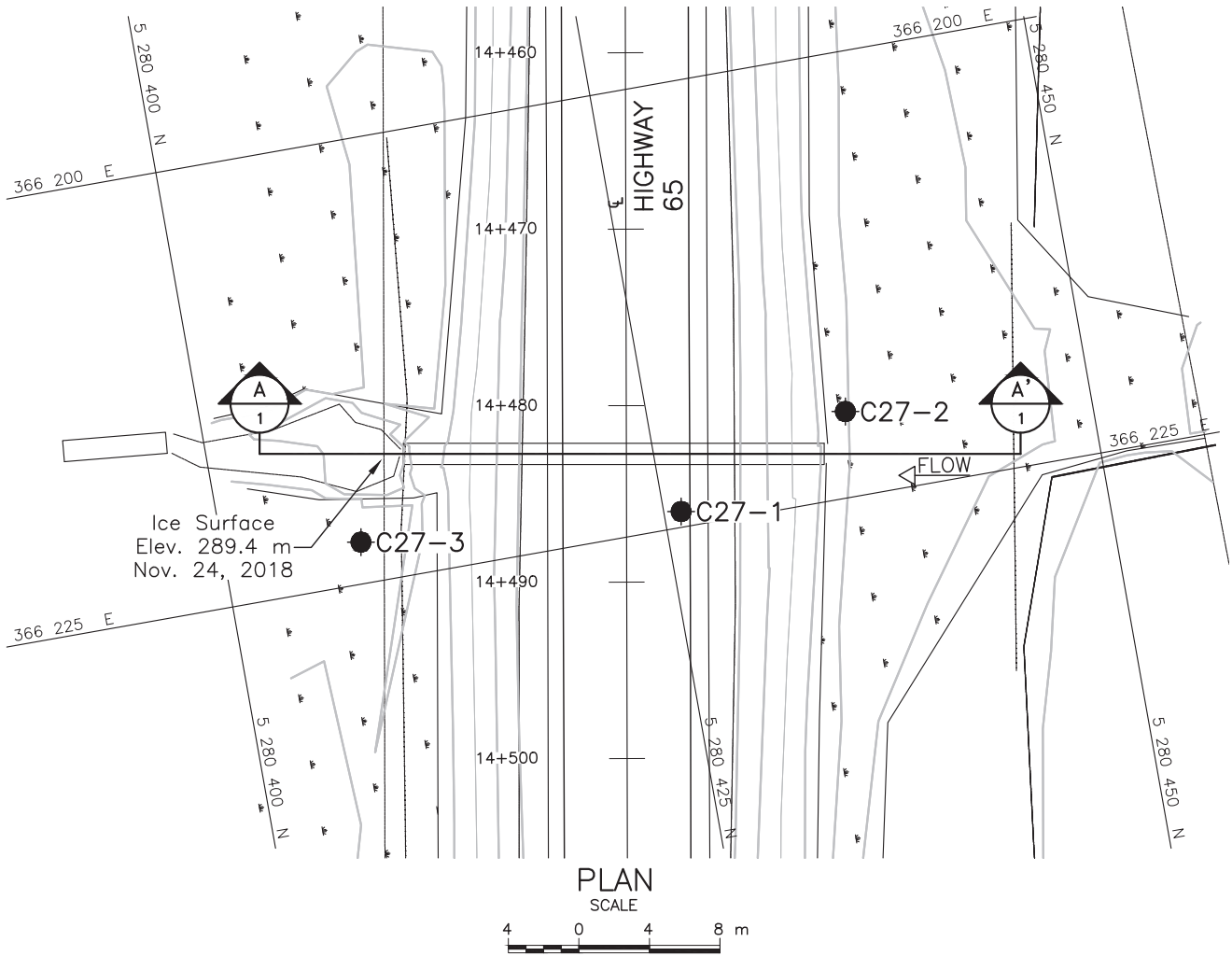


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MJB/AB/JMAC/sb

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**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 14+480  
TOWNSHIP OF BARBER CULVERT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

KEY PLAN  
SCALE  
10 0 10 20 km

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



BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)			
No.	ELEVATION	NORTHING	EASTING
C27-1	291.3	5280426.0	366224.1
C27-2	289.4	5280436.1	366220.2
C27-3	289.4	5280407.8	366222.6

**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. B065BAR.dwg, received MAR 15, 2019.

NO.	DATE	BY	REVISION
Geocres No. 41P-81			
HWY. 65	PROJECT NO. 1896349		DIST.
SUBM'D. MJB	CHKD. TB	DATE: 8/2/2019	SITE:
DRAWN: TR	CHKD. AB	APPD. JMAC	DWG. 1



**Photograph 1: Highway 65 Facing West from Culvert (November 2018)**



**Photograph 2: Culvert Inlet, North End (November 2018)**





**Photograph 3: Culvert Outlet, South End (November 2018)**

**APPENDIX A**

# Record of Boreholes and Drillholes



## 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

#### (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

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

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.

### 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.

### 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

SUD-MTO 001 S:\CLIENTS\MTO\HWY65&66\02 DATA\GINT\1896349.GPJ GAL-MISS GDT 6-3-19 TR

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

PROJECT 1896349		<b>RECORD OF BOREHOLE No C27-1</b>				2 OF 2 <b>METRIC</b>											
G.W.P. 5204-14-00		LOCATION N 5280426.0; E 366224.1 NAD83 MTM ZONE 12 (LAT. 47.660063; LONG. -80.182178)				ORIGINATED BY MR											
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE November 17, 2018				CHECKED BY AB											
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									
	--- CONTINUED FROM PREVIOUS PAGE ---																
278.0	SILT, trace to some clay Loose to compact Brown Wet		12	SS	8		279										
13.3	SILT, some clay, trace sand Compact Brown Wet		13	SS	13		278										
276.5	SILT, trace to some clay Compact Brown Wet		14	SS	22		277										
14.8	SILT, trace to some clay Compact Brown Wet		15	SS	33		276										
274.8	Silty SAND and GRAVEL, some cobbles (TILL) Dense Grey Wet		16	SS	41		275										
16.5	Silty SAND and GRAVEL, some cobbles (TILL) Dense Grey Wet		17	SS	42		274										
270.9	END OF BOREHOLE						273										
20.4	Note:  1. Water level at a depth of 2.3 m below ground surface (Elev. 289.0 m) upon completion of drilling.						272										
							271										

PROJECT 1896349		RECORD OF BOREHOLE No C27-2				1 OF 1 METRIC														
G.W.P. 5204-14-00		LOCATION N 5280436.1; E 366220.2 NAD83 MTM ZONE 12 (LAT. 47.660154; LONG. -80.182228)				ORIGINATED BY MR														
DIST _____ HWY 65		BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring				COMPILED BY GM														
DATUM GEODETIC		DATE January 22, 2019				CHECKED BY AB														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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		ELEVATION SCALE	SHEAR STRENGTH kPa									WATER CONTENT (%)			
289.4	GROUND SURFACE							20	40	60	80	100								
0.0	Fibrous PEAT, trace gravel Very soft Black Frozen		1	SS	1		289													
288.6																				
0.8	SILTY SAND, some gravel, trace organics Loose Grey Wet		2	SS	6		288													
287.9																				
1.5	SILT, trace to some clay, trace gravel Compact Grey Wet		3	SS	10												9	3	83	5
			4	SS	15		287													
			5	SS	10		286										12	0	84	4
			6	SS	12		285													
			7	SS	11												0	0	92	8
							284													
			8	SS	10		283													
							282													
			9	SS	11		281													
							280													
			10	SS	13															
279.6	END OF BOREHOLE																			
9.8	NOTES:  1. Water level at ground surface (Elev. 289.4 m) inside casing upon completion of drilling.  2. Split spoon samples obtained by driving with a half weight hammer. SPT 'N' value has been adjusted to the inferred values that would be obtained using a standard weight hammer.																			

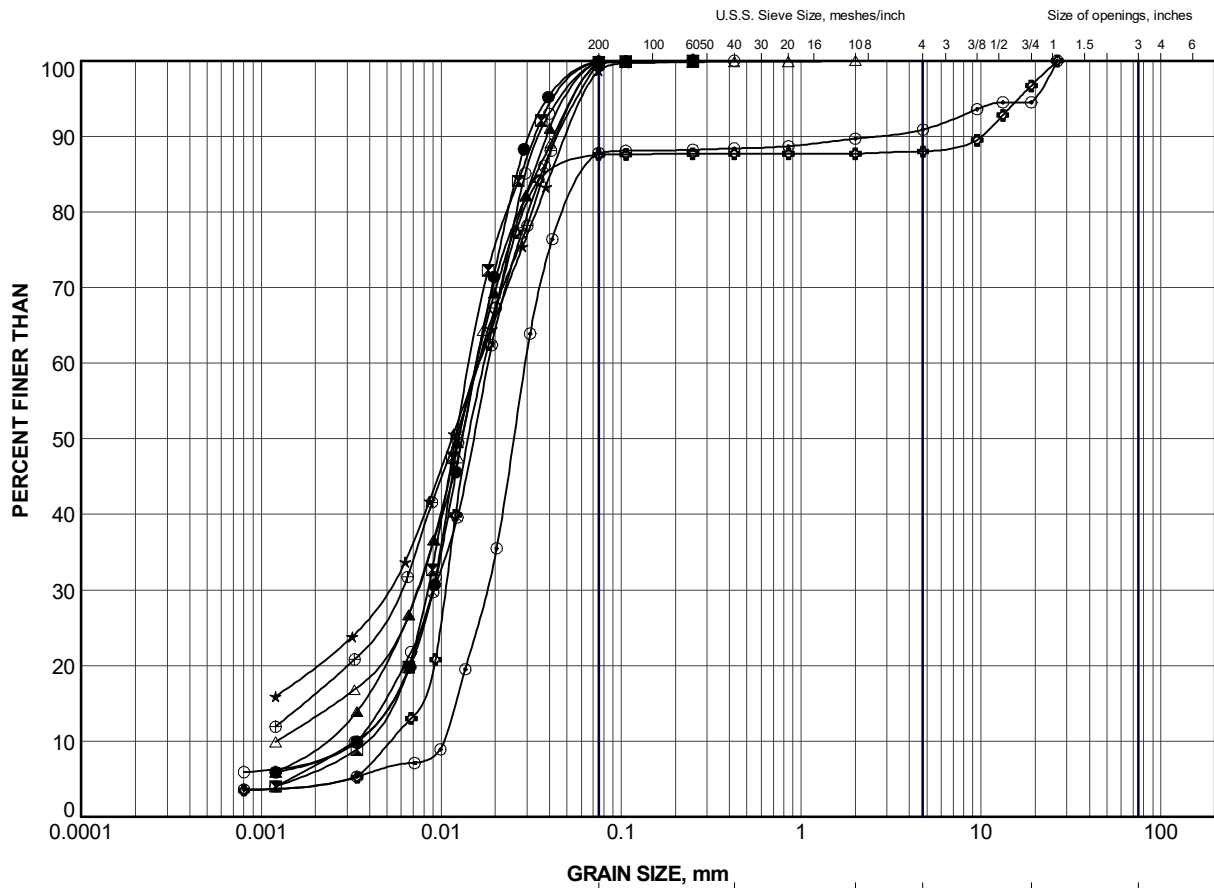
SUD-MTO 001 S:\CLIENTS\MTOT\HWY65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 6-3-19 TR

PROJECT 1896349		RECORD OF BOREHOLE No C27-3				1 OF 1 METRIC											
G.W.P. 5204-14-00		LOCATION N 5280407.8; E 366222.6 NAD83 MTM ZONE 12 (LAT. 47.659901; LONG. -80.182201)				ORIGINATED BY MR											
DIST _____ HWY 65		BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE November 24, 2018				CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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		ELEVATION SCALE	SHEAR STRENGTH kPa									WATER CONTENT (%)
289.4	GROUND SURFACE							20	40	60	80	100					
0.0	CLAYEY SILT, trace to some sand, trace organics Very soft Grey Wet		1	SS	2		289										
288.6	SILT, trace organics/wood Loose Grey Wet		2	SS	8		288										
287.9	SILT, trace to some clay Loose Grey Wet		3	SS	8		287										
1.5	- silty clay laminations at 2.4 m depth		4	SS	8		286										
	- 50 mm thick SILTY CLAY seam at 3.4 m depth		5	SS	5		285										
	- silty clay laminations at 4.5 m depth		6	SS	5		284										
			7	SS	7		283										
			8	SS	10		282										
			9	SS	9		281										
	- silty clay laminations at 7.6 m depth		10	SS	10		280										
279.6	END OF BOREHOLE																
9.8	Note:  1. Water level at a depth of 0.1 m below ground surface (Elev. 289.3 m) upon completion of drilling.  2. Split spoon samples obtained by driving with a half weight hammer. SPT 'N' value has been adjusted to the inferred values that would be obtained using a standard weight hammer.																



**APPENDIX B**

# Laboratory Test Results



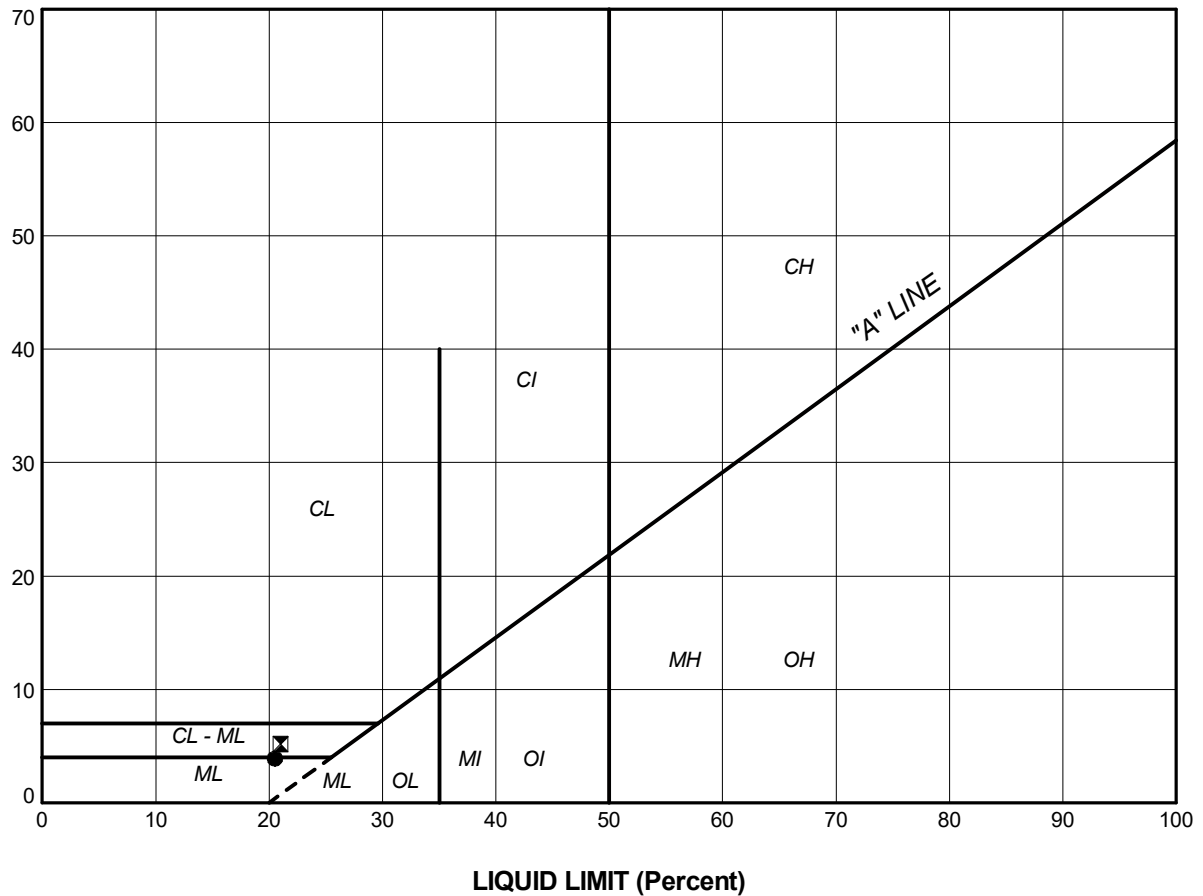
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C27-1	5	287.9
⊠	C27-1	7	286.5
▲	C27-1	10	281.8
★	C27-1	13	277.3
⊙	C27-2	3	287.7
⊛	C27-2	5	286.1
○	C27-2	7	284.6
△	C27-3	3	287.6
⊗	C27-3	6	285.3
⊕	C27-3	9	281.6

PROJECT		HIGHWAY 65 STATION 14+480 TOWNSHIP OF BARBER CULVERT			
TITLE		GRAIN SIZE DISTRIBUTION Silt			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	May 2019	SCALE	N/A	REV.
CHECK	MB	May 2019	FIGURE B-1		
APPR	JMAC	May 2019			
GOLDER		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
●	C27-1	13	20.5	16.6	3.9
⊠	C27-3	3	21.0	15.8	5.2

PROJECT		HIGHWAY 65 STATION 14+480 TOWNSHIP OF BARBER CULVERT			
TITLE		<b>PLASTICITY CHART</b> Silt			
PROJECT No.		1896349		FILE No.	
DRAWN		TR		May 2019	
CHECK		MB		May 2019	
APPR		JMAC		May 2019	
GOLDER		SUDBURY, ONTARIO		SCALE N/A REV.	
				<b>FIGURE B-2</b>	

### RESULTS OF ANALYSES OF SOIL

Maxxam ID		IKA226			IKA226			IKA227	IKA228		
Sampling Date		2018/11/13 10:41			2018/11/13 10:41			2018/11/17 11:30	2018/11/18 12:13		
COC Number		62170			62170			62170	62170		
	UNITS	C14-3 SA 1	RDL	QC Batch	C14-3 SA 1 Lab-Dup	RDL	QC Batch	C27-1 SA 1	C77-1 SA 1	RDL	QC Batch
<b>CONVENTIONALS</b>											
Sulphide	ug/g	7.35	0.50	5872398				<0.55	0.64	0.55	5872398
<b>Calculated Parameters</b>											
Resistivity	ohm-cm	1200		5859836				2000	3800		5859836
<b>CONVENTIONALS</b>											
Redox Potential	mV	140	N/A	5865933				140	130	N/A	5865933
<b>Inorganics</b>											
Soluble (20:1) Chloride (Cl-)	ug/g	430	20	5862969				250	90	20	5862969
Conductivity	umho/cm	868	2	5863312	909	2	5863312	508	266	2	5863312
Available (CaCl2) pH	pH	7.23		5864763				7.54	7.60		5864763
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	5862489				<20	<20	20	5862489
<b>Physical Testing</b>											
Moisture-Subcontracted	%	24	0.30	5872397				17	25	0.30	5872397
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate N/A = Not Applicable											



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