



## FOUNDATION INVESTIGATION REPORT

# Highway 66, Station 18+853, Township of Lebel Culvert Replacement Ministry of Transportation, Ontario GWP 5210-14-00

Submitted to:

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1896349-R09

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GEOCRES NO: 32D-23

LAT: 48.150615

LONG: -79.914596



## Distribution List

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**PART A**

FOUNDATION INVESTIGATION REPORT  
HIGHWAY 66, STA 18+853, TOWNSHIP OF LEBEL  
CULVERT REPLACEMENT  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5210-14-00



## 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 66 at Station 18+853, in the Township of Lebel, Ontario, approximately 4 km northwest of the intersection with Crystal Beach Road. The Key Plan of the general location of this section of Highway 66 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 the Drawing 1. For the purpose of this report, Highway 66 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 south-north direction.

The existing culvert consists of a 1.0 m diameter, 36 m long Corrugated Steel Pipe (CSP). The culvert inlet (south end) and outlet (north end) inverts are at approximately Elevations 339.9 m and 339.0 m, respectively. In general, the topography within the vicinity of the culvert consists of forested hills. The culvert site located approximately 400 m south west of Crystal Lake, near a curve in the highway, and the highway grade at the culvert centreline is approximately Elevation 345.7 m. The embankment is approximately 6.7 m high relative to the culvert invert at the outlet and the embankment/side slopes appear to be relatively performing well, with no visible signs of slope instability or roadway settlement issues, although severe erosion gullying of the upper portion of the embankment side slopes is evident. The ground surface conditions at select locations near the culvert are shown on Photographs 1 to 4.

## 3.0 INVESTIGATION PROCEDURES

Field work for this subsurface exploration was carried out on May 3 and 6 and June 3, 2019, during which time five boreholes (Boreholes C236-1 to C236-5) were advanced at the approximate locations shown on Drawing 1. Boreholes C236-1 to C236-3 were advanced through the roadway embankment using a track mounted CME-55LC drilling rig supplied and operated by George Downing Estate Drilling (Downing) of Grenville-Sur-La-Rouge, Quebec. Boreholes C236-4 and C236-5 were advanced near the south and north toes, respectively, of the highway embankment adjacent to the culvert inlet and outlet, using a portable tripod rig supplied and operated by Landcore Drilling (Landcore) of Chelmsford, Ontario. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

Boreholes C236-1 to C236-3 were advanced through the roadway using 108 mm I.D. Hollow Stem Augers, NW casing with wash boring techniques, and NQ coring. Borehole C236-3 encountered auger refusal at 5.4 m below

ground surface and the auger plug was lost in the borehole at this depth; the remaining portion of the borehole to the termination depth was drilled 1.5 m north of the original borehole. Boreholes C236-4 and C236-5 were advanced using NW casing with wash boring techniques. Three Dynamic Cone Penetration Tests (DCPT) were conducted adjacent to each toe borehole (Boreholes C236-4 and C236-5) to confirm refusal to split spoon sampling. 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 or cathead hammer, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). The groundwater level inside the augers/casing was observed and recorded after the completion of drilling. The boreholes were backfilled in accordance with Ontario Regulation 903 (wells), as amended. The roadway surface at the boreholes drilled through Highway 66 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, Atterberg Limits, and organic content was carried out on selected soil samples. The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable. One soil sample was submitted to Bureau Veritas Laboratories (formerly Maxxam) of Mississauga, an accredited analytical laboratory, for testing a suite of corrosivity indicator parameters.

The as-drilled borehole locations were measured relative to highway chainages/station marked on the pavement by a member of our technical staff and converted into northing/easting coordinates on the plan drawing. The ground surface elevation at the borehole locations was surveyed by Golder, relative to the highway and culvert centreline, with the elevation of the centreline provided by AECOM. The MTM NAD 83-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/DCPT (m)
C236-1	5335210.1 (48.150615)	385554.3 (-79.914596)	345.5	11.4*
C236-2	5335201.8 (48.150539)	385565.8 (-79.914443)	345.5	10.6*
C236-3	5335219.3 (48.150698)	385552.5 (-79.914618)	345.9	12.0*
C236-4	5335194.5 (48.150476)	385548.8 (-79.914673)	339.9	0.7/1.3
C236-5	5335224.2 (48.150739)	385573.0 (-79.914342)	339.7	0.9/1.0

\*Including coring for lengths between 2.9 m and 3.5 m.

## 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 glacially derived ground moraine comprising primarily of till.

Based on geological mapping (MNDM)<sup>2</sup>, the site is underlain by coarse clastic metasedimentary rocks and/or alkaline metavolcanics (diorite) rocks.

### 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 plotted 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 profiles 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 results of the analytical laboratory testing (by Bureau Veritas Laboratories) are summarized in Section 4.4 and the detailed laboratory testing report is included in Appendix B.

The subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented on the Record of Borehole Sheets 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 120 mm to 160 mm thick layer of asphalt pavement was encountered in the roadway boreholes C236-1 to C236-3, between Elevations 345.9 m and 345.5 m. A 5.2 m to 7.3 m thick layer of embankment fill consisting of various layers of silt and silty sand, sand, sand and gravel, sandy gravel were encountered below the asphalt in Boreholes C236-1 to C236-3. Asphalt coated particles were encountered in all three road boreholes at between depths of 0.1 m to 0.3 m below the road surface. Cobbles and/or boulders were noted, or inferred present, as follows at the various roadway boreholes:

- Borehole C236-1: Auger grinding from 3.7 m to 5.3 m depth, with the potential presence of cobbles as inferred from auger grinding.
- Borehole C236-2: Auger grinding from 4.5 m to 5.8 m depth, with the potential presence of cobbles as inferred from auger grinding.

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<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



- Borehole C236-3: Refusal to auger advancement was encountered at a depth of 5.4 m below ground surface and the auger plug was lost at this depth. Confirmation of drilling operations in adjacent borehole encountered cobbles from 5.4 m to 6.1 m depth and a 690 mm boulder at 6.6 m depth.

The SPT “N”-values measured within the non-cohesive fill range between 23 blows and 96 blows per 0.3 m of penetration, indicating a compact to very dense compactness condition.

Grain size distribution analysis was carried out on four samples of the silt to sand layer of the fill and the results are presented on Figure B-1 in Appendix B; and one sample of sandy gravel fill and the result is presented on Figure B-2. The natural moisture content measured on the samples of fill range from 5 per cent to 18 per cent.

#### 4.2.2 Peat

In Borehole C236-3, a 1.0 m thick deposit of amorphous peat was encountered underlying the fill at Elevation 338.4 m. In Boreholes C236-4 and C236-5, a 0.1 m and 0.9 m, respectively, thick layer of peat was encountered from ground surface at Elevations 339.9 m and 339.7.

The SPT “N”-value measured within the amorphous peat deposit is 1 blow per 0.3 m of penetration, indicating that the deposit has a very loose compactness condition.

The natural moisture content measured on one sample of the amorphous peat is 107 per cent.

#### 4.2.3 Silt

A 2.0 m and 0.6 m thick deposit of silt was encountered in Boreholes C236-1 and C236-4, respectively, at Elevations 340.2 m and 339.8 m. Borehole C236-4 was terminated within the silt deposit at a depth of 0.7 m below ground surface, due to split spoon refusal.

The SPT “N”-values measured within this deposit are 1 blow and 18 blows per 0.3 m of penetration, indicating that the deposit has a very loose to compact compactness condition.

An organic content was carried out on one sample of the silt layer in Borehole C236-1 and the result is 4.2 per cent organics. Grain size distribution analysis was carried out on one sample of the silt deposit and the result is presented on Figure B-3 in Appendix B. Atterberg limits testing was carried out on two samples of the silt. One resulted in a non-cohesive sample, and the other result is presented on Figure B-4 in Appendix B. The natural moisture content measured on three sample of the deposit range between 23 per cent and 18 per cent.

#### 4.2.4 Gravely Silty Sand

A 1.5 m thick layer of gravely silty sand was encountered below the fill in Borehole C236-2 at Elevation 339.7 m.

The SPT “N”-value measured within this deposit is 12 blows per 0.3 m of penetration, indicating that the deposit has a compact compactness condition.

Grain size distribution was carried out on one sample of the gravely silty sand deposit and the result is presented on Figure B-5 of Appendix B. The natural moisture content measured on one samples of the deposit is 16 per cent.

### 4.2.5 Till

A 0.8 m and 0.4 m thick layer of silty gravel till to gravelly sand till was encountered in Boreholes C236-1 and C236-2, respectively, at Elevation 338.2 m.

An STP “N”-value measured within the till deposit is 39 blows per 0.3 m of penetration indicating a dense compactness condition.

### 4.2.6 Bedrock

Bedrock was encountered in Boreholes C236-1 to C236-3 at depths ranging from 7.7 m to 8.5 m below roadway surface, between Elevations 337.8 m and 337.4 m, and between 2.9 m and 3.5 m of diorite bedrock was cored. The retrieved bedrock cores are described as fine to medium grained, fresh, grey diorite, as described on the Record of Drillholes presented in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B-6A and B-6B in Appendix B. The Total Core Recovery (TCR) of the bedrock samples range from 96 per cent and 100 per cent. The Rock Quality Designation (RQD) of the bedrock core samples ranges between 85 per cent and 100 per cent and based on the Quality Classification from Table 3.10 of CFEM 2006<sup>3</sup>, the bedrock is considered of good to excellent quality.

## 4.3 Groundwater Conditions

The unstabilized groundwater levels, relative to ground surface measured inside the casing or augers upon completion of drilling are summarized below. The creek was dry at the time of survey in early May 2019 at the inlet; however, the culvert outlet had water in late May at about Elevation 339.5m, as seen in Photograph 4. 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)
C236-1	5.4	340.1
C236-2	5.1	340.4
C236-3	4.9	341.0
C236-4	0.2	339.7
C236-5	Ground Surface	339.7

<sup>3</sup> Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual (CFEM), 4<sup>th</sup> Edition.

## 4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a sample of native silt recovered from Borehole C236-1. The soil sample was submitted to Bureau Veritas Laboratories 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 (µmho/cm)	Soluble Sulphate (SO <sub>4</sub> ) Content (µg/g)	Chloride (Cl) Content (µg/g)	Sulphide (µg/g)	pH
C236-1	8b	6.2 – 6.7	2,400	413	<20 <sup>1</sup>	260	0.84	6.31

Note:

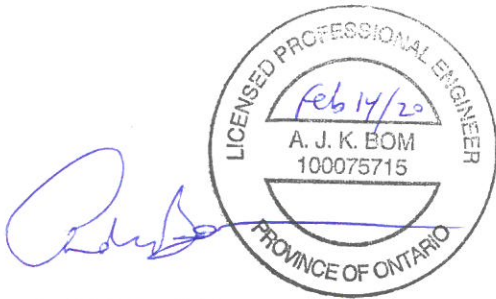
<sup>1</sup> The sulphate concentration is below the reportable detection limit of 20 µg/g.

## 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Mathew Riopelle, under the overall direction of Mr. André Bom, P.Eng., an Associate of Golder. This Foundation Investigation Report was prepared by Mr. Gavin Mundry, and Mr. André Bom, P.Eng., an Associate of Golder, 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.



André Bom, P.Eng.  
*Senior Geotechnical Engineer, Associate*



Jorge M. A. Costa, P.Eng.  
*MTO Foundations Designated Contact, Senior Consultant*

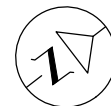
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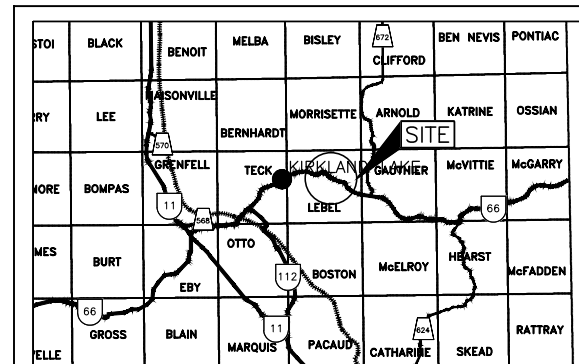
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 5210-14-00



HIGHWAY 66  
STATION 18+853  
TOWNSHIP OF LEBEL CULVERT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



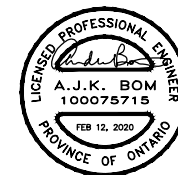
KEY PLAN  
SCALE  
10 0 10 20 km

### LEGEND

- Borehole - Current Investigation
- ⊕ Dynamic Cone Penetration Test - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated  
(Std. Pen. Test, 475 j/blow)
- R Refusal
- 100% Rock Quality Designation (RQD)
- ≡ WL upon completion of drilling

### BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
C236-1	345.5	5335210.1	385554.3
C236-2	345.5	5335201.8	385565.8
C236-3	345.9	5335219.3	385552.5
C236-4	339.9	5335194.5	385548.8
C236-5	339.7	5335224.2	385573.0



### 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.

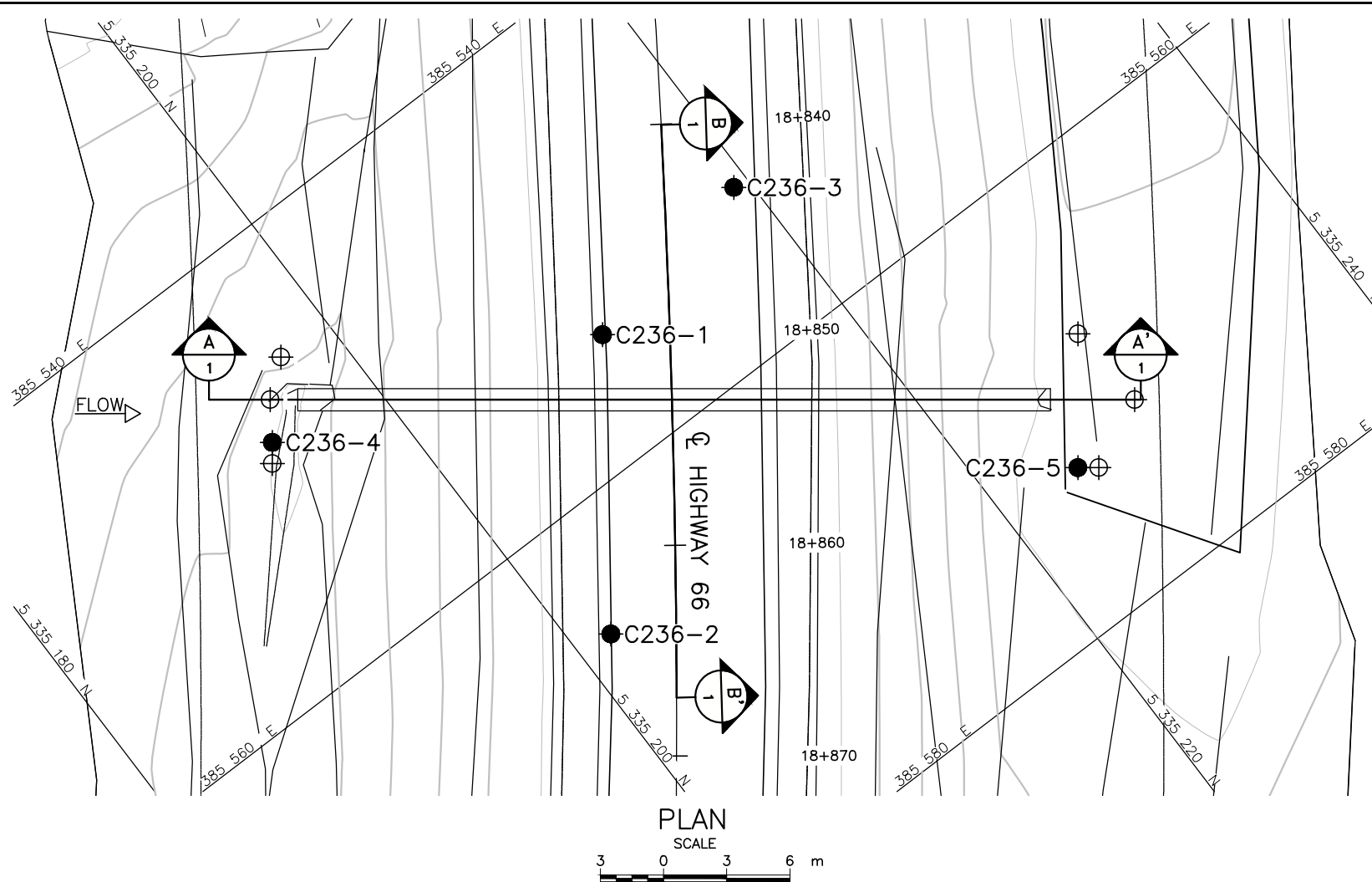
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Base plans provided in digital format by CALLON DIETZ LTD. drawing file no. gwp52101400a.dwg, received AUGUST 14, 2019.

NO.	DATE	BY	REVISION
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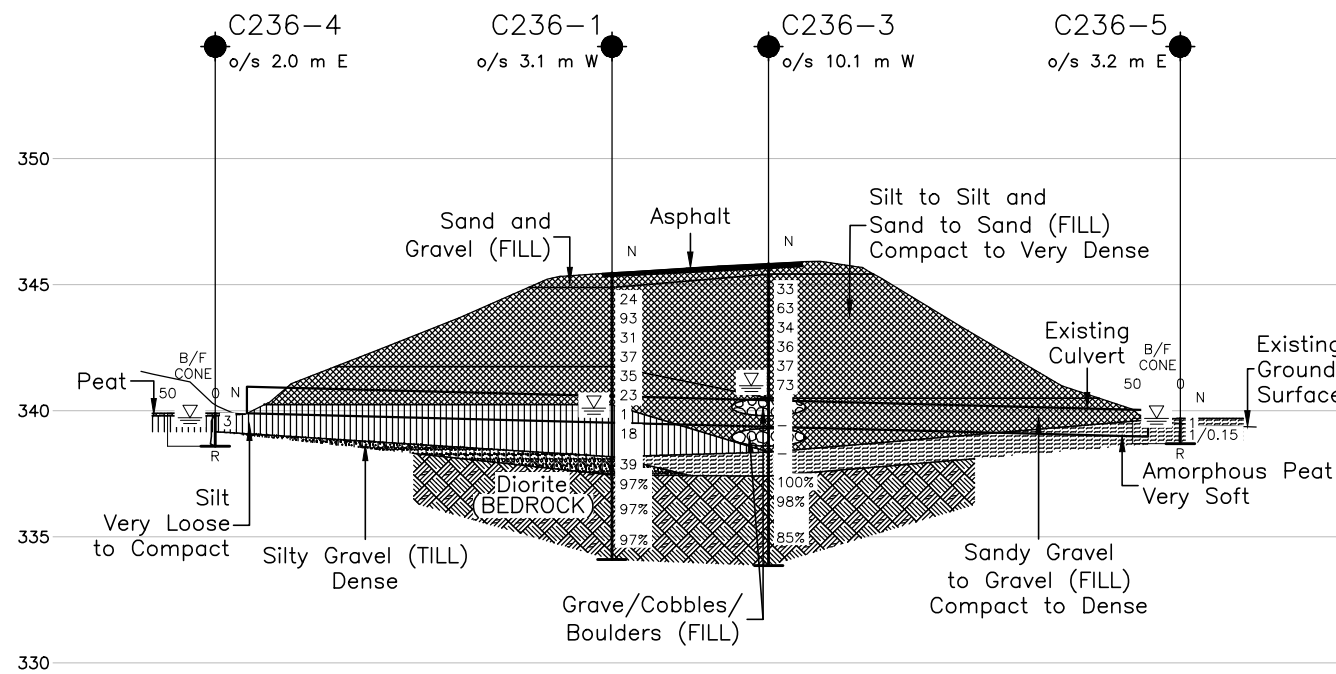
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DRAWN: TR	CHKD. AB	APPD. JMAC
		DWG. 1



### PLAN

SCALE

3 0 3 6 m



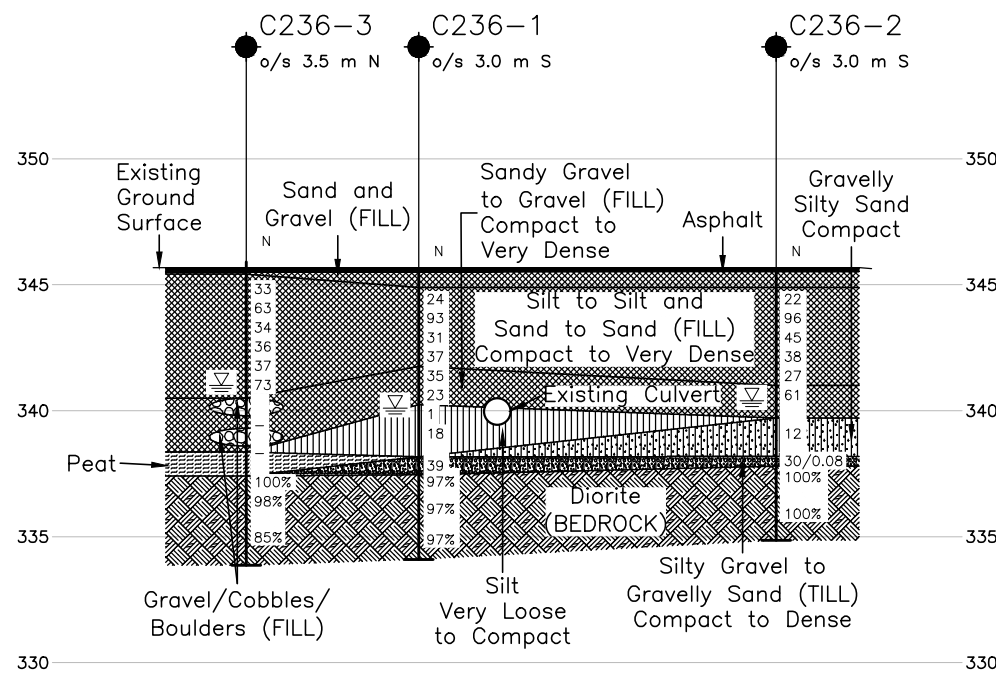
### CULVERT CENTERLINE PROFILE

HORIZONTAL SCALE

3 0 3 6 m

VERTICAL SCALE

3 0 3 6 m



### HIGHWAY CENTERLINE PROFILE

HORIZONTAL SCALE

3 0 3 6 m

VERTICAL SCALE

3 0 3 6 m





**Photograph 1: Road Surface at Culvert Location, Facing West (May 2019)**



**Photograph 2: Embankment South Slope at Culvert Location, Facing East (May 2019)**





**Photograph 3: Culvert Inlet, South Side of embankment (May 2019)**



**Photograph 4: Culvert Outlet, North Side of Embankment (May 2019)**

**APPENDIX A**

# Record of Boreholes



# ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

## MINISTRY OF TRANSPORTATION, ONTARIO

### PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

### MODIFIERS FOR SECONDARY COMPONENTS<sup>1,2</sup>

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

1. Only applicable to components not described by Primary Group Name.

2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

### PENETRATION RESISTANCE

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

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

#### Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q<sub>t</sub>), porewater pressure (u) and sleeve friction (f<sub>s</sub>) are recorded electronically at 25 mm penetration intervals.

#### Dynamic Cone Penetration Resistance (DCPT); N<sub>d</sub>:

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

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

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

### SAMPLES

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

### SOIL TESTS

w	water content
PL, w <sub>p</sub>	plastic limit
LL, w <sub>L</sub>	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 <sub>R</sub>	relative density (specific gravity, G <sub>s</sub> )
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
Y	unit weight

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

### COARSE-GRAINED SOILS

#### Compactness<sup>1</sup>

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

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

4. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

### FINE-GRAINED SOILS

#### Consistency

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

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

### Field Moisture Condition

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

# LIST OF SYMBOLS

## MINISTRY OF TRANSPORTATION, ONTARIO

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 $= (w_l - w_p)$
NP	non-plastic
$w_s$	shrinkage limit
$I_L$	liquidity index $= (w - w_p) / I_p$
$I_C$	consistency index $= (w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (b) Hydraulic Properties

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

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	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

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

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

## WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

## BEDDING THICKNESS

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

## JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

## GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

### Description and Notes

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

### Abbreviations

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

PROJECT 1896349		RECORD OF BOREHOLE No C236-1				1 OF 2 METRIC							
G.W.P. 5210-14-00		LOCATION N 5335210.1; E 385554.3 NAD83 MTM ZONE 12 (LAT. 48.150615; LONG. -79.914596)				ORIGINATED BY MR							
DIST _____ HWY 66		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring				COMPILED BY GM							
DATUM GEODETIC		DATE May 3, 2019				CHECKED BY AB							
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	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL	
345.5	GROUND SURFACE												
0.0	ASPHALT (120 mm)												
0.1	Sand and gravel (FILL)												
344.9	Grey Frozen												
0.6	Asphalt coated particles from 0.2 m to 0.3 m depth		1	SS	24								
	Silt and sand to sand, some silt, trace gravel, trace clay (FILL)		2	SS	93								
	Compact to very dense		3	SS	31							0 43 53 4	
	Brown to grey		4	SS	37								
	Frozen to moist												
341.8	Sandy gravel, some silt (FILL)												
3.7	Compact to dense		5	SS	35							63 23 (14)	
	Dark grey to dark brown		6	SS	23								
	Wet												
	Auger grinding from 3.7 m to 5.3 m depth												
340.2	SILT, some sand, trace gravel, trace clay, trace organics, trace wood		7	SS	1						NP		
5.3	Very loose to compact		8A	SS	18						OC=4.2%		
	Dark brown to black		8B	SS								0 11 82 7	
	Wet												
338.2	Silty GRAVEL, some sand (TILL)		9	SS	39								
7.3	Dense												
	Brown and grey												
	Wet												
337.4	DIORITE (BEDROCK)		1	RC	REC 100%							RQD = 97%	
8.1	For coring details see Record of Drillhole C236-1.		2	RC	REC 100%							RQD = 97%	
			3	RC	REC 100%							RQD = 97%	
334.1	END OF BOREHOLE												
11.4													

Continued Next Page

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

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PROJECT <u>1896349</u>		<b>RECORD OF BOREHOLE No C236-1</b>				2 OF 2 <b>METRIC</b>																			
G.W.P. <u>5210-14-00</u>		LOCATION <u>N 5335210.1; E 385554.3 NAD83 MTM ZONE 12 (LAT. 48.150615; LONG. -79.914596)</u>				ORIGINATED BY <u>MR</u>																			
DIST <u>          </u> HWY <u>66</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring</u>				COMPILED BY <u>GM</u>																			
DATUM <u>GEODETIC</u>		DATE <u>May 3, 2019</u>				CHECKED BY <u>AB</u>																			
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W			W <sub>L</sub>								
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED   + FIELD VANE</span> <span>● QUICK TRIAXIAL   × REMOULDED</span> </div>																		
	NOTE:  1. Water level at a depth of 5.4 m below ground surface (Elev. 340.1 m) upon completion of drilling.																								

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SHEET 1 OF 1

DATUM: GEODETIC

DRILLING CONTRACTOR: Downing Drilling

- Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
- Fault	FO - Foliation	CU - Curved	K - Slickensided	<b>NOTE:</b> For additional abbreviations refer to list of abbreviations & symbols.
R - Shear	CO - Contact	UN - Undulating	SM - Smooth	
- Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
- Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

CHECKED: AB

1 : 60

PROJECT 1896349		RECORD OF BOREHOLE No C236-2				1 OF 1 METRIC								
G.W.P. 5210-14-00		LOCATION N 5335201.8; E 385565.8 NAD83 MTM ZONE 12 (LAT. 48.150539; LONG. -79.914443)				ORIGINATED BY MR								
DIST _____ HWY 66		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring				COMPILED BY GM								
DATUM GEODETIC		DATE May 3, 2019				CHECKED BY AB								
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	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20 40 60					
345.5	GROUND SURFACE													
0.0	ASPHALT (120 mm)													
0.1	Sand and gravel (FILL) Grey Frozen													
344.9														
0.6	Asphalt coated particles from 0.1 m to 0.3 m depth Silt and sand to sand, some silt (FILL) Compact to very dense Brown to grey Frozen to moist		1	SS	22		345							
			2	SS	96		344							
			3	SS	45		343							
			4	SS	38		342							
			5	SS	27		341							
341.0	Sandy gravel (FILL) Very dense Grey and brown Wet		6	SS	61		340							
4.5	Auger grinding from 4.5 m to 5.8 m depth													
339.7	Gravelly SILTY SAND, trace organics Compact Grey Wet		7	SS	12		339							
5.8														
338.2	Gravelly SAND, trace silt (TILL) Compact Red / brown Wet		8	SS	30/0.08		338							
7.3														
337.8	DIORITE (BEDROCK)		1	RC	REC 100%		337							
7.7	For coring details see Record of Drillhole C236-2.		2	RC	REC 100%		336							
							335							
334.9	END OF BOREHOLE													
10.6	NOTE: 1. Water level at a depth of 5.1 m below ground surface (Elev. 340.4 m) upon completion of drilling.													

SHEET 1 OF 1

DATUM: GEODETIC

DRILLING CONTRACTOR: Downing Drilling

- Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
- Fault	FO - Foliation	CU - Curved	K - Slickensided	<b>NOTE:</b> For additional abbreviations refer to list of abbreviations & symbols.
R - Shear	CO - Contact	UN - Undulating	SM - Smooth	
- Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
- Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

CHECKED: AB

1 : 60

PROJECT 1896349		RECORD OF BOREHOLE No C236-3		1 OF 2 METRIC															
G.W.P. 5210-14-00		LOCATION N 5335219.3; E 385552.5 NAD83 MTM ZONE 12 (LAT. 48.150698; LONG. -79.914618)		ORIGINATED BY MR															
DIST _____ HWY 66		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring		COMPILED BY GM															
DATUM GEODETIC		DATE May 6, 2019		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						20	40	60	80	100	20	40
345.9	GROUND SURFACE																		
0.0	ASPHALT (160 mm)																		
345.4	Sand and gravel (FILL) Grey Frozen																		
0.5	Asphalt coated particles from 0.22 m to 0.34 m depth Silt, some sand to sand, trace to some silt, trace gravel, trace clay (FILL) Dense to very dense Grey / brown Moist to wet		1	SS	33														
			2	SS	63														
			3	SS	34														
			4	SS	36														
			5	SS	37														
			6	SS	73														
340.5	Gravel, cobbles and boulders (FILL) Grey Wet  Cobbles and boulders encountered as follows:  Depth (m)      Size (mm) 5.4              120 5.5              70 5.6              50 5.9              230 6.6              690		-	RC	-														
338.4	Amorphous PEAT Dark brown Wet																		
337.4	DIORITE (BEDROCK)  For coring details see Record of Drillhole C236-3.		1	RC	REC 100%														
			2	RC	REC 100%														
			3	RC	REC 96%														

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

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PROJECT <u>1896349</u>		<b>RECORD OF BOREHOLE No C236-3</b>				2 OF 2 <b>METRIC</b>	
G.W.P. <u>5210-14-00</u>		LOCATION <u>N 5335219.3; E 385552.5 NAD83 MTM ZONE 12 (LAT. 48.150698; LONG. -79.914618)</u>				ORIGINATED BY <u>MR</u>	
DIST <u>          </u> HWY <u>66</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring and NQ Coring</u>				COMPILED BY <u>GM</u>	
DATUM <u>GEODETIC</u>		DATE <u>May 6, 2019</u>				CHECKED BY <u>AB</u>	

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>
333.9 12.0	END OF BOREHOLE  NOTE:  1. Auger refusal at 5.4 m depth and lost auger plug. Relocated 1.5 m north to core through cobbles and boulders and to continue with borehole.  2. Water level at a depth of 4.9 m below ground surface (Elev. 341.0 m) upon completion of drilling.																

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PROJECT: 1896349

LOCATION: N 5335219.3; E 385552.5

NAD83 MTM ZONE 12 (LAT. 48.150698; LONG. -79.914618)

INCLINATION: -90° AZIMUTH: —

**RECORD OF DRILLHOLE: C236-3**

SHEET 1 OF 1

DRILLING DATE: May 6, 2019

DATUM: GEODETIC

DRILL RIG: CME55 LC Track Mount

DRILLING CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate										BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage										PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular										PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break										BR - Broken Rock																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
							RECOVERY										R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY										Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
							TOTAL CORE %					SOLID CORE %							TYPE AND SURFACE DESCRIPTION					Jr					Ja					Jn							k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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DEPTH SCALE



1 : 60

**GOLDER**

LOGGED: MR

CHECKED: AB

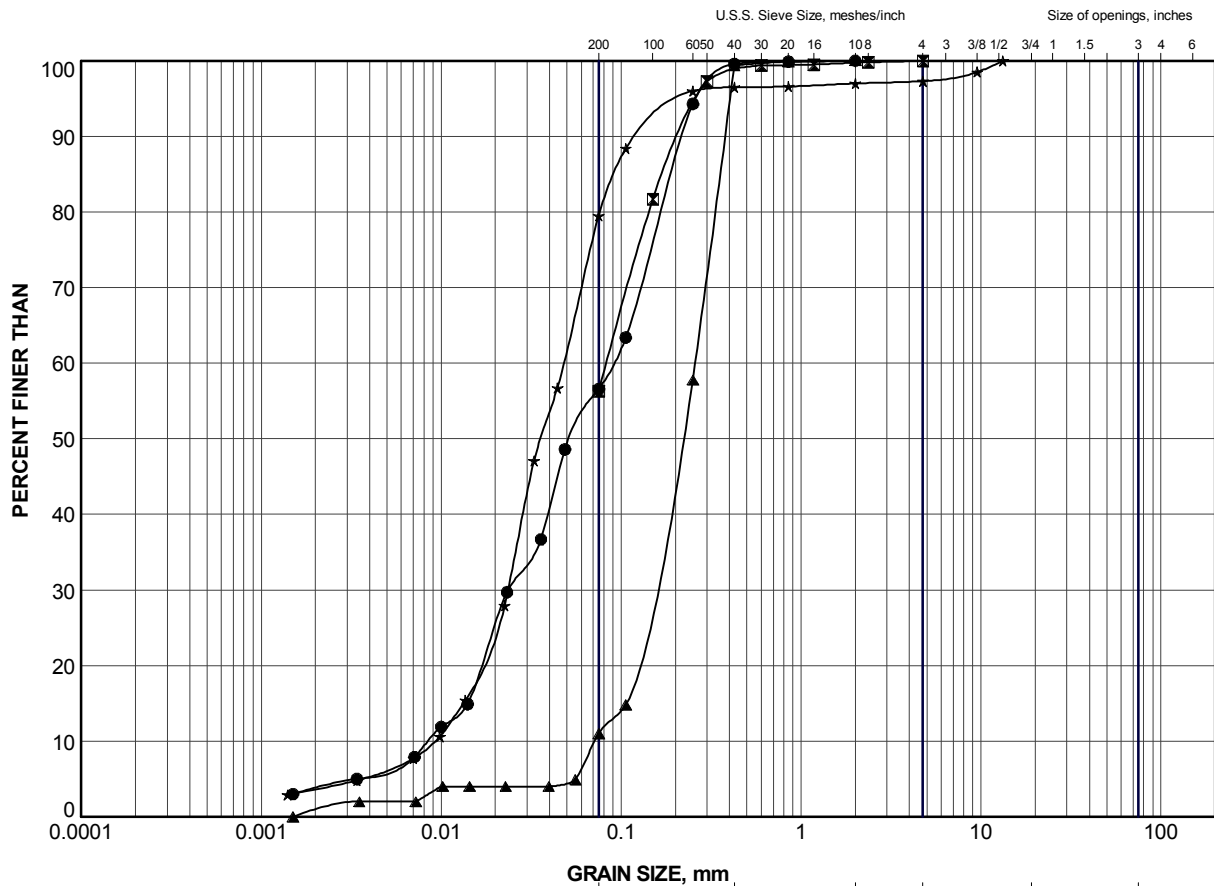
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PROJECT 1896349		<b>RECORD OF BOREHOLE No C236-4</b>				1 OF 1 <b>METRIC</b>												
G.W.P. 5210-14-00		LOCATION N 5335194.5; E 385548.8 NAD83 MTM ZONE 12 (LAT. 48.150476; LONG. -79.914673)				ORIGINATED BY MR												
DIST _____ HWY 66		BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring				COMPILED BY GM												
DATUM GEODETIC		DATE June 3, 2019				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										WATER CONTENT (%)
339.9	GROUND SURFACE																	
0.9	PEAT, trace silt Dark brown Wet		1	SS	3													
339.2	SILT, trace sand Very loose Grey / brown Wet																	
0.7	END OF BOREHOLE SPLIT-SPOON REFUSAL																	
338.6	END OF DCPT (HAMMER BOUNCING)																	
1.3	NOTE:  1. Water level at a depth of 0.2 m below ground surface (Elev. 339.7 m) upon completion of drilling.  2. Advanced DCPT 1.3 m south of the culvert centerline and refusal at a depth of 1.1 m below ground surface.  3. Advanced DCPT 1.2 m south and 2.5 m east of the culvert south east corner and refusal at a depth of 1.3 m below ground surface.  4. Advanced DCPT 0.8 m south and 1.5 m west of the culvert south west corner and refusal at a depth of 1.3 m below ground surface.																	

PROJECT 1896349		RECORD OF BOREHOLE No C236-5				1 OF 1 METRIC											
G.W.P. 5210-14-00		LOCATION N 5335224.2; E 385573.0 NAD83 MTM ZONE 12 (LAT. 48.150739; LONG. -79.914342)				ORIGINATED BY MR											
DIST _____ HWY 66		BOREHOLE TYPE Portable Equipment, NW Casing and Wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE June 3, 2019				CHECKED BY AB											
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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			
339.7	GROUND SURFACE																
0.0	Amorphous PEAT Very soft Dark brown Wet		1	SS	1												
338.8	END OF BOREHOLE SPLIT-SPOON REFUSAL		2	SS	1/0.15		339										OC=15.0%
1.0	END OF DCPT (HAMMER BOUNCING)  NOTE:  1. Water level at ground surface (Elev. 339.7 m) upon completion of drilling.  2. Advanced DCPT 4.0 m north of the culvert centerline and refusal at a depth of 0.9m below ground surface.  3. Advanced DCPT 2.3 m north and 2.7 m east of the culvert north east corner and refusal at a depth of 0.8 m below ground surface.  4. Advanced DCPT 1.3 m north and 2.6 m west of the culvert north west corner and refusal at a depth of 1.0 m below ground surface.																

**APPENDIX B**

# Laboratory Test Results

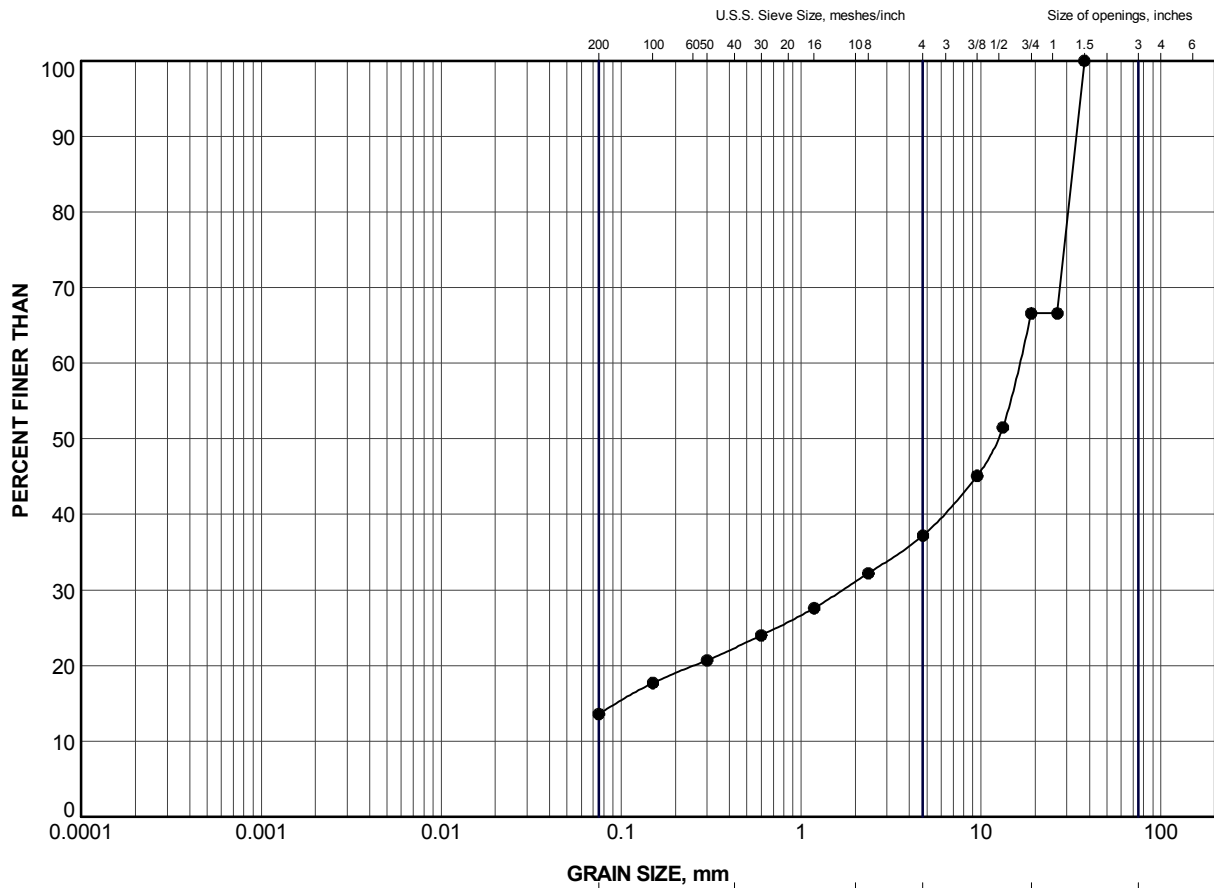


CLAY AND SILT	GRAVEL SIZE, mm						Cobble Size
	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C236-1	3	342.9
⊠	C236-2	5	341.4
▲	C236-3	3	343.3
★	C236-3	5	341.8


PROJECT		HIGHWAY 66 STATION 18+861 TOWNSHIP OF LEBEL CULVERT			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> Silt to Sand (FILL)			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	Oct 2019	SCALE	N/A	REV.
CHECK	AB	Oct 2019	<b>FIGURE B-1</b>		
APPR	JMAC	Oct 2019			
GOLDER		SUDBURY, ONTARIO			



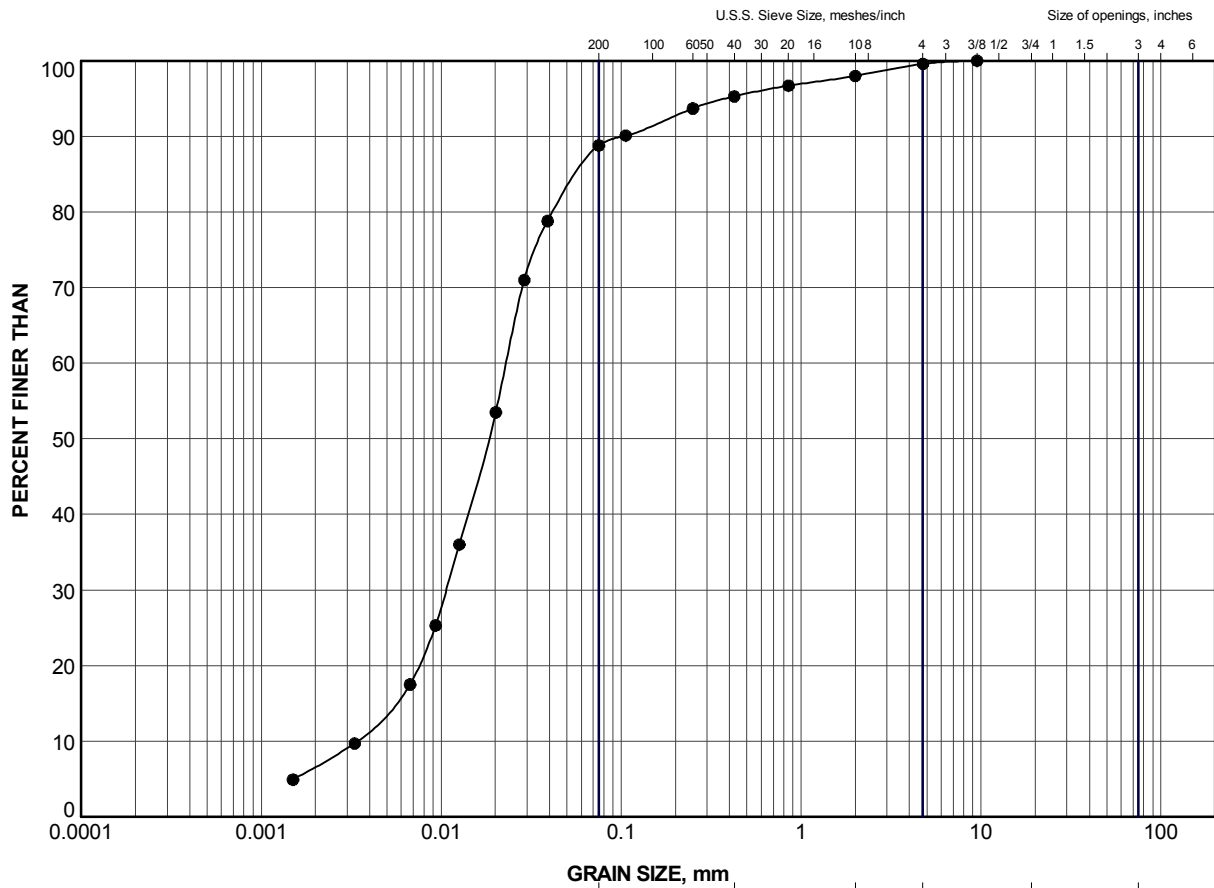
CLAY AND SILT	GRAVEL SIZE, mm						Cobble Size
	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C236-1	5	341.4

PROJECT						HIGHWAY 66 STATION 18+861 TOWNSHIP OF LEBEL CULVERT					
TITLE						<b>GRAIN SIZE DISTRIBUTION</b> Sandy Gravel (FILL)					
PROJECT No.				1896349		FILE No.				1896349.GPJ	
DRAWN		TR		Oct 2019		SCALE		N/A		REV.	
CHECK		AB		Oct 2019		APPR		JMAC		Oct 2019	
 <b>GOLDER</b> SUDBURY, ONTARIO						<b>FIGURE B-2</b>					



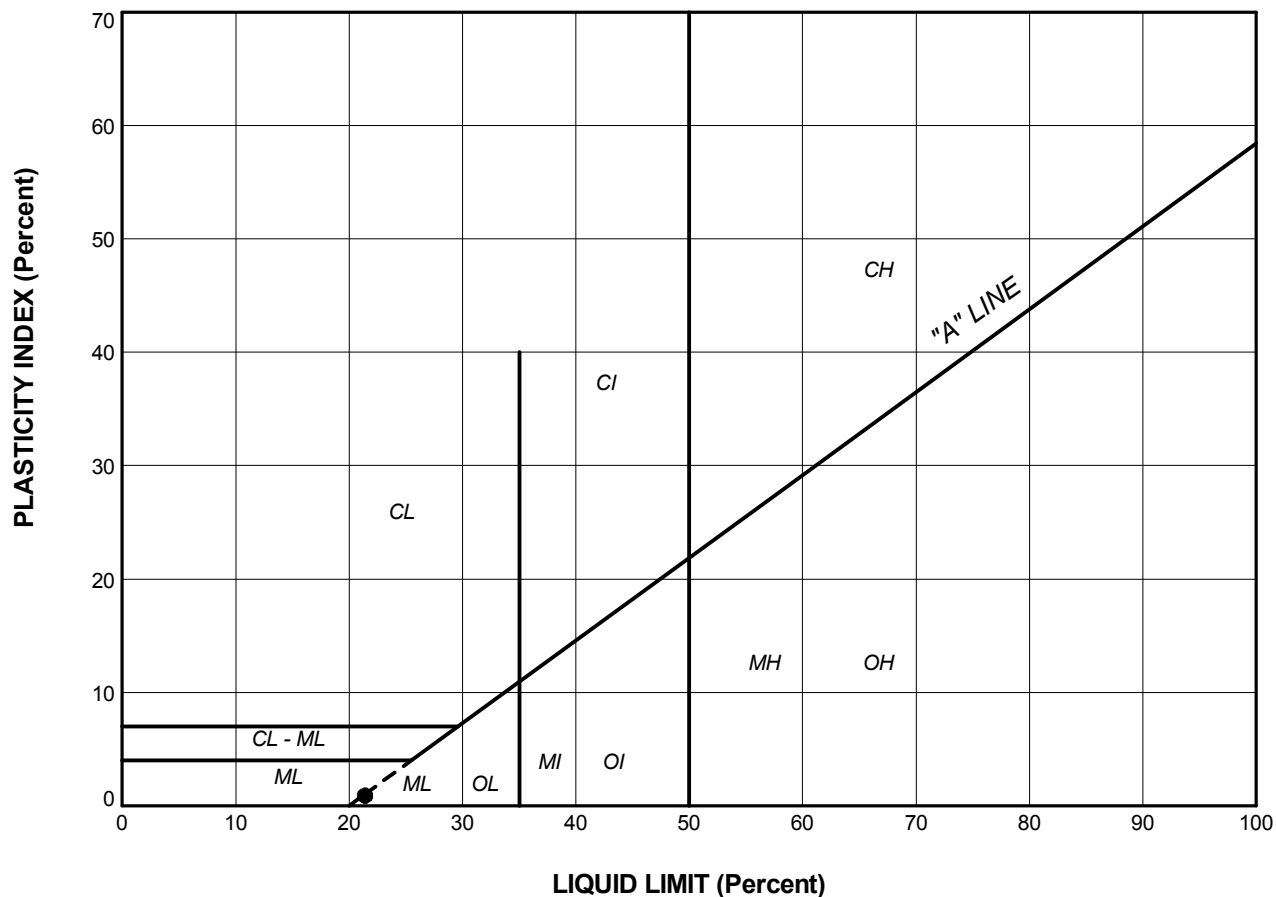


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

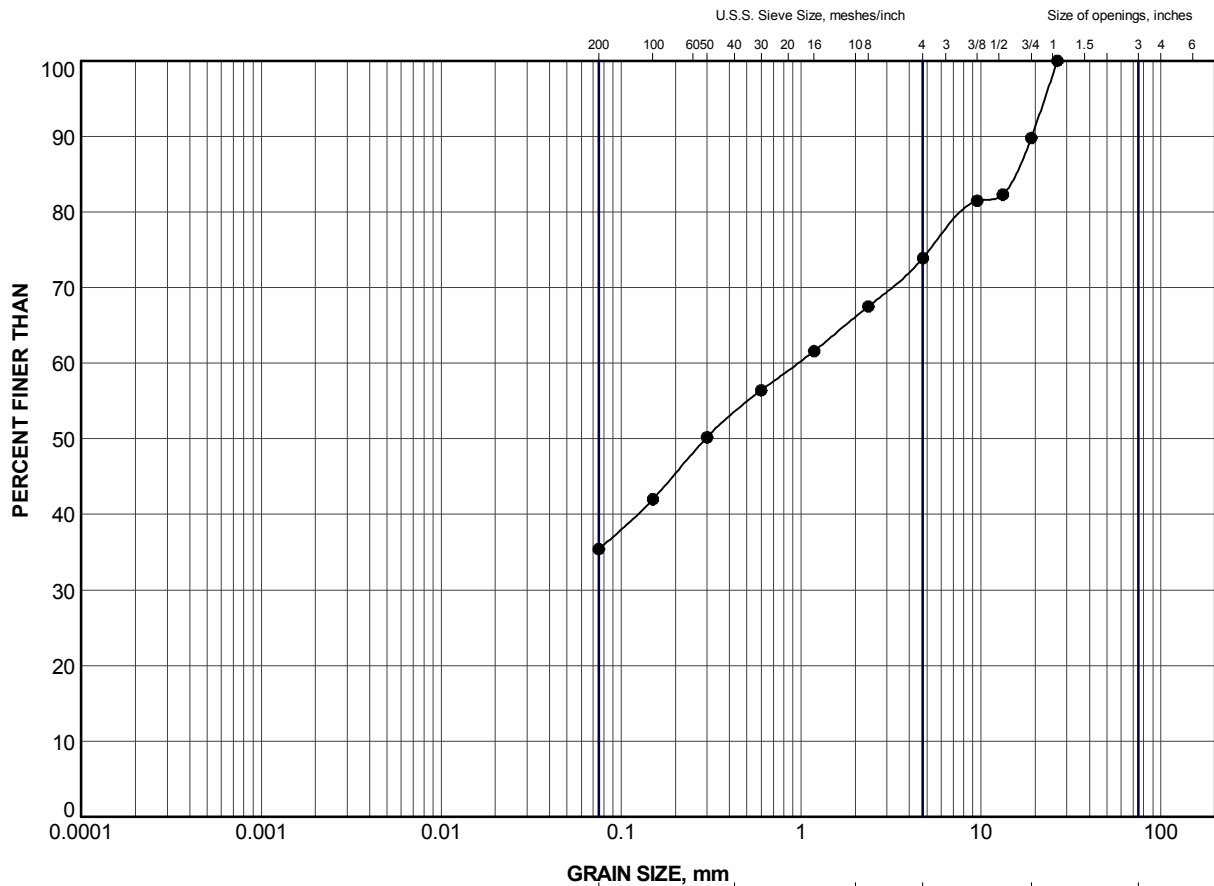
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C236-1	8B	338.9

PROJECT						HIGHWAY 66 STATION 18+861 TOWNSHIP OF LEBEL CULVERT					
TITLE						<b>GRAIN SIZE DISTRIBUTION</b> SILT					
PROJECT No.				1896349		FILE No.				1896349.GPJ	
DRAWN	TR	Oct 2019	SCALE		N/A	REV.					
CHECK	AB	Oct 2019					<b>FIGURE B-3</b>				
APPR	JMAC	Oct 2019									
GOLDER						SUDBURY, ONTARIO					



PROJECT						HIGHWAY 66 STATION 18+861 TOWNSHIP OF LEBEL CULVERT					
TITLE						PLASTICITY CHART SILT					
PROJECT No.			1896349			FILE No.			1896349.GPJ		
DRAWN	TR	Oct 2019	SCALE	N/A	REV.	FIGURE B-4					
CHECK	AB	Oct 2019									
APPR	JMAC	Oct 2019									
SUDBURY, ONTARIO											



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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C236-2	7	339.1

PROJECT		HIGHWAY 66 STATION 18+861 TOWNSHIP OF LEBEL CULVERT			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> GRAVELLY SILTY SAND			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	Oct 2019	SCALE	N/A	REV.
CHECK	AB	Oct 2019	<b>FIGURE B-5</b>		
APPR	JMAC	Oct 2019			
GOLDER		SUDBURY, ONTARIO			

# Bedrock Core Photographs

Figure B-6A

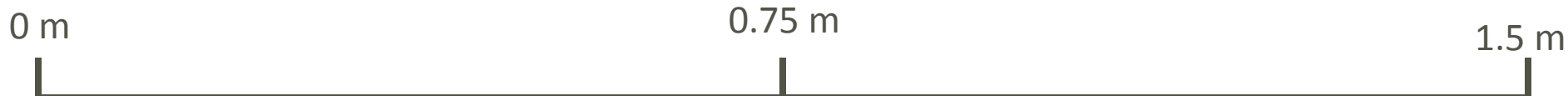
Highway 66, Station 18+853, Township of Lebel Culvert



**Borehole C236-1**  
Elevation 337.5 m to 334.1 m



**Borehole C236-2**  
Elevation 337.8 m to 334.9 m



## Bedrock Core Photographs

Figure B-6B

Highway 66, Station 18+853, Township of Lebel Culvert





BUREAU  
VERITAS

BV Labs Job #: B9D3975  
Report Date: 2019/06/03

Golder Associates Ltd  
Client Project #: 1896349(2100)  
Site Location: HWY 66  
Sampler Initials: MR

### RESULTS OF ANALYSES OF SOIL

BV Labs ID		JTI430			JTI430		JTI431	JTI432		
Sampling Date		2019/04/30 10:30			2019/04/30 10:30		2019/05/01 16:15	2019/05/03 10:45		
COC Number		127611			127611		127611	127611		
	UNITS	C263-1	RDL	QC Batch	C263-1 Lab-Dup	QC Batch	C260-1	C236-1	RDL	QC Batch
<b>CONVENTIONALS</b>										
Sulphide	ug/g	<0.30	0.30	6150574			<0.30	0.84	0.30	6150574
<b>Calculated Parameters</b>										
Resistivity	ohm-cm	2700		6129977			4000	2400		6129977
<b>Inorganics</b>										
Soluble (20:1) Chloride (Cl-)	ug/g	120	20	6133046			61	260	20	6133046
Conductivity	umho/cm	366	2	6135430			252	413	2	6135430
Available (CaCl2) pH	pH	7.95		6133358	8.09	6133358	8.05	6.31		6133358
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	6133048			<20	<20	20	6133048
<b>Physical Testing</b>										
Moisture-Subcontracted	%	33	0.30	6150575			31	15	0.30	6150575
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate										



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