



March 17, 2016

## DRAFT DETAIL FOUNDATION INVESTIGATION REPORT

**DOG RIVER CULVERT - SITE NO. 48C-218/C  
HIGHWAY 527, DISTRICT OF THUNDER BAY  
UNSURVEYED TERRITORY  
MINISTRY OF TRANSPORTATION, ONTARIO  
G.W.P 6302-14-00, W.P. 6300-14-01**

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DRAFT REPORT





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**DRAFT DETAIL FOUNDATION REPORT  
DOG RIVER CULVERT SITE NO. 48-218/C**

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# **PART A**

**DETAIL FOUNDATION INVESTIGATION REPORT  
DOG RIVER CULVERT – SITE NO. 48C-218/C  
HIGHWAY 527, DISTRICT OF THUNDER BAY  
UNSURVEYED TERRITORY  
MINISTRY OF TRANSPORTATION, ONTARIO  
G.W.P. 6302-14-00, W.P. 6300-14-01**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Hatch Mott MacDonald (HMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Dog River culvert (Site No. 48C-218/C). The Dog River culvert is located in the District of Thunder Bay on Highway 527 at STA 21+844, approximately 40 km north of Highway 11/17. The key plan showing the general location of this section of Highway 527 and the location of the investigated area are shown on Drawing 1.

## **2.0 SITE DESCRIPTION**

The Dog River Culvert is located on Highway 527 at STA 21+844, approximately 40 km north of the junction of Highway 11/17 (see the key plan on Drawing 1). The existing culvert consists of twin Steel Plate Corrugated Steel Pipe (SPCSP), the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in this area consists of rolling terrain to the north of the culvert location to relatively flat in all other directions. The dog river borders the site on the east and west side of the roadway and has areas of standing water, organic terrain consisting of tall grasses, cattails and small shrubs and the river drains westerly. Beyond the right-of-way and the bordering the edges of the Dog River, the area has moderate to heavy coniferous tree cover. At the culvert location, the highway grade is at Elevation 461.7 m and the invert is at about Elevation 458.7 m. The water level measured by others on April 30, 2012 was Elevation 459.05 m. Ground Surface conditions at the culvert inlet (east end) and outlet (west end) areas are shown on Photographs 1 to 3, attached.

## **3.0 INVESTIGATION PROCEDURES**

The field work for this subsurface investigation was carried out on December 5 and 6 2014, during which time five (5) boreholes (Boreholes DG-1, DG-2, DG-2A, DG-3 and DG-4) were advanced. Boreholes DG-1 and DG-4 were advanced using track-mounted CME-55 drill rig whereas Boreholes DG-2, DG-2A and DG-3 were advanced using a truck-mounted CME 55 drill rig. Both drill rigs were supplied by and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

All boreholes were advanced through the overburden using NW casing, wash boring and where required NQ coring 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) procedures (ASTM D1586). The groundwater levels in the open boreholes were observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. All boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The 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 and cared for the soil and rock 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



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content determinations, grain size distributions, and Atterberg limits tests were carried out on selected soil samples. In addition, unconfined compressive strength (UCS) tests were carried out on selected specimens of the bedrock core recovered from the boreholes. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the river water was obtained during the field investigation at the Dog River Culvert location on February 3, 2015, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters, including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline and existing culvert and converted into Northing/Easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing, provided by MTO in January 2015 (drawing BC4848905275.dwg). The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to geodetic datum and borehole depths at each borehole locations are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
DG-1	5408291.8	370262.2	458.8	4.1
DG-2	5408306.9	370269.4	461.9	1.8
DG-2A	5408308.7	370268.3	462.0	7.1
DG-3	5408300.0	370279.0	461.5	4.5
DG-4	5408320.6	370284.3	459.2	3.2

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on the Northern Ontario Engineering Geology Terrain (NOEGTS)<sup>1</sup> mapping, the subsoils in the vicinity of the Dog River culvert site generally consist of ground moraine deposits, comprised of mainly sandy till subsoils. Bordering the culvert to the north, the landform of the area is considered to be an undulating bedrock plain.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)<sup>2</sup>, the site is underlain by bedrocks of the Archean area, comprised of metasedimentary rocks consisting of mainly paragneisses and migmatites.

<sup>1</sup> Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52ANW

<sup>2</sup> Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.



## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing 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 in Section 4 are uncorrected. The stratigraphic boundaries shown on the boreholes records and on the interpreted stratigraphic section on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for holes through the embankment) overlying cohesionless deposits of silty sand to sand and gravel and cobbles, which is underlain by bedrock. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Thickness (m)	Elevation (m)	N Values (blows)	Laboratory Testing
				Consistency or Relative Density	
<b>Asphalt</b>	DG-2; DG-2A DG-3	0.030 – 0.050	462.0 – 461.5	n/a	n/a
<b>(FILL)<sup>1</sup></b> gravelly sand to sandy gravel, trace to some silt, brown, frozen to wet	DG-2; DG-2A DG-3	1.8; 3.5 – 4.5	462.0 – 461.4	N = 11 – 100 <sup>2</sup>	w = 9% – 15 % 1 – MH and 2 – M (Fig. B1)
				<b>Compact to Very Dense</b>	
<b>Silty Sand to Sand and Gravel to Gravel and Cobbles<sup>3</sup></b> , trace silt, trace organics, brown to dark brown, wet	DG-1 DG-2A DG-3 DG-4	0.7 – 3.2	459.2 – 458.4	N = 4 - 41 <sup>4</sup>	w = 9 % - 39% 3 – MH (Fig. B2)
				<b>Loose to Dense</b>	

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration

w = Natural Moisture Content (%)

MH = Combined Sieve and Hydrometer analysis

M = Sieve analysis for particle size

Notes:

<sup>1</sup> Refusal was encountered in Borehole DG-2 at 1.8 m and an additional borehole DG-2A was advanced through the deposit to a depth of 3.6 m, indicative of the presence of cobbles and/or boulders within the deposit. In Borehole DG-3, a 90 mm cobble was encountered at 2.2 m depth, requiring NW casing and NQ coring techniques to advance the borehole through the fill.



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<sup>2</sup>Two SPT 'N'-values of 102 blows and 142 blows per 0.3 m of penetration were recorded, however these values are inferred to be indicative of the frozen state of the material and are not representative. One split spoon did not penetrate the full sample depth inferred indicative of the presence of cobbles and/or boulders within the fill.

<sup>3</sup>In Borehole DG-1, cobbles were recovered from 0.5 m to 0.8 m depth, requiring the use of NW casing and NQ coring techniques to advance the borehole through this deposit. In Borehole DG-4 cobbles ranging from 75 mm to 225 mm diameter were recovered from NW casing and NQ coring through this deposit.

<sup>4</sup>In three instances, the split spoon did not penetrate the full sample depth, inferred to be indicative of the presence of cobbles and/or boulders within the deposit. .

### Refusal/Bedrock

Refusal to further split spoon or casing penetration was encountered in Boreholes DG-2 (inferred to be on cobbles/boulder) and DG-3, corresponding to Elevation 460.1 m and 457.0 m, respectively. Bedrock was cored in Boreholes DG-1 and DG-2 and the depth to the bedrock surface and bedrock surface elevations are presented below.

Borehole No.	Depth to Bedrock (below ground surface) (m)	Bedrock Surface Elevation (m)	Core Length (m)
DG-1	2.4	456.4	1.7
DG-2A	5.5	456.5	1.6

The retrieved bedrock core is described as grey-black, fine grained, fresh, basalt, with areas of white, medium grained inclusions and dykes, as presented on the Record of Drillhole sheets in Appendix A. Photographs of the retrieved bedrock core samples are shown on Figure B3. A more detailed description of the bedrock properties encountered in the boreholes is provided below.

Borehole No.	Depth/ Elevation (m)	Solid Core Recovery (SCR)	Rock Quality Designation (RQD)	Quality Classification Table 3.10 of CFEM 2006 <sup>3</sup>	UCS (MPa)	Strength Classification Table 3.5 of CFEM 2006
DG-1	2.4/456.4	72% and 100%	72% and 100%	Fair to Good	72	(R4) Strong
DG-2A	5.5/456.5	50%	61%	Fair	100	(R4) Strong

### Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The river ice level was measured at Elevation 458.8 m on December 6, 2014. The water level measured

<sup>3</sup> Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition.



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by others on April 30, 2012 was Elevation 459.05 m. Groundwater and river water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
DG-1	0.3	458.5
DG-2	1.2	460.7
DG-2A	1.8	460.2
DG-3	0.9	460.6
DG-4	0.2	459.0

### 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Cody Walter and Mr. Mathew Riopelle, under the overall direction of Mr. David Muldowney, P.Eng. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Ms. Sarah E. M. Poot, P.Eng., an Associate of Golder, provided a technical review of the report. Mr. Jorge M. A. Costa, P.Eng., the Designated MTO Foundations Contact and Principal of Golder, conducted an independent quality control review and technical audit of this report.





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### Report Signature Page

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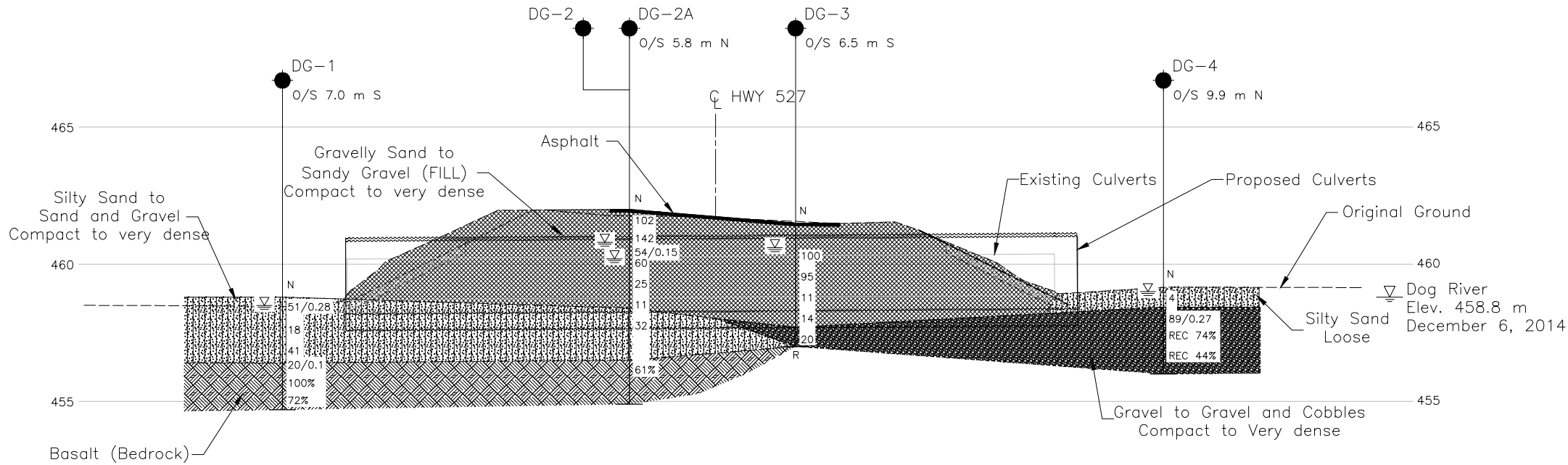
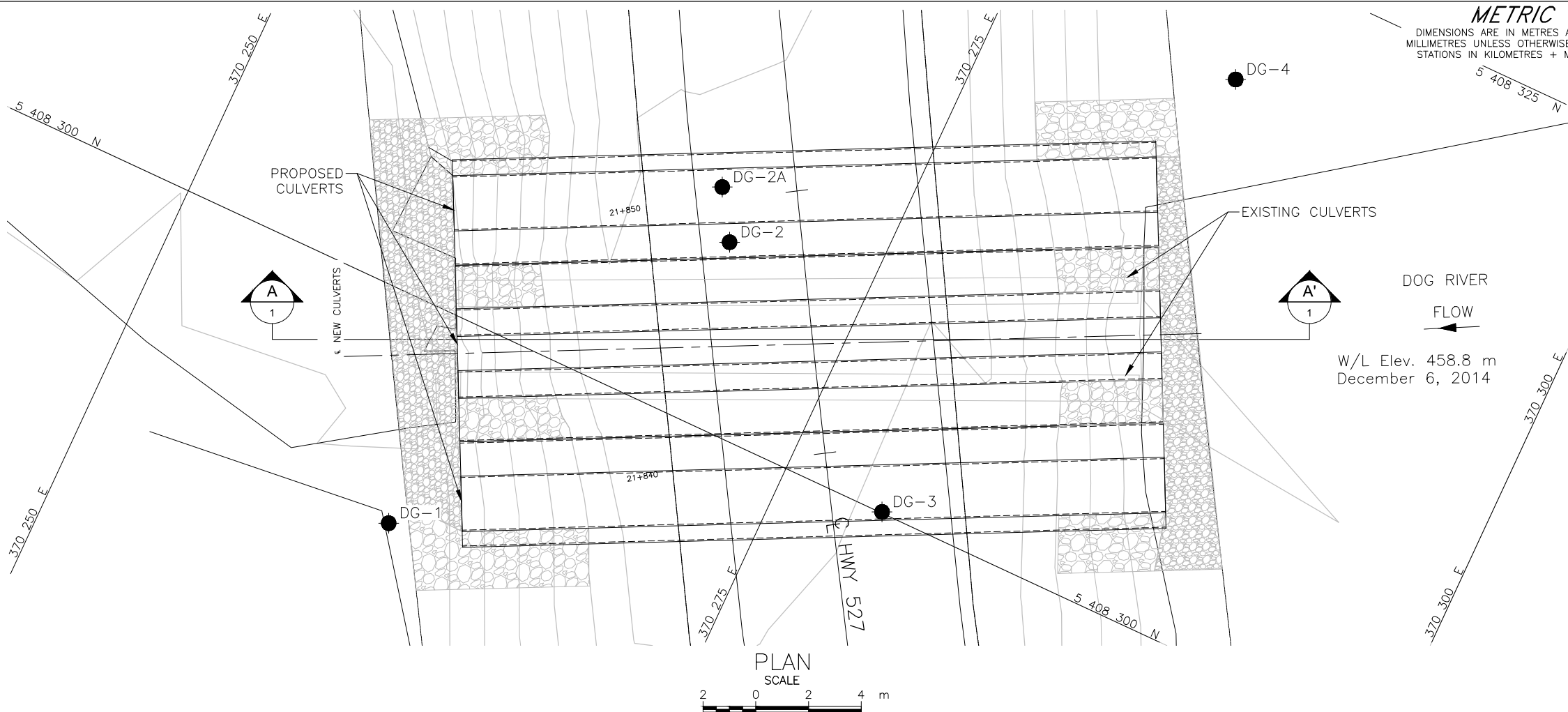
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**Table 1: Summary Details of Existing Culvert**

Culvert Location	Site #	Approximate Height of Embankment <sup>1</sup>	Existing Culvert			Approximate Invert Elevation <sup>2</sup>	
			Type	Approximate Dimension <sup>2</sup>	Approximate Length	West End of Culvert	East End of Culvert
Hwy 527 STA 21+844	48C-218/C	3.0 m	Twin Steel Plate Corrugated Steel Pipe (SPCSP)	2.6 m x 1.5 m (each SP CSP)	26 m	458.7 m	458.9 m

Notes: 1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the culvert.  
2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (Drawing BC4848905275.dwg).

Prepared by: AC  
Checked by: SEMP  
Reviewed by: JMAC

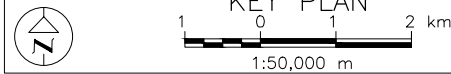
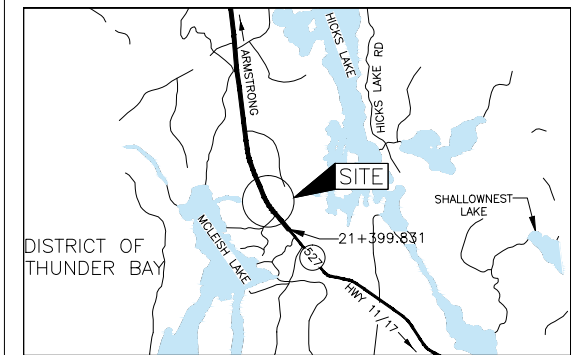


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HIGHWAY 527  
DOG RIVER CULVERT STA 21+844  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



#### LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
DG-1	458.8	5408291.8	370262.2
DG-2	461.9	5408306.9	370269.4
DG-2A	462.0	5408308.7	370268.3
DG-3	461.5	5408300.0	370279.0
DG-4	459.2	5408320.6	370284.3

#### 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.

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

#### REFERENCE

Base plans provided in digital format by MTO, drawing file no. BC4848905275, dated MAY 2012, received FEB 2, 2015. Culvert GA drawing no. ST-343033-DOG RIVER CULVERTS-01-GA-CSP.dwg, received DEC 15, 2015.

NO.	DATE	BY	REVISION
Geocres No., PROJECT NO. 1411523 DIST. SUBM'D. AC CHKD. DAM DATE: 3/10/2016 SITE:48C-218/C DRAWN: TB CHKD. SEMP APPD. JMAC DWG. 1			

**DRAFT**





## PHOTOGRAPHS

**Photograph 1: Dog River Culvert  
East Side - Inlet (Taken from MTO, OSIM\_08-27-2013)**



**Photograph 2: Dog River Culvert  
West Side - Outlet (Taken from MTO, OSIM\_08-27-2013)**





## PHOTOGRAPHS

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**Photograph 3: Dog River Culvert  
East Side - Inlet (Golder – December 5, 2014)**







# 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

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	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

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



## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

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

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

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

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

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

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

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

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 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

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

#### (b) Cohesive Soils Consistency

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

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <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
$SO_4$	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





## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### 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 1411523		RECORD OF BOREHOLE No DG-1				1 OF 1 METRIC													
G.W.P. 6302-14-00		LOCATION N 5408291.8; E 370262.2				ORIGINATED BY CW													
DIST _____ HWY 527		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY SEMP													
DATUM GEODETIC		DATE December 5, 2014				CHECKED BY DAM													
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 (%)	
458.8	GROUND SURFACE							20	40	60	80	100							
0.0	Silty SAND to SAND and GRAVEL, trace clay Compact to very dense Brown to grey Frozen to wet		1	SS	51/0.28		458										OC=0.9%	7 59 30 4	
	Cobbles encountered between 0.5 m and 0.8 m depth.		2	SS	18		457												
			3	SS	41														
			4	SS	20/0.1														
456.4	BASALT BEDROCK		1	RC	REC 100%		456											RQD = 100%	
2.4	Bedrock cored from 2.4 m depth to 4.1 m depth.  For coring details see Record of Drillhole DG-1.		2	RC	REC 98%		455											RQD = 72%	
454.7	END OF BOREHOLE																		
4.1	Note:  1. Water level at a depth of 0.3 m below ground surface (Elev. 458.5 m) upon completion of drilling.																		

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

SHEET 1 OF 1

DATUM: GEODETIC

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

CHECKED: DAM

SUD-RCK 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

PROJECT 1411523		<b>RECORD OF BOREHOLE No DG-2</b>				1 OF 1 <b>METRIC</b>														
G.W.P. 6302-14-00		LOCATION N 5408306.9; E 370269.4				ORIGINATED BY MR														
DIST _____ HWY 527		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY SEMP														
DATUM GEODETIC		DATE December 5, 2014				CHECKED BY DAM														
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 (%)		
461.9	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT (30 mm)		1	SS	102	▽	461													
	Gravelly sand, some silt, trace clay (FILL)																			
	Very dense Brown Frozen to wet		2	SS	142															
460.1	END OF BOREHOLE REFUSAL TO FURTHER CASING ADVANCEMENT		3	SS	54/0.15															
1.8	Note:  1. Water level at a depth of 1.2 m below ground surface (Elev. 460.7 m) upon completion of drilling.																			

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No DG-2A				1 OF 1 METRIC											
G.W.P. 6302-14-00		LOCATION N 5408308.7; E 370268.3		ORIGINATED BY MR													
DIST HWY 527		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY SEMP													
DATUM GEODETIC		DATE December 6, 2014		CHECKED BY DAM													
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 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									
462.0	GROUND SURFACE																
0.0	ASPHALT (30 mm)																
	Gravelly sand, trace to some silt (FILL) Compact to very dense Brown Frozen to wet																
			1	SS	60												
			2	SS	25												
			3A	SS	11												
458.4			3B														
3.6	SAND and GRAVEL some silt, trace organics, trace broken rock fragments Dense Grey Wet		4	SS	32												
456.5																	
5.5	BASALT BEDROCK																
	Bedrock cored from 5.5 m depth to 7.1 m depth.  For coring details see Record of Drillhole DG-2A.		1	RC	REC 100%												
454.9																	
7.1	END OF BOREHOLE																
	Note:  1. Water level at a depth of 1.8 m below ground surface (Elev. 460.2 m) upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:

PROJECT: 1411523

**RECORD OF DRILLHOLE: DG-2A**

SHEET 1 OF 1

LOCATION: N 5408308.7 ;E 370268.3

DRILLING DATE: December 6, 2014

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55-Track

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

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 NOTE: For additional abbreviations refer to list of abbreviations & symbols.																NOTES WATER LEVELS INSTRUMENTATION	
								RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY k, cm/s				Diametral Point Load Index (MPa)	RMC -Q AVG		
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10	5	1	0				
								88 88																	

DEPTH SCALE

1 : 50






LOGGED: MR

CHECKED: DAM

SUD-RCK 1411523.GPJ GAL-MISS.GDT 0403/16 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No DG-3			1 OF 1 METRIC											
G.W.P. 6302-14-00			LOCATION N 5408300.0; E 370279.0			ORIGINATED BY MR											
DIST _____ HWY 527			BOREHOLE TYPE NW Casing, Wash Boring			COMPILED BY SEMP											
DATUM GEODETIC			DATE December 6, 2014			CHECKED BY DAM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m <sup>3</sup>	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60					
461.5	GROUND SURFACE																
8.9	ASPHALT (50 mm)																
	Sandy gravel, trace silt (FILL)																
	Compact to very dense																
	Brown																
	Frozen to wet																
	90 mm cobble at 2.2 m depth.																
			1	SS	100		461										
			2	SS	95		460										
			3	SS	11		459										
			4	SS	14		458										
457.7	GRAVEL, trace sand																
3.8	Compact																
	Grey																
457.0	Wet		5	SS	20		457										
4.5	END OF BOREHOLE																
	SPLIT SPOON REFUSAL (HAMMER BOUNCING)																
	Note:																
	1. Water level at a depth of 0.9 m below ground surface (Elev. 460.6 m) upon completion of drilling.																
	2. Poor recovery in all split-spoons, mostly gravel recovered.																

<b>PROJECT</b> 1411523		<b>RECORD OF BOREHOLE No DG-4</b>		1 OF 1 <b>METRIC</b>	
G.W.P. 6302-14-00		LOCATION N 5408320.6; E 370284.3		ORIGINATED BY CW	
DIST _____ HWY 527		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY SEMP	
DATUM GEODETIC		DATE December 5, 2014		CHECKED BY DAM	

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		WATER CONTENT (%)					GR SA SI CL					
459.2	GROUND SURFACE							20 40 60 80 100												
0.0	Silty SAND, some clay, trace to some gravel, some organics Loose Brown Frozen to wet		1	SS	4		459										6	51	29	14
458.4																				
0.8	GRAVEL and COBBLES (rock fragments) Very dense Grey Wet		2	SS	89/0.27		458													
			3	RC	REC 74%		457													
	Cobbles ranging from 75 mm to 225 mm diameter encountered between 0.8 m and 3.2 m depths.		4	RC	REC 44%		456													
456.0	END OF BOREHOLE																			
3.2	Note:  1. Water level at a depth of 0.2 m below ground surface (Elev. 459.0 m) upon completion of drilling.																			

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 04/03/16 DATA INPUT:





# APPENDIX B

## Laboratory Testing



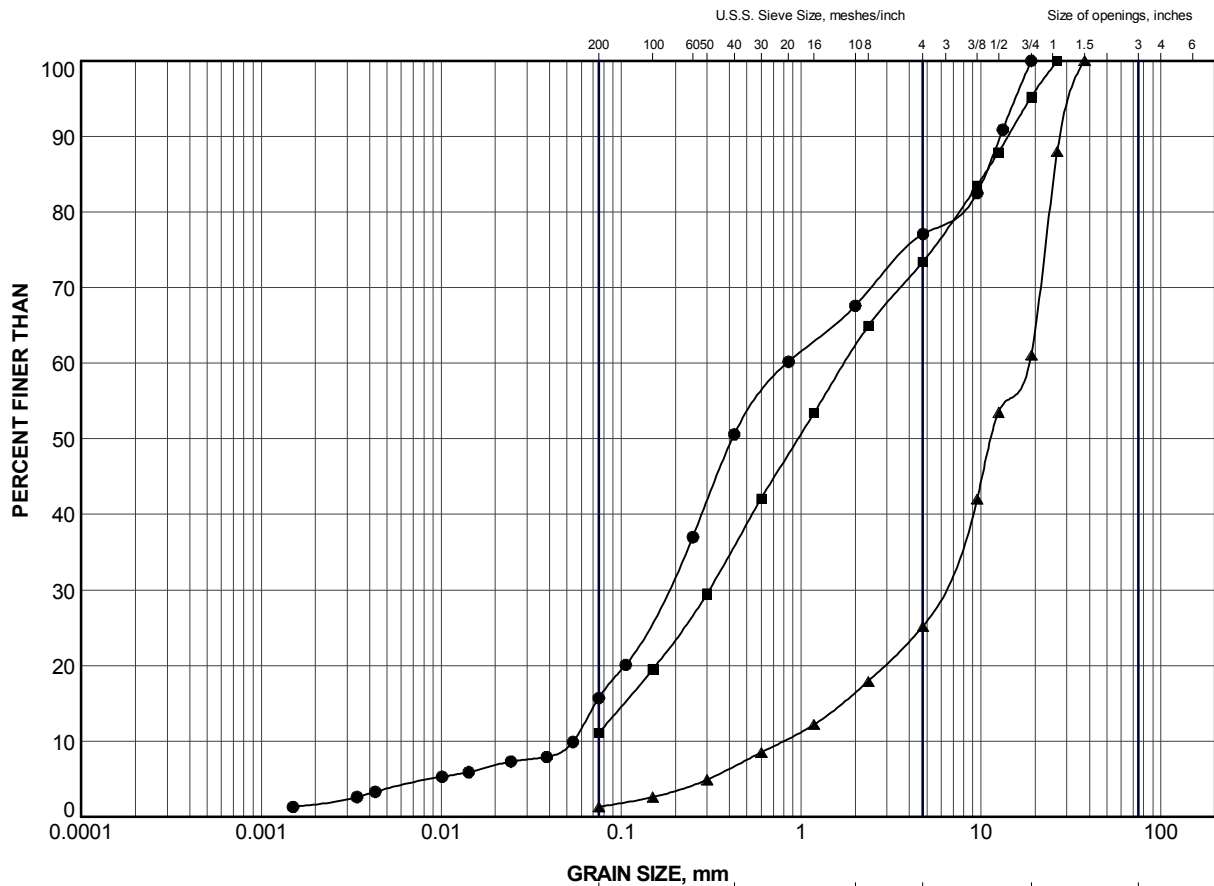
**DRAFT DETAIL FOUNDATION REPORT  
DOG RIVER CULVERT SITE NO. 48-218/C**

**Table B1: Summary of Analytical Testing of Dog River Water Sample**

Parameter	Units	Result
Chloride (CL)	mg/L	5.02
Sulphate (SO4)	mg/L	1.62
Conductivity (EC)	µS/cm	57.2
Resistivity	ohms*cm	17483
pH	n/a	7.04


- Notes:
1. Sample obtained on February 3, 2015.
  2. Analytical testing carried out by ALS Canada Ltd.

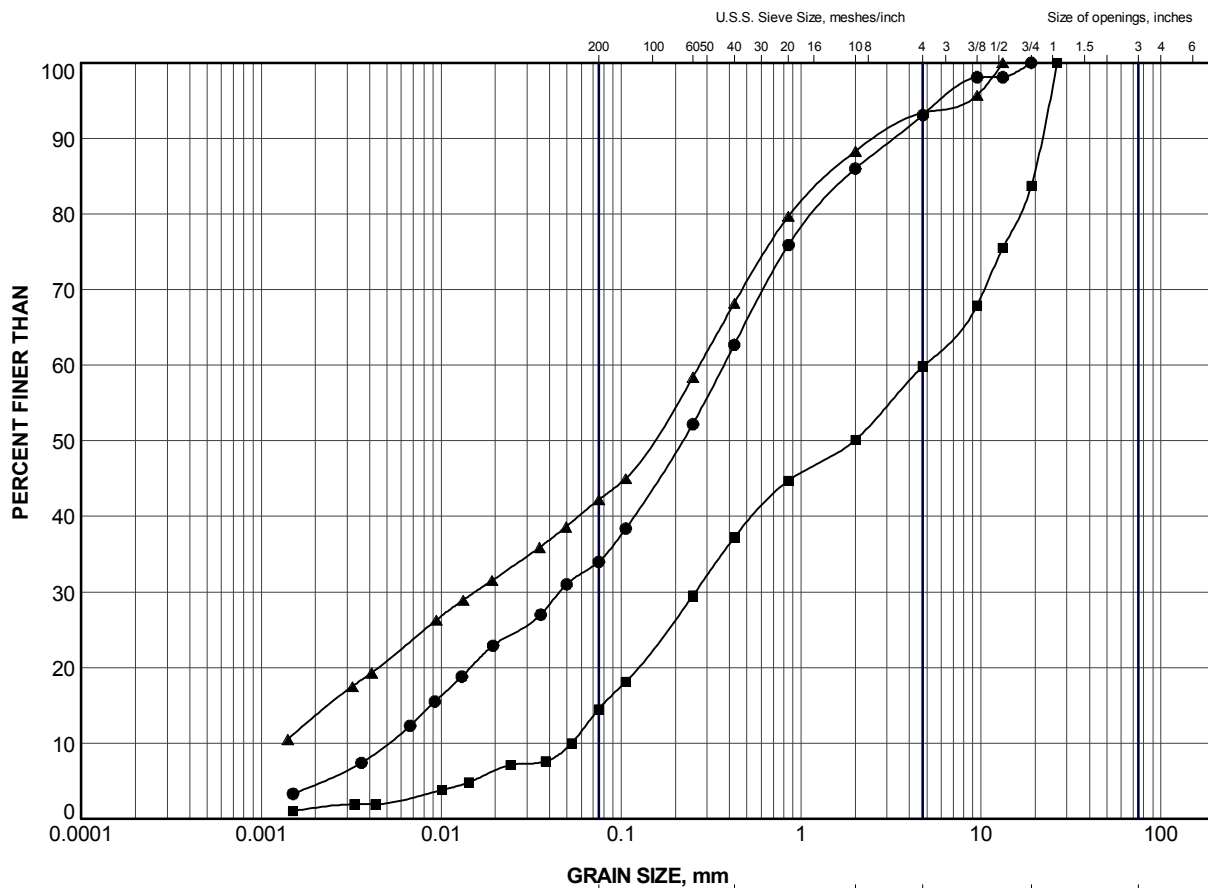
Prepared by: AC  
Checked by: SEMP  
Reviewed by: JMAC



### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	DG-2	2	460.8
■	DG-2A	1	460.2
▲	DG-3	4	458.2

PROJECT					
HIGHWAY 527 DOG RIVER CULVERT STA 21+844					
TITLE					
GRAIN SIZE DISTRIBUTION GRAVELLY SAND to SANDY GRAVEL (FILL)					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	Feb 2015	SCALE	N/A	REV.
CHECK	DAM	Feb 2015			
APPR	FJH	Feb 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B1</b>		



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	DG-1	2	457.7
■	DG-1	3	457.0
▲	DG-4	1	458.9

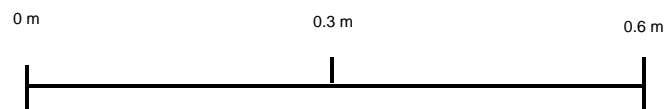
PROJECT					
HIGHWAY 527 DOG RIVER CULVERT STA 21+844					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY SAND to SAND and GRAVEL					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	Feb 2015	SCALE	N/A	REV.
CHECK	DAM	Feb 2015			
APPR	FJH	Feb 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B2</b>		




Borehole DG-1  
Elevation 456.4 m to 454.7 m



Borehole DG-2A  
Elevation 456.5 m to 454.9 m



PROJECT		HIGHWAY 527 DOG RIVER CULVERT STA 21+844			
TITLE		BEDROCK CORE PHOTOGRAPHS			
	PROJECT No.	1411523		FILE No. ----	
	DESIGN	AC	Feb. 2015	SCALE	AS SHOWN
	CADD	--		REV.	
	CHECK	DAM	Feb. 2015	<b>FIGURE B3</b>	
	REVIEW	FJH	Feb. 2015		

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