



FOUNDATION INVESTIGATION REPORT

Bear Creek Culvert Replacement - Site 44X-0209/C0
Highway 518, Station 17+932 Monteith Township
District of Parry Sound
Ministry of Transportation, Ontario
GWP 5202-13-00, WP 5202-13-01

Submitted to:

GHD

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1776446 - R01

February 18, 2020

GEOCRES No.: 31E-402

Lat: 45.434678

Long: -79.620956



Distribution List

3 Copies + 1 PDF Copy: Ministry of Transportation, Ontario, North Bay, ON (NE Region)

1 Copy + 1 PDF Copy: Ministry of Transportation, Ontario, Downsview, ON (Foundations)

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PART A

FOUNDATION INVESTIGATION REPORT
BEAR CREEK CULVERT REPLACEMENT
SITE 44X-0209/C0 - HIGHWAY 518, STA. 17+932 MONTEITH
TOWNSHIP DISTRICT OF PARRY SOUND
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5202-13-00, WP 5202-13-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by GHD, on behalf of the Ministry of Transportation, Ontario (MTO), to provide detail design Foundation Engineering services for the replacement of the Bear Creek Culvert (Site No. 44X-0209/C0). The existing Bear Creek Culvert is located on Highway 518 at about Station 17+932 Monteith Township in the District of Parry Sound, Ontario (approximately 27.7 km west of Highway 11). The key plan showing the general location of this section of Highway 518 and the location of the investigated area is presented on Drawing 1.

The Terms of Reference (TOR) for the Foundation investigation are outlined in MTO's Request for Proposal (RFP) for Assignment 5016-E-0037 (dated March 2017) and the subsequent clarifications and addenda. Golder's Scope of Work is outlined in our proposal, dated June 14, 2017, which is included in Section 17.8 of GHD's technical proposal for this assignment.

This work has been carried out in accordance with Golder's Supplementary Specialty Plan for Foundation Engineering services for this project, dated September 13, 2017.

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. For the purpose of this report, Highway 518 is oriented in a west-east direction with the culvert aligned perpendicular to the highway, generally in a north-south orientation.

In general, the topography within the vicinity of the culvert consists of relatively flat terrain, which is heavily forested beyond the highway right-of-way (ROW), with visible bedrock outcrops located about 50 m and 150 m east of the culvert on the south and north sides of the highway, respectively. The topography along the south side of the highway in the culvert area is relatively flat and covered with grass and small shrubs; and appears to be an old highway alignment or previous detour alignment.

At the culvert location, the highway grade is at approximately Elevation 299.5 m and the existing highway embankment is approximately 1.6 m to 2.5 m high relative to the ground surface at the toe of embankment slope borehole locations (or about 5.8 m to 5.9 m high relative to the existing culvert inverts). The existing embankment side slopes are generally inclined at about 2.5 horizontal to 1 vertical (2.5H:1V) above approximately Elevation 297 m, and are locally steepened to about 0.25H:1V and 0.4H:1V below about Elevation 297 m (i.e., about 2.5 m below the road surface) along the north and south side slopes, respectively, to the toe of slope.

The existing culvert consists of a 4.4 m wide by 2.8 m high structural plate corrugated steel pipe arch (SPCSPA). Based on the survey drawing (E1086518.dwg) provided by GHD, the existing culvert invert is at about Elevation 295.2 m and 295.1 m at the north (inlet) and south (outlet) ends, respectively. The creek water level, as surveyed by Golder on December 11, 2017, was Elevation 296.8 m. The ground surface conditions in the area around the culvert location are shown on Photographs 1 to 4.

Based on the Ontario Structure Inspection Manual (OSIM) report, dated June 22, 2018, the existing culvert is generally in poor condition, with some minor deterioration of several elements, including more significant deterioration of the structural steel coatings and culvert barrel. The existing highway embankment is also noted to be in good condition. Based on our site observations at the time of the field investigation and a review of the

available site photographs/satellite images, the existing embankment in the culvert area generally appears to be performing satisfactorily with little to no evidence of soil movement, tilted vegetation, or tension cracks; however, it is noted that the highway was resurfaced in 2013.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface exploration was carried out between December 4 and 11, 2017, and February 8, 2018, during which time, four boreholes (Boreholes BC-1 to BC-4) were advanced at approximately the locations shown on Drawing 1. Boreholes BC-1 and BC-4 were advanced at the toe of the embankment side slopes near the culvert inlet and outlet, respectively, while Boreholes BC-2 and BC-3 were advanced from the roadway platform. Boreholes BC-2, BC-3, and BC-4 were advanced using a rubber tire ATV- (or “buggy”) mounted CME-55 drilling rig and Borehole BC-1 was advanced using portable tripod drilling equipment and a portable Hilti core drill to facilitate bedrock coring. The ATV-mounted drilling rig and portable tripod equipment were supplied and operated by Landcore Drilling Inc, of Chelmsford, Ontario, and the Hilti core drill was supplied and operated by Golder. Traffic control was performed in accordance with the Ontario Traffic Control Manual Book 7 – Temporary Conditions by Fowler Construction Company Limited of Bracebridge, Ontario.

The boreholes were advanced using 108 mm inside diameter hollow-stem augers, NW casing with wash boring techniques, and NQ coring (as required). Water from the local creek was used for wash boring and coring operations. 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 or a cathead hammer (for the borehole advanced using the portable tripod) in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). The groundwater levels in the open boreholes were observed during and upon completion of the drilling/coring operations, as described on the borehole records 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; and logged the boreholes. The soil and rock 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 were carried out on selected soil samples. In addition, an unconfined compression (UC) test was carried out on a specimen of the retrieved bedrock core for determination of its uniaxial compression strength (UCS). The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable.

The as-drilled borehole locations were measured by a member of our technical staff relative to the existing culvert and roadway centreline, using a measuring tape and converted into northing/easting coordinates on the plan drawing. Given the relatively short distances between the boreholes and the existing structure, the measurements are considered to be accurate to within 0.5 m horizontally. The ground surface elevations at the borehole locations were obtained using a survey level and rod and the survey loop was closed to within 0.1 m vertically. The boreholes were surveyed relative to the highway centerline at the culvert location, the elevation of which was obtained from the plan drawing (E10865181.dwg) provided by GHD. The NAD 83 MTM CSRS CBNv6-2010.0 (Zone 10) northing and easting coordinates, World Geodetic System 1984 (WGS 84) 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	Location (NAD 83, MTM Zone 10)		Location (WGS 84)		Ground Surface Elevation (m)	Borehole Depth ¹ (m)
	Northing	Easting	(Latitude)	(Longitude)		
BC-1	5032757.9	295322.6	45.434699	-79.621135	297.0	4.6
BC-2	5032765.4	295344.0	45.434767	-79.620862	299.6	7.0
BC-3	5032752.1	295335.7	45.434647	-79.620968	299.5	9.9
BC-4	5032754.8	295351.2	45.434671	-79.620769	297.9	7.1

Note(s): 1. Borehole depths include between 3.2 m and 3.3 m of bedrock coring.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on the Surficial Geology of Southern Ontario mapping by the Ministry of Natural Resources and Forestry (MNRF)¹, the subsoils in the vicinity of the Bear Creek Culvert site consist of alluvial deposits comprised of clay, silt, sand, gravel, and may contain organic remains; bordered by Precambrian bedrock-drift complexes and glaciolacustrine deposits primarily comprised of sand and gravel with minor silt and clay deposits.

Based on geological mapping by the Ministry of Northern Development and Mines (MNDM)², the site is underlain by bedrock of the central gneiss belt, including mafic rock comprised of amphibolite, gabbro, diorite, and mafic gneisses; bordered by migmatites rocks and gneisses of undetermined protolith commonly comprised of layered biotite gneisses and migmatites with localized quartzofeldspathic gneisses, orthogneisses, and paragneisses.

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 and Record of Drillhole 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 Boreholes and in Section 4, are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profiles 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 subsurface conditions encountered at the site consist of surface treatment and granular embankment fill (for boreholes advanced through the roadway platform) and topsoil (for boreholes advanced near

¹ Ontario Ministry of Natural Resources and Forestry, Surficial Geology of Southern Ontario. Ontario Geological Society Electronic Mapping.

² Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – Southern Sheet, Ontario Geological Survey - Map 2544

the embankment toe of slope) underlain by interlayered deposits of gravelly sand, silty clay, silt, and silty sand to silt and sand underlain by bedrock at relatively shallow depth below ground surface. A detailed description of the soil deposits, bedrock, and groundwater conditions encountered in the boreholes is provided in the following sections.

4.2.1 Surface Treatment

A 15 mm and 20 mm thick layer of surface treatment was encountered at ground surface in Boreholes BC-2 and BC-3, respectively.

4.2.2 Topsoil

A 50 mm thick deposit of topsoil was encountered from ground surface in Boreholes BC-1 and BC-4.

4.2.3 Granular Embankment Fill

A 3.8 to 4.5 m thick layer of granular embankment fill was encountered below the surface treatment in Boreholes BC-2 and BC-3, respectively, which were advanced from the roadway platform. A 1.5 m thick layer of granular fill was encountered below the topsoil in Borehole BC-4, which was advanced near the north toe of the embankment side slope. The granular fill consists an upper 0.3 m thick layer of sand and gravel in Boreholes BC-2 and BC-3, underlain by brown to grey, moist to wet, gravelly sand to sand and gravel, trace to some silt. The granular fill was noted to contain cobbles and boulders (ranging in size from 175 mm to 400 mm) in Borehole BC-2 and trace organics in Borehole BC-4.

Standard Penetration Test (SPT) 'N'-values measured within the granular fill range from 3 blows to 30 blows per 0.3 m of penetration, indicating a very loose to compact compactness condition. In two instances, the split-spoon sampler encountered refusal (i.e., hammer bouncing): one SPT 'N'-value of 18 blows for 0.3 m of penetration was recorded with a subsequent 30 blows for 0.05 m of penetration (and hammer bouncing) in the lower portion of the sample interval, due to the presence of cobbles and boulders; and one SPT 'N'-value of 33 blows for 0.28 m of penetration was recorded at the top of the underlying bedrock.

The moisture content measured on two samples of the sand and gravel to gravelly sand fill are 6 per cent and 14 per cent.

The results of the grain size distribution tests completed on two samples of the granular fill are shown on Figure B-1 in Appendix B.

4.2.4 Silt and Sand

A deposit of brown to grey, moist to wet, silt and sand, trace to some gravel, trace to some organics was encountered below the topsoil in Borehole BC-1. The surface of the silt and sand deposit was encountered at Elevation 296.9 m and the deposit is 1.3 m thick.

The SPT 'N'-values within the silt and sand deposit are 5 blows and 2 blows per 0.3 m of penetration indicating a very loose to loose compactness condition.

The moisture content measure on two samples of the silt and sand is 26 per cent and 38 per cent.

The result of a grain size distribution test completed on one selected sample of the silt and sand deposit is shown on Figure B-2A in Appendix B.

Atterberg limits tests were carried out on the two samples of the silt and sand deposit: one test indicated a non-plastic condition; and one test measured a liquid limit of 26 per cent, a plastic limit of 22 per cent, and a plasticity index of 4 per cent, indicating that the silt and sand deposit is slightly plastic, as shown on Figure B-2B. The other Atterberg limit test returned a non-plastic test result.

4.2.5 Gravelly Sand

A deposit of grey, wet, gravelly sand, trace to some silt was encountered underlying the granular fill in Borehole BC-3. The surface of the gravelly sand deposit was encountered at Elevation 295.0 m and the deposit is 1.1 m thick.

The SPT 'N'-value measured within the gravelly sand deposit is 23 blows per 0.3 m of penetration indicating a compact compactness condition.

The moisture content measured on one sample of the gravelly sand deposit is 9 per cent.

The result of the grain size distribution test completed on a sample of the gravelly sand is shown on Figure B-3 in Appendix B.

4.2.6 Silty Clay

A deposit of brown to grey, wet, silty clay was encountered underlying the granular fill in Borehole BC-4. The surface of the silty clay deposit was encountered at Elevation 296.4 m and the deposit is 0.7 m thick.

The SPT 'N'-value measured within the silty clay deposit is 5 blows per 0.3 m of penetration suggesting a firm consistency.

4.2.7 Silt

A deposit of brown to grey, wet, silt, trace sand, trace to some clay was encountered underlying the silty clay deposit in Borehole BC-4. The surface of the silt was encountered at Elevation 295.7 m and the deposit was 0.7 m thick.

The SPT 'N'-value measured within the silt deposit is 7 blows per 0.3 m of penetration indicating a loose compactness condition.

The moisture content measured on one sample of the silt deposit is 33 per cent.

The result of the grain size distribution tests completed on one sample of the silt deposit is shown on Figure B-4 in Appendix B.

An Atterberg limit test was carried out on one sample of the silt deposit, which indicated a non-plastic condition.

4.2.8 Silty Sand

A deposit of brown to grey, wet, silty sand, trace gravel was encountered below the gravelly sand deposit in Borehole BC-3 and underlying the silt deposit in Borehole BC-4. The surface of the silty sand deposit was encountered at Elevations 293.9 m and 295.0 m in the respective boreholes, and the deposit is 1.1 and 0.9 m thick, respectively. A boulder of about 300 mm in size was encountered at the interface of the silty sand deposit within the silt deposit at about 2.9 m depth (i.e., Elev. 295.0 m) in Borehole BC-4.

Standard Penetration Test (SPT) 'N'-values measured in the silty sand deposit are 7 blows and 19 blows per 0.3 m of penetration indicating a loose to compact compactness condition.

The natural moisture content measured on one sample of the silty sand deposit is 15 per cent.

The result of the grain size distribution test completed on one sample of the silty sand deposit is shown on Figure B-5 in Appendix B.

4.2.9 Bedrock

Bedrock was encountered below the overburden soils in Boreholes BC-1 to BC-4. The bedrock surface elevations and cored lengths in each borehole are presented below.

Borehole No.	Bedrock Surface Elevation (m)	Core Length (m)
BC-1	295.6	3.2
BC-2	295.8	3.2
BC-3	292.8	3.2
BC-4	294.1	3.3

The retrieved bedrock core in Boreholes BR-1 to BR-4 is described as a fresh, fine to medium grained, strongly foliated, strong, dark grey to black to pink granite biotite gneiss. More detailed descriptions of the bedrock cores are presented on the Record of Drillhole sheets in Appendix A. Photographs of the bedrock core samples and the result of an unconfined compression (UC) test are presented on Figures B-5 and B-6, respectively, which are included in Appendix B. The bedrock properties from the retrieved cores are summarized below.

Borehole No.	Total Core Recovery (%)	Solid Core Recovery (%)	Rock Quality Designation (%)	Quality Classification (Table 3.10 of CFEM 2006 ³)	Uniaxial Compressive Strength (MPa)	Strength Classification (Table 3.5 of CFEM 2006 ³)
BC-1	100	29 - 85	69 - 98	Fair to Excellent	-	
BC-2	100	72 - 96	92 - 96	Excellent	97	(R4 – Strong)
BC-3	100	91 - 100	79 - 100	Good to Excellent	-	
BC-4	100	94 - 100	94 - 100	Excellent	-	

4.2.10 Groundwater Conditions

The unstabilized groundwater levels measured in the open boreholes upon completion of drilling/coring are summarized below. The creek water level, as surveyed by Golder on December 11, 2017, was Elevation 296.8 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)
BC-1	0.2	296.8
BC-2	3.3	296.3
BC-3	2.8	296.7
BC-4	2.3	295.6

The water levels in Boreholes BC-1 to BC-4 would have been affected by water introduced into the boreholes during washing boring for NW casing advancement and/or during NQ coring operations; however, the water levels in the open boreholes are generally consistent with the surveyed creek water level at the time of the investigation.

4.3 Analytical Test Results of Soil Sample

A sample of the silty sand deposit from Borehole BC-3 (i.e., Sample No. 8) was obtained during the field investigation using appropriate sampling protocols and submitted to Maxxam Analytics under chain of custody procedures and tested for a suite of corrosivity indicator parameters including: pH, resistivity, conductivity, sulphates, and chlorides. The results of the analytical testing are presented in Appendix C and are summarized below.

³ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Parameter	Units	Results Borehole BC-3, Sample No. 8 (Elevation 293.1 m)
Resistivity	ohm-cm	11,000
Conductivity	µmho/cm	91
pH	pH	6.59
Sulphate	µg/g	ND ¹
Chloride	µg/g	35

Note(s): 1. ND = Not Detected (i.e., the sulphate concentration is below the reportable detection limit of 20 µg/g).

5.0 CLOSURE

The field drilling program was supervised by Mr. Matthew Riopelle and Mr. Shane Albert under the overall direction of Mr. David Muldowney, P.Eng. This Foundation Investigation Report was prepared by Mr. Adam Core, P. Eng., and Mr. David Muldowney, P.Eng., provided a technical review of the report. Mr. Jorge M. A. Costa, P. Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of this report.

Signature Page

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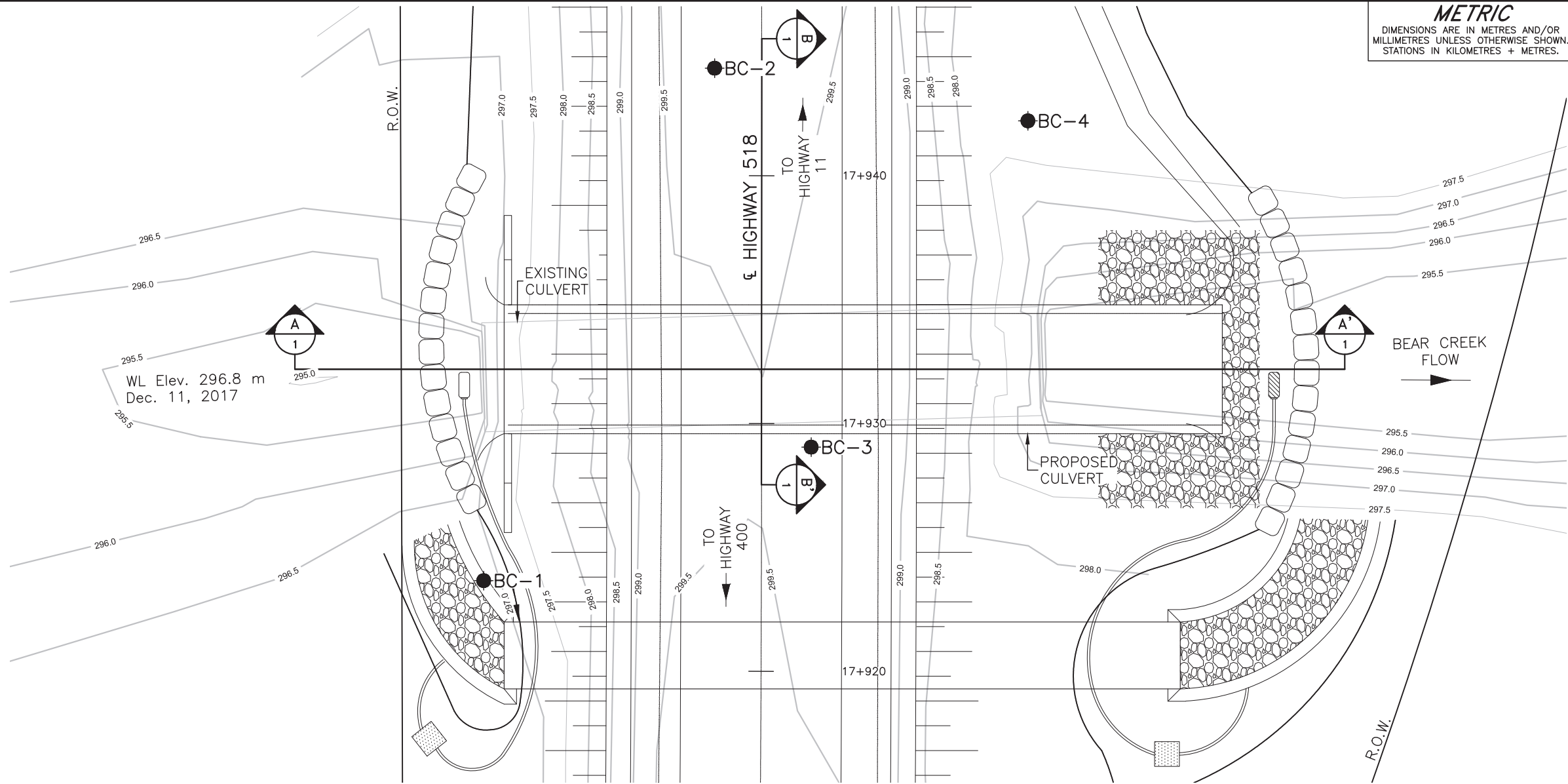


Jorge M. A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

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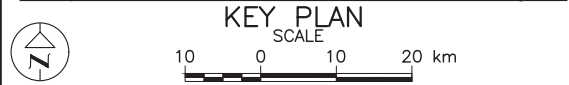
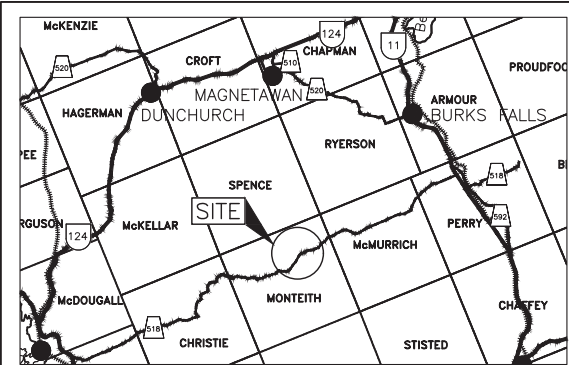


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

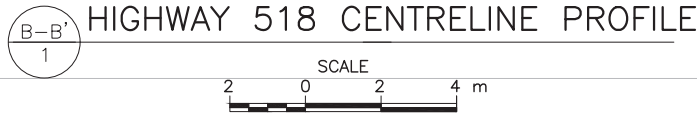
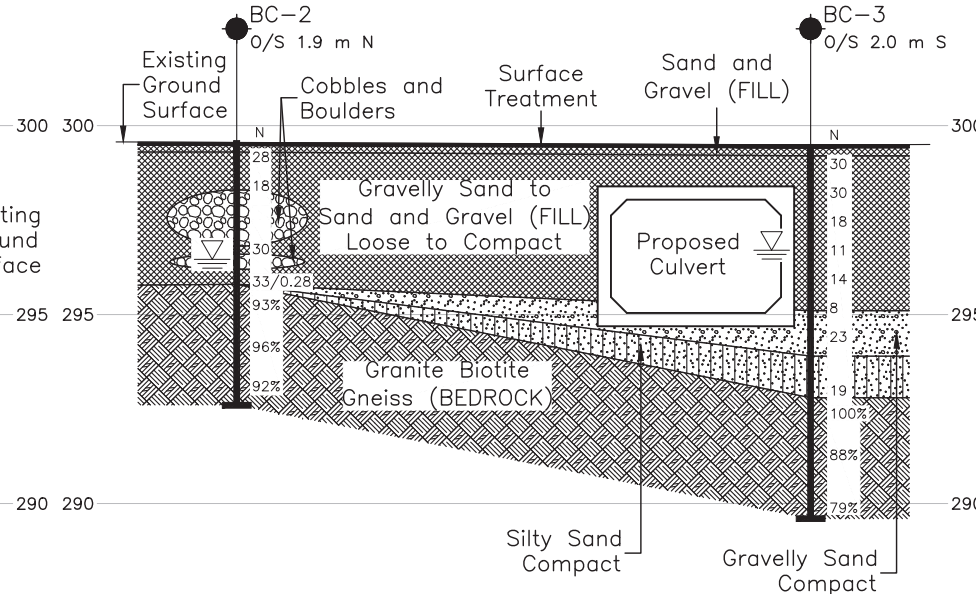
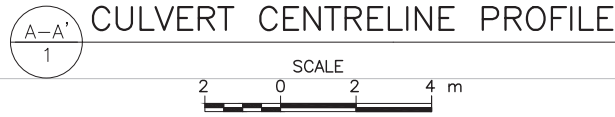
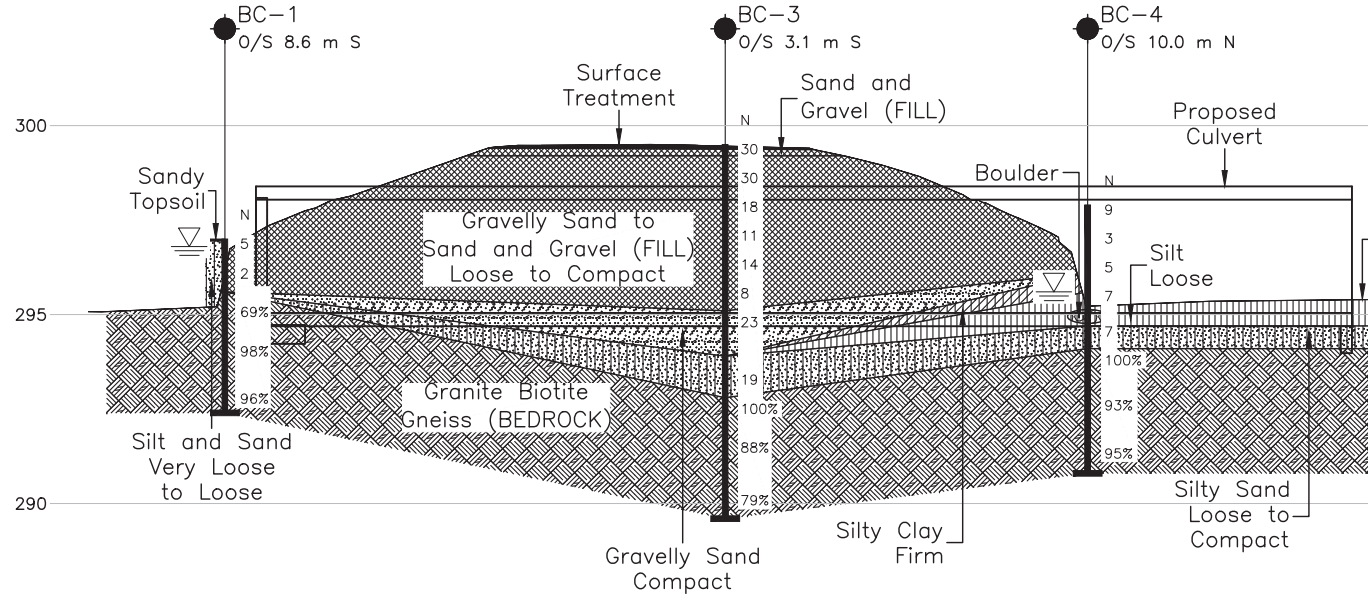
CONT No.
WP No. 5202-13-01

HIGHWAY 518
BEAR CREEK CULVERT
STA. 17+932 MONTEITH TOWNSHIP
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 10)			
No.	ELEVATION	NORTHING	EASTING
BC-1	297.0	5032757.9	295322.6
BC-2	299.6	5032765.4	295344.0
BC-3	299.5	5032752.1	295335.7
BC-4	297.9	5032754.8	295351.2



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 GHD, drawing file No. E10865181.dwg, received APRIL 17, 2018 and drawing file No. 44-209-C-HWY 518 - Ret Wall on N end.dwg, received AUGUST 22, 2019

NO.	DATE	BY	REVISION
Geocres No. 31E-402			
HWY. 518	PROJECT NO. 1776446		DIST. .
SUBM'D.	CHKD. AC	DATE: 2/12/2020	SITE: 44X-0209/CO
DRAWN: TR	CHKD. DAM	APPD. JMAC	DWG. 1



Photograph 1: Highway 518 at Bear Creek Culvert, Facing West (December 2017)



Photograph 2: Highway 518 at Bear Creek Culvert, Facing East (December 2017)



Photograph 3: Bear Creek at Culvert Inlet, Facing North (December 2017)



Photograph 4: Culvert Outlet, Facing North (December 2017)

APPENDIX A

Record of Boreholes and Drillholes

LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
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 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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 ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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

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

<u>Description</u>	<u>Bedding Plane Spacing</u>
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

<u>Description</u>	<u>Spacing</u>
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

<u>Term</u>	<u>Size*</u>
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 <u>1776446</u>		RECORD OF BOREHOLE No BC-1		1 OF 2 METRIC																											
W.P. <u>5202-13-01</u>		LOCATION <u>N 5032757.9; E 295322.6 NAD83 MTM ZONE 10 (LAT. 45.434699; LONG. -79.621135)</u>		ORIGINATED BY <u>MR</u>																											
DIST <u> </u> HWY <u>518</u>		BOREHOLE TYPE <u>NW Casing and NQ Coring</u>		COMPILED BY <u>AC</u>																											
DATUM <u>GEODETIC</u>		DATE <u>December 11, 2017 and February 8, 2018</u>		CHECKED BY <u>DAM</u>																											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																										
297.0	GROUND SURFACE																														
0.9	Sandy TOPSOIL (50 mm) Frozen		1	SS	5																										
	SILT and SAND, trace to some gravel, trace to some clay, trace organics Very loose to loose Brown to grey Moist to wet		2	SS	2																										
295.6	Split-spoon refusal (i.e. hammer bouncing) at 1.3 m depth. GRANITE BIOTITE GNEISS (BEDROCK)		1	RC	REC 100%																										
1.4	Bedrock cored from 1.4 m depth to 4.6 m depth. For coring details see Record of Drillhole BC-1.		2	RC	REC 100%																										
			3	RC	REC 100%																										
292.4	END OF BOREHOLE																														
4.6	Notes: 1. Water level at a depth of 0.2 m below ground surface (Elev. 296.8 m) upon completion of drilling. 2. Three DCPTs advanced 1 m north (shown above), 1 m southwest (shown above), and 1 m east (not shown) of Borehole BC-1. DCPT refusal (i.e. cone bouncing) encountered at depths of 1.32 m, 1.30 m, and 1.27 m, respectively. 3. Bedrock coring completed February 8, 2018 utilizing a Hilti core drill in a separate borehole advanced 0.3 m west of Borehole BC-1.																														

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INCLINATION: -90° AZIMUTH: —

DRILLING CONTRACTOR: Landcore Drilling

DATUM: GEODETIC

1 : 60



CHECKED: DAM

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PROJECT 1776446		RECORD OF BOREHOLE No BC-2				1 OF 2 METRIC											
W.P. 5202-13-01		LOCATION N 5032765.4; E 295344.0 NAD83 MTM ZONE 10 (LAT. 45.434767; LONG. -79.620862)				ORIGINATED BY SA											
DIST HWY 518		BOREHOLE TYPE NW Casing and NQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE December 5, 2017				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
299.6	GROUND SURFACE																
0.0	SURFACE TREATMENT (15 mm)																
299.3	Sand and gravel, trace silt (FILL)		1	SS	28												
0.3	Brown Moist																
	Gravelly sand, trace to some silt (FILL)		2	SS	18												
	Compact																
	Brown to grey																
	Moist to wet																
	Split-spoon refusal (i.e. hammer bouncing) at 1.3 m depth. Switched to NQ Coring.		-	RC	REC 41%												
	Cobbles and boulders encountered as follows:																
	Depth (m) Diameter (mm)																
	1.3 200		3	SS	30												
	1.6 175																
	3.0 400																
			-	RC	REC 100%												
295.8	GRANITE BIOTITE GNEISS (BEDROCK)		4	SS	33/0.28												
3.8	Bedrock cored from 3.8 m depth to 7.0 m depth.																
	For coring details see Record of Drillhole BC-2.																
			1	RC	REC 100%												RQD = 93%
			2	RC	REC 100%												RQD = 96%
			3	RC	REC 100%												RQD = 92%
292.6	END OF BOREHOLE																
7.0	Note: 1. Water level at a depth of 3.3 m below ground surface (Elev. 296.3 m) upon completion of coring.																

INCLINATION: -90° AZIMUTH: —

DRILLING CONTRACTOR: Landcore Drilling

DATUM: GEODETIC

1 : 60



CHECKED: DAM

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PROJECT <u>1776446</u>		RECORD OF BOREHOLE No BC-3				1 OF 2 METRIC														
W.P. <u>5202-13-01</u>		LOCATION <u>N 5032752.1; E 295335.7 NAD83 MTM ZONE 10 (LAT. 45.434647; LONG. -79.620968)</u>				ORIGINATED BY <u>SA</u>														
DIST <u> </u> HWY <u>518</u>		BOREHOLE TYPE <u>NW Casing and NQ Coring</u>				COMPILED BY <u>AC</u>														
DATUM <u>GEODETIC</u>		DATE <u>December 5, 2017</u>				CHECKED BY <u>DAM</u>														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20	40	60	80	100						20	40	60
299.5	GROUND SURFACE																			
0.0	SURFACE TREATMENT (20 mm)																			
299.2	Sand and gravel, trace silt (FILL)		1	SS	30															
0.3	Brown to grey Moist																			
	Sand and gravel, trace to some silt (FILL)		2	SS	30															
	Loose to compact Brown to grey Moist to wet																			
			3	SS	18															
			4	SS	11															
			5	SS	14															
			6	SS	8															
295.0																				
4.5	Gravelly SAND, trace to some silt Compact Grey Wet		7	SS	23															
293.9	SILTY SAND, trace gravel Compact Brown to grey Wet		8	SS	19															
292.8	GRANITE BIOTITE GNEISS (BEDROCK)		1	RC	REC 100%															
	Bedrock cored from 6.7 m depth to 9.9 m depth.																			
	For coring details see Record of Drillhole BC-3.		2	RC	REC 100%															
			3	RC	REC 100%															
289.6	END OF BOREHOLE																			
9.9	Note: 1. Water level at a depth of 2.8 m below ground surface (Elev. 296.7 m) upon completion of coring.																			

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PROJECT: 1776446

LOCATION: N 5032752.1; E 295335.7

NAD83 MTM ZONE 10 (LAT. 45.434647; LONG. -79.620968)

INCLINATION: -90° AZIMUTH: —

RECORD OF DRILLHOLE: BC-3

SHEET 2 OF 2

DRILLING DATE: December 5, 2017

DATUM: GEODETIC

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore 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 <div>NOTE: For additional abbreviations refer to list of abbreviations & symbols.</div>										DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
								FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	CONDUCTIVITY k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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DEPTH SCALE

1 : 60



GOLDER

LOGGED: SA

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PROJECT 1776446		RECORD OF BOREHOLE No BC-4				1 OF 2 METRIC											
W.P. 5202-13-01		LOCATION N 5032754.8; E 295351.2 NAD83 MTM ZONE 10 (LAT. 45.434671; LONG. -79.620769)				ORIGINATED BY SA											
DIST HWY 518		BOREHOLE TYPE NW Casing and NQ Coring				COMPILED BY AC											
DATUM GEODETIC		DATE December 4, 2017				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
297.9	GROUND SURFACE																
0.9	TOPSOIL (50 mm)		1	SS	9												
	Gravelly sand to sand and gravel, trace to some silt, trace organics (FILL) Very loose to compact Brown Moist		2	SS	3												
296.4																	
1.5	SILTY CLAY, trace to some sand, trace gravel Firm Brown to grey Wet		3	SS	5												
295.7																	
2.2	Poor recovery in Sample No. 5 SILT, trace sand, trace to some clay Loose Brown to grey Wet		4	SS	7												
295.0																	
2.9	SILTY SAND, trace gravel Loose Brown Wet		-	RC	REC 100%												
			5	SS	7												
294.1																	
3.8	A 300 mm boulder was encountered at 2.9 m depth. GRANITE BIOTITE GNEISS (BEDROCK) Bedrock cored from 3.8 m depth to 7.1 m depth. For coring details see Record of Drillhole BC-4.		1	RC	REC 100%												
			2	RC	REC 100%												
			3	RC	REC 100%												
290.8	END OF BOREHOLE																
7.1	Note: 1. Water level at a depth of 2.3 m below ground surface (Elev. 295.6 m) upon completion of coring.																

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PROJECT: 1776446

RECORD OF DRILLHOLE: **BC-4**

SHEET 2 OF 2

LOCATION: N 5032754.8; E 295351.2

DRILLING DATE: December 4, 2017

DATUM: GEODETIC

NAD83 MTM ZONE 10 (LAT. 45.434671; LONG. -79.620769)

DRILL RIG: CME 55

INCLINATION: -90° AZIMUTH: —

DRILLING CONTRACTOR: Landcore 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 NOTE: For additional abbreviations refer to list of abbreviations & symbols.										DISCONTINUITY DATA										Diametral Point Load Index (MPa)		RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
	FLUSH	RECOVERY						R.Q.D. %	FRACT. INDEX METRES	TYPE AND SURFACE DESCRIPTION						HYDRAULIC CONDUCTIVITY k, cm/s				Jr	Ja	Jn	10 ⁶	10 ⁵	10 ⁴	10 ³																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
		TOTAL CORE %								SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS	1	2	3	4	1	2	3								4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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4	NW	BEDROCK SURFACE		294.1			Grey/brown 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

DEPTH SCALE

1 : 60



GOLDER

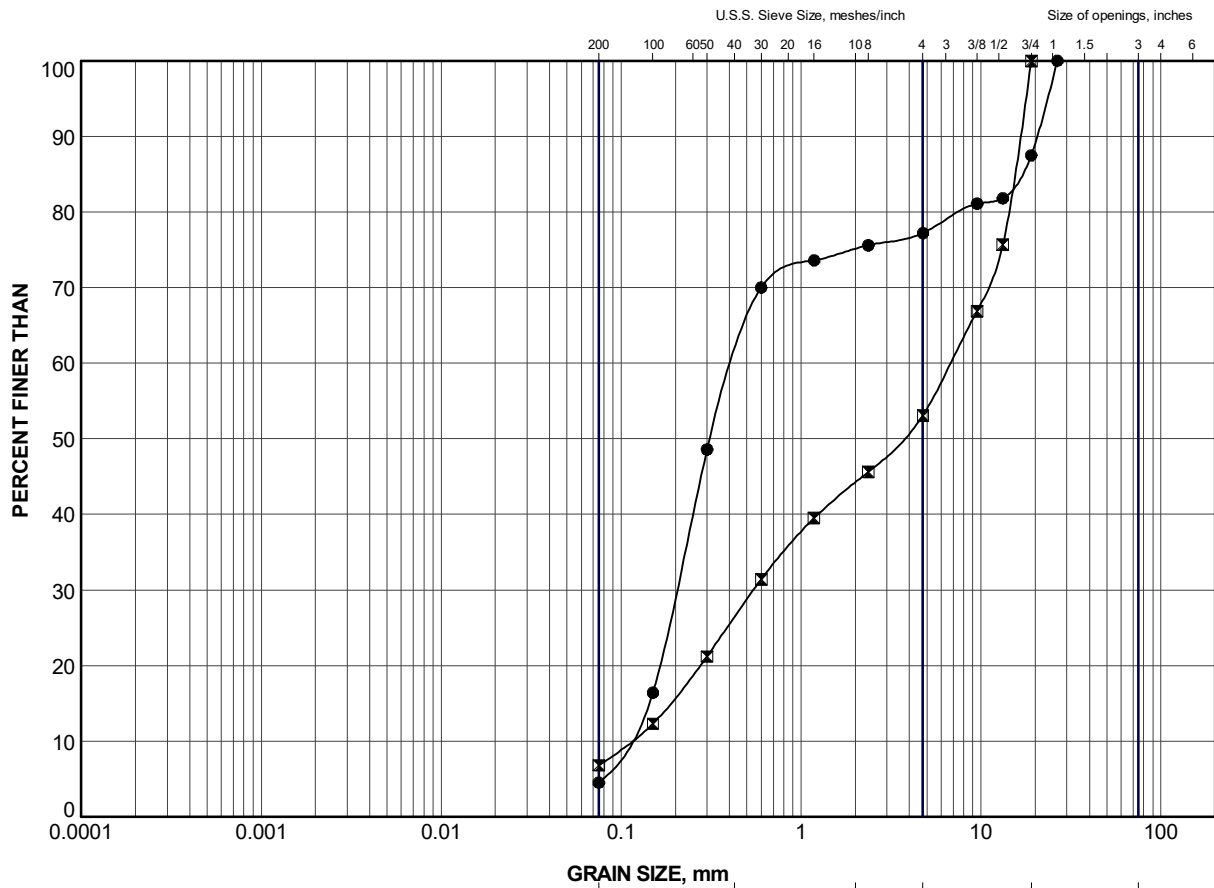
LOGGED: SA

CHECKED: DAM

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APPENDIX B

Geotechnical Laboratory Test Results

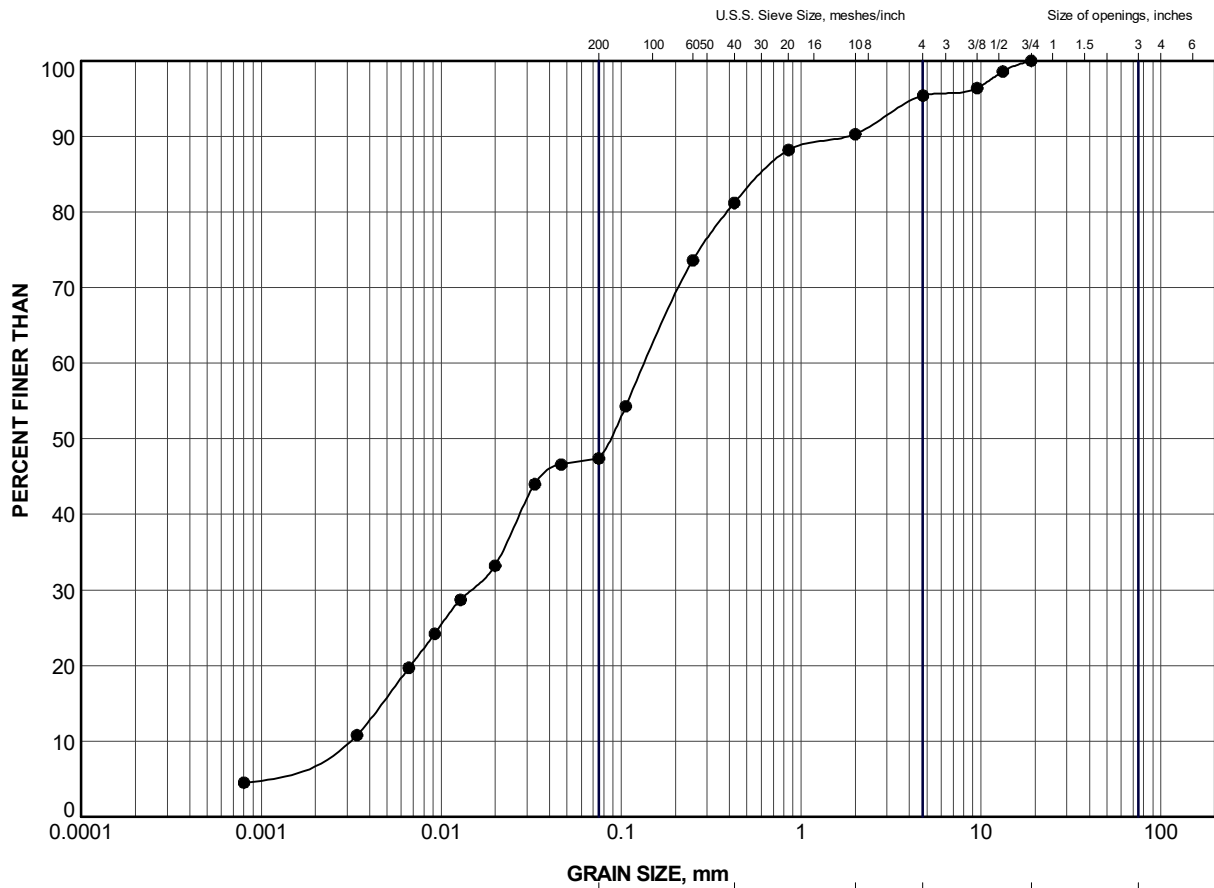


CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC-2	2	298.6
×	BC-3	3	297.7

PROJECT					
HIGHWAY 518 BEAR CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION Gravelly Sand to Sand and Gravel (FILL)					
PROJECT No.		1776446		FILE No.	
DRAWN		TR		Nov 2019	
CHECK		DAM		Nov 2019	
APPR		JMAC		Nov 2019	
GOLDER		SUDBURY, ONTARIO		SCALE N/A	
REV.		FIGURE		B-1	



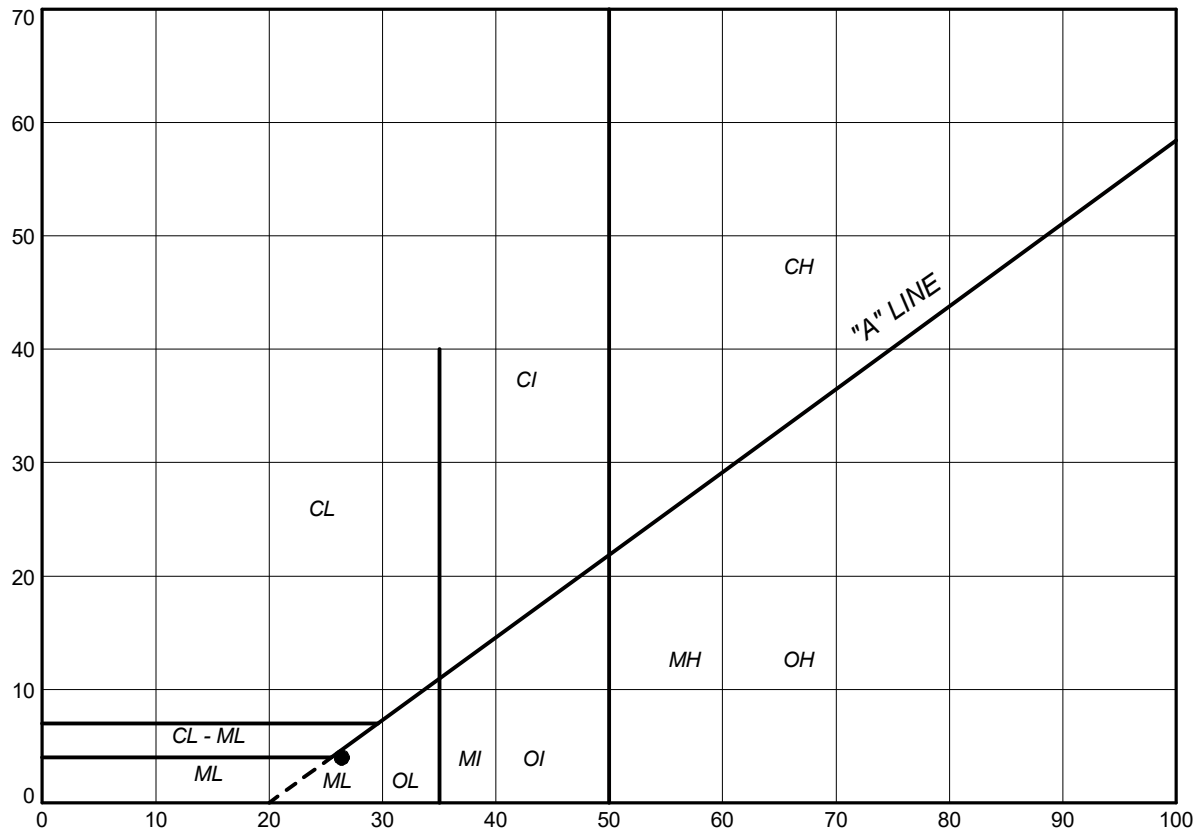
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC-1	2	295.9

PROJECT					
HIGHWAY 518 BEAR CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION Silt and Sand					
PROJECT No. 1776446			FILE No. 1776446.GPJ		
DRAWN	TR	Nov 2019	SCALE	N/A	REV.
CHECK	DAM	Nov 2019			
APPR	JMAC	Nov 2019			
GOLDER SUDBURY, ONTARIO			FIGURE B-2A		

PLASTICITY INDEX (Percent)



LIQUID LIMIT (Percent)

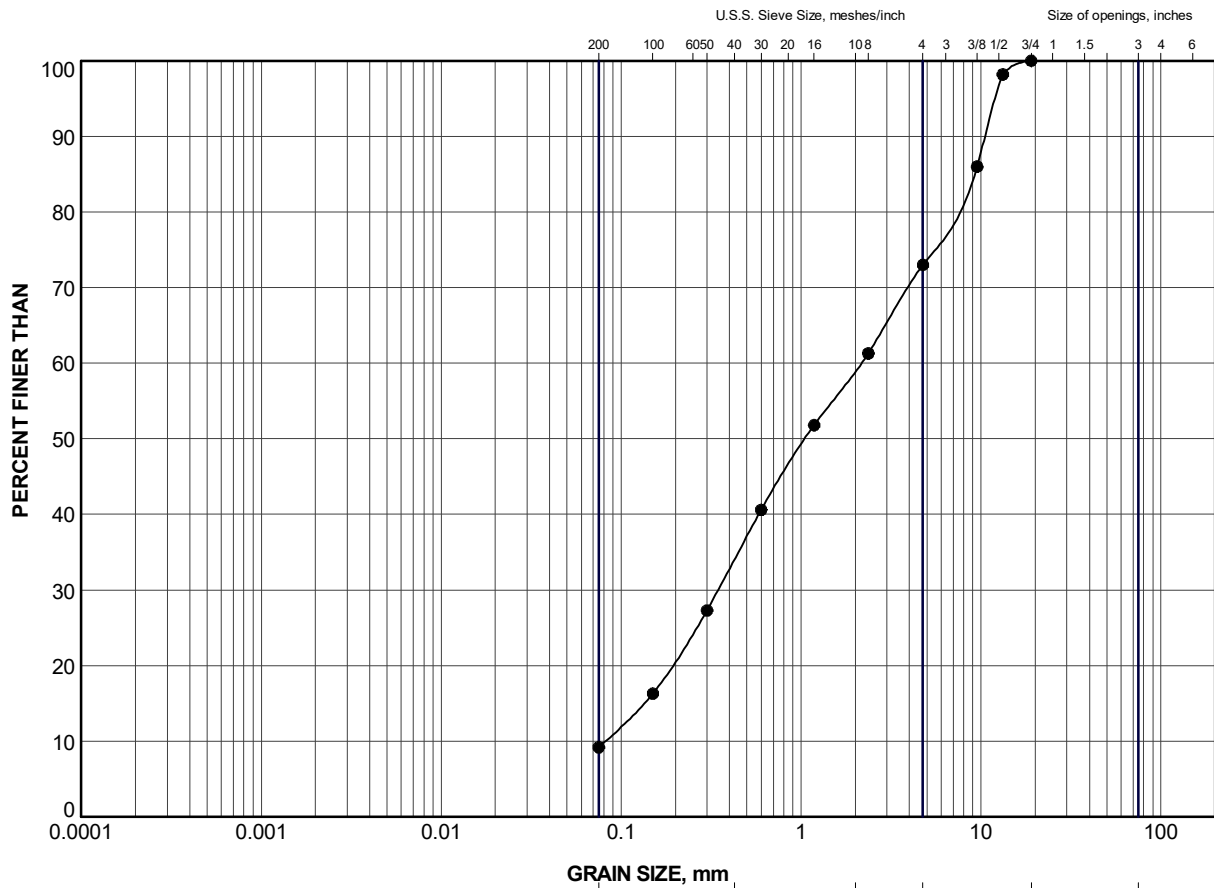
SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BC-1	1	26.4	22.4	4.0


PROJECT					
HIGHWAY 518 BEAR CREEK CULVERT					
TITLE					
PLASTICITY CHART Silt and Sand					
PROJECT No. 1776446			FILE No. 1776446.GPJ		
DRAWN	TR	Nov 2019	SCALE	N/A	REV.
CHECK	DAM	Nov 2019			
APPR	JMAC	Nov 2019			
GOLDER			FIGURE B-2B		
SUDBURY, ONTARIO					

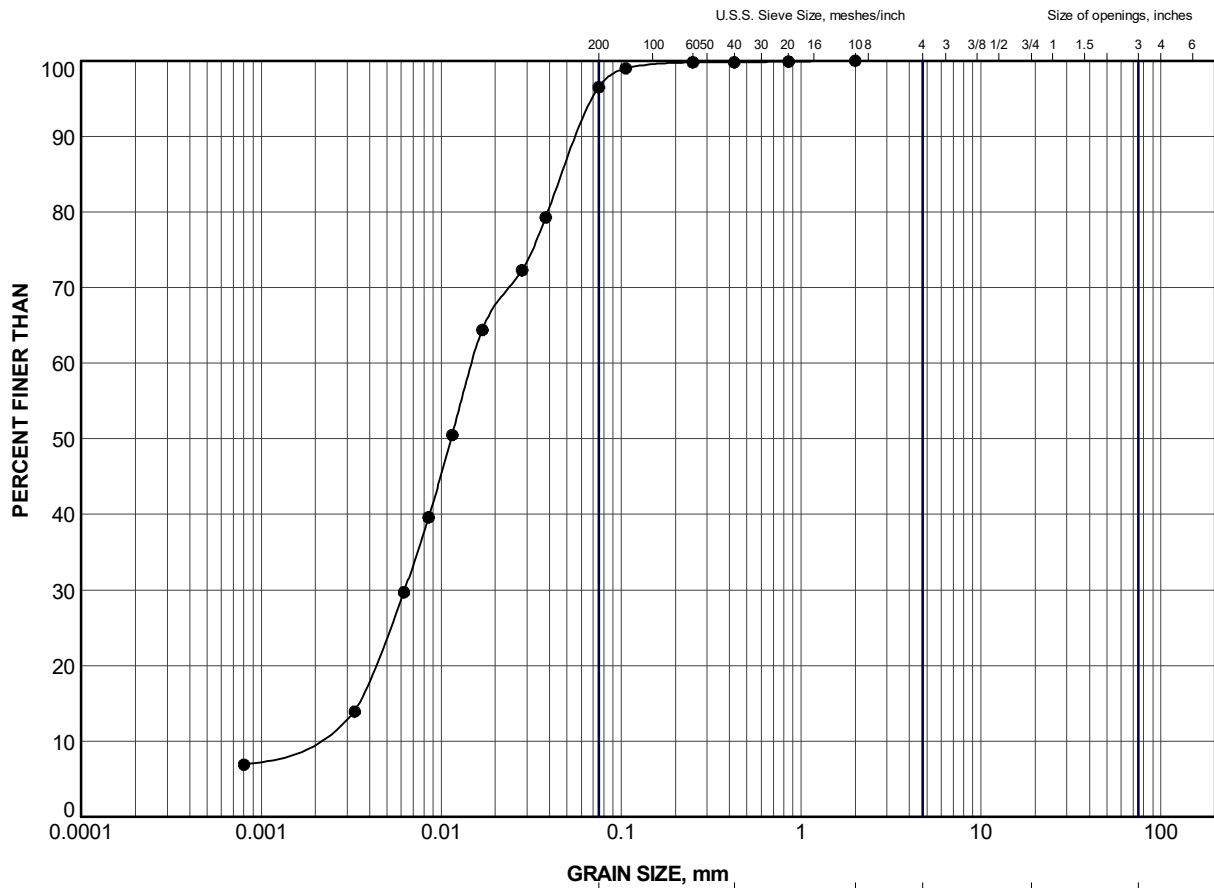


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC-3	7	294.6


PROJECT						HIGHWAY 518 BEAR CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION Gravelly Sand					
PROJECT No.			1776446			FILE No.			1776446.GPJ		
DRAWN	TR	Nov 2019	SCALE	N/A	REV.	FIGURE B-3					
CHECK	DAM	Nov 2019									
APPR	JMAC	Nov 2019									
 GOLDER SUDBURY, ONTARIO											

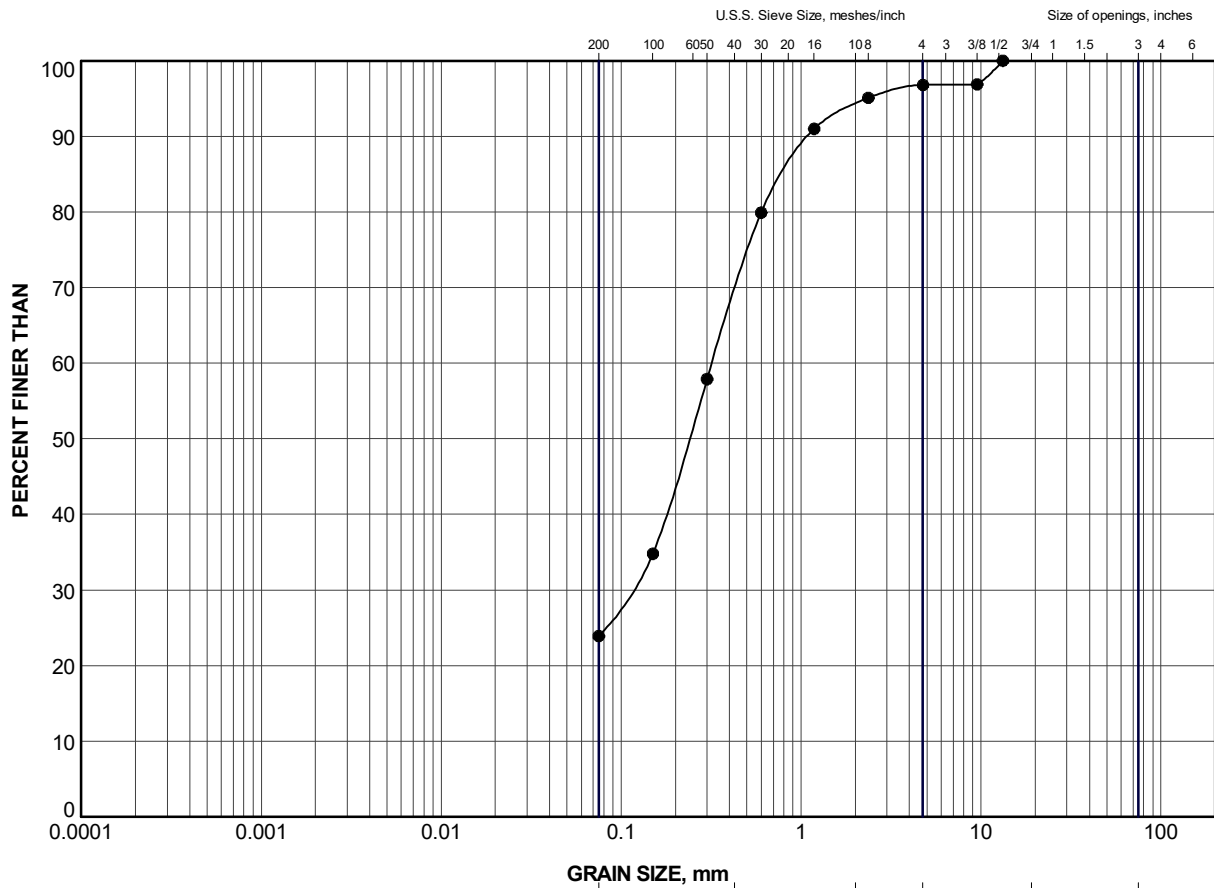


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC-4	4	295.3

PROJECT					
HIGHWAY 518 BEAR CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION Silt					
PROJECT No. 1776446			FILE No. 1776446.GPJ		
DRAWN	TR	Nov 2019	SCALE	N/A	REV.
CHECK	DAM	Nov 2019			
APPR	JMAC	Nov 2019			
 GOLDER SUDBURY, ONTARIO			FIGURE B-4		



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

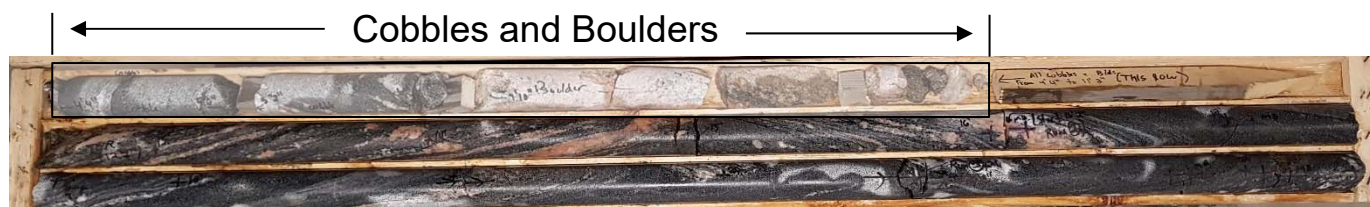
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC-4	5	294.6

PROJECT					
HIGHWAY 518 BEAR CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION Silty Sand					
PROJECT No. 1776446			FILE No. 1776446.GPJ		
DRAWN	TR	Nov 2019	SCALE	N/A	REV.
CHECK	DAM	Nov 2019			
APPR	JMAC	Nov 2019			
GOLDER SUDBURY, ONTARIO			FIGURE B-5		



Borehole BC-1: Elevation 295.6 m to 292.4 m



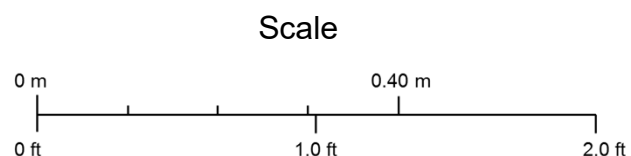
Borehole BC-2: Elevation 295.8 m to 292.6 m




Borehole BC-3: Elevation 292.8 m to 289.6 m



Borehole BC-4: Elevation 294.1 m to 290.8 m



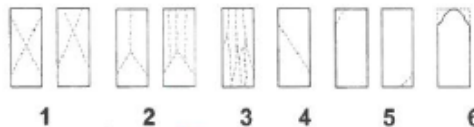
PROJECT		HIGHWAY 518 BEAR CREEK CULVERT			
TITLE		BEDROCK CORE PHOTOGRAPHS			
	PROJECT No. 1776446			FILE No.	
	DESIGN	AC	Dec. 19	SCALE	As Shown
	CADD	--		FIGURE B-6	
	CHECK	DAM	Dec. 19		
	REVIEW	JMAC	Dec. 19		

SUMMARY OF ROCK CORE TEST DATA

PROJECT NO.: 1776446/2300
 PROJECT NAME: MTO/5016-E-0037/Hwys 124,400,518
 TYPE OF UNIT: Rock Core
 TESTED BY: JM
 DATE TESTED: April 20, 2018

GOLDER LAB NUMBER	S276				
BOREHOLE NUMBER:	BC-2				
SAMPLE NUMBER:	N/A				
DEPTH OF TESTED CORE (ft)	15'1/4"-15' 4 2/3"				
LENGTH AS CUT (mm)	99.0				
DIAMETER (mm)	47.7				
DENSITY (kg/m3)	2718				
COMPRESSIVE STRENGTH (KN)	173.4				
CORRECTED STRENGTH (MPa)	97.2				
TYPE OF FRACTURE	3				

Type of Fracture



COMMENTS:

PROJECT

**HIGHWAY 518
BEAR CREEK CULVERT**

TITLE

Summary of Rock Core Test Data



PROJECT No. 1776446

FILE No.

DESIGN AC Dec. 19

SCALE As Shown VER. 1.

CADD --

CHECK DAM Dec. 19

REVIEW JMAC Dec. 19

FIGURE B-7

APPENDIX C

Analytical Laboratory Test Results

Your Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Your C.O.C. #: 641586-01-01

Attention: David Muldowney

Golder Associates Ltd
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2018/01/03
Report #: R4927509
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B755485

Received: 2017/12/15, 14:01

Sample Matrix: Soil
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	3	N/A	2017/12/27	CAM SOP-00463	EPA 325.2 m
Conductivity	3	N/A	2017/12/27	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl ₂ EXTRACT	3	2017/12/28	2017/12/28	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	3	2017/12/20	2017/12/27	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	3	N/A	2017/12/27	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

Your Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Your C.O.C. #: 641586-01-01

Attention: David Muldowney

Golder Associates Ltd
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2018/01/03
Report #: R4927509
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7S5485

Received: 2017/12/15, 14:01

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Fatemeh Habibagahi, Project Manager Assistant
Email: FHabibagahi@maxxam.ca
Phone# (905) 817-5700

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF SOIL

Maxxam ID		FTW859	FUN106	FUN107		
Sampling Date		2017/12/14 13:00	2017/12/05 12:00	2017/12/07 13:30		
COC Number		641586-01-01	641586-01-01	641586-01-01		
	UNITS	HC-1(HARRIS CREEK CULVERT HWY 121)	BC-3(BEWR CREEK HWY 518)	C27-2(CULVERT27 HWY124)	RDL	QC Batch

Calculated Parameters						
Resistivity	ohm-cm	5100	11000	2300		5325054
Inorganics						
Soluble (20:1) Chloride (Cl)	ug/g	56	35	210	20	5329429
Conductivity	umho/cm	197	91	444	2	5330818
Available (CaCl2) pH	pH	7.44	6.59	6.66		5333167
Soluble (20:1) Sulphate (SO4)	ug/g	ND	ND	ND	20	5329488
RDL = Reportable Detection Limit						
QC Batch = Quality Control Batch						
ND = Not detected						

Maxxam ID		FUN107		
Sampling Date		2017/12/07 13:30		
COC Number		641586-01-01		
	UNITS	C27-2(CULVERT27 HWY124) Lab-Dup	RDL	QC Batch
Inorganics				
Available (CaCl2) pH	pH	6.71		5333167
Soluble (20:1) Sulphate (SO4)	ug/g	ND	20	5329488
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				
Lab-Dup = Laboratory Initiated Duplicate				
ND = Not detected				

Maxxam Job #: B7S5485
Report Date: 2018/01/03

Golder Associates Ltd
Client Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Sampler Initials: SA

TEST SUMMARY

Maxxam ID: FTW859
Sample ID: HC-1(HARRIS CREEK CULVERT HWY 121)
Matrix: Soil

Collected: 2017/12/14
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5329429	N/A	2017/12/27	Deonarine Ramnarine
Conductivity	AT	5330818	N/A	2017/12/27	Tahir Anwar
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Resistivity of Soil		5325054	2017/12/27	2017/12/27	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

Maxxam ID: FUN106
Sample ID: BC-3(BEWR CREEK HWY 518)
Matrix: Soil

Collected: 2017/12/05
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5329429	N/A	2017/12/27	Deonarine Ramnarine
Conductivity	AT	5330818	N/A	2017/12/27	Tahir Anwar
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Resistivity of Soil		5325054	2017/12/27	2017/12/27	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

Maxxam ID: FUN107
Sample ID: C27-2(CULVERT27 HWY124)
Matrix: Soil

Collected: 2017/12/07
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5329429	N/A	2017/12/27	Deonarine Ramnarine
Conductivity	AT	5330818	N/A	2017/12/27	Tahir Anwar
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Resistivity of Soil		5325054	2017/12/27	2017/12/27	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

Maxxam ID: FUN107 Dup
Sample ID: C27-2(CULVERT27 HWY124)
Matrix: Soil

Collected: 2017/12/07
Shipped:
Received: 2017/12/15

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5333167	2017/12/28	2017/12/28	Tahir Anwar
Sulphate (20:1 Extract)	KONE/EC	5329488	N/A	2017/12/27	Deonarine Ramnarine

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.0°C
Package 2	7.0°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1776446 T2200/MTP/GHD HWY124/5
Site Location: HWY 124 HARRIS CREEK
Sampler Initials: SA

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5329429	Soluble (20:1) Chloride (Cl)	2017/12/27	116	70 - 130	104	70 - 130	ND, RDL=20	ug/g	NC	35
5329488	Soluble (20:1) Sulphate (SO4)	2017/12/27	115	70 - 130	110	70 - 130	ND, RDL=20	ug/g	NC	35
5330818	Conductivity	2017/12/27			100	90 - 110	ND,RDL=2	umho/cm	0.40	10
5333167	Available (CaCl2) pH	2017/12/28			100	97 - 103			0.70	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

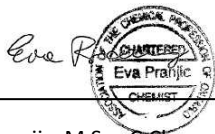
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference $\leq 2 \times \text{RDL}$).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Ewa Pranjić, M.Sc., C.Chem, Scientific Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel: (905) 817-5700 Toll-free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name: #7575 Golder Associates Ltd		Company Name:		Quotation #: B70916		Maxxam Job #:	
Attention: David Muldowney		Attention:		P.O. #:		Bottle Order #:	
Address: 33 Mackenzie Street Suite 100		Address:		Project: 1776446 P2200		COC #:	
Sudbury ON P3C 4Y1		Address:		Project Name: MTO/GHD HWY124/518		Project Manager:	
Tel: (705) 524-6861 x		Tel:		Site #: Hwy 124 Harris Creek		Alison Cameron	
Fax: (705) 524-1984 x		Fax:		Sampled By: S Albert		C#641586-01-01	
Email:		Email:					

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)		Other Regulations		Special Instructions
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw	
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558	<input type="checkbox"/> Storm Sewer Bylaw	
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC	<input type="checkbox"/> MISA	Municipality	
<input type="checkbox"/> Table		<input type="checkbox"/> PWQO		
		<input type="checkbox"/> Other		

Include Criteria on Certificate of Analysis (Y/N)?

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle):	Metals / Hg / Cr / VI	Corrosivity on Water
1	HC-1	Harris Creek Culvert Hwy 124	17/12/14	13:00	Soil			X
2								
3								
4								
5								
6								
7								
8								
9								
10								

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT:
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.

Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: Time Required: ☐

Rush Confirmation Number: (call lab for #)

of Bottles: Comments:

15-Dec-17 14:01
Alison Cameron
B7S5485
URE ENV-1215

Received in Sudbury

* RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	# jars used and not submitted	Laboratory Use Only		
Shane Albert / Shane Albert		17/12/15	2:01 PM	J. Clement		17/12/15	2:01 PM		Time Sensitive	Temperature (°C) on Receipt	Custody Seal
				Sudbury Customer Center		2017/12/16	10:20			6/6/16	Present
											Intact
											Yes
											No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

CHAIN OF CUSTODY RECORD

62087

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required	
Company Name: <u>#3575 Golden Associates</u>	Company Name:	Quotation #: <u>370916</u>	<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS		
Contact Name: <u>David Mukherjee</u>	Contact Name:	P.O. # / AFE#:					
Address: <u>58 McKenzie St. Suite 100</u>	Address:	Project #: <u>1116446 P.320</u>	Rush TAT (Surcharges will be applied)				
Phone: <u>(705) 524-6861</u> Fax: <u>(705) 524-1984</u>	Phone:	Site Location: <u>1701 G.H.D. Hwy 124/518</u>	<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days				
Email:	Email:	Site #:	Date Required:				
		Sampled By: <u>S. Albest</u>	Rush Confirmation #:				
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY							
Regulation 153		Other Regulations		Analysis Requested		LABORATORY USE ONLY	
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other <input type="checkbox"/> Table <input type="checkbox"/> FOR RSC (PLEASE CIRCLE) Y / N		<input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> PWQO Region <input type="checkbox"/> Other (Specify) <input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED)		REFER TO BACK OF COC REG 153 METALS & INORGANICS REG 153 ICP/MS METALS REG 153 METALS (Hb, Cr, V, ICP/MS Metals, HWS - B) REG 153 METALS (Hb, Cr, V, ICP/MS Metals, HWS - B)		CUSTODY SEAL Y / N Present Intact COOLER TEMPERATURES N N 7.7°C COOLING MEDIA PRESENT: <input checked="" type="checkbox"/> Y <input type="checkbox"/> N COMMENTS	
Include Criteria on Certificate of Analysis: Y / N							
SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM							
SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / Cr / V	RTX / PHC / F1	PHCS / F2 - F4
1 <u>BC-3 & Bar Creek Hwy 518</u>	<u>2017/12/05</u>	<u>12:00</u>	<u>Soil</u>	<u>3</u>			
2 <u>C 27-2 & Culvert 27 Hwy 124</u>	<u>2017/12/07</u>	<u>13:30</u>	<u>Soil</u>	<u>3</u>			
3 <u>HL-1 & Harris Creek Culvert Hwy 124</u>	<u>2017/12/14</u>	<u>12:00</u>	<u>Soil</u>	<u>3</u>			
4							
5							
6							
7							
8							
9							
10							
RELINQUISHED BY: (Signature/Print)				DATE: (YYYY/MM/DD)		TIME: (HH:MM)	
<u>ADONNE-KAY DE SOUZA</u>				<u>2017/12/19</u>		<u>13:20</u>	
RECEIVED BY: (Signature/Print)				DATE: (YYYY/MM/DD)		TIME: (HH:MM)	
<u>B.G. / Bradley Frappier</u>				<u>2017/12/19</u>		<u>13:20</u>	
<u>Julia S. / J. S. / J. S.</u>				<u>2017/12/20</u>		<u>08:53</u>	
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