



January 14, 2013

## DETAIL FOUNDATION INVESTIGATION REPORT

ENGLEHART (BLANCHE) RIVER BRIDGE REPLACEMENT  
HIGHWAY 573, SITE NO. 47-028  
MUNICIPALITY OF CHARLTON AND DACK, ONTARIO  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5109-05-00

**Submitted to:**  
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REPORT





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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail design services for the replacement of three (3) structures carrying Highway 573 over the Englehart (Blanche) River in the Municipality of Charlton and Dack, Ontario (northwest of Englehart). This report addresses Bridge Site No. 47-028, the most westerly of the three (3) structures.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed replacement structure by borehole drilling, in situ testing and laboratory testing on selected samples. The location of the site is shown in the key plan on Drawing 1.

Preliminary subsurface information for this project is available and was provided by the MTO, in a report titled:

- Preliminary Foundation Investigation and Design Report, Englehart (Blanche) River Bridge Replacement, Highway 573, Site No. 47-028, GWP 5109-05-00, GEOCRE No. 31M-84, dated May 10, 2010, by Golder Associated Ltd.

## **2.0 SITE DESCRIPTION**

The bridge site is situated in the Township of Charlton and Dack on Highway 573 crossing the Englehart (Blanche) River, approximately 1.1 km west of the junction with Highway 560. The surrounding land use is mainly for recreational activities. The land surface is grass and tree-covered, extending beyond the limits of the site. The banks adjacent to the river are vegetated with landscaped grass and small shrubs, and bedrock is exposed in several areas. The river is a regulated watercourse used for power generation by Kagawong Power Inc. A footbridge crossing the river is located to the north of the existing bridge structure and a water control dam is located about 20 m upstream (south) of the existing bridge. The river flows from south to north.

The existing single-span concrete bridge was constructed in 1927 and has a width of 6.4 m and a span length of 10.5 m. The existing highway grade is between about Elevation 258.1 m and 258.3 m.

## **3.0 INVESTIGATION PROCEDURES**

The fieldwork at the bridge site was carried out on June 9 and between July 8 and July 24, 2012, at which time a total of nine (9) boreholes (BL-1, BL-2, BL-4, BL-5, BL-6, BL-7, BL-8, BR-04, and BR-05) were advanced at the site. Seven (7) boreholes are located at the corners of the bridge abutments, and one (1) borehole located on each of the east and west approach embankments. Four (4) boreholes (BH09-9 to BH09-12) that were drilled on October 7, 2009, at this site as part of the Preliminary Foundation Investigation are also used to supplement the current subsurface investigation. The locations of the boreholes are summarized in Table 1, shown in plan on Drawing 1, and noted on the respective Record of Borehole sheets in Appendix A. The boreholes were drilled using either a portable D-25 drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario, or a CME 75 truck-mounted drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers and NW casing. Soil samples were obtained, where possible, at intervals of depth of 0.75 m, using a 50 mm outer



diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Auger samples were typically taken just below the asphalt pavement or at the ground surface.

The boreholes were advanced to depths between 0.9 m and 5.8 m below the existing ground surface, including bedrock coring for lengths between 1.8 m and 3.5 m in five (5) boreholes. Boreholes BL-2, BL-6 and BL-7 were located on exposed bedrock and were not cored.

The groundwater conditions in the open boreholes were observed during the drilling operations and a piezometer was installed in Borehole BH09-12 to allow monitoring of the groundwater level at this location. The piezometer consists of a 19 mm O.D. rigid polyvinyl chloride (PVC) tubing with a 1.5 m long-slotted screen and a flush-mounted cap. The water level readings are presented on the Record of Borehole sheets in Appendix A. The boreholes were backfilled with bentonite as per Ontario Regulation 903 (as amended) upon completion of drilling.

Traffic protection was carried out for the boreholes drilled within the roadway in accordance with our Traffic Protection Plan and the MTO Book 7 Temporary Conditions Manual.

The fieldwork was supervised throughout by members of our engineering and technical staff who located the boreholes, arranged for the clearance of underground service locations, supervised the drilling and sampling operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content and grain size distribution) was carried out on selected soil samples.

The locations of the proposed foundation elements were staked in the field by Callon Dietz relative to the proposed abutment locations based on the dimensions shown on a preliminary drawing provided by MH dated June 2012. Callon Dietz provided the elevations of the staked locations and Golder surveyed the ground surface elevation of the boreholes that were drilled in 2009, referencing an existing benchmark located on the south concrete wing wall between Site Nos. 47-030 and 47-029 (BM ONR No. 8010845206). The ground surface and water surface elevations are referenced to Geodetic datum. The northing and easting coordinates (MTM NAD83) were determined by plotting the boreholes relative to the existing bridge on the June 2012 GA provided by MH and converting to the coordinate system. The northing and easting coordinates, ground surface elevations and the borehole depths are summarized below.



Borehole	Borehole Location		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
BH09-9	5297264.8	379552.8	258.2	0.9
BH09-10	5297259.4	379554.0	258.2	2.3
BH09-11	5297257.9	379540.6	258.3	2.5
BH09-12	5297261.0	379540.6	258.1	2.8
BL-1	5297263.0	379537.8	258.4	5.5
BL-2	5297263.7	379541.2	254.5	0.0
BL-4	5297266.7	379554.8	257.2	5.8
BL-5	5297253.3	379539.9	256.7	4.2
BL-6	5297254.0	379543.2	255.4	0.0
BL-7	5297256.2	379553.6	255.1	0.0
BL-8	5297257.0	379556.9	256.3	3.9
BR-4	5297255.0	379528.3	258.3	4.2
BR-5	5297268.3	379574.1	258.2	2.1

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Published literature<sup>1</sup> indicates that the site is located in the transition zone between the Western Abitibi Subprovince of the Superior Province (to the north) and the Huronian Supergroup (to the south). The bedrock geology follows the river valley and consists of mafic metavolcanic rock (Geology of Ontario; OGS Special Volume 4)<sup>1</sup>.

Terrain mapping by the Ontario Geological Survey<sup>2</sup> describes the subsurface soils in the vicinity of the site as silty colluvial slopewash and debris creep sheet with minor talus.

### 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions, as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the attached Record of Borehole sheets in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and of the soil cuttings. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown on Drawing 1.

<sup>1</sup> Geology of Ontario, 1991. Ontario Geological Survey, Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

<sup>2</sup> Northern Ontario Engineering Geology Terrain Study, OGS Map Reference Numbers 5020 and 5021.



In general, the subsoils at the structure site consist of asphalt underlain by granular fill and/or rock fill. In one borehole, a 1.4 m thick layer of decomposed wood was encountered below the rock fill to the refusal depth.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### **4.2.1 Asphalt**

Boreholes BH09-9 to BH09-12, BR4 and BR-5 were drilled through the pavement and penetrated through an approximately 200 mm to 380 mm thick layer of asphalt. In Boreholes BH09-10, BH09-12, BR-4 and BR-5 interlayers of gravelly sand fill ranging in thickness from 60 mm to 240 mm were encountered between asphalt layers. The ground surface at these boreholes ranges from Elevation 258.3 m to 258.1 m.

#### **4.2.2 Fill**

Granular fill and rock fill was encountered underlying the pavement materials in Boreholes BH09-9 to BH09-12, BR-4, and BR-5 and at ground surface in Boreholes BL-1, BL-4, BL-5 and BL-8. The top of the fill was encountered between Elevation 258.4 m and 256.3 m and the total thickness of the granular fill and rock fill, including a layer of wood, is between 0.5 m and 2.5 m.

In Boreholes BL-1, BL-5, BL-8, BR-4, BR-5, BH09-9, BH09-11 and BH09-12, the fill layer was encountered below the asphalt and is between 0.1 m and 1.0 m thick. It is comprised of sandy gravel to gravelly sand fill containing trace silt and trace organics. Underlying the asphalt or granular fill or at ground surface, Boreholes BL-1, BL-4, BH09-9, BH09-10, BH09-11 and BH09-12, and BR-4 encountered rock fill in a gravelly sand to sand and gravel matrix. Wood was encountered dispersed within the rock fill in Borehole BH09-12 and a 1.4 m thick layer of partially decomposed wood was encountered below the rock fill in this borehole at Elevation 256.7 m. The augers were noted to be sliding to the east in Borehole BH09-12 during advancement of the lower 0.4 m.

Grinding of the augers was noted during advancement through the fill material in Boreholes BH09-9 and BH09-10, located on the proposed east abutment. Empty split-spoons were recovered within the rock fill in Borehole BH09-10 and there was an absence of auger cutting returns between the depths of 0.8 m and 2.3 m below ground surface, indicating the presence of voids within the rock fill.

SPT 'N'-values measured within the sand and gravel fill and rock fill range from 4 blows to 43 blows per 0.3 m of penetration, indicating a loose to dense relative density. In Boreholes BR-4 and BR-5, SPT 'N'-values of 87 blows and 45 blows per 0.3 m of penetration were measured as the split-spoon sampler penetrated an asphalt interlayer. In some boreholes, the split-spoon sampler did not penetrate the full sampler depth and was noted to be bouncing on rock fill material or inferred bedrock.

The natural water content measured on samples of the granular fill and rock fill ranges between about 3 per cent and 10 per cent.

Grain size distributions for three samples of the sandy gravel to sand and gravel fill are shown on Figure B-1 in Appendix B.





The natural water content measured on two samples of the decomposed wood layer in Borehole BH09-12 are about 130 per cent and 304 per cent and the organic content of these two samples is 36 per cent and 83 per cent, respectively.

#### **4.2.3 Silty Sand**

In Borehole BR-5, a 0.4 m thick layer of wet, brown silty sand containing trace gravel was encountered underlying the granular fill at Elevation 256.5 m.

An SPT 'N'-value measured in the silty sand deposit is 8 blows per 0.3 m of penetration indicating a loose relative density.

A grain size distribution test was carried out on the sample of silty sand and the results are shown on Figure B-2.

The natural moisture content measured on the sample of silty sand is 20 per cent.

#### **4.2.4 Bedrock/Refusal**

Bedrock was encountered and cored for core lengths between 3.2 m and 3.5 m in Boreholes BL-1, BL-4, BL-5 and BL-8 and 1.8 m in Borehole BR-4. Bedrock was exposed in Boreholes BL-2, BL-6 and BL-7. The presence of bedrock was inferred from auger and/or sampler refusal in Boreholes BH09-10 to BH09-12. Borehole BH09-9 is inferred to have terminated in the rock fill. In Borehole BH09-12, located on the east side of the river, the augers were observed to be sliding to the east on inferred bedrock between about 2.4 m and 2.8 m below ground surface. The inferred bedrock surface/refusal was encountered at the depths and elevations presented below.

<b>Location</b>	<b>Borehole</b>	<b>Depth to Refusal (m)</b>	<b>Refusal/Bedrock Surface Elevation (m)</b>	<b>Comments</b>
West Approach	BR-4	2.4	255.9	Bedrock Cored
West Abutment	BL-1	2.3	256.1	Bedrock Cored
	BL-2	0.0	254.5	Exposed Bedrock
	BL-5	0.8	255.9	Bedrock Cored
	BL-6	0.0	255.4	Exposed Bedrock
	BH09-11	2.5	255.8	Auger refusal on inferred bedrock surface
	BH09-12	2.8	255.3	Augers sliding east possibly on sloping bedrock, from 2.4 m to 2.8 m depth; auger and spoon refusal on inferred bedrock surface
East Abutment	BH09-9	0.9	257.3	Auger and spoon refusal on rock fill
	BL-4	2.3	254.9	Bedrock Cored
	BL-7	0.0	255.1	Exposed Bedrock
	BL-8	0.5	255.8	Bedrock Cored
	BH09-10	2.3	255.9	Auger refusal on inferred bedrock surface
East Approach	BR-5	2.1	256.1	Auger refusal on inferred bedrock surface



Based on a review of the bedrock core samples, the bedrock at the site generally consists of fine grained, slightly weathered, massive to weakly foliated, grey mafic intrusive.

The Total Core Recovery (TCR) is 100 per cent for all core samples. The Solid Core Recovery (SCR) ranges from about 30 per cent to 94 per cent. Rock Quality Designation (RQD) values measured on the recovered bedrock core samples range from 44 per cent to 100 per cent, indicating that the rock is of poor to excellent quality in accordance with Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)<sup>3</sup>. In Borehole BR-4, SCR and RQD values of 0 per cent were measured in the uppermost approximately 0.3 m core drill run.

Laboratory unconfined compressive strength (UCS) testing was carried out on four core samples of the bedrock. The UCS values, presented on the Record of Drillhole sheets in Appendix A and summarized below, indicate that the bedrock is very strong ( $R5, 100 \text{ MPa} < \text{UCS} < 250 \text{ MPa}$ ) in accordance with Table 3.5 of CFEM (2006).

Borehole/ Core Run	Elevation (m)	UCS (MPa)
BL-1/#2	255.3	152
BL-4/#2	253.4	124
BL-5/#3	253.2	147
BL-8/#2	254.5	200

Exposed bedrock within the river channel in the vicinity of the existing bridge appears to be mafic intrusive which is consistent with the geology of the area. The bedrock surface is relatively flat between the dam upstream of the existing bridge and the existing bridge and is sloping downwards towards the river to the north through the river channel.

#### **4.2.5 Groundwater Conditions**

In general, the soil/fill samples taken in the boreholes were moist to wet. The boreholes advanced during the preliminary foundation investigation phase of the project were dry upon the completion of drilling. A piezometer was installed in Borehole BH09-12 and the piezometer was dry on November 26, 2009. The boreholes advanced for the detail foundation investigation encountered a water level located near the bedrock surface or within the bedrock, ranging from Elevation 256.2 m to 254.3 m, measured at depths ranging from 0.9 m to 3.7 m below ground surface. The water level in the river, measured by others in September 2009, was Elevation 255.4 m at the location of the existing bridge. The river water level for a 50-year storm event is Elevation 257.2 m and for a 1000-year storm event is Elevation 258.5 m, as provided by MH in December 2012.

### **5.0 CLOSURE**

The field drilling program was supervised by Mr. Ed Savard and Mr. Indulis Dumpis. This report was prepared by Mr. Evan Childerhose, P.Eng. An independent quality control review of the report was provided by Mr. Jorge M.A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project.

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







## Report Signature Page

GOLDER ASSOCIATES LTD.



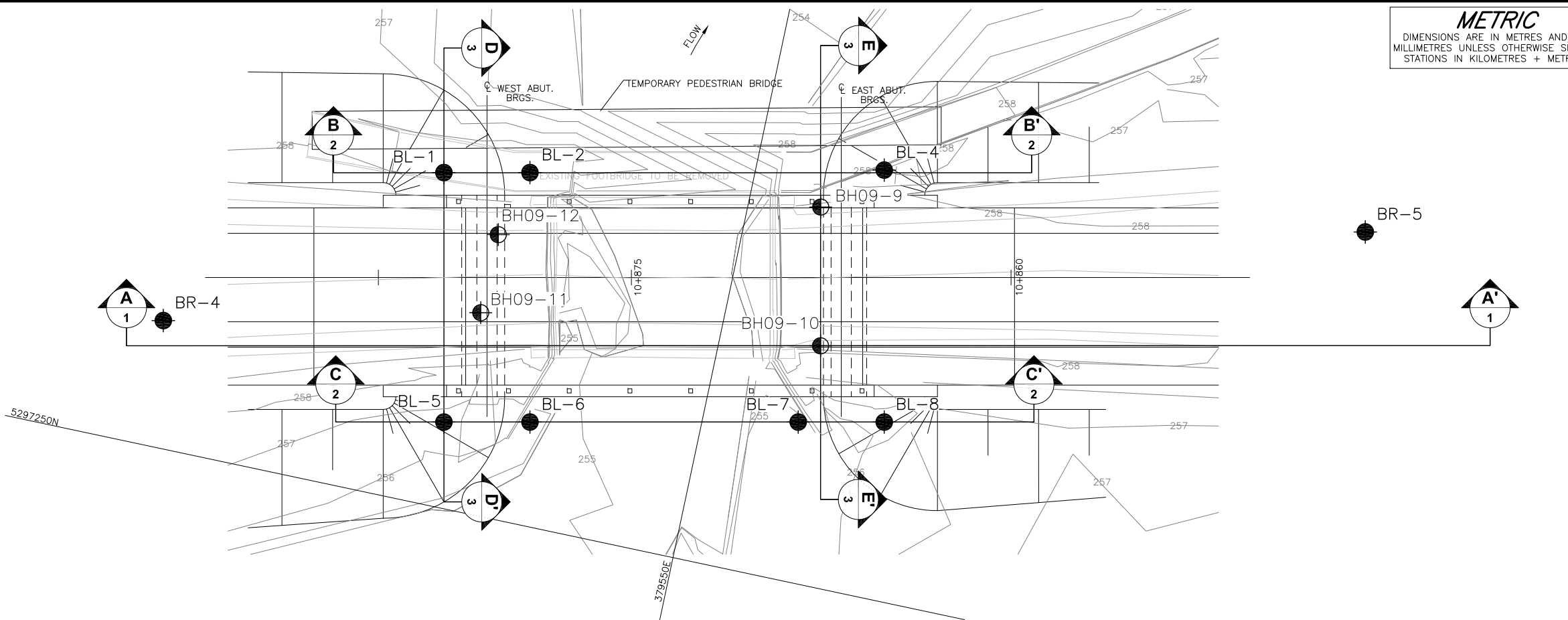
Evan Childerhose, P.Eng.  
Geotechnical Engineer



Jorge M.A. Costa, P.Eng.  
Designated MTO Contact, Principal

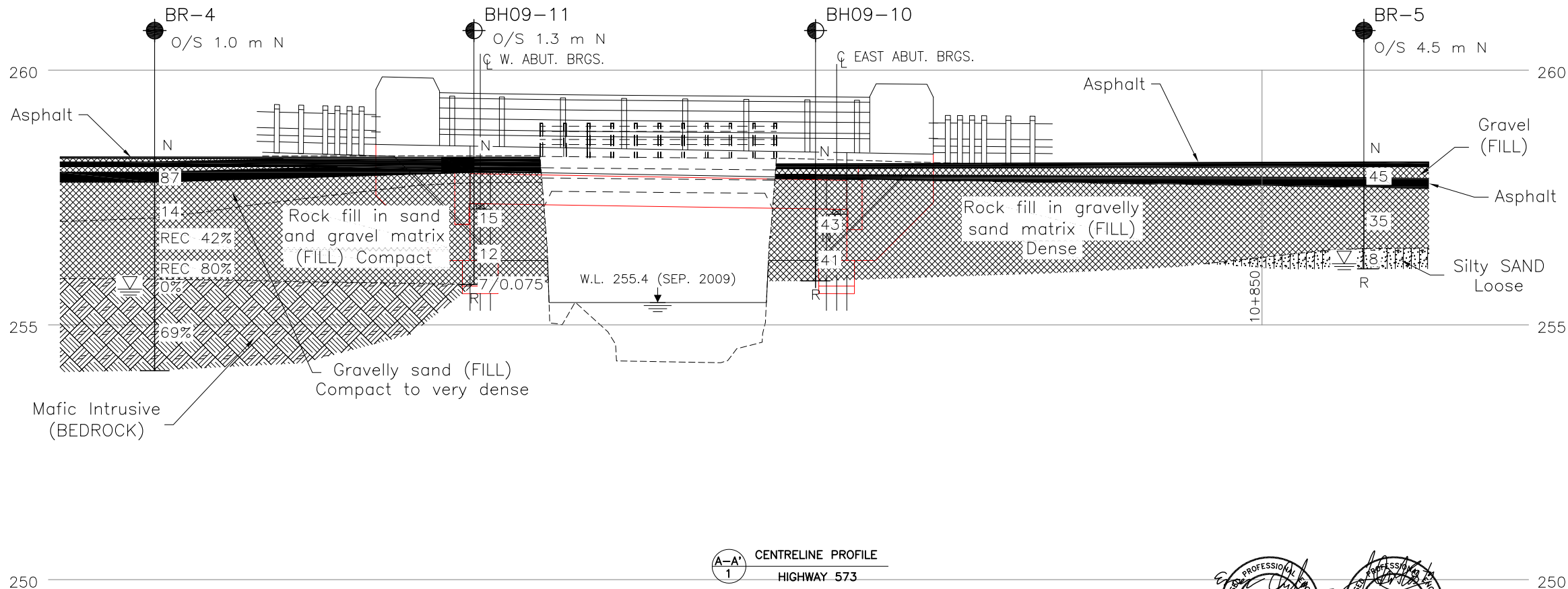
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PLAN

SCALE  
0 2 m



A-A' 1 CENTRELINE PROFILE  
HIGHWAY 573

HORIZONTAL SCALE  
0 2 4 m  
VERTICAL SCALE  
0 1 2 m

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

CONT No.  
WP No. 5109-05-00

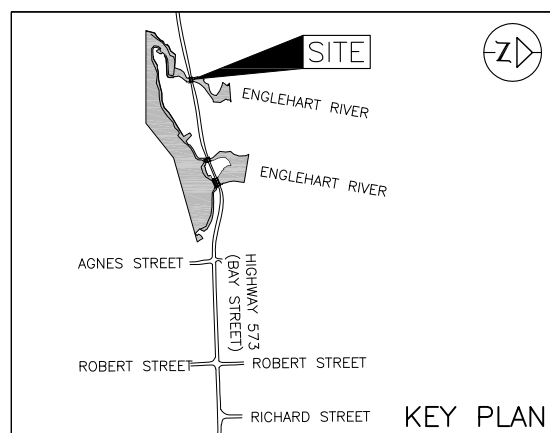
ENGLEHART (BLANCHE) RIVER  
HIGHWAY 573 BRIDGE 47-028  
BOREHOLE LOCATION AND SOIL  
STRATA



SHEET



**Golder Associates Ltd.**  
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- ⊕ Borehole - Previous Investigation
- 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 (%)
- ≡ WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
BL-1	258.4	5297263.0	379537.8
BL-2	254.5	5297263.7	379541.2
BL-4	257.2	5297266.7	379557.8
BL-5	256.7	5297253.3	379539.9
BL-6	255.4	5297254.0	379543.2
BL-7	255.1	5297256.2	379553.6
BL-8	256.3	5297257.0	379556.9
BR-4	258.3	5297255.0	379528.4
BR-5	258.2	5297268.3	379574.1
BH09-9	258.2	5297264.8	379552.8
BH09-10	258.2	5297259.4	379554.0
BH09-11	258.3	5297257.9	379540.6
BH09-12	258.1	5297261.0	379540.6

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

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 Morrison Hershfield, drawing file nos. 47028-01.dwg, received June 13, 2012.

NO.	DATE	BY	REVISION
Geocres No. 31M-98			
HWY. 573	PROJECT NO. 11-1191-0032		DIST.
SUBM'D. EC	CHKD. SEMC	DATE: DEC 2012	SITE: 47-028
DRAWN: TB	CHKD.	APPD. JMAC	DWG. 1





# APPENDIX A

## Record of Boreholes and Drillholes



## 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	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) 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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

### V. MINOR SOIL CONSTITUENTS

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## 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

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

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

#### (a) Index Properties (continued)

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

#### (b) Hydraulic Properties

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

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

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

#### (d) Shear Strength

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

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

Notes: 1  
2

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

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



## 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

<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		11-1191-0032		<b>RECORD OF BOREHOLE No BL-1</b>				1 OF 1 <b>METRIC</b>									
W.P.		5109-05-00		LOCATION		N 5297263.0; E 379537.8		ORIGINATED BY ID									
DIST		HWY 573		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring		COMPILED BY AC									
DATUM		GEODETIC		DATE		July 12, 2012		CHECKED BY EC									
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									
258.4	GROUND SURFACE							20	40	60	80	100					
0.0	Sandy gravel, trace silt (FILL) Loose Brown Moist		1	SS	8		258										
257.7																	
0.7	Rock fill in a sandy gravel matrix (FILL) Compact Grey Wet		1	RC	REC 100%		257										
			2	SS	13												
256.1																	
2.3	MAFIC INTRUSIVE (BEDROCK)  Bedrock cored from 2.3 m depth to 5.5 m depth.  For coring details see Record of Drillhole BL-1.		2	RC	REC 100%		256										RQD = 70%
			3	RC	REC 100%		255										RQD = 74%
			4	RC	REC 100%		254										RQD = 100%
252.9							253										
5.5	END OF BOREHOLE  Note:  1. Water level at a depth of 3.7 m below ground surface (Elev. 254.4 m) upon completion of drilling.  2. Auger refusal encountered at 0.7 m depth, switched to NW Casing.																

PROJECT: 11-1191-0032

**RECORD OF DRILLHOLE: BL-1**

SHEET 1 OF 1

LOCATION: N 5297263.0 ; E 379537.8

DRILLING DATE: July 12, 2012

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker 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				Diametral Point Load Index (MPa)	SQC AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
							FLUSH	TOTAL CORE %			B Angle	DP w.z. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	K <sub>g</sub> cm/s	10 <sup>6</sup>			10 <sup>5</sup>	10 <sup>4</sup>	10 <sup>3</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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DEPTH SCALE

1 : 50



LOGGED: ID




CHECKED: EC

SUD-ROK 11-1191-0032.GPJ GAL-MISS GDT 17/08/12 DATA INPUT:



SUD-MTO 001 11-1191-0032+BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:

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

PROJECT 11-1191-0032		<b>RECORD OF BOREHOLE No BL-4</b>				1 OF 1 <b>METRIC</b>												
W.P. 5109-05-00		LOCATION N 5297266.7; E 379554.8				ORIGINATED BY ID												
DIST HWY 573		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY AC												
DATUM GEODETIC		DATE July 24, 2012				CHECKED BY EC												
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 (%)
257.2	GROUND SURFACE							20	40	60	80	100						
0.0	Rock fill in a gravelly sand matrix (FILL) Compact Brown Moist		1	SS	5		257											
			2	SS	6		256											
			3	SS	15/0.08													
254.9		1	RC	REC 100%	255													
2.3	MAFIC INTRUSIVE (BEDROCK)  Bedrock cored from 2.3 m depth to 5.8 m depth.  For coring details see Record of Drillhole BL-4.		1	RC	REC 100%		254										RQD = 62%	
			2	RC	REC 100%		253											RQD = 86%
			3	RC	REC 100%		252											RQD = 100%
251.4																		
5.8	END OF BOREHOLE  Note:  1. Water level at a depth of 2.9 m below ground surface (Elev. 254.3 m) upon completion of drilling.  2. Auger refusal encountered at 1.5 m depth, switched to NW Casing.																	

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:

PROJECT: 11-1191-0032

**RECORD OF DRILLHOLE: BL-4**

SHEET 1 OF 1

LOCATION: N 5297266.7 ; E 379554.8

DRILLING DATE: July 24, 2012

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker 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	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY				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	k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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DEPTH SCALE






1 : 50



LOGGED: ID

CHECKED: EC

MTO-RCK 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:

PROJECT		11-1191-0032				<b>RECORD OF BOREHOLE No BL-5</b>				1 OF 1 <b>METRIC</b>							
W.P.		5109-05-00		LOCATION		N 5297253.3; E 379539.9				ORIGINATED BY ID							
DIST		HWY 573		BOREHOLE TYPE		NW Casing, NQ Coring				COMPILED BY AC							
DATUM		GEODETIC		DATE		July 9 and 10, 2012				CHECKED BY EC							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
256.7	GROUND SURFACE						20	40	60	80	100						
0.0	Sandy gravel, trace silt (FILL) Compact Brown Moist		1	SS	23												71 26 (3)
255.9	MAFIC INTRUSIVE (BEDROCK)																
0.8	Bedrock cored from 0.8 m depth to 4.2 m depth.  For coring details see Record of Drillhole BL-5.		1	RC	REC 100%												RQD = 57%
			2	RC	REC 100%												RQD = 80%
			3	RC	REC 100%												RQD = 96%
252.5	END OF BOREHOLE																
4.2	Note:  1. Water level at a depth of 1.4 m below ground surface (Elev. 255.4 m) upon completion of drilling.																



SHEET 1 OF 1

DATUM: GEODETIC

DRILLING CONTRACTOR: Walker Drilling Ltd.

CHECKED: EC

MTO-RCK 001 11-1191-0032+BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:





SUD-MTO 001 11-1191-0032+BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:

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



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

PROJECT		11-1191-0032				RECORD OF BOREHOLE No BL-8				1 OF 1 METRIC							
W.P.		5109-05-00		LOCATION		N 5297257.0; E 379556.9				ORIGINATED BY		ID					
DIST		HWY 573		BOREHOLE TYPE		NW Casing, NQ Coring				COMPILED BY		AC					
DATUM		GEODETIC		DATE		July 9, 2012				CHECKED BY		EC					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
256.3	GROUND SURFACE						20	40	60	80	100						
0.0	Sand and gravel, some silt, trace organics (FILL)		1	SS	20		256										
255.8	Compact Brown Moist																
0.5	MAFIC INTRUSIVE (BEDROCK)		1	RC	REC 100%		255										RQD = 80%
	Bedrock cored from 0.5 m depth to 3.9 m depth.																
	For coring details see Record of Drillhole BL-8.		2	RC	REC 100%		254									RQD = 92%	
			3	RC	REC 100%		253									RQD = 44%	
252.4	END OF BOREHOLE																
3.9	Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 255.4 m) upon completion of drilling.																

PROJECT: 11-1191-0032

## RECORD OF DRILLHOLE: BL-8

SHEET 1 OF 1

LOCATION: N 5297257.0 ; E 379556.9

DRILLING DATE: July 9, 2012

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: D-25

DRILLING CONTRACTOR: Walker Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		TOP OF BEDROCK		255.8															
1	July 9, 2012 NG Coring	MAFIC INTRUSIVE Fine grained Slightly weathered Massive to weakly foliated Grey		0.5	1	GREY 100%						JIR JIR JIR JIR							
2					2	GREY 100%						JIR JIR JIR							
3					3	GREY 100%						MB JIR JIR							
4		END OF DRILLHOLE		252.4								JIR JIR JIR							
5																			
6																			
7																			
8																			
9																			
10																			

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: EC

MTO-RCK 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:

PROJECT 11-1191-0032				<b>RECORD OF BOREHOLE No BR-4</b>				1 OF 1 <b>METRIC</b>														
W.P. 5109-05-00				LOCATION N 5297255.0; E 379528.3				ORIGINATED BY EHS														
DIST _____ HWY 573				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring				COMPILED BY AC														
DATUM GEODETIC				DATE June 9, 2012				CHECKED BY EC														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
								<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>														
258.3	GROUND SURFACE																					
0.0	ASPHALT (30 mm)		1	SS	87																	
0.5	Gravelly sand, trace silt (FILL) Brown Moist		2	SS	14																	
257.1	ASPHALT (100 mm)																					
1.2	Gravelly sand, trace silt (FILL) Brown Moist		1	RC	REC 42%																	
	ASPHALT (150 mm)																					
	Gravelly sand, trace silt (FILL) Brown Moist		2	RC	REC 80%																	
255.9	Rockfill in a sand and gravel matrix (FILL) (as recovered in a core barrel)		3	RC	REC 100%																	
2.4	MAFIC INTRUSIVE (BEDROCK)																					
	Bedrock cored from 2.4 m depth to 4.2 m depth.		4	RC	REC 100%																	
	For coring details see Record of Drillhole BR-4.																					
254.1	END OF BOREHOLE																					
4.2	Notes:  1. Water level at a depth of 2.6 m below ground surface (Elev. 255.8 m) upon completion of drilling.  2. Auger refusal at 1.2 m depth, switched to NW casing.																					







[illegible]

DEPTH SCALE

1 : 50

LOGGED: EHS

CHECKED: EC

PROJECT <u>11-1191-0032</u>		<b>RECORD OF BOREHOLE No BR-5</b>				1 OF 1 <b>METRIC</b>								
W.P. <u>5109-05-00</u>		LOCATION <u>N 5297268.3; E 379574.1</u>				ORIGINATED BY <u>EHS</u>								
DIST <u>          </u> HWY <u>573</u>		BOREHOLE TYPE <u>108 mm I.D. Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>AC</u>								
DATUM <u>GEODETIC</u>		DATE <u>June 9, 2012</u>				CHECKED BY <u>EC</u>								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
258.2	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	ASPHALT (60 mm)		1	SS	45		258							
0.5	Gravel, some sand, trace silt (FILL) Brown Moist		2	SS	35		257							
256.5	ASPHALT (150 mm) Gravel, some sand, trace silt (FILL) Dense Brown Moist to wet		3	SS	8									
256.1	Silty SAND, trace gravel Loose Brown Wet													1 74 (25)
2.1	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL  Note:  1. Water level at a depth of 2.0 m below ground surface (Elev. 256.2 m) upon completion of drilling.													

PROJECT 11-1191-0032		<b>RECORD OF BOREHOLE No BH09- 9</b>				1 OF 1 <b>METRIC</b>										
W.P. 5302-05-00		LOCATION N 5297264.8; E 379552.8				ORIGINATED BY EHS										
DIST HWY 573		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers; NW Casing, Wash Boring				COMPILED BY AMW										
DATUM GEODETIC		DATE October 7, 2009				CHECKED BY EC										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
258.2	GROUND SURFACE															
0.0	ASPHALT															
0.3	Gravelly sand, trace silt (FILL) Brown Moist		1	AS												
257.3	Rock fill in a gravelly sand, trace silt matrix (FILL)		2	SS	15/10/5											
0.9	End of Borehole Auger and Spoon Refusal															
<p>Notes:</p> <p>1. Augers grinding at 0.46 m depth. Difficult drilling to 0.76 m depth. Switched to NW Casing.</p> <p>2. Ran casing to 0.82 m depth into boulder; borehole advancement stopped due to large void created during casing advancement. Borehole backfilled using bentonite powder mixed with water to fill voids.</p> <p>3. Borehole dry upon completion of drilling.</p>																

SUD-MTO 001 11-1191-0032-BH09.GPJ GAL-MISS.GDT 23/08/12 DATA INPUT:

PROJECT		RECORD OF BOREHOLE No BH09-10				1 OF 1 METRIC							
W.P. 5302-05-00		LOCATION N 5297259.4; E 379554.0				ORIGINATED BY EHS							
DIST _____ HWY 573		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AMW							
DATUM GEODETIC		DATE October 7, 2009				CHECKED BY EC							
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					
258.2	GROUND SURFACE						20 40 60 80 100		20 40 60				
0.0	ASPHALT		1	AS		258							
0.3	Gravelly sand, trace silt (FILL) Brown												
	ASPHALT		2	SS	43	257							
	Rock fill in a gravelly sand, some silt matrix (FILL) Dense Brown												
	Very difficult drilling throughout		3	SS	41								
255.9						256							
2.3	End of Borehole Auger Refusal												
Notes: 1. Sample 2: Spoon empty. No cutting return from 0.8 m to 2.3 m depths. 2. Borehole dry upon completion of drilling.													

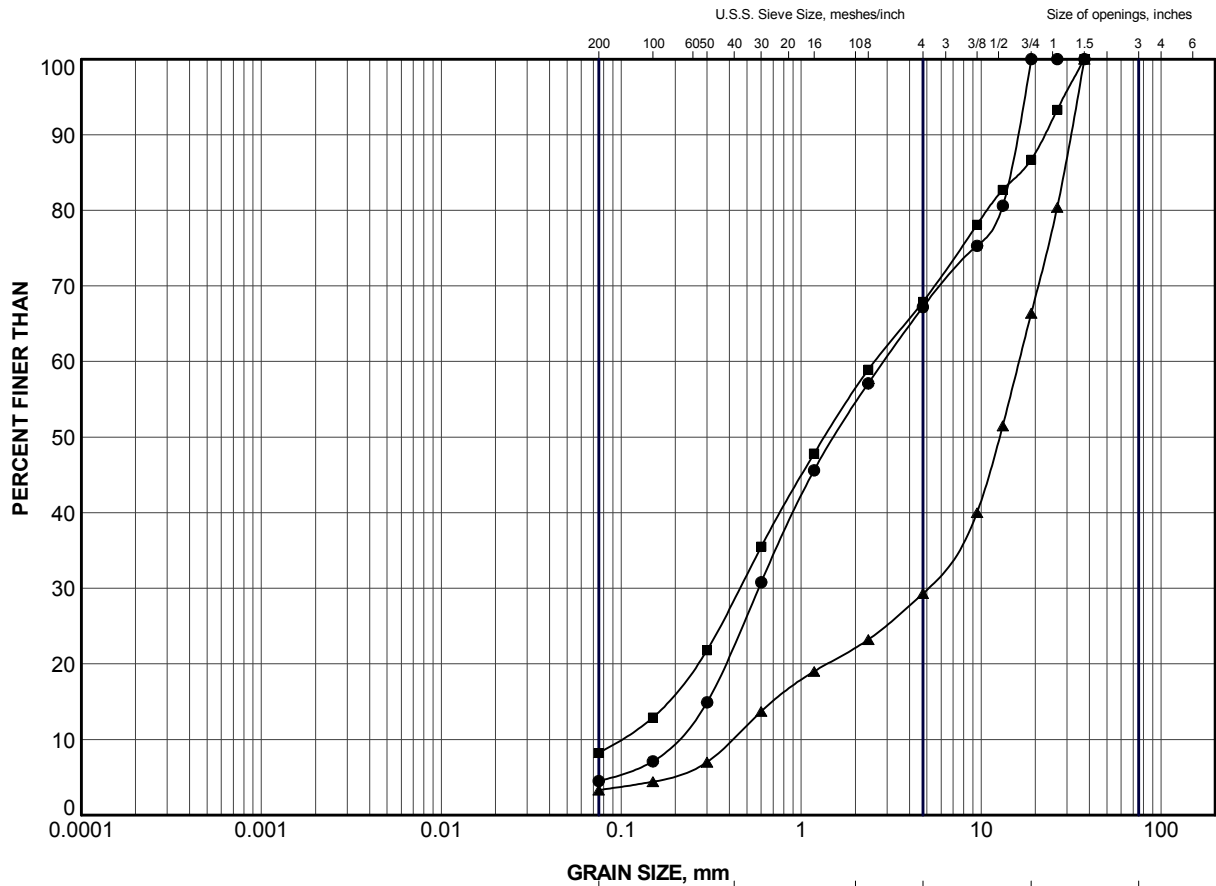
PROJECT		RECORD OF BOREHOLE No BH09-11				1 OF 1 METRIC										
W.P. 5302-05-00		LOCATION N 5297257.9; E 379540.6				ORIGINATED BY EHS										
DIST _____ HWY 573		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AMW										
DATUM GEODETIC		DATE October 7, 2009				CHECKED BY EC										
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								
258.3	GROUND SURFACE						20	40	60	80	100					
0.0 258.0	ASPHALT															
0.5	Gravelly sand, trace silt (FILL) Brown Moist Rock fill in a sand and gravel, trace silt matrix (FILL) Compact Brown Moist		1	AS												
			2	SS	15											
			3	SS	12											
255.8	End of Borehole Auger Refusal		4	SS	7/0.075											
2.5	Note: 1. Borehole dry upon completion of drilling.															

PROJECT 11-1191-0032		<b>RECORD OF BOREHOLE No BH09-12</b>				1 OF 1 <b>METRIC</b>							
W.P. 5302-05-00		LOCATION N 5297261.0; E 379540.6				ORIGINATED BY EHS							
DIST _____ HWY 573		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY AMW							
DATUM GEODETIC		DATE October 7, 2009				CHECKED BY EC							
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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED		WATER CONTENT (%) W <sub>p</sub> — W — W <sub>L</sub>		γ	GR SA SI CL
258.1	GROUND SURFACE							20 40 60 80 100	20 40 60				
0.0	ASPHALT						258						
	Gravelly sand, trace silt (FILL)		1	AS	-								32 60 (8)
0.6	Brown Moist												
	ASPHALT												
	Sand and gravel, trace silt (FILL)		2	SS	7		257						
256.7	Brown Moist												
1.4	Rock fill in a gravelly sand, trace to some silt matrix, some wood (FILL)		3	SS	4							303.5	OC = 83%
	Loose Grey Wet						256						
	Partially decomposed wood (FILL)		4	SS	3/0 15							129.8	OC = 36%
255.3	Very loose Brown Wet												
2.8	End of Borehole Auger and Spoon Refusal												
Notes: 1. Spoon refusal at 2.4 m depth. Augers sliding east on rock between 2.4 m and 2.8 m. 2. Borehole dry upon completion of drilling. 3. Piezometer dry on November 26, 2009.													



# APPENDIX B


## Laboratory Test Results



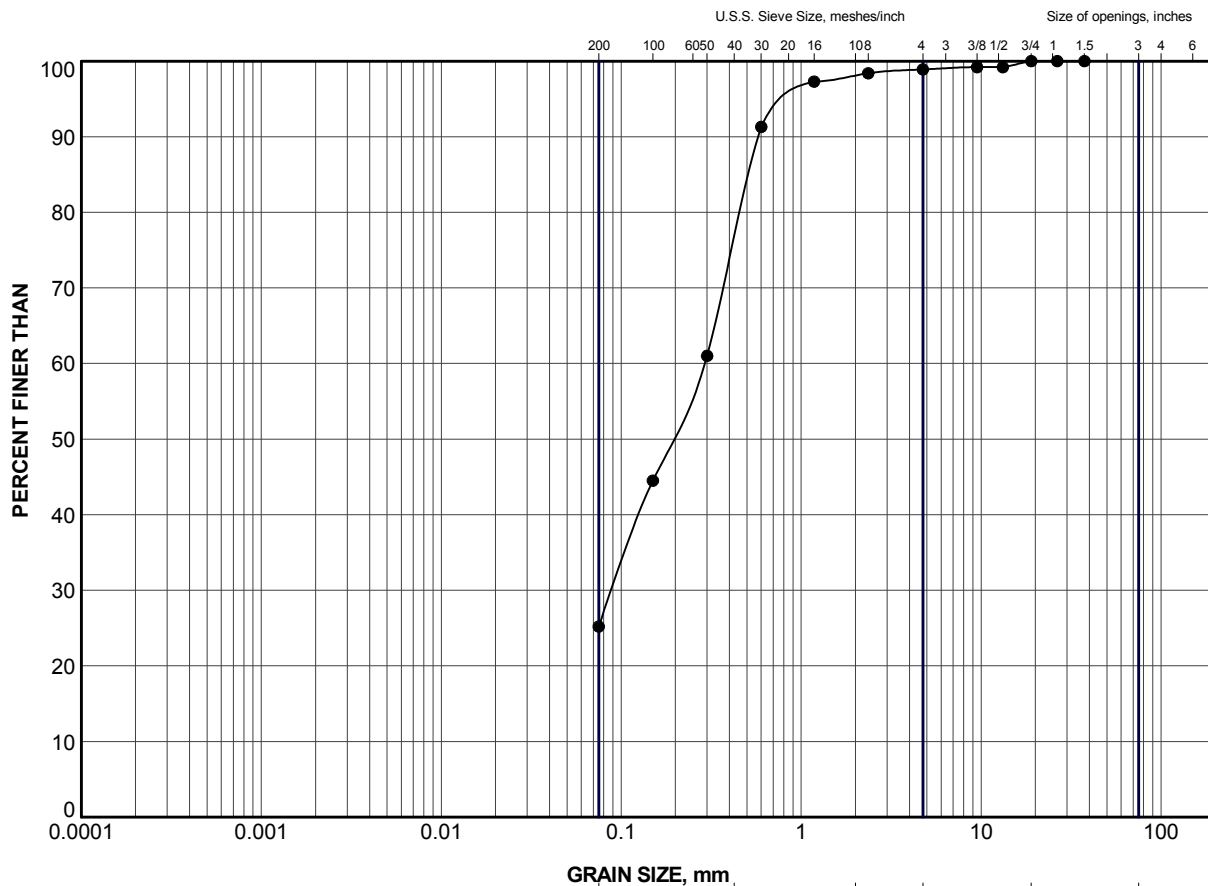
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH09-11	2	257.3
■	BH09-12	1	257.6
▲	BL-5	1	256.2

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-028					
TITLE					
GRAIN SIZE DISTRIBUTION Gravelly Sand to Sand and Gravel (FILL)					
PROJECT No.		11-1191-0032		FILE N41-1191-0032+BH09.GPJ	
DRAWN	TB	Aug 2012	SCALE	N/A	REV.
CHECK	EC	Aug 2012			
APPR	SEMC	Aug 2012			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B1</b>		






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

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BR-5	3	256.4

PROJECT					
HIGHWAY 573 ENGLEHART (BLANCHE) RIVER, BRIDGE 47-028					
TITLE					
GRAIN SIZE DISTRIBUTION Silty Sand					
PROJECT No.		11-1191-0032		FILE N11-1191-0032+BH09.GPJ	
DRAWN	TB	Aug 2012	SCALE	N/A	REV.
CHECK	EC	Aug 2012			
APPR	SEMC	Aug 2012			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B2</b>		

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