



December 14, 2011

FOUNDATION INVESTIGATION REPORT

**SUCKER CREEK NBL BRIDGE, SITE NO. 44-447/1
HIGHWAY 69 FOUR-LANING FROM 0.4 KM NORTH OF HIGHWAY 7182
(SHEBESHEKONG ROAD) NORTHERLY 11 KM
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5005-08-00, WP 5193-06-01**

Submitted to:
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GEOCRES No.: 41H-80

Report Number: 07-1191-0020-B6

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- 1 e-copy MMM Group, Thornhill, Ontario
- 1 Copy Golder Associates Ltd., Sudbury, Ontario

REPORT



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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by MMM Group (MMM) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Highway 69 northbound lane (NBL) bridge crossing Sucker Creek. This project is part of the detail design for the four-laning of Highway 69 from 0.4 km north of Highway 7182 (Shebeshekong Road) northerly for 11 km. The general location of this section of the Highway 69 four-laning alignment is shown on the Key Plan on the Contract Drawing.

This report addresses the investigation carried out for the Highway 69 NBL bridge structure crossing Sucker Creek and the associated approach embankments. Separate reports detail the foundation investigations for the related SBL bridge structure, swamp and pond crossings, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed structure location, including the associated approach embankments, by borehole drilling, rock coring and laboratory testing on selected soil and rock core samples. The investigated areas are shown on the Contract Drawing.

2.0 SITE DESCRIPTION

The proposed NBL bridge crossing Sucker Creek is a 97 m long 3-span structure, located in the Township of Harrison along the new Highway 69 alignment, about 1.5 km south of Highway 529 and about 400 m east of the existing Highway 69 alignment. The proposed grade at the new Highway 69 south and north approach embankments will be at about Elevation 201 m and 203 m, respectively, which is about 7 m above the existing ground surface at the south approach and about 15 m above the existing ground surface at the north approach.

In general, the topography in the area of the overall project limits consists of rolling terrain including densely treed areas and numerous bedrock outcrops separated by low-lying swamps. At the crossing location, Sucker Creek is about 15 m wide and situated in a valley about 60 m wide. Bedrock is exposed within or near the footprint of the proposed south abutment and south pier and to the north of the north abutment. The ground surface at the borehole locations within the limits of the proposed structure and approach embankment areas is between Elevation 183.4 m and Elevation 195.3 m.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation at the location of the proposed structure was carried out in two stages and included the drilling of a total of fifteen (15) boreholes and one (1) Dynamic Cone Penetration Test (DCPT) at approximately the locations shown on the Contract Drawing. The field investigation was carried out as follows:

- Between February 9 and March 3, 2009, the following boreholes and DCPT were advanced using a track mounted CME-55 supplied and operated by Landcore Drilling Ltd. (Landcore) of Sudbury, Ontario:
 - Five (5) boreholes at the south abutment (Boreholes B6-1 to B6-5);
 - One (1) borehole at the north pier (Borehole B6-7);



- Two (2) boreholes and one (1) DCPT at the north abutment (Boreholes B6-10 and B6-11 and DCPT B6-DC1); and
 - One (1) borehole for each of the south and north approach embankments (Boreholes B6-13 and B6-14, respectively). Borehole B6-14 was advanced by hand excavation.
- On March 14, 2009, five (5) boreholes (Boreholes B6-6 and B6-6a to B6-6d) were drilled at the south pier using portable equipment, supplied and operated by OGS Inc. (OGS) of Ottawa, Ontario.

The boreholes were advanced using 108 mm inside diameter (I.D.) continuous flight hollow stem augers, 'NW' casing and wash boring or portable equipment using 'BW' or 'NW' casing and wash boring. One borehole was advanced using hand auger methods. Soil samples were obtained, where possible, continuously or at intervals of depth of 0.75 m to 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Rock core samples were obtained in 'NQ' size using either an 'NQ' size core barrel or a thin-walled core barrel which fits inside BW casing. The groundwater conditions in the open boreholes were observed during the drilling operations. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation (O.Reg.) 903 (as amended).

The boreholes were advanced to auger/split-spoon refusal or cored into the bedrock to depths ranging from 0.1 m to 21.1 m below existing ground surface, or snow surface at one location and included coring bedrock for lengths of between 3.0 m and 3.5 m in Boreholes B6-2 to B6-4, B6-6, B6-6b, B6-6c, B6-7 and B6-10.

The fieldwork was supervised throughout by members of our engineering and technical staff, who located the boreholes based on the survey carried out by MMM, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil and rock 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, Atterberg limits and grain size distribution) was carried out on selected samples. A consolidated drained direct shear test was performed on a sample of sand from Borehole B5-7 for determination of the effective angle of internal friction. Strength testing (uniaxial compression and point load index) was also carried out on selected specimens of the rock core.

The centreline of Highway 69 was surveyed and staked in the field by MMM in September 2009, and the borehole locations were staked by MMM in December 2008, and February 2009. Where boreholes were relocated from the original staked locations, Golder resurveyed and located the new borehole relative to MMM's stakes. The borehole locations shown on the Contract Drawing and summarized below are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum.



Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
B6-1	5051546.2	236870.1	195.3	0.4
B6-2	5051551.1	236869.0	194.9	3.3
B6-3	5051547.5	236864.7	194.6	3.6
B6-4	5051544.0	236860.4	194.5	3.9
B6-5	5051548.9	236859.3	193.7	0.7
B6-6	5051576.8	236858.1	185.5	3.5
B6-6a	5051573.3	236853.8	187.5	0.1
B6-6b	5051578.1	236852.7	184.9	3.4
B6-6c	5051575.5	236863.6	189.7	3.4
B6-6d	5051580.3	236862.5	185.9	0.2
B6-7	5051611.2	236851.4	183.4	21.1
B6-10	5051640.2	236843.9	188.3	7.8
B6-11	5051637.4	236839.4	188.5	4.0
B6-13	5051532.9	236868.0	195.3	1.7
B6-14	5051655.8	236840.4	193.2	0.1
B6-DC1	5051643.7	236848.2	188.0	3.7

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)¹, this section of Highway 69 lies within the physiographic region known as the Georgian Bay Fringe which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of very shallow deposits of sand, silt and clay overlying metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localised low-lying swampy areas, containing peat and/or organic soils overlying soft/loose native soils, are present in valleys between the bedrock knobs and ridges.

The bedrock in the area consists typically of gneisses of the Britt Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in *Geology of Ontario, OGS Special Volume 4*² (OGS, 1991). Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

¹ Chapman, L.J. and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

² Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



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 and rock samples, are presented on the Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory tests carried out on selected soil and rock samples are presented in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. It should be noted that the interpreted stratigraphy shown on the Contract Drawings is a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between boreholes will exist and is to be expected.

In general, bedrock outcrops are present on the south side of the creek in places overlain with a surficial layer of topsoil and thin deposits of sand and silt. On the north side of the creek, bedrock outcrops are also present north of the proposed bridge footprint, similarly in places overlain with a surficial layer of topsoil and then deposits of sand and gravelly sand to sand and gravel. The total thickness of overburden is variable at the site, ranging from approximately 0.1 m to 0.7 m on the south side of the creek and from approximately 0.1 m to 17.6 m on the north side of the creek.

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

4.2.1 Organics/Topsoil

A deposit of moist, brown organics or topsoil was encountered at ground surface, or below the snow, at each of the boreholes. The top of the organics layers were encountered between Elevation 195.3 m and 183.4 m and the thickness of the deposit ranges between 0.1 m and 0.4 m.

4.2.2 Sand and Silt

A deposit of moist, brown sand and silt was encountered below the organics or topsoil in Boreholes B6-3 to B6-5 and B6-13. The surface of the deposit was encountered between Elevation 195.0 m and 193.5 m and ranges in thickness from 0.3 m to 0.5 m. As discussed in Section 4.2.4, a layer of clayey silt was encountered within the deposit of sand and silt in Borehole B6-13.

A grain size distribution test was carried out on one sample of the sand and silt deposit and the results are shown on Figure B-1.

The natural moisture content of one sample of the sand and silt is 47 percent.

4.2.3 Clayey Silt

Within the sand and silt deposit in Borehole B6-13, a layer of moist, brown, clayey silt was encountered. The surface of this layer was encountered at Elevation 194.5 m, and its thickness is 0.6 m.

One SPT 'N'-value measured within the clayey silt deposit is 36 blows per 0.3 m of penetration indicating a hard consistency.



An Atterberg limits test carried out on the sample of the clayey silt yielded a liquid limit of 25 percent, a plastic limit of 14 percent and a plasticity index of 11 percent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B-2 in Appendix B and indicate that the material is a clayey silt of low plasticity.

The natural moisture content of the sample is 16 percent.

4.2.4 Sand

A deposit of moist to wet, brown to grey sand, trace to some gravel and trace to some silt was encountered below the topsoil in Boreholes B6-7, B6-10 and B6-11 located on the north side of the creek. The deposit contained occasional cobbles in Boreholes B6-10 and B6-11. The surface of the deposit was encountered between Elevation 183.2 m and 188.1 m and the thickness of the deposit ranges between 2.7 m and 15.0 m.

SPT 'N'-values measured within the sand/gravelly sand deposit range between 0 blows (i.e. weight of hammer) and 64 blows per 0.3 m of penetration. Typically, the 'N'-values range between 5 and 25 blows per 0.3 m of penetration, indicating a loose to compact relative density, and the presence of very loose or very dense layers.

The grain size distributions of five samples of the sand deposit are shown on Figures B-3 in Appendix B.

The natural water content measured on samples of the deposit range between 5 percent and 28 percent.

A laboratory consolidated drained direct shear (DS) test was carried out on one selected sample of the sand deposit from Borehole B6-7. The detailed test results are shown on Figure B-4 in Appendix B and the results are summarized below.

Borehole/Sample Number	Depth / Elevation (m)	Effective Cohesion Intercept, c' (kPa)	Effective Angle of Internal Friction, ϕ' (degrees)
B6-7/6	4.9/178.5	0	38

Note: The assessed shear strength parameters are only valid over the range of stress conditions employed in the direct shear test.

Heaving sands were noted in several boreholes despite a full head of water being maintained inside the augers/casing. Lower SPT 'N'-values were typically recorded below the elevation where heaving sands were encountered, typically between depths of about 9.1 m depth.

4.2.5 Gravelly Sand to Sand and Gravel

In Boreholes B6-7 and B6-11, a deposit of wet, brown or grey, gravelly sand to sand and gravel was encountered below the sand deposit. The surface of the deposit was encountered at Elevations 168.2 m and 185.4 m in Boreholes B6-7 and B6-11, respectively, and the thickness of the deposit is 2.4 m and 0.9 m, respectively.



SPT 'N'-values measured within the sand and gravel to gravelly sand deposit are 18 blows per 0.3 m of penetration to 50 blows per 0.1 m of penetration, indicating a compact to very dense relative density, and essentially refusal to split-spoon advancement at one sample depth in Borehole B6-7.

A grain size distribution test was carried out on one sample of the gravelly sand deposit and the results are shown on Figure B-5.

The natural moisture content of one sample of the deposit is 11 percent.

4.2.6 Refusal/Bedrock

Bedrock was encountered and cored in Boreholes B6-2 to B6-4, B6-6, B6-6b, B6-6c, B6-7 and B6-10. The bedrock surface was inferred from hand excavation, auger, casing or split-spoon refusal in the remaining boreholes. The bedrock surface (inferred or actual) was encountered in the boreholes at depths ranging from 0.1 m to 17.6 m below ground surface, ranging from Elevation 194.9 m and 165.8 m, as presented in Table B-1.

Based on a review of the bedrock core samples, the bedrock at the site consists of gneiss and the core samples are described as grey to pinkish grey, fine to coarse grained and fresh to slightly weathered, except in Borehole B6-7 where the bedrock is a mafic intrusive, and the core samples are greenish grey, fine to medium grained and moderately to slightly weathered.

The Total Core Recovery (TCR) is 100 percent for all core samples. The Rock Quality Designation (RQD) measured on the core samples typically ranges from about 75 percent to 100 percent, indicating a rock mass of good to excellent quality. The uppermost core sample in Boreholes B6-6 and B6-7 measured RQD values of 35 percent and 0 percent, respectively, indicating a rock mass of very poor to poor quality. The RQD typically increased with depth. The Solid Core Recovery (SCR) typically ranges from 75 percent to 100 percent, increasing with depth. The uppermost core samples in Boreholes B6-6 and B6-7 measured a SCR of 36 percent and 0 percent, respectively.

Laboratory Uniaxial Compressive Strength (UCS) testing was carried out on seven core samples of the bedrock. The UCS ranges from about 71 MPa to 136 MPa for the gneiss bedrock and is 109 MPa for the mafic intrusive bedrock as summarized in Table B-2, indicating strong to very strong rock.

Point load strength tests were carried out on selected core samples of the bedrock. Diametral point load strength index values are shown on the Record of Drillhole Sheets and are summarized in Table B-3 in Appendix B. The diametral point load index (I_{50}) results from the laboratory tests carried out on core samples range from about 3 MPa to 7 MPa for the gneiss bedrock and about 10 MPa for the mafic intrusive bedrock. These index values correspond to estimated UCS values ranging between 58 MPa and 142 MPa, based on a relationship between I_{50} and UCS which is given by a correlation factor (K) in accordance with ASTM D5731-08, which varies depending on the size of the core samples and the strength of the rock. For this site, these UCS values are based on an estimated average correlation factor (K) of 20 for the gneiss and 11 for the mafic intrusive bedrock, which was calculated based on a comparison of the UCS test results and the point load strength test results. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.



Based on the laboratory UCS tests and the point load test results, in accordance with Table 3.5 in CFEM (2006)³, the estimated intact strength of the gneiss and mafic intrusive bedrock ranges from strong (R4, 50 MPa < UCS <100 MPa) to very strong (R5, 100 MPa < UCS <250 MPa).

4.2.7 Groundwater Conditions

The water levels were noted immediately after the drilling operations in the boreholes. In general, the soil samples taken in the boreholes were noted to be moist to wet. Where bedrock either was exposed or was encountered at shallow depth below ground surface, the open boreholes were dry. The water level measured in Borehole B6-7, B6-10 and B6-11 is at depths ranging between 1.3 m to 3.7 m below ground surface, corresponding to Elevation 182.1 m to 185.0 m.

It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events.

5.0 CLOSURE

The field personnel supervising the drilling program were Mr. Ed Savard and Mr. Trevor Moxam. This report was prepared by Mr. Adam Wissink, EIT and André Bom, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.

³ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.



Report Signature Page

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

CONT No. WP No. 5193-06-01

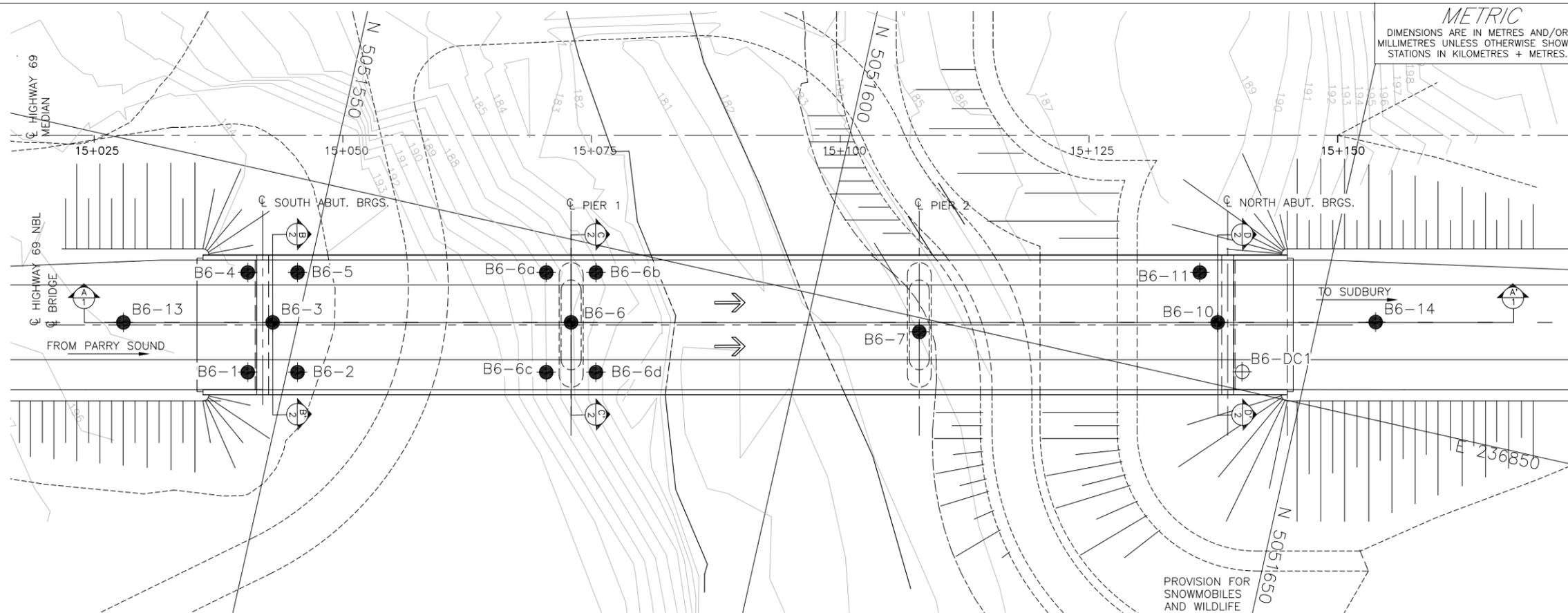
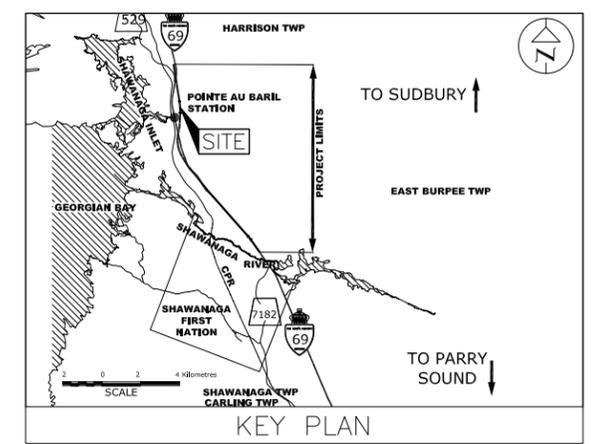


HIGHWAY 69
SUCKER CREEK (NBL)
BOREHOLE LOCATIONS
AND SOIL STRATA

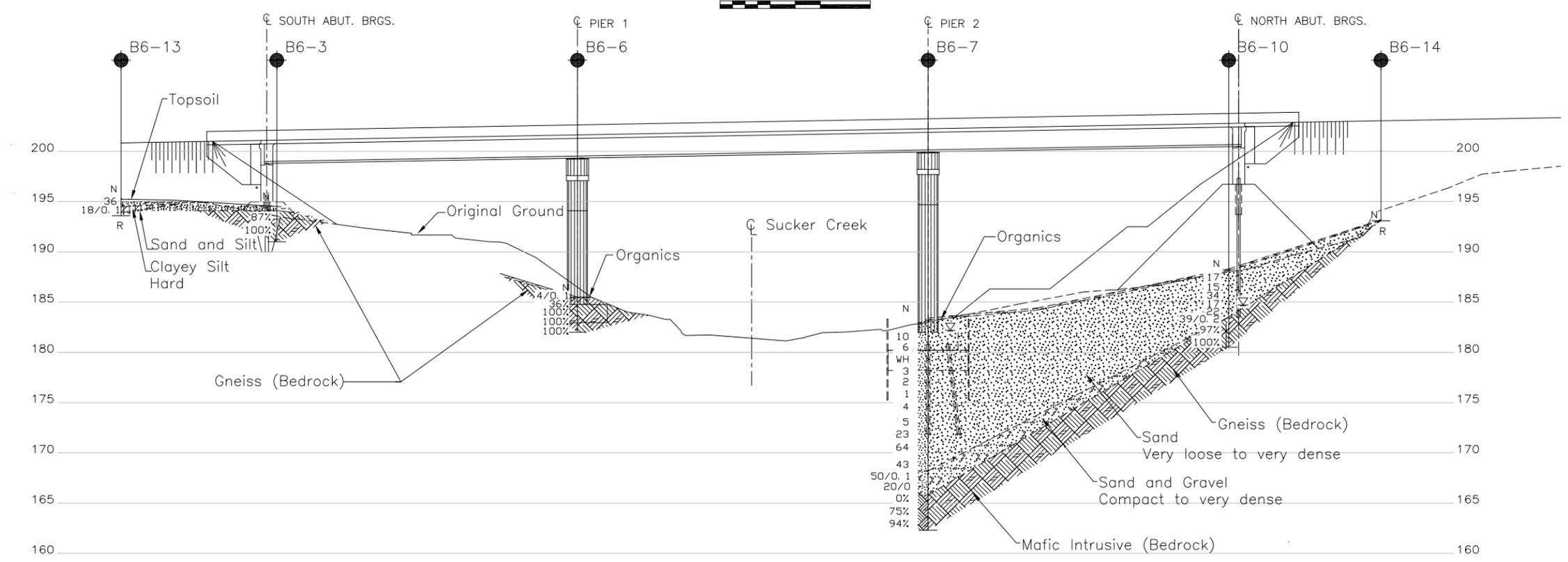
SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



PLAN



CENTRELINE PROFILE
HIGHWAY 69 NBL



LEGEND

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

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
B6-1	195.3	5051546.2	236870.1
B6-2	194.9	5051551.1	236869.0
B6-3	194.6	5051547.5	236864.7
B6-4	194.5	5051544.0	236860.4
B6-5	193.7	5051548.9	236859.3
B6-6	185.5	5051576.8	236858.1
B6-6a	187.5	5051573.3	236853.8
B6-6b	184.9	5051578.1	236852.7
B6-6c	189.7	5051575.5	236863.6
B6-6d	185.9	5051580.3	236862.5
B6-7	183.4	5051611.2	236851.4
B6-10	188.3	5051640.2	236843.9
B6-11	188.5	5051637.4	236839.4
B6-13	195.3	5051532.9	236868.0
B6-14	193.2	5051655.8	236840.4
B6-DC1	188.0	5051643.7	236848.2

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.

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.

NO.	DATE	BY	REVISION

Geocres No. 41H-80

HWY. 69	PROJECT NO. 07-1191-0020	DIST.
SUBM'D.	CHKD. AB	DATE: DEC 2011
DRAWN: PL	CHKD. SEMC	APPD. JMAC
		SITE: 44-447/1
		DWG. 1

REFERENCE
Base plans provided in digital format by MMM, drawing file nos. 44_447-1_01-GENERAL ARRANGEMENT INTEGRAL (31m), received August 18, 2011





APPENDIX A

Record of Boreholes and Drillholes



LIST OF SYMBOLS

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

1. 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
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. 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

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

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	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_a	coefficient of secondary consolidation
m_v	coefficient of volume change
C_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 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
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.).

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.

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

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	psf
	kPa	
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.



WEATHERING 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 texture and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	> 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	< 6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	> 3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	< 50 mm

GRAIN SIZE

<u>Terms</u>	<u>Size*</u>
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2 mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

* Note: Grains > 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 varies 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 separation) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to (W.R.T.) 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 abbreviated description of the discontinuities, whether naturally occurring separation such as fractures, bedding planes and foliation planes or mechanically induced fractures 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

- B - Bedding
- FO - Foliation / Schistosity
- CL - Cleavage
- SH - Shear Plane / Zone
- VN - Vein
- F - Fault
- CO - Contact
- J - Joint
- FR - Fracture
- MF - Mechanical Fracture
- ⊥ - Perpendicular To
- || - Parallel To
- P - Polished
- K - Slickensided
- SM - Smooth
- R - Rough
- ST - Stepped
- PL - Planar
- U - Undulating
- C - Curved



RECORD OF BOREHOLE No B6- 1 1 OF 1 **METRIC**

PROJECT 07-1191-0020 W.P. 5193-06-01 LOCATION N 5051546.2; E 236870.1 ORIGINATED BY EHS

DIST HWY 69 BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers COMPILED BY AMW

DATUM Geodetic DATE February 9, 2009 CHECKED BY AB

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	20	40	60	80					
195.3	GROUND SURFACE															
0.0	Silty TOPSOIL															
194.9	Brown															
0.4	Moist															
	End of Borehole Auger Refusal															
	Note: 1. Borehole dry upon completion of drilling.															

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6-2	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051551.1; E 236869.0</u>	ORIGINATED BY <u>EHS</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>February 9, 2009</u>	CHECKED BY <u>AB</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								
194.9	GROUND SURFACE						20	40	60	80	100					
0.0	Silty TOPSOIL	[Hatched]														
0.2	Brown Moist GNEISS (BEDROCK)	[Hatched]														
	Bedrock cored from 0.2 m depth to 3.3 m depth.	[Hatched]	1	RC	REC 100%	194										RQD = 100%
	For coring details refer to Record of Drillhole B6-2.	[Hatched]	2	RC	REC 100%	193										RQD = 97%
		[Hatched]				192										
191.6	End of Borehole															
3.3	Note: 1. Borehole dry upon completion of drilling.															

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6-3	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051547.5; E 236864.7</u>	ORIGINATED BY <u>EHS</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>February 9, 2009</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
194.6	GROUND SURFACE																
0.0	Silty TOPSOIL Brown Moist		1	AS	-												0 42 38 20
194.1	SAND and SILT, some clay Brown Moist		1	RC	REC 100%		194										RQD = 87%
0.5	GNEISS (BEDROCK) Bedrock cored from 0.5 m depth to 3.6 m depth. For coring details refer to Record of Drillhole B6-3.		2	RC	REC 100%		193										RQD = 100%
191.0	End of Borehole						191										
3.6	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6- 4	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051544.0; E 236860.4</u>	ORIGINATED BY <u>EHS</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>February 10, 2009</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
194.5	GROUND SURFACE																
0.0	Silty TOPSOIL																
0.2	Brown Moist																
193.8	SAND and SILT, some clay		1	AS	-		194										
0.7	Brown Moist																
	GNEISS (BEDROCK)																
	Bedrock cored from 0.7 m depth to 3.9 m depth.		1	RC	REC 100%		193										RQD = 100%
	For coring details refer to Record of Drillhole B6-4.																
			2	RC	REC 100%		192										RQD = 100%
			3	RC	REC 100%		191										RQD = 100%
190.6	End of Borehole																
3.9	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B6- 4

SHEET 1 OF 1

LOCATION: N 5051544.0 ;E 236860.4

DRILLING DATE: February 10, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRALLIC CONDUCTIVITY		Diameter Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION	
							TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION		Jr	Ja	Jun	k, cm/s				
							FLUSH	FLUSH			B Angle	DIP w.r.t. CORE AXIS	10	10	10	10				
		Refer to Previous Page		193.8																
1		GNEISS Fine to medium grained Fresh Strong Grey Healed vertical joint from 0.9 to 2.0 m.		0.7	1															
2	02/10/09 NG Coring																			
3					2															
4		End of Drillhole		190.6	3															UCS = 71 MPa
5				3.9																
6																				
7																				
8																				
9																				
10																				

MTO-RCK 001: 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT: 12/12/11 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB



RECORD OF BOREHOLE No B6- 5 1 OF 1 **METRIC**

PROJECT 07-1191-0020 W.P. 5193-06-01 LOCATION N 5051548.9; E 236859.3 ORIGINATED BY EHS

DIST HWY 69 BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers COMPILED BY AMW

DATUM Geodetic DATE February 10, 2009 CHECKED BY AB

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	20	40	60	80					
193.7	GROUND SURFACE															
0.0	Silty TOPSOIL		1	AS	-											
0.2	Brown Moist															
193.0	SAND and SILT, some clay															
0.7	Brown Moist End of Borehole Auger Refusal															
<p>Note: 1. Borehole dry upon completion of drilling.</p>																

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6- 6	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051576.8; E 236858.1</u>	ORIGINATED BY <u>TDM</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>March 14, 2009</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W			W _L	20	40	60	80	100	10	20
185.5	GROUND SURFACE																							
0.0	ORGANICS		1	SS	4/0.1																			
0.2	Brown Moist GNEISS (BEDROCK)	[Hatched Pattern]	1	RC	REC 100%	185																	RQD = 36%	
	Bedrock cored from 0.2 m depth to 3.5 m depth. For coring details refer to Record of Drillhole B6-6.	[Hatched Pattern]	2	RC	REC 100%	184																	RQD = 100%	
		[Hatched Pattern]	3	RC	REC 100%	183																	RQD = 100%	
		[Hatched Pattern]	4	RC	REC 100%	182																	RQD = 100%	
182.0	End of Borehole					182																		
3.5	Note: 1. Borehole dry upon completion of drilling.																							

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B6- 6

SHEET 1 OF 1

LOCATION: N 5051576.8 ;E 236858.1

DRILLING DATE: March 14, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRALLIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION		
							TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION		Jr	Ja	Jun	k, cm/s				φ	ψ
							FLUSH	FLUSH			B Angle	DIP w.r.t. CORE AXIS	10	10	10	10				2	4
		Refer to Previous Page		185.3																	
1	04/14/09 Thin-Wall N Coring	GNEISS Fine to coarse grained Slightly weathered to 1.6 m depth, fresh below 1.6 m depth Very strong Pinkish grey		0.2	1																
2				2																	
3				3																	
4				4																	
		End of Drillhole		182.0																	
5				3.5																	
6																					
7																					
8																					
9																					
10																					

UCS = 136 MPa

MTD-RCK 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: TDM

CHECKED: AB



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No B6- 6a** 1 OF 1 **METRIC**
 W.P. 5193-06-01 LOCATION N 5051573.3; E 236853.8 ORIGINATED BY TDM
 DIST HWY 69 BOREHOLE TYPE Portable Equipment COMPILED BY AMW
 DATUM Geodetic DATE March 14, 2009 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W			W _L	GR
187.5	GROUND SURFACE																	
0.0 0.1	ORGANICS Brown Moist End of Borehole Refusal to Further Penetration (Hammer Bouncing) Note: 1. Borehole dry upon completion of drilling.		1	SS	3/0-13													

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6- 6c	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051575.5; E 236863.6</u>	ORIGINATED BY <u>TDM</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>March 14, 2009</u>	CHECKED BY <u>AB</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	20	40	60	80					
189.7	GROUND SURFACE															
0.0 189.4 0.3	ORGANICS Brown Moist GNEISS (BEDROCK) Bedrock cored from 0.3 m depth to 3.4 m depth. For coring details refer to Record of Drillhole B6-6c.		1	SS	2/0.15 REC											
			1	RC	100%											RQD = 100%
			2	RC	REC 100%											RQD = 100%
			3	RC	REC 100%											RQD = 85%
			4	RC	REC 100%											RQD = 100%
186.3 3.4	End of Borehole Note: 1. Borehole dry upon completion of drilling.															

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B6- 6c

SHEET 1 OF 1

LOCATION: N 5051575.5 ;E 236863.6

DRILLING DATE: March 14, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: OGS Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRALLIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION		
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jun				k, cm/s	ψ
							⊗	⊗			⊗	⊗	⊗	⊗	⊗	⊗				⊗	⊗
		Refer to Previous Page		189.4																	
1	03/14/09 Thin-Wall N Coring	GNEISS Fine to coarse grained Slightly weathered Strong Pinkish grey		0.3	1																
				2																	
2				3																	
				4																	
3				186.3														UCS = 92 MPa			
4		End of Drillhole		3.4																	
5																					
6																					
7																					
8																					
9																					
10																					

MTD-RCK 001: 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT: 12/12/11 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: TDM

CHECKED: AB



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No B6- 6d** 1 OF 1 **METRIC**

W.P. 5193-06-01 LOCATION N 5051580.3; E 236862.5 ORIGINATED BY TDM

DIST HWY 69 BOREHOLE TYPE Portable Equipment COMPILED BY AMW

DATUM Geodetic DATE March 14, 2009 CHECKED BY AB

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	20	40	60	80						100	20	40	60	80	100	10	20
185.9	GROUND SURFACE																							
0.0	ORGANICS		1	SS	4/0.15																			
0.2	Brown Moist End of Borehole Refusal to Further Penetration (Hammer Bouncing)																							
	Note: 1. Borehole dry upon completion of drilling.																							

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

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

RECORD OF BOREHOLE No B6- 7 1 OF 2 **METRIC**

PROJECT 07-1191-0020 W.P. 5193-06-01 LOCATION N 5051611.2; E 236851.4 ORIGINATED BY EHS

DIST HWY 69 BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring COMPILED BY AMW

DATUM Geodetic DATE February 26 and March 3, 2009 CHECKED BY AB

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								
183.4	GROUND SURFACE						20	40	60	80	100					
0.0	Silty ORGANICS Brown Moist	[Symbol]				183										
0.2	SAND, some silt, trace to some gravel Very loose to compact Brown Wet	[Symbol]	1	SS	10	182										
		[Symbol]	2	SS	6	181										
	Sand and silt seams at 2.5 m depth.	[Symbol]	3	SS	WH	180							○		3 65 32 0	
		[Symbol]	4	SS	3	179							○			
		[Symbol]	5	SS	2	178							○			
		[Symbol]	6	SS	1	177							○		8 79 (13)	
		[Symbol]	7	SS	4	176										
		[Symbol]	8	SS	5	175										
		[Symbol]	9	SS	23	174										
	Approximately 1.8 m of heaving sands at 9.1 m depth. Switch to NW Casing, Wash Boring.	[Symbol]	10	SS	64	173										
	Becoming dense to very dense below 12.2 m depth.	[Symbol]	11	SS	43	172										
		[Symbol]	12	SS	64	171										
	Becoming grey below 13.6 m depth.	[Symbol]	13	SS	43	170							○		18 76 (6)	
		[Symbol]	14	SS	43	169										

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

Continued Next Page

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



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No B6- 7** 2 OF 2 **METRIC**
 W.P. 5193-06-01 LOCATION N 5051611.2; E 236851.4 ORIGINATED BY EHS
 DIST HWY 69 BOREHOLE TYPE 108 I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring COMPILED BY AMW
 DATUM Geodetic DATE February 26 and March 3, 2009 CHECKED BY AB

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	20	40	60	80						100	20	40	60	80	100	10	20	30
168.2	SAND and GRAVEL Very dense Grey Wet Difficulty advancing casing below 15.2 m depth.		12	SS	50/0.1																				
15.2																									
165.8																									
17.6	MAFIC INTRUSIVE (BEDROCK) Bedrock cored from 17.6 m depth to 21.1 m depth. For coring details refer to Record of Drillhole B6-7.		1	RC	REC 100%																			RQD = 0%	
165																								RQD = 75%	
164																									RQD = 94%
163			3	RC	REC 100%																				
162.3	End of Borehole Note: 1. Water level measured at a depth of 1.3 m below ground surface (Elev. 182.1 m) upon completion of drilling.																								
21.1																									

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

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

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B6-7

SHEET 1 OF 1

LOCATION: N 5051611.2 ; E 236851.4

DRILLING DATE: February 26 and March 3, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRALLIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION		
							TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION		Jr	Ja	Jun	k, cm/s				φ	ψ
							FLUSH				B Angle	DIP w.r.t. CORE AXIS									
		Refer to Previous Page		165.8																	
18		MAFIC INTRUSIVE Fine to medium grained Moderately weathered to 18.4 m depth, slightly weathered below 18.4 m depth Very strong Greenish grey		17.6	1																
19	09/09/09 NQ Coring	Heavily jointed (broken core) between 17.6 m and 18.5 m depths.			2																
20					3																
21		End of Drillhole		162.3														UCS = 109 MPa			
				21.1																	
22																					
23																					
24																					
25																					
26																					
27																					

MTD-RCK 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6-10	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051640.2; E 236843.9</u>	ORIGINATED BY <u>EHS</u>
DIST <u> </u> HWY <u>69</u>	BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>February 25, 2009</u>	CHECKED BY <u>AB</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								
						20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	10 20 30	10 20 30			
188.3 0.0	GROUND SURFACE															
0.2	Sandy ORGANICS Brown Moist	[Pattern]														
	SAND, trace to some gravel, trace to some silt, occasional cobbles Compact to dense Brown Moist	[Pattern]	1	AS	-		188									
		[Pattern]	2	SS	17		187					○			0 79 (21)	
		[Pattern]	3	SS	15		186									
		[Pattern]	4	SS	34		185									
		[Pattern]	5	SS	17		184					○			15 81 (4)	
	Becoming wet below 3.7 m depth.	[Pattern]	6	SS	22		183									
		[Pattern]	7	SS	39/0.2		182									
183.5 4.8	GNEISS (BEDROCK)															
	Bedrock cored from 4.8 m depth to 7.8 m depth.	[Pattern]	1	RC	REC 100%		183								RQD = 97%	
	For coring details refer to Record of Drillhole B6-10.	[Pattern]	2	RC	REC 100%		182								RQD = 100%	
		[Pattern]					181									
180.5 7.8	End of Borehole															
	Note: 1. Water level measured at a depth of 3.7 m below ground surface (Elev. 184.6 m) upon completion of drilling.															

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: B6-10

SHEET 1 OF 1

LOCATION: N 5051640.2 ;E 236843.9

DRILLING DATE: February 25, 2009

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRALLIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG.	NOTES WATER LEVELS INSTRUMENTATION				
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	Type and Surface Description	Jr	Ja	Jun				k, cm/s	φ	ψ	σ
							FLUSH	FLUSH			FLUSH	FLUSH	FLUSH	FLUSH	FLUSH	FLUSH				FLUSH	FLUSH	FLUSH	FLUSH
		Refer to Previous Page		183.5																			
5		GNEISS Fine to medium grained Fresh Very strong Grey		4.8	1														UCS = 114 MPa				
6	02/25/09 NG Coring																						
7					2																		
8		End of Drillhole		180.5																			
7.8																							
9																							
10																							
11																							
12																							
13																							
14																							

MTD-RCK 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6-11	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051637.4; E 236839.4</u>	ORIGINATED BY <u>EHS</u>
DIST <u>HWY 69</u>	BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>February 25, 2009</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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	
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100						SHEAR STRENGTH kPa
188.5	SNOW SURFACE																	
0.0	SNOW																	
0.4	Sandy ORGANICS Brown Moist SAND, trace to some silt, trace to some gravel, occasional cobbles Compact Brown Moist		1	SS	24		188											
			2	SS	27		187											
			3	SS	16		186											
185.4																		
3.1	Gravelly SAND Compact Brown Wet		4	SS	18	∇	185									26	68	(6)
184.5			5	SS	9/0.1													
4.0	End of Borehole Refusal to Further Penetration Auger Penetration Note: 1. Water level measured at a depth of 3.5 m below ground surface (Elev. 185.0 m) upon completion of drilling. 2. Borehole moved 0.7 m north due to boulder at ground surface at original borehole location.																	

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>	RECORD OF BOREHOLE No B6-13	1 OF 1 METRIC
W.P. <u>5193-06-01</u>	LOCATION <u>N 5051532.9; E 236868.0</u>	ORIGINATED BY <u>EHS</u>
DIST <u> </u> HWY <u>69</u>	BOREHOLE TYPE <u>108 I.D. Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>AMW</u>
DATUM <u>Geodetic</u>	DATE <u>February 9, 2009</u>	CHECKED BY <u>AB</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	20	40	60	80						100	SHEAR STRENGTH kPa
											○ UNCONFINED	+ FIELD VANE						
											● QUICK TRIAXIAL	× REMOULDED						
											WATER CONTENT (%)							
											20	40	60	80	100	10	20	30
195.3	GROUND SURFACE																	
0.0	Silty TOPSOIL																	
195.0	Brown Moist																	
0.3																		
194.5	SAND and SILT																	
0.8	Brown Moist																	
193.9	CLAYEY SILT, some fine sand		1	SS	36													
	Hard																	
193.6	Brown Moist		2	SS	18/0.1													
	Brown Moist																	
1.7	SAND and SILT, trace gravel																	
	Compact																	
	Brown Moist																	
	End of Borehole																	
	Refusal to Further Penetration																	
	Note:																	
	1. Borehole dry upon completion of drilling.																	

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:



PROJECT 07-1191-0020 **RECORD OF BOREHOLE No B6-14** 1 OF 1 **METRIC**
 W.P. 5193-06-01 LOCATION N 5051655.8; E 236840.4 ORIGINATED BY EHS
 DIST HWY 69 BOREHOLE TYPE Hand Excavation COMPILED BY AMW
 DATUM Geodetic DATE February 26, 2009 CHECKED BY AB

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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
193.2	GROUND SURFACE															
0.0 0.1	ORGANICS Brown Moist End of Borehole															
	Note: 1. Borehole located on bedrock outcrop. 2. Borehole dry upon completion of excavation.															

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

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



PROJECT 07-1191-0020 **RECORD OF PENETRATION TEST No B6-DC1** 1 OF 1 **METRIC**
 W.P. 5193-06-01 LOCATION N 5051643.7; E 236848.2 ORIGINATED BY EHS
 DIST HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AMW
 DATUM Geodetic DATE February 26, 2009 CHECKED BY AB

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			20	40	60	80	100						20	40	60
188.0 0.0	GROUND SURFACE																		
184.3 3.7	End OF DCPT Refusal to Further Penetration (Hammer Bouncing) (20 Blows/0.1 m)																		

SUD-MTO 001 07-1191-0020 B6 BH LOGS METRIC.GPJ GAL-MISS.GDT 12/12/11 DATA INPUT:

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



APPENDIX B

Laboratory Test Results

**TABLE B-1
REFUSAL/BEDROCK ELEVATIONS
HIGHWAY 69 SUCKER CREEK NBL – STA 15+025 TO 15+150
GWP 5005-08-00, WP 5193-06-01**

Borehole	Depth to Refusal/Bedrock Surface (m)	Refusal/Bedrock Surface Elevation (m)	Comments
B6-1	0.4	194.9	Auger Refusal
B6-2	0.2	194.7	Bedrock Surface
B6-3	0.5	194.1	Bedrock Surface
B6-4	0.7	193.8	Bedrock Surface
B6-5	0.7	193.0	Auger Refusal
B6-6	0.2	185.3	Bedrock Surface
B6-6a	0.1	187.4	Split-Spoon Refusal
B6-6b	0.3	184.6	Bedrock Surface
B6-6c	0.3	189.4	Bedrock Surface
B6-6d	0.2	185.7	Split-Spoon Refusal
B6-7	17.6	165.8	Bedrock Surface
B6-10	4.8	183.5	Bedrock Surface
B6-11	4.0	184.5	Auger/Split-Spoon Refusal
B6-13	1.7	193.6	Split-Spoon Refusal
B6-14	0.1	193.1	Bedrock Exposed by Hand Excavation
B6-DC1	3.7	184.3	DCPT Refusal

Compiled by: AMW
Checked by: AB
Reviewed by: JMAC

TABLE B-2
UNIAXIAL COMPRESSION STRENGTH TEST RESULTS
HIGHWAY 69 SUCKER CREEK NBL – STA 15+025 TO 15+150
GWP 5005-08-00, WP 5193-06-01

Borehole Number	Sample Depth (m)	Sample Elevation (m)	Rock Type	Core Diameter (mm)	Uniaxial Compressive Strength (MPa)
B6-2	0.7	194.2	Gneiss	47	100
B6-4	2.1	192.4	Gneiss	48	71
B6-6	1.2	184.3	Gneiss	51	136
B6-6b	2.4	182.5	Gneiss	51	82
B6-6c	2.9	186.8	Gneiss	51	92
B6-7	20.6	162.8	Mafic Intrusive	48	109
B6-10	5.6	182.7	Gneiss	48	114

Compiled by: AMW
 Checked by: AB
 Reviewed by: JMAC

TABLE B-3
POINT LOAD STRENGTH TEST RESULTS
HIGHWAY 69 SUCKER CREEK NBL – STA 15+025 TO 15+150
GWP 5005-08-00, WP 5193-06-01

Borehole Number	Sample Depth ¹ (m)	Sample Elevation (m)	Rock Type	Test Type ²	Core Diameter (mm)	Ram Pressure (MPa)	Load (kN)	I _s Diametral ² (MPa)	I _s 50 mm ² (MPa)	Approximate UCS ² (MPa)
B6-2	1.9	193.0	Gneiss	D	47	10.6	0.01007	4.5	4.4	88
B6-2	2.8	192.1	Gneiss	D	48	9.3	0.00885	3.9	3.8	76
B6-2	3.1	191.9	Gneiss	D	47	10.3	0.00973	4.3	4.2	84
B6-4	2.7	191.8	Gneiss	D	48	15.4	0.01460	6.5	6.3	126
B6-4	3.1	191.4	Gneiss	D	47	11.7	0.01111	4.9	4.8	98
B6-4	3.7	190.8	Gneiss	D	48	12.0	0.01138	5.1	4.9	99
B6-6	1.5	184.0	Gneiss	D	51	14.0	0.01325	5.1	5.1	102
B6-6	2.4	183.1	Gneiss	D	51	14.7	0.01394	5.3	5.4	108
B6-6	3.0	182.5	Gneiss	D	51	19.4	0.01839	7.1	7.1	142
B6-6b	1.2	183.7	Gneiss	D	51	17.0	0.01615	6.3	6.3	126
B6-6b	2.7	182.2	Gneiss	D	51	14.2	0.01344	5.1	5.2	104
B6-6b	3.4	181.5	Gneiss	D	51	13.4	0.01270	4.9	4.9	98
B6-6c	0.9	188.8	Gneiss	D	51	7.8	0.00736	2.8	2.9	58
B6-6c	2.4	187.3	Gneiss	D	51	12.7	0.01206	4.6	4.7	94
B6-7	18.8	164.6	Mafic Intrusive	D	48	23.8	0.02260	10.0	9.8	108
B6-10	5.4	182.9	Gneiss	D	48	11.3	0.01073	4.8	4.6	92
B6-10	6.2	182.1	Gneiss	D	48	11.5	0.01092	4.8	4.7	94
B6-10	6.9	181.4	Gneiss	D	47	15.8	0.01496	6.7	6.5	130

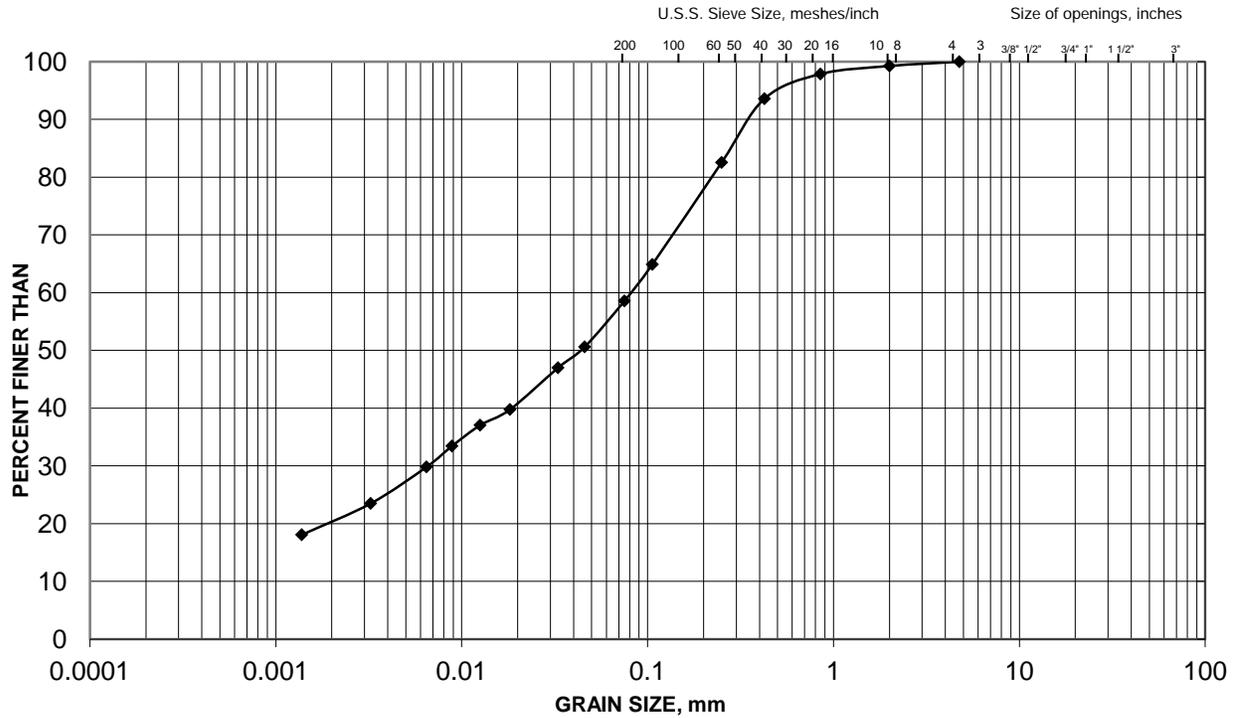
NOTES:

1. Depths are given below the ground surface at the borehole location.
2. Where: D = Diametral test;
I_s Diametral = Uncorrected point load strength;
I_s 50 mm = Corrected point load strength; and
UCS = Uniaxial compressive strength = I_s 50 mm X K. Values of 20 and 11 have been used for the Gneiss and Mafic Intrusive, respectively, based on correlation with UCS for this site ("Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock Mech. Sci. and Geomechanical Abst., Vol 22, No. 2, 1985, pp. 53-60.

Compiled by: AMW
Checked by: AB
Reviewed by: JMAC

GRAIN SIZE DISTRIBUTION
Sand and Silt

FIGURE
B-1



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

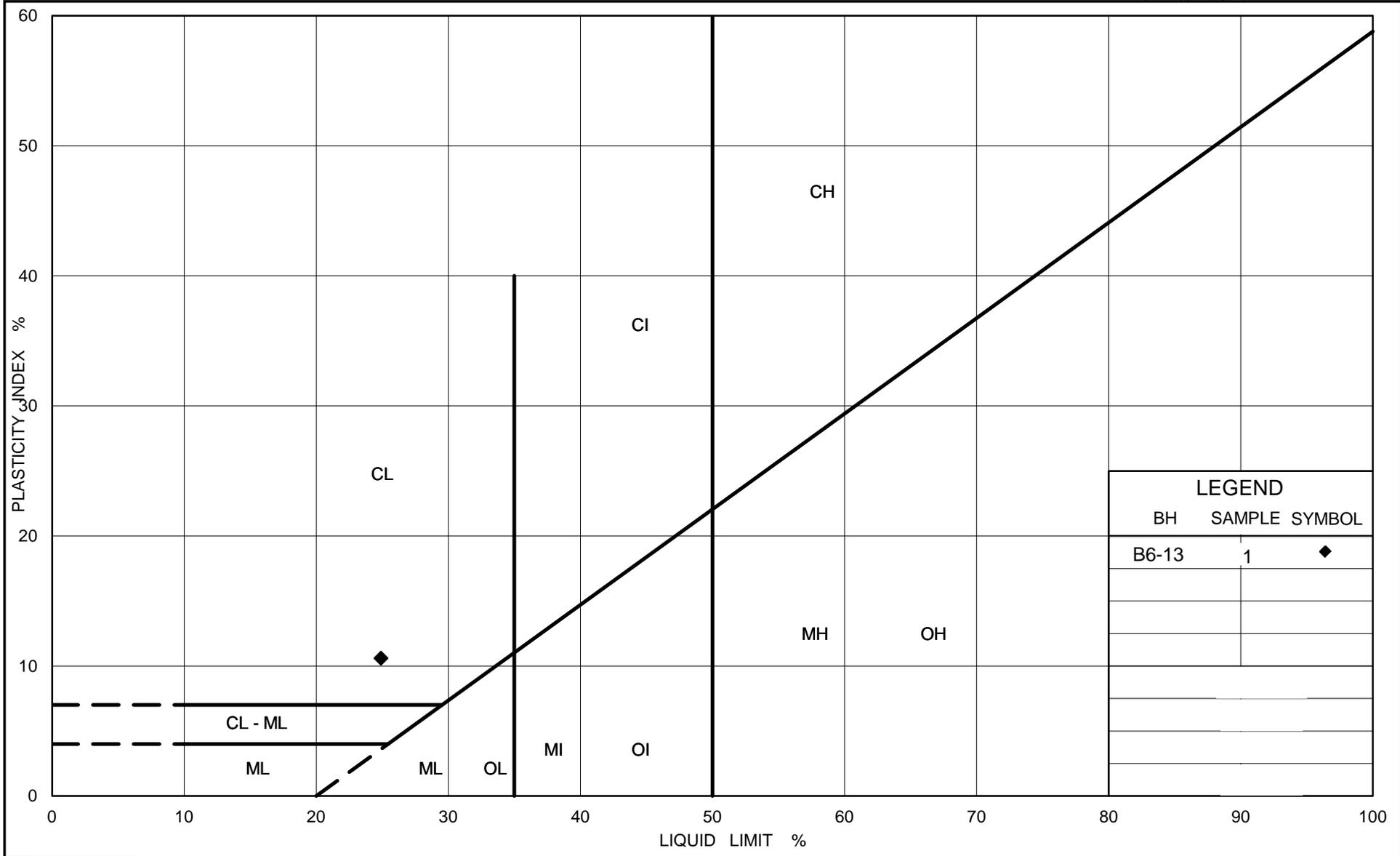
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	B6-3	1	194.2

Project Number: 07-1191-0020-B6
Checked By: AB

Golder Associates

Date: December 2011

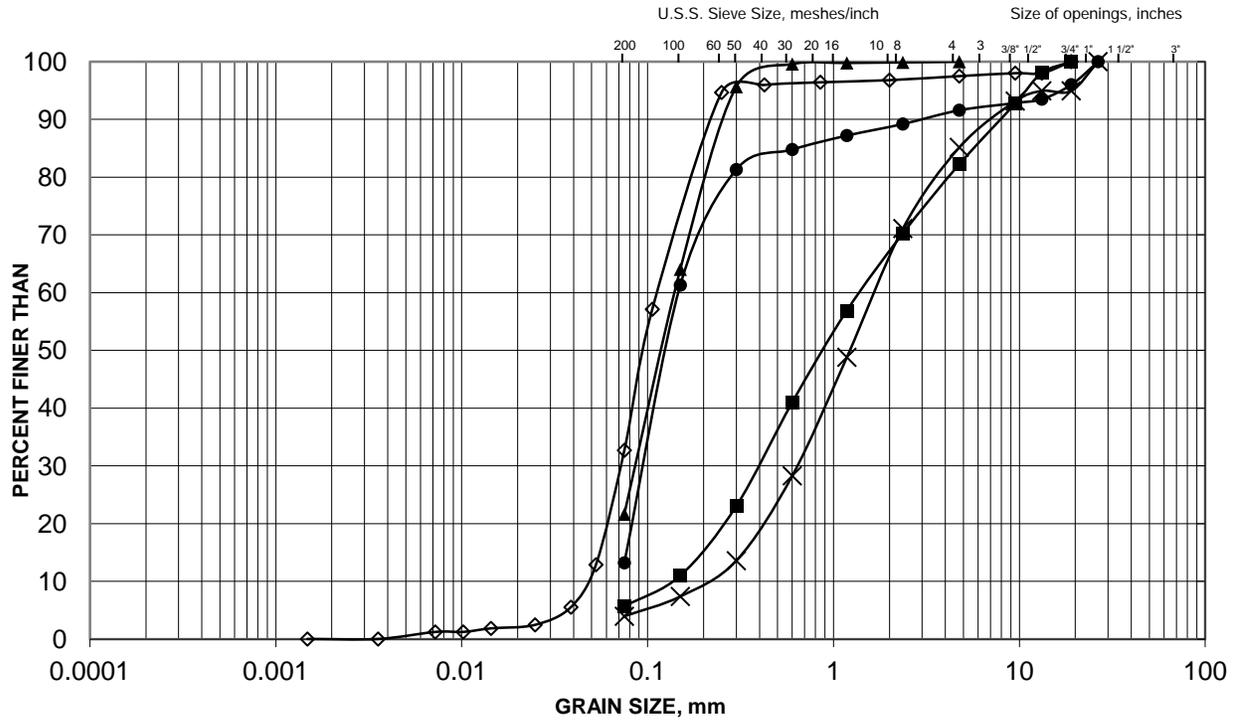


GRAIN SIZE DISTRIBUTION

Sand

FIGURE

B-3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◊	B6-7	3	180.9
●	B6-7	7	177.0
■	B6-7	11	169.4
▲	B6-10	2	187.2
×	B6-10	5	184.9

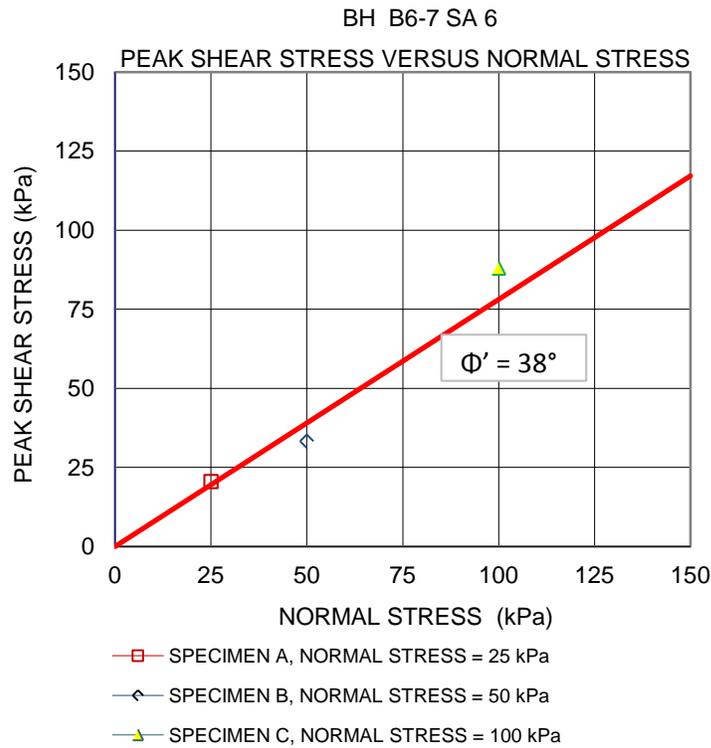
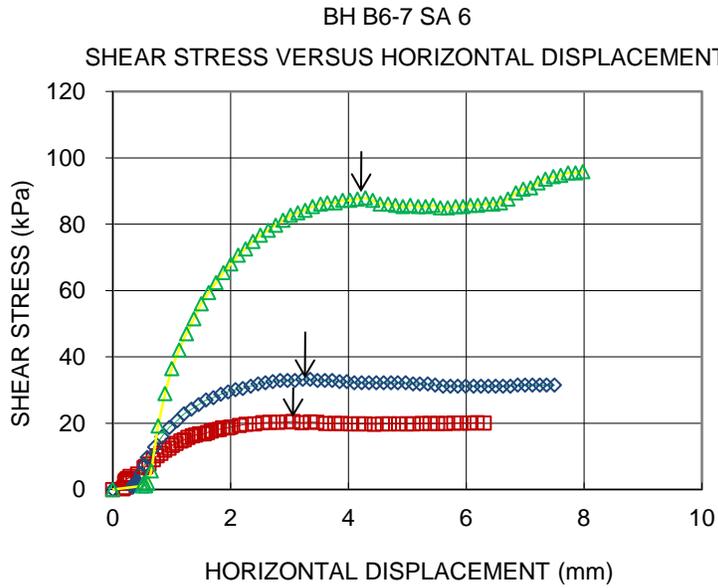
Project Number: 07-1191-0020-B6

Checked By: AB

Golder Associates

Date: December 2011

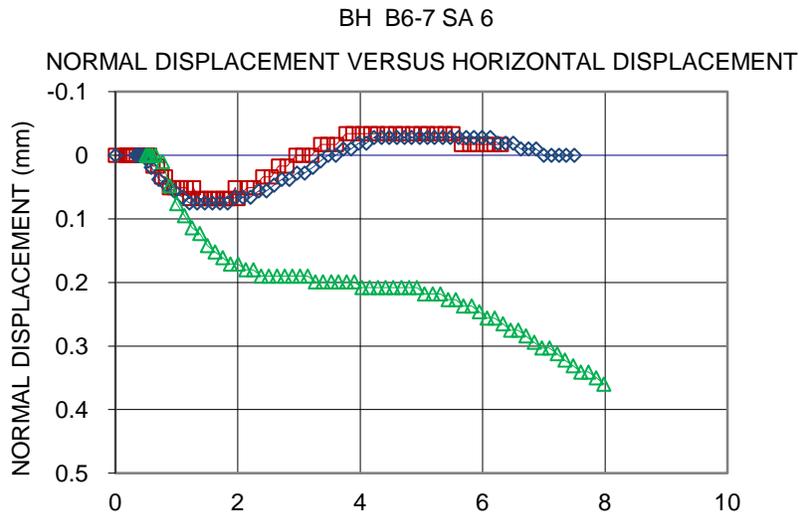
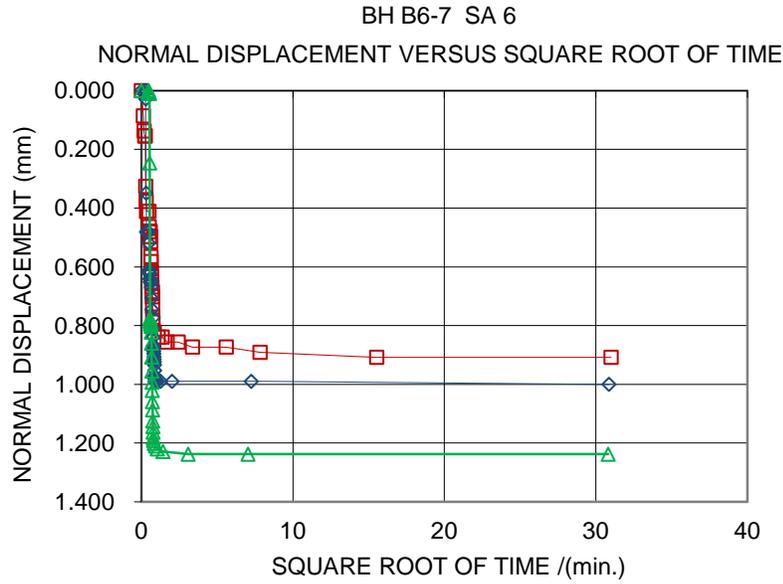
CONSOLIDATED DRAINED DIRECT SHEAR TEST Sand		FIGURE B-4 (Sheet 1 of 3)		
TEST STAGE	A	B	C	
BOREHOLE NUMBER	B6-7	B6-7	B6-7	
SAMPLE NUMBER	6	6	6	
SAMPLE DEPTH, (m)	4.6-5.2	4.6-5.2	4.6-5.2	
SAMPLE HEIGHT, (mm)	26.70	26.00	26.30	
SAMPLE LENGTH, (mm)	59.60	59.60	59.90	
WATER CONTENT, BEFORE TEST, (%)	-	-	-	
NORMAL (CONSOLIDATION) STRESS, (kPa)	25.00	50.00	100.00	
WATER CONTENT, AFTER TEST, (%)	21.89	21.84	22.13	
DISPLACEMENT RATE, mm/min	0.12	0.12	0.12	
TIME TO FAILURE, HOURS	0.4	0.4	0.6	
PEAK SHEAR STRESS, (kPa)	20.53	33.24	87.97	
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	3.06	3.23	4.29	
DRY DENSITY, initial, Mg/m ³	1.53	1.59	1.52	
WET DENSITY, initial, Mg/m ³	-	-	-	
TEST NOTES:				
<p>Tested sample was screened through #4 (4.75 mm) sieve (9.8% retained on #4). Each specimen was prepared dry with low compaction, normal stresses applied and then submerged in the shear box.</p>				
Date:	December 2011	Prepared By:	LH	
Project No.	07-1191-0020-B6	Checked By:	MM	
Golder Associates				



Date: December 2011
 Project No. 07-1191-0020-B6

Golder Associates

Prepared By: LH
 Checked By: MM



HORIZONTAL DISPLACEMENT (mm)

- SPECIMEN A, NORMAL STRESS = 25 kPa
- ◇— SPECIMEN B, NORMAL STRESS = 50 kPa
- △— SPECIMEN C, NORMAL STRESS = 100 kPa

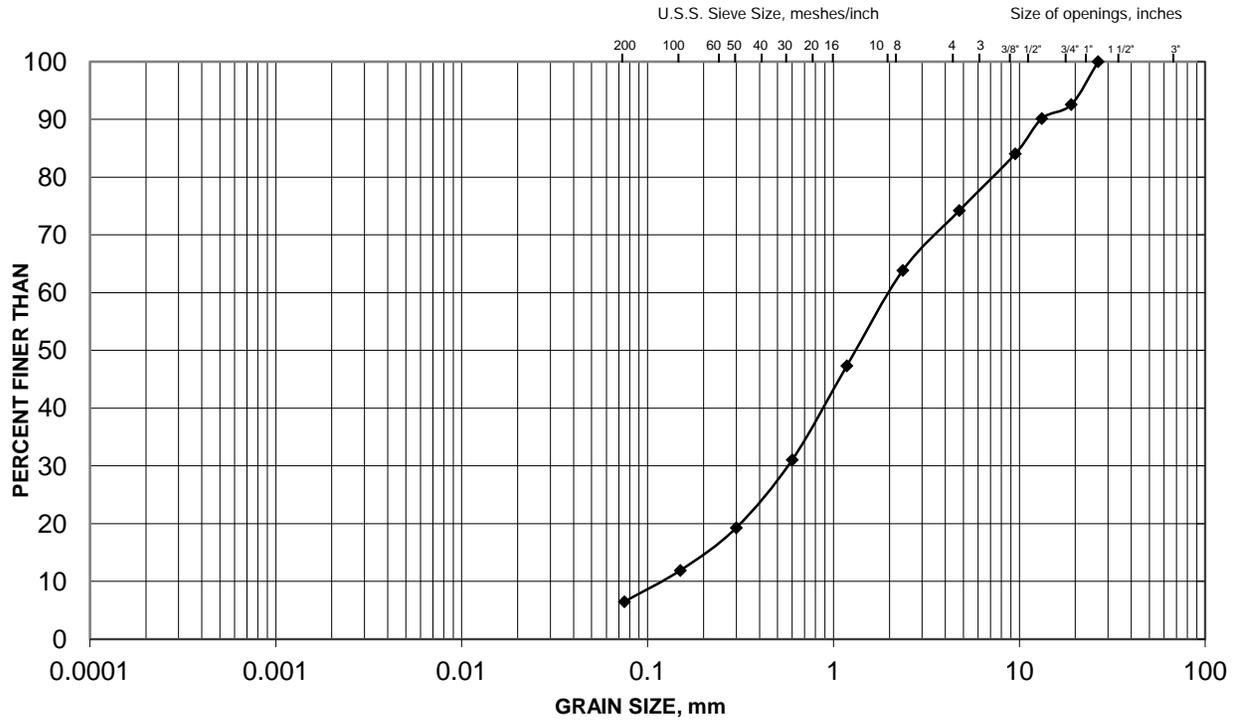
Date: December 2011
 Project No. 07-1191-0020-B6

Golder Associates

Prepared By: LH
 Checked By: MM

GRAIN SIZE DISTRIBUTION
Gravelly Sand

FIGURE
B-5



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	B6-11	4	185.1

Project Number: 07-1191-0020-B6
Checked By: AB

Golder Associates

Date: December 2011

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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