

Golder Associates Ltd.

1010 Lorne Street
Sudbury, Ontario, Canada P3C 4R9
Telephone 705-524-6861
Fax 705-524-1984



REPORT ON

**FOUNDATION INVESTIGATION AND DESIGN
VARIABLE MESSAGE SIGN #9
HIGHWAY 11 SOUTHBOUND, NEAR HIGHWAY 11B JUNCTION
G.W.P 5671-04-00
MINISTRY OF TRANSPORTATION, ONTARIO
COBALT, ONTARIO**

Submitted to:

IBI Group
230 Richmond Street West, 5th Floor
Toronto, Ontario
M5V 1V6

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November 24, 2006



06-1191-021-9

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November 2006

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PART A

**FOUNDATION INVESTIGATION REPORT
VARIABLE MESSAGE SIGN #9
HIGHWAY 11 SOUTHBOUND, NEAR HIGHWAY 11B JUNCTION
G.W.P 5671-04-00
MINISTRY OF TRANSPORTATION, ONTARIO
COBALT, ONTARIO**

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) to carry out a foundation investigation as part of the detailed design for a variable message sign (VMS) cantilever structure on Highway 11 Southbound, near the junction of Highway 11B in Cobalt, Ontario, for the Ministry of Transportation, Ontario (MTO). The general location of the site is shown on the Key Plan on Drawing 1.

The terms of reference for the scope of work were outlined in Golder's proposal P61-9106, dated March 2, 2006, that formed part of the Consultant's Agreement (Number 5005-E-0054) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project dated May 2006. The plans and profiles detailing the proposed sign location were provided to Golder by IBI in September 2006.

2.0 SITE DESCRIPTION

There were two possible locations for the VMS structure along Highway 11 Southbound, in Cobalt, Ontario. Site A was located approximately 0.5 km south of the junction with Highway 11B, and Site B was located approximately 6.3 km north of the junction, at Station 12+570. Once preliminary drilling results were presented to IBI and MTO, Site B was chosen as the preferred site. South of the junction, the terrain is generally flat with low-lying swampy areas, while north of the junction, rock outcrops are visible and the area is mainly treed. Elevations were not provided for Site A. The ground surface at the proposed structure location is at approximately Elevation 302.1 m at Site B.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The subsurface investigation work was carried out by Golder on July 13 and 14, 2006, at which time three sampled boreholes were advanced. Borehole BH06-1 was advanced in the shoulder of Highway 11 at approximate Station 12+578 (Site B) and boreholes BH06-2 and BH06-3 were advanced on the shoulders of Highway 11 at Site A. The borehole location at Site B is shown on Drawing 1.

The foundations investigation was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The boreholes were advanced using hollow stem augers and NQ-size diamond drilling equipment. Soil samples were obtained, where possible, at intervals ranging from 0.75 m to 1.5 m in depth, using a 50 mm outside diameter split-spoon sampler in accordance with Standard Penetration Test procedures (ASTM D1586-99). Rock core samples were obtained in the bedrock, where possible. Borehole BH06-1 was advanced to a depth of 4.3 m below the existing ground surface while boreholes BH06-2 and BH06-3 were advanced to a depth of 9.8 m below the existing ground surface. The groundwater conditions in the open boreholes were observed during the drilling operations, and the results of the water level measurements are shown on the Record of Borehole sheets following the text of this report. The boreholes were backfilled with bentonite holeplug in accordance with Ontario Regulation 128 (Amendment to O. Reg. 903).

The fieldwork was supervised throughout by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services and traffic control, supervised 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 Golder's Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Classification testing such as water content and grain size distribution was carried out to MTO and/or ASTM Standards, as relevant. Point load tests were carried out on the rock core to MTO Standards.

The boreholes were located using the stakes and/or paint marks sited in the field by IBI. Northing and easting coordinates were not provided, so stations and offsets were determined. The elevations, referenced to the geodetic datum, were obtained from a site survey conducted by surveyors retained by IBI. The elevations and stations and offsets are depicted on the Record of Borehole and Drillhole sheets and on Drawing 1.

4.0 GENERAL SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology and Site Stratigraphy

In the vicinity of the two sites, glaciofluvial outwash deposits comprising sand and gravel overlie the Middle Precambrian rocks of the Cobalt Group (Northern Ontario Engineering Geology Terrain Study, OGS Map 5041). The bedrock is characterized by sandstone and siltstone of the Lorrain and Gowganda Formations, including quartz sandstone, micaceous and aluminous quartz sandstone, quartz-feldspar sandstone, minor conglomerate and siltstone, and argillite (Sudbury-Cobalt Geological Compilation Series; OGS Map 2361).

4.2 Subsurface Conditions

Detailed descriptions of the subsurface conditions at this site are provided in the following sections of this report, and 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 samples, are given on the Record of Borehole and Drillhole sheets following the text of this report. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests and in situ testing. 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.

4.3 Site A

Borehole BH06-2 was drilled in the southbound lane shoulder and borehole BH06-3 was drilled in the northbound lane shoulder, approximately 0.5 km south of the junction with Highway 11B.

4.3.1 Fill

A total thickness of 0.6 m of Granular 'A' fill was encountered in both boreholes at this site. The natural water content of the Granular 'A' fill ranged from 3 percent to 4 percent.

Beneath the Granular 'A' fill in both boreholes, 1.1 m to 1.2 m of silty sand fill was encountered. The Standard Penetration Test (SPT) 'N' values measured within the silty sand fill ranged between 4 and 15 blows per 0.3 m of penetration, indicating that this material has a very loose to compact relative density. The natural water content of the silty sand fill ranged from 4 percent to 10 percent.

4.3.2 Organics

A very thin deposit of dark brown to black, silty organic material was encountered below the fill. The layer is 50 mm to 150 mm thick, and the surface of the deposit was encountered at 1.7 m and 1.8 m depth in borehole BH06-2 and BH06-3, respectively.

4.3.3 Sand

A deposit of fine to medium sand containing trace silt was encountered below the organic material in both boreholes, at depths between 1.7 m and 2.0 m. Both boreholes were terminated at a depth of 9.8 m below ground surface within the sand deposit.

The measured SPT 'N' values within the sand deposit ranged from weight of the hammer (0 blows) to 10 blows per 0.3 m of penetration, indicating that the deposit has a very loose to compact relative density.

The natural water content of the sand deposit ranged from 19 percent to 29 percent. Grain size distribution tests on several samples of the sand are shown on Figure 1.

4.3.4 Groundwater Conditions

Details of the groundwater conditions and water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets following the text of this report. In general, the samples taken in the boreholes were noted to be moist to wet. Groundwater levels observed in the open boreholes BH06-2 and BH06-3 ranged from 2.1 m to 2.2 m depth below the existing ground surface upon completion of drilling, respectively. It should be noted that these water levels do not represent stabilized water levels and that groundwater elevations will vary depending on precipitation and local soil permeability.

4.4 Site B

Borehole BH06-1 was drilled on the southbound shoulder and had a ground surface at Elevation 302.1 m.

4.4.1 Fill

A total thickness of 0.6 m of Granular 'A' fill was encountered in the borehole drilled at this site.

4.4.2 Bedrock

Borehole BH06-1 encountered bedrock below the fill, at a depth of 0.6 m. About 3.7 m of bedrock coring was carried out. Based on the recovered rock core samples, the bedrock consists of fine to medium grained, interbedded siltstone and argillite. The bedrock is dark grey in colour and is slightly weathered.

Rock Quality Designation (RQD) values measured on the recovered bedrock core samples ranged from 13 to 96 percent, but generally measured above 70 percent, indicating that the rock is very poor to excellent quality, and generally good quality.

Point load testing performed on two samples of the rock core resulted in unconfined compressive strengths of 96 MPa and 115 MPa, as shown in Table 1. Using the Intact Rock Strength Classification table, these values indicate the bedrock is classified as strong to very strong.

4.5 Closure

The fieldwork was carried out by an intermediate technician from our Sudbury office under the coordination of Mr. André Bom, P.Eng. This report was prepared by Ms. Kerry Salvatori Lee, P.Eng., and was reviewed by Ms. Sarah Poot, P.Eng., Senior Geotechnical Engineer. Mr. Fintan J. Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted a quality control review of the report.

GOLDER ASSOCIATES LTD.



André Bom, P.Eng.
Geotechnical Engineer



Sarah E. M. Poot, P.Eng.
Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.
Designated MTO Contact



AB/KSL/SEP/FJH/lb

TABLE 1
POINT LOAD TEST RESULTS
G.W.P 5671-04-00
VMS #9, COBALT (SITE B)

<i>Borehole Number</i>	<i>Sample Depth (m)</i>	<i>Rock Type</i>	<i>Test Type</i>	<i>Core Diameter (mm)</i>	<i>Ram Pressure (MPa)</i>	<i>Load (kN)</i>	<i>I_s Diametral (MPa)</i>	<i>I_s (50 mm) (MPa)</i>	<i>Approximate UCS (MPa)</i>
BH06-1	2.1	Interbedded Siltstone and Argillite	D	47.0	11.52	0.011	4.94	4.81	96
BH06-1	4.0	Interbedded Siltstone and Argillite	D	47.0	13.73	0.013	5.89	5.73	115

- 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 = Unconfined compressive strength = I_s 50 mm x 20 (based on experience with similar rock types).
 3. Based on removal of the 2 highest and 2 lowest values

Compiled by: AB
Checked by: SEP

TABLE 2
DESIGN PARAMETERS FOR SOIL
G.W.P 5671-04-00
VMS #9, COBALT (SITE A)

<i>Borehole No.</i>	<i>Stratum</i>	<i>Depth¹ (m)</i>	<i>Groundwater Depth (m)</i>	<i>Design Parameters²</i>			
				Φ'	γ	γ'	K_p
BH06-2 and BH06-3	Compact to loose silty sand fill	0 to 1.8	2.1	-	-	-	-
	Organic material	1.8 to 2.0		-	-	-	-
	Very loose to compact sand	Below 2.0		27	18	8	2.7

NOTES:

1. Depths are given below the ground surface at the borehole location.
2. Design parameters: ϕ' = effective friction angle (degrees);
 γ = bulk unit weight (kN/m³);
 γ' = effective unit weight below the groundwater level (kN/m³); and
 K_p = passive earth pressure coefficient.

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N 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

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.)

Consistency

	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

(b) Cohesive Soils

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.

IV. SOIL TESTS

w water content
w_p plastic limit
w_i liquid limit
C consolidation (oedometer) test
CHEM chemical analysis (refer to text)
CID consolidated isotropically drained triaxial test¹
CIU consolidated isotropically undrained triaxial test with porewater pressure measurement¹
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
SO₄ 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.

S:\FINALDATA\ABBREV\2000\LOFA-D00.DOC

LIST OF SYMBOLS

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

I. General

π	3.1416
in x ,	natural logarithm of x
\log_{10}	x or $\log x$, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density \times acceleration due to gravity)

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	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 $= \sigma'_p / \sigma'_{vo}$

(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_i	sensitivity

- Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 Shear strength = (Compressive strength)/2

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

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

Description	Bedding Plane Spacing
Very thickly bedded	> 2 m
Thickly bedded	0.6 m to 2m
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

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

GRAIN SIZE

Term	Size*
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

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 separations) 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 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

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	

PROJECT 06-1191-021-9B

RECORD OF BOREHOLE No BH06-1

1 OF 1 **METRIC**

W.P. 5671-04-00

LOCATION Station 12+578.5, Offset 10.6 Left

ORIGINATED BY DB

DIST HWY 11

BOREHOLE TYPE Power Auger, 108mm ID Hollow Stem Augers

COMPILED BY AB

DATUM Geodetic

DATE 7/13/06

CHECKED BY SEP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT 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
302.1 0.0	GROUND SURFACE Granular 'A' (FILL)		1	AS	-		302								GR SA SI CL
301.5 0.6	Interbedded Siltstone and Argillite (BEDROCK)						301								
	Bedrock cored from 0.6m to 4.3m depth						300								
	For bedrock coring details see Record of Drillhole BH06-1						299								
297.8 4.3	End of Borehole						298								

LOCATION: Station 12+578.5, Offset 10.6 Left

DRILLING DATE: 07/13/06

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: NW CASING

DRILLING CONTRACTOR

DRILLING CONTRACTOR: Landcore

[illegible]

DEPTH SCALE

1 : 50



LOGGED: DB

CHECKED: AB

PROJECT <u>06-1191-021-9A</u>		RECORD OF BOREHOLE No BH06-2		1 OF 1 METRIC	
W.P. <u>5671-04-00</u>		LOCATION <u>Not Provided</u>		ORIGINATED BY <u>DB</u>	
DIST <u>HWY 11</u>		BOREHOLE TYPE <u>Power Auger, 108mm ID Hollow Stem Augers</u>		COMPILED BY <u>AB</u>	
DATUM <u>Geodetic</u>		DATE <u>07/13/06</u>		CHECKED BY <u>SEP</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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100					10 20 30				
0.0	GROUND SURFACE																
	Granular 'A' (FILL)		1	AS	-												
-0.6																	
0.6	Silty fine sand (FILL)		2	DO	15										1 94 5 0		
	Compact to loose																
	Brown																
	Moist																
-1.7																	
1.7	Silty organic material		3	DO	7												
	Black																
	Medium to fine Sand, trace silt																
	Compact to very loose																
	Grey																
	Wet																
			4	DO	10												
			5	DO	3										0 97 3 0		
			6	DO	4												
			7	DO	7												
			8	DO	4										0 94 6 0		
			9	DO	WH												
			10	DO	7												
-9.8																	
9.8	End of Borehole																
	Notes: 1. Water level at 2.1m depth upon completion of drilling.																

PROJECT 06-1191-021-9A

RECORD OF BOREHOLE No BH06-3

1 OF 1 **METRIC**

W.P. 5671-04-00

LOCATION Not Provided

ORIGINATED BY DB

DIST HWY 11

BOREHOLE TYPE Power Auger, 108mm ID Hollow Stem Augers

COMPILED BY AB

DATUM Geodetic

DATE 07/14/06

CHECKED BY SEP

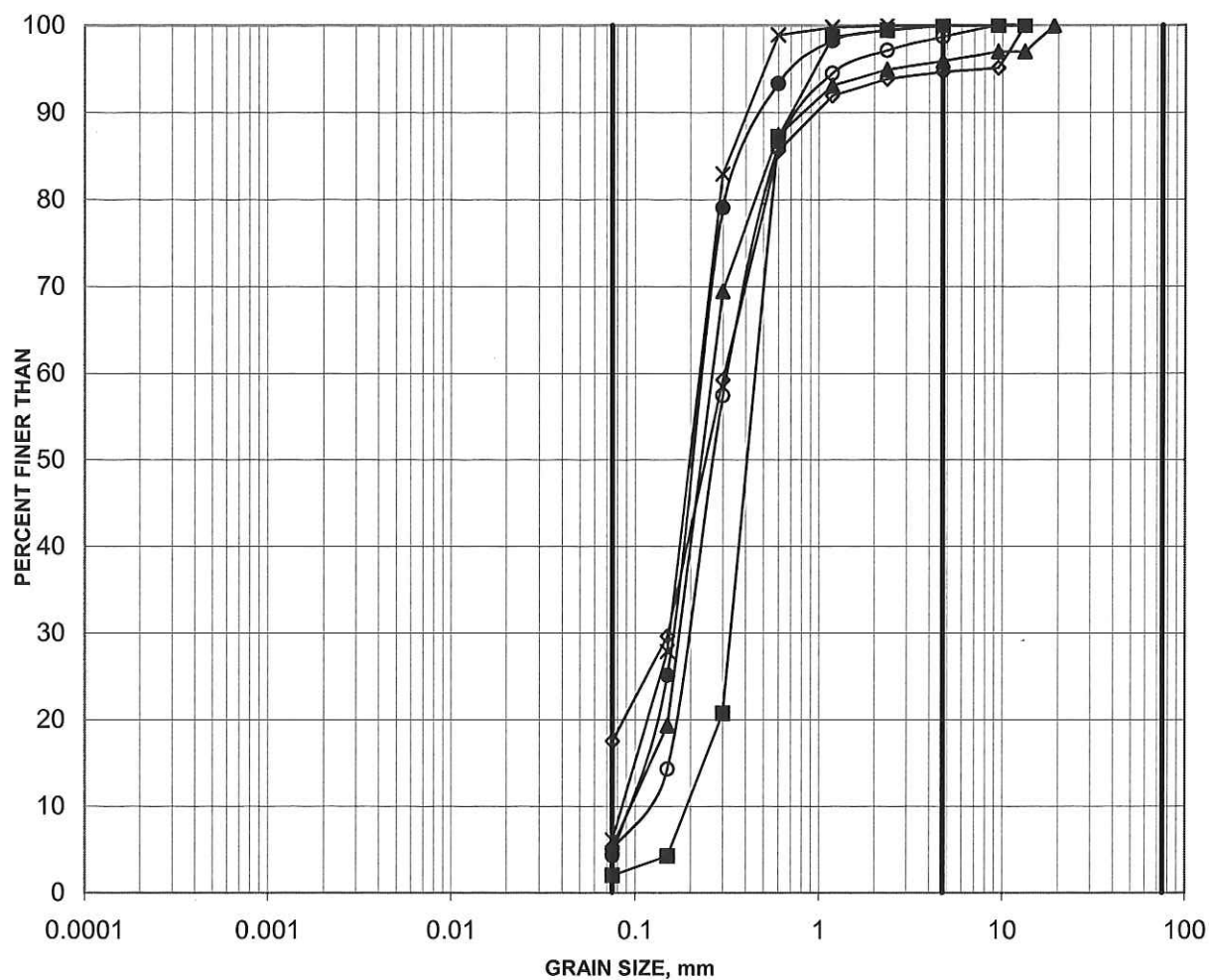
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
0.0	GROUND SURFACE																
-0.6	Granular 'A' (FILL)		1	AS	-												
0.6	Silty, fine to medium sand, trace gravel (FILL) Loose Brown Moist		2	DO	9												5 77 18 0
-1.8	Silty organic material Black		3	DO	4												
2.0	Fine to medium Sand, trace silt Loose to compact Grey Wet		4	DO	9												
			5	DO	10												
			6	DO	14												4 91 5 0
			7	DO	8												
			8	DO	4												0 95 5 0
			9	DO	8												
			10	DO	4												
-9.8	End of Borehole																
9.8	Notes: 1. Water level at 2.2m depth upon completion of drilling.																

MIS-MTO 001 06-1191-021 SOIL.GPJ GAL-MISS.GDT 11/22/06

GRAIN SIZE DISTRIBUTION

Sand

FIGURE 1



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

	Borehole	Sample	Depth (m)
○	06-2	2	1.1
■	06-2	5	3.4
×	06-2	8	6.4
◇	06-3	2	1.1
▲	06-3	6	4.1
●	06-3	8	6.4

APPENDIX A
NON-STANDARD SPECIAL PROVISIONS (NSSPs)

CONCRETE SIGN SUPPORT STRUCTURE FOOTINGS - Item No.
EXCAVATION – Item No.

Non-Standard Special Provision

✓ This special provision is to highlight the construction concerns for the installation of VMS#9A (Cobalt). The Contactor shall be alerted that the overburden soils at the sign location include cohesionless and water-bearing sands, which are susceptible to soil cave-in, sloughing and boiling. The contractor is responsible to ensure that appropriate construction procedures and equipment are used for the caisson construction.

CONCRETE SIGN SUPPORT STRUCTURE FOOTINGS – Item No.
ANCHORS INTO ROCK – Item No.

Non-Standard Special Provision

Rock Anchors Testing

All proposed testing procedures shall be in general conformance with ASTM D 3689-90 and ASTM D 114381 (Re-approved 1994). Field testing shall be carried out in the presence of, and the results reviewed and approved by, the Contract Administrator.

Performance Tests

Performance testing shall be carried out on two rock anchors to confirm that the design load of the rock dowels can be achieved for the installation of VMS#9 (Cobalt). The Contract Administrator will select the rock dowels to be tested.

Performance test shall be by axial tensioning using a hydraulic jack with a capacity of at least 1.5 times the ultimate strength of the dowels.

Rock anchors shall be loaded and unloaded in 3 cycles and measurements of the displacement of the anchor shall be carried out at each load increment (step) in accordance with the following schedule:

Cycle-Step	1-1	1-2	1-3	2-1	2-2	2-3	2-4
% Design Load	50	75	25	50	75	100	25
Cycle-Step	3-1	3-2	3-3	3-4	3-5		
% Design Load	50	75	100	110	25		

The design load shall be taken as 360 kN for 35M anchors, 252 kN for 30M anchors, 180 kN, for 25M anchors, and 108 kN for 20M anchors.

Displacement measurements shall be carried out at each load increment using calibrated displacement gauges capable of measuring movements of 0.0025 cm. Measurements shall be referenced to an independent fixed referenced point.

Rock anchors which fail to meet the acceptance criteria shall be replaced at the Contractor's expense and re-tested. If a rock anchor fails, 3 additional rock anchors shall be tested at the same sign footing as directed by the Contract Administrator.

Acceptance criteria for the rock dowels shall be in accordance with the Post-tensioning Institute (1985) as follows:

The anchors are acceptable if the total elastic movement is greater than 80% of the theoretical elastic elongation of the free stressing and is less than the theoretical elongation of the free stressing length plus 50% of the bond length.

Performance Tests

All anchors must be proof-tested to 110% of the design load.

Basis of Payment

Payment at the Contract Price for the above tender item shall include full compensation for all labour, equipment and material to do the work.

CONCRETE SIGN SUPPORT STRUCTURE FOOTINGS - Item No.
MASS CONCRETE – Item No.

Non-Standard Special Provision

Scope

The work under this item shall include all supply and placement of the mass concrete under sign footings for the VMS#9B (Cobalt).

The purpose of the mass concrete pad is to provide a level working surface on the irregular founding bedrock surface.

Construction

Work under this item shall satisfy the following requirements:

The surface of the sign footing founding rock shall be exposed, cleaned, and any loose, fractured rock shall be removed so that sound rock is exposed;

The mass concrete shall have a strength equal to that used for the structural footings;

The mass concrete shall be placed on the exposed clean, sound, founding rock surface as per the Contract Drawings and Documents;

The thickness of the mass concrete shall depend on the slope and irregularities in the exposed founding rock surface.

Basis of Payment

Payment at the contract price shall include all labour, equipment and materials to carry out the above work.

PART B

**FOUNDATION DESIGN REPORT
VARIABLE MESSAGE SIGN #9
HIGHWAY 11 SOUTHBOUND, NEAR HIGHWAY 11B JUNCTION
G.W.P 5671-04-00
MINISTRY OF TRANSPORTATION, ONTARIO
COBALT, ONTARIO**

5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides foundation design recommendations for the proposed variable message sign foundations. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site and from site observations. The interpretation and recommendations provided are intended only to provide the designers with sufficient information to assess the feasible alternatives and to design the proposed sign foundations. As such, where comments are made on construction, they are provided only in order to highlight those aspects which could affect the planning of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

5.2 Site A – Cantilever Sign Foundations in Soil

At this sign support location (Highway 11 Southbound, about 0.5 km south of the junction with Highway 11B), very loose to compact sand was encountered. Caisson foundations for overhead sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual*. The *Sign Support Manual* includes a standard caisson foundation design (Section 3 and Standard Drawings SS118-3, SS118-4 and SS118-5), in which the caissons are extended 5 m below the design frost depth except where bedrock is encountered within this depth. For sign foundation design, the frost depth in the Cobalt area may be taken as 2.2 m. The typical caisson founding level would therefore be 7.2 m below the ground surface. At this site, the depth to bedrock is greater than the standard foundation length; therefore, the foundations for these sign supports should be designed as caissons in soil. The standard design is based on the following minimum soil conditions:

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where there are extensive poor fill materials or materials softer or looser than those of the standard cases.

The soils at this site are cohesionless. Based on the review of the subsurface information, the soils at this sign location have friction angles that do not meet the input parameters used in developing the standard; therefore, the standard caisson foundation design cannot be applied. For these subsurface conditions, a site-specific design is required. The stratigraphy and design parameters for the subsurface conditions encountered in the boreholes at the sign support locations are given in Table 2.

For cohesionless soils, the unfactored passive lateral earth pressure, P_p (kPa), distributed along the depth of the caisson foundation, may be calculated using the following equations:

$$\begin{aligned} P_p &= K_p \gamma d_w && \text{above the groundwater table; and} \\ P_p &= K_p \gamma d_w + K_p \gamma' (d - d_w) && \text{below the groundwater table} \end{aligned}$$

where K_p is the passive earth pressure coefficient;
 γ is the bulk unit weight (kN/m³);
 γ' is the effective unit weight below the groundwater level (kN/m³);
 d is the depth below the ground surface (m); and
 d_w is the depth to the groundwater level (m).

The lateral earth pressure may be assumed to act over an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance. In the design of the foundations, the passive resistance within the upper 2.2 m below ground surface should be neglected to account for frost action.

5.3 Site B – Cantilever Sign Foundations in Bedrock

At the sign support location (Highway 11 Southbound, Station 12+570) bedrock is present very close to the ground surface. The foundations for the sign supports can be designed as caissons socketted into the rock or, alternatively, as spread footings anchored to the bedrock. Recommendations for these two foundation options are provided in Sections 5.3.1 and 5.3.2. Spread footings anchored to the bedrock are considered to be the more practical and cost-effective option for the sign supports, since it would avoid the coring of large-diameter caissons into the strong to very strong interbedded siltstone and argillite bedrock at this location.

5.3.1 Caisson Foundations Socketted into Rock

The variable message sign foundations should be designed in accordance with the MTO's *Sign Support Manual*. In the standard design, caisson foundations are extended 5 m below the design

frost depth, unless bedrock is encountered within this depth. The frost depth in the Cobalt area may be taken as 2.2 m.

The depth to the surface of the bedrock in this location was encountered at a depth less than the standard founding level (frost depth plus 5 m). In accordance with Standard Drawing SS118-3 of MTO's *Sign Support Manual*, where bedrock is encountered at a depth, z (in metres), of less than 5 m below the bottom of the frost layer, the required depth of the foundation below the frost layer may be taken as follows:

$$z + (5 \text{ m} - z) / 2$$

Based on the above equation, the caisson for the support of the overhead sign should be extended to a total depth of 3.1 m, which corresponds to an embedment of 2.5 m into the interbedded siltstone and argillite bedrock.

Intact rock samples of the interbedded siltstone and argillite bedrock measured uniaxial compressive strengths between about 95 MPa and 115 MPa indicating the bedrock is strong to very strong. In order to minimize coring within the strong to very strong bedrock, consideration should be given to the use of foundations anchored to the rock as described in the following section.

5.3.2 Spread Footings

Anchored spread footings are the preferred option, from a foundations perspective, for support of the overhead sign. It is recommended that spread footings for support of this sign be placed on the surface of the bedrock or with nominal embedment into the bedrock, just below the upper fractured zone, at an approximate founding elevation of 301.5 m at borehole BH06-1.

Sub-excavation of any loose, fractured bedrock will be required prior to the construction of the footing. In this regard, MTO's Special Provision SP902S01 should be included in the Contract Documents, requiring inspection and approval of the foundation area by the Quality Verification Engineer prior to footing construction, to ensure that all loose and/or fractured rock has been removed from the foundation areas. Variation in the bedrock surface should be anticipated at the sign support locations, and a Non-Standard Special Provision (NSSP) should be included in the Contract Documents for mass concrete placement to accommodate variations in the bedrock surface. A sample is included in Appendix A for reference.

Resistance to lateral forces / sliding resistance between the concrete footings and the interbedded siltstone and argillite bedrock should be calculated in accordance with Section 6.7.5 of the CHBDC. The coefficient of friction, $\tan \delta'$, may be taken as 0.70 for cast-in-place concrete footings constructed on the clean surface of the bedrock. This represents an unfactored value; in

accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

This sliding resistance can be supplemented as necessary by anchoring into the bedrock. The horizontal resistance of the anchors is dependent on the strength of the bedrock, grout and steel. Where the rock mass is as strong as or stronger than concrete, as is the case for this site, the design of the anchors in the rock may be handled in the same way as the dowel embedment into the concrete, assuming that the unconfined compressive strength of the grout is similar to that of the concrete. The rock anchors should have a minimum embedded length within the bedrock of 1.0 m, and the structural strength of the dowel and the compressive strength of the grout should not be exceeded.

Rock anchors can also be used to provide uplift resistance, to supplement the weight of the sign footing if necessary. For uplift of the anchors, a factored value of 500 kPa may be assumed for the grout-to-rock bond stress for ULS design. The actual bond stress along the rock-grout interface may vary from the design value given. Normal construction practice would use pull-out testing to verify the actual bond stress. However, in this case, pull-out testing may not be practical for the limited number of anchors at this site. The bond stress given is considered to be a conservative value to be used where pull-out testing is not practical. If a higher factored bond stress of 650 kPa is desired, then pull-out testing would be mandatory. If required, an NSSP should be included in the Contract Documents to cover this testing, and a sample is included in Appendix A for reference.

The required anchor lengths for resistance of uplift loads should also be checked against a conical mode of failure through the rock mass. For this type of failure, taking into account the potential for intersecting sets of discontinuities, it is common practice to consider the dead weight of the rock (based on a unit weight of bedrock of 25 kN/m^3) within a cone extending from the centre of the bond zone to the rock surface with an apex angle of 90 degrees

5.4 Construction Considerations

It is recommended that NSSPs be included in the Contract Documents to warn the Contractor of the following items which are expected to affect the installation of the variable message sign foundations:

- **Control of overburden soils for caisson foundations:** Excavations for the sign foundations at Site A will be advanced through generally cohesionless soils, which should be expected to be unstable above and below the groundwater level at this site. It should be anticipated that the caisson holes will have to be advanced using a temporary liner, possibly in conjunction with fluid support, in order to minimize ground loss during drilling and concrete placement. The contractor is responsible to ensure that appropriate construction procedures and equipment are used for the caisson construction.

- **Mass concrete:** For Site B, an allowance for mass concrete should be included to accommodate variations in the bedrock surface for spread footings.
- **Anchor pull-out testing:** For Site B, the actual bond stress along the rock-grout interface may vary from the design value given, and should be verified by field testing, if the higher bond stress value is used. This requirement can be waived if the lower bond stress value is used in the design.

These NSSPs have been developed by Golder and are attached in Appendix A.

5.5 Closure

This report was prepared by Ms. Kerry Salvatori Lee, P.Eng., a Geotechnical Engineer, and the technical aspects were reviewed by Ms. Sarah Poot, P.Eng., a Senior Geotechnical Engineer with Golder. Mr. Fintan J. Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted a quality control review of the report.

GOLDER ASSOCIATES LTD.

K. Salvatori Lee

Kerry L. Salvatori Lee, P.Eng.
Geotechnical Engineer

S. E. M. Poot

Sarah E. M. Poot., P.Eng.
Senior Geotechnical Engineer



F. J. Heffernan

Fintan J. Heffernan, P.Eng.
Designated MTO Contact



AB/KSL/SEP/FJH/lb

METRIC
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STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5671-04-00

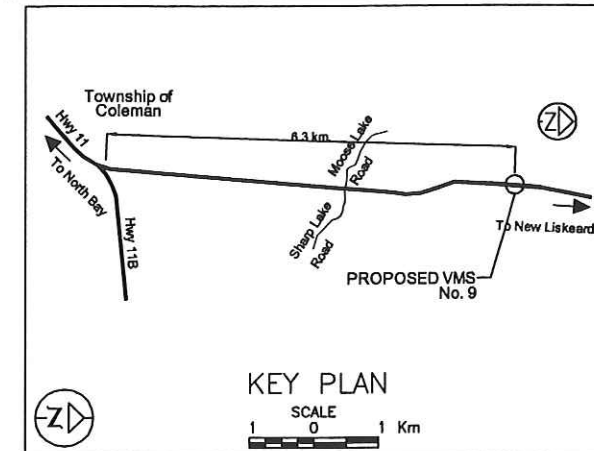


SHEET

HIGHWAY 11, COBALT
OVERHEAD SIGN STATION 12+570
BOREHOLE LOCATION PLAN



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND			
Borehole			
No.	ELEVATION	STATION	OFFSET
BH06-1	302.13	12+578.5	10.6 LEFT

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.

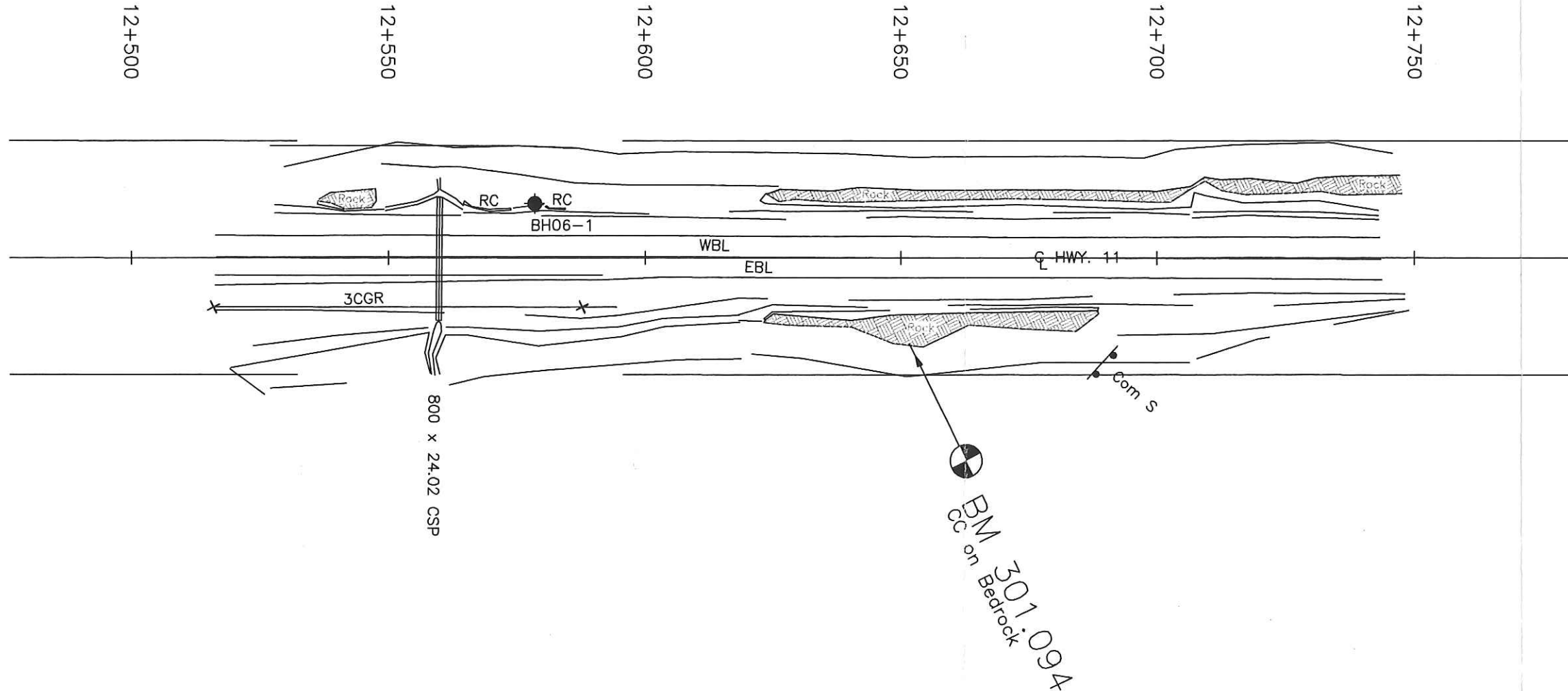
The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

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 IBI, drawing file no. SB06019b.dwg, dated October, 2006, received October 3, 2006.

NO.	DATE	BY	REVISION
Geocres No. 31M-69			
HWY. 11	PROJECT NO.06-1191-021-9B		DIST.
SUBM'D. KSL	CHKD. SEP	DATE: NOV 2006	SITE:
DRAWN: RN	CHKD.	APPD. FJH	DWG. 1



PLAN
SCALE
10 0 10 20 m



PHASE I – QUALITY CONTROL CHECKLIST
DOCUMENT REVIEW, INVESTIGATION, TESTING AND FOUNDATION REPORTING
FOUNDATION INVESTIGATION AND DESIGN
HIGHWAY 11 & 17 CHANGEABLE MESSAGE SIGNS (CMS)
NORTHEASTERN REGION, G.W.P. 5671-04-00

Number	Item	Initial and Date		Project Specific Comments
		Complete	In Progress	
1	Review of project documentation and available Foundation Reports.	√ June 2006		Reviewed project documentation, terms of reference in RFP, available geological information, borehole information and survey drawings for the study area.
2	Site Visit to inspect the terrain and the performance of existing structures and/or roads.	√ June and July 2006		Project Manager visited sites in June and July 2006.
3	Location, number and depth of boreholes and any other subsurface investigations, and sample frequency.	√ August 2006		Boreholes were advanced at the site as follows: <ul style="list-style-type: none"> Sudbury – A total of two boreholes were advanced to between 3.4 m and 5.0 m depth. This includes between 2.6 m and 4.4 m of NQ bedrock coring in each borehole. Sault Ste. Marie – A total of two boreholes were advanced to 12.8 m depth. North Bay – A total of four boreholes were advanced to between 4.2 m and 7.3 m depth. This includes between 2.0 m and 3.6 m of NQ bedrock coring in each borehole. Cobalt - A total of three boreholes were advanced to between 4.3 m and 9.8 m depth. This includes 3.7 m of NQ bedrock coring in one borehole.
4	Determination of groundwater elevation in boreholes.	√ August 2006		Groundwater levels were measured with respect to ground surface in all open boreholes upon completion of drilling.
5	Number of laboratory tests and type of laboratory tests.	√ August 2006		A total of 45 split spoon samples were obtained in the boreholes. A total of 34 water contents and 6 grain size distributions tests. On samples of bedrock, a total of 12 point load tests were carried out.
6	Abandonment of boreholes and site restoration.	√ August 2006		The boreholes were backfilled with bentonite as per Ontario Reg. 128 (amendment to O. Reg. 903).
7	Surveying of boreholes.	√ Sept. 2006		The as-drilled locations were staked in the field and the station and offset and elevation were measured by survey. The elevations were referenced to geodetic datum.
8	Submission of Foundation Investigation and Design Reports, via the TPM to MTO's Project Manager and to the MTO Foundation Group.	√ Oct. 2006		Draft reports not submitted to MTO Foundations group for this project – Northeastern Geotechnical will review reports.
9	Report signed and sealed by two P.Eng.'s from Golder, one of whom is the Designated MTO Contact.	√ Oct. 2006		
10	Report(s) in two sections i) Foundation Investigation Report ii) Foundation Design Report	√ Oct. 2006		

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DOCUMENT REVIEW, INVESTIGATION, TESTING AND FOUNDATION REPORTING
FOUNDATION INVESTIGATION AND DESIGN
HIGHWAY 11 & 17 CHANGEABLE MESSAGE SIGNS (CMS)
NORTHEASTERN REGION, G.W.P. 5671-04-00**

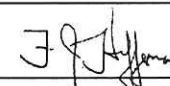
Number	Item	Initial and Date		Project Specific Comments
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11	Foundation Investigation Report presents a subsurface model under the plan limits of foundation elements, and at the immediate approaches within 20 m of the structure. Reports consist of factual information only. Includes sections on Site Description, Investigation Procedures, and Description of Subsurface Conditions.	√ Oct. 2006		n/a
12	Presentation of Record of Borehole sheets to MTO format.	√ Oct. 2006		
13	Presentation of Borehole Location Plan and Soil Strata drawing to MTO format.	√ Oct. 2006		Cross sections at the VMS Sign locations not necessary.
14	Presentation of Figures (Grain Size Distribution, etc.) to MTO format.	√ Oct. 2006		
15	Foundation Design Report presents discussion and recommendations for design with recommendations in accordance with the Highway Bridge Design Code currently in effect at MTO pertaining to both temporary and permanent conditions of the Project.	√ Oct. 2006		
16	Appropriate range of alternatives considered.	√ Oct. 2006		
17	Structure foundations design addressed including axial and lateral resistances for shallow / deep foundations.	√ Oct. 2006		
18	Earth pressure design addressed.	√ Oct. 2006		
19	Embankment design addressed, including settlement analysis for the new approaches, and stability of existing embankments during construction.	√ Oct. 2006		n/a
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NORTHEASTERN REGION, G.W.P. 5671-04-00

Number	Item	Initial and Date		Project Specific Comments
		Complete	In Progress	
21	Construction concerns addressed including any required specifications and special provisions for materials and specialized construction activities and recommendations for methods of overcoming anticipated construction problems.	√ Oct. 2006		Non-standard special provisions included in appendices in the reports as follows: NSSP – Ground Control NSSP – Rock Fill Excavation NSSP – Anchor Pull-out Testing NSSP – Mass Concrete NSSP – Arrestor Bed Restoration
22	MTO and TPM comments addressed in final Foundation Investigation Design Reports.	√ Oct. 2006		MTO comments on draft reports contained in letter dated October 27, 2006. MTO comments addressed in final reports and in Golder response to MTO comments letter dated November 23, 2006.

Milestone Quality Review No. 1: Audit Report
(submission of Final Reports)

Designated MTO Contact



Date November 24, 2006

Project Manager



Date November 24, 2006

**PHASE I – QUALITY CONTROL CHECKLIST
DOCUMENT REVIEW, INVESTIGATION, TESTING AND FOUNDATION REPORTING
FOUNDATION INVESTIGATION AND DESIGN
HIGHWAY 11 & 17 CHANGEABLE MESSAGE SIGNS (CMS)
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STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.5671-04-00

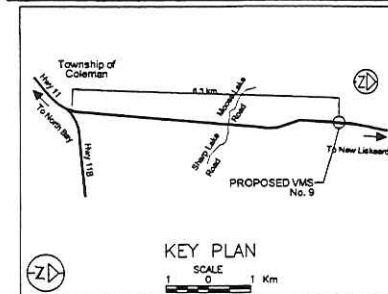


HIGHWAY 11, COBALT
OVERHEAD SIGN STATION 12+570
BOREHOLE LOCATION PLAN

SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

Borehole			
No.	ELEVATION	STATION	OFFSET
BH06-1	302.13	12+578.5	10.6 LEFT

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REFERENCE

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PLAN
SCALE
10 0 10 20 m

12+500

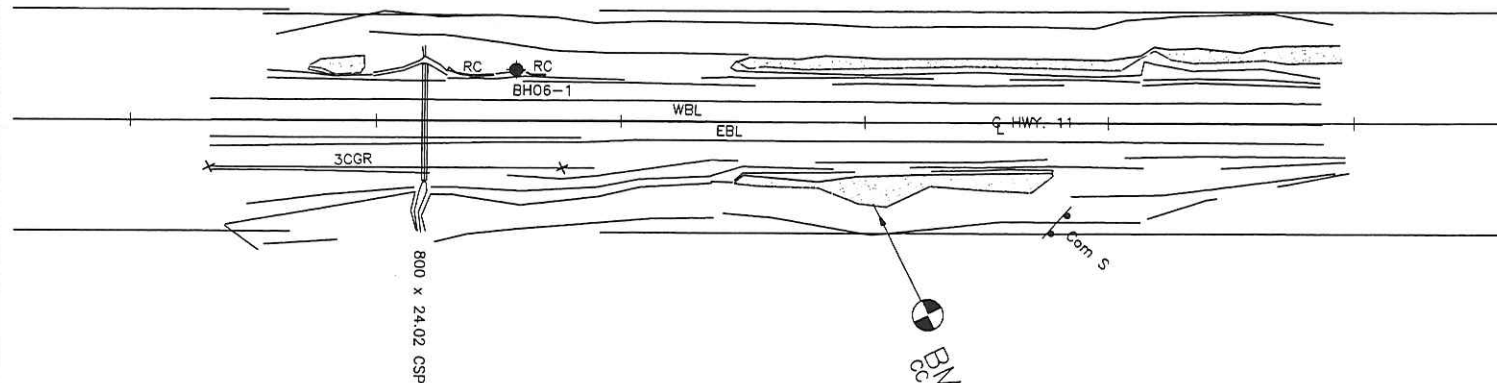
12+550

12+600

12+650

12+700

12+750



NO.	DATE	BY	REVISION
1	NOV 24/06	FJH	1
Geocres No. 31M-69			
HWY. 11	PROJECT NO.06-1191-021-9B	DIST.	
SUBM'D. KSL	CHKD. SEP	DATE: NOV 2006	SITE:
DRAWN: RN	CHKD.	APPD. FJH	DWG. 1