

Golder Associates Ltd.

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



**FOUNDATION INVESTIGATION AND DESIGN REPORT  
VARIABLE MESSAGE SIGN #9  
HIGHWAY 11 SOUTHBOUND NEAR HIGHWAY 11B JUNCTION  
COBALT, ONTARIO  
G.W.P. 5219-06-00**

Submitted to:

IBI Group  
230 Richmond Street West, 5<sup>th</sup> Floor  
Toronto, Ontario  
M5V 1V6

GEOCRES. NO.: 31M-71

**DISTRIBUTION**

- 6 Copies - Ministry of Transportation, Ontario  
North Bay, Ontario (Northeastern Region)
- 2 Copies - IBI Group  
Toronto, Ontario
- 2 Copies - Golder Associates Ltd.  
Sudbury, Ontario



January 10, 2008



07-1191-0039-9

## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
<b>PART A - FOUNDATION INVESTIGATION REPORT</b>	
1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	2
3.0 INVESTIGATION PROCEDURES.....	3
3.1 Foundation Investigation .....	3
4.0 GENERAL SITE GEOLOGY AND SUBSURFACE CONDITIONS .....	5
4.1 Regional Geology and Site Stratigraphy .....	5
4.2 Subsurface Conditions .....	5
4.2.1 Fill .....	5
4.2.2 Organics .....	6
4.2.3 Sand .....	6
4.2.4 Groundwater Conditions .....	6
4.3 Closure .....	7
<b>PART B - FOUNDATION DESIGN REPORT</b>	
5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS.....	8
5.1 General.....	8
5.2 Sign Foundation .....	8
5.2.1 Spread Footing .....	8
5.2.2 Geotechnical Resistance .....	10
5.2.3 Resistance to Lateral Loads .....	11
5.3 Construction Considerations .....	11
5.4 Closure .....	12

In Order  
Following Page 12

Lists of Abbreviations and Symbols  
Record of Borehole Sheets (BH06-2, BH06-3)  
Drawing 1  
Figures 1 and 2  
Appendix A

## **TABLE OF CONTENTS (CONTINUED)**

### **LIST OF DRAWINGS**

Drawing 1 Highway 11, Cobalt, Variable Message Sign #9 (Station 17+112), Borehole  
Locations

### **LIST OF FIGURES**

Figure 1 Grain Size Distribution – Silty Sand (FILL)  
Figure 2 Grain Size Distribution – Sand

### **LIST OF APPENDICES**

Appendix A Non-Standard Special Provisions  
- Control of Overburden Soils for Foundation Excavations

**PART A**

**FOUNDATION INVESTIGATION REPORT  
VARIABLE MESSAGE SIGN #9  
HIGHWAY 11 SOUTHBOUND NEAR HIGHWAY 11B JUNCTION  
COBALT, ONTARIO  
G.W.P 5762-04-00**

## **1.0 INTRODUCTION**

In 2006, Golder Associates Ltd. (Golder) was retained by IBI Group (IBI) to carry out a foundation investigation for two possible variable message sign (VMS) locations in Cobalt, Ontario, for the Ministry of Transportation, Ontario (MTO). 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. The results of the investigation are summarized in:

“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. GEOCREC. No. 31M-69”

Initially, MTO was proposing a cantilever sign structure at Site A. Consideration was also given to a truss mounted sign with supports on each side of the highway. We understand the MTO has decided to locate the Cobalt VMS at Site A as a single pole mounted sign founded on a spread footing. We further understand the proposed sign location has not changed from the location where the subsurface investigation was carried out in 2006. The general location of the site is shown on Drawing 1.

## **2.0 SITE DESCRIPTION**

The proposed sign will be located approximately 0.5 km south of the junction with Highway 11B at Station 17+112, offset 4.5 m from the southbound edge of pavement. The terrain on either side of the highway is generally flat with low-lying swampy areas. A shallow ditch parallels the southbound lane about 17 m to the west of the highway shoulder. A number of paved and gravel surface driveways connect to the highway on both sides of the proposed sign location.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Foundation Investigation**

As presented in the original Foundation Investigation and Design Report, dated November 24, 2006 (GEOCRE. No. 31M-69), the subsurface investigation work at the proposed VMS #9 locations Site A and Site B was carried out on July 13 and 14, 2006. Borehole BH06-1 was advanced at the proposed Site B location; Borehole BH06-2 at Station 17+112 in the southbound shoulder of Highway 11 and Borehole BH06-3 at Station 17+105 in the northbound shoulder of the highway were advanced at the proposed Site A location. BH06-3 was advanced for the alternative of constructing a truss mounted sign with supports on either side of Highway 11. The locations of Boreholes BH06-2 and BH06-3 pertinent to the presently proposed Site A location of VMS #9 are shown on Drawing 1.

The foundation investigation in 2006 was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. Boreholes BH06-2 and BH06-3 were advanced to a depth of 9.8 m below the existing ground surface using hollow stem augers. 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). The groundwater conditions in the open boreholes were observed during the drilling operations, and the results of the water level measurements upon completion of drilling 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 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.

The boreholes were located using the stakes and/or paint marks sited in the field by IBI. For Borehole BH06-1 at Site B, the elevation, referenced to the geodetic datum, was obtained from a site survey conducted by surveyors retained by IBI. It should be noted that subsequent to completion of the 2006 field investigation, the MTO decided that Site B was the preferred location for VMS #9. Therefore, the MTO considered that it was not necessary to survey the actual locations of the two boreholes drilled at Site A.

We understand that Site A was reconsidered in 2007 as the final location of VMS #9. The exact sign location was reportedly established by IBI in the field during a September 2007 site visit and confirmed on October 26, 2007 during a follow-up visit. The locations of the two boreholes were established in 2006 by Golder using a hand-held GPS set to UTM coordinates and then converted in 2007 by Sutcliffe Rody Quesnel Inc. (SRQ) to MTM coordinates.



## **4.0 GENERAL SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology and Site Stratigraphy**

In the vicinity of Site A, glaciofluvial outwash deposits comprising sand and gravel overlie the Middle Precambrian rocks of the Cobalt Group<sup>1</sup>. The bedrock is characterized by sandstone and siltstone of the Lorrain and Gowganda Formations<sup>2</sup>, including quartz sandstone, micaceous and aluminous quartz sandstone, quartz-feldspar sandstone, minor conglomerate and siltstone, and argillite.

### **4.2 Subsurface Conditions**

Detailed descriptions of the subsurface soil and groundwater conditions as encountered in Boreholes BH06-2 and BH06-3 advanced during this investigation, together with the results of the laboratory tests carried out on selected samples, are given on the Record of Borehole 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 (SPTs) 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.

As indicated previously, Borehole BH06-2 was drilled in the shoulder of the southbound lane adjacent to the proposed sign location; Borehole BH06-3 was drilled approximately 7 m south of BH06-2 in the shoulder of the northbound lane of Highway 11.

#### **4.2.1 Fill**

A total thickness of 0.6 m of Granular 'A' fill was encountered in both boreholes at this site. The measured natural water contents of the Granular 'A' fill were 3 percent and 4 percent.

Beneath the Granular 'A' fill in both boreholes, a 1.1 m and 1.2 m thick layer of silty sand fill was encountered. The 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 had a very loose to compact relative density. The measured natural water contents of the silty sand fill were 4 percent and 10 percent. Grain size distribution tests on two samples of the silty sand fill are shown on Figure 1.

---

<sup>1</sup> Northern Ontario Engineering Geology Terrain Study, OGS Map 5041

<sup>2</sup> Sudbury Cobalt Geological Compilation Series, OGS Map 2361

#### **4.2.2 Organics**

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

#### **4.2.3 Sand**

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

The measured SPT 'N' values within the sand deposit ranged from weight of the hammer (0 blows) to 14 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 four samples of the sand are shown on Figure 2.


#### **4.2.4 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 were 2.1 m and 2.2 m depths 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.


### 4.3 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 Mr. André Bom, P.Eng., and was reviewed by Mr. André Zerwer, an Associate and Senior Geotechnical Engineer for Golder and Mr. Jorge Costa, a Principal and Designated MTO Contact for Golder. Mr. Costa also conducted a quality control review of the report.

#### GOLDER ASSOCIATES LTD

  
André Bom, P.Eng.  
Geotechnical Engineer



  
André Zerwer, P.Eng.  
Associate/Senior Geotechnical Engineer

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

  
AB/AZ/JMAC/lb

**PART B**

**FOUNDATION DESIGN REPORT  
VARIABLE MESSAGE SIGN #9  
HIGHWAY 11 SOUTHBOUND NEAR HIGHWAY 11B JUNCTION  
COBALT, ONTARIO  
G.W.P 5762-04-00**

## **5.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

### **5.1 General**

This section of the report provides foundation design recommendations for the proposed variable message sign (VMS #9) foundation. 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 Sign Foundation**

We understand the proposed sign will be located on the west side of Highway 11 approximately 4.5 m from the edge of pavement at Station 17+112 facing the southbound traffic. Borehole BH06-2 was advanced in the southbound shoulder at Station 17+112 and encountered a very loose to compact sand at a depth of about 1.7 m below ground surface to the full depth of the borehole. The unstabilized groundwater level in the open borehole upon completion of drilling was 2.1 m below the existing ground surface. Similar subsurface conditions were encountered at Borehole BH06-3 on the opposite (east) side of the highway.

Overhead sign supports are typically designed with a standard caisson foundation in accordance with the requirements in MTO's *Sign Support Manual*. However, 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 outlined in the standard cases. Based on a review of the subsurface information, the soils at this sign location have lower effective friction angles than required for the standard caisson design. For these subsurface conditions, a site-specific design is required.

We understand from IBI that the preferred alternative for the proposed foundation design is a spread footing, as decided by IBI's structural engineer.

#### **5.2.1 Spread Footing**

As noted in Section 5.2, the unstabilized groundwater level in Borehole BH06-2 was encountered at a depth of 2.1 m below the existing ground surface. Based on the depth of frost penetration

isopleths for Northern Ontario<sup>3</sup>, the depth of frost penetration for the Cobalt area is approximately 2.2 m; therefore, the founding depth of the spread footing will be at a minimum of 2.2 m below existing ground surface.

Depending on the season of construction, during excavation for the spread footing, the groundwater level is anticipated to be encountered at or above the proposed founding depth. Open cut excavations may not be practical for the proposed footing construction due to the anticipated shallow groundwater level and the proximity of Highway 11 located adjacent to the proposed excavation, unless appropriate dewatering is carried out to adequately depress the groundwater level.

In addition, basal instability due to groundwater pressures may occur during construction. According to the CFEM<sup>4</sup>, basal instability in cohesionless soils takes the form of piping/heave in the subgrade and is associated with groundwater flow. Shoring and possibly controlled dewatering will likely be required at this site to excavate the subsoils to the proposed founding depth. However, if dewatering is carried out, it should be carefully monitored as it may negatively impact the existing highway pavement structure locally. Should dewatering and shoring be used during construction, the contractor should design the shoring in accordance with MTO's Special Provision No. 105S19, to meet Performance Level 2.

Relevant design parameters for the shoring are provided below:

Design Parameter	Native Sand
Unit Weight above Groundwater Level $\gamma$ (kN/m <sup>3</sup> )	20
Unit Weight below Groundwater Level $\gamma'$ (kN/m <sup>3</sup> )	10
Friction Angle $\phi$ (°)	27
$K_a$ *	0.37
$K_p$ *	2.66
$K_o$ *	0.45

\* Earth pressure coefficients for horizontal backfill.

During construction, stockpiles should be placed well away from the edge of the excavation, and their height should be controlled so they do not surcharge the sides of the excavation and/or overall slope.

<sup>3</sup> Ontario Provincial Standard Drawing (OPSD) 3090.100

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

The depth of the shoring embedment below the excavation base is dependent on the size of excavation. A greater embedment depth may be required for larger excavations. Furthermore, the stability of the excavation base must be considered in the shoring design.

Disturbance of the underlying materials during construction of the spread footing could influence the settlement of the structure. MTO's Special Provision No. 902S01 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 the foundation areas has been adequately prepared.

The base of the excavation should be free of water and loose soil prior to placing concrete. Should the materials at bearing level become saturated or disturbed, we recommend that the affected material be removed prior to placing concrete. It is recommended that the prepared subgrade be protected using a 150 mm thick mud mat comprised of a minimum 5 MPa concrete or working mat composed of a minimum 300 mm thick mat of compacted Granular 'B' Type II or Granular 'A' meeting MTO's Special Provision SP110S13, placed across the bottom of the excavation immediately upon completion of the excavation and review by the QVE to limit the disturbance and to provide a platform for construction of the spread footing.

### **5.2.2 Geotechnical Resistance**

Spread footings constructed on the properly prepared subgrade at or below the depth given in Section 5.2.1 may be designed based on a factored value of 300 kPa at Ultimate Limit States (ULS) for a spread footing, rectangular in shape up to 5.0 m long by 2.5 m wide. For the same spread footing dimension indicated above, a geotechnical resistance value of 100 kPa for Serviceability Limit States (SLS; for 25 mm settlement) design may be assumed. Design of the proposed sign foundation should also be checked for and provisions made to resist buoyant forces.

The ULS resistance and settlement are dependent on the footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the selected footing width/diameter or founding depths differs from those given above.

The geotechnical resistances provided above are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with the *Canadian Highway Bridge Design Code (CHBDC)*.

### 5.2.3 Resistance to Lateral Loads

Resistance to lateral forces / sliding resistance between the concrete footings and the prepared subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. For cast-in-place concrete footings constructed on the generally loose to compact sand or compacted granular pad, the coefficient of friction,  $\tan \phi'$ , can be taken as 0.5. This value is unfactored; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

### 5.3 Construction Considerations

The excavation around and above the spread footing may be backfilled using an approved granular material meeting MTO's Special Provision SP110S13 such as Granular 'A' or 'B' Type II placed in 300 mm loose lifts and uniformly compacted to 95 per cent standard Proctor maximum dry density. The use of native excavated materials as backfilled material is not recommended.

It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of the following item which is expected to affect the installation of the variable message sign foundation:


- **Control of overburden soils for spread footings:** Excavations for the sign foundations 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 excavations will have to be advanced using shoring, possibly in conjunction controlled dewatering or with fluid support, in order to minimize ground loss during excavation and concrete placement. The contractor is responsible to ensure that appropriate construction procedures and equipment are used for spread footing construction. An example NSSP to warn the contractor of such conditions is presented in Appendix A.




## 5.4 Closure

This report was prepared by Mr. André Bom, P.Eng., a Geotechnical Engineer, and the technical aspects were reviewed by Mr. André Zerwer, an Associate and Senior Geotechnical Engineer for Golder and Mr. Jorge M.A. Costa, a Principal with Golder. Mr. Costa, also a Designated MTO Contact for Golder, conducted a quality control review of the report.

### GOLDER ASSOCIATES LTD.

  
André Bom, P.Eng.  
Geotechnical Engineer



  
André Zerwer, P.Eng.  
Associate/Senior Geotechnical Engineer

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



AB/AZ/JMAC/lb

## 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

#### Piezcone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

Density Index (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

#### (b) Cohesive Soils

#### Consistency

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

### IV. SOIL TESTS

w	water content
w <sub>p</sub>	plastic limit
w <sub>l</sub>	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
D <sub>R</sub>	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

## LIST OF SYMBOLS

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

### I. GENERAL

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

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

#### (a) Index Properties

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

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x 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
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

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

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

PROJECT		RECORD OF BOREHOLE No BH06-2				1 OF 1 METRIC											
W.P. 5762-04-00		LOCATION N 5248888.8 ; E 398381.1				ORIGINATED BY DB											
DIST _____ HWY 11		BOREHOLE TYPE Power Auger, 108mm ID Hollow Stem Augers				COMPILED BY AB											
DATUM Geodetic		DATE 07/13/06				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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
288.5	GROUND SURFACE							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
0.0	Granular 'A' (FILL)		1	AS	-												
287.9	Silty sand (FILL) Compact to loose Brown Moist		2	DO	15												1 94 (5)
286.8	Silty organic material Black SAND, trace silt Compact to very loose Grey Wet		3	DO	7												
1.7			4	DO	10												
			5	DO	3												0 97 (3)
			6	DO	4												
			7	DO	7												
			8	DO	4												0 94 (6)
			9	DO	WH												
			10	DO	7												
278.7	End of Borehole																
9.8	Notes: 1. Water level at a depth of 2.1m (Elev. 286.4m) upon completion of drilling.																

[illegible]

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

CONT No.  
WP No. 5674-04-01

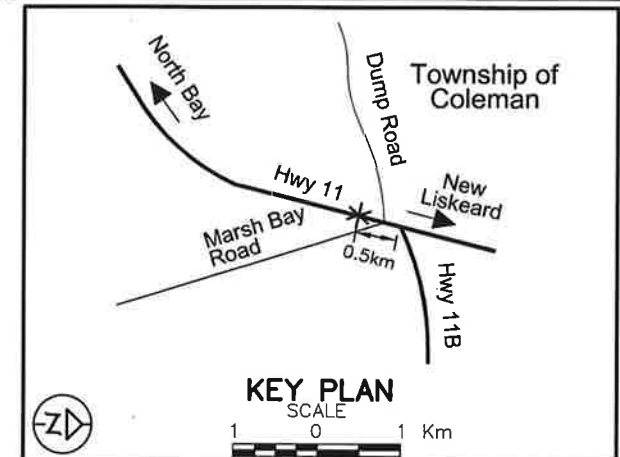


HIGHWAY 11, COBALT  
VARIABLE MESSAGE SIGN #9  
(STATION 17+112)  
BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.  
SUDBURY, ONTARIO, CANADA



### LEGEND

Borehole Location

No.	ELEVATION(m)	COORDINATES	
		NORTHING	EASTING
BH06-2	288.5	5248888.8	3938381.1
BH06-3	288.5	5248879.8	3938388.1

### NOTES

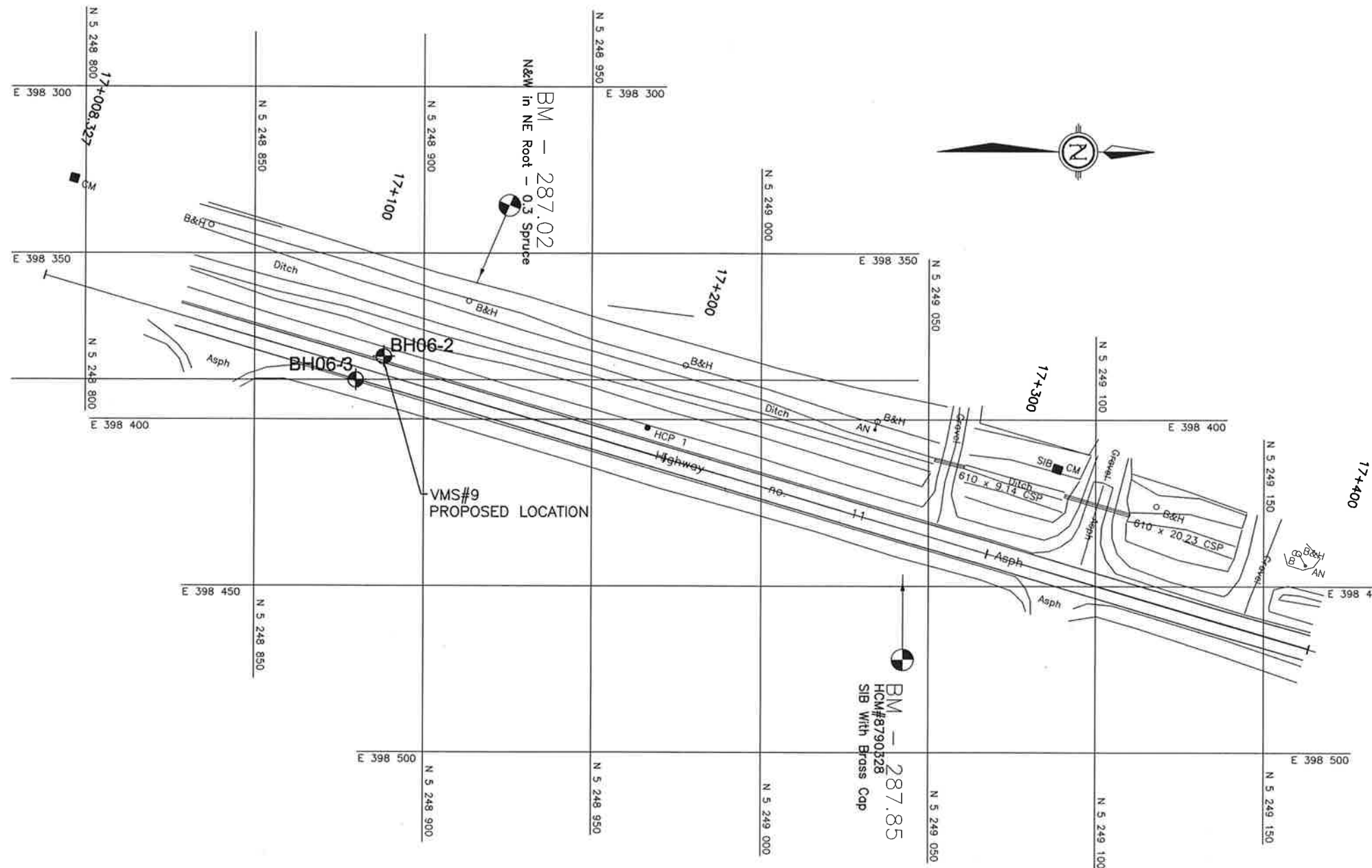
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The 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. Cobalt.dwg and VSM#9.dwg dated December, 2007, received December 4, 2007.

NO.	DATE	BY	REVISION
Geocres No. 31M-71			
HWY: 11	PROJECT NO. 07-1191-0039-9		DIST.
SUBM'D. AB	CHKD. JMAC	DATE: JAN. 2008	SITE:
DRAWN: BB	CHKD.	APPD. JMAC	DWG. 1



### PLAN

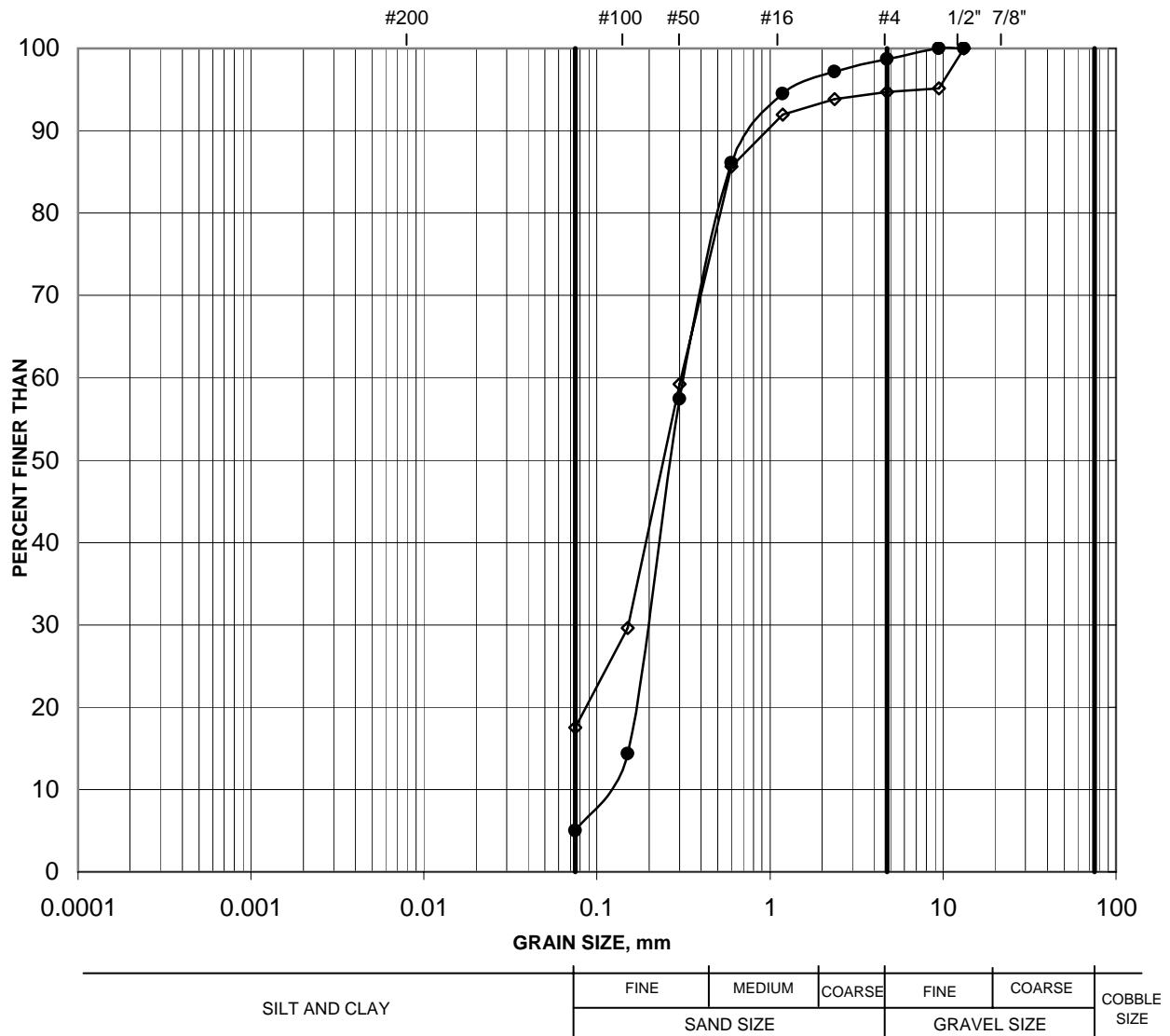
SCALE  
20 0 20 40 m



# GRAIN SIZE DISTRIBUTION

## Silty Sand (FILL)

FIGURE 1



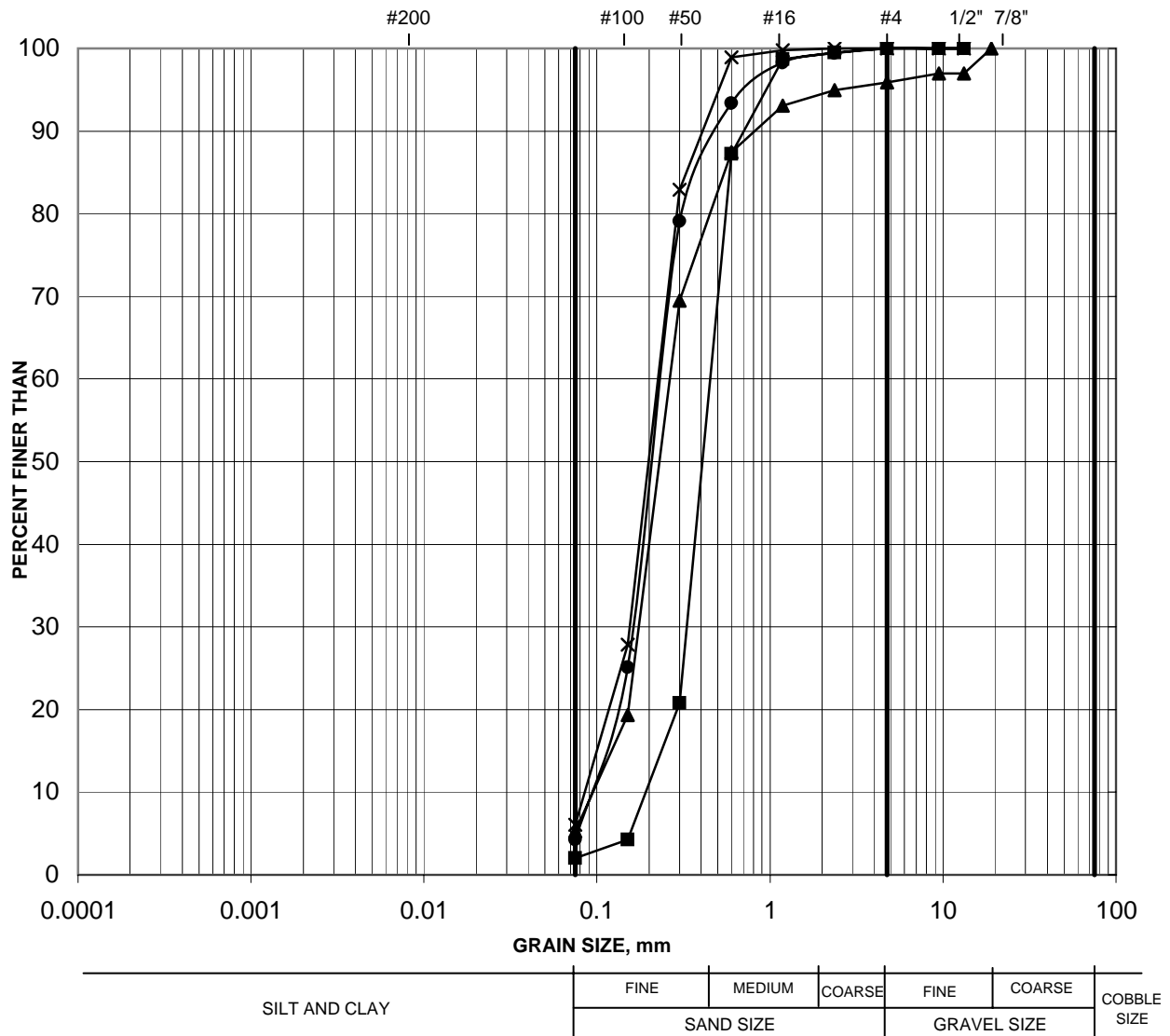
	Borehole	Sample	Elevation (m)
●	06-2	2	284.4
◇	06-3	2	284.4

Project: 07-1191-0039-9  
(Originally reported under 06-1191-021-9)

# GRAIN SIZE DISTRIBUTION

Sand

FIGURE 2



	Borehole	Sample	Elevation (m)
■	06-2	5	285.1
×	06-2	8	282.1
▲	06-3	6	284.4
●	06-3	8	282.1

Project: 07-1191-0039-9  
(Originally reported under 06-1191-021-9)



**APPENDIX A**  
**NON-STANDARD SPECIAL PROVISION**

**CONTROL OF OVERBURDEN SOILS FOR FOUNDATION EXCAVATIONS -**  
**Item No.**

---

**Non-Standard Special Provision**

---

This special provision is to highlight the construction concerns for the installation of VMS#9 (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 construction.

**Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the Work.

END OF SECTION