



November 28, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

**VARIABLE MESSAGE SIGN #22
HIGHWAY 101 WESTBOUND
APPROXIMATELY 0.6 KM EAST OF HIGHWAY 17
WAWA, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5143-11-00**

Submitted to:

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REPORT



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PART A

FOUNDATION INVESTIGATION REPORT

VARIABLE MESSAGE SIGN #22

HIGHWAY 101 WESTBOUND

APPROXIMATELY 0.6 KM EAST OF HIGHWAY 17

WAWA, ONTARIO

GWP 5143-11-00



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by IBI Group (IBI) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for a variable message sign (VMS #22) on Highway 101 westbound in Wawa, Ontario. 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 MTO's Request for Proposal (RFP) dated January 11, 2010. Golder's Proposal P0-1191-0006, dated February 5, 2010 and subsequent Change Request No. 1, dated December 3, 2010, and Revised Change Request No. 2, dated October 31, 2011, formed part of IBI's agreement (Number 5009-E-0018) for this project. The work was carried out in accordance with Golder's Quality Control Plan for this project dated August 23, 2010. The site plan was provided to Golder by EXP Services Inc. on behalf of IBI in September 2014.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed sign by methods of borehole drilling, in situ testing and laboratory testing on selected soil samples.

2.0 SITE DESCRIPTION

The proposed VMS #22 is to be located on the west side of Highway 101 alignment, approximately 0.6 km north of the intersection with Highway 17 at approximately STA 10+784 in the Township of McMurray, Wawa, Ontario. This section of Highway 101 consists of a two-lane highway with fully paved shoulders. For the purposes of this report, the Highway 101 alignment is in an east-west orientation and therefore locally may differ from that shown on the drawing, which represents magnetic north. The ground surface of the highway embankment at the proposed structure location is at approximately Elevation 287.5 m.

The topography of the site consists of a generally flat-lying area with scattered trees bordering both sides of the highway corridor. Bordering the east side of the highway corridor is an exposed bedrock outcrop and an all-terrain vehicle trail parallel to the highway alignment. Bordering the site to the west is a park area comprised of a parking area and playground. Two photographs of the site are presented following the text of this report.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation for the VMS #22 structure was carried out on December 13, 2011, at which time one sampled Borehole (BH-VMS#22) was advanced to the south of the proposed location of VMS #22 due to the presence of overhead electrical lines in close proximity to the sign location. The location of the borehole is shown on Drawing 1.

The foundation investigation was carried out using a truck-mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The borehole was advanced to a depth of 9.8 m below ground surface, using 108 mm inner diameter (I.D.) hollow stem augers. Soil samples were obtained within the sampled borehole at intervals of depth of about 0.75 m to 1.5 m, using a 50 mm outside diameter split-spoon sampler operated by an automatic hammer on the truck mounted drill rig, performed in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Details of the subsurface conditions encountered at the borehole locations are shown on the Record of Borehole sheet following the text of this report. The borehole was backfilled with bentonite upon completion of drilling in accordance with Ontario Regulation 903 Wells (as amended).



The fieldwork was supervised throughout by a member of Golder's technical staff, who located the borehole, arranged for the clearance of underground services and for traffic protection, observed the drilling, sampling and in situ testing operations, logged the boreholes and DCPT, 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 classification testing (water contents and grain size distributions) of selected soil samples. All of the laboratory tests were carried out to MTO and/or ASTM standards, as appropriate.

The as-drilled borehole location was measured in reference to stakes positioned at the proposed sign locations by IBI and the location was subsequently converted into MTM NAD 83 coordinates in AutoCAD. The ground surface elevation at the borehole location was inferred from the cross section survey provided IBI. The coordinates of the borehole and the ground surface elevation and drilled depth are provided below.

Borehole Number	MTM NAD83 Zone 13 Northing (m)	MTM NAD83 Zone 13 Easting (m)	Ground Surface Elevation (m)	Depth Drilled (m)
BH-VMS#22	5 315 517.2	246 376.8	287.5	9.8

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geology

Based on terrain mapping by the Ontario Geological Survey¹, the subsurface soils in the vicinity of the site consist of outwash plain deposits comprising primarily sands and gravels. Immediately adjacent to the roadway along the north side is a jagged bedrock ridge. The bedrock in the vicinity of the site is characterized by the Ministry of Natural Resources² maps as felsic to intermediate metavolcanic rocks very closely bordered by mafic metavolcanic rocks both of the early Precambrian era.

4.2 General Overview of Local Subsurface Conditions

The detailed descriptions of the subsurface soil and groundwater conditions as encountered in the borehole advanced during this investigation, together with the results of the laboratory tests carried out on selected samples, are given on the attached Record of Borehole sheet in Appendix A and the soil laboratory test sheets provided in Appendix B. The results of the in situ field tests (i.e. SPT 'N'-values) as presented on the Record of Borehole sheets and in this section are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheet are inferred from non-continuous sampling, observations of drilling progress and the results of SPTs. These boundaries, therefore, represent transitions between material types rather than exact planes of geological change. Further, subsurface conditions will vary beyond the borehole location.

¹ Ontario Geological Survey, Ministry of Northern Development and Mines, and Northeast Science and Information Section, Ministry of Natural Resources 2005. Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Map 41NNE, September 2014.

² Ministry of Natural Resources, 1980, Geological Highway Map, Northern Ontario, Map 2440.



In summary, the subsoil conditions at the site consist of granular fill (roadway shoulder materials) underlain by a deposit of loose to compact silt to silt and sand. A more detailed description of the subsurface conditions encountered in the borehole is provided in the following sections.

4.2.1 Sand to Sand and Gravel (Fill)

A 110 mm thick layer of asphalt was encountered from ground surface at Elevation 287.5 m. Underlying the asphalt, a 1.4 m thick deposit of moist, brown fill, comprised of an upper layer of sand and gravel and lower layer of sand, was encountered.

One SPT 'N'-value measured within the granular fill is 16 blows per 0.3 m of penetration, indicating a compact relative density.

4.2.2 Silt to Silt and Sand

A deposit of moist, brown to grey, silt and sand grading to silt at depth was encountered below the fill deposit. The surface of the silt to silt and sand deposit was encountered at Elevation 286.1 m and was explored for a thickness of 8.4 m without penetrating through the deposit.

The SPT 'N'-values measured in the silt to silt and sand deposit range from 6 blows to 22 blows per 0.3 m of penetration, indicating a loose to compact relative density.

Grain size distribution tests were carried out on four samples of the silt to silt and sand deposit and the test results are presented on Figure B1 in Appendix B.

4.2.3 Groundwater Conditions

Borehole BH-VMS#22 was dry upon completion of drilling as noted on the Record of Borehole sheet. It should be noted that the groundwater elevation will fluctuate seasonally depending on precipitation and should be expected to rise during wet periods of the year.

5.0 CLOSURE

The fieldwork for this project was carried out by Mr. Ed Savard from our Sudbury office under the coordination of Mr. David Muldowney, P.Eng.. This report was prepared by, Mr. Adam Core, E.I.T., and the technical aspects were reviewed by Ms. Sarah E. M. Poot, P.Eng., Associate. Mr. Jorge M.A. Costa, P.Eng., a Principal with Golder and Designated MTO Contact for Golder, conducted a quality control review of the report.



Report Signature Page

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PART B

FOUNDATION DESIGN REPORT

VARIABLE MESSAGE SIGN #22

HIGHWAY 101 WESTBOUND

APPROXIMATELY 0.6 KM EAST OF HIGHWAY 17

WAWA, ONTARIO

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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the proposed Variable Message Sign (VMS #22) on the west side of Highway 101 in Wawa, Ontario. The recommendations are based on interpretation of the factual data obtained from the borehole and auger probes 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 feasible foundation design alternatives and to design the proposed sign foundation. 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.

6.2 Sign Foundation

We understand that the proposed sign will be located on the north side of Highway 101 at STA 10+784 facing the westbound traffic with the centre of the footing located approximately 4.5 m from the edge of the pavement.

Borehole BH-VMS#22 was advanced at STA 10+784 within the travelled lane approximately 5.6 m from the centre of the proposed sign location (i.e., approximately 1.1 m west of the edge of the pavement) and encountered asphalt and granular fill to a depth of 1.4 m below the existing ground surface, underlain by a deposit of loose to compact silt to silt and sand extending to a depth of 9.8 m below the ground surface. The borehole was noted to be dry upon completion of drilling.

VMS pole mounted sign supports are typically designed using a standard caisson foundation in accordance with the requirements in MTO's Sign Support Manual (2011). Based on discussions with IBI and the structural designer, given the existing subsurface conditions at the location of the proposed sign support foundations, the preferred foundation alternative for supporting the overhead sign is a standard caisson founded on native soils. Alternatively, a spread footing option is also suitable, from a foundation perspective and the foundation options are discussed in Sections 6.2.2 and 6.2.3.

Table 1 (attached) summarizes the advantages, disadvantages, relative costs and risks/consequences of the foundation alternatives.

6.2.1 Frost Protection

As shown on Ontario Provincial Standard Drawing (OPSD) 3090.100 (Foundation, Frost Penetration Depths for Northern Ontario), the depth of frost penetration for the Wawa area is about 2.2 m. As such, it is recommended that the spread footing, if adopted as the support foundation, be covered with a minimum thickness of 2.2 m of soil cover or equivalent thickness of insulation for protection from frost penetration.

6.2.2 Caisson Foundation

A caisson foundation for the overhead sign should be designed in accordance with the requirements in the Sign Support Manual (2011) for standard size signs. The Sign Support Manual (2011) includes a standard caisson



foundation design (Section 8 and Standard Drawing SS118-3), in which caissons are extended 5 m below the design frost depth (2.2 m for this site), except where bedrock is encountered within this depth. For a pole mounted sign foundation for the VMS #22 site, the minimum caisson founding depth would therefore be 7.2 m below ground surface.

The minimum design parameters/values specified in the Sign Support Manual (2011) for caissons are applicable to the design of the foundation for VMS #22 given that the minimum soil conditions for Case 1 (Sand) are available:

- Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third portion of the caisson below the design frost depth.

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:

$$P_p = K_p \gamma d_w \text{ above the groundwater table; and}$$

$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) \text{ below the groundwater table}$$

where K_p is the passive earth pressure coefficient;

γ is the bulk unit weight of the soil (kN/m³);

γ' is the effective unit weight of the soil 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).

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. In addition, for foundation design, full passive resistance will be mobilized only where the ground surface in front of and behind the caisson is level. The K_p value of the sand deposit is 2.78 for the upper 2/3 of the caisson section (i.e., for Φ equal to 28°) and 3.0 for the lower 1/3 of the caisson section (i.e., for Φ equal to 30°). Where sloping ground is present adjacent to the caisson foundation or where the foundation will be installed at the crest of an embankment, the K_p values used in the calculation of the passive resistance should be adjusted to account for the presence of the sloping ground.

Based on the subsurface conditions encountered at the proposed sign location (i.e., loose to compact silt to silt and sand), the installation of the caisson should be carried out with a temporary steel liner to avoid the open hole from caving or sloughing prior to pouring concrete. Although at the time of drilling the borehole was noted to be dry, if water is encountered as the caisson hole is advanced, balanced head condition should be maintained inside the liner at all times during construction to reduce the potential for base heave and ground loss. If the liner is generally dry following augering/excavation, cast-in-place concrete may be used; however, tremie concrete will be required if dewatering inside the liner is not possible.

As concrete is placed in the liner-protected hole (by tremie placement method when under water) the temporary steel liner should be removed progressively to the extent that the surface of the concrete is always within the steel liner to prevent caving-in of the hole, and removal of the liner can occur simultaneously.



Consideration can be given to leaving the steel liner in place permanently. However, the standard caisson foundation design for a cantilever static sign support, as specified in the Sign Support Manual (2011), assumes that there is intimate contact between the poured concrete and the subgrade soils, which cannot occur with use of a permanent steel liner. If the temporary steel liner is to be left in place, the design for the caisson foundation should be checked considering a friction factor between the steel and the native subgrade soil of $\tan \delta = 0.25$.

6.2.3 Spread Footing

This section of the report provides recommendations for the support of VMS #22 on a spread footing as an alternative to a caisson foundation.

A spread footing constructed on the properly prepared subgrade at or below the frost penetration depth given in Section 6.2.1 may be designed based on a factored geotechnical axial resistance of 250 kPa at Ultimate Limit States (ULS) for a footing rectangular in shape up to 5.0 m long by 2.5 m wide. A geotechnical axial reaction value of 100 kPa at Serviceability Limit States (for 25 mm settlement) may be used for design for the same footing dimension. 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 dimensions or founding depth differs from those given above. The geotechnical resistances provided above are given for loads that will be applied perpendicular to the surface of the footing. Where the load is not applied perpendicular to the surface of the footing, inclination of the loads should be taken into account in accordance with Clauses 6.7.4 and C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC, 2006) and the related commentary.

Resistance to lateral forces / sliding resistance between the concrete footing and the prepared subgrade should be calculated in accordance with Section 6.7.5 of the CHBDC. For a cast-in-place concrete footing constructed directly on the native silt to silt and sand, the coefficient of friction, $\tan \delta$, can be taken as 0.50. If the footing is constructed on a compacted sand and gravel working pad, the coefficient of friction, $\tan \delta$ may be taken as 0.55. The above noted values are unfactored.

An open cut excavation of short duration through the granular fill and sand deposit is considered feasible for the proposed footing. The excavation for the proposed footing should be carried out in accordance with the latest Occupational Health and Safety Act for Construction Projects (OHSA). When referencing OHSA, the existing granular fill should be considered as "Type 3 Soil" and temporary excavation side slopes should be made no steeper than 1 horizontal (H) to 1 vertical (V). Depending on the groundwater level at the time of construction, the excavation side slopes may have to be flatter (i.e. 2H:1V).

Care must be taken by the Contractor during excavation of the footing adjacent to the highway to minimize impact to the existing roadway. Provision for protection of the existing pavement structure will be required in accordance with Ontario Provincial Standard Specifications (OPSS) 539 (Temporary Protection Systems), designed to meet Performance Level 2. Relevant design parameters for the shoring are provided below.



Design Parameter	Granular Fill & Sand
Unit Weight of soil above Groundwater Level γ (kN/m ³)	20
Unit Weight of soil below Groundwater Level γ' (kN/m ³)	10
Friction Angle ($^{\circ}$)	28
K_a^*	0.36
K_p^*	2.78
K_o^*	0.53

* 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 the overall local embankment slope. For this site, the distance between the crest of the excavation and the toe of the stockpile should generally be greater than the diameter of the base of the stockpile.

Disturbance of the underlying materials during construction of the spread footing could influence the settlement of the structure. Therefore, OPSS 902 (Excavating and Backfilling – Structures) should be included in the Contract Documents, requiring inspection and approval of the foundation area by the Quality Verification Engineer (QVE) prior to footing construction, to ensure that the foundation area has been adequately prepared for construction of the spread footing.

The base of the excavation should be free of water and loose soil prior to placing concrete. Should the material(s) at bearing level become saturated or disturbed, we recommend that the affected material be removed immediately prior to placing concrete. Protection of the prepared subgrade or backfilling to the design base of footing elevation could consist of granular working pad comprised of compacted Granular 'A' or Granular 'B' Type II meeting the requirements in OPSS.PROV 1010 (Aggregates). The working pad would be placed across the bottom of the excavation immediately upon completion of the excavation and review by the QVE. The Granular 'A' or Granular 'B' Type II should be placed in maximum 300 mm loose lifts and uniformly compacted to the requirements outlined in OPSS 501 (Compacting).

6.3 Construction Considerations

The performance of the caisson is dependent on the cleanliness of the base of the caisson such that all loose cuttings are removed to ensure the concrete is in intimate contact with the founding stratum at the base of the shaft. The inspection of the base of the shafts can be accomplished, after flushing and cleaning of the base by means of a Shaft Inspection Device (SID) such as a video camera. Should the camera inspection indicate that loosened/unacceptable soil is present at the base; the caisson base would need to be re-cleaned and re-inspected. The drilling and construction of the caisson foundations should be observed throughout by the QVE to confirm that the conditions encountered are consistent with the information obtained from the boreholes and that the required base and cleanliness has been achieved. At the least, the caisson should be measured for depths to verify/confirm that it is fully open/unobstructed to the design and drilled depth.



The excavation around and above the spread footing if this foundation alternative is adopted should be backfilled using an approved granular material such as OPSS.PROV 1010 (Aggregates) Granular 'A' or 'B' (Type I or II) placed in 300 mm thick loose lifts and uniformly compacted to the requirements outlined in OPSS 501 (Compacting). The existing native silt to silt and sand soils at this site are not suitable for re-use as backfill within the excavation, or for re-use in the roadway shoulder, as the fines content of the materials greatly exceeds the maximum fines (i.e., smaller than 75 µm) content granular materials specified in OPSS.PROV 1010 (Aggregates).

The final grade surrounding the sign should be sloped to promote drainage of surface water and from the pavement structure away from the pavement and sign, to the adjacent ditch and surfaced with topsoil and seed in accordance with OPSS 804 (Seed and Cover), or granular sheeting in accordance with OPSS.PROV 1004 (Aggregates - Miscellaneous). If the resulting side slopes in the immediate vicinity of the sign support foundation are steeper than 2 Horizontal to 1 Vertical, the slope should be covered with R-10 Rip-Rap, in accordance with OPSS.PROV 1004 (Aggregates - Miscellaneous), to reduce the potential for erosion of the slope locally.

7.0 CLOSURE

This report was prepared by Mr. Adam Core, E.I.T. and the technical aspects were reviewed by Ms. Sarah E. M. Poot, P.Eng., Associate. Mr. Jorge M. A. Costa, P.Eng., a Principal with Golder and Designated MTO Contact for Golder, conducted a quality control review of the report.



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- Ministry of Natural Resources, 1980, Geological Highway Map, Northern Ontario, Map 2440.
- Ministry of Transportation, Ontario, 2011. Sign Support Manual. Policy, Planning & Standards Division, Engineering Standards Branch, Bridge Office, April 2011.
- Occupational Health and Safety Act and Regulation for Construction Projects, January 2006.
- Ontario Geological Survey, Ministry of Natural Resources 2005. Ministry of Northern Development and Mines, and Northeast Science and Information Section, Digital Northern Ontario Engineering Geology Terrain Study (NOEGTS); Map 41NNE, September 2014.
- Unified Facilities Criteria, U.S. Navy. 1982. NAVFAC Design Manual 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.

STANDARDS

ASTM International

- | | |
|------------|---|
| ASTM D1586 | Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils |
|------------|---|

Ontario Provincial Standard Drawings

- | | |
|---------------|---|
| OPSD 3090.100 | Foundation, Frost Penetration Depths for Northern Ontario |
|---------------|---|

Ontario Provincial Standard Specifications

- | | |
|----------------|--|
| OPSS 501 | Construction Specification for Compacting |
| OPSS 539 | Construction Specification for Temporary Protection Systems |
| OPSS 902 | Construction Specification for Excavating and Backfilling – Structures |
| OPSS.PROV 1004 | Material Specification for Aggregates – Miscellaneous |
| OPSS.PROV 1010 | Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material |

Ontario Water Resources Act

- | | |
|---------------------------|-------|
| Ontario Regulation 903/90 | Wells |
|---------------------------|-------|



FOUNDATION REPORT
VMS #22 HIGHWAY 101 WESTBOUND GWP 5143-11-00

Table 1: Evaluation of Foundation Alternatives

Options	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Caisson	1	<ul style="list-style-type: none">■ Typical foundation alternative for sign of standard size.■ Subsurface conditions are suitable on standard caisson design as per the Sign Support Manual.	<ul style="list-style-type: none">■ Requires specialized drilling equipment.■ Temporary liner for soil support likely required during installation for sloughing and caving of cohesionless deposits.■ Depending on water level at time of construction, dewatering could be required within the liner for concrete placement in the dry or concrete would have to be placed by tremie methods below water.■ May require a levelling pad (fill or excavation of slope) to accommodate drilling equipment.	<ul style="list-style-type: none">■ Mobilization of specialized drilling equipment is relatively expensive, compared to equipment required to construct spread footing.■ Reduced cost if equipment is available locally for construction of other sign caisson foundations for the project.	<ul style="list-style-type: none">■ Risk of need for placement of concrete by tremie methods if unable to dewater within caisson liner.
Spread Footing	2	<ul style="list-style-type: none">■ Conventional construction and construction equipment.■ Design easily adaptable for non-standard sign size/configuration.	<ul style="list-style-type: none">■ Larger excavation required compared to caisson with potential impact to roadway.■ Site specific design to determine footing size to satisfy all loading conditions required.	<ul style="list-style-type: none">■ Much lower overall cost compared to caisson.■ Additional costs required for control of overburden but most likely an open cut excavation can be carried out as location of sign foundation not immediately adjacent to paved roadway.	<ul style="list-style-type: none">■ Dewatering/unwatering of excavation most likely not required at this site.

Note: This table should be read in conjunction with the Foundation Investigation and Design Report.

Compiled by: AC Reviewed by: JMAC

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

CONT No.
GWP No.5143-11-00

VARIABLE MESSAGE SIGN #22
HIGHWAY 101, WAWA
BOREHOLE LOCATION

SHEET



KEY PLAN

LEGEND

Approximate Borehole Location

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
BH-VMS#22	287.5	5315517.2	246376.8

NOTES

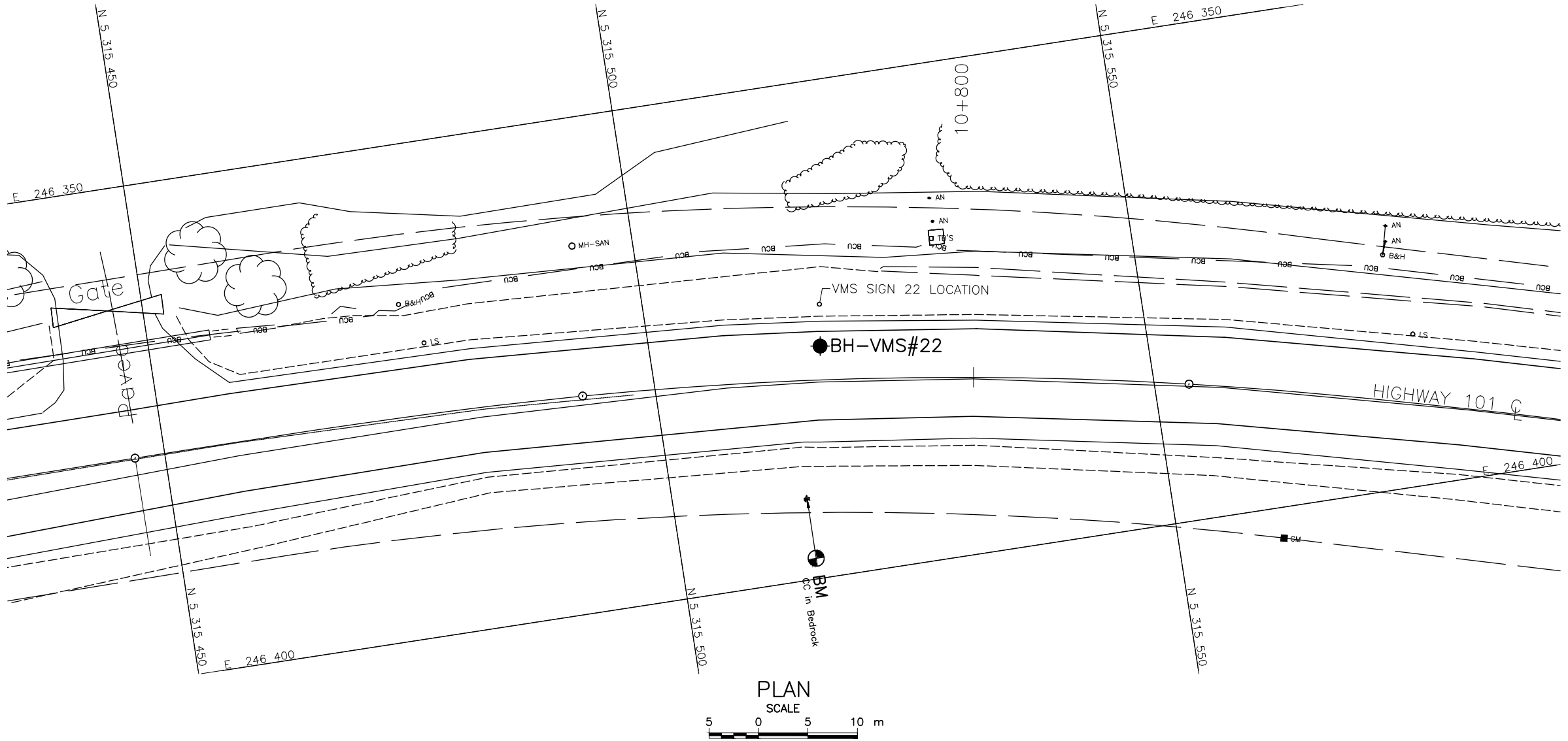
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

Key plan provided in digital format by IBI, drawing file no. TM-TWG-keyplan.dwg, received December 7, 2010.
Base plans provided in digital format by IBIGroup, drawing file no. VMS SIGN 22.dwg, received Sep 03, 2014.



NO.	DATE	BY	REVISION
Geocres No. 41N-30			
HWY. 101	PROJECT NO. 10-1191-0006		DIST. .
SUBM'D.	CHKD.	DATE: 11/28/2014	SITE: VMS #22
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 1



Photograph 1: Looking north from sign location



Photograph 2: Looking south from sign location





APPENDIX A

Record of Borehole and Drillhole



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

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

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



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

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

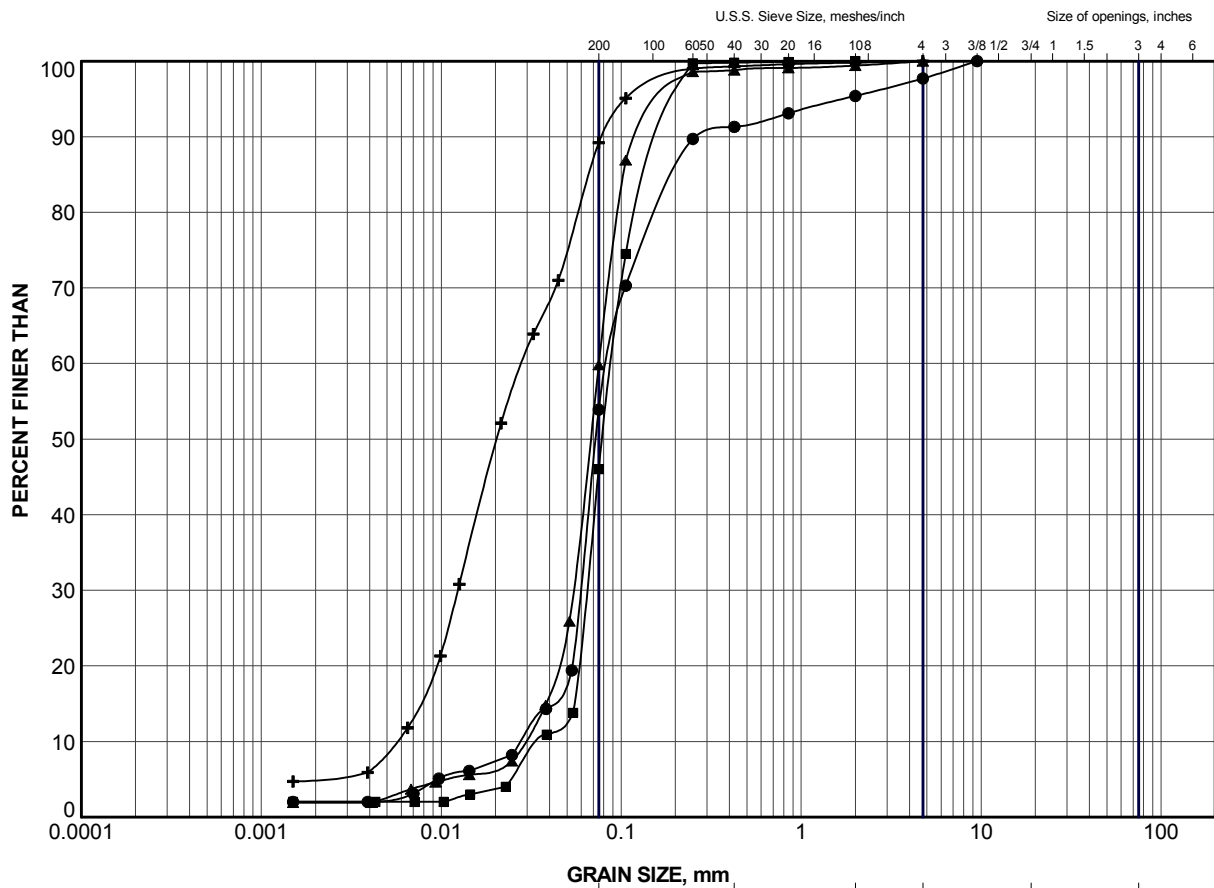
PROJECT		10-1191-0006		RECORD OF BOREHOLE No BH-VMS#22				1 OF 1 METRIC						
G.W.P.		5143-11-00		LOCATION		N 5315517.2; E 246376.8		ORIGINATED BY EHS						
DIST		HWY 101		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY AC						
DATUM		GEODETIC		DATE		December 13, 2011		CHECKED BY SEMP						
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						
287.5	GROUND SURFACE							20 40 60 80 100						
0.0	ASPHALT (110 mm)		1	AS	-		287							
	Sand to sand and gravel (FILL)		2	AS	-									
	Compact		3	SS	16									
	Brown													
	Moist													
286.1							286							
1.4	SILT, trace to some sand to SILT and SAND, trace gravel, trace clay		4	SS	6									0 46 52 2
	Loose to compact													
	Brown to grey		5	SS	8		285							0 54 44 2
	Moist													
			6	SS	6		284							
			7	SS	8		283							0 41 57 2
			8	SS	6		282							
			9	SS	14		281							0 11 84 5
			10	SS	16		280							
							279							
			11	SS	22		278							
277.7	END OF BOREHOLE													
9.8	Notes: 1. Borehole dry upon completion of drilling.													

SUD-MTO 001 1011910006.GPJ GAL-MISS.GDT 24/11/14 DATA INPUT:



APPENDIX B


Laboratory Test Results



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-VMS#22	4	285.7
■	BH-VMS#22	5	284.9
▲	BH-VMS#22	7	283.4
+	BH-VMS#22	9	281.1

PROJECT						HIGHWAY 101 VARIABLE MESSAGE SIGN #22					
TITLE						GRAIN SIZE DISTRIBUTION SILT to SILT and SAND					
PROJECT No.			10-1191-0006			FILE No.			1011910006.GPJ		
DRAWN	TB	Oct 2014	SCALE	N/A	REV.	FIGURE B1					
CHECK	AB	Oct 2014									
APPR	JMAC	Oct 2014									
 Golder Associates SUDBURY, ONTARIO											

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