



**March 24, 2015**

**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**TRI-CHORD OVERHEAD STATIC SIGN  
HIGHWAY 11 STATION 11+279  
APPROXIMATELY 500 M NORTH OF THE GRAVENHURST PATROL YARD  
ASSIGNMENT NO. 7, AGREEMENT NO. 5013-E-0034  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5450-09-00**

**Submitted to:**

Ministry of Transportation, Ontario  
Pavements and Foundations Section  
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**GEOCRES NO.: 31D-599**

**Report Number:** 14-1181-0014-7000 R3

**Distribution:**

6 Copies - Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)

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**REPORT**



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# PART A

FOUNDATION INVESTIGATION REPORT

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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by The Ministry of Transportation, Ontario (MTO), Northeastern Region to provide foundation engineering services for a proposed tri-chord overhead static sign located approximately 500 m north of the Gravenhurst Patrol Yard over the northbound lanes of Highway 11. The general location of the site is shown on the Key Plan on Drawing 1. This work has been carried out under Retainer Agreement # 5013-E-0034.

This assignment was carried out under the Terms of Reference (TOR) provided to Golder by MTO on December 3, 2014, and Golder's scope of work and cost estimate, dated December 9, 2014. The purpose of this investigation is to establish the subsurface conditions at the proposed location of the overhead sign by methods of borehole drilling, rock coring, in situ testing and laboratory testing on selected samples.

The station of the proposed overhead sign was provided by MTO on the Overhead Sign Borehole Location drawing, received on February 2, 2015. The existing overhead sign is located at approximately STA 11+283 and faces northbound traffic. The proposed sign is at STA 11+279.

## **2.0 SITE DESCRIPTION**

The proposed tri-chord overhead static sign is to be located over the northbound lanes and Bethune Drive exit ramp of Highway 11 at STA 11+279 in the Township of Muskoka. This section of Highway 11 consists of a four lane divided highway, comprised of two northbound lanes and two southbound lanes separated by a grass median, which contains the northbound lane exit ramp to Bethune Drive.

At the location of the proposed sign, the east and west granular surfaced shoulders are approximately 3 m and 1 m wide, respectively. At the proposed sign location the roadway embankment is approximately 1 m high sloping upwards from east to west. The surface conditions were not visible at the time of the investigation due to snow cover; however, rock outcrops were visible immediately east of the Highway 11 embankment at the proposed sign location. The ground surface at the proposed east and west foundation elements is at about Elevations 258 m and 259 m, respectively.

In general, the topography in the vicinity of the proposed structure is gently rising towards the north and west, with bedrock outcrops in close proximity to the proposed east foundation element. Based on existing topography drainage is essentially from west to east. At the location of the proposed sign, the Bethune Drive exit ramp highway embankment runs essentially parallel to the northbound lanes of Highway 11. An existing overhead sign is located at STA 11+283, located approximately 4 m north of the proposed sign. Two photographs of the site are presented following the text of this report.

## **3.0 INVESTIGATION PROCEDURES**

The subsurface investigation for the tri-chord overhead static sign was carried out between January 13 and 21, 2015, during which time two boreholes (OHS3-1 and OHS3-2) were advanced at the location of the proposed overhead sign, as shown on Drawing 1.

The field investigation was carried out using a truck-mounted CME75 drill rig supplied and operated by Canadian Soil Drilling of Springwater, Ontario. The boreholes were advanced through the overburden using 108 mm inner diameter hollow-stem augers, and extended into bedrock using HW casing HQ coring equipment. In general, soil



samples of the overburden were obtained at depth intervals of 0.75 m, using a 50 mm O.D. split-spoon sampler driven by an automatic hammer and carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard Penetration Test). The boreholes were backfilled with bentonite and cuttings upon completion in accordance with Ontario Regulation 903 Wells (as amended). Details of the subsurface conditions encountered at the borehole/drillhole locations are shown on the Record of Borehole and Drillhole sheets in Appendix A.

The groundwater conditions and water level(s) in the open borehole were observed during the drilling operations and are described on the Record of Borehole sheets.

The fieldwork was observed by a member of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes and drillholes, and examined and cared for the soil and bedrock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, grain size distribution, and organic content) was carried out on selected soil samples. Unconfined Compressive Strength (UCS) tests were carried out on select bedrock core samples. The results of the laboratory testing are presented on the Record of Borehole and Drillhole sheets and are included in Appendix B.

Our staff determined the proposed sign location in the field by referencing the existing overhead sign location based on the plans provided as part of the TOR. The boreholes were located in the field as close to the proposed structure foundation elements as practical based on existing site access conditions. The boreholes chainage and offset were recorded and the location was subsequently converted into MTM NAD 83 in AutoCAD. The final plan and cross section drawings provided by MTO, dated February 5, 2015, indicate that the location of the proposed sign is at STA 11+279 and the ground surface elevations at the borehole locations were determined using the elevation cross section. The boreholes location given in the Record of Borehole and Record of Drillhole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevation is referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

<b>Borehole Number</b>	<b>Chainage (Muskoka Twp.)</b>	<b>Offset from Centerline of Northbound Lanes of Hwy 11 (m)</b>	<b>MTM NAD83 Zone 10 Northing (m)</b>	<b>MTM NAD83 Zone 10 Easting (m)</b>	<b>Ground Surface Elevation (m)</b>	<b>Depth Drilled<sup>1</sup> (m)</b>
OHS3-1	STA 11+286	5.5 RT	4 973 785.4	315 333.8	258.3	5.0
OHS3-2	STA 11+286	12.0 LT	4 973 784.9	315 316.2	258.3	8.2

<sup>1</sup>Includes bedrock coring.



## 4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

### 4.1 Regional Geology

Based on published geologic information, made publically available from the Ontario Ministry for Northern Development and Mines<sup>1</sup> through “OGS Earth”, the surficial soils in the vicinity of the proposed tri-chord overhead static sign are generally part of a bedrock drift complex consisting of thin discontinuous overburden overlying Precambrian terrain. Published information from the Ontario Ministry for Northern Development and Mines<sup>2</sup> through “OGS Earth” indicates that the proposed sign is located in the Central Gneiss Belt of the Grenville Province, which contains rocks from 1.0 Ga to 1.6 Ga in age, consisting primarily of zones of mafic, igneous, migmatitic and metasedimentary rocks.

### 4.2 Site Stratigraphy

Detailed descriptions of the subsurface soil, bedrock 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 attached Record of Borehole and Drillhole sheets 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 and Drillhole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of in-situ testing. These boundaries, therefore, represent transitions between material types rather than exact planes of geological change.

In general, the subsurface conditions encountered at the proposed sign location consist of loose to very dense sand to gravelly sand (roadway shoulder material and embankment fill) underlain by granite/gneiss bedrock. Detailed descriptions of the subsurface conditions are provided in the following sections of this report.

#### 4.2.1 Fill

Fill comprised of brown, sand to gravelly sand containing trace to some silt and trace clay was encountered at the ground surface or underlying 200 mm of topsoil fill in Boreholes OHS3-1 and OHS3-2, respectively. The sand to gravelly sand fill deposit was encountered at Elevations 258.3 m and 258.1 m with thicknesses of 2.4 m and 4.9 m in Boreholes OHS3-1 and OHS3-2, respectively.

SPT ‘N’-values measured within the fill range from 6 blows to 93 blows per 0.3 m of penetration indicating a loose to very dense relative density. Three SPT ‘N’-values measured within the fill did not penetrate the full test length due to contact with coarse gravel or the underlying bedrock.

The natural water content measured on six samples of the granular fill stratum range from about 2 per cent to 12 per cent.

The results of grain size distribution tests completed on three samples of the fill are shown on Figure B1 in Appendix B.

<sup>1</sup> Ontario Geologic Survey. 2003. Surficial Geology of Southern Ontario. Ontario Ministry of Northern Development and Mines.

<sup>2</sup> Ontario Geologic Survey. 2000. Bedrock Geology, Seamless Coverage of the Province of Ontario. Ontario Ministry of Northern Development and Mines.



#### **4.2.2 Bedrock**

Bedrock was encountered underlying fill material in Boreholes OHS3-1 and OHS3-2 at a depth of 2.4 m and 5.1 m (Elevations 255.9 m and 253.2 m), and was cored for lengths of 2.6 m and 3.1 m, respectively. Based on review of the bedrock core samples, the bedrock is described as medium strong to strong, fresh to slightly weathered, grey to pinkish grey granite or gneiss. Photographs of the bedrock cores are shown on Figure B2 in Appendix B.

The Rock Quality Designation (RQD) measured on the recovered bedrock core samples range between 69 per cent and 92 per cent, indicating the rock is of fair to excellent quality in accordance with Table 3.10 of the Canadian Foundation Engineering Manual (CFEM), 2006<sup>3</sup>.

Two UCS tests were performed on samples of the rock core and measured Uniaxial Compressive Strengths of 94 MPa and 36 MPa, which indicate that the bedrock is medium strong to strong, in accordance with Table 3.5 of the CFEM (2006)<sup>3</sup>.

#### **4.2.3 Groundwater Conditions**

The unstabilized groundwater level measured in Borehole OHS3-1 upon completion of drilling was observed at a depth of 1.7 m below ground surface (Elevation 256.6 m) prior to the start of coring operations. Borehole OHS3-2 caved at 3.2 m depth and the groundwater level was not encountered within this depth.

The groundwater elevation as encountered in the boreholes may not be representative of the static groundwater level since the groundwater level may not have stabilized upon completion of overburden drilling. Furthermore, the groundwater elevation will vary depending on seasonal fluctuations, precipitation and local soil permeability.

### **5.0 CLOSURE**

The drilling program was supervised by Mr. David Marmor, EIT. This report was prepared by Mr. Matthew Thibeault, EIT and reviewed by Ms. Sarah E. M. Poot, P.Eng. a senior geotechnical engineer and Associate with Golder. Mr. Fintan J. Heffernan, P.Eng., Golder's Designated MTO Contact for Foundations for this assignment, conducted an independent quality control review of the report.

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





## Report Signature Page

**GOLDER ASSOCIATES LTD.**

*Matt Thibeault*

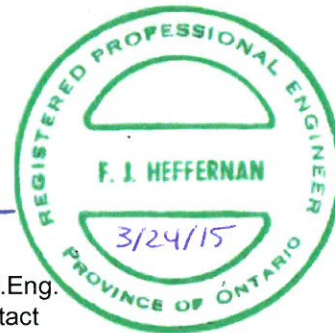
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# PART B

FOUNDATION DESIGN REPORT

TRI-CHORD OVERHEAD STATIC SIGN

HIGHWAY 11 STATION 11+279

APPROXIMATELY 500 M NORTH OF THE GRAVENHURST PATROL YARD

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## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

This section of the report provides foundation design recommendations for the proposed tri-chord overhead static sign. The recommendations are based on interpretation of the factual data obtained from the boreholes and drillholes 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.

### **6.1 General**

Golder understands that the proposed tri-chord overhead static sign will be located over the northbound lanes of Highway 11 and exit ramp to Bethune Drive with the footings located approximately 9.0 m east and 12.3 m west of the Highway 11 northbound lanes centreline at STA 11+279 in the Geographic Township of Muskoka.

Borehole OHS3-1 was advanced 5.5 m east of the Highway 11 northbound lanes centreline at STA 11+286, in the vicinity of the proposed east foundation element. The material encountered consists of dense to very dense sand to gravelly sand fill (roadway shoulder material and embankment fill) overlying the granite/gneiss bedrock at Elevation 255.9 m.

Borehole OHS3-2 was advanced 12.0 m west of the Highway 11 northbound lanes centreline at STA 11+286, in the vicinity of the proposed west foundation element. The material encountered consists of loose to very dense sand to gravelly sand (roadway shoulder material and embankment fill) overlying the gneiss bedrock at Elevation 253.2 m.

Golder understands that the proposed sign supports will be designed as a “tri-chord static sign support” as defined in MTO’s Sign Support Manual (2011).

### **6.2 Overhead Sign Foundation**

Tri-chord static sign supports are typically designed with two standard concrete caisson foundations in accordance with the requirements of the Sign Support Manual (2011) for ground mounted signs. The standard caisson design assumes normal competent soil conditions of uniform composition, with minimum soil parameters as specified in the Sign Support Manual (2011). Based on the results of foundation investigation, subsurface conditions at the sign location include loose to very dense fill material and bedrock within the typical caisson depth at which a site specific design is required, as specified in the Sign Support Manual (2011).

Based on the existing ground conditions, the foundations for the sign support can be designed as a single concrete caisson at the base of each support leg socketed into the rock, or, alternatively, the sign can be supported on a spread footing, founded on an engineered fill pad. Recommendations for these foundation options are provided in Sections 6.2.2 and 6.2.3.

Table 1 (following the body of this report) summarizes the advantages, disadvantages, relative costs and risks/consequences of the foundation alternatives. Based on the subsurface conditions and comparison of



options in Table 1, concrete caisson foundations socketed into bedrock are the preferred foundation option. A concrete caisson will allow use of the standard sign support foundation design as outlined in the Sign Support Manual (2011), with only slight modifications. Using a caisson eliminates the need for an open excavation, and the associated potential cost of temporary excavation protection, groundwater control, backfilling, and the risk of the excavation having a negative impact on existing lanes of traffic.

### **6.2.1 Frost Protection**

As shown on Ontario Provincial Standard Drawings (OPSD) 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario), the depth of frost penetration for the Gravenhurst area is about 1.7 m. As such, it is recommended that shallow foundations be covered with a minimum thickness of 1.7 m of soil cover or equivalent thickness of insulation for protection from frost penetration. If this amount of soil cover cannot be provided, rigid polystyrene foam insulation (i.e. Styrofoam SM or equivalent) could be used, extending out horizontally 1.7 m from the edges of the footing. Approximately 25 mm of insulation is required for every 0.3 m to 0.5 m of equivalent soil cover.

### **6.2.2 Caisson Foundation**

As noted above, caisson foundations for overhead sign supports should be designed in accordance with the requirements in the Sign Support Manual (2011). The Sign Support Manual (2011) includes a standard caisson foundation design for tri-chord static sign support footings (Section 4 and Standard Drawing SS118-3). The standard design specifies a caisson diameter of 1.0 m, and a depth of 5.0 m below the design frost depth, except where bedrock is encountered within this depth. For this sign/site, the frost depth is approximately 1.7 m, as stated in Section 6.2.1. The standard caisson foundation design as specified in MTO's Sign Support Manual (2011) assumes competent, uniform soil conditions and for non-cohesive material assumes a friction angle of 28° for the upper 2/3 of the caisson length below the frost depth and a friction angle of 30° for the lower 1/3 of caisson length below the frost depth.

In determining the founding elevation for the caissons, given the presence of bedrock within 5.0 m of the existing road surface at both footing locations, the standard sign design can be utilized, with a requirement for socketing into bedrock. For concrete caissons socketed into bedrock, the lateral resistance will be developed primarily from the fixity (in concrete) within the drilled sockets. However, a lateral resistance within the fill equivalent to half the thickness of the fill can also be utilized, based on the SPT N values within the fill. Based on Drawing SS118-3, the note indicates that the depth of the rock socket will be:

$$L_R = Y + (L - Y)/2$$

where:  $L_R$  = revised length below frost depth (m)

$L$  = standard caisson length below frost depth = 5 m

$Y$  = depth in soil below the frost depth (or equivalent depth) (m)

Rock socket lengths of 2.4 m and 1.7 m are required and for the east and west caissons, respectively.

The bedrock at the proposed footing locations is classified as medium strong to strong and of fair to excellent quality. As such, appropriate equipment and construction procedures (such as coring or churn drilling techniques) would be required to advance the sockets into the bedrock.



It should be noted that due to the undulating nature bedrock in the area, it is possible that the bedrock at the caisson location may be encountered above/below the depth at which the bedrock was encountered in the boreholes.

At the time of drilling, the ground water level was encountered at Elevation 256.6 m in Borehole OHS3-1. In order to reduce the potential for base heave in the bottom of the caissons and ground loss, the caissons should be advanced with a full balanced head condition and maintained at all times during construction/drilling. Tremie concrete placement will likely be required when placing concrete within the liner.

As concrete is placed in the liner-protected hole (by tremie placement method) 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. As the caisson will be socketed into the bedrock, consideration can be given to leaving the steel liner in place permanently.

### **6.2.3 Spread Footings**

#### **6.2.3.1 Spread Footings on Engineered Fill**

As an alternative to a standard sign design for a caisson socketed into bedrock, consideration could be given to founding both the east and west footings at ground surface on an engineered fill pad upon the removal of all or a portion of the existing fill, provided proper insulation is placed as outlined in Section 6.2.1. The excavation of fill material would need to extend 0.5 m horizontally beyond the edges of the footing and slope downward at a gradient of 1H:1V to the base of the excavation. At the east footing, the fill should be removed and replace the full depth to the bedrock surface at a depth of 2.4 m. At the west footing, the fill should be removed to a depth of 2.4 m, or to the surface of the very dense fill material. Given that the fill removal extends up to a depth of 2.4 m below existing ground surface, roadway protection would need to be implemented to maintain the flow of traffic during the installation.

Spread footings constructed on an engineered fill pad consisting of Granular 'B' Type II placed and compacted in accordance with OPSS.PROV 206 (or OPSS.PROV 209 if wet conditions are encountered), with an assumed friction angle of 35° and unit weight of 20 kN/m<sup>3</sup>, may be designed based on a factored geotechnical axial resistance 700 kPa at Ultimate Limit States (ULS) and a geotechnical axial reaction of 350 kPa at Serviceability Limit States (SLS) for 25 mm of settlement.

#### **6.2.3.2 Spread Footings on Bedrock**

As an alternative to spread footings on an engineered fill pad, consideration could be given to spread footings on bedrock for both the east and west foundation elements. The advantage of footings on bedrock is the greater geotechnical resistances achieved for the footing and the elimination of differential settlement between the west and east footings. However, the disadvantage of constructing the footings on bedrock is the potential additional costs associated with bedrock excavation or the need for mass concrete to achieve a level surface.

The bedrock surface should be properly prepared by removing loose and shattered rock fragments prior to placing footing concrete or mass concrete. A Non Standard Special Provision (NSSP) for levelling the bedrock surface should be included in the Contract Documents; an example NSSP is provided in Appendix C. Depending on the final bedrock surface slope, doweling of the footing to bedrock could be required.



For the east and west footings bearing directly on the bedrock surface, a factored geotechnical resistance at Ultimate Limit States (ULS) of 1 MPa may be used for design. Serviceability Limit States (SLS) for 25 mm settlement conditions do not apply for footings founded on the properly prepared bedrock surface.

### **6.2.3.3 Spread Footing Design Considerations**

Spread footings constructed directly on the existing fill are not recommended. As the water level and the placement methods at the time of construction are unknown, the fill could potentially comprise of deleterious materials, which would impact the performance of the spread footings.

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 calculated geotechnical resistance/reaction for the spread footings do not account for eccentric loading. Eccentric loading should be taken into account by the designer 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 on a engineered fill, the unfactored coefficient of friction,  $\tan \delta$ , can be taken as 0.55.

Open cut excavations of short duration through the granular fill are considered feasible for the proposed footings. Excavations for the proposed footings 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). Also, based on these groundwater levels, it is likely that most of the engineered fill placement will be in dry conditions, however, the engineered fill can be placed in wet conditions in accordance with OPSS.PROV 209 if the groundwater level is encountered during placement.

Care must be taken by the contractor excavating adjacent to the highway and maintaining the excavation open during footing construction to minimize impact to the existing roadway. Provision for protection of the existing pavement structure may be required and should be in accordance with MTO's Ontario Provincial Standard Specifications (OPSS) 539 (Temporary Protection Systems), designed to meet Performance Level 2. Lane closures will likely be required for the areas of the sign foundation excavations depending on the size of the excavations. Relevant design parameters for the shoring are provided below.

Design Parameter	Sand to Gravelly 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 ( $^{\circ}$ )	30
$K_a^*$	0.33
$K_p^*$	3.0
$K_o^*$	0.5

\* Earth pressure coefficients for horizontal backfill.





During construction, stockpiles should be placed well away from the edge of the excavations, 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.

For a spread footing placed on engineered fill pad, 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 QVE should also approve that the bedrock surface has been reached at the east foundation prior to placing engineered fill. There are no special requirements for preparation of the bedrock surface prior to fill placement as water may be present precluding an inspection.

#### **6.2.4 Construction Considerations**

The excavation around and above the spread footing or caisson cap may be backfilled using 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 fill soils to be excavated to the footing founding level at this site are not suitable for re-use within the excavation but selected portions of the material may be re-used in the roadway shoulder if the maximum fines (i.e. smaller than 75 µm) content is less than 8 per cent.

For the construction of concrete caissons, the performance of the rock socket will depend to a large degree on the condition of the bedrock, or other material, at the base of the shaft. The base must be cleaned to remove all loose cuttings to ensure that the concrete is in intimate contact with the founding stratum. The caisson should be measured for depth to verify/confirm that the entire drilled length is open to the base of the rock socket.

The drilling and construction of the caisson foundations should be observed throughout by the Quality Verification Engineer (QVE) to confirm that the conditions encountered are consistent with the information obtained from the borehole and that the required tip elevation and base cleanliness has been achieved.

The final grade surrounding the sign should be sloped to promote surface water drainage away from the pavement and sign, to the adjacent ditch, and surfaced with top soil 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 exceed 2 Horizontal to 1 Vertical, R-10 Rip-Rap, in accordance with OPSS.PROV 1004 (Aggregates - Miscellaneous), should be used to reduce the potential for erosion of the slope locally.

Control of groundwater in overburden soils for spread footings or caissons will be required as excavation for the sign foundation will be advanced through generally cohesionless fill which, if below the groundwater table, should be expected to be unstable and susceptible to soil cave-in, sloughing and boiling. It should be anticipated that the excavation will have to be advanced using shoring, possibly in conjunction with controlled dewatering, to minimize ground loss during excavation and concrete placement. The contractor is responsible for ensuring that appropriate construction procedures and equipment are used for construction. An example NSSP to warn the contractor of such conditions is presented in Appendix C.



## **7.0 CLOSURE**

This report was prepared by Mr. Matthew Thibeault, E.I.T. and the technical aspects reviewed by Ms. Sarah E. M. Poot, P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Fintan J. Heffernan, P.Eng., Golder's Designated MTO Contact for Foundations for this assignment, conducted an independent quality control review of the report.





## Report Signature Page

**GOLDER ASSOCIATES LTD.**

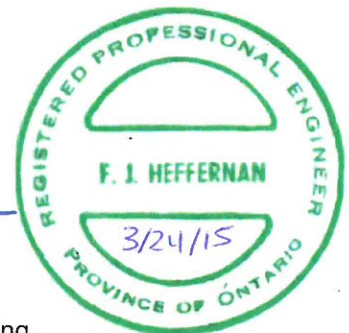
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MT/SEMP/FJH/kp

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\\Golder.Gds\Gal\Whitby\Active\\_2014\1181- Geotechnical & Pavement\14-1181-0014 MTO EOI 5013-E-0034 NER Retainer\Assignment 7\Reporting\Final\OHS3\14-1181-0014-7000 RPT  
15Mar24 Gravenhurst OHS3 FIDR.Docx



## REFERENCES

- Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition, BiTech Publications.
- Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-06, 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.
- Ministry of Transportation, Ontario, 2011. Sign Support Manual. Policy, Planning & Standards Division, Engineering Standards Branch, Bridge Office, April 2011.
- Ministry of Transportation, Ontario, 2014. Foundation Investigation and Design Report, Cantilever Overhead Static Sign, Highway 11 Northbound Station 24+547, Approximately 900 m South of the Gravenhurst Patrol Yard, GWP 5450-09-00, by Golder Associates Ltd. (Report No. 14-1181-0014-3000)
- Occupational Health and Safety Act and Regulation for Construction Projects, 2014.
- Ontario Geologic Survey. 2003. Surficial Geology of Southern Ontario. Ontario Ministry of Northern Development and Mines.
- Ontario Geologic Survey. 2000. Bedrock Geology, Seamless Coverage of the Province of Ontario. Ontario Ministry of Northern Development and Mines.
- Unified Facilities Criteria, U.S. Navy. 1986. NAVFAC Design Manuals 7.01 and 7.02. Soil Mechanics, Foundation and Earth Structures. Alexandria, Virginia.
- ASTM International
- |            |   |
|------------|---|
| ASTM D1586 | Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils |
|------------|---|
- Ontario Provincial Standard Drawings
- |               |   |
|---------------|---|
| OPSD 3090.101 | Foundation, Frost Penetration Depths for Southern 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



**FOUNDATION REPORT, TRI-CHORD OVERHEAD STATIC SIGN  
HIGHWAY 11 GWP 5450-09-00**

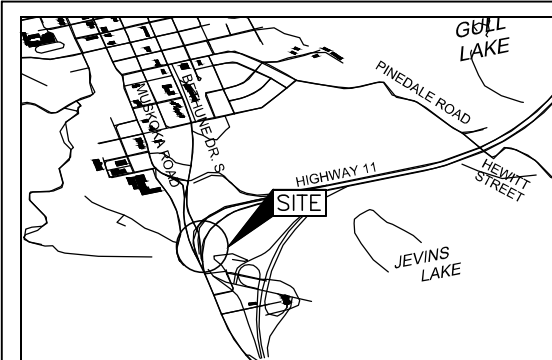
**Table 1: Evaluation of Foundation Alternatives**

Options	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Caissons	1	<ul style="list-style-type: none"> <li>Standard sign support foundation design as outlined in the Sign Support Manual (2011).</li> <li>Smaller excavation required compared to spread footings with less potential to impact roadway.</li> </ul>	<ul style="list-style-type: none"> <li>May require a levelling pad (fill or excavation of slope) to accommodate the caisson drilling equipment.</li> <li>Temporary liner for soil support may be required during installation to prevent sloughing and caving of cohesionless fill material.</li> <li>Depending on water level at time of construction, dewatering required within liner for concrete placement in the dry or placement by tremie methods below water may have to be adopted.</li> <li>Potential difficulty socketing caissons into strong bedrock that may require specialized equipment.</li> </ul>	<ul style="list-style-type: none"> <li>Mobilization of specialized drilling equipment is relatively expensive, compared to equipment required to construct spread footing.</li> </ul>	<ul style="list-style-type: none"> <li>Risk of lower/higher founding elevation if bedrock depth within footprint is lower/higher than encountered in boreholes.</li> <li>Risk of need for placement of concrete by tremie methods if unable to dewater within caisson liner.</li> </ul>
Spread Footings	2	<ul style="list-style-type: none"> <li>Conventional construction and construction equipment.</li> <li>Design easily adaptable for non-standard sign size/configuration.</li> </ul>	<ul style="list-style-type: none"> <li>Larger excavation required compared to caisson with potential impact to roadway.</li> <li>Additional cost to remove existing fill and construct an engineered fill pad or to remove fill and properly prepare bedrock surface.</li> <li>Depending on water level at time of construction, local dewatering and/or temporary shoring of excavation may be required.</li> </ul>	<ul style="list-style-type: none"> <li>Lower overall cost compared to caisson.</li> <li>Additional costs required for control of overburden as applicable.</li> </ul>	<ul style="list-style-type: none"> <li>Risk of requiring dewatering and/or temporary shoring during construction depending on season of construction.</li> <li>Risk of excavations impacting existing lanes of traffic.</li> </ul>

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

Compiled by: SEMP  
Reviewed by: FJH

**SHEET**



## KEY PLAN



## LEGEND

● Borehole – Current Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
OHS3-1	258.3	4973785.4	315333.8
OHS3-2	258.3	4973784.9	315316.2

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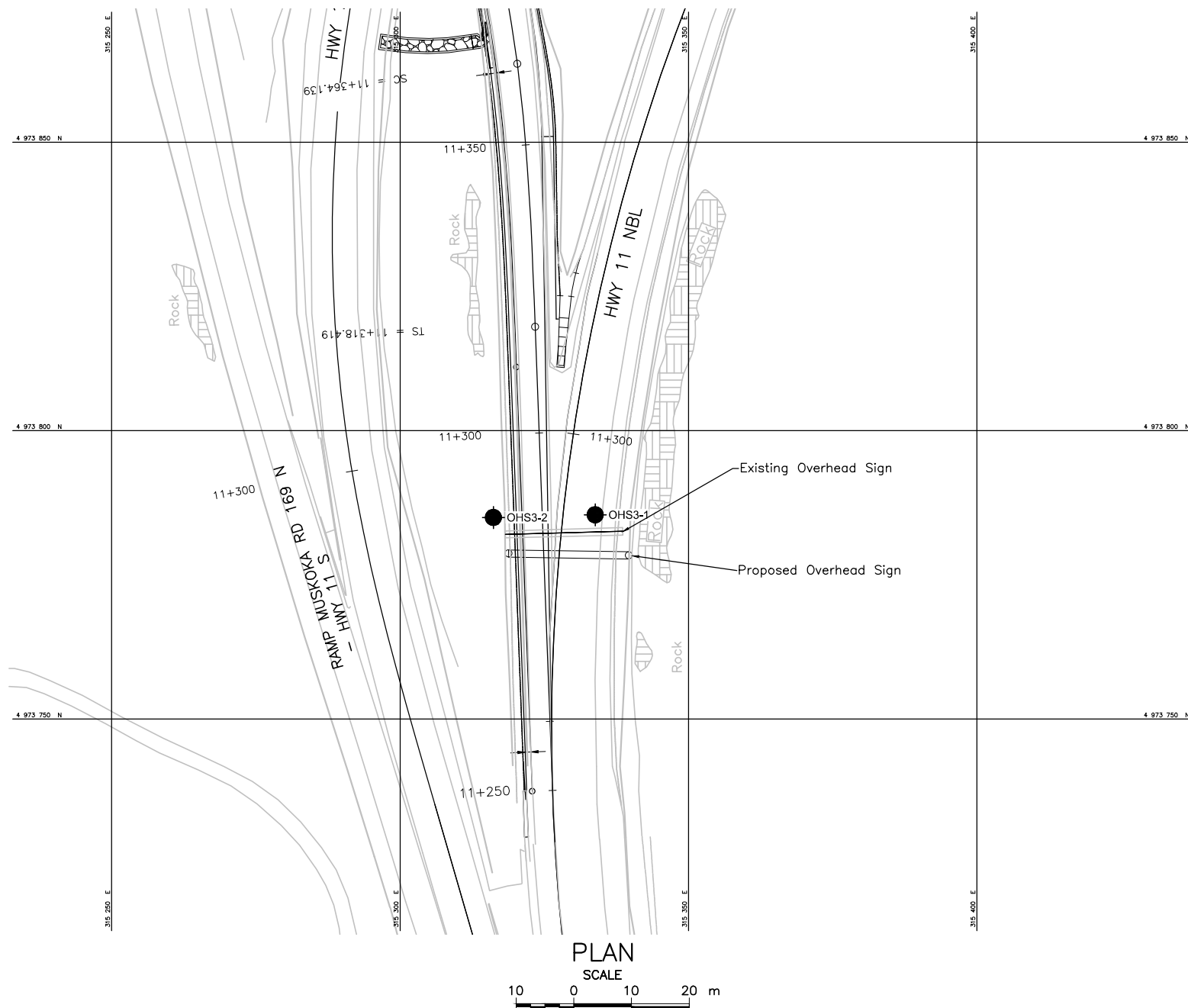
NOTES

This drawing is for borehole locations 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 Ministry of Transportation, Ontario,  
drawing file nos. X-60318949-C-HWY169-UNDERPASS-BASE -  
MODIFIED.dwg AND X-60318949-X-HWY169-UNDERPASS-DES-01.dwg,  
received January 02, 2015.



NO.		DATE		BY	
REVISION					
Geocres No. 31D-599					
HWY. 11			PROJECT NO. 14-1181-0014		DIST. .
SUBM'D. MT		CHKD. SEMP		DATE: 3/18/2015	
DRAWN: JJJ		CHKD. .		APPD. FJH	
				SITE: .	
				DWG. 1	



**Photograph 1: Looking south towards proposed sign location**



**Photograph 2: Looking north towards proposed sign location**





# APPENDIX A

## Record of Boreholes and Drillholes





## 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
FoS	factor of safety

### II. STRESS AND STRAIN

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

### III. SOIL PROPERTIES

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

### (a) Index Properties (continued)

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

### (b) Hydraulic Properties

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

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

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

### (d) Shear Strength

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

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

Notes: 1  
2

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

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



## 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 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) 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 <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.

### 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





## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

### JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

### CORE CONDITION

#### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

#### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

#### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

### DISCONTINUITY DATA

#### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

#### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

#### Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

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

MSUD-MTO 001 14-1118-0014.GPJ GAL-MISS.GDT 13/02/15 DATA INPUT:

SHEET 2 OF 2

DATUM: GEODETIC

DRILLING CONTRACTOR: Canadian Soil Drilling

CHECKED: SEMP

SUD-RCK 1194 14-1118-0014.GPJ GAL-MISS.GDT 13/02/15 DATA INPUT:

PROJECT 14-1181-0014		<b>RECORD OF BOREHOLE No OHS3-2</b>				1 OF 2 <b>METRIC</b>						
G.W.P. 5450-09-00		LOCATION N 4973784.9; E 315316.2				ORIGINATED BY DM						
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, HW Casing				COMPILED BY MT						
DATUM GEODETIC		DATE January 20 and 21, 2015				CHECKED BY SEMP						
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>			WATER CONTENT (%)
258.3	GROUND SURFACE											
0.0	Topsoil (FILL)											
0.2	Sand to gravelly sand, trace to some silt, trace clay (FILL) Loose to very dense Brown Moist to wet		1	AS	-		258					
			2	SS	6							
							257					
			3	SS	22							
							256					
			4	SS	55							
							255					
			5	SS	93							
							254					
			6	SS	100/0.25							
							253					
			7	SS	108/0.23							
253.2	Spoon bouncing at 5.1 m depth.											
5.1	GNEISS (BEDROCK)		1	RC	REC 87%		253					RQD = 87%
	Bedrock cored from 5.1 m depth to 8.2 m depth.						252					RQD = 69%
	For coring details see Record of Drillhole OHS3-2.		2	RC	REC 100%		251					RQD = 88%
			3	RC	REC 95%							
250.1	END OF BOREHOLE											
8.2	Note:  1. Borehole caved to 3.2 m depth (Elev. 255.1). Water level not encountered to 3.2 m depth.											

SUD-MTO 001 14-1118-0014.GPJ GAL-MISS.GDT 13/02/15 DATA INPUT:

SHEET 2 OF 2

DATUM: GEODETIC

DRILLING CONTRACTOR: Canadian Soil Drilling

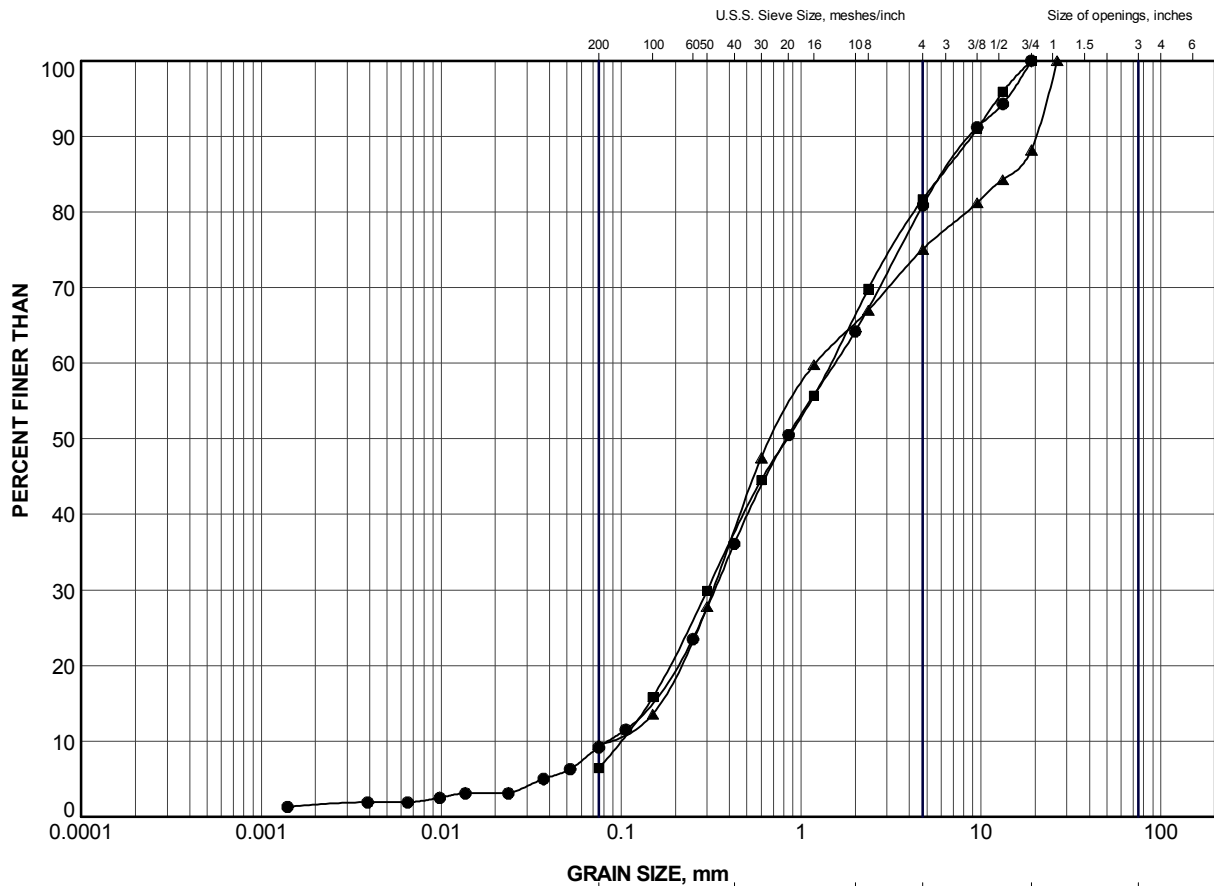
CHECKED: SEMP

SUD-RCK 1194 14-1118-0014.GPJ GAL-MISS.GDT 13/02/15 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)
●	OHS3-1	1	257.3
■	OHS3-2	2	257.3
▲	OHS3-2	5	255.1

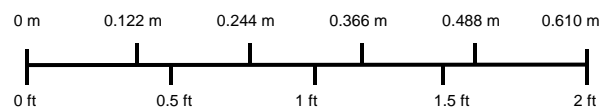
PROJECT		HIGHWAY 11 OVERHEAD SIGN STA 11+279				
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> SAND to GRAVELLY SAND (FILL)				
 <b>Golder Associates</b> SUDBURY, ONTARIO		PROJECT No.		14-1181-0014		
		FILE No.		14-1118-0014.GPJ		
		DRAWN	JJL	Mar 2015	SCALE	N/A
		CHECK	SEMP	Mar 2015	REV.	
		APPR	FJH	Mar 2015		
		<b>FIGURE B1</b>				




Borehole OHS3-1  
Elevation 255.9 m to 253.3 m



Borehole OHS3-2  
Elevation 253.2 m to 250.1 m



PROJECT		HIGHWAY 11 OVERHEAD SIGN STA 11+279			
TITLE		BEDROCK CORE PHOTOGRAPH			
		PROJECT No. 14-1181-0014-7000		FILE No. ----	
		DESIGN	MT	FEB 2015	SCALE AS SHOWN REV.
		CADD	--		
		CHECK	SEMP	FEB 2015	
		REVIEW	--	--	
FIGURE B2					





# APPENDIX C

## Non-Standard Special Provision

**CONTROL OF OVERBURDEN SOIL FOR FOUNDATION EXCAVATION – Item No.**

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Non-Standard Special Provision

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The Contactor is hereby notified that the overburden soil deposits at the sign location are cohesionless and water-bearing sand and gravelly sand, which are susceptible to soil cave-in, sloughing and boiling if the groundwater level is higher than the base of the excavation for the support of the sign foundation. The Contractor shall ensure that appropriate construction procedures and equipment are employed to maintain the excavation open and adequately cleaned to allow for construction of the sign foundation in-the-dry.

**SUBGRADE PREPARATION EXCAVATION – Item No.**

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Non-Standard Special Provision

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**Scope of Work**

The scope of work for the above noted tender item includes bedrock excavation at the Overhead sign at Station 11+279 footings to provide a level bedrock surface for the footing.

**Construction**

Prior to placing concrete for the proposed footings, the bedrock shall be levelled using hoe ram or equivalent such that the surface of the bedrock is sloping less than 10 degrees throughout the footprint. The exposed bedrock must be cleaned by removing loose debris and rock shatter. The QVE shall review the footing subgrade prior to placing concrete.

**Basis of Payment**

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

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