JULY 2012

FOUNDATION INVESTIGATION AND DESIGN REPORT

VARIABLE MESSAGE SIGN
HIGHWAY 69 FOUR-LANING
FROM 1.0 KM NORTH OF THE NEW HIGHWAY 559 INTERCHANGE NORTHERLY TO 1.5 KM NORTH OF HIGHWAY 7182 (SHEBESHEKONG ROAD) FOR 17 KM
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 5402-05-00

Submitted to:
McCormick Rankin, a member of MMM Group Limited
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

REPORT

GEOCRES No: 41H-110

Report Number: 07-1111-0029-5

Distribution:

3 Copies - Ministry of Transportation, Ontario, North Bay, Ontario, (Northeastern Region)
1 Copy - Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
1 Copy - McCormick Rankin, a member of MMM Group Limited, Mississauga, Ontario
2 Copies - Golder Associates Ltd., Mississauga, Ontario

Golder Associates

Table of Contents

LIST OF TABLES

LIST OF DRAWINGS

LIST OF APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT
VARIABLE MESSAGE SIGN
HIGHWAY 69 FOUR-LANING
FROM 1.0 KM NORTH OF THE NEW HIGHWAY 559 INTERCHANGE NORTHERLY TO 1.5 KM NORTH OF HIGHWAY 7182 (SHEBESHEKONG ROAD) FOR 17 KM
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P. 5402-05-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin, a member of MMM Group Limited (MRC) on behalf of Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for one (1) variable message sign (VMS) located along the proposed Highway 69 alignment within the Phase 1 section of the project. The proposed work is part of the four-laning of Highway 69 from 1.0 km north of the new Highway 559 Interchange northerly to 1.5 km north of Highway 7182 (Shebeshekong Road), which involves high fill embankments and embankments over swamps, the New Woods Road and Shebeshekong Road interchanges and structures, the Shawanaga River and Site 9 Road structures, as well as culvert crossings. The general location/extent of the Phase 1 section of the new Highway 69 four-laning alignment within which the variable message sign is located is shown on the Site Location Plan on Drawing 1. The general location of the VMS is shown on Drawings 1 and 2.

The Terms of Reference and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2007. Golder's proposal for foundation engineering services associated with the variable message sign is contained in Section 6.8 of MRC's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Project Specific Supplementary Specialty Plan for foundation engineering services for this project, dated July 4, 2007.

This report addresses the investigation carried out for the proposed variable message sign along Highway 69 only. Separate reports address the foundation investigations and design for the related swamp crossings, high fill areas for the associated interchange ramps and roadways, culverts and other bridge structures for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed variable message sign foundations by borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The foundation limits for this investigation were located in the field using survey stakes put down by Callon Dietz Inc. (Callon Dietz), a professional surveying company retained by MRC. The area of the investigation is show in plan on Drawing 2.

2.0 SITE DESCRIPTION

The proposed VMS is located at STA 18+380, on the proposed Highway 69 NBL alignment in the Township of Carling.

In general, the topography in the area of the VMS consists of rolling terrain including densely treed areas and low-lying swamps containing areas of standing water with various types of vegetation and organic soils immediately to the north. The immediate area surrounding the proposed VMS is flat and covered by shrubs and trees. Bedrock outcrops are present to the east and west of the site.

The existing ground surface at the proposed locations of the VMS supports is at about Elevation 214.1 m and 215.2 m, generally sloping downward from the west to the east. At this location, the proposed Highway 69 NBL embankment will be up to about 3 m above the existing ground surface.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the investigation at the VMS location was carried out on May 19, 2009, during which time two (2) boreholes were drilled near the shoulders of the proposed Highway 69 NBL, at or near the proposed VMS supports. The boreholes, designated as Boreholes VMS1-01 and VMS1-02 were advanced at the locations shown in plan on Drawing A1 in Appendix A.

The field investigation was carried out using a track-mounted Diedrich D-25 drill rig, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden using 165 mm outside diameter (O.D.) solid-stem augers, and soil samples were obtained at 0.75 m intervals of depth using 50 mm outside diameter (O.D.) split-spoon samplers driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586 Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the Soil). Samples of the bedrock were obtained using an 'NQ' size rock core barrel.

The boreholes were advanced through the overburden to auger and/or sampler refusal (i.e. inferred bedrock) and bedrock was confirmed by coring in both boreholes. The boreholes were advanced to depths of up to about 6.1 m below existing ground surface, including coring of bedrock for core lengths up to about 3.1 m.

The groundwater conditions in the open boreholes were observed during the drilling operations and a piezometer was installed in Borehole VMS1-01 to permit monitoring of the water level at this location. The piezometer consists of 32 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the sand pack/screen was backfilled to the surface with bentonite pellets/grout. Piezometer installation details and water level readings are described on the Record of Borehole sheets presented in Appendix A. The borehole in which a standpipe piezometer was not installed was backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 Wells (as amended).

The field work was observed by a member of our 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 examined and cared for the soil and rock samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga 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, such as water content and grain size distribution, was carried out on selected soil samples. Classification of the bedrock rock mass quality with respect to the Rock Quality Designation is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)[1]. Point load strength tests, both perpendicular to the core axis (diametral test) and along the core axis (axial test) were performed on selected samples of the rock core to provide an indication of the point load strength index (Is_{50})[2] of the rock. The bedrock was then classified with respect to strength based on the Is_{50} values as suggested in Table 3.5 of the Canadian Foundation Engineering Manual (2006)[1]. The results of the laboratory testing are included in Appendix A.

The as-drilled borehole locations and ground surface elevations were surveyed by a member of our technical staff, referenced to the survey stakes put down by Callon Dietz. The borehole locations provided in the Record of Borehole and Drillhole sheets as well as on Drawing A1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to geodetic datum, and are summarized below.

Borehole No.	Location (MTM NAD 83)		Collar Elevation (Geodetic Datum) (m)	Depth Drilled (m)
	Northing	Easting		
VMS1-01	5038325.5	251183.9	215.2	6.1
VMS1-02	5038337.3	251194.8	214.1	4.1

[1] Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition.

[2] International Society for Rock Mechanics (ISRM), 1985. Suggested Method for Determining Point Load Strength. Int. J. Rock Mech. Min. Sci. and Geomech. Abst., Vol. 22, No 2, pp 51-60.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in The Physiography of Southern Ontario[3], this section of Highway 69 lies within the physiographic region known as the Georgian Bay Fringe, which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

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

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

4.2 Subsurface Conditions

The detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes advanced for this investigation, together with the results of the laboratory tests carried out on selected soil and rock core samples, are presented on the attached Record of Borehole and Drillhole sheets in Appendix A. 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 Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions at the proposed variable message sign consist of a cohesionless deposit of silty sand to sand and silt underlain by granite gneiss bedrock. At one borehole location, the upper portion of the cohesionless stratum was visually observed to contain organic material.

The following sections provide information on the subsoils and groundwater conditions encountered in the boreholes advanced at the proposed variable message sign location.

4.2.1 Organic Silty Sand

An approximately 0.6 m thick layer of organic silty sand containing rootlets was encountered at the ground surface at about Elevation 215.2 m in Borehole VMS1-01.

The Standard Penetration Test (SPT) 'N' value measured within this layer is 3 blows per 0.3 m of penetration, indicating a very loose relative density.

The natural water content measured on one (1) sample of the organic silty sand is about 27 percent.

---

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

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

4.2.2 Silty Sand to Sand and Silt

A deposit of reddish brown to grey silty sand to sand and silt, trace gravel and containing rootlets was encountered below the organic silty sand deposit in Borehole VMS1-01 and at the ground surface in Borehole VMS1-02. The near surface portion of the deposit in Borehole VMS1-02 was observed to be slightly organic, and cobbles were encountered within the lower portion of the deposit in Borehole VMS1-01. The top of the deposit is at about Elevation 214.6 m and 214.1 m, and the thickness of the deposit is about 2.4 m and 1.1 m in Boreholes VMS1-01 and VMS1-02, respectively.

The Standard Penetration Test (SPT) 'N'-values measured within this deposit range from 6 blows to 84 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The high SPT 'N'-values were recorded within the lower portion of the deposit where cobbles were encountered.

The natural water content measured on two (2) samples of this deposit is about 14 percent and 17 percent.

The grain size distribution on one (1) sample of this deposit is presented on Figure A1 in Appendix A.

4.2.3 Bedrock

Bedrock was encountered and core samples were recovered below the deposit of silty sand to sand and silt in Boreholes VMS1-01 and VMS1-02. The depth to bedrock below ground surface and the corresponding bedrock surface elevation is summarized below.

Borehole No.	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Refusal Type
VMS1-01	3.0	212.2	Bedrock Cored
VMS1-02	1.1	213.0	Bedrock Cored

Based on the rock core samples, the bedrock consists of granite gneiss. In general, the bedrock samples are described as fresh, strongly foliated, medium to coarse grained with phenocryst and feldspar banding, low to moderate porosity and pink to grey to black. The Rock Quality Designation (RQD) measured on the core samples ranges from 90 percent to 100 percent, indicating a rock mass of excellent quality. The Total Core Recovery (TCR) of the core samples is about 100 percent, and the Solid Core Recovery (SCR) of the core samples recovered is about 98 percent and 100 percent.

Laboratory point load strength tests were performed on selected samples of the rock core. The axial and diametral point load strength index values are shown on the Record of Drillhole sheets and are presented in Table A1 in Appendix A. The axial tests carried out on nine (9) specimens of the granite gneiss bedrock measured Is_{50} values ranging from about 7.0 MPa to 11.8 MPa and the diametral tests carried out on nine (9) specimens of the granite gneiss bedrock measured Is_{50} values ranging from about 4.3 MPa to 6.7 MPa.

Also presented in Table A1 are the estimated Unconfined Compressive Strength (UCS) values for each sample tested for point load strength based on a relationship between Is_{50} and UCS which is given by a correlation factor (K) in accordance with ASTM D5731 Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classification, which may vary depending on the size of the core sample and the strength of the rock, as well as the estimated UCS of bedrock core samples from other structure sites in the area of the Variable Message Sign. For this site, the UCS values are based on an estimated average correlation factor (K) of 20.

Based on the axial point load testing results, the granite gneiss bedrock is classified as strong (R4, 50 MPa < UCS < 100 MPA) to very strong (R5, 100 MPa < UCS < 250 MPa).

4.2.4 Groundwater Conditions

In general, the soil samples taken in the boreholes were moist to wet. A standpipe piezometer was installed in Borehole VMS1-01 to permit monitoring of the water level at this site. Details of the piezometer installation are shown the Record of Borehole sheets in Appendix A. The groundwater level measured in the piezometer installation about two months following completion of drilling is summarized below.

Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement
VMS1-01	215.2	213.3	July 15, 2009

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

Mr. Matt J. Riopelle, field technician with Golder, directed the field drilling program. This report was prepared by Ms. T. Veronica Ayetan, P. Eng. and Mr. Christopher Ng, P. Eng., and was reviewed by Mr. J. Paul Dittrich, P. Eng., a senior geotechnical engineer and Principal with Golder. Mr. Jorge M. A. Costa, P. Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

LICENSED PROFESSIONAL ENGINEER
T. V. AYETAN
100130071
PROVINCE OF ONTARIO

T. Veronica Ayetan, P. Eng.
Geotechnical Engineer

J. Paul Dittrich, P. Eng.
Senior Geotechnical Engineer, Principal

LICENSED PROFESSIONAL ENGINEER
J. M. A. COSTA
PROVINCE OF ONTARIO

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

TVA/CN/JPD/JMAC/sm

n:\active\2007\1111\07-1111-0029 - mrc - hwy 69 four-laning -\report\final\5 - variable message sign\07-1111-0029-5 rpt 12jul26 highway 69 variable message sign.docx

PART B

FOUNDATION DESIGN REPORT

VARIABLE MESSAGE SIGN

HIGHWAY 69 FOUR-LANING

FROM 1.0 KM NORTH OF THE NEW HIGHWAY 559

INTERCHANGE NORTHERLY TO 1.5 KM NORTH OF

HIGHWAY 7182 (SHEBESHEKONG ROAD) FOR 17 KM

MINISTRY OF TRANSPORTATION, ONTARIO

G.W.P. 5402-05-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides geotechnical parameters and recommendations for the design and construction of foundations for the proposed variable message sign. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation for this project. The interpretation and recommendations presented are intended to provide the designers with sufficient information to design the proposed sign foundations. Where comments are made on construction, they are provided in order to highlight those aspects which could affect the planning of the project, and for which special provisions or operational constraints may be required during construction. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

Golder Associates Ltd. (Golder) was retained by McCormick Rankin, a member of MMM Group Limited (MRC) on behalf of Ministry of Transportation, Ontario (MTO) to provide an assessment of foundation options, geotechnical parameters and recommendations on foundation aspects for a proposed variable message sign which is to be located along the new Highway 69 at approximately STA 18+380 in the Township of Carling.

The overall project involves the design of a 17 km section of the new Highway 69 four-laning alignment north of Nobel, Ontario, including high fill embankments and embankments over swamps, the Woods Road and Shebeshekong Road interchanges and structures, the Shawanaga River and Site 9 Road structures, culvert crossings, and over-head signs.

6.2 Variable Message Sign Foundations

Variable message sign supports are typically designed with a “standard” caisson foundation, in accordance with the requirements in MTO’s *Sign Support Manual (2011)*. However, given that the bedrock at the proposed VMS location at this site is present at relatively shallow depth below ground surface, the foundations for the support of the variable message sign can be designed as caissons socketted into the bedrock or as spread footings dowelled into bedrock. Recommendations for these two foundation options are provided in Sections 6.2.1 and 6.2.2. The advantages, disadvantages, relative costs and risks/consequences for each of the foundation options are summarized in Table 1.

6.2.1 Caissons

As noted above, caisson foundations for variable message sign supports should be designed in accordance with the requirements in MTO’s *Sign Support Manual (2011)*. The *Sign Support Manual* includes a standard caisson foundation design for changeable message sign supports (Section 8 and Standard Drawings SS118-6, SS118-7 and SS118-8), in which the caisson extends 5 m below the design frost depth, except where bedrock is encountered within this depth. As shown on the depth of frost penetration isopleths for Southern Ontario in OPSD 3090.101 (Foundation, Frost Penetration Depth), the estimated depth of frost penetration at the site is approximately 1.8 m.

In accordance with Standard Drawing SS118-6 of MTO's *Sign Support Manual*, where bedrock is encountered at a depth less than 5 m below the bottom of the depth of frost penetration, the required depth of the caisson foundation below the frost depth may be taken as follows:

$$L = Y + \frac{5-Y}{2}$$

where: L = length of caisson below depth of frost penetration (m)

Y = distance between depth of frost penetration and depth to bedrock (m)

Based on the above equation, the lengths of caissons as well as the length of caisson socketted into the gneiss bedrock for the variable message sign are summarized below.

Borehole No.	Depth to Bedrock (m)	Depth of Frost Penetration (m)	Distance between Depth of Frost Penetration and Depth to Bedrock, Y (m)	Caisson Length Below Depth of Frost Penetration, L (m)	Total Caisson Length (m)	Length of Caisson Socketted into Bedrock (m)
VMS1-01 (West Support)	3.0	1.8	3.0 – 1.8 = 1.2	3.1	3.1 + 1.8 = 4.9	4.9 – 3.0 = 1.9
VMS1-02 (East Support)	1.1	1.1	1.1 – 1.1 = 0.0	2.5	2.5 + 1.1 = 3.6	3.6 – 1.1 = 2.5

Because the overburden at the VMS location is relatively thin, essentially thinner than the depth of frost penetration at one foundation location (VMS1-02), the caissons will derive lateral resistance from the length of caisson socketted into bedrock. As some value of lateral resistance will be provided by the thicker overburden at one of the sign foundations (VMS1-01), the geotechnical design parameter values for the overburden soil are presented in Table 2. The column of soil above the depth of frost penetration should be neglected in the assessment of passive lateral resistance.

The bedrock at the proposed variable message sign location is classified as strong to very strong and as such, appropriate equipment and construction procedures (such as coring or churn drilling techniques) would be required to advance the sockets into the bedrock.

6.2.2 Spread Footings

As an alternative to caissons socketted into bedrock, consideration could be given to using spread footings to support the proposed VMS. At the proposed variable message sign location, the spread footing could be founded on either the very dense sand and silt deposit below the frost penetration depth or on the bedrock. The advantage of constructing spread footings as compared to constructing caissons is the elimination of coring or churn drilling into the strong to very strong bedrock. However, the disadvantages of using spread footings for the support of the VMS is the need for larger excavations and potential need for dewatering.

Based on the General Arrangement (GA) drawing for the proposed variable message sign and associated information provided by MRC on July 28, 2011, it is understood that spread footings founded on bedrock is the preferred option at this location. Spread footings founded on bedrock is also the preferred option from a foundation perspective as the excavation depth to bedrock is relatively shallow and drilling of/into bedrock is not required. As such, recommendations for geotechnical axial resistance and resistance to lateral loads for footings or bedrock are only provided in the sections below. Considering the shallow depth to bedrock, it may be necessary to anchor the footings to bedrock to achieve adequate lateral resistance. In addition, variations in the bedrock surface elevation are to be expected in the area of the proposed variable message sign and as such, mass concrete and/or hoe ramming may be required to achieve a level footing at the design elevations.

The bedrock encountered at the proposed VMS location is of excellent quality, but nevertheless, the founding surface should be properly prepared (i.e. sub-excavated of any loose or fractured bedrock). Where the bedrock surface is above the design elevation of the footing, hoe ramming may be required to achieve the founding grade of the underside of the footing. Conversely, where bedrock surface is below the design elevation of the footing, mass concrete would be required to raise the founding grade to the design elevation of the underside of the footing. Given the uneven and sloping nature of the bedrock surface, a Non-Standard Special Provision (NSSP) for mass concrete should be included in the Contract Documents in the event that a thicker footing is required; an example NSSP is provided in Appendix B.

Excavations for the proposed spread footings should be carried out in accordance with the latest Occupational Health and Safety Act for Construction Projects (OHSA). When referencing OHSA, the native silty sand to sand and silt deposit should be considered as a “Type 3 Soil”. As such, excavations should be sloped at a gradient of 1 Horizontal to 1 Vertical (1H:1V) or flatter. For excavations into the bedrock, if necessary, the overall slope to the cut face may be formed vertically, or near vertically (i.e. about 0.5H:1V).

Given the anticipated limited size of the excavation and limited overburden thickness, seepage into the excavation should be adequately controlled by pumping from properly filtered sumps. However, it should be noted that the groundwater levels are subject to seasonal fluctuations and precipitation events and as such, the proposed construction method and/or the construction schedule should be planned accordingly.

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 any existing adjacent embankment slopes.

Inspection and approval of the foundation areas by the Quality Verification Engineer prior to footing construction should be carried out as required in accordance with OPSS 902 (Excavating and Backfilling), to ensure that all loose soils and/or fractured rock has been removed from the foundation areas and that the foundation base has been properly prepared for the placement of concrete.

6.2.2.1 Geotechnical Axial Resistance

For spread footings bearing directly on the properly prepared bedrock surface or on mass concrete over bedrock, a factored geotechnical axial resistance at Ultimate Limit States (ULS) of 10 MPa may be used for design (in accordance with Section 9.2 in CFEM (2006)). Serviceability Limit States (SLS) conditions do not apply for footings founded on bedrock or on mass concrete.

The geotechnical resistances provided above are given for loads 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 Clauses 6.7.4 and C6.7.4 of the *Canadian Highway Bridge Design Code (CHBDC)* and its *Commentary*.

6.2.2.2 Resistance to Lateral Loads

Resistance to lateral forces/sliding resistance between the concrete footings and the gneiss bedrock surface should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The following summarizes the coefficient of friction, tan δ, for the interface materials.

Interface Materials	Coefficient of Friction (tan δ)
Concrete footing on Bedrock	0.70

This value represents an unfactored value; in accordance with *CHBDC*, a factor of 0.8 is to be applied in calculating the horizontal resistance.

For footings on bedrock, the sliding/lateral resistance between the concrete footing/mass concrete and the bedrock may be supplemented by dowelling into the bedrock, if necessary. The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. A factored ULS value of 750 kPa may be assumed for the grout-to-rock bond stress along the shaft/socket of the dowel in the bedrock. This value refers to the rock-grout interface strength and can be used for tension design. The actual bond stress along the rock-grout interface may vary from the design value and should therefore be verified in the field as noted below. For the proposed variable message sign location where the rock mass is stronger than concrete, the design of the dowels into the bedrock may be considered in the same way as dowels embedded into the concrete. This assumes that the Unconfined Compressive Strength (UCS) of the grout will be similar to that of the concrete. The dowels should have a 1 m minimum embedded length within the bedrock, and the structural strength of the dowel and compressive strength of the grout should not be exceeded. If dowelling is required for structural considerations, a Non-Standard Special Provision (NSSP) should be included in the Contract Documents to specify the installation, materials and testing of the dowels; an example is provided in Appendix B.

6.3 Construction Considerations

The excavations around and above the spread footings may be backfilled using an approved granular material such as MTO's Special Provision 110S13 (Aggregates) Granular 'A' or 'B' Type I placed and compacted in accordance with OPSS 501, or Granular 'B' Type II placed and compacted in accordance with Special Provision 314S01 (Granular 'B' Type II).

The final grade surrounding the sign supports should be sloped to promote surface water drainage and pavement structure drainage away from the pavement and sign supports, to the adjacent ditches.

As the excavations, either for spread footings or caissons, will extend through cohesionless soils and likely to below the groundwater level(s), it is recommended that a NSSP be included in the Contract Documents to warn the Contractor of these conditions which may affect the installation of the variable message sign foundations. An example NSSP is provided in Appendix B.

7.0 CLOSURE

This report was prepared by Ms. T. Veronica Ayetan, P. Eng. and Mr. Christopher Ng, P. Eng. The technical aspects were reviewed by Mr. J. Paul Dittrich, P. Eng., a senior geotechnical engineer and Principal with Golder. Mr. Jorge M. A. Costa, P. Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

Christopher Ng, P. Eng.
Senior Geotechnical Engineer

J. Paul Dittrich, P. Eng.
Senior Geotechnical Engineer, Principal

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

TVA/CN/JPD/JMAC/sm

n:\active\2007\1111\07-1111-0029 - mrc - hwy 69 four-laning -\report\final\5 - variable message sign\07-1111-0029-5 rpt 12jul26 highway 69 variable message sign.docx

REFERENCES

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd., British Columbia.

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA-S6-06. 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.

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

Geology of Ontario. 1991. Ontario Geological Society, Special Volume 4, Part 2. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

International Society for Rock Mechanics (ISRM), 1985. Suggested Methods for Determining Point Load Strength. International Society for Rock Mechanics Commission on Testing methods, Int. J. Rock Mech. Min. Sci. and Geomech. Abst., Vol 22, No 2, pp 51-60; as referenced in ASTM Designation: D 5731-08 "Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications".

Ministry of Transportation, Ontario, 2011. Sign Support Manual. Policy, Planning and Standards Division, Engineering Standards Branch, Bridge Office

STANDARDS:

ASTM International:

ASTM D 1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D 5731	Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications

Ministry of Transportation Ontario:

Special Provision 110S13	Amendment to OPSS 1010 – Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material.
Special Provision 314S01	Amendment to OPSS 314 – Construction Specification for Untreated Granular, Subbase, Base, Surface Shoulder and Stockpiling.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91	Construction Projects
Ontario Regulation 443/09	Amendment to Ontario Regulation 213

Ontario Provisional Standard Drawing:

OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario.

Ontario Provincial Standard Specification:

OPSS 902	Construction Specification for Excavating and Backfilling – Structures
OPSS 501	Construction Specification for Compacting

Ontario Water Resources Act:

Ontario Regulation 903	Well

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

w	water content
w_l 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

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

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
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, 60º 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^2 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	c_u, s_u 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

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

Golder Associates

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^{o} 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		

TABLE 1
EVALUATION OF FOUNDATION ALTERNATIVES – VARIABLE MESSAGE SIGN

Option	*Rank*	*Advantages*	*Disadvantages*	*Relative Costs*	*Risks / Consequences*
Caissons socketted into Bedrock	2	• No post-construction settlement; and, • Soil cover for frost protection is not required for caissons socketted into bedrock.	• Coring or churn drilling into the strong to very strong bedrock will be required to advance sockets for caisson construction.	• Relatively higher cost of installation compared with spread footings; and, • Additional cost associated with specialized drilling equipment to advance the caisson holes into the bedrock.	• Specialized drilling equipment will be required to socket caissons into bedrock.
Spread Footings founded on and dowelled into Bedrock	1	• Relative ease of construction; • No bedrock coring and/or churn drilling required; • No post-construction settlement; and, • Soil cover for frost protection is not required for footings on bedrock.	• Larger excavation of overburden is required; • Larger volume of excavation spoils will be produced; • Mass concrete may be required to achieve level footing; • Dowels may be required to anchor spread footings (due to structural considerations); and, • Groundwater control may be required. • .	• Relatively lower cost in comparison to caissons socketted into bedrock; • Additional cost required for the disposal of larger volume of excavation spoils; and, • Additional costs required for dowelling into the bedrock.	• Risk that additional excavation and/or mass concrete may be required if bedrock is encountered below the design founding elevation during construction; and, • Must ensure foundation base is properly prepared for concrete placement.

Prepared By: TVA/CN

Reviewed By: JPD/JMAC

n:\active\2007\1111\07-1111-0029 - mrc - hwy 69 four-laning -\report\final\5 - variable message sign\tables\07-1111-0029-11 tbl 1 evaluation of foundation alternatives - variable message sign.docx

TABLE 2
GEOTECHNICAL DESIGN PARAMETERS – VARIABLE MESSAGE SIGN

Sign Support	Borehole No.	Stratum	Depth [1] (m)	Elevation (m)	Groundwater Elevation (m)	Design Parameters [2]				
						c_u	ϕ'	γ	γ'	K_p [3]
VMS1 (West Support)	VMS1-01	Very loose organic silty sand	0.0 – 0.6	215.2 – 214.6	213.3	-	28	18	8	2.8
		Loose silty sand	0.6 – 1.4	214.6 – 213.8		-	30	20	10	3.0
		Very dense sand and silt	1.4 – 3.0	213.8 – 212.2		-	32	21	11	3.2
		Granite Gneiss Bedrock	Below 3.0	Below 212.2		-	-	-	-	-
VMS1 (East Support)	VMS1-02	Loose silty sand	0.0 – 0.6	214.1 – 213.5	N/A	-	30	20	10	3.0
		Very Dense Silty Sand	0.6 – 1.1	213.5 – 213.0		-	32	21	11	3.2
		Granite Gneiss Bedrock	Below 1.1	Below 213.0		-	-	-	-	-

NOTES:

1. Depths are given for the borehole location; the ground surface elevation at the borehole location when surveyed should be compared to the ground surface elevation at the actual sign support location, and the depths of the soil strata adjusted accordingly.
2. Design parameters: c_u = undrained shear strength (kPa);
   ϕ' = effective friction angle (degrees);
   γ = bulk unit weight (kN/m^3);
   γ' = effective unit weight below the groundwater level (kN/m^3); and
   K_p = passive earth pressure coefficient.
3. Although the passive resistance in the upper 1.8 m should be neglected to account for frost action, ϕ' and K_p parameters are given in the event that the ground surface elevation varies significantly between the borehole and sign support locations.

Prepared By: TVA

Reviewed By: JPD/JMAC

n:\active\2007\1111\07-1111-0029 - mrc - hwy 69 four-laning -\report\final\5 - variable message sign\tables\07-1111-0029-11 tbl 2 geotechnical design parameters - variable message sign.docx

MINISTRY OF TRANSPORTATION, ONTARIO

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

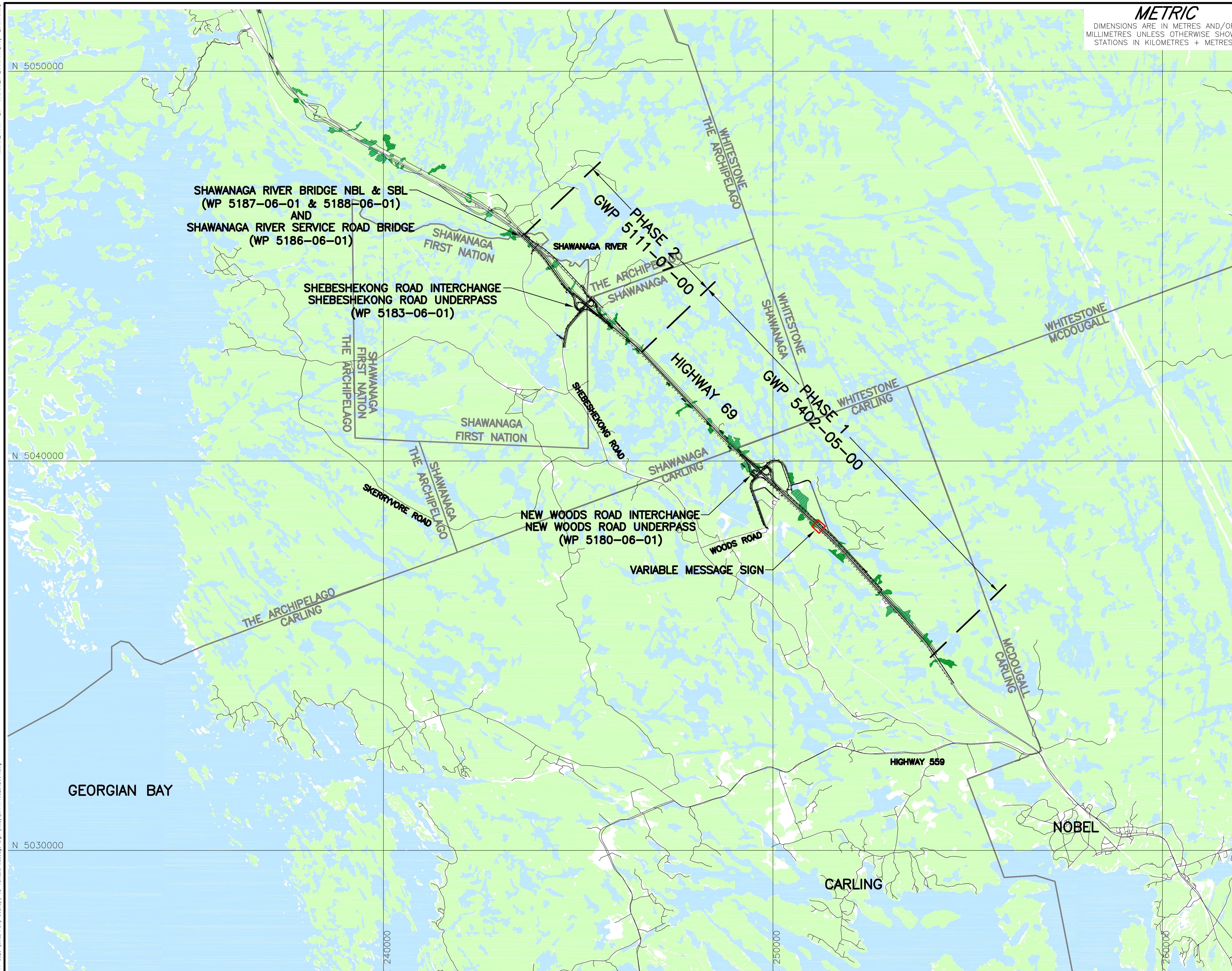
CONT No.
GWP No. 5402–05–00

SHEET

HIGHWAY 69
SITE LOCATION PLAN

Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
NOT TO SCALE

PLAN

SCALE
1 0 1 2 km

REFERENCE
Base Data – MNR NRVIS, obtained 2004, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Datum : NAD 83 Projection : MTM Zone 10

NO.	DATE	BY	REVISION

Geocres No. 41H–110

HWY. 69		PROJECT NO. 07–1111–0029	DIST.
SUBM'D. VA	CHKD. VA	DATE: July 2012	SITE:
DRAWN: JFC/CD	CHKD. CN	APPD. JPD/JMAC	DWG. 1

PLOT DATE: July 24, 2012

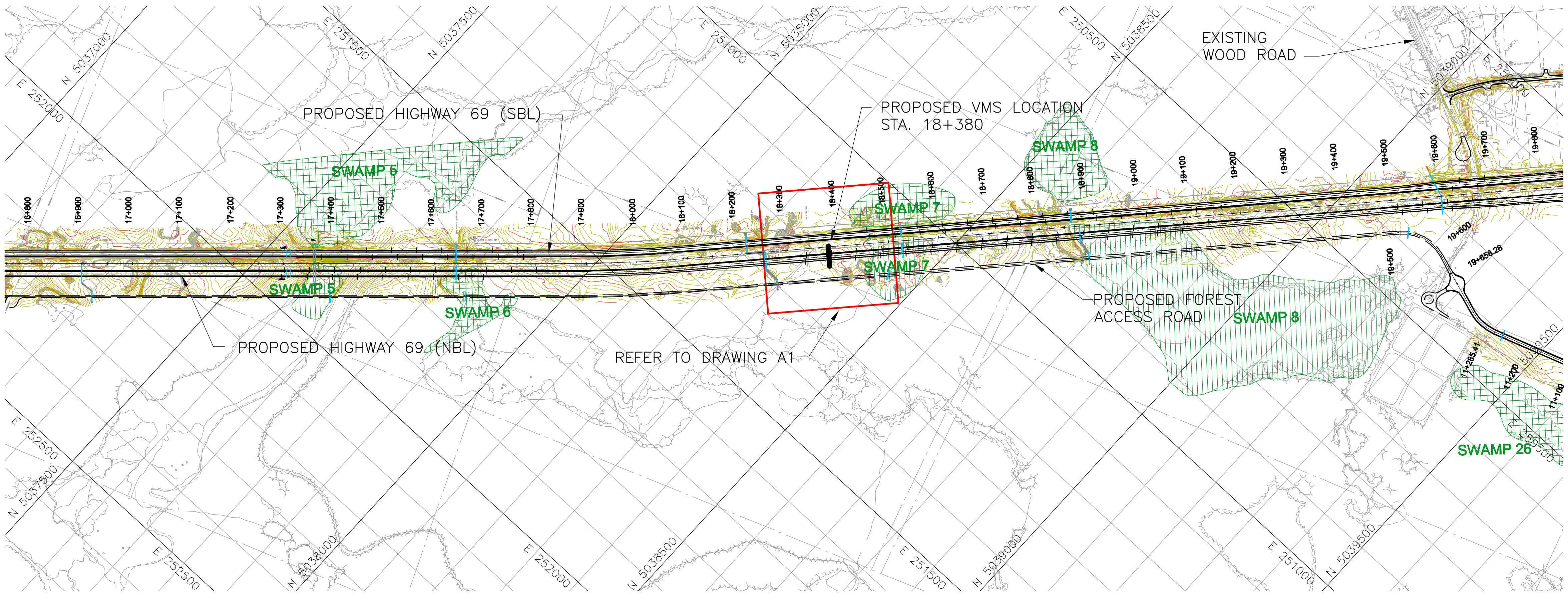
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5402–05–00

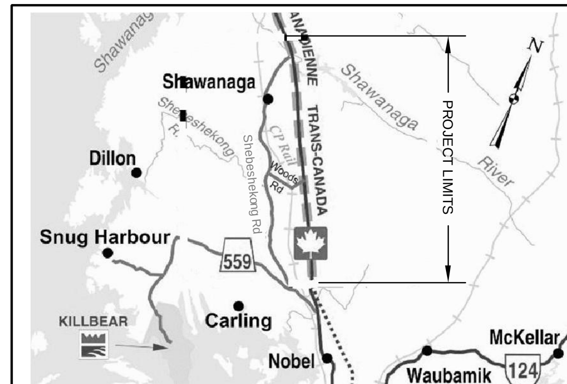
HIGHWAY 69
VARIABLE MESSAGE SIGN (VMS)
INDEX PLAN

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN
SCALE
100 0 100 200 m



KEY PLAN
SCALE
3.7 0 3.7 km

REFERENCE
Base plans provided in digital format by MRC, drawing file 5271XB01.DWG, 5271–XPD–ARCHIPELAGO.dwg, 5271–XPD–Carling.dwg, 5271–XPD–SHAWANAGA.dwg, PR # 5377–02–00–PR–1.dwg, received October 1, 2007, and h6878_PHASE1_XA1, h6878_PHASE1_XN1.dwg, received January 21, 2009, h6878_PHASE2_XA1, h6878_PHASE2_XN1.dwg, received January 21, 2009 9 and h6878_PHASE1_XN1.dwg, received September 19, 2011.

NO.	DATE	BY	REVISION

Geocres No. 41H–110

HWY. 69		PROJECT NO. 07–1111–0029	DIST.
SUBM'D. VA	CHKD. VA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. 2

APPENDIX A

Highway 69 NBL – Variable Message Sign – STA 18+380

Foundation Design

RECORD OF BOREHOLE No VMS1-01

SHEET 1 OF 2 **METRIC**

PROJECT 07-1111-0029
G.W.P. 5402-05-00
LOCATION N 5038325.5 ;E 251183.9
ORIGINATED BY MJR
DIST HWY 69
BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers and NW Casing, Wash Boring
COMPILED BY AT
DATUM Geodetic
DATE May 19, 2009
CHECKED BY VA

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
215.2	GROUND SURFACE					
0.0	Organic Silty SAND, containing rootlets. Very loose. Dark brown to reddish brown. Moist	1	SS	3	~30	
214.6 / 0.6	Silty SAND, trace gravel, containing rootlets. Loose. Reddish brown. Moist	2	SS	9		
213.8 / 1.4	SAND and SILT, trace gravel, containing cobbles. Very dense. Reddish brown to grey. Moist to wet	3	SS	52	~17	2 66 32 0
		4	SS	84		
212.2 / 3.0	Granite Gneiss (BEDROCK). Bedrock cored from 3.0 m to 6.1 m. For bedrock coring details, refer to Record of Drillhole VMS1-01	1	RC	REC 100%		RQD = 90%
		2	RC	REC 100%		RQD = 100%
209.1 / 6.1	END OF BOREHOLE					

NOTE:

1. Water level measured in piezometer at a depth of 1.9 m below ground surface (Elev. 213.3 m) on July 15, 2009.

Column headers: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (215, 214, 213, 212, 211, 210); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

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

GTA-MTO 001 07-1111-0029-CULVERT-PHASE I-.GPJ GAL-MISS.GDT 7/23/12 DD/SAC

RECORD OF DRILLHOLE: VMS1-01

PROJECT: 07-1111-0029
SHEET 2 OF 2
LOCATION: N 5038325.5 ;E 251183.9
DRILLING DATE: May 19, 2009
DATUM: Geodetic
INCLINATION: -90°   AZIMUTH: ---
DRILL RIG: Diedrich D-25
DRILLING CONTRACTOR: Walker Drilling

JN - Joint, FLT - Fault, SH - Shear, VN - Vein, CJ - Conjugate; BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage; PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular; PO - Polished, K - Slickensided, SM - Smooth, RO - Rough, VR - Very Rough; MB - Mechanical Break, BR - Broken Rock. NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN (FLUSH)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	NOTES
		Continued from Record of Borehole VMS1-01	212.23				
3	NW Casing May 19, 2009	GRANITE GNEISS Fresh, strongly foliated, medium to coarse grained with phenocrysts and feldspar banding, low porosity, strong to very strong, pink, grey and black	2.97	1	Grey 100	FO,CURo FO,UNRo FO,CURo FO,CURo	(Axial) 10.1 MPa (Axial) 11.8 MPa (Axial) 10.5 MPa
4	NQ RC May 19, 2009						
5				2	Grey 100	FO,UNVR	
6			209.13 6.07				
		END OF DRILLHOLE					

Depth scale: 7, 8, 9, 10, 11, 12

Columns also shown: SYMBOLIC LOG; RECOVERY (TOTAL CORE %, SOLID CORE %) 80 60 40 20; R.Q.D. % 80 60 40 20; FRACT. INDEX PER 0.3 m 5 10 15 20; B Angle 0 90 180 270; DIP w.r.t. CORE AXIS 0 30 60 90; Jr; Ja; Jn; HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}; Diametral Point Load Index (MPa) 2 4 6; RMC -Q' AVG.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MJR
CHECKED: JB/VA

Golder Associates

RECORD OF BOREHOLE No VMS1-02

METRIC

PROJECT 07-1111-0029		ORIGINATED BY MJR	
G.W.P. 5402-05-00	LOCATION N 5038337.3 ;E 251194.8	ORIGINATED BY MJR	
DIST	HWY 69	BOREHOLE TYPE 165 mm O.D. Continuous Flight Solid Stem Augers and NW Casing, Wash Boring	COMPILED BY AT
DATUM Geodetic		DATE May 19, 2009	CHECKED BY VA

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
214.1	GROUND SURFACE					214		
0.0	Silty SAND, trace gravel, slightly organic, containing rootlets Loose Grey Moist	1	SS	6				
213.5 / 0.6	Silty SAND, trace gravel Very dense Grey Wet	2	SS	31/0.15		213	~17	
213.0 / 1.1	Granite Gneiss (BEDROCK) Bedrock cored from 1.1 m to 4.1 m For bedrock coring details, refer to Record of Drillhole VMS1-02	1	RC	REC 100%		212		RQD = 93%
		2	RC	REC 97%		211		RQD = 97%
210.0 / 4.1	END OF BOREHOLE NOTE: 1. Water level in open borehole not noted upon completion of drilling.							

Column headings also include: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; GR SA SI CL.

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

PROJECT: 07-1111-0029

RECORD OF DRILLHOLE: VMS1-02

LOCATION: N 5038337.3 ;E 251194.8

DRILLING DATE: May 19, 2009

DATUM: Geodetic

DRILL RIG: Diedrich D-25

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: Walker Drilling

JN - Joint, FLT - Fault, SH - Shear, VN - Vein, CJ - Conjugate; BD - Bedding, FO - Foliation, CO - Contact, OR - Orthogonal, CL - Cleavage; PL - Planar, CU - Curved, UN - Undulating, ST - Stepped, IR - Irregular; PO - Polished, K - Slickensided, SM - Smooth, RO - Rough, VR - Very Rough; MB - Mechanical Break, BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	DISCONTINUITY TYPE AND SURFACE DESCRIPTION	Diametral Point Load Index (MPa) / NOTES
		Continued from Record of Borehole VMS1-02	213.03				
	NW Casing May 19, 2009	GNEISS Fresh, strongly foliated, medium grained with phenocrysts and feldspar banding, moderate porosity, strong to very strong, pink, grey and black	1.07			FO,UNSM FO,CUSM FO,CURo FO,UNVR FO,PLSM	(Axial) 9.5 MPa (Axial) 9.2 MPa (Axial) 10.7 MPa
2				1	Grey 100	FO,UNSM FO,IRVR	
3	NQ RC May 19, 2009			2	Grey 100		(Axial) 7.0 MPa (Axial) 9.7 MPa (Axial) 9.5 MPa
4		END OF DRILLHOLE	210.02 4.08				
5							
6							
7							
8							
9							
10							
11							

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: MJR

CHECKED: JB/VA

GTA-RCK 018 07-1111-0029-CULVERT-PHASE I-.GPJ GAL-MISS.GDT 7/23/12 DD/SAC

MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No.
GWP No. 5402–05–00

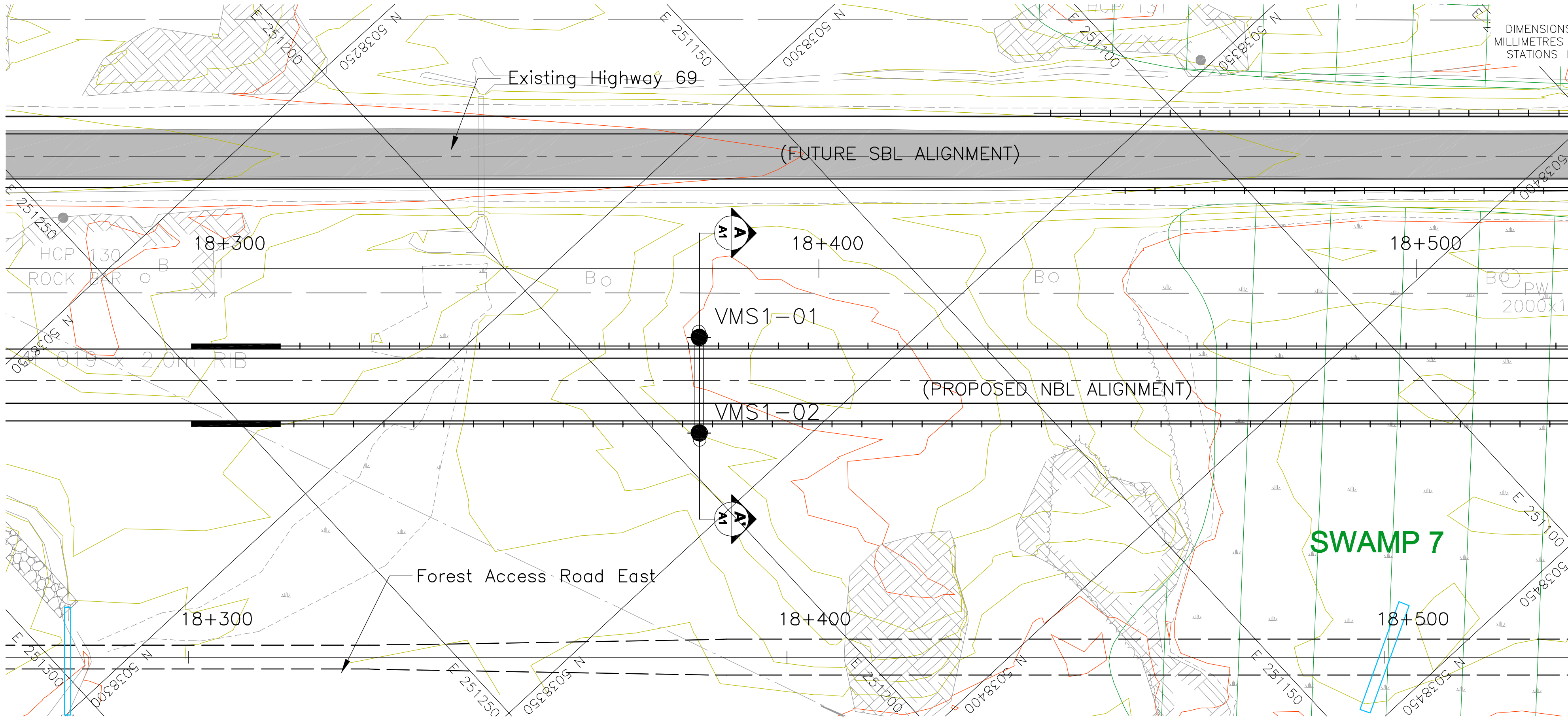
SHEET

HIGHWAY 69 (NBL)

VARIABLE MESSAGE SIGN STA 18+380

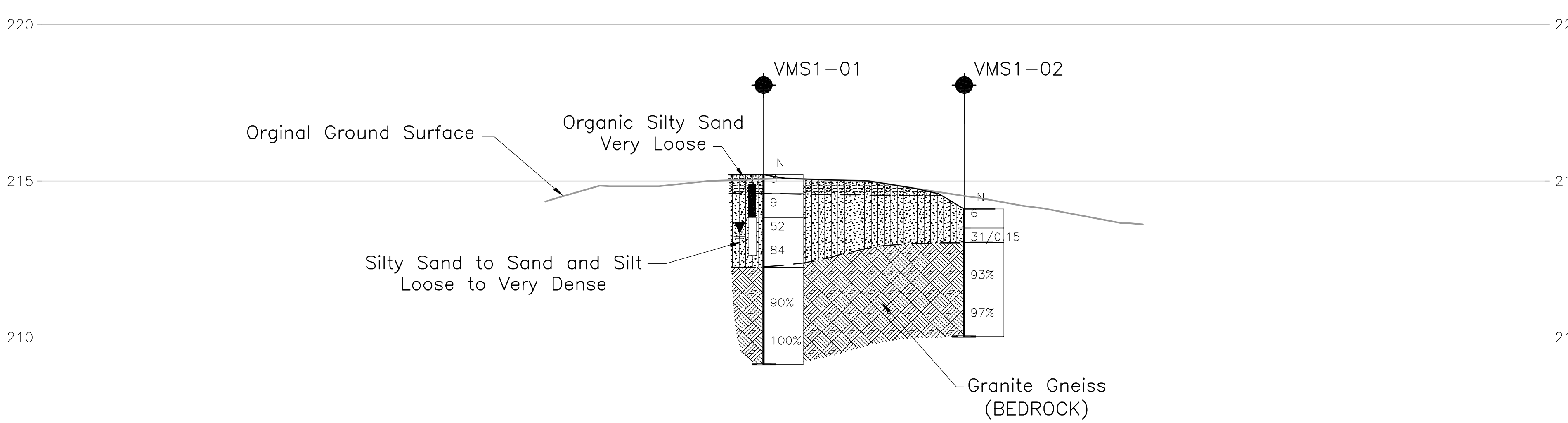
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

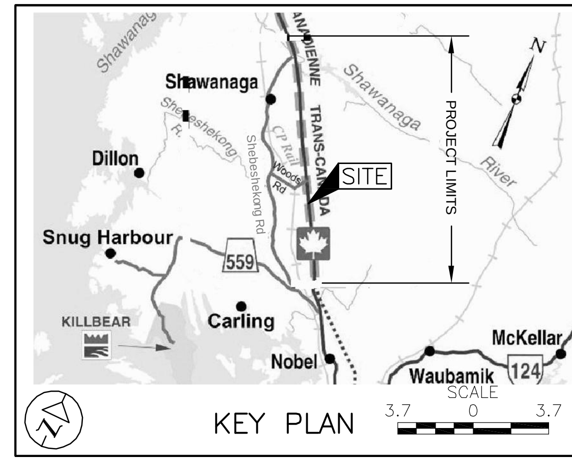
SCALE
10 0 10 20 m



A-A'
A1

CROSS–SECTION STA. 18+380
HIGHWAY 69 (NBL)

HORIZ. SCALE
10 0 10 20 m
2 0 2 4 m
VERT. SCALE



KEY PLAN

SCALE
3.7 0 3.7 km

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on July 15, 2009

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
VMS1–01	215.2	5038325.5	251183.9
VMS1–02	214.1	5038337.3	251194.8

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 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 MRC, drawing file 5271XB01.DWG, 5271–XPD–ARCHIPELAGO.dwg, 5271–XPD–Carling.dwg, 5271–XPD–SHAWANAGA.dwg, PR # 5377–02–00–PR–1.dwg, received October 1, 2007 and h6878_PHASE1_XA1, h6878_PHASE1_XN1.dwg, received January 21, 2009 and h6878_PHASE1_XN1.dwg, received September 19, 2011..

LICENSED PROFESSIONAL ENGINEER C.C. NG 100086170 July 24, 2012 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA July 24, 2012 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

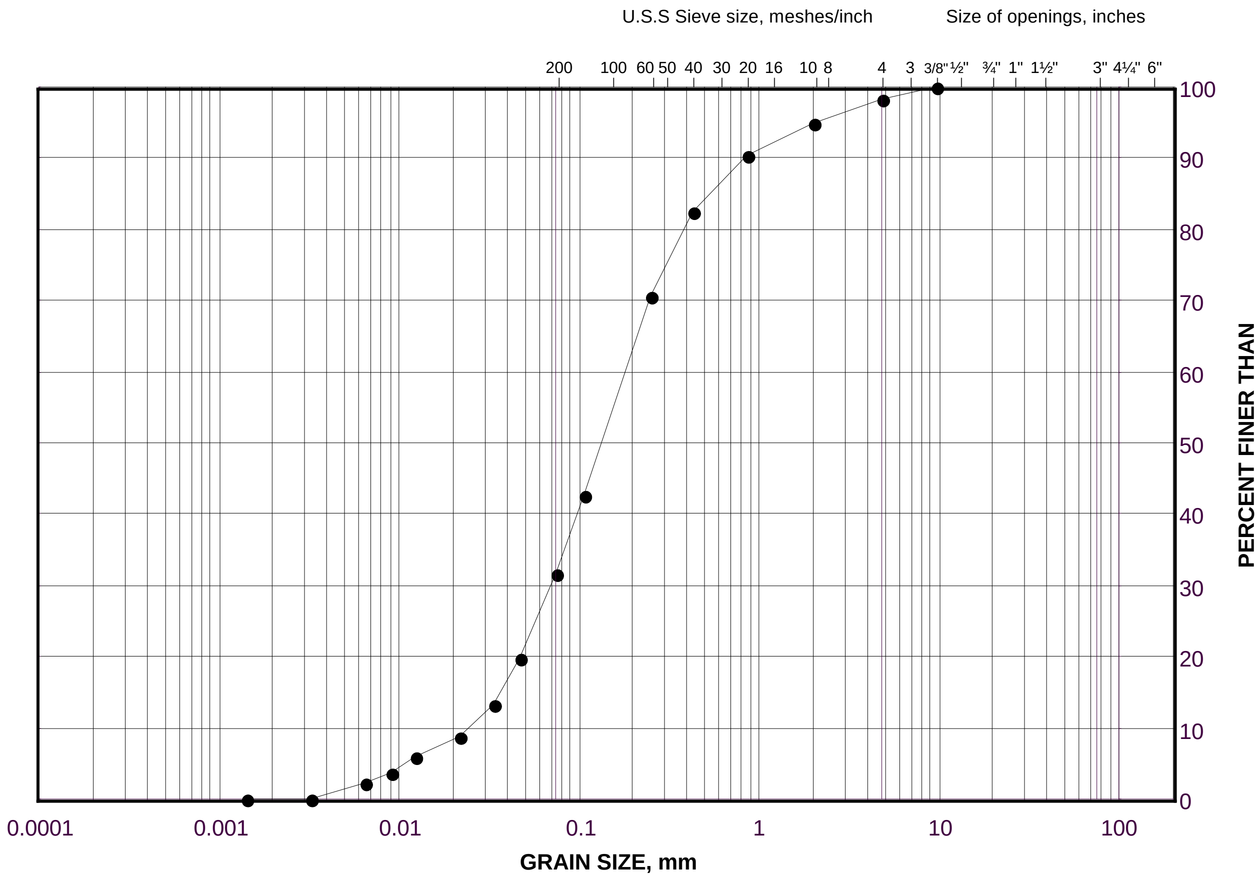
Geocres No. 41H–110

HWY. 69		PROJECT NO. 07–1111–0029	DIST.
SUBM'D. VA	CHKD. VA	DATE: July 2012	SITE:
DRAWN: JFC	CHKD. CN	APPD. JPD/JMAC	DWG. A1

GRAIN SIZE DISTRIBUTION

Sand and Silt

FIGURE A1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	VMS1-01	3	213.4

Project Number: 07-1111-0029

Checked By: TVA

Golder Associates

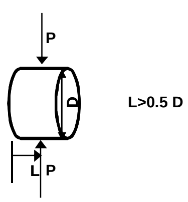
Date: 25-Feb-11

TABLE A1
POINT LOAD TEST ON ROCK SAMPLES

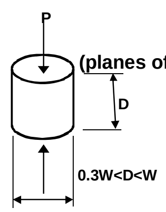
Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Core Length (mm)	Core [(2)] Diameter (mm)	**Is (50mm) (MPa)**	**Approx. UCS Value [(1)] (MPa)**
VMS1-01	1	3.0	212.2	Granite Gneiss	Diametral	101.6	47.00	5.609	112
VMS1-01	1	3.1	212.1	Granite Gneiss	Diametral	88.9	47.00	6.711	134
VMS1-01	1	3.1	212.1	Granite Gneiss	Axial	27.0	47.00	10.054	201
VMS1-01	1	3.1	212.1	Granite Gneiss	Axial	20.0	47.00	11.771	235
VMS1-01	1	3.2	212.0	Granite Gneiss	Diametral	88.9	47.00	4.533	91
VMS1-01	1	3.2	212.0	Granite Gneiss	Axial	25.0	47.00	10.526	211
VMS1-02	1	1.3	212.8	Granite Gneiss	Diametral	127.0	47.00	4.253	85
VMS1-02	1	1.3	212.8	Granite Gneiss	Axial	30.0	47.00	9.490	190
VMS1-02	1	1.4	212.7	Granite Gneiss	Diametral	127.0	47.00	4.416	88
VMS1-02	1	1.4	212.7	Granite Gneiss	Axial	25.0	47.00	9.244	185
VMS1-02	1	1.4	212.7	Granite Gneiss	Axial	25.0	47.00	10.711	214
VMS1-02	1	1.5	212.6	Granite Gneiss	Diametral	228.6	47.00	4.858	97
VMS1-02	2	2.7	211.4	Granite Gneiss	Diametral	114.3	47.00	5.893	118
VMS1-02	2	2.8	211.3	Granite Gneiss	Diametral	101.6	47.00	6.227	125
VMS1-02	2	2.9	211.2	Granite Gneiss	Diametral	127.0	47.00	4.942	99
VMS1-02	2	2.9	211.2	Granite Gneiss	Axial	30.0	47.00	7.005	140
VMS1-02	2	2.9	211.2	Granite Gneiss	Axial	30.0	47.00	9.727	195
VMS1-02	2	3.0	211.1	Granite Gneiss	Axial	35.0	47.00	9.526	191

[(1)] Is_{50} x K, from ASTM Designation: D 5731-08 "Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications. A value of K = 20 has been estimated for this site.
[(2)] Actual distance between point load cones at time of failure.

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS
note: Diametral tests are perpendicular to core axis
(planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS
note: Axial tests are parallel to core axis
(planes of weakness)



Compiled by: AM/AT
Reviewed by: TVA/CN

APPENDIX B

Non-Standard Special Provisions

Mass Concrete – Item No.

Special Provision

Scope of Work

The scope of work for the above noted tender item includes the supply and placement of mass concrete under the variable message sign spread footings to raise the founding grade to the design level of the underside of the footings.

Construction

Concrete shall be the same strength as the footing concrete and placed in accordance with OPSS 904 Concrete Structures.

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.

END OF SECTION

<u>Dowels Into Rock</u> – Item No.

Special Provision

Scope of Work

Work under this item is for the placement and field testing of dowels into rock.

Construction

Dowels into rock shall be constructed in accordance with OPSS 904 Concrete Structures. All reinforcing steel supplied shall be in accordance with OPSS 1440 (Steel Reinforcement for Concrete) (dowel bars conforming to CSA Standard CSAG30.18, Grade 400).

For dowels into rock, holes shall be drilled to the required depth and size. Hole diameter shall be two times the nominal diameter of the dowel. Each hole shall be cleaned out, grouted and the dowel set in place. Grout shall be of the same strength as the footing concrete, or at least 25 MPa at 28 days.

If the hole contains water, the Contractor shall remove the water, otherwise, a tremie procedure shall be used to completely fill the hole with grout. The dowel shall be forced into the hole after the grout has been placed and while it is still fresh.

Rock Dowel Testing

All proposed testing procedures shall be in general conformance with ASTM D3689-90 and ASTM D1143M-07. Field testing must be carried out in the presence of, and the results reviewed and approved by, the Contract Administrator.

Performance Tests

The following table summarizes the number of dowels into rock where performance testing shall be carried out to confirm that the design load of the rock dowels can be achieved. The Contract Administrator will select the rock dowels to be tested.

Structure	**Number of Dowels for Performance Testing**
Variable Message Sign	2 per spread footing

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

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

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

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

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

Displacement measurements shall be carried out at each load increment using calibrated displacement gauges capable of measuring movements of 0.025 mm. Measurements shall be referenced to an independent fixed referenced point.

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

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

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

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.

END OF SECTION

<u>Control of Overburden Soils</u> – Item No.

Special Provision

Scope of Work

Excavations for the variable message sign will be advanced through cohesionless soils, which should be expected to be unstable below the groundwater level. Where cohesionless soil deposits are encountered, appropriate construction equipment and procedures will be required to minimize ground loss during excavation and concrete placement.

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.

END OF SECTION

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
2390 Argentia Road
Mississauga, Ontario, L5N 5Z7
Canada
T: +1 (905) 567 4444

Golder Associates