



**March 13, 2015**

## **FOUNDATION INVESTIGATION AND DESIGN REPORT**

**EMBANKMENT OVER SWAMP, TOWNSHIP OF SHAWANAGA  
HIGHWAY 7182 RECONSTRUCTION  
FROM THE CARLING/SHAWANAGA TOWNSHIP BOUNDARY, NORTHERLY  
7.3 KM  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5163-10-00**

**Submitted to:**

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**REPORT**

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# **PART A**

**FOUNDATION INVESTIGATION REPORT  
EMBANKMENT OVER SWAMP, TOWNSHIP OF SHAWANAGA  
RECONSTRUCTION OF HIGHWAY 7182  
FROM THE CARLING/SHAWANAGA TOWNSHIP BOUNDARY,  
NORTHERLY 7.3 KM  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5163-10-00**



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the roadway embankment crossing a swamp area and for replacement of two culverts as part of the reconstruction of Highway 7182 (Shebeshekong Road) in the Township of Shawanaga. The proposed reconstruction of Highway 7182 extends from the boundary of the Townships of Carling and Shawanaga, northerly for 7.3 km. The locations of the swamp crossing and culverts are shown on the Index Plan on Drawing 1.

The original Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated November 2012. Golder's proposal (Scope of Work) for foundation engineering services associated with the swamp crossing and culvert replacements is contained in Section 6.8 of MH's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated June 18, 2013. The drawings showing the vertical profile and cross-sections along the Highway alignment were provided to Golder by MH on December 17, 2014.

This report addresses the investigation carried out at the roadway embankment swamp crossing only.

The purpose of this investigation is to obtain subsurface information along the existing highway alignment at the swamp crossing by methods of borehole drilling, bedrock coring, in situ testing and laboratory testing on selected soil and rock samples. The foundation investigation was carried out within the limits of the swamp area as defined in the Terms of Reference. The boreholes for the swamp crossing were located in the field by Golder and were surveyed relative to stakes and/or nail pins installed by Tulloch Engineering (Tulloch), a licensed surveyor retained by MH. The investigation area is shown in plan on Drawing 2.

## **2.0 SITE DESCRIPTION**

The existing Highway 7182 is oriented generally in a south-north direction extending from Highway 559 at the south end to Highway 69 at the north end in the Township of Shawanaga, Ontario. The area of the swamp crossing is located between approximately STA 10+200 and 10+345 on Highway 7182, extending over a length of about 145 m.

In general, the topography within the project limits consists of rolling terrain, including densely treed areas and numerous bedrock outcrops separated by low-lying swamps containing areas of standing water and various types of vegetation and organic soils. The ground surface at the borehole and DCPT locations advanced within the limits of the swamp crossing, including through the existing Highway 7182 embankments, varies between Elevation 206.4 m and 204.9 m, referenced to Geodetic datum. Section 4.0 of this report presents a detailed description for the area of the swamp crossing.

## **3.0 INVESTIGATION PROCEDURES**

The field investigation for the swamp crossing area was carried out between June 9 and 16, 2014 during which time a total of eight boreholes and seven Dynamic Cone Penetration Tests (DCPTs) were advanced within the identified swamp area.



The results of the borehole investigation and dynamic cone penetration test are presented on the Record of Borehole/Drillhole sheets and Record of DCPTs in Appendix A.

The field borehole investigation was carried out using portable equipment and a truck-mounted CME 55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The boreholes were advanced through the overburden using 203 mm outer diameter (O.D.) continuous flight hollow-stem augers and 'NW' casing. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm O.D. split-spoon sampler driven by an automatic hammer on the truck-mounted drill rig in accordance with Standard Penetration Test (SPT) procedures.<sup>1</sup> Boreholes advanced by portable equipment employed a full-weight hammer lifted manually and dropped from the standard SPT height. Bedrock samples were recovered using an 'NQ'-size rock core barrel. Field vane shear tests were carried out in cohesive soils for assessment of undrained shear strengths<sup>2</sup> using MTO Standard 'N'-size vanes. The boreholes and DCPTs were advanced to depths of up to about 10.3 m (including coring of bedrock for a core length of about 1.8 m to 3.7 m) below existing ground surface.

Where possible, the groundwater conditions in the open boreholes were observed during and upon completion of drilling operations. All open boreholes were backfilled with bentonite pellets upon completion in accordance with Ontario Regulation 903, Wells (as amended).

The fieldwork was observed by a member of Golder's engineering and technical staff who located the boreholes, arranged for the clearance of underground services, observed the drilling and sampling operations, and logged the boreholes. The soil and rock samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, organic content, grain size distribution and Atterberg limits) was carried out on selected soil samples. Unconfined compression strength testing was carried out on a selected specimen of the rock core. The results of the laboratory testing are included in Appendix B.

Classification of the rock mass quality of the bedrock with respect to the Rock Quality Designation (RQD) is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)<sup>3</sup> while the strength of the bedrock core samples is based on Table 3.5 of CFEM (2006). The degree of weathering of the bedrock samples and the strength classification of the intact rock mass based on field identification are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM, 1985)<sup>4</sup> standard classification system.

The as-drilled borehole locations, in stations and offset, were measured relative to the centerline alignment and were subsequently converted to MTM NAD 83 coordinates in AutoCAD. Borehole top elevations were surveyed by a member of Golder's technical staff in reference to temporary benchmarks that were surveyed by Tulloch. The borehole locations shown on the Record of Borehole/Drillhole sheets and Drawing 2 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

<sup>1</sup> ASTM D1586 – Standard Test Method for Standard Penetration Test.

<sup>2</sup> ASTM D2573 – Standard Test Method for Field Vane Strength Shear Test.

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

<sup>4</sup> International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech. Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.



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Borehole/DCPT Designation	Location (MTM NAD 83)		Ground Surface Elevation	Borehole/ DCPT Depth
	Northing	Easting		
S1-01	5,039,636.4	246,346.6	205.5	3.8
S1-02	5,039,653.7	246,327.1	205.7	10.3
S1-03	5,039,655.6	246,300.4	204.9	8.7
S1-04	5,039,685.5	246,258.1	206.2	7.9
S1-05	5,039,689.3	246,287.4	205.2	2.8
S1-06	5,039,679.1	246,311.3	205.0	4.2
S1-07	5,039,660.6	246,330.3	205.7	10.1
S1-08	5,039,639.4	246,375.6	206.2	5.8
S1-DC01A	5,039,631.3	246,374.0	206.4	1.2
S1-DC01B	5,039,630.4	246,375.8	206.4	1.7
S1-DC02	5,039,664.9	246,276.1	205.0	7.7
S1-DC03A	5,039,692.6	246,261.4	206.3	2.1
S1-DC03B	5,039,691.7	246,263.2	206.3	2.3
S1-DC04	5,039,658.3	246,356.8	205.0	4.2
S1-DC05	5,039,688.5	246,289.2	205.1	1.8

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*<sup>5</sup>, this section of Highway 7182, formerly 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<sup>6</sup>. Deposition of Paleozoic strata and later erosion during glaciation exposed these Precambrian rocks.

<sup>5</sup> 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.

<sup>6</sup> Ontario Geological Society, 1991. *Geology of Ontario*, Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.





## **4.2 Subsurface Conditions**

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are provided in Appendices A and B, respectively. The results of the in situ field tests (i.e. SPT 'N'-values and field vanes) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the profile on Drawings 2 and 3 are inferred from non-continuous sampling, observations of drilling progress and the results of in situ field tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. It should be noted that the interpreted stratigraphy as shown on Drawings 2 and 3 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the swamp area consist of a surface layer of fill or peat underlain by alternating deposits of cohesive and non-cohesive soils overlying the granitic gneiss bedrock. Bedrock outcrops are encountered at the limits of the swamp area.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

### **4.2.1 Sand to Sandy Gravel Fill**

Boreholes S1-02, S1-04, S1-07 and S1-08 were advanced through the shoulder of the existing Highway 7182 and penetrated a layer of non-cohesive fill which generally consists of brown to grey sand, trace to some gravel, to sandy gravel, trace to some silt, trace clay. The lower portion of the fill deposit as encountered in Borehole S1-02 is described as organic silty sand containing organic materials. The top of the fill layer ranges from about Elevation 206.2 m to 205.7 m and its thickness varies between about 1.5 m and 2.3 m.

The SPT 'N'-values measured within the non-cohesive fill layer generally range from 7 blows to 23 blows per 0.3 m of penetration, indicating a loose to compact relative density. An SPT 'N'-value of 2 blows per 0.3 m of penetration was measured within the lower organic silty sand portion of the fill layer in Borehole S1-02, suggesting a very loose relative density.

The natural water content measured on three samples of the fill ranges from about 2 per cent to 16 per cent and on a sample of organic silty sand is about 82 per cent. The organic content measured on a sample of the sand fill is about 1 per cent, and on a sample of the organic silty sand fill is about 9 per cent.

The grain size distributions of three samples of sand to gravelly sand fill and one sample of organic silty sand fill are shown on Figures B1-A and B1-B, respectively, in Appendix B.

Atterberg limits tests were completed on the fines portion of a sample of sand fill and a sample of organic silty sand fill, and indicate that the fines portion of these materials is non-plastic.

### **4.2.2 Peat**

A deposit of fibrous or amorphous peat was encountered immediately below ground surface in Boreholes S1-01, S1-03, S1-05 and S1-06, and below the fill layer in Boreholes S1-02, S1-04 and S1-07. The peat layer was not encountered in Borehole S1-08. The surface of the peat was encountered between Elevation 205.4 m and





203.4 m and it ranges from 0.7 m to 3.8 m in thickness except at Borehole S1-01, where the layer is only 0.1 m thick and directly overlies bedrock.

The SPT 'N'-values measured within the peat layer range from 0 blows (weight of hammer) to 2 blows per 0.3 m of penetration, suggesting a very soft consistency.

The natural water content measured on four samples of the peat ranges from about 42 per cent to 812 per cent.

#### **4.2.3 Clayey Organic Silt**

Boreholes S1-03 and S1-06 penetrated approximately 1.2 m and 0.8 m thick layers of clayey organic silt below the peat deposit at about Elevation 201.1 m and 203.6 m, respectively.

SPT 'N'-values of 0 blows (weight of hammer) per 0.3 m of penetration were measured within the clayey organic silt deposit in both boreholes.

The natural water content measured on three samples of this deposit ranges from 100 per cent to 187 per cent. The organic content measured on a sample of this layer is about 9 per cent.

Atterberg limits test were completed on two samples of this deposit and measured liquid limits of about 133 per cent and 134 per cent, plastic limits of about 52 per cent and 46 per cent and plasticity indices of about 81 per cent and 88 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B2 in Appendix B and indicate that the material is classified as clayey organic silt.

#### **4.2.4 Clayey Silt to Clay**

A deposit of brown to grey clayey silt to clay was encountered below the fill in Borehole S1-08, underlying the peat and/or clayey organic silt layers in Boreholes S1-02, S1-04 and S1-06, and below the silt and sand to silty sand deposit in Boreholes S1-03 and S1-07. The top of this deposit was encountered between Elevation 204.7 m and 199.3 m, and the thickness of the deposit varies between about 0.8 m and 3.1 m. Boreholes S1-03 and S1-06 were terminated within this deposit on refusal to further penetration of split-spoon sampler and/or casing at depths of about 8.7 m and 4.2 m corresponding to Elevation 196.2 m and 200.8 m, respectively.

The SPT 'N'-values measured within cohesive deposit range from 0 blows (weight of rod or hammer) to 1 blow per 0.3 m of penetration. In situ field vane tests were carried out within this deposit in Boreholes S1-02, S1-04, S1-06 and S1-07 and measured undrained shear strengths ranging from approximately 10 kPa to 19 kPa, and sensitivity values of between 2 and 8. The measured SPT 'N'-values and field vane test results indicate that the deposit has a very soft to soft consistency.

The natural water content measured on nine samples of the clayey silt to clay deposit ranges from about 38 per cent to 89 per cent.

Atterberg limits tests were completed on four samples of this deposit and measured liquid limits ranging from about 27 per cent to 62 per cent, plastic limits ranging from about 15 per cent to 29 per cent and plasticity indices of about 12 per cent to 33 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B3 in Appendix B and indicate that the material is classified as clayey silt of low plasticity to clay of high plasticity.



#### **4.2.5 Silt and Sand to Sand and Gravel**

A non-cohesive soil deposit was encountered underlying the peat layer in Boreholes S1-05 and S1-07, below the clayey organic silt layer in Borehole S1-03 and underlying the cohesive deposit in Boreholes S1-02 and S1-08. In Borehole S1-07, non-cohesive soil layers were encountered both above and below the silty clay deposit. The non-cohesive deposit is underlain by granitic gneiss bedrock in all boreholes except Borehole S1-03, where it is underlain by the clayey silt deposit. The top of this deposit ranges from Elevation 204.5 m to 199.9 m, and the thickness of the deposit varies between about 0.3 m and 1.9 m.

The SPT 'N'-values measured within the non-cohesive deposit generally range from 7 blows per 0.15 m of penetration to 22 blows per 0.3 m of penetration, indicating a loose to compact relative density. An SPT 'N'-value of 0 blows (weight of hammer) per 0.3 m of penetration was measured at the interface of this deposit and overlying cohesive deposit in Borehole S1-08; however, this value is considered to be more representative of the silty clay deposit and/or disturbance due to groundwater inflow to the borehole during sampling.

The natural water content measured on five samples of the non-cohesive deposit ranges from about 13 per cent to 24 per cent.

The deposit is generally comprised of silt and sand, to gravelly silt and sand, to silty sand to sand to gravelly sand to sand and gravel. Auger grinding was noted within this deposit in Boreholes S1-02 and S1-07, and it is interpreted to represent the presence of cobbles and/or boulders. The results of grain size distribution tests completed on four samples of the non-cohesive deposit are shown on Figure B4 in Appendix B.

#### **4.2.6 Refusal / Bedrock**

The bedrock surface in all boreholes and DCPTs is inferred by refusal to further penetration of the split-spoon sampler, and/or refusal to further advancement of the auger and/or casing or dynamic cone penetration, at depths between about 0.1 m and 8.7 m below ground surface (between about Elevation 205.4 m and 196.2 m). The bedrock was cored in Boreholes S1-01, S1-02, S1-04, S1-05, S1-07 and S1-08, with between about 1.8 m and 3.7 m of core samples were recovered.

Based on a review of the bedrock core samples, the bedrock consists of granitic gneiss and the core samples are generally described as fresh, foliated, grey, medium to coarse crystalline, faintly to moderately porous, and strong to very strong, as presented on the drillhole records sheets in Appendix A.

The Rock Quality Designation (RQD) measured on the core samples is generally between about 82 per cent and 100 per cent, indicating a rock mass of good to excellent quality; one RQD value of 42 per cent was measured within the upper portion of the bedrock in Borehole S1-05, indicating a rock mass of poor quality in this area. The Total Core Recovery (TCR) of the core samples is between 94 per cent and 100 per cent, and the Solid Core Recovery (SCR) of the core samples is between 58 per cent and 100 per cent.

An Unconfined Compression (UC) test<sup>7</sup> was carried out on a selected core sample of the bedrock and measured a uniaxial compressive strength of about 98 MPa. The details of the UC test are presented in Table B1 in Appendix B. Based on the laboratory UC test result, the approximate uniaxial compressive strength of the granitic gneiss bedrock is classified as strong ( $R_4$ ,  $50 \text{ MPa} < \text{UCS} < 100 \text{ MPa}$ ).

<sup>7</sup> ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens.



### **4.3 Groundwater Condition**

In general, the soil samples taken in the boreholes were moist to wet. The groundwater level was measured in the open boreholes upon completion of overburden drilling and ranges from about Elevation 204.7 m to 203.3 m measured at depths between 0.3 m and 2.9 m below the ground surface. However, these measured levels may not represent the stabilized groundwater level at the site. In general, it should be expected that the groundwater level is at or near the natural ground surface at the site.

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

### **5.0 CLOSURE**

Mr. Indulis Dumpis, a senior technician with Golder, directed the drilling program. This report was prepared by Mr. Al Varshoi, EIT, and reviewed by Mr. Christopher Ng, P.Eng., a geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and Principal with Golder, conducted an independent quality control review of the report.



## Report Signature Page

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ARV/CN/LCC/arv/jl

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# **PART B**

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## **6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS**

### **6.1 General**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to assess the foundation aspects for the detail design of the proposed rehabilitation of a section of embankment over a swamp as part of the Highway 7182 reconstruction in the Township of Shawanaga, Ontario. This section of the report provides an interpretation of the geotechnical data obtained during the investigation, and discussion and recommendations on the foundation aspects of the design of the proposed rehabilitation.

The recommendations provided herein are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

### **6.2 Assessment of Embankments Over Swamp Area**

The Highway 7182 swamp crossing is located between approximately STA 10+200 and 10+345, for a length of about 145 m. Based on the vertical profiles and cross-sections of the Highway 7182 alignment provided to Golder by MH on December 17, 2014, the geometry of the Highway 7182 embankment will remain unchanged; there will be no grade raise, and no embankment widening is required. The proposed works involve rehabilitation of the pavement structure and embankment shoulders to improve the overall condition and performance of the highway.

Golder has completed an assessment and analysis of the global stability and settlement of the existing embankment under the proposed rehabilitation strategy conditions, to determine whether any additional foundation-related strategies are required to be incorporated into the rehabilitation program. The results of the stability and settlement assessments are presented in Sections 6.2.1 and 6.2.2, respectively. In summary, given that the highway embankment geometry is to remain unchanged, there are no issues related to stability or settlement of the existing embankment and, as such, no additional foundation mitigation measures will be required as part of the proposed rehabilitation program.

#### **6.2.1 Stability**

Based on the results of the subsurface investigation and review of the highway profile drawings, the critical section for stability (i.e. maximum thickness of soft compressible foundation soils) for this area is at about STA 10+285, where the embankment height is about 1.5 m and the combined thickness of organic and cohesive deposits is about 8.1 m. The stability analyses were carried out at the critical section using total and effective stress parameters with the commercially available program SLIDE 6.0, produced by Rocscience Inc., and applying the Morgenstern-Price method. The geotechnical engineering parameters employed in the analyses are presented below.



Soil Deposit	Bulk Unit Weight	Total Stress Analysis		Effective Stress Analysis	
		Friction Angle, $\phi$	Undrained Shear Strength, $s_u$	Effective Friction Angle, $\phi'$	Effective Cohesion, $c'$
Compact Granular Fill	21 kN/m <sup>3</sup>	33°	--	33°	0 kPa
Very Soft Peat	12 kN/m <sup>3</sup>	0°	10 kPa	26°	0 kPa
Very Soft Clayey Organic Silt	17 kN/m <sup>3</sup>	0°	10 kPa	28°	0 kPa
Compact Silty Sand	20 kN/m <sup>3</sup>	30°	--	30°	0 kPa
Very Soft to Soft Clayey Silt to Silty Clay	18 kN/m <sup>3</sup>	29°	0 kPa	29°	0 kPa

The analyses indicate that the existing, up to 1.5 m high Highway 7182 embankment has a Factor of Safety (FoS) of greater than 1.3 for a deep-seated, global failure surface as shown on Figures 1 and 2, and as such, stability mitigation measures are not required as part of the proposed pavement and shoulder rehabilitation work.

### 6.2.2 Settlement

Given that the highway grade will remain unchanged and that embankment widening is not being proposed for the rehabilitation, there will be no additional loads applied to the foundation soils and therefore no additional primary consolidation settlements will occur.

Based on the results of the settlement analysis carried out at the critical section at STA 10+285 (i.e. maximum thickness of soft compressible foundation soils), it is estimated that primary consolidation settlement of the organic and cohesive deposits is complete and that the magnitude of secondary consolidation (creep) settlement is estimated to be less than 30 mm over the next 15 years. Given that the ongoing long-term creep settlement meets the performance criteria contained in Section 1.2 of "MTO's Embankment Settlement Criteria for Design", dated July 2010, settlement mitigation measures are not required.

## 7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Al Varshoi, EIT, and reviewed by Mr. Christopher Ng, P.Eng., a geotechnical engineer and Associate with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact and a Principal with Golder, conducted an independent quality control review of the report.





## Report Signature Page

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Designated MTO Contact, Principal

ARV/CN/LCC/arv/jl

n:\active\2012\1111\12-1111-0102 mh - highway 7182 - shawana\reports\1 - swamp 10+200 to 10+345\final\12-1111-0102-1 rpt 15mar13 highway 7182 embankment over swamp  
fidr.docx



## REFERENCES

Bowles, J.E. 1984. Physical and Geotechnical Properties of Soils, Second Edition. McGraw Hill Book Company, New York.

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

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Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL-6800, Research Project 1493-6. Prepared for Electric Power Research Institute, Palo Alto, California.

Peck, R.B., Hanson, W.E., and Thornburn, T.H. 1974. Foundation Engineering, Second Edition, John Wiley and Sons, New York.

Unified Facilities Criteria, U.S. Navy. 1986. NAVFAC Design Manual 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
ASTM D2573	Standard Test Method for Field Vane Shear Test in Cohesive Soil
ASTM D7012	Standard Test Method for Strength and Elastic Moduli of Intact Rock Core Specimen

### Commercial Software:

Settle<sup>3D</sup> (Version 2.0) by Rocscience Inc.

Slide (Version 6.0) by Rocscience Inc.

### Contract Design Estimating and Documentation (CDED):

Special Provision 105S21 Amendment to OPSS 501 – Water Requirements and Quality Control for Compaction – Method B

Special Provision 206S03 Amendment to OPSS 206 – Earth Excavation, Grading; Rock Excavation, Grading.

Special Provision 539S02 Amendment to OPSS 539 – Protection System



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**FOUNDATION REPORT - HIGHWAY 7182 RECONSTRUCTION  
EMBANKMENT OVER SWAMP - GWP 5163-10-00**

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Ministry of Transportation Ontario:

MTO Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates. September 2010.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213      Construction Projects (as amended)

Ontario Water Resources Act:

Ontario Regulation 903      Wells (as amended)



## 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

#### (a) Index Properties

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

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density 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
$C_\alpha$	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

Notes: 1  
2

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

## WEATHERING STATE

**Fresh:** no visible sign of weathering

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

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

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

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

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

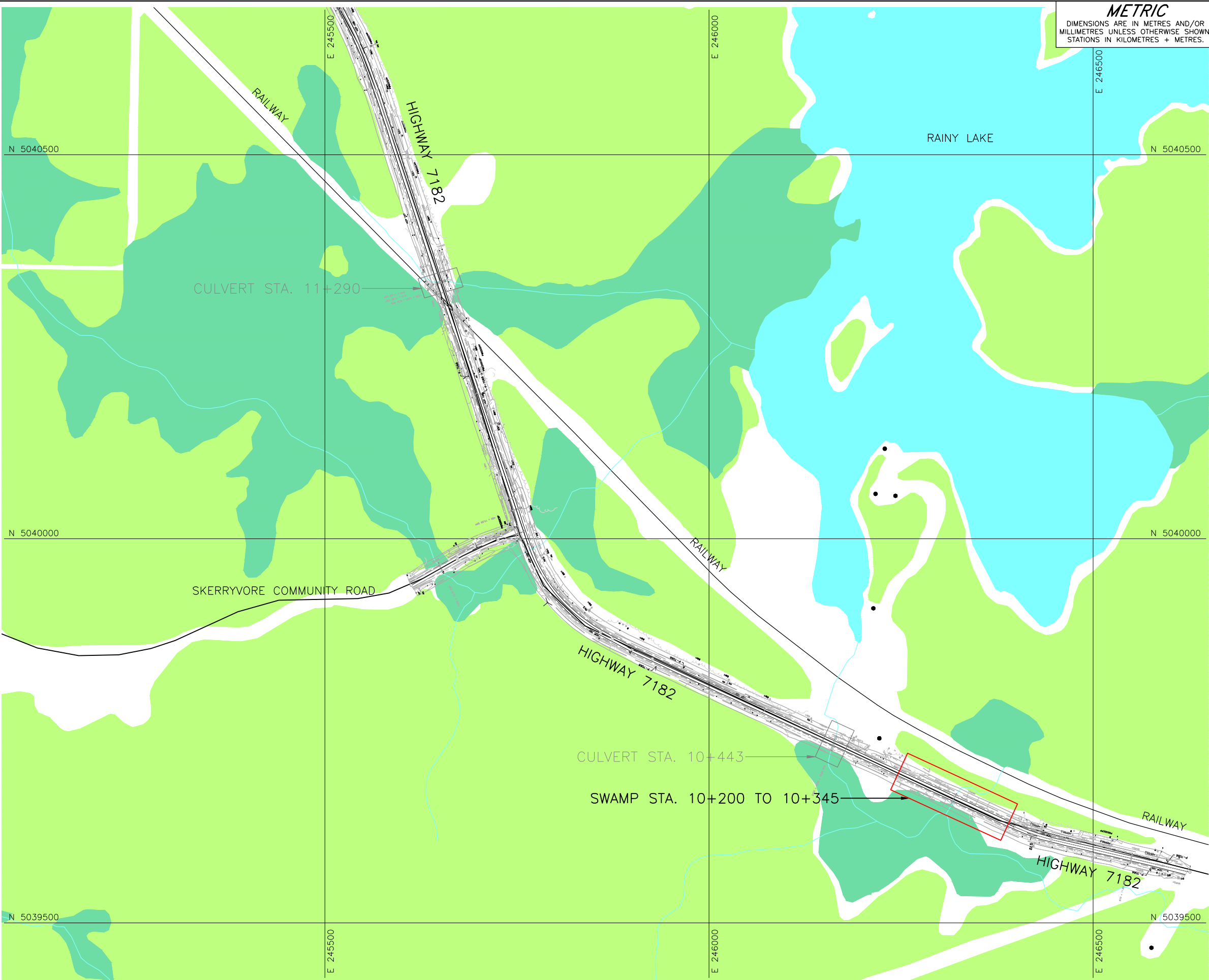
### Abbreviations

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	



# DRAWINGS



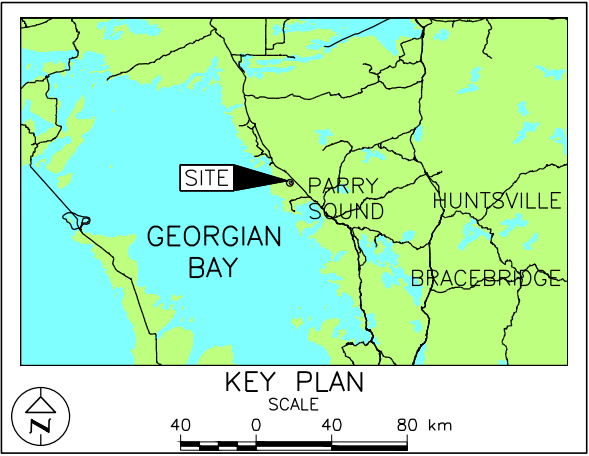


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 5163-10-00

HIGHWAY 7182  
SWAMP  
INDEX PLAN

SHEET



**NOTES**

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

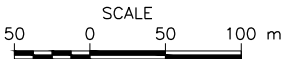
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

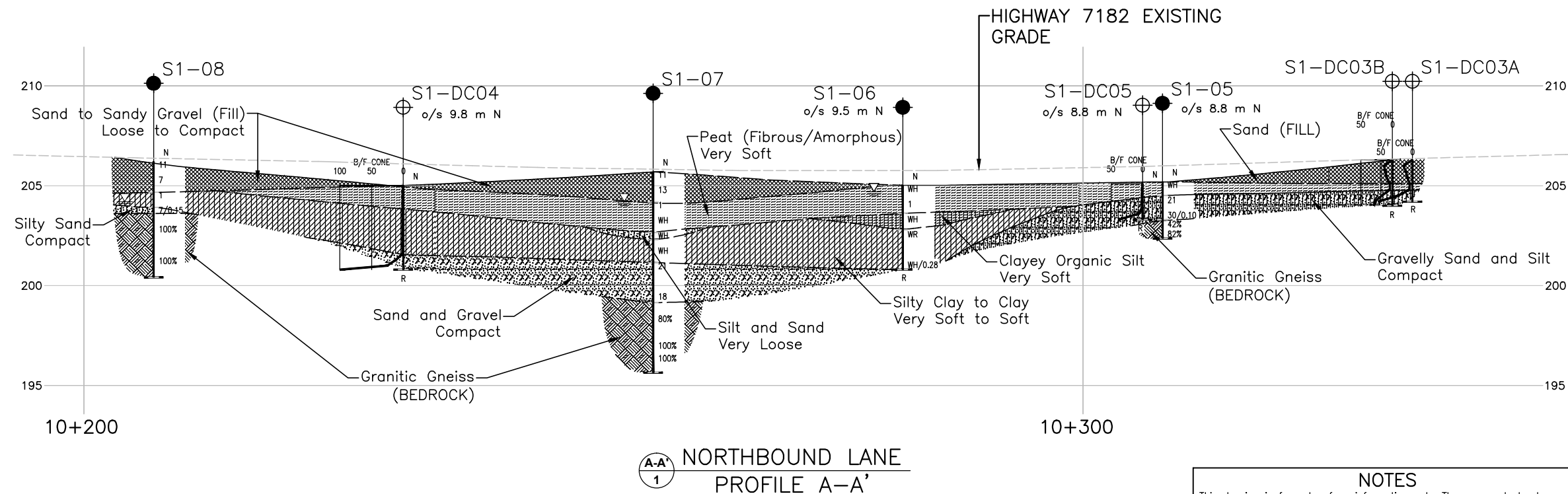
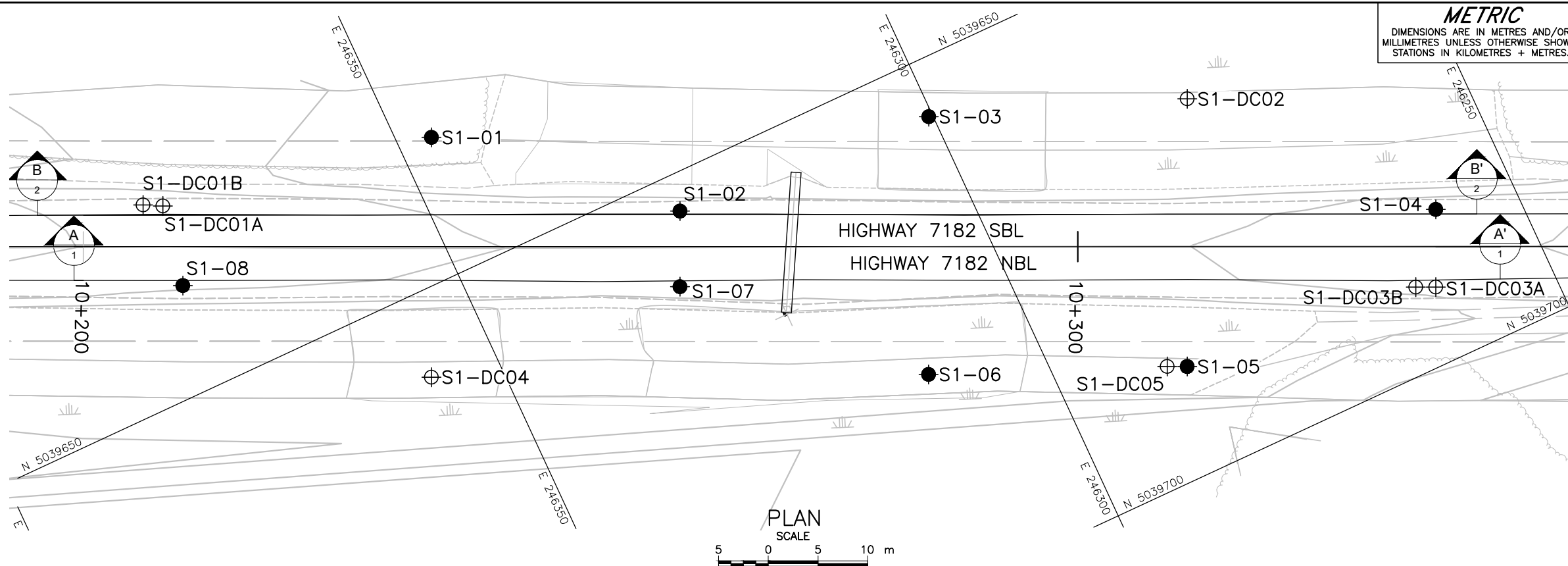
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

**REFERENCE**

Base plans, profile and topographic data provided in digital format by Morrison Hershfield, drawing file nos. bc04537182001.dwg and Alignment-profile.dwg, dated Dec., 2013, received Dec. 17, 2014

NO.	DATE	BY	REVISION
Geocres No. 41H-149			
HWY. 7182		PROJECT NO. 12-1111-0102	DIST. .
SUBM'D. CN	CHKD. CN	DATE: 2/4/2015	SITE: .
DRAWN: MR	CHKD. CN	APPD. LCC	DWG. 1



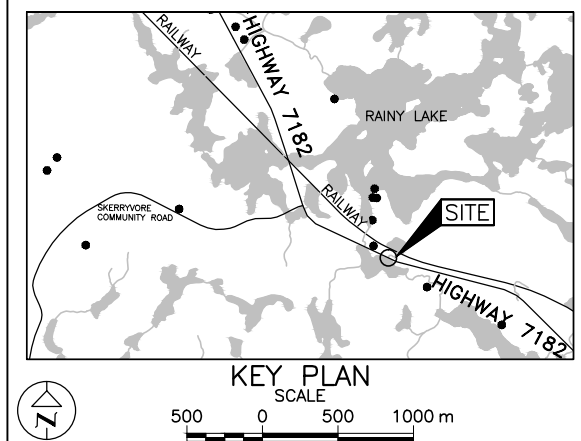


## NOTES

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CONT No.  
GWP No. 5163-10-00HIGHWAY 7182  
STA. 10+200 TO 10+345 (NBL)  
BOREHOLE LOCATIONS AND SOIL  
STRATA

## LEGEND

- Borehole
- ⊕ Dynamic Cone Penetration Test
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL upon completion of drilling
- R Refusal

## BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
S1-01	205.5	5039636.4	246346.6
S1-02	205.7	5039653.7	246327.1
S1-03	204.9	5039655.6	246300.4
S1-04	206.2	5039685.5	246258.1
S1-05	205.2	5039689.3	246287.4
S1-06	205.0	5039679.1	246311.3
S1-07	205.7	5039660.6	246330.3
S1-08	206.2	5039639.4	246375.6
S1-DC01A	206.4	5039631.3	246374.0
S1-DC01B	206.4	5039630.4	246375.8
S1-DC02	205.0	5039664.9	246276.1
S1-DC03A	206.3	5039692.6	246261.4
S1-DC03B	206.3	5039691.7	246263.2
S1-DC04	205.0	5039658.3	246356.8
S1-DC05	205.1	5039688.5	246289.2

## REFERENCE

Base plans, profile and topographic data provided in digital format by Morrison Hershfield, drawing file nos. bc04537182001.dwg and Alignment-profile.dwg, dated Dec., 2013, received Dec. 17, 2014

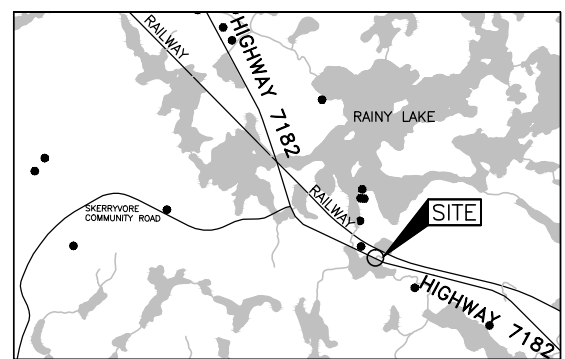
NO.	DATE	BY	REVISION
1	2/4/2015	LCC	1
Geocres No. 41H-149			
HWY. 7182	PROJECT NO. 12-1111-0102		DIST. .
SUBM'D. ARV	CHKD. CN	DATE: 2/4/2015	SITE: .
DRAWN: MR	CHKD. CN	APPD. LCC	DWG. 2



CONT No.  
GWP No. 5163-10-00




**HIGHWAY 7182**  
STA. 10+200 TO STA. 10+345 (SBL)  
**SOIL STRATA**

**SHEET**



KEY PLAN  
SCALE  
500 0 500 1000 m

## LEGEND

- |   |  |
|---|--|
|  | Borehole   |
|  | Dynamic Cone Penetration Test                                      |
| N   | Standard Penetration Test Value                                    |
| 16  | Blows/0.3m unless otherwise stated<br>(Std. Pen. Test, 475 j/blow) |
| 100%  | Rock Quality Designation (RQD)                                     |
|  | WL upon completion of drilling                                     |
| R   | Refusal  |

BOREHOLE AND DCPT CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
S1-01	205.5	5039636.4	246346.6
S1-02	205.7	5039653.7	246327.1
S1-03	204.9	5039655.6	246300.4
S1-04	206.2	5039685.5	246258.1
S1-DC01A	206.4	5039631.3	246374.0
S1-DC01B	206.4	5039630.4	246375.8
S1-DC02	205.0	5039664.9	246276.1

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NO.	DATE	BY	REVISION	
Geocres No. 41H-149				
HWY. 7182		PROJECT NO.		DIST.
SUBM'D. ARV	CHKD. CN	DATE: 2/4/2015		SITE:
DRAWN: MR	CHKD. CN	APPD. LCC		DWG. 3





# FIGURES



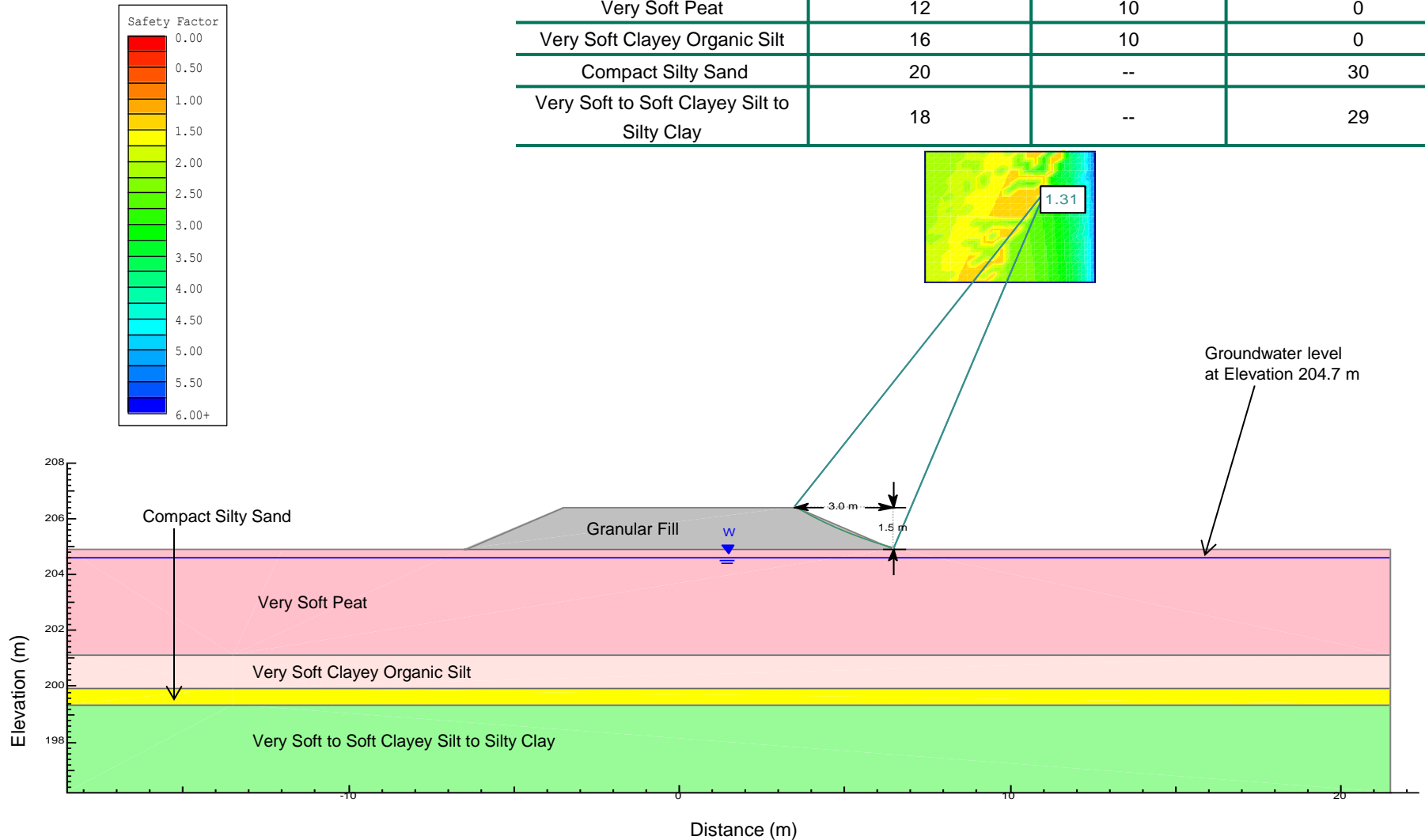
# Embankment over Swamp Total Stress Analysis – STA 10+285

Figure 1

NOTE:

1. All dimensions are in metres.

Material Name	Unit Weight (kN/m <sup>3</sup> )	Undrained Shear Strength (kPa)	Friction Angle (degrees)
Compact Granular Fill	21	0	33
Very Soft Peat	12	10	0
Very Soft Clayey Organic Silt	16	10	0
Compact Silty Sand	20	--	30
Very Soft to Soft Clayey Silt to Silty Clay	18	--	29



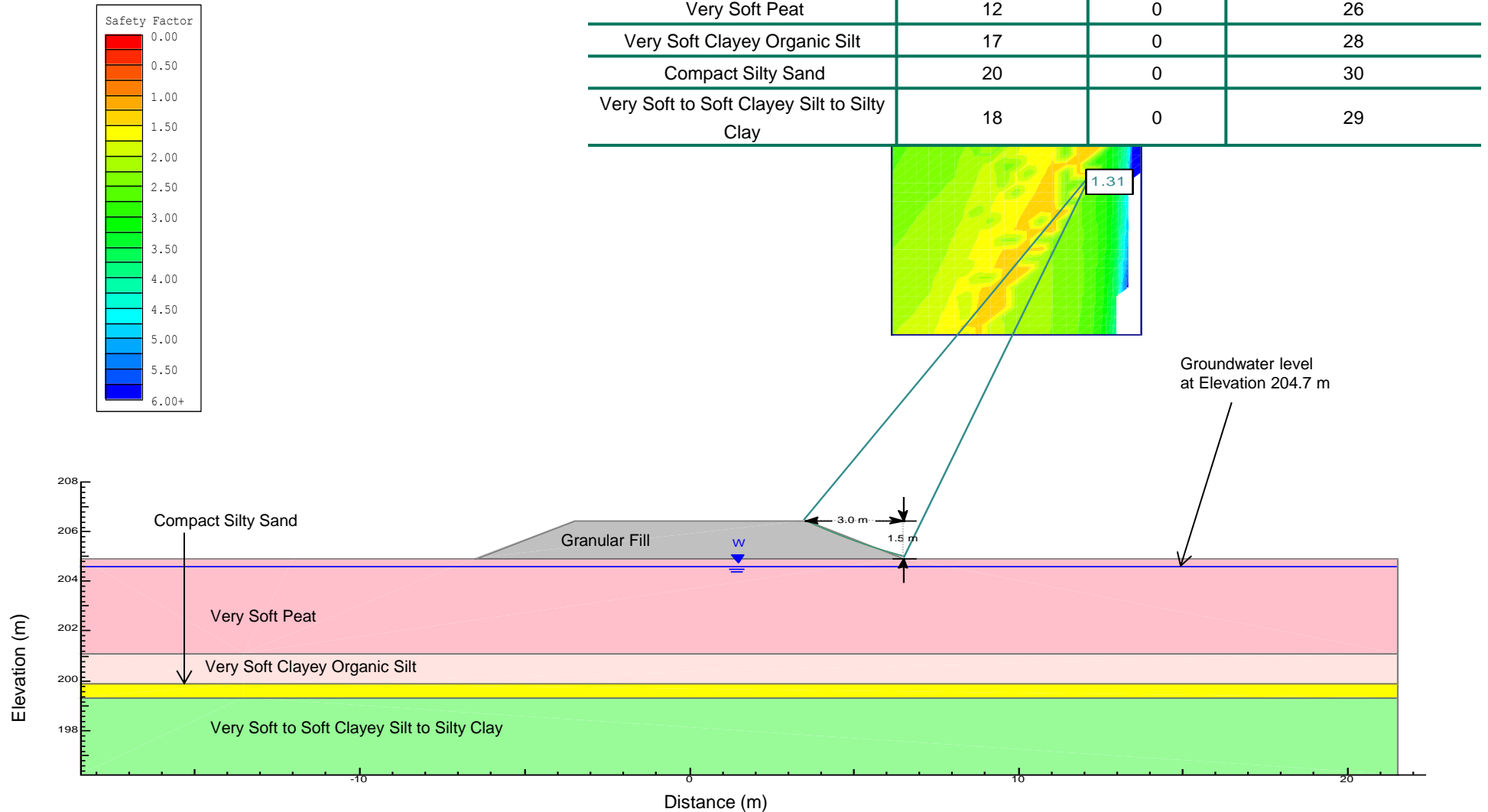


## Embankment over Swamp Effective Stress Analysis – STA 10+285

Figure 2

NOTE:

1. All dimensions are in metres.





# APPENDIX A

## Record of Borehole/Drillhole and DCPT Sheets



PROJECT 12-1111-0102			RECORD OF BOREHOLE No S1-01			SHEET 1 OF 1			METRIC								
G.W.P. 5163-10-00			LOCATION N 5039636.4 ;E 246346.6			ORIGINATED BY GM											
DIST _____ HWY 7182			BOREHOLE TYPE NW Casing, Wash Boring			COMPILED BY MT											
DATUM Geodetic			DATE June 16, 2014			CHECKED BY CN											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
205.5	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT (Fibrous) Black Wet		1	SS	WH/0.10												
	Granitic Gneiss (BEDROCK)		1	RC	REC 100%		205										RQD = 99%
	Bedrock cored from depths of 0.1 m to 3.8 m.		2	RC	REC 100%		204										RQD = 98%
	For bedrock coring details refer to Record of Drillhole S1-01.		3	RC	REC 100%		203										RQD = 100%
201.7	END OF BOREHOLE						202										
3.8	NOTE:  1. Wet soils were encountered immediately below ground surface.																

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: LANDCORE DRILLING

CHECKED: CN

PROJECT 12-1111-0102		RECORD OF BOREHOLE No S1-02		SHEET 1 OF 1		METRIC							
G.W.P. 5163-10-00		LOCATION N 5039653.7 ; E 246327.1		ORIGINATED BY ID									
DIST HWY 7182		BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY MT									
DATUM Geodetic		DATE June 11, 2014		CHECKED BY CN									
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
205.7	GROUND SURFACE						20 40 60 80 100	20 40 60					
0.0	Sandy gravel, trace to some silt (FILL) Compact Grey Moist		1	SS	23								
			2	SS	20								67 27 (6)
204.2													
1.5	Organic silty sand, trace clay, trace gravel (FILL) Very loose Brown Wet		3	SS	2								1 70 25 4 Non-Plastic
203.4													
2.3	PEAT (Amorphous), with silty sand seams Very soft Dark brown to black Wet		4	SS	WH								
			5	SS	WH								
202.0													
3.7	CLAY Very soft to soft Brown Wet		6	SS	WH								
200.4													
5.3	SAND, some silt, some gravel, trace clay Compact Grey Wet		7	SS	11								13 68 16 3
	Auger grinding between depths of 5.3 m and 7.2 m.		8	SS	22								
198.5													
7.2	Granitic Gneiss (BEDROCK)  Bedrock cored from depths of 7.2 m to 10.3 m.  For bedrock coring details refer to Record of Drillhole S1-02.		1	RC	REC 100%								RQD = 87%
			2	RC	REC 100%								RQD = 100%
195.4													
10.3	END OF BOREHOLE  NOTE:  1. Water level in open borehole measured at a depth of 2.0 m below ground surface (Elev. 203.7 m) upon completion of drilling.												

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

PROJECT: 12-1111-0102

**RECORD OF DRILLHOLE: S1-02**

SHEET 1 OF 1

LOCATION: N 5039653.7 ;E 246327.1

DRILLING DATE: June 12, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: LANDCORE DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	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.												NOTES
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec			Diametral Point Load Index (MPa)	RMC -Q AVG																																													
								TOTAL CORE %	SOLID CORE %									10	10	10																																															
8	NW Coring	Continued from Record of Borehole S1-02  Fresh, foliated, grey, medium to coarse crystalline, faintly to moderately porous, strong to very strong GRANITIC GNEISS		198.54 7.16	1	GREY 100%																																																													
9	NQ Coring Double-Tube Sampling																			2	GREY 100%																																														
10		END OF DRILLHOLE		195.43 10.27																																																															
11																																																																			
12																																																																			
13																																																																			
14																																																																			
15																																																																			
16																																																																			
17																																																																			

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: CN

PROJECT <u>12-1111-0102</u>		<b>RECORD OF BOREHOLE No S1-03</b>		SHEET 1 OF 1		<b>METRIC</b>	
G.W.P. <u>5163-10-00</u>		LOCATION <u>N 5039655.6 ; E 246300.4</u>		ORIGINATED BY <u>GM</u>			
DIST <u>          </u> HWY <u>7182</u>		BOREHOLE TYPE <u>NW Casing, Wash Boring</u>		COMPILED BY <u>MT</u>			
DATUM <u>Geodetic</u>		DATE <u>June 16, 2014</u>		CHECKED BY <u>CN</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								20   40   60   80   100	w <sub>p</sub> w   w <sub>L</sub>						
						○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED									
204.9	GROUND SURFACE														
0.0	PEAT (Amorphous) Very soft Black Moist		1	SS	WH		204								
			2	SS	WH										
			3	SS	WH		203							812	
			4	SS	WH										
			5	SS	WH		202								
201.1															
3.8	Clayey ORGANIC SILT Very soft Grey Wet		6	SS	WH		201						100.8		
199.9			7	SS	WH		200						187.34		
5.0	Silty SAND Grey Wet														
199.3															
5.6	CLAYEY SILT to SILTY CLAY, trace sand Very soft Brown to grey Wet		8	SS	WH		199						88.6		
							198								
			9	SS	WH		197								
196.2			10	SS	5/0.05										
8.7	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL  NOTE:  1. Water level in open borehole measured at a depth of 0.3 m below ground surface (Elev. 204.6 m) upon completion of drilling.														

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

PROJECT 12-1111-0102		RECORD OF BOREHOLE No S1-04		SHEET 1 OF 1		METRIC														
G.W.P. 5163-10-00		LOCATION N 5039685.5 ; E 246258.1		ORIGINATED BY ID																
DIST _____ HWY 7182		BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY MT																
DATUM Geodetic		DATE June 12, 2014		CHECKED BY CN																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL			
							20 40 60 80 100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	W <sub>p</sub>	W	W <sub>L</sub>	20 40 60			OC=0.8%		
206.2	GROUND SURFACE						206													
0.0	Sand, some gravel, trace to some silt, trace clay, trace organics (FILL) Compact Brown to grey Moist		1	SS	10		205											14 74 9 3 Non-Plastic		
204.7			2	SS	11															
1.5	PEAT (Amorphous), with sand seams Very soft Dark brown to black Wet		3	SS	2		204													
			4	SS	1															
203.2							203													
3.0	SILTY CLAY, trace sand Very soft to soft Grey Wet		5	SS	WH		202													
201.9			6	SS	4/0.05															
4.3	Granitic Gneiss (BEDROCK)						201											RQD = 87%		
	Bedrock cored from depths of 4.3 m to 7.9 m.  For bedrock coring details refer to Record of Drillhole S1-04.		1	RC	REC 100%		200													
			2	RC	REC 100%		199											RQD = 100%		
198.3																				
7.9	END OF BOREHOLE																			
	NOTE:  1. Water level in open borehole measured at a depth of 2.9 m below ground surface (Elev. 203.3 m) upon completion of drilling.																			

PROJECT: 12-1111-0102

# RECORD OF DRILLHOLE: S1-04

SHEET 1 OF 1

LOCATION: N 5039685.5 ;E 246258.1

DRILLING DATE: June 12, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: LANDCORE DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	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.	NOTES
5	NW Casing	Continued from Record of Borehole S1-04		201.87 4.33	1	GREY 100%							
6	NQ Coring Double-Tube Sampling	Fresh, foliated, grey, medium to coarse crystalline, faintly to moderately porous, strong to very strong GRANITIC GNEISS											
7					2	GREY 100%							
8		END OF DRILLHOLE		198.30 7.90									
9													
10													
11													
12													
13													
14													

DEPTH SCALE

1 : 50






LOGGED: ID

CHECKED: CN

GTA-RCK 018 S:\CLIENTS\MTN\HIGHWAY 718202 DATA\GINT\1211110102.GPJ GAL-MISS.GDT 03/12/15 TB



PROJECT 12-1111-0102		RECORD OF BOREHOLE No S1-05				SHEET 1 OF 1		METRIC									
G.W.P. 5163-10-00		LOCATION N 5039689.3 ; E 246287.4				ORIGINATED BY GM											
DIST _____ HWY 7182		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY MT											
DATUM Geodetic		DATE June 16, 2014				CHECKED BY CN											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
205.2	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH		205										
204.5																	
0.7	Gravelly SILT and SAND, trace clay Compact Grey Wet		2	SS	21		204										25 37 35 3
203.4			3	SS	30/0.10												
1.8	Granitic Gneiss (BEDROCK)																
	Bedrock cored from depths of 1.8 m to 2.8 m.		1	RC	REC 100%		203										RQD = 42%
202.4			2	RC	REC 94%												RQD = 82%
2.8	For bedrock coring details refer to Record of Drillhole S1-05. END OF BOREHOLE																
NOTE: 1. Wet soils were encountered extending from the ground surface.																	

PROJECT: 12-1111-0102

**RECORD OF DRILLHOLE: S1-05**

SHEET 1 OF 1

LOCATION: N 5039689.3 ;E 246287.4

DRILLING DATE: June 16, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Tripod

DRILLING CONTRACTOR: LANDCORE DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	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 <b>NOTE:</b> For additional abbreviations refer to list of abbreviations & symbols.														NOTES		
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	B Angle	DIP w.r.t. CORE AXIS	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY K, cm/sec			Diametral Point Load Index (MPa)		RMC -Q AVG	
								TOTAL CORE %	SOLID CORE %					TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 <sup>-6</sup>	10 <sup>-5</sup>				10 <sup>-4</sup>
2	NQ Coring Double-Tube Sampling	Continued from Record of Borehole S1-05		203.30																			
		Fresh, foliated, grey, medium to coarse crystalline, faintly to moderately porous, strong to very strong GRANITIC GNEISS		1.90	1	GREY 100%																	
				202.36	2	GREY 100%																	
3		END OF DRILLHOLE		2.84																			
4																							
5																							
6																							
7																							
8																							
9																							
10																							
11																							

DEPTH SCALE



1 : 50



LOGGED: GM

CHECKED: CN

GTA-RCK 018 S:\CLIENTS\MTN\HIGHWAY 718202 DATA\GINT\121110102.GPJ GAL-MISS.GDT 03/12/15 TB

PROJECT 12-1111-0102			RECORD OF BOREHOLE No S1-06			SHEET 1 OF 1			METRIC									
G.W.P. 5163-10-00			LOCATION N 5039679.1 ; E 246311.3			ORIGINATED BY GM												
DIST _____ HWY 7182			BOREHOLE TYPE NW Casing, Wash Boring			COMPILED BY MT												
DATUM Geodetic			DATE June 13, 2014			CHECKED BY CN												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
205.0	GROUND SURFACE							20	40	60	80	100						
0.0	PEAT (Amorphous) Very soft Black Wet		1	SS	WH													
			2	SS	1													
203.6	Clayey ORGANIC SILT, trace sand Very soft Grey Wet		3	SS	WH													
202.8			4	SS	WR													
2.2	CLAY Very soft Brown Wet																	
200.8	END OF BOREHOLE SPLIT-SPOON REFUSAL		5	SS	WH/0.28													
4.2	NOTE:  1. Water level in open borehole measured at a depth of 0.3 m below ground surface (Elev. 204.7 m) upon completion of drilling.																	

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PROJECT 12-1111-0102		RECORD OF BOREHOLE No S1-07		SHEET 1 OF 1		METRIC									
G.W.P. 5163-10-00		LOCATION N 5039660.6 ; E 246330.3		ORIGINATED BY ID											
DIST HWY 7182		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY MT											
DATUM Geodetic		DATE June 16, 2014		CHECKED BY CN											
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa							
205.7	GROUND SURFACE														
0.0	Sand, some gravel, trace to some silt (FILL) Compact Brown to grey Moist		1A	SS	11										
			1B												
			2	SS	13										
204.2															
1.5	PEAT (Amorphous) Very soft Dark brown to black Wet		3	SS	1										
			4	SS	WH										
202.7															
202.3	SILT and SAND, trace to some clay, trace gravel Very loose Grey Wet		5A	SS	WH										
3.4			5B												
	SILTY CLAY, trace sand Soft Grey Wet		6	SS	WH										
201.1															
4.6	SAND and GRAVEL, trace silt Compact Grey Wet		7	SS	21										
	Auger grinding at a depth of 5.4 m.														
199.1			8	SS	18										
6.6	Granitic Gneiss (BEDROCK)  Bedrock cored from depths of 6.6 m to 10.1 m.  For bedrock coring details refer to Record of Drillhole S1-07.		1	RC	REC 100%										
			2	RC	REC 100%										
			3	RC	REC 100%										
195.6															
10.1	END OF BOREHOLE														
	NOTES:  1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 204.2 m) inferred from the field moisture condition of the obtained samples.  2. Additional borehole was advanced approximately 1.5 m east of Borehole S1-07 to carry out in situ field vane tests between depths of 3.5 m and 4.3 m below ground surface.														

PROJECT: 12-1111-0102

**RECORD OF DRILLHOLE: S1-07**

SHEET 1 OF 1

LOCATION: N 5039660.6 ;E 246330.3

DRILLING DATE: June 16, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: LANDCORE DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN																	NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
						FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY K, cm/sec		Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION			Jr	Ja			Jn	10 <sup>0</sup>	10 <sup>1</sup>		10 <sup>2</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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7	NW Casing	Continued from Record of Borehole S1-07 Fresh, foliated, grey, medium to coarse crystalline, faintly to moderately porous, strong to very strong GRANITIC GNEISS		199.10 6.60	1	GREY 100%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														</

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: CN

GTA-RCK 018 S:\CLIENTS\MT\HIGHWAY 718202 DATA\GINT\1211110102.GPJ GAL-MISS.GDT 03/12/15 TB

PROJECT 12-1111-0102		RECORD OF BOREHOLE No S1-08		SHEET 1 OF 1		METRIC											
G.W.P. 5163-10-00		LOCATION N 5039639.4 ;E 246375.6		ORIGINATED BY ID													
DIST HWY 7182		BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY MT													
DATUM Geodetic		DATE June 13, 2014		CHECKED BY CN													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60	W <sub>p</sub> W W <sub>L</sub>							
206.2	GROUND SURFACE																
0.0	Sand, trace to some gravel, to sandy gravel (FILL) Loose to compact Grey to brown Moist		1	SS	11		206										
			2	SS	7		205										
204.7	SILTY CLAY, trace organics Very soft Grey Wet		3	SS	1		204										
203.9	Silty SAND, trace to some gravel Compact Grey Wet		4	SS	7/0.15		203										
203.6	Granitic Gneiss (BEDROCK)  Bedrock cored from depths of 2.6 m to 5.8 m.  For bedrock coring details refer to Record of Drillhole S1-08.		1	RC	REC 100%		202										
2.6			2	RC	REC 100%		201										
200.4	END OF BOREHOLE																
5.8	NOTE:  1. Water level in open borehole measured at a depth of 2.0 m below ground surface (Elev. 204.2 m) upon completion of drilling.																

PROJECT: 12-1111-0102

**RECORD OF DRILLHOLE: S1-08**

SHEET 1 OF 1

LOCATION: N 5039639.4 ;E 246375.6

DRILLING DATE: June 13, 2014

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Truck Mount

DRILLING CONTRACTOR: LANDCORE DRILLING

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	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.										NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
				DEPTH (m)	FLUSH			RECOVERY		R.Q.D. %	FRACT INDEX PER 0.3 m	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION			Jr		Ja			Jn	10 <sup>-6</sup> cm <sup>3</sup> /sec	10 <sup>-4</sup> cm <sup>3</sup> /sec	10 <sup>-2</sup> cm <sup>3</sup> /sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
3	NW Casing	Continued from Record of Borehole S1-08 Fresh, foliated, grey, medium to coarse crystalline, faintly to moderately porous, strong to very strong GRANITIC GNEISS		203.61 2.59	1	GREY 100%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

DEPTH SCALE

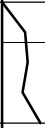
1 : 50



LOGGED: ID

CHECKED: CN

GTA-RCK 018 S:\CLIENTS\MTD\HIGHWAY 718202 DATA\GINT\121110102.GPJ GAL-MISS.GDT 03/12/15 TB

PROJECT <u>12-1111-0102</u>		<b>RECORD OF DCPT No S1-DC01A</b>		SHEET 1 OF 1		<b>METRIC</b>																		
G.W.P. <u>5163-10-00</u>		LOCATION <u>N 5039631.3 ; E 246374.0</u>		ORIGINATED BY <u>ID</u>																				
DIST <u>          </u> HWY <u>7182</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>MT</u>																				
DATUM <u>Geodetic</u>		DATE <u>June 12, 2014</u>		CHECKED BY <u>CN</u>																				
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa																
206.4	GROUND SURFACE						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>																	
0.0	Dynamic Cone Penetration Test (DCPT)																							
205.2	END OF DCPT Refusal to Further Penetration																							
1.2																								

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB




PROJECT <u>12-1111-0102</u>		<b>RECORD OF DCPT No S1-DC01B</b>		SHEET 1 OF 1		<b>METRIC</b>											
G.W.P. <u>5163-10-00</u>		LOCATION <u>N 5039630.4 ;E 246375.8</u>		ORIGINATED BY <u>ID</u>													
DIST <u>          </u> HWY <u>7182</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>MT</u>													
DATUM <u>Geodetic</u>		DATE <u>June 12, 2014</u>		CHECKED BY <u>CN</u>													
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
206.4	GROUND SURFACE						20	40	60	80	100						
0.0	Dynamic Cone Penetration Test (DCPT)																
204.7																	
1.7	END OF DCPT Refusal to Further Penetration																

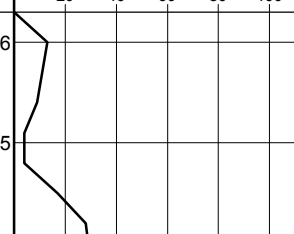
GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

PROJECT 12-1111-0102		RECORD OF DCPT No S1-DC02		SHEET 1 OF 1		METRIC										
G.W.P. 5163-10-00		LOCATION N 5039664.9 ; E 246276.1		ORIGINATED BY GM												
DIST _____ HWY 7182		BOREHOLE TYPE Dynamic Cone Penetration Test		COMPILED BY MT												
DATUM Geodetic		DATE June 13, 2014		CHECKED BY CN												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
205.0	GROUND SURFACE						20	40	60	80	100					
0.0	Dynamic Cone Penetration Test (DCPT)						20	40	60	80	100	20	40	60	kN/m <sup>3</sup>	GR SA SI CL
197.3	END OF DCPT Refusal to Further Penetration															

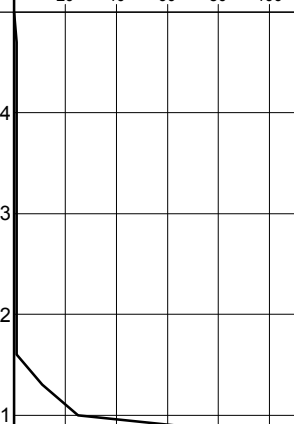
GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

PROJECT <u>12-1111-0102</u>		RECORD OF DCPT No <b>S1-DC03A</b>		SHEET 1 OF 1		<b>METRIC</b>				
G.W.P. <u>5163-10-00</u>		LOCATION <u>N 5039692.6 ; E 246261.4</u>		ORIGINATED BY <u>ID</u>						
DIST <u>          </u> HWY <u>7182</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>MT</u>						
DATUM <u>Geodetic</u>		DATE <u>June 16, 2014</u>		CHECKED BY <u>CN</u>						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
206.3 0.0	GROUND SURFACE Dynamic Cone Penetration Test (DCPT)									
204.2 2.1	END OF DCPT Refusal to Further Penetration									

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

PROJECT 12-1111-0102		RECORD OF DCPT No S1-DC03B				SHEET 1 OF 1		METRIC											
G.W.P. 5163-10-00		LOCATION N 5039691.7 ; E 246263.2				ORIGINATED BY ID													
DIST _____ HWY 7182		BOREHOLE TYPE Dynamic Cone Penetration Test				COMPILED BY MT													
DATUM Geodetic		DATE June 16, 2014				CHECKED BY CN													
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
206.3	GROUND SURFACE						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>					<div style="display: flex; justify-content: space-between;"> <span>20 40 60</span> <span>20 40 60</span> </div>							
0.0	Dynamic Cone Penetration Test (DCPT)					206													
						205													
204.0						204													
2.3	END OF DCPT Refusal to Further Penetration																		

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

PROJECT		12-1111-0102		RECORD OF DCPT No S1-DC04		SHEET 1 OF 1		METRIC														
G.W.P.		5163-10-00		LOCATION		N 5039658.3 ; E 246356.8		ORIGINATED BY														
DIST		HWY 7182		BOREHOLE TYPE		Dynamic Cone Penetration Test		COMPILED BY														
DATUM		Geodetic		DATE		June 13, 2014		CHECKED BY														
CN																						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa														
205.0	GROUND SURFACE						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>					<div style="display: flex; justify-content: space-between;"> <span>20 40 60</span> <span>20 40 60</span> </div>										
0.0	Dynamic Cone Penetration Test (DCPT)																					
200.8	END OF DCPT Refusal to Further Penetration																					
4.2																						

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB

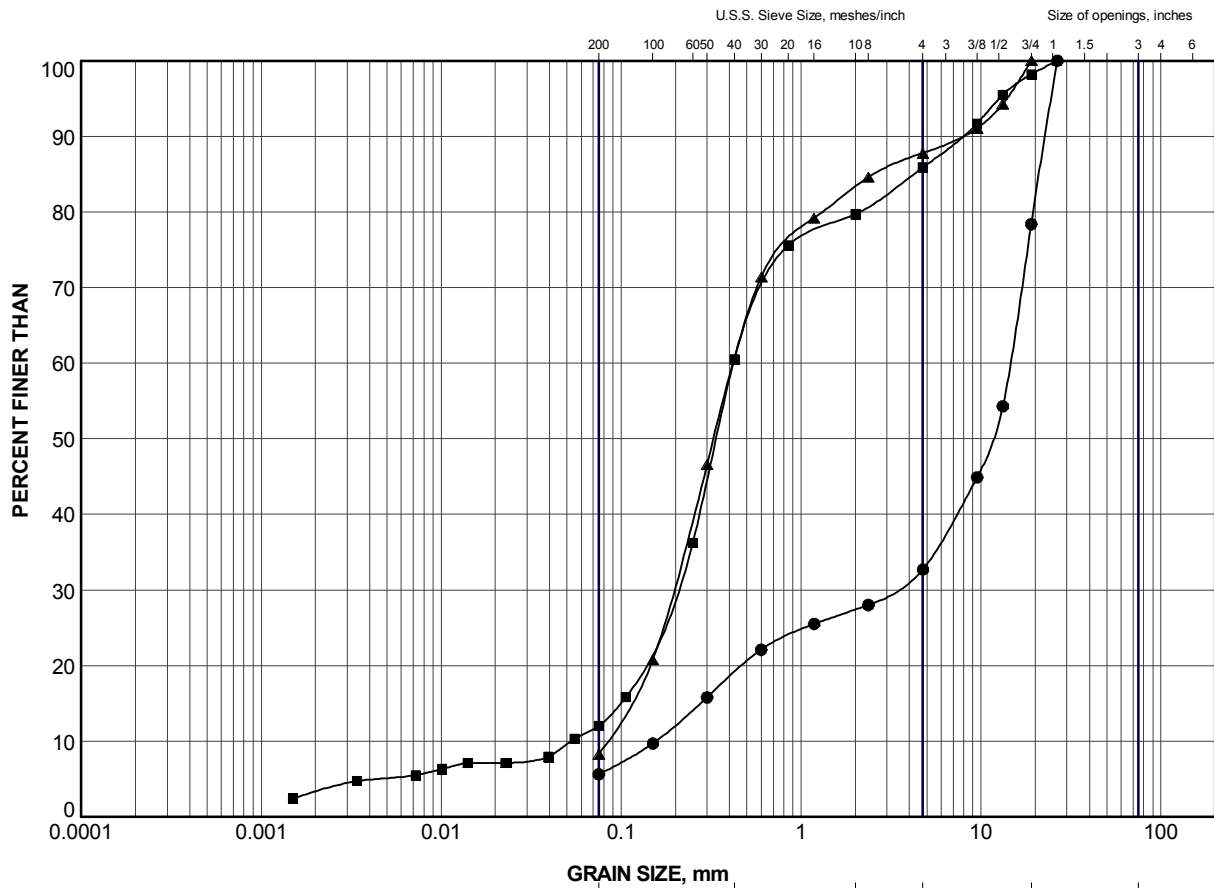
PROJECT 12-1111-0102		RECORD OF DCPT No S1-DC05				SHEET 1 OF 1		METRIC									
G.W.P. 5163-10-00		LOCATION N 5039688.5 ; E 246289.2				ORIGINATED BY GM											
DIST _____ HWY 7182		BOREHOLE TYPE Dynamic Cone Penetration Test				COMPILED BY MT											
DATUM Geodetic		DATE June 16, 2014				CHECKED BY CN											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
205.1	GROUND SURFACE						20	40	60	80	100						GR SA SI CL
0.0	Dynamic Cone Penetration Test (DCPT)						20	40	60	80	100						
203.3	END OF DCPT Refusal to Further Penetration						20	40	60	80	100						
1.8							20	40	60	80	100						

GTA-MTO 001 S:\CLIENTS\MTOWHIGHWAY\_7182\02\_DATA\GINT\1211110102.GPJ GAL-GTA.GDT 03/12/15 TB




# APPENDIX B

## Laboratory Test Results

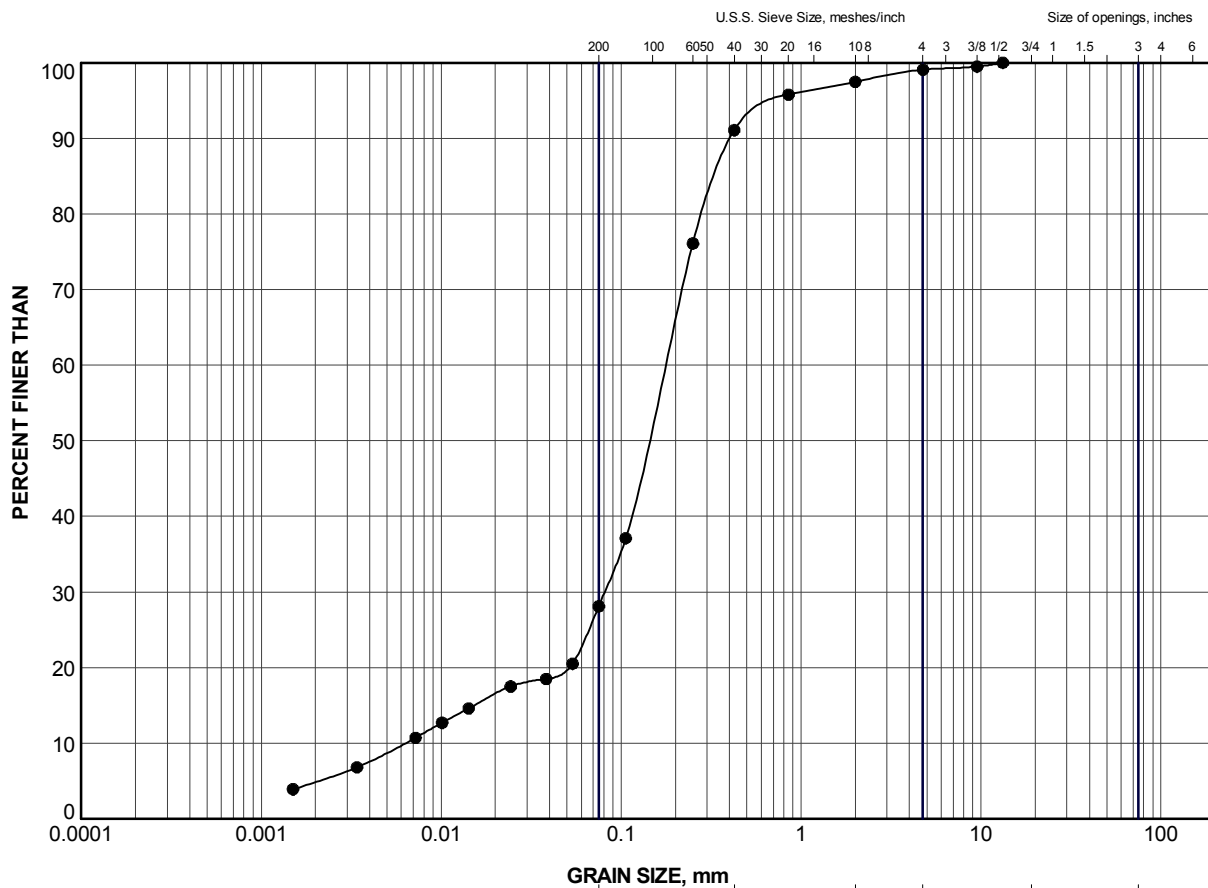


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	S1-02	2	204.6
■	S1-04	2	205.1
▲	S1-07	2	204.6

PROJECT				
HIGHWAY 7182 RECONSTRUCTION				
TITLE				
GRAIN SIZE DISTRIBUTION				
SAND to SANDY GRAVEL (FILL)				
PROJECT No.		12-1111-0102		FILE No.
DRAWN		TB	Mar 2015	SCALE N/A
CHECK		MCK	Mar 2015	REV.
APPR		CN	Mar 2015	
 <b>Golder Associates</b> SUDBURY, ONTARIO		<b>FIGURE B1-A</b>		






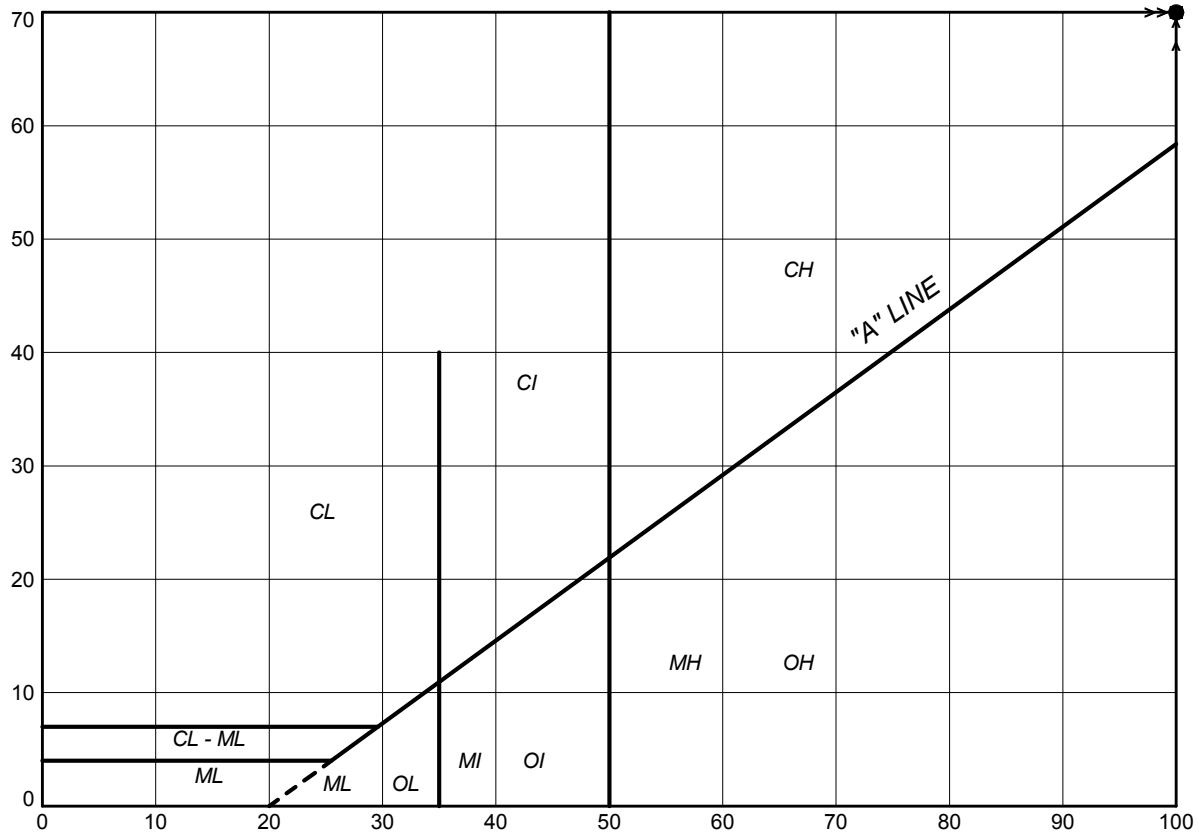
CLAY AND SILT	SAND SIZE			GRAVEL SIZE		Cobble Size
	fine	medium	coarse	fine	coarse	

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	S1-02	3	203.9

PROJECT					
HIGHWAY 7182 RECONSTRUCTION					
TITLE					
GRAIN SIZE DISTRIBUTION					
ORGANIC SILTY SAND (FILL)					
PROJECT No.		12-1111-0102		FILE No. 1211110102.GPJ	
DRAWN	TB	Mar 2015	SCALE	N/A	REV.
CHECK	MCK	Mar 2015			
APPR	CN	Mar 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B1-B</b>		

PLASTICITY INDEX (Percent)




LIQUID LIMIT (Percent)

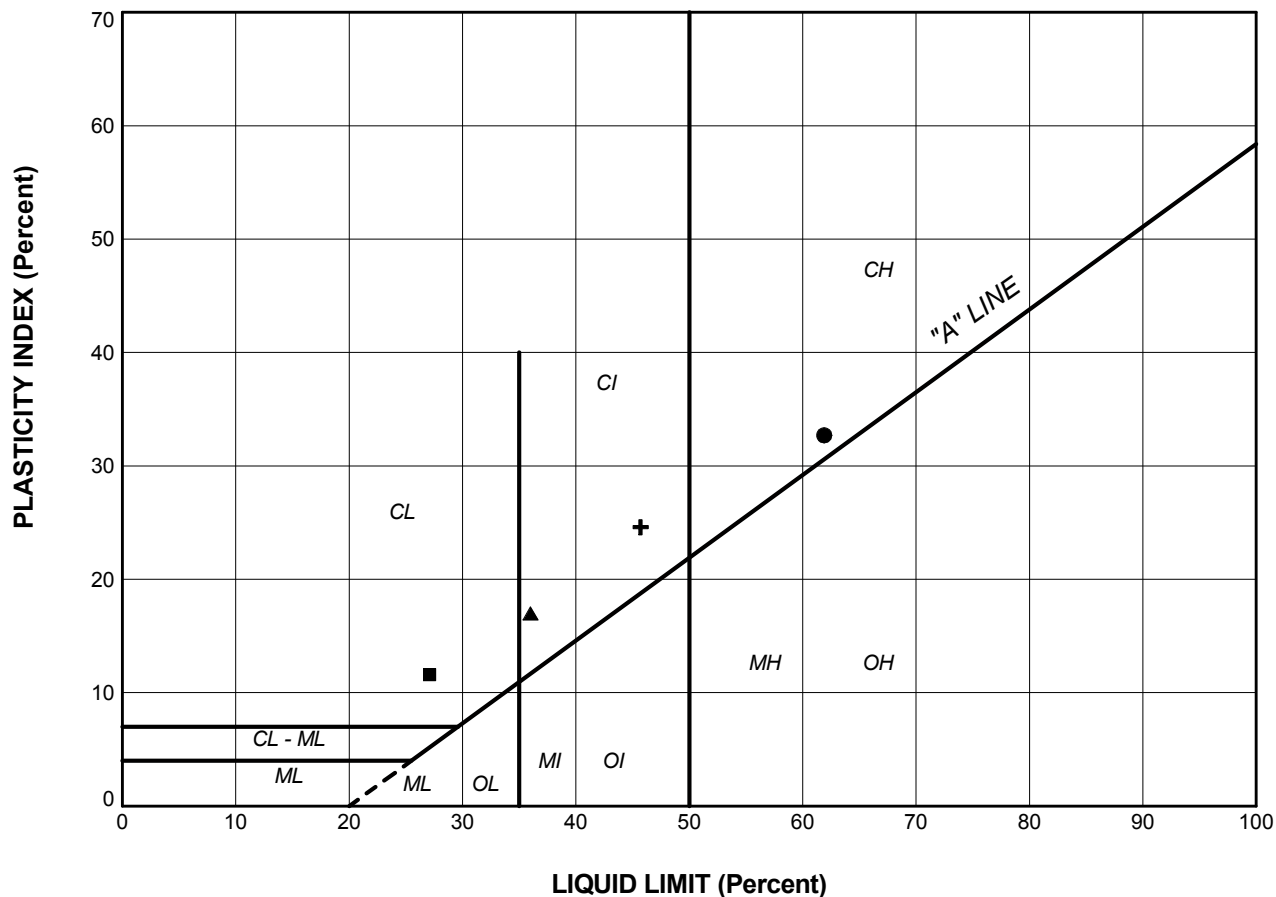
**SOIL TYPE**  
C = Clay  
M = Silt  
O = Organic

**PLASTICITY**  
L = Low  
I = Intermediate  
H = High

### LEGEND


SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	S1-03	7	133.8	45.7	88.1
■	S1-06	3	133.2	52.0	81.2

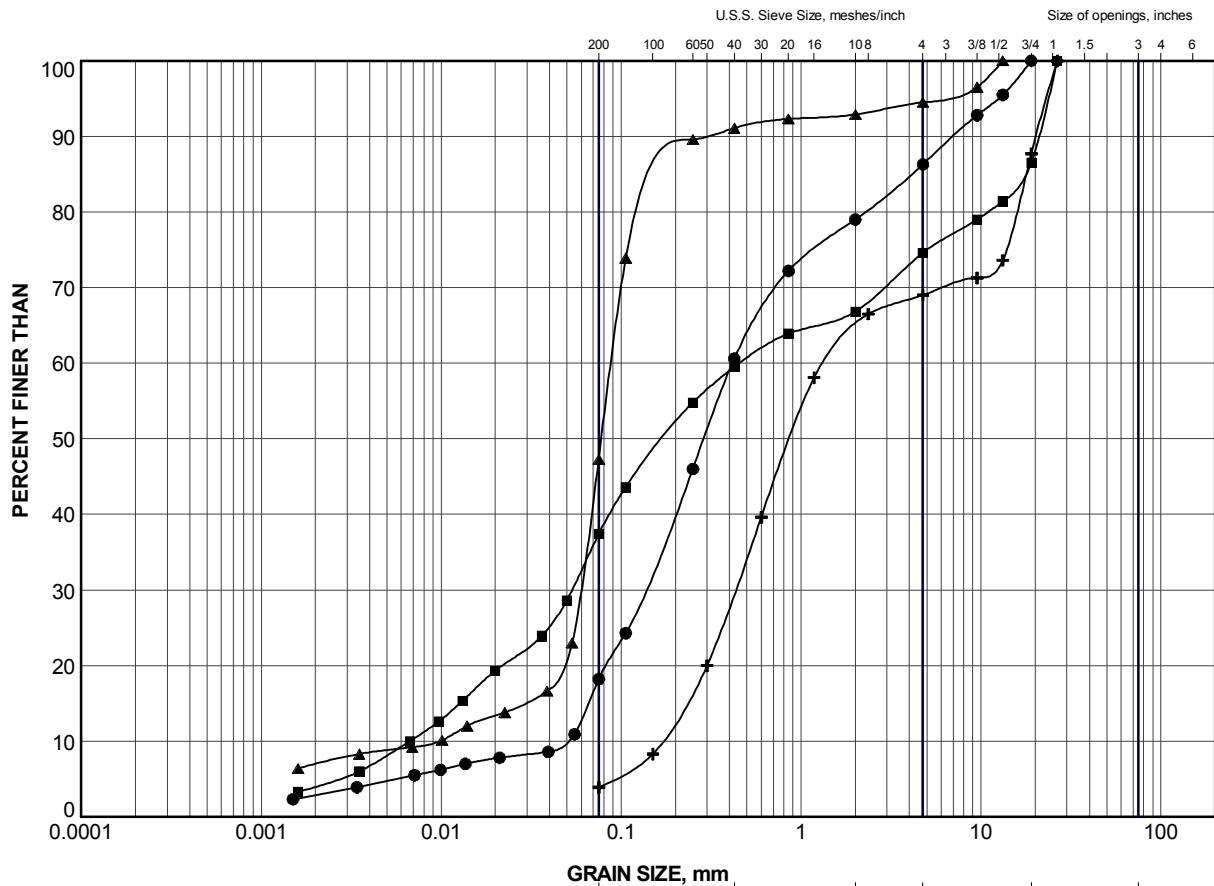
PROJECT					
HIGHWAY 7182 RECONSTRUCTION					
TITLE					
PLASTICITY CHART					
CLAYEY ORGANIC SILT					
PROJECT No.		12-1111-0102		FILE No.	
				1211110102.GPJ	
DRAWN	TB	Mar 2015	SCALE	N/A	REV.
CHECK	MCK	Mar 2015			
APPR	CN	Mar 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B2</b>		



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	S1-02	6	61.9	29.2	32.7
■	S1-03	9	27.1	15.5	11.6
▲	S1-04	5	36.0	19.0	17.0
+	S1-08	3	45.7	21.1	24.6


PROJECT					
HIGHWAY 7182 RECONSTRUCTION					
TITLE					
PLASTICITY CHART					
CLAYEY SILT to CLAY					
PROJECT No. 12-1111-0102			FILE No. 1211110102.GPJ		
DRAWN	TB	Mar 2015	SCALE	N/A	REV.
CHECK	MCK	Mar 2015			
APPR	CN	Mar 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B3</b>		



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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	S1-02	7	200.1
■	S1-05	2	204.1
▲	S1-07	5A	202.5
+	S1-07	8	199.4

PROJECT					
HIGHWAY 7182 RECONSTRUCTION					
TITLE					
<b>GRAIN SIZE DISTRIBUTION</b> SILT and SAND to GRAVELLY SILT and SAND to SAND to SAND and GRAVEL					
PROJECT No.		12-1111-0102		FILE No.	1211110102.GPJ
DRAWN	TB	Mar 2015	SCALE	N/A	REV.
CHECK	MCK	Mar 2015			
APPR	CN	Mar 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B4</b>		

**Golder Associates Ltd.**

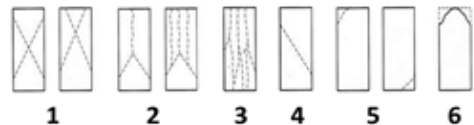
1010 Lorne Street  
Sudbury, Ontario, Canada P3C 4R9  
Telephone: (705) 524-6861  
Fax: (705) 524-1984

**TABLE B1 - SUMMARY OF ROCK CORE TEST DATA**

**PROJECT NO.:** 12-1111-0102  
**JOB NAME:** Swamp - Highway 7182/Shawanaga  
**TYPE OF UNIT:** Bedrock Core

<b>GOLDER LAB NUMBER</b>	<b>G0734</b>
<b>BOREHOLE</b>	<b>S1-07</b>
<b>DATE TESTED</b>	<b>Aug. 12, 2014</b>
<b>DEPTH OF TESTED CORE (m)</b>	<b>7.6</b>
<b>LENGTH AS CUT (mm)</b>	<b>99.0</b>
<b>DIAMETER (mm)</b>	<b>47.3</b>
<b>DENSITY (kg/m3)</b>	<b>2823</b>
<b>COMPRESSIVE STRENGTH (KN)</b>	<b>172.3</b>
<b>UNIAXIAL COMPRESSIVE STRENGTH (MPa)</b>	<b>98.0</b>
<b>TYPE OF FRACTURE</b>	<b>3</b>

*Type of Fracture*



Tested by: SA  
Reviewed by: CN

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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South America	+ 55 21 3095 9500

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**Canada**  
**T: +1 (905) 567 4444**

