



November 12, 2013

FOUNDATION INVESTIGATION REPORT

**HIGHWAY 11 - SIX MILE CREEK CULVERT AT STATION 16+381
TOWNSHIP OF DEVITT, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 164-98-00, WP 5244-05-01, SITE NUMBER 39W-124**

Submitted to:

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario, Canada L3T 0A1



GEOCRES NO.: 42G-42

Report Number: 10-1191-0038-R02

Distribution:

1 PDF Copy: Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)
1 PDF Copy: Ministry of Transportation, Ontario, Downsview, Ontario (Foundations Section)
1 Copy: MMM Group, Thornhill, Ontario
1 PDF Copy: Golder Associates Ltd., Sudbury, Ontario

REPORT





Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
3.0 INVESTIGATION PROCEDURES	1
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	2
4.1 Regional Geology	2
4.2 Subsurface Conditions.....	3
4.2.1 Fill	3
4.2.2 Peat.....	4
4.2.3 Silty Clay to Clay	5
4.2.4 Silt to Sand and Silt.....	5
4.2.5 Sand and Silt to Gravelly Silt (Till).....	5
4.2.6 Bedrock/Refusal.....	6
4.2.7 Groundwater Conditions	6
5.0 CLOSURE.....	6

REFERENCES

TABLES

Table 1	Evaluation of Culvert Types
---------	-----------------------------

DRAWINGS

Drawing 1	Borehole Locations and Soil Strata
Drawing 2	Soil Strata

APPENDICES

Appendix A Record of Boreholes

List of Symbols and Abbreviations
Lithological and Geotechnical Rock Description Terminology
Record of Boreholes – 6M-1 to 6M-9, 6M-4a
Record of Drillhole – 6M-2

Appendix B Laboratory Test Results

Table B1	Summary of Analytical Testing of Six Mile Creek Water Sample
Figure B1	Grain Size Distribution – Gravelly Sand to Sand (Fill)



FOUNDATION REPORT HIGHWAY 11 SIX MILE CREEK CULVERT

Figure B2	Grain Size Distribution – Silty Clay (Fill)
Figure B3	Plasticity Chart – Silty Clay (Fill)
Figure B4	Plasticity Chart – Silty Clay to Clay
Figure B5	Grain Size Distribution – Silt
Figure B6	Grain Size Distribution – Sand and Silt (Till)
Figure B7	Plasticity Chart – Sand and Silt (Till)



**FOUNDATION REPORT
HIGHWAY 11 SIX MILE CREEK CULVERT**

PART A

FOUNDATION INVESTIGATION REPORT

HIGHWAY 11 – SIX MILE CREEK CULVERT AT STATION 16+381

TOWNSHIP OF DEVITT, ONTARIO

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 164-98-00, WP 5244-05-01, SITE NUMBER 39W-124



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by MMM Group Ltd. (MMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Highway 11 Six Mile Creek culvert at STA 16+381 in the Township of Devitt, Ontario. The Key Plan showing the general location of this section of Highway 11 and the location of the investigated area are shown on Drawing 1. The purpose of this investigation is to establish the subsurface conditions at the location of the proposed culvert by borehole drilling, in situ testing and laboratory testing on selected samples.

2.0 SITE DESCRIPTION

The Six Mile Creek culvert is located east side of Val Côté, Ontario, approximately 19.5 km east of the east junction of Highway 583. In general, the topography in the area of the overall project limits consists of flat terrain utilized as farmland, with moderate tree cover. The existing highway grade is at about Elevation 245 m and the water surface at the culvert inlet was measured by Golder at Elevation 240.3 m on October 21, 2011. The existing culvert is a three-cell timber culvert with two cell sizes at 2.1 m and the third cell at 1.7 m. In addition, a single 1.8 m Structural Plate Corrugated Steel Pipe culvert is located on the east side of the timber culvert. The existing culverts are about 30 m long.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation was carried out between October 20 to 22, 2011, on March 20, 2012 and on July 3, 2013, during which time a total of ten (10) boreholes (6M-1 to 6M-9 and 6M-4a) were advanced for the proposed culvert replacement as shown on Drawing 1. Boreholes 6M-1 to 6M-7 and 6M-4a were advanced using a track-mounted CME 45 supplied and operated by KC Drilling Ltd. of Belle Ewart, Ontario, including Borehole 6M-2 to a depth of 6.8 m. Borehole 6M-2, below a depth of 6.8 m, and Boreholes 6M-8 and 6M-9 were advanced using a track-mounted CME 55 supplied and operated by Landcore Drilling Inc. of Sudbury, Ontario. The Record of Boreholes sheets are provided in Appendix A.

The boreholes were advanced to depths ranging between 3.0 m and 13.2 m below existing ground. Each of the boreholes for the investigation were advanced using either 150 mm outer diameter (O.D.) continuous flight solid stem augers or 108 mm inner diameter continuous flight hollow stem augers, except below a depth of 6.8 m in Borehole 6M-2, below which NW casing and NQ coring were used to advance the borehole from 6.8 m to the bottom of the borehole at 13.2 m depth. Soil samples were generally obtained at intervals of depth of about 0.75 m to 1.5 m, using a 50 mm O.D. split-spoon sampler, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). A total of 3.3 m of bedrock was cored in Borehole 6M-2. The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The fieldwork was supervised throughout by members 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 Sudbury Geotechnical



FOUNDATION REPORT HIGHWAY 11 SIX MILE CREEK CULVERT

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, Atterberg limits and grain size distribution) was carried out on selected soil samples. The results of the laboratory testing are included in Appendix B.

A sample of the creek water was obtained on October 22, 2011, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters. The results of the analytical testing are summarized in Table B1 in Appendix B, together with the detailed analytical laboratory test results.

The as-drilled borehole locations for the current investigation were measured in the field relative to stakes installed by MMM. Golder referenced as-drilled borehole ground surface elevations to the stakes. The ground surface elevations at the borehole locations are referenced to Geodetic datum. The as-drilled borehole locations for the investigation, the ground elevations and borehole depths at the drilled locations are shown in the table below.

Borehole	Location (m)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting		
6M-1	5 500 521.4	348 446.0	241.9	3.3
6M-2	5 500 527.4	348 466.5	244.7	13.2
6M-3	5 500 553.3	348 455.2	242.5	3.3
6M-4	5 500 554.3	348 428.6	243.5	3.0
6M-4a	5 500 561.9	348 430.3	241.7	3.1
6M-5	5 500 564.1	348 400.8	243.4	4.6
6M-6	5 500 526.8	348 494.3	245.1	5.8
6M-7	5 500 525.2	348 528.4	245.5	8.0
6M-8	5 500 534.3	348 448.1	244.5	7.7
6M-9	5 500 536.1	348 478.8	244.2	4.4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Published literature indicates that the site is located in the Quetico Subprovince of the Superior Province (Geology of Ontario; OGS Special Volume 4)¹. The bedrock in a large area within and surrounding the Town of Hearst consists of muscovite-bearing granitic rocks (peraluminous), and may include biotite granite. Beyond the muscovite-bearing granitic boundary, bedrock consists of metasedimentary rocks.

Based on terrain mapping by the Ontario Geological Survey², the subsurface soils in the vicinity of the site consist of ground moraine deposits of clayey till.

¹ Geology of Ontario, 1991. Ontario Geological Survey, special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.

² Northern Ontario Engineering Geology Terrain Study, OGS Electronic Map, printed July 2011



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 given on the Record of Boreholes sheets attached in Appendix A. Detailed results of the laboratory testing of the soil samples are provided in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and cuttings. 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. The inferred soil stratigraphy based on the results of the boreholes at the culvert location is shown on Drawings 1 and 2.

In general, the subsoils at the structure site consist of embankment fill (gravel to clayey silt) and underlain by an organic layer, which in turn is underlain sand and silt layer transitioning into glacial till. Possible bedrock, cobbles or boulders were encountered in eight of the boreholes around the culvert; whereas, bedrock was confirmed in one borehole at the centreline of the culvert. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Fill

Various fill materials were encountered from ground surface at each of the boreholes advanced at the site. For each borehole, the following provides a summary of the fill types and thicknesses.

- Borehole 6M-1 was advanced near the south embankment toe on the west side of the creek and encountered 0.1 m of topsoil fill from ground surface (Elevation 241.9 m) underlain by 0.7 m of sand and silt fill with trace gravel and some organics.
- Borehole 6M-2 was advanced through the existing highway embankment in the eastbound lane on the east side of the culvert and encountered 140 mm of asphalt from ground surface (Elevation 244.7 m) underlain by 4.3 m of sand and gravel to sand fill.
- Borehole 6M-3 was advanced near the north embankment toe on the west side of the creek and encountered 0.1 m of topsoil fill from ground surface (Elevation 242.5 m) underlain by 1.5 m of clayey silt fill with some organics.
- Borehole 6M-4 was advanced about 40 m west of the culvert through the north shoulder and encountered 3.0 m of sand fill from surface (Elevation 243.5 m). Clay pockets were encountered within the fill material and the borehole was terminated within the fill material likely on cobbles and boulders near the surface of the native sand and silt till.
- Borehole 6M-4a was advanced approximately 8 m north of Borehole 6M-4 and encountered 1.7 m of sand fill from ground surface (Elevation 241.7 m) underlain by 0.6 m of clayey topsoil fill.
- Borehole 6M-5 was advanced about 70 m west of the culvert through the north shoulder and encountered 1.5 m of sand fill from ground surface (Elevation 243.4 m) underlain by 1.5 m of sand and silt fill with an organic pocket encountered within the sample obtained at about Elevation 241.0 m.



FOUNDATION REPORT HIGHWAY 11 SIX MILE CREEK CULVERT

- Borehole 6M-6 was advanced about 30 m east of the culvert through the north shoulder and encountered 2.3 m of sand and gravel to sand from ground surface (Elevation 245.1 m).
- Borehole 6M-7 was advanced about 60 m east of the culvert north of the north embankment toe and encountered 0.6 m of gravel fill from ground surface (Elevation 245.5 m).
- Borehole 6M-8 was advanced through the existing highway embankment in the eastbound lane on the west side of the culvert and encountered 200 mm of asphalt from ground surface (Elevation 244.5 m) underlain by 4.3 m of sand and gravel to sand fill.
- Borehole 6M-9 was advanced near the north embankment toe on the east side of the creek and encountered 0.3 m of topsoil fill from ground surface (Elevation 244.2 m) underlain by 1.5 m of clayey silt to silty clay fill.

SPT 'N'-values measured within the cohesionless fill (gravel, sand, silt) range between 2 blows and 39 blows per 0.3 m of penetration, indicating a very loose to dense relative density. SPT 'N'-values measured within the clayey silt to silty clay fill in Borehole 6M-3 and 6M-9 range between 7 blows and 17 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency. One SPT 'N'-value measured in the clayey topsoil in Borehole 6M-4a is 15 blows per 0.3 m of penetration, suggesting a very stiff consistency.

A grain size distribution test was carried out on four samples of the gravelly sand to sand fill and the results are shown on Figure B1 in Appendix B.

A grain size distribution test was carried out on one sample of the clayey silt to silty clay fill and the results are shown on Figure B2 in Appendix B.

Atterberg limits testing carried out on one sample of the clayey silt to silty clay fill yielded liquid limits of about 41 per cent, plastic limits of about 20 per cent and a plasticity index of about 22 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B3 in Appendix B and indicate that the deposit consists of silty clay of intermediate plasticity. The natural water content measured on samples of the gravelly sand to sand fill range between about 4 per cent and 13 per cent; whereas, the natural water content measured on one sample of the clayey silt to silty clay fill was about 26 per cent.

4.2.2 Peat

A deposit of black amorphous peat was encountered beneath the sand and silt fill in Borehole 6M-1 at a depth of 0.8 m (Elevation 241.1 m) and below the clayey silt fill in Borehole 6M-3 at a depth of 1.6 m (Elevation 240.9 m) with thicknesses of 0.7 m at both locations.

Two SPT 'N'-value measured within the peat are 5 blows and 13 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

The natural water content measured on two samples of the peat are about 34 per cent and 43 per cent.



4.2.3 Silty Clay to Clay

A deposit of grey silty clay to clay was encountered below the sand and gravel fill in Borehole 6M-6 at a depth of 2.3 m (Elevation 242.8 m) and below the gravel fill in Borehole 6M-7 at a depth of 0.6 m (Elevation 2.3 m) with thicknesses of 0.6 m and 2.3 m in the respective boreholes.

SPT 'N'-values recorded within the silty clay to clay range from 10 blows to 20 blows per 0.3 m of penetration, suggesting the cohesive deposit has a stiff to very stiff consistency.

Atterberg limits testing carried out on two samples of the silty clay to clay deposit yielded liquid limits of about 51 per cent and 41 per cent, plastic limits of about 22 per cent and 19 per cent and plasticity indices of about 29 per cent and 21 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B4 in Appendix B and indicate that the deposit consists of silty clay of intermediate plasticity to a clay of high plasticity.

The natural water content measured on two samples of the silty clay to clay were about 22 per cent and 33 per cent.

4.2.4 Silt to Sand and Silt

A deposit of grey silt to sand and silt, trace gravel, trace to some clay was encountered below the peat in Borehole 6M-1 and 6M-2, below the silty clay to clay deposit in Boreholes 6M-6 and 6M-7 and below the fill in Borehole 6M-9. The silt to sand and silt deposit was encountered between Elevation 242.6 m and Elevation 239.4 m. The thickness of the deposit is between 0.7 m and 2.6 m.

SPT 'N'-values recorded within the silt to sand and silt range from 8 blows and 38 blows per 0.3 m of penetration, indicating the cohesionless deposit has a loose to dense relative density.

Grain size distribution tests carried out for two samples of the silt to sand and silt deposit are shown on Figure B5, in Appendix B.

The natural water content measured on samples of the silt to sand and silt are about 22 per cent.

4.2.5 Sand and Silt to Gravelly Silt (Till)

A deposit of grey sand and silt to gravelly silt till, trace clay was encountered below the silt to sand and silt in Borehole 6M-2 at Elevation 239.4 m, with a thickness of 4.6 m. Cobbles were encountered within this deposit as split-spoon refusal was encountered at a depth of 6.1 m (Elevation 238.6 m) and auger refusal was encountered at a depth of 6.8 m (Elevation 237.9 m). Boreholes 6M-1, 6M-3, 6M-4a, 6M-5, 6M-6, 6M-7, 6M-8 and 6M-9 were terminated within the glacial till after penetrating between about 0.8 m and 3.2 m into the deposit, with the surface of the deposit encountered at these boreholes between about Elevation 239.4 m and 241.2 m.

Three SPT 'N'-values measured within the sand and silt to gravelly silt till range between 22 blows and greater than 100 blows per 0.3 m of penetration (split-spoon refusal where applicable).

A grain size distribution for eleven samples of the sand and silt to gravelly silt till deposit is shown on Figure B6, in Appendix B.



FOUNDATION REPORT HIGHWAY 11 SIX MILE CREEK CULVERT

Atterberg limits testing carried out on one sample of the deposit yielded a liquid limit of about 16 per cent, a plastic limit of about 11 per cent and a plasticity index of about 5 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B7 in Appendix B and indicate that the deposit is classified as a clayey silt to silt.

The natural water content measured on two samples of the sand and silt till are between about 10 per cent and 17 per cent.

4.2.6 Bedrock/Refusal

Bedrock was encountered below the sand and silt till in Borehole 6M-2 at a depth of 9.9 m below ground surface, corresponding to Elevation 234.8 m, and a 3.4 m length of bedrock core was recovered. The upper 1.5 m of bedrock is described as a fine grained, slightly weathered, white quartz and the lower 1.9 m of bedrock is described as a fine grained, slightly weathered to fresh, grey metasediment. The total core recovery measured on the recovered core samples is 100 per cent, the Solid Core Recovery ranges from 52 per cent to 90 per cent and the Rock Quality Designation (RQD) values range between 54 per cent and 88 per cent, indicating that the bedrock is of fair to good quality, as per CFEM (2006).

Refusal to split spoon, auger and/or DCPT advancement was encountered in and adjacent to Boreholes 6M-1 and 6M-3 to 6M-9 at depths from 3.1 m to 8.0 m below ground surface, with elevations from Elevation 236.8 m to Elevation 240.5 m.

4.2.7 Groundwater Conditions

Boreholes 6M-2, 6M-4, 6M-4a and 6M-5 were dry upon completion of drilling. In Boreholes 6M-1, 6M-3, 6M-6, 6M-7, 6M-8 and 6M-9, unstabilized water levels measured upon the completion of drilling range from depths of 1.0 m to 3.5 m, between Elevation 239.9 m to 242.1 m. On October 21, 2011 the water level in Six Mile Creek was surveyed by Golder to be at Elevation 240.3 m. Groundwater and creek water levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

5.0 CLOSURE

The field personnel supervising the drilling program were Mr. Indulis Dumpis and Mr. Matthew Thibeault, EIT. This report was prepared by Mr. Matthew Thibeault, EIT, and was reviewed by Mr. Andre Bom, P.Eng. A quality control review of the report was provided by Mr. Fintan Heffernan, P.Eng., Golder's Designated MTO Contact for this project.



FOUNDATION REPORT HIGHWAY 11 SIX MILE CREEK CULVERT


Report Signature Page

GOLDER ASSOCIATES LTD.

Matthew Thibeault

Matthew Thibeault, EIT
Geotechnical Engineering Intern

André Bom



André Bom, P.Eng.
Geotechnical Engineer

F. J. Heffernan

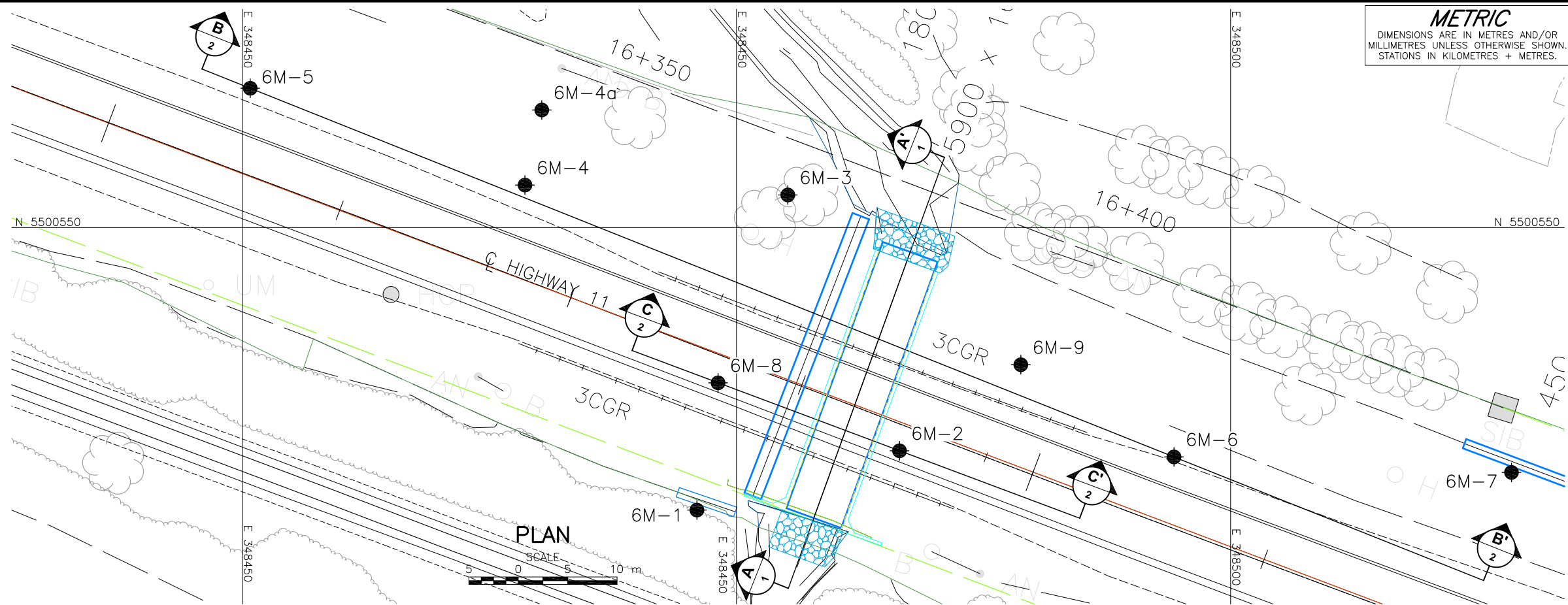


Fintan J. Heffernan, P.Eng.
Designated MTO Contact

MT/AB/FJH/kp

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

n:\active\2010\1190 sudbury\1191\10-1191-0038 mmm hwy 11 mattawishkwia river\reporting\final report\r02 - 6 mile creek\10-1191-0038-r02 final fidr 13nov12 6 mile creek.docx

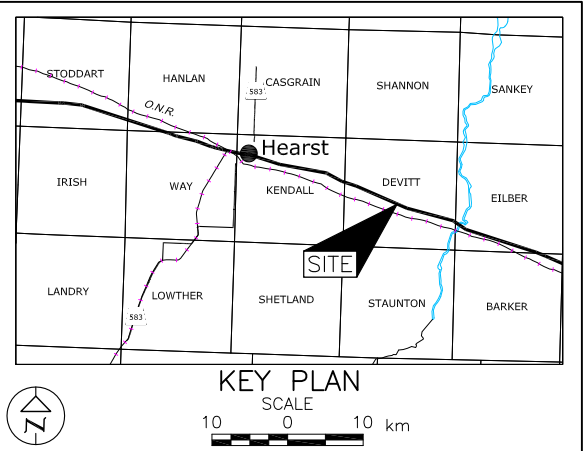


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.164-98-00

HIGHWAY 11
CULVERT AT STA. 16+381
BOREHOLE LOCATIONS AND
SOIL STRATA

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
6M-1	241.9	5500521.4	348446.0
6M-2	244.7	5500527.4	348466.5
6M-3	242.5	5500553.3	348455.2
6M-4	243.5	5500554.3	348428.6
6M-4a	241.7	5500561.9	348430.3
6M-5	243.4	5500564.1	348400.8
6M-6	245.1	5500526.8	348494.3
6M-7	245.5	5500525.2	348528.4
6M-8	244.5	5500534.3	348448.1
6M-9	244.2	5500536.1	348478.8

NOTES

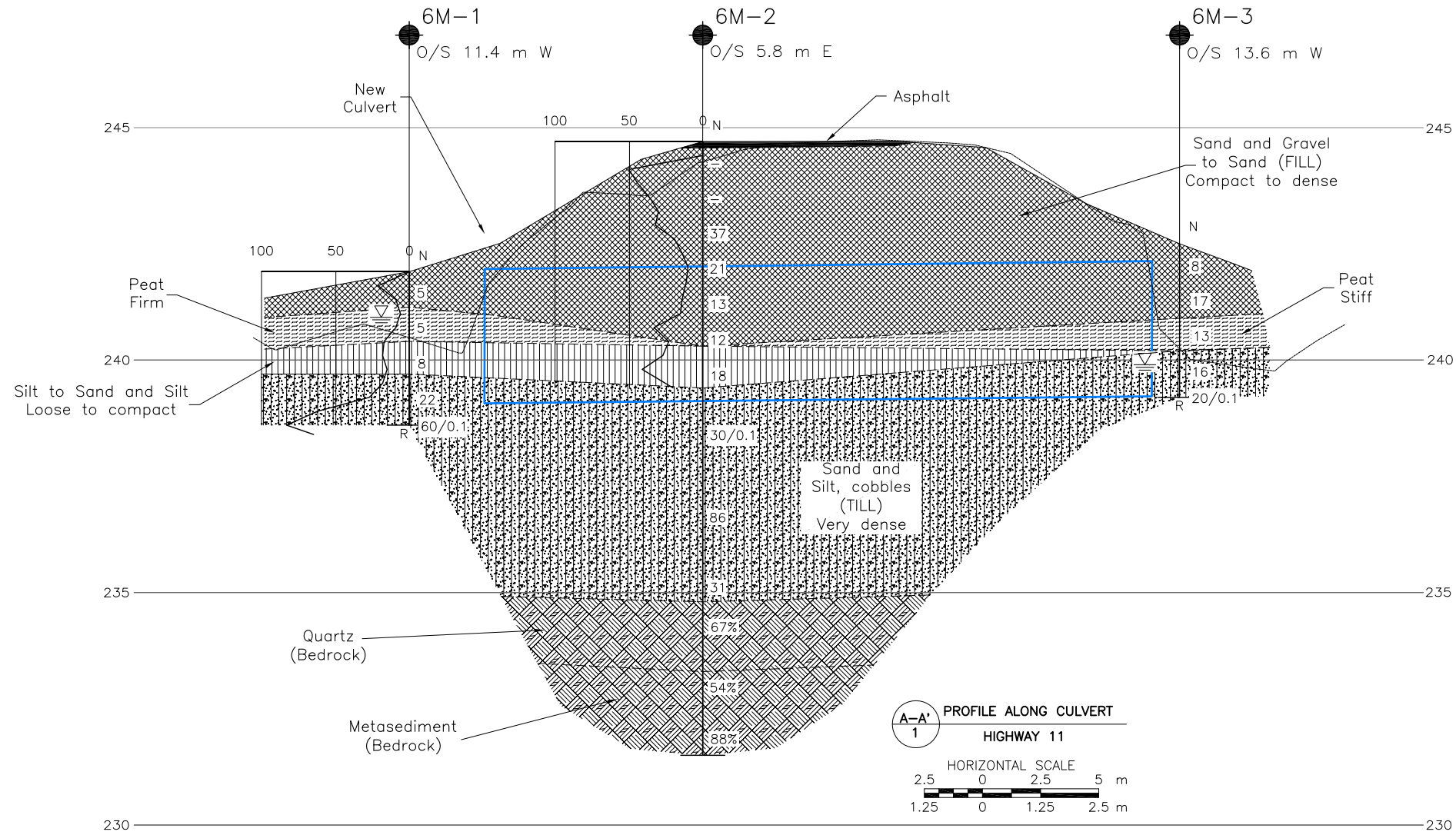
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

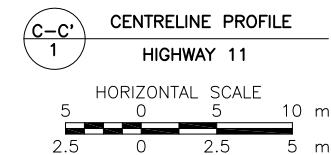
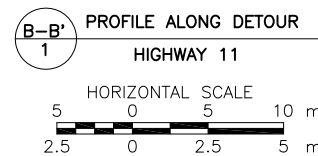
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

Base plans provided in digital format by MMM, drawing file BASE-PLAN.dwg and Hwy 11 - Align-C2.dwg, received NOV 2013 and updated culvert invert elevations in profile on Sept. 24, 2013.



NO.	DATE	BY	REVISION
Geocres No. 42G-42			
HWY. 11		PROJECT NO. 10-1191-0038	
SUBM'D. MT		CHKD. AB	DATE: NOV 2013
DRAWN: TB		CHKD. FJM	APPD.
		DIST. SITE: 39W-124/C	
		DWG. 1	





CONT No.
GWP No.164-98-00

HIGHWAY 11
CULVERT AT STA. 16+385
SOIL STRATA

SHEET



LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
6M-3	242.5	5500553.3	348455.2
6M-4	243.5	5500554.3	348428.6
6M-5	243.4	5500564.1	348400.8
6M-6	245.1	5500526.8	348494.3
6M-7	245.5	5500525.2	348528.4
6M-8	244.5	5500534.3	348448.1

NOTES

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

The 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.

[illegible]



**FOUNDATION REPORT
HIGHWAY 11 SIX MILE CREEK CULVERT**

APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

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

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

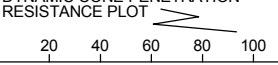







The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

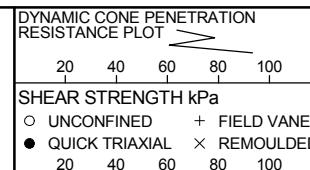
Description and Notes

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

Abbreviations

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

PROJECT 10-1191-0038			RECORD OF BOREHOLE No 6M-1			1 OF 1 METRIC					
W.P. 164-98-00			LOCATION N 5500521.4; E 348446.0			ORIGINATED BY MT					
DIST HWY 11			BOREHOLE TYPE 150 mm O.D. Solid Stem Augers			COMPILED BY MT					
DATUM Geodetic			DATE October 20, 2011			CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
241.9	GROUND SURFACE										
0.0	Topsoil (FILL) Black Moist		1	SS	5	 241					4 33 52 11
241.1	Sand and silt, trace gravel, some organics (FILL) Loose Brown / Black Moist to wet		2	SS	5						
240.4	PEAT (Amorphous) Firm Black Moist to wet		3	SS	8						
239.7	SILT to SAND and SILT, trace to some clay, trace gravel Loose Grey Moist to wet		4	SS	22						
238.6	SAND and SILT (TILL) Compact to very dense Grey Wet		5	SS	60/0.1						
3.3	END OF BOREHOLE SPOON AND AUGER REFUSAL										
Note: 1. Water level at a depth of 1.0 m below ground surface (Elev. 240.9 m) upon completion of drilling. 2. Advanced DCPT 1 m west of Borehole 6M-1. Refusal at a depth of 3.5 m.											

PROJECT		10-1191-0038		RECORD OF BOREHOLE No 6M-2		1 OF 2 METRIC							
W.P.		164-98-00		LOCATION		N 5500527.4; E 348466.5							
DIST		HWY 11		BOREHOLE TYPE		150 mm O.D. Solid Stem Augers, NW Casing, NQ Coring							
DATUM		Geodetic		DATE		October 21, 2011 and March 20, 2012.							
						ORIGINATED BY MT/ID							
						COMPILED BY MT							
						CHECKED BY AB							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
244.7	GROUND SURFACE												
0.0	ASPHALT (140mm)		1	AS	-								
0.1	Sand and gravel to sand, trace to some silt (FILL) Compact to dense Brown Moist		2	AS	-								
			3	SS	37								
			4	SS	21								2 80 (18)
			5	SS	13								
			6	SS	12								
240.3	SILT to SAND and SILT Compact Grey Moist		7	SS	18								
239.4	SAND and SILT, trace to some clay, trace gravel, cobbles (TILL) Very dense Grey Moist		8	SS	30/0.1								3 37 52 8
	Augered through cobbles at 6.1 m depth.												
	Auger refusal at 6.8 m depth, NW Casing and NQ Coring below 6.8 m depth.												
			9	SS	86								19 33 40 8
			10	SS	31								1 64 31 4
234.8	QUARTZ (BEDROCK)		1	RC	REC 100%								RQD = 67%
	Bedrock cored from 9.9 m depth to 13.2 m depth. For coring details see Record of Drillhole 6M-2.		2	RC	REC 100%								RQD = 54%
233.3	METASEDIMENT (BEDROCK)		3	RC	REC 100%								RQD = 88%
231.5	END OF BOREHOLE												

Continued Next Page

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

SUD-MTO 001 1011910038 6MI.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT <u>10-1191-0038</u>		RECORD OF BOREHOLE No 6M-2				2 OF 2 METRIC											
W.P. <u>164-98-00</u>		LOCATION <u>N 5500527.4; E 348466.5</u>				ORIGINATED BY <u>MT/ID</u>											
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>150 mm O.D. Solid Stem Augers, NW Casing, NQ Coring</u>				COMPILED BY <u>MT</u>											
DATUM <u>Geodetic</u>		DATE <u>October 21, 2011 and March 20, 2012.</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---																
	Notes: 1. Borehole dry upon completion of drilling. 2. Advanced DCPT 1 m east of Borehole 6M-2. Refusal at a depth of 5.3 m. 3. On October 21, 2011, auger refusal encountered at 6.8 m depth (Elev. 237.9 m). Returned to site on March 20, 2012 and advanced NW Casing and NQ Coring below 6.8 m depth.																

SUD-MTO 001 1011910038 6M.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT: 10-1191-0038

RECORD OF DRILLHOLE: 6M-2

SHEET 1 OF 1

LOCATION: N 5500527.4 ; E 348466.5

DRILLING DATE: October 21, 2011 and March 20, 2012.

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 45

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY				R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diameter Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
				DEPTH (m)				TOTAL CORE %	SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³			
10	NW Casing March 20, 2012	REFER TO PREVIOUS PAGE		234.8																				
		QUARTZ Fine grained Slightly weathered White		9.9	1	Grey 100%																		
11																								
12		METASEDIMENT Fine grained Slightly weathered to 12.2 m depth, fresh below 12.2 m Grey		233.3																				
				11.4	2	Grey 100%																		
13					3	Grey 100%																		
		END OF DRILLHOLE		231.5																				
		Note: 1. Joints generally undulating and rough.		13.2																				
14																								
15																								
16																								
17																								
18																								
19																								

DEPTH SCALE



1 : 50



LOGGED: MT/ID

CHECKED: AB


SUD-RCK 1011910038 6MIGPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT 10-1191-0038		RECORD OF BOREHOLE No 6M-3				1 OF 1 METRIC												
W.P. 164-98-00		LOCATION N 5500553.3; E 348455.2				ORIGINATED BY MT												
DIST _____ HWY 11		BOREHOLE TYPE 150 mm O.D. Solid Stem Augers				COMPILED BY MT												
DATUM Geodetic		DATE October 21, 2011				CHECKED BY AB												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
242.5	GROUND SURFACE							20	40	60	80	100						
0.0	Topsoil (FILL) Black Moist		1	SS	8		242											
	Clayey silt, some organics (FILL) Stiff to very stiff Grey Moist		2	SS	17													
240.9	PEAT (Amorphous) Stiff Black Moist	3	SS	13														
240.2																		
2.3	SAND and SILT, trace gravel, trace clay (TILL) Compact to dense Grey Moist to wet	4	SS	16														
239.2			5	SS	20/0.1													
3.3	END OF BOREHOLE SPOON AND AUGER REFUSAL Note: 1. Water level at a depth of 2.6 m below ground surface (Elev. 239.9 m) upon completion of drilling.																	




SUD-MTO 001 1011910038 6M.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT		10-1191-0038				RECORD OF BOREHOLE No 6M-4				1 OF 1 METRIC							
W.P.		164-98-00		LOCATION		N 5500554.3; E 348428.6				ORIGINATED BY				MT			
DIST		HWY 11		BOREHOLE TYPE		150 mm O.D. Solid Stem Augers				COMPILED BY				MT			
DATUM		Geodetic		DATE		October 20, 2011				CHECKED BY				AB			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
243.5	GROUND SURFACE																
0.0	Sand, trace to some gravel, trace to some silt (FILL) Loose to compact Brown Moist Clay pockets encountered in Samples 1 and 4.		1	SS	8												
			2	SS	12												
			3	SS	7												
			4	SS	7												
240.5	END OF BOREHOLE AUGER REFUSAL																
3.0	Note: 1. Borehole dry upon completion of drilling. 2. Attempted to advance borehole 1 m west of Borehole 6M-4. Auger refusal encountered at a depth of 3.2 m (Elev 240.3 m).																

SUD-MTO 001 1011910038 6M.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:



PROJECT 10-1191-0038		RECORD OF BOREHOLE No 6M-4a				1 OF 1 METRIC											
W.P. 164-98-00		LOCATION N 5500561.9; E 348430.3				ORIGINATED BY MT											
DIST _____ HWY 11		BOREHOLE TYPE 150 mm O.D. Solid Stem Augers				COMPILED BY MT											
DATUM Geodetic		DATE October 20, 2011				CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
241.7	GROUND SURFACE							20	40	60	80	100					
0.0	Sand, trace gravel (FILL) Loose Brown Moist		1	SS	6												
			2	SS	6												
240.0																	
1.7	Clayey topsoil, some sand, some gravel (FILL) Very stiff Black Moist		3	SS	15												
239.4																	
2.3																	
	SAND and SILT, trace to some clay, trace gravel (TILL) Loose to dense Grey Moist		4	SS	7												4 33 54 9
238.6																	
3.1	END OF BOREHOLE SPOON AND AUGER REFUSAL		5	SS	20/0.1												
	Note: 1. Borehole dry upon completion of drilling. 2. Advanced borehole approximately 8.0 m north of Borehole 6M-4.																

SUD-MTO 001 1011910038 6M.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT <u>10-1191-0038</u>		RECORD OF BOREHOLE No 6M-5				1 OF 1 METRIC											
W.P. <u>164-98-00</u>		LOCATION <u>N 5500564.1; E 348400.8</u>				ORIGINATED BY <u>MT</u>											
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>150 mm O.D. Solid Stem Augers</u>				COMPILED BY <u>MT</u>											
DATUM <u>Geodetic</u>		DATE <u>October 20, 2011</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100									
243.4	GROUND SURFACE																
0.0	Sand, some gravel, trace to some silt (FILL) Loose Brown Moist		1	SS	7												
			2	SS	8												
241.9																	
1.5	Sand and silt, trace to some clay, trace gravel (FILL) Loose to dense Grey / brown / black Moist		3	SS	12												
			4	SS	18												
240.4	Organic pockets encountered in Sample 4.																
3.0	Sandy SILT, trace to some clay, trace to some gravel (TILL) Dense Grey Moist		5	SS	40												
			6	SS	43												
238.8																	
4.6	END OF BOREHOLE SPOON AND AUGER REFUSAL Note: 1. Borehole dry upon completion of drilling.		7	SS	24/0.1												

SUD-MTO 001 1011910038 6M.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:



PROJECT 10-1191-0038				RECORD OF BOREHOLE No 6M-6				1 OF 1 METRIC									
W.P. 164-98-00				LOCATION N 5500526.8; E 348494.3				ORIGINATED BY MT									
DIST HWY 11				BOREHOLE TYPE 150 mm O.D. Solid Stem Augers				COMPILED BY MT									
DATUM Geodetic				DATE October 21, 2011				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
245.1	GROUND SURFACE							20	40	60	80	100					
0.0	Sand and gravel to sand, trace silt (FILL) Very loose to compact Brown Moist		1	SS	12		245										
			2	SS	19		244										23 65 (12)
			3	SS	2		243										
242.8																	
2.3	CLAY, some silt, trace gravel, trace sand Stiff Grey Moist		4	SS	10		242										
242.2																	
2.9	SILT to SAND and SILT, trace clay Compact to dense Grey Moist to wet		5	SS	21		241										0 2 94 4
			6	SS	38		240										
240.0			7	SS	23												
5.1	SAND and SILT (TILL) Very dense Grey Wet		8	SS	57/0 1												
239.3																	
5.8	END OF BOREHOLE SPOON AND AUGER REFUSAL																
	Note: 1. Water level at a depth of 3.5 m below ground surface (Elev. 241.6 m) upon completion of drilling.																

PROJECT 10-1191-0038			RECORD OF BOREHOLE No 6M-7			1 OF 1 METRIC												
W.P. 164-98-00			LOCATION N 5500525.2; E 348528.4			ORIGINATED BY MT												
DIST _____ HWY 11			BOREHOLE TYPE 150 mm O.D. Solid Stem Augers			COMPILED BY MT												
DATUM Geodetic			DATE October 20, 2011			CHECKED BY AB												
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
245.5	GROUND SURFACE							20	40	60	80	100						
0.0	Gravel, trace to some silt, some organics (FILL) Compact		1	SS	20		245											
244.9	Brown / Black Moist						244											
0.6	SILTY CLAY, trace sand Stiff to very stiff Brown to grey Moist		2	SS	13		243											
			3	SS	20		242											
		4	SS	19	241													
242.6	SILT to SAND and SILT, trace clay Compact to dense Grey Moist to wet	5	SS	15	240													
2.9		6	SS	34	239													
		7	SS	18	238													
		8	SS	60														
240.0	SAND and SILT, some gravel, trace clay (TILL) Very dense Grey Moist to wet																	
5.5		9	SS	80/10.1														
237.5	END OF BOREHOLE SPOON AND AUGER REFUSAL																	
8.0	Note: 1. Water level at a depth of 3.4 m below ground surface (Elev. 242.1 m) upon completion of drilling.																	

SUD-MTO 001 1011910038 6M.GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT		10-1191-0038				RECORD OF BOREHOLE No 6M-8				1 OF 1 METRIC								
W.P.		164-98-00		LOCATION		N 5500534.3; E 348448.1				ORIGINATED BY ID								
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY MT								
DATUM		Geodetic		DATE		July 3, 2013				CHECKED BY AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
244.5	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT (200 mm)																	
0.2	Sand and gravel to sand (FILL) Loose to dense Brown Moist		1	SS	39	▽	244											
			2	SS	20		243											
			3	SS	25		242											
			4	SS	7		241											
			5	SS	8		240											
			6	SS	7		239											
240.0			7	SS	58		238											
4.5	SAND and SILT, trace to some clay, trace gravel (TILL) Very dense Grey Moist		8	SS	62		237											
236.8			9	SS	100/12													
7.7	END OF BOREHOLE SPOON REFUSAL Note: 1. Water level at a depth of 3.2 m below ground surface (Elev. 241.3 m) upon completion of drilling.																	

SUD-MTO 001 1011910038 6M/GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:

PROJECT 10-1191-0038				RECORD OF BOREHOLE No 6M-9				1 OF 1 METRIC									
W.P. 164-98-00				LOCATION N 5500536.1; E 348478.8				ORIGINATED BY ID									
DIST HWY 11				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers				COMPILED BY MT									
DATUM Geodetic				DATE July 3, 2013				CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
244.2	GROUND SURFACE							20	40	60	80	100					
0.0 243.9 0.3	Topsoil (FILL) Black Moist		1	SS	7		244										0 4 48 48
	Clayey silt to silty clay, trace to some sand (FILL) Stiff Brown Moist to wet		2	SS	8		243										
			3	SS	9												
242.0					242												
2.2	SILT, some sand Compact Grey Moist to wet	4	SS	15													
241.2					241												
3.0	Gravelly SILT, some sand, trace clay (TILL) Compact to very dense Grey Wet	5	SS	23												25 18 52 5	
		6	SS	106/0.25													
239.8 4.4	END OF BOREHOLE AUGER REFUSAL						240										
Note: 1. Water level at a depth of 3.5 m below ground surface (Elev. 240.7 m) upon completion of drilling.																	

SUD-MTO 001 1011910038 6M/GPJ GAL-MISS.GDT 25/10/13 DATA INPUT:



APPENDIX B

Laboratory Test Results



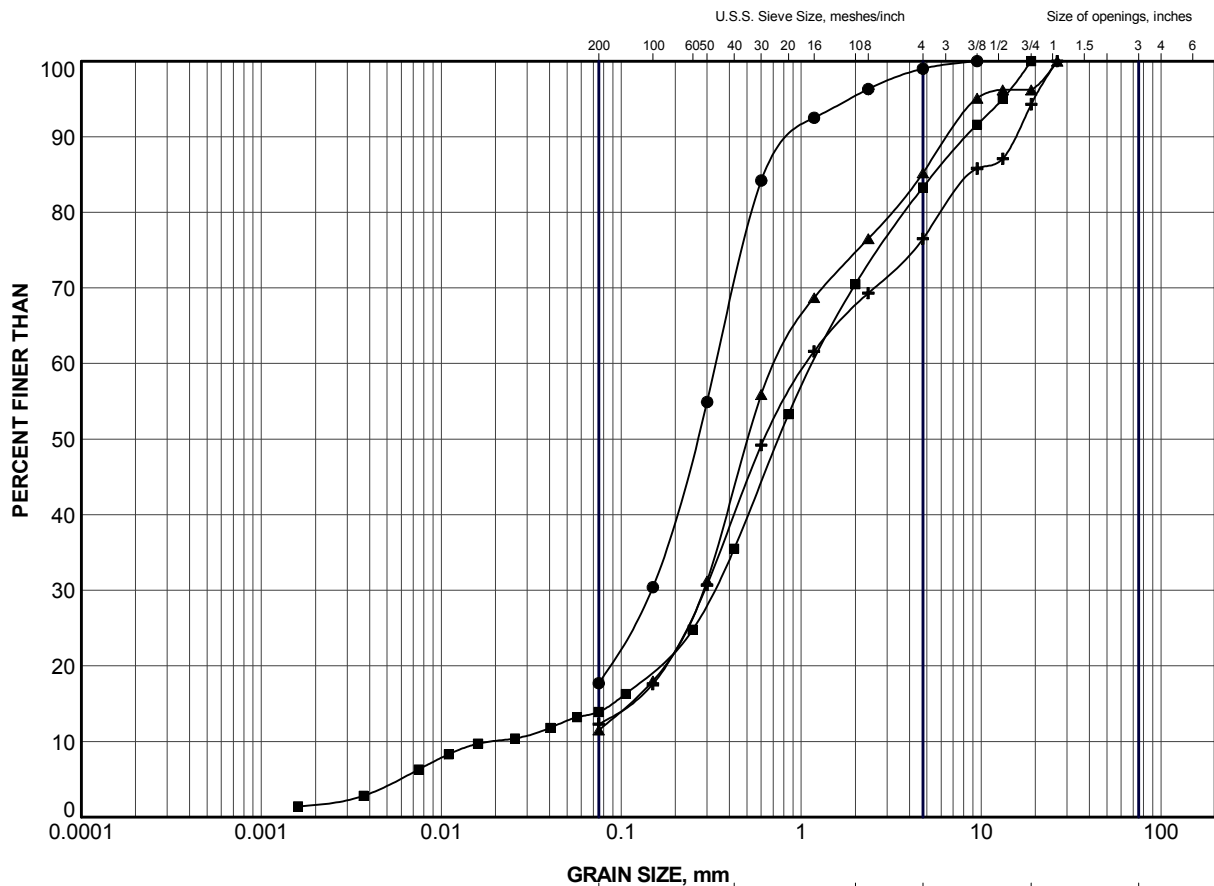
FOUNDATION REPORT HIGHWAY 11 SIX MILE CREEK CULVERT

Table B1 - Summary of Analytical Testing of Six Mile Creek Water Sample

Parameter	Units	Reportable Detection Limit	Result
Dissolved Chloride	mg/L	1	9
Dissolved Sulphate	mg/L	1	Not Detected
Conductivity	mS/cm	0.001	0.130
Resistivity	ohm-cm	n/a	7700
pH	n/a	n/a	7.58

Notes: 1. Sample obtained on October 22, 2011.
2. Analytical testing carried out by Maxxam Analytics.


Checked by: AB

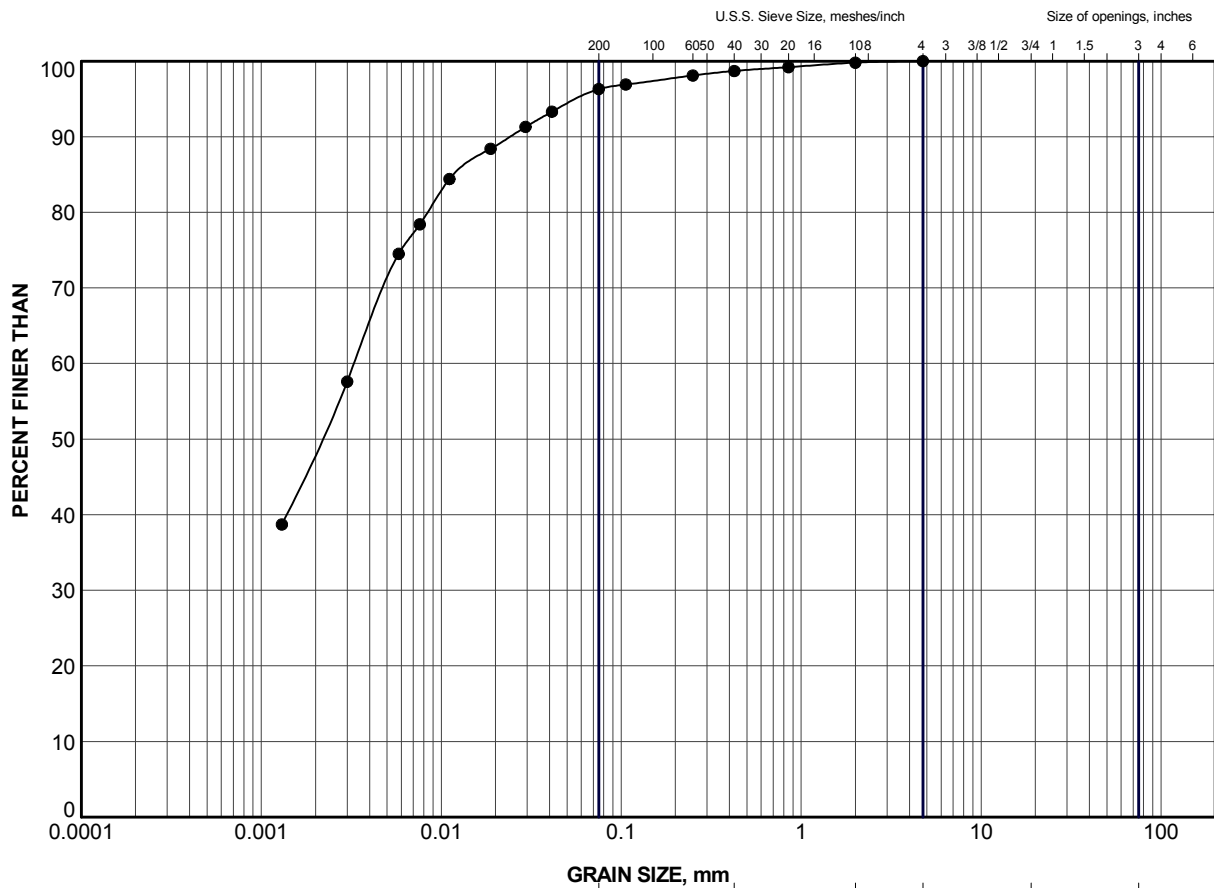


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	6M-2	4	242.1
■	6M-4	4	240.9
▲	6M-5	2	242.3
+	6M-6	2	244.0

PROJECT					
HIGHWAY 11 SIX MILE CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION GRAVELLY SAND TO SAND (FILL)					
PROJECT No.		10-1191-0038		FILE No. 1011910038 6MILGPJ	
DRAWN	TB	Aug 2013	SCALE	N/A	REV.
CHECK	AB	Aug 2013	FIGURE B1		
APPR		Aug 2013			
 Golder Associates SUDBURY, ONTARIO					



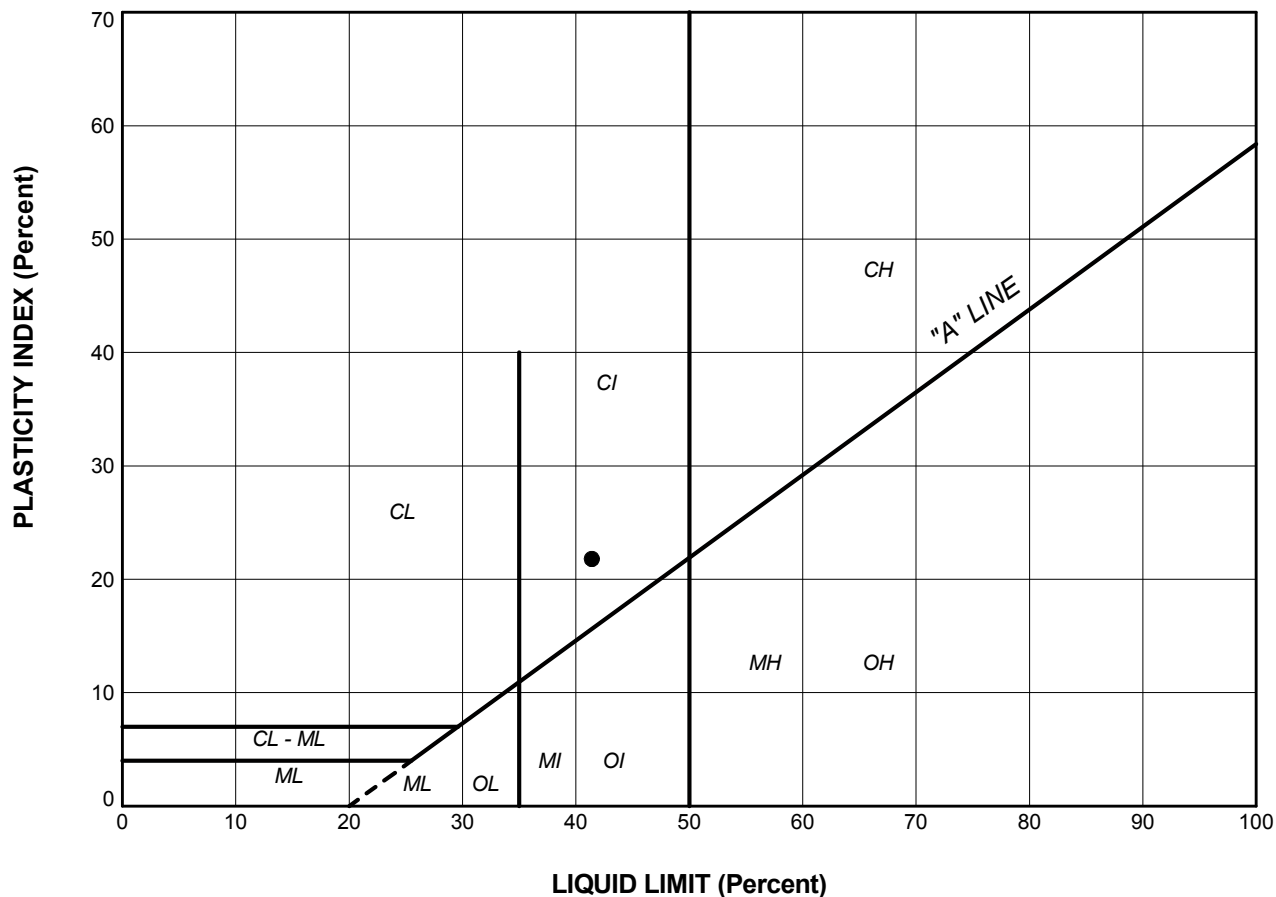
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		


LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	6M-9	3	242.4

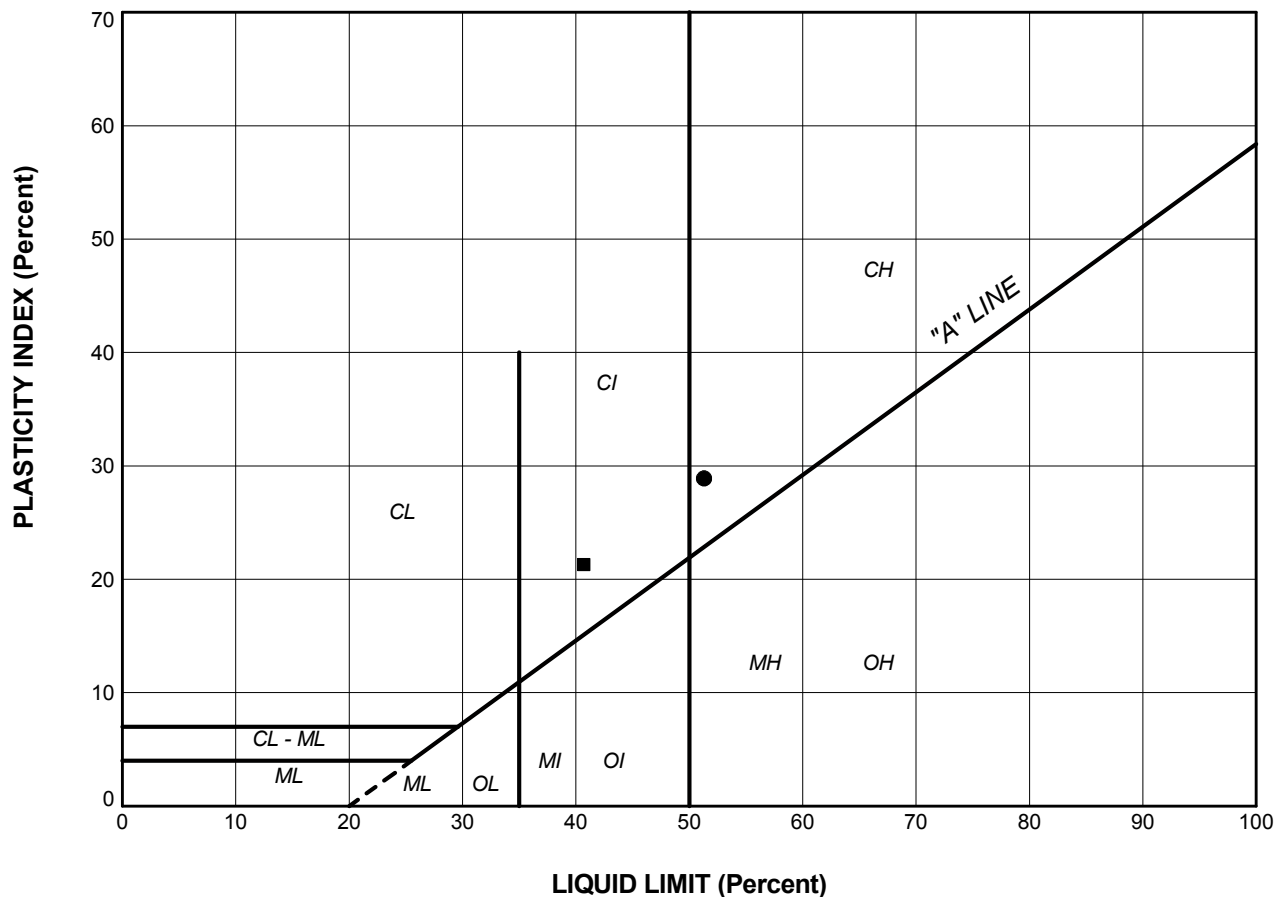
PROJECT					HIGHWAY 11 SIX MILE CREEK CULVERT				
TITLE					GRAIN SIZE DISTRIBUTION SILTY CLAY (FILL)				
PROJECT No.		10-1191-0038		FILE No.		1011910038 6M/GPJ			
DRAWN	TB	Aug 2013		SCALE	N/A	REV.			
CHECK	AB	Aug 2013		FIGURE B2					
APPR		Aug 2013							






PROJECT		HIGHWAY 11 SIX MILE CREEK CULVERT						
TITLE		PLASTICITY CHART SILTY CLAY (FILL)						
 Golder Associates SLIDBURY ONTARIO	PROJECT No.		10-1191-0038		FILE No.		1011910038 6MLGPJ	
	DRAWN	TB	Aug 2013		SCALE		N/A	REV.
	CHECK	AB	Aug 2013		FIGURE B3			
	APPR		Aug 2013					

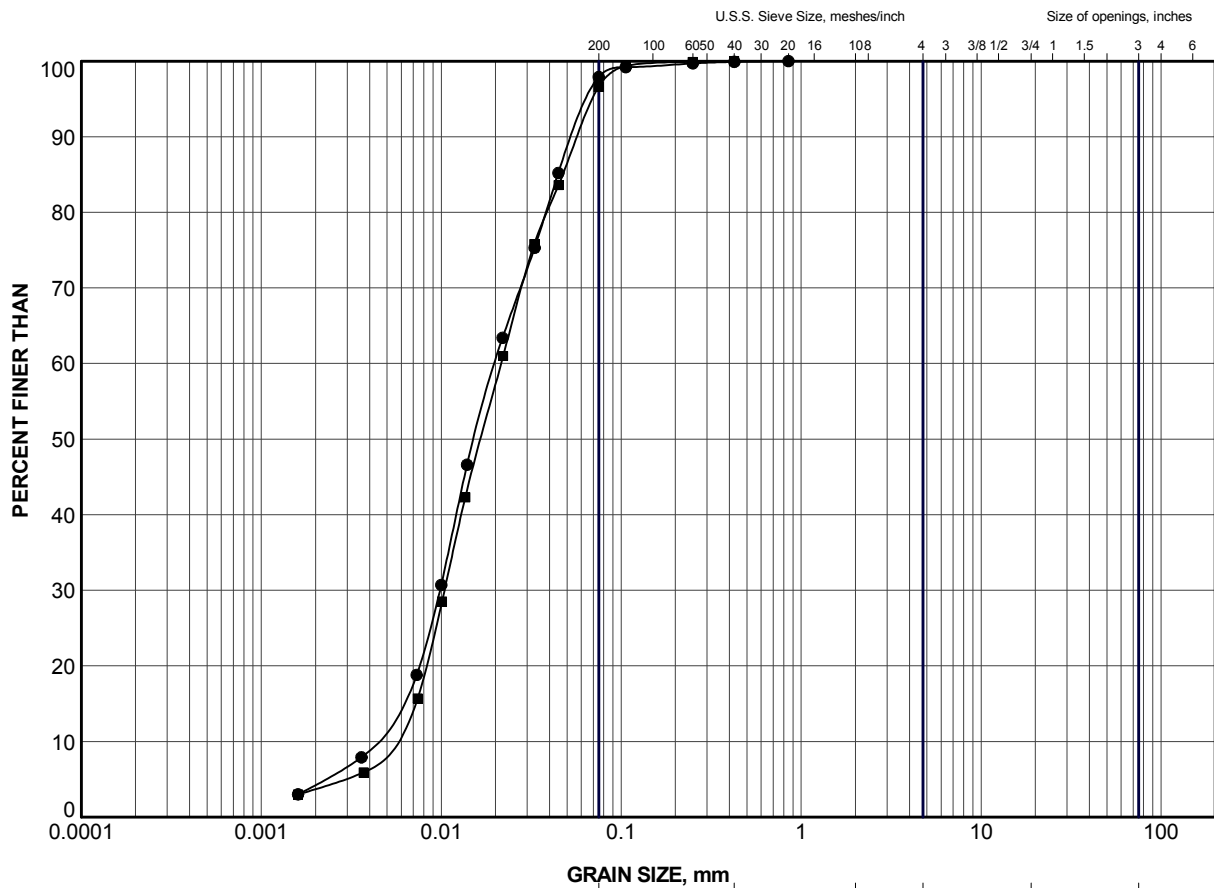




LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	6M-6	4	51.3	22.4	28.9
■	6M-7	3	40.7	19.4	21.3


PROJECT					HIGHWAY 11 SIX MILE CREEK CULVERT				
TITLE					PLASTICITY CHART SILTY CLAY TO CLAY				
PROJECT No. 10-1191-0038			FILE No. 1011910038 6MLGPJ						
DRAWN	TB	Aug 2013	SCALE	N/A	REV.				
CHECK	AB	Aug 2013							
APPR		Aug 2013							
 Golder Associates SUDBURY, ONTARIO			FIGURE B4						

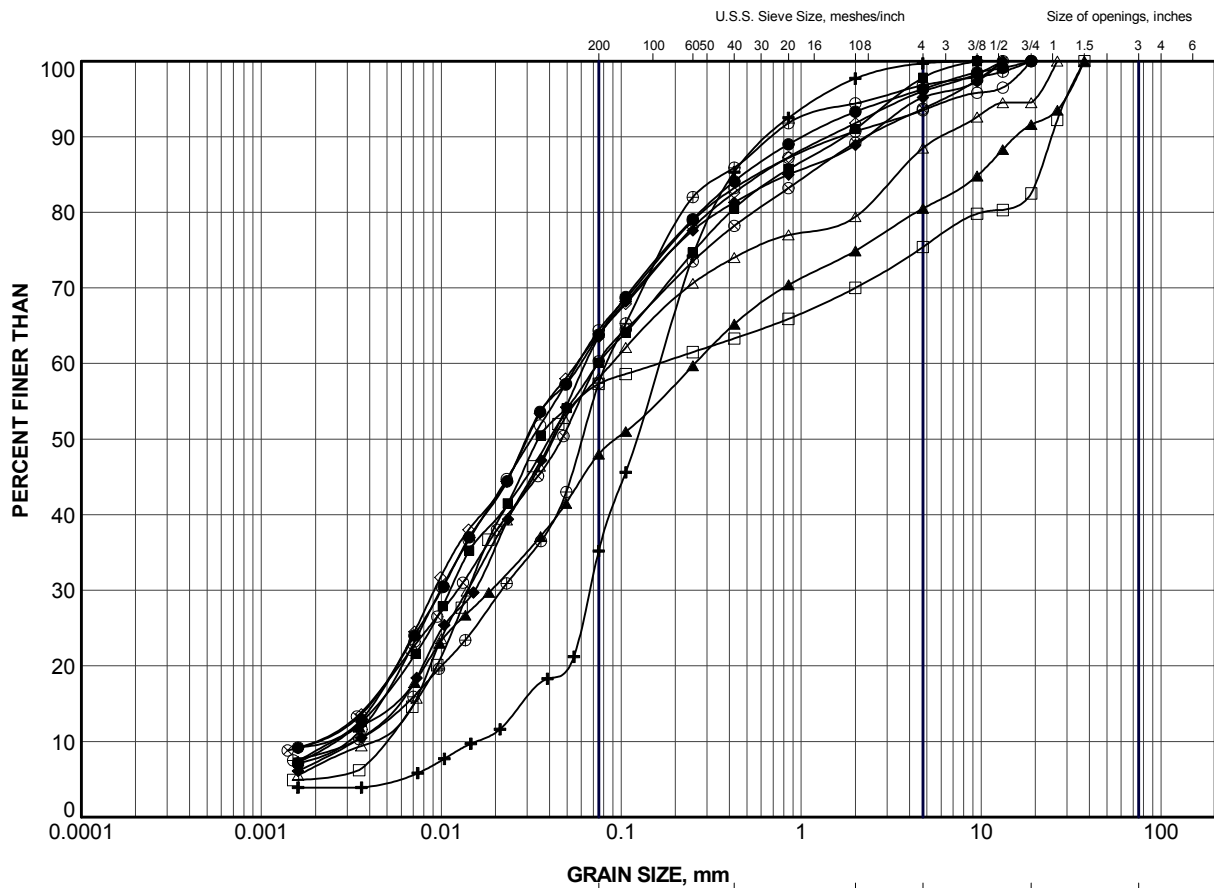


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	6M-6	6	241.0
■	6M-7	6	241.4

PROJECT						HIGHWAY 11 SIX MILE CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.			10-1191-0038			FILE No.			1011910038 6MILGPJ		
DRAWN	TB	Aug 2013		SCALE	N/A	REV.					
CHECK	AB	Aug 2013									
APPR		Aug 2013									
 Golder Associates SUDBURY, ONTARIO				FIGURE B5							



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	6M-1	4	239.3
■	6M-2	8	238.6
▲	6M-2	9	236.8
+	6M-2	10	235.3
◆	6M-3	4	239.9
◇	6M-4a	4	239.1
○	6M-5	6	239.3
△	6M-7	8	239.1
⊗	6M-8	7	239.6
⊕	6M-8	9	236.8
□	6M-9	5	240.9

PROJECT

HIGHWAY 11
SIX MILE CREEK CULVERT

TITLE

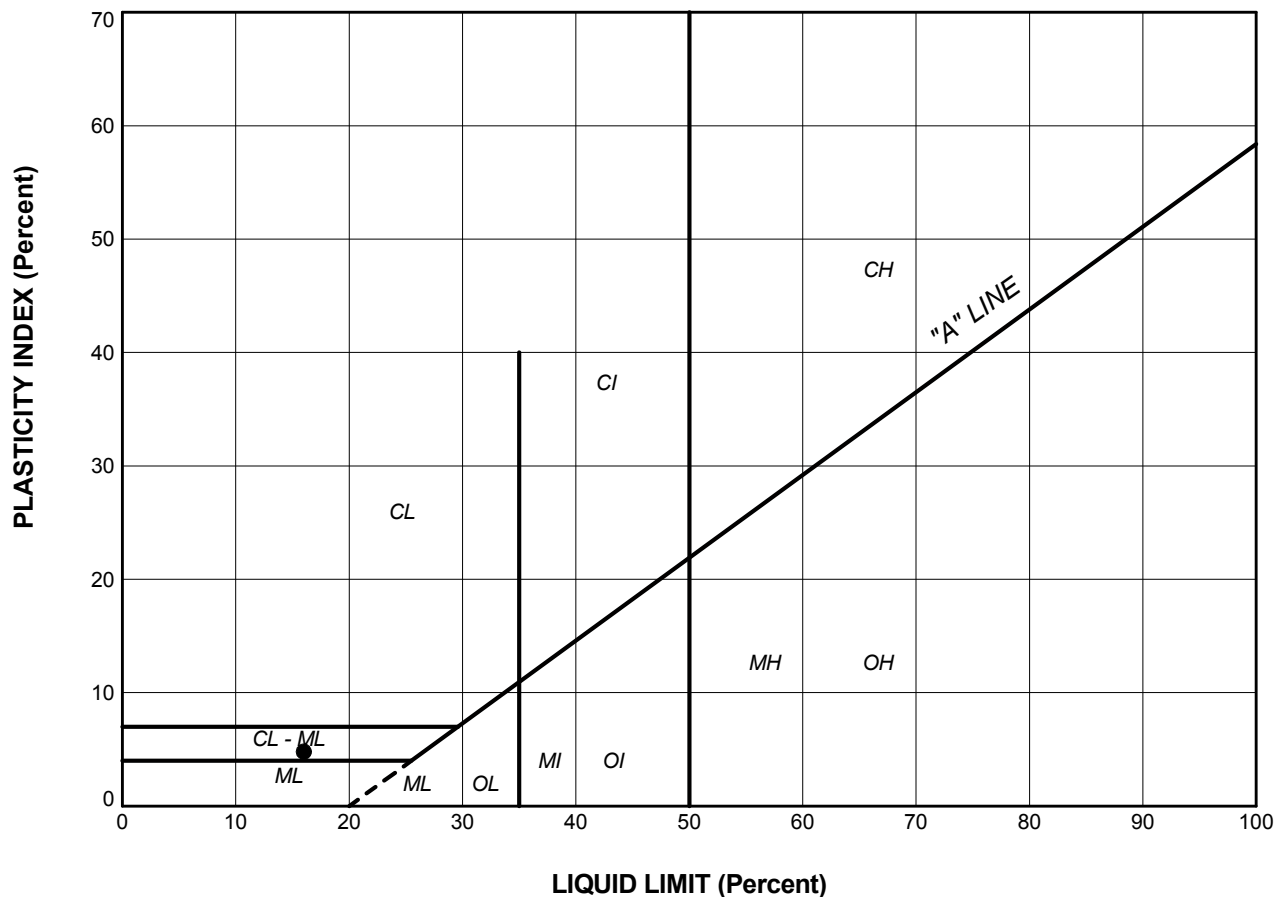
GRAIN SIZE DISTRIBUTION
SAND AND SILT (TILL)



Golder Associates
SUDBURY, ONTARIO

PROJECT No.	10-1191-0038	FILE No.	1011910038 6MILGPJ
DRAWN	TB	Aug 2013	SCALE N/A
CHECK	AB	Aug 2013	REV.
APPR		Aug 2013	

FIGURE B6



PROJECT					
HIGHWAY 11 SIX MILE CREEK CULVERT					
TITLE					
PLASTICITY CHART SAND AND SILT (TILL)					
PROJECT No. 10-1191-0038			FILE No. 1011910038 6MLGPJ		
DRAWN	TB	Aug 2013	SCALE	N/A	REV.
CHECK	AB	Aug 2013	FIGURE B7		
APPR		Aug 2013			

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.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
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.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

