



January 30, 2013

FOUNDATION INVESTIGATION REPORT

NBL AND SBL UNGULATE CULVERTS AT STA 11+198, SITE 44-594/C1-C2
HIGHWAY 69 FOUR-LANING FROM 0.4 KM NORTH OF HIGHWAY 7182
(SHEBESHEKONG ROAD) NORTHERLY 11 KM
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5403-05-00, WP 5133-12-20 & -21

Submitted to:

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GEOCRES No.: 41H-116

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REPORT





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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by MMM Group (MMM) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Highway 69 Northbound Lane (NBL) and Southbound Lane (SBL) Ungulate Culverts. This project is part of the detail design for the four-laning of Highway 69 from 0.4 km north of Highway 7182 (Shebeshekong Road) northerly for 11 km. The general location of this section of the Highway 69 four-laning alignment is shown on the Key Plan on Drawing 1, following the text of this report.

This report addresses the investigation carried out for the Highway 69 NBL and SBL Ungulate Culverts and associated Retained Soil System (RSS) walls at Station 11+198 in Phase 1 of the project limits. Separate reports have been submitted detailing the foundation investigations for other culverts, bridges and embankments crossing swamps for the project.

The purpose of this investigation is to establish the subsurface conditions at the proposed culverts and RSS walls, by borehole drilling, rock coring and laboratory testing on selected soil and bedrock core samples. The investigated areas are shown on Drawing 1, following the text of this report. The details of the culverts are presented in Table 1.

2.0 SITE DESCRIPTION

The proposed Highway 69 NBL and SBL Ungulate Culverts are located in the Township of Harrison, about 3 km south of South Shore Road. The NBL culvert will extend across the proposed NBL embankment, which is generally within, or in proximity to, the existing Highway 69 roadway embankment in this area. The proposed NBL embankment will be up to about 8.0 m high above existing grade at the west toe of the embankment, and about 4.5 m high above the existing embankment roadway grade. The culvert will extend across the proposed SBL embankment, which will be up to about 9.0 m high above existing grade.

In general, the topography in the area of the overall project limits consists of rolling terrain including densely treed areas and numerous bedrock outcrops separated by low-lying swamps. The topography in the immediate NBL culvert area is comprised of a generally flat and low-lying swamp on the west side of the existing embankment and exposed bedrock on the east side of the existing embankment. The proposed SBL culvert is located within a generally flat and low-lying swamp.



3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with the two (2) 7 m wide by 5 m high ungulate crossing culverts was carried out between February 21 and March 6, 2012, during which time a total of three (3) boreholes (LG-1 to LG-3) and two (2) dynamic cone penetration tests (DCPTs) (LG-DC1 to LG-DC2) were advanced along the alignment of the culverts. In addition, pertinent boreholes and DCPTs from the field investigation carried out by Golder for the Phase 1 Swamp and Pond Crossings were utilized to supplement this current investigation. The locations of the boreholes and details of the proposed culverts are summarized in Table 1, and the locations of the boreholes and culverts are shown on Drawing 1 (attached).

The field investigation was carried out using a truck- and a track-mounted CME 55 and portable equipment, supplied and operated by Landcore Drilling of Sudbury, Ontario. The boreholes were advanced through the overburden using 108 mm inside diameter (I.D.) hollow stem augers or NW casing with wash boring. Soil samples were obtained continuously or at intervals of depths of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler (operated by automatic hammers, or 1/3 weight hammers on the portable equipment swamp boreholes), performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were carried out in cohesive soils for determination of undrained shear strength (ASTM D2573). Samples of bedrock were obtained in Borehole LG-3 using an 'NQ' size rock core barrel. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Reg. 903 (as amended).

The boreholes drilled during the previous and current investigation at the culvert sites were advanced to depths up to 12.3 m below existing ground surface, generally penetrating 3 m into competent material, which is defined as material that will provide resistance to settlement or instability of the embankments, or to refusal. Most boreholes were terminated on refusal to further auger, casing and/or split-spoon advancement and bedrock coring was carried out at one borehole location. The depths to refusal in boreholes and in the DCPTs where bedrock was not cored do not confirm bedrock surface elevations, but may be inferred to indicate potential proximity to the bedrock surface.

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 (Appendix A). It should be noted that groundwater elevations, as encountered in the boreholes, may not be representative of static groundwater levels since the groundwater levels may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

The fieldwork was monitored by members of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil and rock core samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury geotechnical laboratory, where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected representative soil samples. Strength testing (uniaxial compression) was also carried out on one selected specimen of the bedrock core.



The centreline of the highway was surveyed and staked in the field by MMM prior to drilling, and wooden stakes were also installed near the northeast and northwest corners of the NBL culvert for reference. The as-drilled borehole locations and ground surface elevations were measured/surveyed by members of our technical staff, referenced to the survey stakes. The borehole locations, presented on the Record of Borehole sheets and shown on Drawing 1, are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The as-drilled borehole locations, ground surface elevations and drilled depths for all the boreholes and DCPTs associated with this component of the culvert investigation in Phase 1 are summarized below.

Borehole/ DCPT	Location (m)		Ground Surface Elevation (m)	Drilled Depth (m)
	Northing	Easting		
LG-1	5048584.9	238900.8	198.1	11.4
LG-2	5048570.3	238892.2	194.5	9.0
LG-3	5048594.9	238906.8	198.1	5.9
S6-2	5048541.8	238862.7	194.3	5.9
S6-3	5048553.4	238884.1	194.3	12.3
S6-4	5048560.9	238903.1	194.5	10.6
LG-DC1	5048606.7	238905.6	196.7	0.7
LG-DC2	5048599.5	238917.6	197.6	1.1
S6-DC1	5048573.7	238881.6	194.7	3.7
S6-DC2	5048529.1	238884.3	194.3	3.5

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)¹, this section of Highway 69 lies within the physiographic region known as the Georgian Bay Fringe which extends along the east side of Georgian Bay through the Parry Sound and Muskoka areas, then eastward from Muskoka in patches into the area north of the Kawartha Lakes.

This part of the Georgian Bay Fringe physiographic region was never submerged during periods of glacial recession. As a result, the surficial soils in this area consist of very shallow deposits of sand, silt and clay overlying metamorphic bedrock and numerous bare knobs and ridges of bedrock are present throughout the area. Localized low-lying swampy areas, containing peat and/or organic soils overlying 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, 1991)². Deposition of Paleozoic strata initially covered the bedrock and later erosion during glaciation exposed these Precambrian rocks.

¹ 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.

² Ontario Geological Society, 1991. *Geology of Ontario 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 and bedrock samples, are presented on the Record of Borehole and Drillhole sheets in Appendix A. The results of the laboratory tests carried out on selected soil samples are presented 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 the results of SPT measurements. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond the boreholes will exist and is to be expected.

In general, the subsoils in the area of the ungulate crossing culvert consist of embankment fill or peat underlain by cohesive deposits of silty clay to clay and/or cohesionless deposits of silty sand to sand and gravel. The total thickness of overburden is variable at the site, ranging from about 12.3 m at the midpoint of the SBL culvert to no overburden at the east side of the NBL culvert where bedrock is exposed.

A detailed description of the subsurface conditions at each investigated culvert alignment is provided in the following sections of this report.

4.2.1 Highway 69 NBL – STA 11+198

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 11+198 in Harrison Township are shown on Drawing 1. A total of three boreholes and two DCPTs were completed to investigate the subsurface conditions at this culvert location. Two boreholes (Boreholes LG-2 and LG-3) were advanced near the ends of the culvert and one borehole (Borehole LG-1) was advanced near the midpoint of the culvert. In addition, two DCPTs (LG-DC1 and LG-DC2) were advanced near the footprint of the east head walls to confirm the depth to refusal at these locations.

Fill

Boreholes LG-1 and LG-3 were advanced through the existing Highway 69 embankment and penetrated a layer of asphalt about 65 mm and 135 mm thick respectively, underlain by a deposit of granular fill comprised of sand and gravel to sand, with cobbles inferred from the split-spoon sampling operations. The top of the embankment (surface of the asphalt) is at Elevation 198.1 m and the thickness of the fill in Boreholes LG-1 and LG-3 is 4.3 m and 1.8 m respectively.

SPT 'N'-values recorded within the granular fill range between 1 blow and 23 blows per 0.3 m of penetration, indicating a very loose to compact relative density. A SPT 'N'-value of 50 blows per 0.1 m of penetration was noted, indicating the presence of cobbles.

The grain size distribution of one sample of the sand fill is shown on Figure B1.

The natural water content measured on a sample of the fill is about 9 per cent.



Peat

A deposit of black fibrous and/or amorphous peat was encountered at ground surface in Borehole LG-2 at Elevation 194.5 m and the thickness of the deposit is 3.2 m.

SPT 'N'-values recorded within this deposit are 0 blows (weight of hammer/rods) per 0.3 m of penetration, suggesting a very soft consistency.

The natural water content measured on a sample of this deposit is about 134 per cent.

Silty Clay to Clay

A deposit of grey silty clay to clay was encountered underlying the embankment fill in Borehole LG-1 and the peat in Borehole LG-2. The top of the deposit was encountered at 4.4 m and 3.2 m below ground surface, corresponding to Elevation 193.7 m and 191.3 m, and the thickness of the cohesive deposit is 1.2 m and 2.5 m in the respective boreholes.

The SPT 'N'-values measured within this deposit are 0 blows (weight of hammer/rods) per 0.3 m of penetration, suggesting a very soft consistency.

Atterberg limits testing was carried out on two samples of the silty clay to clay and the test results indicate liquid limits of about 36 per cent and 55 per cent, plastic limits of about 17 per cent and 23 per cent and plasticity indices of about 19 per cent and 32 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B2 and indicate that the material is classified as a silty clay of medium plasticity to a clay of high plasticity.

Measured water content on two samples of this deposit are 44 per cent and 51 per cent.

Silty Sand to Sand and Gravel

A deposit of brown to grey silty sand to sand and gravel, containing trace clay was encountered underlying the clay in Boreholes LG-1 and LG-2 and underlying the fill in Borehole LG-3. Cobbles were noted at depths within the deposit in Boreholes LG-1 and LG-2, as indicated on the borehole records. The top of this deposit was encountered between 1.9 m and 5.7 m below ground surface, ranging between Elevation 196.2 m and 188.8 m and the thickness of the deposit in Borehole LG-3 is 1.0 m. The deposit was not likely fully penetrated in Boreholes LG-1 and LG-2 after drilling 3.3 m and 5.8 m, respectively, into the deposit.

SPT 'N'-values recorded within this deposit range between 4 blows and 64 blows per 0.3 m of penetration, indicating a very loose to very dense relative density. SPT 'N'-values of 50 blows and 87 blows per 0.1 m of penetration were also measured near the bottom of the deposit in Borehole LG-2, likely as a result of cobbles present within the deposit.

The grain size distributions of two samples of this deposit are shown on Figure B3.

The natural water content measured on samples of this deposit range between about 9 per cent and 15 per cent.



Bedrock/Refusal

Bedrock was encountered underlying the sand in Borehole LG-3 at a depth of 2.9 m below ground surface, corresponding to Elevation 195.2 m, and 3.0 m of bedrock core was recovered. Based on a review of the bedrock core sample, the bedrock consists of fine to coarse grained, fresh, pink and grey gneiss.

The Total Core Recovery (TCR) for the core samples in Borehole LG-3 is 100 per cent and the Solid Core Recovery (SCR) ranges from about 7 per cent to about 87 per cent due to the presence of vertical joints encountered between 3.2 m and 5.0 m depths. The RQD measured on the recovered bedrock core sample ranges from 94 per cent to 100 per cent, indicating that the rock is of excellent quality according to Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)³.

A Uniaxial Compressive Strength (UCS) test was carried out on a representative sample of the rock core taken from Borehole LG-3 and the measured UCS is 67 MPa, indicating that the bedrock is strong (R_4 , $50 \text{ MPa} < \text{UCS} < 100 \text{ MPa}$) according to Table 3.5 of CFEM (2006)³. Visual examination of the broken core sample after the UCS test revealed the presence of a healed joint within the tested sample.

In Borehole LG-2, refusal to further split-spoon penetration was encountered at a depth of 9.0 m below ground surface (Elevation 185.5 m). In DCPTs LG-DC1 and LG-DC2 refusal to further penetration was encountered at depths of 0.7 m and 1.1 m below ground surface, corresponding to Elevation 196.0 m and 196.5 m at the respective boreholes.

Groundwater Conditions

The unstabilized water level in Boreholes LG-1 to LG-3 was measured at depths between 0.2 m and 1.8 m below ground surface, corresponding to between Elevations 194.3 m and 196.9 m. Groundwater/surface water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.2.2 Highway 69 SBL – STA 11+198

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 11+198 in Harrison Township are shown on Drawing 1. The culvert will extend across the proposed SBL embankment, which will be up to about 9.0 m above existing grade. One borehole was completed to investigate the subsurface conditions at this culvert location, supplemented with three swamp boreholes. One borehole (Borehole LG-2) was advanced near the end of the culvert and one borehole (Borehole S6-3) was advanced near the midpoint of the culvert. In addition, one borehole (S6-4) and one DCPT (S6-DC1) were advanced near the ends of the east wing walls and one borehole (S6-2) and one DCPT (S6-DC2) were advanced near the end of the west wing walls. The topography of this section of proposed highway is a generally flat and low-lying swamp.

³ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 9th Edition. The Canadian Geotechnical Society ??BiTech Publisher Ltd., British Columbia



Peat

A deposit of black fibrous and amorphous peat was encountered at ground surface in Boreholes LG-2 and S6-2, to S6-4. The top of the deposit was encountered between Elevation 194.5 m and 194.3 m and the thickness of the peat deposit ranges from 2.9 m to 3.7 m.

The SPT 'N'-values recorded within this deposit are between 0 blows (weight of hammer/rods) and 2 blows per 0.3 m of penetration, suggesting a very soft consistency.

Measured water content on samples of this deposit range between about 115 per cent and 626 per cent.

Silty Clay to Clay

A deposit of grey silty clay to clay was encountered underlying the peat in Boreholes LG-2 and S6-2 to S6-4. The overall thickness of the cohesive deposit ranges from 1.4 m to 4.0 m and the top of the deposit was encountered between 2.9 m and 3.7 m below ground surface, ranging between Elevation 191.4 m and 190.6 m. In Boreholes S6-3 and S6-4 the silty clay to clay deposit is inter-layered with a 0.8 m and 0.3 m thick layer of grey sand to silty sand at a depth of 4.4 m (Elevation 189.9 m) and 5.5 m (Elevation 189.0 m), respectively.

The SPT 'N'-values measured within this cohesive deposit range are 0 blows (weight of hammer/rods) and 1 blow per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 17 kPa to 29 kPa. The SPT 'N'-values together with the in situ field vane tests suggest the cohesive deposit has a very soft to firm consistency. An SPT 'N'-value of 1 blow per 0.3 m of penetration was measured within the sand seam in Borehole S6-3, indicating a very loose relative density.

Atterberg limits testing was carried out on four samples of the silty clay to clay and the test results indicate liquid limits ranging from about 36 per cent to 57 per cent, plastic limits ranging from about 17 per cent to 24 per cent and plasticity indices ranging from about 17 per cent to 32 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B2 and indicate that the material is classified as a silty clay of medium plasticity to a clay of high plasticity.

The grain size distribution of one sample of the silty clay portion of the deposit is shown on Figure B4. The grain size distribution of two samples of the sand seam are shown on Figure B3.

Measured water content on samples of this deposit range between about 44 per cent and 87 per cent.

Silty Sand to Sand and Gravel

A deposit of brown to grey silty sand to sand and gravel containing trace clay was encountered below the silty clay to clay deposit in Boreholes LG-2 and S6-2 to S6-4. The top of this deposit was encountered between about 4.3 m and 7.7 m below ground surface, between about Elevation 190.0 m and 186.6 m. The deposit is between 1.6 m and 4.0 m thick in Boreholes LG-2, S6-2 and S6-4 where penetrated to refusal to further split-spoon advancement, and was not fully penetrated in Boreholes S6-3 after drilling 4.6 m into the deposit.

The SPT 'N'-values measured within this deposit range between 3 blows and 37 blows per 0.3 m of penetration, indicating a very loose to very dense relative density. In Boreholes LG-2 and S6-2, SPT 'N'-values of 50 blows



and 87 blows per 0.1 m of penetration and 60 blows per 0.15 m of penetration were measured near the bottom of the boreholes indicating a very dense relative density, likely as a result of cobbles within the deposit.

The natural water content measured on samples of this deposit range between about 9 per cent and 15 per cent.

The grain size distributions of three samples of this deposit are shown on Figure B3.

An Atterberg limits test carried out on a sample of the gravelly sand deposit from Borehole S6-3 indicates non-plastic fines.

Refusal

In Borehole S6-2 and LG-2, refusal to further split-spoon penetration was encountered at a depth of about 5.9 m and 9.0 m below ground surface respectively, corresponding to Elevations 188.4 m and 185.5 m.

Groundwater Conditions

The unstabilized water level in Boreholes S6-2, S6-3, S6-4 and LG-2 was measured at ground surface to a depth of 0.2 m below ground surface, corresponding to Elevation 194.3 m and 194.5 m. Groundwater/surface water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The field personnel supervising the drilling program were Mr. Ed Savard and Mr. Shane Albert. This report was prepared by Mr. Evan Childerhose, P.Eng. and Mr. André Bom, P.Eng. The technical aspects were reviewed by Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project, who also carried out a quality control review of the report.

Report Signature Page

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EC/AB/JMAC/cl/kp

N:\Active\2007\1190 Sudbury\1191\07-1191-0020 MMM Hwy 69 Twinning\7000 Reporting\Final\Ungulate Culvert\07-1191-0020-UC FINAL RPT 13Jan30 FIR Ungulate Culvert.Docx



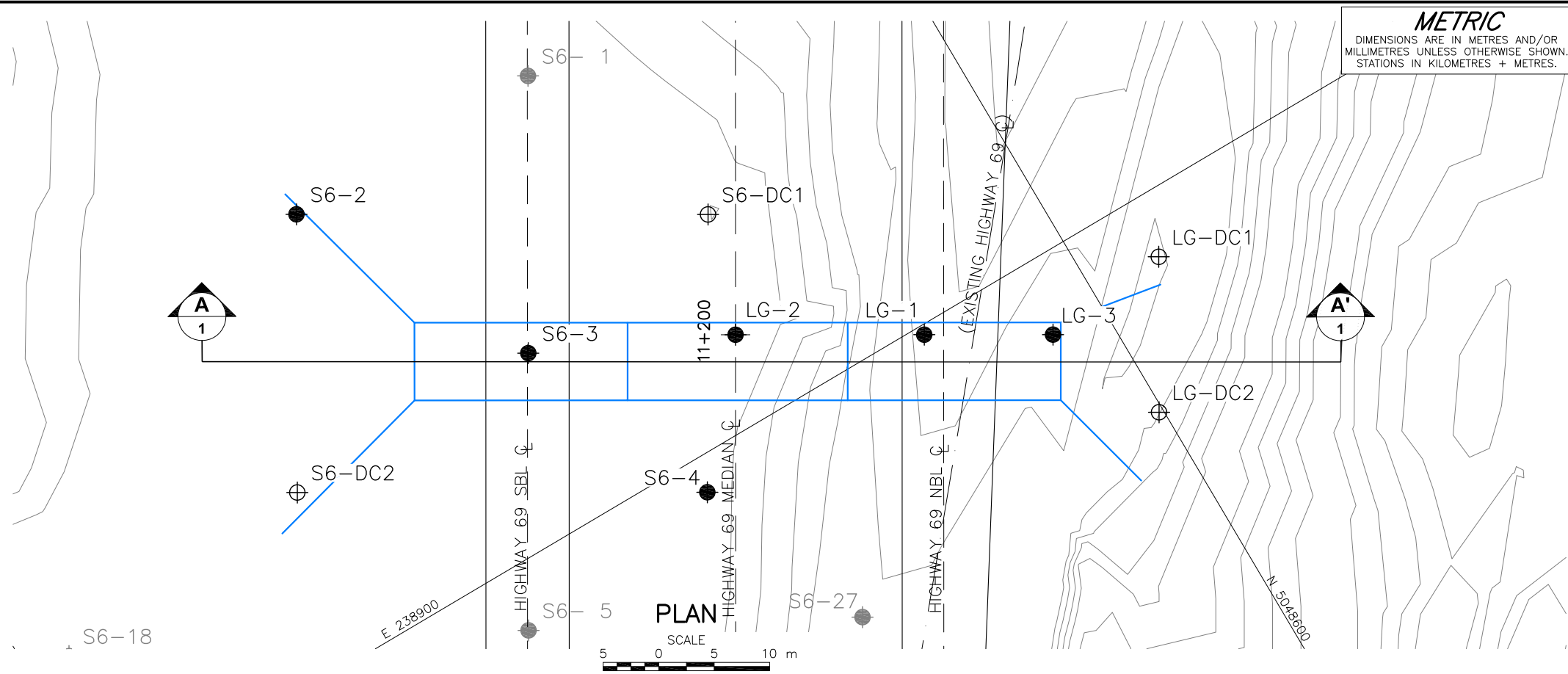
FOUNDATION REPORT - HIGHWAY 69 UNGULATE CULVERTS
GWP 5403-05-00, WP 5133-12-20 & -21

Table 1: Summary of Culvert Details

Culvert Location (Associated Swamp)	Approximate Proposed Embankment Height (m)	Invert Elevations ¹		Culvert Dimensions ¹			Walls	Boreholes/DCPTs
		East End of Culvert (m)	West End of Culvert (m)	Width (m)	Height (m)	Length (m)		
Highway 69 NBL STA 11+198	8.0	195.9	195.1	7.0	5.0	19.2	RSS	3 Boreholes (LG-2 that is shared with SBL culvert, LG-1 and LG-3) 2 DCPTs (LG-DC1 and LG-DC2)
Highway 69 SBL STA 11+198 (Swamp 6)	9.0	194.2	194.0	7.0	5.0	19.2	RSS	1 Borehole (LG-2 that is shared with NBL culvert) 3 Swamp Boreholes (S6-2 to S6-4) 2 Swamp DCPTs (S6-DC1 and S6-DC2)

Note: ¹ Invert elevations and culvert dimensions provided by MMM on April 17, 2012.

Prepared by: EC
Checked by: AB/JMAC



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

CONT No.
WP No.5133-12-20 & 21

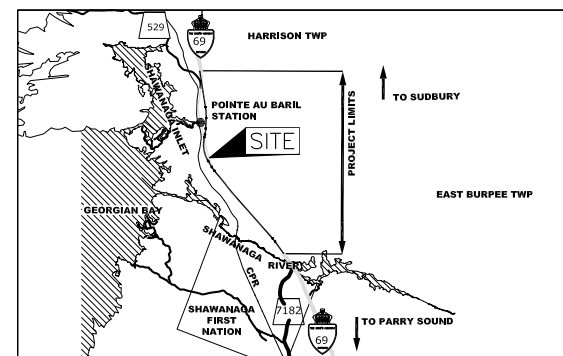


HIGHWAY 69
CULVERTS AT STA. 11+198
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN

SCALE
0 4 km

LEGEND

- Borehole
- ⊕ Dynamic Cone Penetration Test
- 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

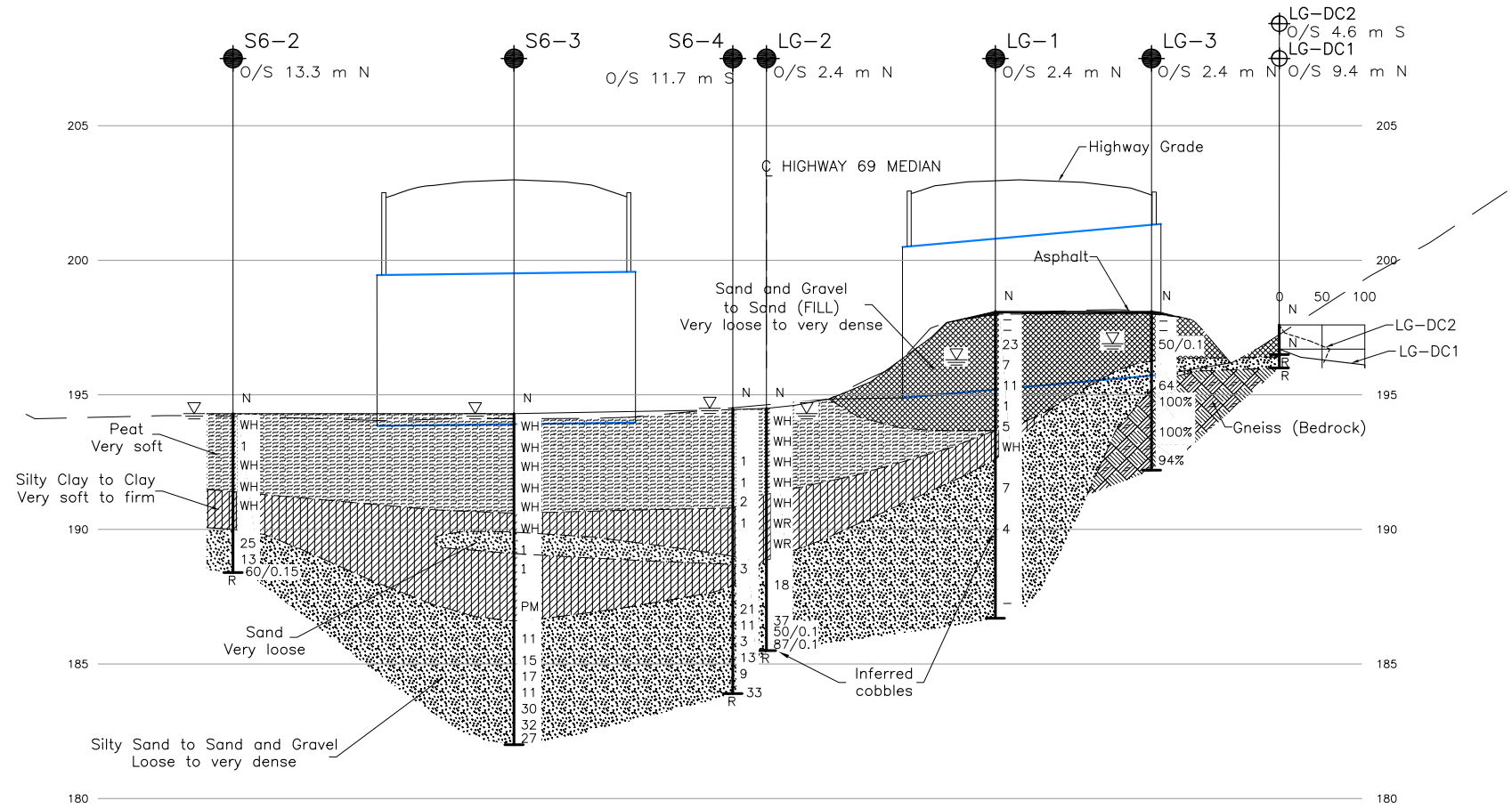
No.	ELEVATION	NORTHING	EASTING
LG-1	198.1	5048584.9	238900.8
LG-2	194.5	5048570.3	238892.2
LG-3	198.1	5048594.9	238906.8
LG-DC1	196.7	5048606.7	238905.6
LG-DC2	197.6	5048599.6	238917.6
S6-2	194.3	5048541.8	238862.7
S6-3	194.3	5048553.4	238884.1
S6-4	194.5	5048560.9	238903.1
S6-DC1	194.7	5048573.7	238881.6
S6-DC2	194.3	5048529.1	238884.3

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.



A-A' PROFILE ALONG CULVERTS
HIGHWAY 69

HORIZONTAL SCALE
0 10 m
VERTICAL SCALE
2.5 5 m



REFERENCE

Base plan provided in digital format by MMM Group, drawing file no. Hwy 69 Design - Rollplan - Golder Foundation.dwg (received Dec. 2007) and key plan, drawing file no. Hwy 69-529-Project key plan (received Apr. 2008). Culvert locations provided by MMM in drawing file no. Animal Crossing CV-Harrison-11+200x5.dwg (received April 17, 2012)

NO.	DATE	BY	REVISION
NO.	DATE	BY	REVISION
Geocres No. 41H-116			
HWY. 69		PROJECT NO. 07-1191-0020	
SUBM'D. EC		SITE:44-594/C1-C2	
DRAWN: TB		DWG. 1	



APPENDIX A

Record of Boreholes and Drillholes



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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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) 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

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



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

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

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

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



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

<u>Description</u>	<u>Bedding Plane Spacing</u>
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

<u>Description</u>	<u>Spacing</u>
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

<u>Term</u>	<u>Size*</u>
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 07-1191-0020			RECORD OF BOREHOLE No LG-1			1 OF 1 METRIC														
W.P. 5403-05-00			LOCATION N 5048584.9; E 238900.8			ORIGINATED BY EHS														
DIST _____ HWY 69			BOREHOLE TYPE 108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring			COMPILED BY EC														
DATUM Geodetic			DATE February 21, 2012 and March 5, 2012			CHECKED BY AB														
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
198.1	ROAD SURFACE							20 40 60 80 100												
0.0	ASPHALT		1	AS	-		198													
	Sand and gravel to sand, trace silt (FILL)		2	AS	-															
	Very loose to compact		3	SS	23		197													
	Brown		4	SS	7		196													
	Moist to wet		5	SS	11		195													
			6	SS	1		194													
			7	SS	5		193													
193.7	CLAY, trace sand		8	SS	WH		192													
4.4	Firm						191													
	Grey						190													
	Wet						189													
192.5	SAND to SAND and GRAVEL, some silt, trace clay		9	SS	7		188													
	Loose to very dense		10	SS	4		187													
	Grey																			
	Wet																			
	Cobbles inferred from auger grinding at 8.4 m depth, switched to NW casing.		11	SS	-															
	Hammer bouncing at 10.4 m depth.																			
186.7	END OF BOREHOLE																			
11.4	Note: 1. Water level at a depth of 1.8 m below ground surface (Elev. 196.3 m) upon completion of drilling.																			

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT		7-1191-0020		RECORD OF BOREHOLE No LG-2				1 OF 1 METRIC									
W.P.		5403-05-00		LOCATION		N 5048570.3; E 238892.2		ORIGINATED BY SA									
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring		COMPILED BY EC									
DATUM		Geodetic		DATE		March 5, 2012		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 (%)
194.5	GROUND SURFACE																
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH	▽	194										
			2	SS	WH		193										
193.1	PEAT (Amorphous) Very soft Black Wet		3	SS	WH		192										
1.4			4	SS	WH		191										
191.3	SILTY CLAY Very soft Grey Wet		5	SS	WH		191										
3.2			6	SS	WR		190										
			7	SS	WR		189										
							188										
188.8	Silty SAND to SAND and GRAVEL, trace clay Compact to very dense Brown Wet		8	SS	18		188										
5.7							187										
			9	SS	37		186										
			10	SS	50/0.1												
185.5	Cobbles inferred from spoon sampling and casing grinding below 8.5 m depth.		11	SS	87/0.1												
9.0	END OF BOREHOLE SPOON REFUSAL																
	Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 194.3 m) upon completion of drilling.																

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT		07-1191-0020		RECORD OF BOREHOLE No LG-3				1 OF 1 METRIC								
W.P.		5403-05-00		LOCATION		N 5048594.9; E 238906.8		ORIGINATED BY EHS								
DIST		HWY 69		BOREHOLE TYPE		108mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY EC								
DATUM		Geodetic		DATE		March 6, 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 (%)				
198.1	ROAD SURFACE						20	40	60	80	100	20	40	60		
0.9	ASPHALT		1	AS	-											
	Sand and gravel to sand, trace to some silt, cobbles below 0.8 m depth (FILL)		2	AS	-											
	Very Dense		3	SS	50/10.1											
	Brown															
	Moist to wet															
196.2																
1.9	SAND, some silt, trace gravel		4	SS	64											
	Very dense															
	Grey															
	Wet															
195.2																
2.9	GNEISS (BEDROCK)		1	RC	REC 100%											RQD = 100%
	Bedrock cored from 2.9 m depth to 5.9 m depth.		2	RC	REC 100%											RQD = 100%
	For coring details see Record of Drillhole LG-3.		3	RC	REC 100%											RQD = 94%
192.2																
5.9	END OF BOREHOLE															
	Note:															
	1. Water level at a depth of 1.2 m below ground surface (Elev. 196.9 m) upon completion of drilling.															

SUD-MTO 001 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT: 07-1191-0020

RECORD OF DRILLHOLE: LG-3

SHEET 1 OF 1

LOCATION: N 5048594.9 ; E 238906.8

DRILLING DATE: March 6, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME-55

DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR FLUSH % RETURN	JN - Joint FLT - Fault SHR- 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 MB- Mechanical Break										BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
							RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY		Diameter 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	k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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DEPTH SCALE




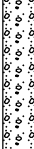
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LOGGED: EHS

CHECKED: AB

SUD-RCK 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 18/12/12 DATA INPUT:

PROJECT 07-1191-0020			RECORD OF BOREHOLE No S6-2			1 OF 1 METRIC												
W.P. 5403-05-00			LOCATION N 5048541.8; E 238862.7			ORIGINATED BY MR												
DIST HWY 69			BOREHOLE TYPE Portable Equipment, NW Casing Wash Boring			COMPILED BY MM												
DATUM Geodetic			DATE February 27, 2008			CHECKED BY AB												
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	GR SA SI CL	
								20 40 60 80 100	20 40 60 80 100	W _p W W _L	10 20 30							
194.3 0.0	GROUND SURFACE PEAT (Amorphous) Very soft Black Wet		1	SS	WH		194											
			2	SS	1		193											
			3	SS	WH		192											
			4	SS	WH		191											
191.4 2.9	SILTY CLAY Very soft to soft Grey Wet		5	SS	WH		190											
190.0 4.3	SAND and GRAVEL Compact Grey Wet		6	SS	25		189											
188.4 5.9	End of Borehole Spoon Refusal Notes: 1. Water level at ground surface upon completion of drilling. 2. Split spoon samples obtained by driving with a 1/3 weight hammer; SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer.		8	SS	60/0.15													

SUD-MTO 001 07-1191-0020 S6 (SBL SITE 9 RD_C76)METRIC.GPJ GAL-MISS.GDT 2608/11 DATA INPUT:

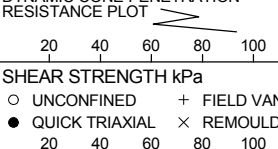
PROJECT		07-1191-0020		RECORD OF BOREHOLE No S6-3				1 OF 1 METRIC						
W.P.		5403-05-00		LOCATION		N 5048553.4; E 238884.1		ORIGINATED BY MR						
DIST		HWY 69		BOREHOLE TYPE		Portable Equipment, NW Casing Wash Boring		COMPILED BY MM						
DATUM		Geodetic		DATE		February 26, 2008		CHECKED BY AB						
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						
194.3	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30				
0.0	PEAT (Fibrous) Very soft Black Wet		1	SS	WH		194						248.7	
193.5														
0.8	PEAT (Amorphous) Very soft Black Wet		2	SS	WH		193						626.1	
			3	SS	WH		192							
			4	SS	WH		191						190.8	
190.6														
3.7	SILTY CLAY Very soft Grey Wet		6	SS	WH		190							0 1 40 59
189.9														
4.4	SAND, trace to some silt, trace clay, trace gravel Very loose Grey Wet		7	SS	1		189							2 75 19 4
189.1														
5.2	SILTY CLAY to CLAY Very soft to soft Grey Wet		8	SS	1		188	2 +						
								2 +						
			9	TO	PM		187							
186.6								5 +						
7.7	Gravelly SAND, some silt Compact to dense Grey Wet		10	SS	11		186							
			11	SS	15		185							
			12	SS	17		184							
			13	SS	11		183							
			14	SS	30									
			15	SS	32									
			16	SS	27									
182.0							182							
12.3	End of Borehole													
Notes: 1. Water level at ground surface upon completion of drilling. 2. Split spoon samples obtained by driving with a 1/3 weight hammer; SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer.														

SUD-MTO 001 07-1191-0020 S6 (SBL SITE 9 RD_C76)METRIC.GPJ GAL-MISS.GDT 2608/11 DATA INPUT:

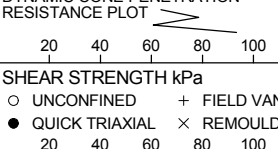
PROJECT 07-1191-0020			RECORD OF BOREHOLE No S6-4			1 OF 1 METRIC															
W.P. 5403-05-00			LOCATION N 5048560.9; E 238903.1			ORIGINATED BY MR															
DIST _____ HWY 69			BOREHOLE TYPE Portable Equipment, NW Casing Wash Boring			COMPILED BY MM															
DATUM Geodetic			DATE February 28, 2008			CHECKED BY AB															
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			GR SA SI CL		
194.5	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30								
0.0	PEAT (Fibrous) Very soft to soft Black Wet		1	SS	2		194														
193.7	PEAT (Amorphous) Very soft to soft Black Wet		2	SS	1		193										114.8				
0.8			3	SS	1		192										325				
			4	SS	1		191														
			5	SS	2		190														
190.8	SILTY CLAY Very soft to firm Grey Wet		6	SS	1		189														
3.7							188														
							187														
							186														
							185														
							184														
189.0	Silty SAND, trace clay, trace gravel Very loose Grey Wet		7a	SS	3		183														
188.7	CLAY Soft Grey Wet		7b	SS	3		182														
5.8							181														
187.9	Silty SAND, some gravel, trace clay Very loose to dense Brown to grey Wet		8	SS	21		180														
6.6			9	SS	11		179														
			10	SS	3		178														
			11	SS	13		177														
			12	SS	9		176														
			13	SS	33		175														
183.9	End of Borehole Spoon Refusal						174														
10.6	Notes: 1. Water level at ground surface upon completion of drilling. 2. Split spoon samples obtained by driving with a 1/3 weight hammer; SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer.						173														

SUD-MTO 001 07-1191-0020 S6 (SBL SITE 9 RD_C76)METRIC.GPJ GAL-MISS.GDT 2608/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>		RECORD OF PENETRATION TEST No LG-DC1		1 OF 1 METRIC	
W.P. <u>5403-05-00</u>		LOCATION <u>N 5048606.7 ;E 238905.6</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>DYNAMIC CONE PENETRATION TEST</u>		COMPILED BY <u>EC</u>	
DATUM <u>Geodetic</u>		DATE <u>March 5, 2012</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 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						
196.7 0.0	GROUND SURFACE START OF DCPT						196				
196.0 0.7	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)										

PROJECT <u>07-1191-0020</u>		RECORD OF PENETRATION TEST No LG-DC2		1 OF 1 METRIC	
W.P. <u>5403-05-00</u>		LOCATION <u>N 5048599.6 ;E 238917.6</u>		ORIGINATED BY <u>EHS</u>	
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>DYNAMIC CONE PENETRATION TEST</u>		COMPILED BY <u>EC</u>	
DATUM <u>Geodetic</u>		DATE <u>March 5, 2012</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 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						
197.6 0.0	GROUND SURFACE START OF DCPT						197				
196.5 1.1	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)										

SUD-MTO 002 07-1191-0020-9100 CULVERTS BH LOGS.GPJ GAL-MISS.GDT 27/03/12 DATA INPUT:

PROJECT <u>07-1191-0020</u>		RECORD OF PENETRATION TEST No S6-DC1		1 OF 1 METRIC	
W.P. <u>5403-05-00</u>		LOCATION <u>N 5048573.7; E 238881.6</u>		ORIGINATED BY <u>MR</u>	
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>MM</u>	
DATUM <u>Geodetic</u>		DATE <u>February 26, 2008</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					
194.7 0.0	GROUND SURFACE														
191.0 3.7	End of DCPT Refusal to Further Penetration (109 Blows/0.08 m)														

SUD-MTO 001 07-1191-0020 S6 (SBL_SITE 9 RD_C76)METRIC.GPJ GAL-MISS.GDT 2608/11 DATA INPUT:

PROJECT <u>07-1191-0020</u>		RECORD OF PENETRATION TEST No S6-DC2				1 OF 1 METRIC										
W.P. <u>5403-05-00</u>		LOCATION <u>N 5048529.1; E 238884.3</u>				ORIGINATED BY <u>MR</u>										
DIST <u> </u> HWY <u>69</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>				COMPILED BY <u>MM</u>										
DATUM <u>Geodetic</u>		DATE <u>February 27, 2008</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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
194.3 0.0	GROUND SURFACE						20	40	60	80	100					
							20	40	60	80	100					
							20	40	60	80	100					
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APPENDIX B

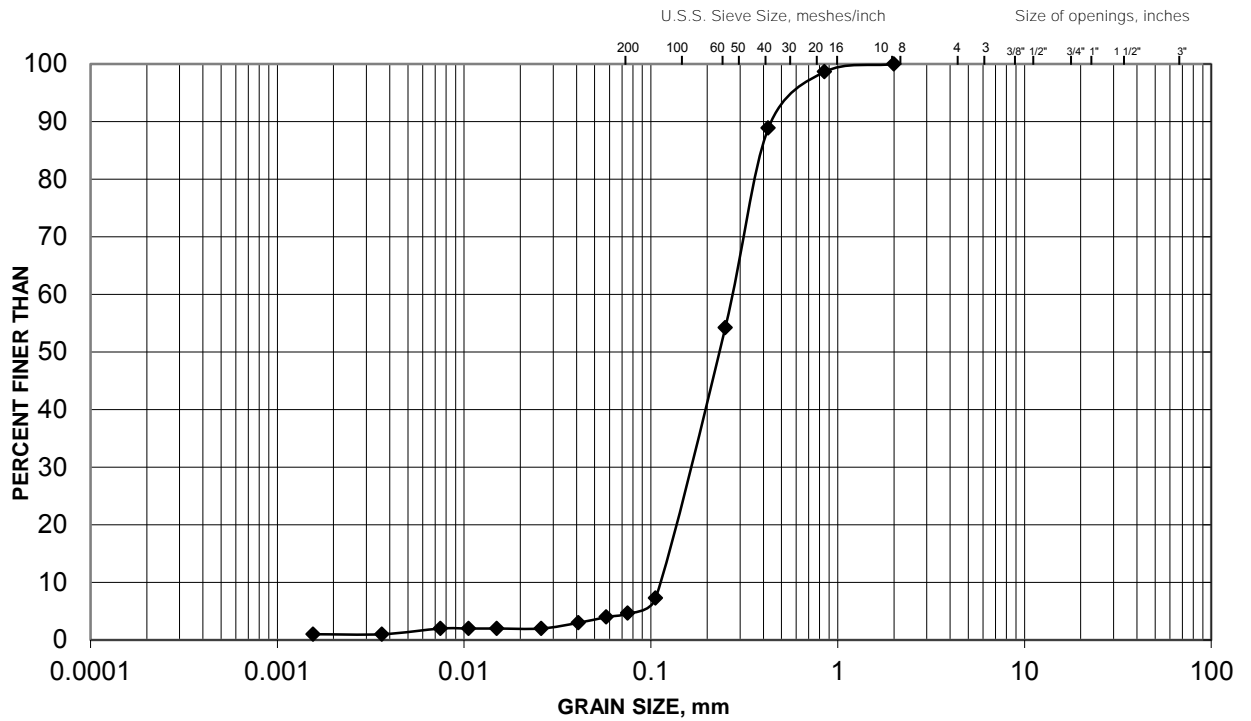
Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sand (FILL)
Highway 69 NBL and SBL STA 11+198

FIGURE

B1



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

LEGEND

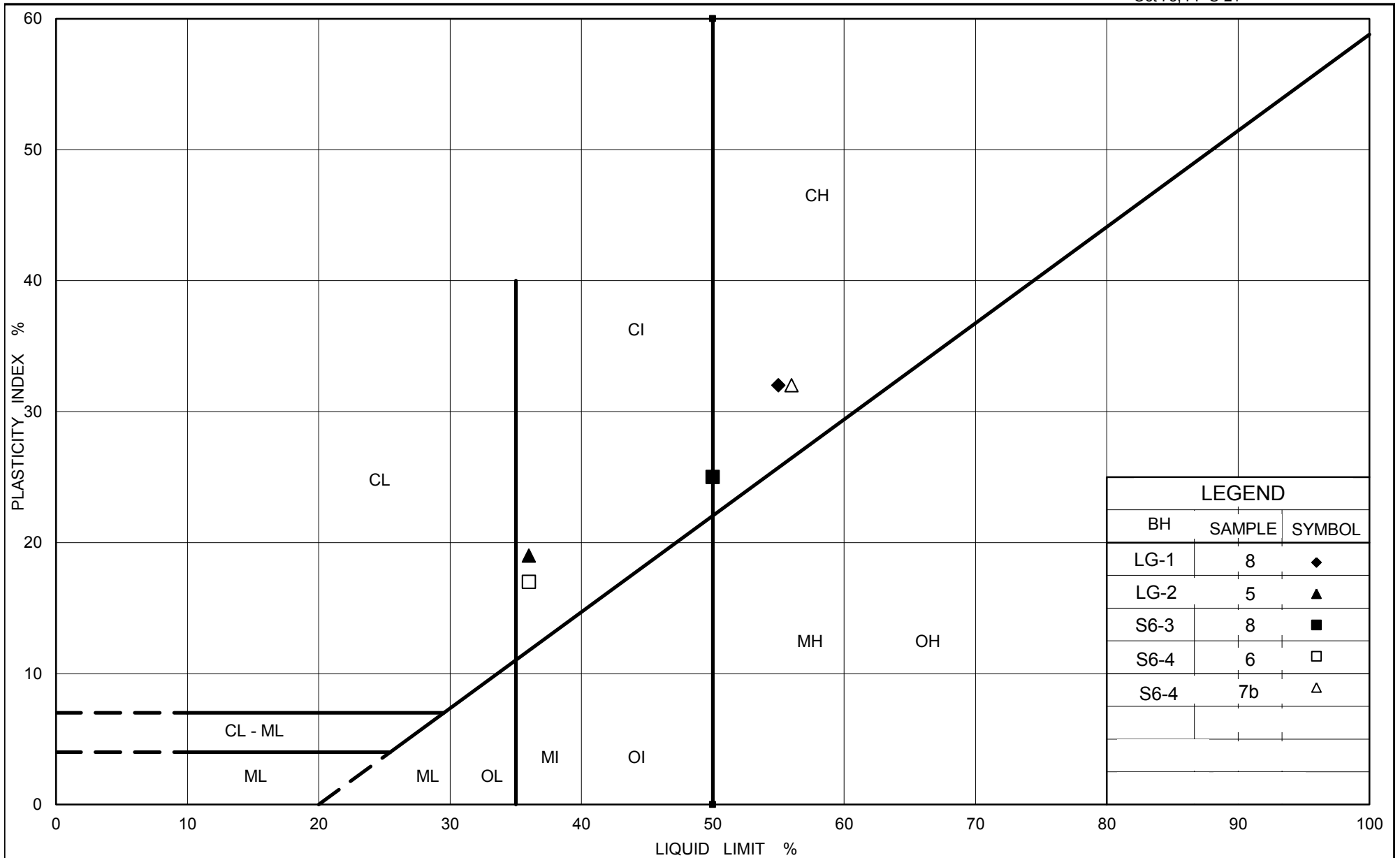
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	LG-1	4	196.3

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Ministry of Transportation
Ontario

PLASTICITY CHART
Silty Clay to Clay
Highway 69 NBL and SBL STA 11+198

Figure B2

Project No. 07-1191-0020

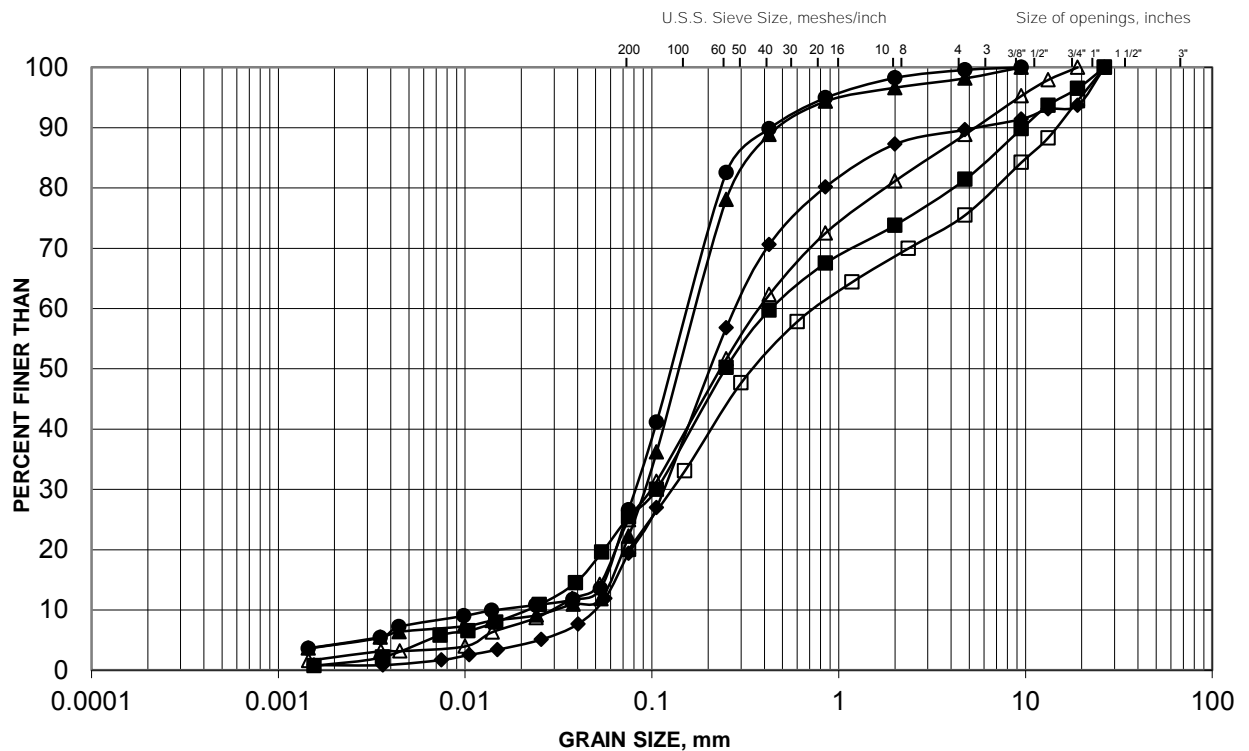
Checked By: EC/AB

GRAIN SIZE DISTRIBUTION

Silty Sand to Gravelly Sand
Highway 69 NBL and SBL STA 11+198

FIGURE

B3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
◆	LG-1	10	190.2
■	LG-2	8	188.1
▲	S6-3	7	189.4
●	S6-4	7a	188.8
△	S6-4	10	186.0
□	S6-3	13	184.1

Project Number: 07-1191-0020

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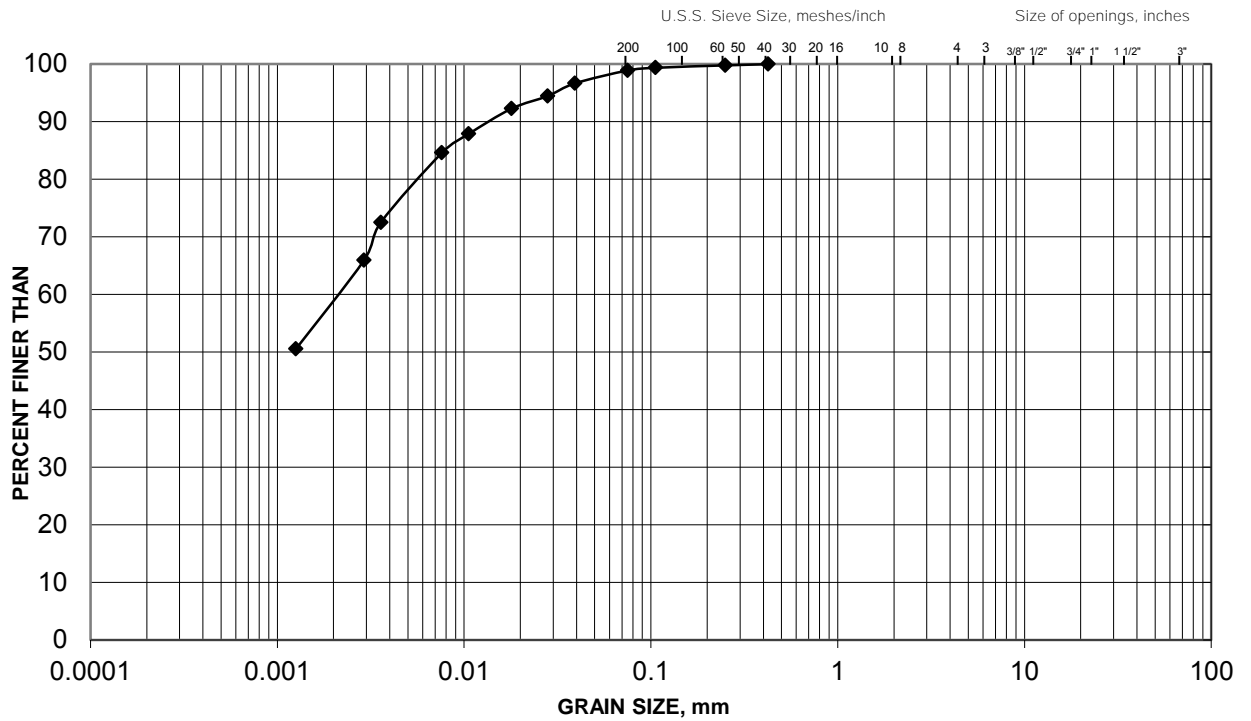
Date: January 2013

GRAIN SIZE DISTRIBUTION

Silty Clay
Highway 69 NBL and SBL STA 11+198

FIGURE

B4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
—◆—	S6-3	6	190.2

Project Number: 07-1191-0020

Checked By: EC/AB

Golder Associates

Date: January 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.

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