



December 4, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

**HIGHWAY 60 CULVERT REPLACEMENTS
UNKNOWN CREEK CULVERTS
SITES 43-232/C, 43-234/C AND 43-236/C
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5198-10-00**

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REPORT





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PART A

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Limited (LEA) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the three Unknown Creek culverts, Sites 43-232/C, 43-234/C and 43-236/C on Highway 60 in Algonquin Park, Ontario. The general locations of the culverts are shown on the Key Plan on Figure 1.

The Terms of Reference and Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2013. Golder's proposal for foundation engineering services associated with the culvert replacements is contained in Section 6.8 of LEA's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project dated May 10, 2013.

This report addresses the investigation carried out for the three Unknown Creek culverts only. Separate reports will be submitted detailing the foundation investigations for other culvert replacements for this project.

The purpose of this investigation is to establish the subsurface conditions at the locations of the proposed culverts by methods of borehole drilling, in situ testing and laboratory testing on selected soil and bedrock samples.

2.0 SITE DESCRIPTION

The two Unknown Creek culvert Sites 43-232/C and 43-234/C are located on the existing Highway 60 alignment about 11.0 km and 11.3 km west of Highway 127, respectively, in Airy Township. The Unknown Creek culvert Site 43-236/C is also on Highway 60 about 26.5 km west of Highway 127, in Sproule Township. The culvert locations and culvert details (size, length, type, etc.) are summarized in Table 1. The approximate locations of the culverts are shown on Figure 1.

In general, the topography of the three sites consists of numerous bedrock outcrops separated by creeks and swamps containing areas of standing water and various types of vegetation and organic soils, including dense tree cover in non-swamp areas. Photographs of the topography and vegetation conditions at the three culvert sites are presented in Appendices A to C.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation for the three Unknown Creek culvert sites was carried out between June 13 and July 15, 2013, September 12 and October 30, 2013, and February 5 to 7, 2014, during which period a total of thirty-nine (39) boreholes and nine (9) Dynamic Cone Penetration Tests (DCPTs) were advanced at the three culvert sites. A summary of the boreholes advanced at each culvert site is presented in Table 1 and the locations of the boreholes and culvert sites are shown on Drawings A1, B1 and C1 in Appendices A to C, respectively.

The field investigation between June and July 2013 was carried out using a track mounted CME 55 or portable equipment supplied and operated by Landcore Drilling Inc. of Chelmsford, Ontario. The field investigation in September and October 2013 was carried out using a truck mounted CME-55, CME-45 mounted on a raft or track (where required) supplied and operated by George Downing Estate Drilling Ltd. (Downing) of Grenville-Sur-La-Rouge, Quebec. The field investigations in February 2014 were carried out using portable equipment supplied and operated by Downing.



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The boreholes were advanced through the overburden using 108 mm inside diameter hollow stem augers, or NW casing with wash boring techniques. Where coring was required, a NQ size core barrel was used. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter split-spoon sampler operated by an automatic hammer on the track-mounted drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Boreholes advanced by portable equipment generally employed a full weight hammer lifted manually and dropped from the SPT height. At some borehole locations where portable equipment was used, as noted on the applicable Record of Borehole sheets, half weight hammers were used and the SPT 'N' values were corrected, as appropriate. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Shear Strength Test) using MTO Standard 'N' size vanes. All open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes were advanced to depths ranging from 0.2 m to 16.1 m below existing ground surface or water surface, generally to refusal or penetrating up to about 3 m into competent material, which is defined as material that will provide resistance to settlement or instability of the embankment, or into bedrock. Bedrock was exposed at Boreholes UC2-11 and UC3-6.

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 Appendices A to C. Groundwater elevations as encountered in the boreholes may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized on completion of drilling. Furthermore, groundwater elevations will vary depending on seasonal fluctuations, precipitation and local soil permeability.

A sample of the creek water was obtained during the field investigation at each culvert location, 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 2, following the text of this report.

The fieldwork was observed 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 samples. The soil and bedrock samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples and core underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. Classification testing (water content, grain size distribution and Atterberg limits) was carried out on selected soil samples. Strength testing by uniaxial compression was carried out on selected specimen of the rock core.

The as-drilled borehole locations were measured in reference to the existing culverts, or relative to marked stations placed on the pavement surface by LEA's surveyors, and the locations were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to temporary benchmarks consisting of either the marked station on the pavement surface or horizontal control points installed by LEA's surveyors, or inferred from the survey provided by LEA. The elevations of the temporary benchmarks were obtained from the survey provided by LEA. The borehole locations given on the Record of Borehole sheets and shown on Drawings A1 to C1 are positioned relative to



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MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations and ground surface elevations are as follows:

Culvert Location (Township)	Borehole	MTM NAD 83 Coordinates (m)		Ground*/Water Surface Elevation (m)	Borehole Depth (m) (Includes Water Column)
		Northing	Easting		
Unknown Creek Culvert, Site 43-232/C, STA 12+158 (Airy)	UC3-1**	5 046 993.6	400 606.1	407.3	6.2
	UC3-2	5 047 008.5	400 615.5	411.7	10.2
	UC3-3**	5 047 014.3	400 635.0	406.2	6.5
	UC3-4	5 047 045.7	400 584.4	411.8	0.3
	UC3-5	5 046 959.2	400 640.2	409.6	0.2
	UC3-6	5 047 054.3	400 597.9	411.6	***
	UC3-7**	5 046 972.2	400 660.4	405.8	1.8
	UC3-8	5 046 991.2	400 603.2	407.6	3.3
	UC3-9	5 047 003.2	400 596.4	406.0	6.4
	UC3-10	5 047 018.5	400 635.8	406.2	5.4
	UC3-11	5 047 004.2	400 642.9	406.2	4.3
	UC3-12	5 047 013.3	400 617.2	411.8	10.7
	UC3-13	5 046 999.9	400 625.8	411.6	6.9
Unknown Creek Culvert, Site 43-234/C, STA 11+826 (Airy)	UC2-1**	5 047 286.3	400 454.2	412.4	5.5
	UC2-2**	5 047 289.0	400 434.6	413.4	8.8
	UC2-3**	5 047 272.5	400 430.2	411.5	5.9
	UC2-4	5 047 290.8	400 458.5	410.1/411.5	5.8
	UC2-5	5 047 302.2	400 450.1	410.3/411.5	3.7
	UC2-6	5 047 279.8	400 419.9	410.2/411.0	1.6
	UC2-7	5 047 269.3	400 426.3	410.5/411.0	3.4
	UC2-8	5 047 333.5	400 422.3	410.9/411.8	6.8
	UC2-9	5 047 247.4	400 473.2	414.4	0.4
	UC2-10	5 047 322.8	400 405.6	412.9	0.3
	UC2-11	5 047 238.7	400 459.8	414.5	***
	UC2-12	5 047 279.9	400 446.1	413.6	6.9
	UC2-13	5 047 293.4	400 437.5	413.5	3.4
Unknown Creek Culvert, Site 43-236/C, STA 11+830 (Sproule)	UC1-1**	5 048 533.1	388 338.5	394.7	8.1
	UC1-2	5 048 539.8	388 326.8	395.9	13.4
	UC1-3**	5 048 547.9	388 327.9	395.1	2.3
	UC1-4	5 048 547.9	388 318.1	392.9/393.2	7.4
	UC1-5	5 048 552.2	388 326.0	392.6/394.7	6.9
	UC1-6	5 048 528.9	388 340.6	392.4/393.2	5.1
	UC1-7	5 048 537.1	388 347.2	393.2	8.8
	UC1-8	5 048 497.9	388 288.8	394.1	12.5
	UC1-9	5 048 524.7	388 281.0	394.2	14.0
	UC1-10	5 048 576.0	388 369.2	395.3	0.4
	UC1-11	5 048 553.4	388 388.5	393.3/393.5	10.4
	UC1-12	5 048 536.3	388 328.8	396.0	12.1
	UC1-13	5 048 541.4	388 337.4	395.9	16.1

Notes: *Bottom of Creek where borehole drilled in the water

**DCPT driven adjacent to the borehole

***Bedrock Outcrop



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on NOEGTS¹ mapping, the subsoils at the three culvert sites consists of bedrock outcrops separated by organic deposits and glaciofluvial deposits.

Published literature indicates that the bedrock in the area typically consists of migmatic rocks and gneisses within the Central Gneiss Belt, a subdivision of the Grenville Structural Province (OGS, 1991)².

4.2 General Overview of Local 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 presented on the Record of Borehole sheets and the laboratory test sheets in Appendices A to C for the Unknown Creek Culvert Sites 43-232/C, 43-234/C and 43-236/C, respectively. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and in situ testing. 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 subsurface stratigraphy as encountered in the boreholes advanced for the culverts are shown in profile and cross-section on Drawings A1, B1 and C1. The orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north. For the purposes of this report, the Highway 60 alignment is in an east-west orientation and therefore may differ from those shown on the drawings which represent magnetic north.

Detailed descriptions of the subsurface conditions at each investigated culvert crossing are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

4.3 Unknown Creek Culvert, Site 43-232/C

The plan cross-section and profile at Unknown Creek culvert Site 43-232/C showing the borehole locations and interpreted stratigraphy at approximately STA 12+158 in Airy Township are shown on Drawing A1. The height of the embankment at this location is about 6.0 m and the existing three cell wood box culvert is about 1.9 m high by 5.4 m wide and 33 m long. A total of 13 boreholes and 4 DCPTs were advanced at the culvert site:

- Boreholes UC3-1 to UC3-3 were advanced at the culvert inlet/outlet and midpoint;
- Borehole UC3-4 to UC3-7 were advanced approximately 50 m away from the culvert along the toes of the embankment slope;
- Boreholes UC3-8 and UC3-9 were advanced south of the south end of the culvert;
- Boreholes UC3-10 and UC3-11 were advanced north of the north end of the culvert; and

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping.

² Ontario Geological Survey, 1991. Geology of Ontario, 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.



- Borehole UC3-12 and UC3-13 was advanced through the roadway approximately 8 m east and west of the culvert.

Embankment Fill

Boreholes UC3-2, UC3-12 and UC3-13 were advanced through the existing roadway and encountered a 100 mm thick layer of asphalt with the roadway surface ranging from Elevations 411.8 m and 411.6 m. Below the asphalt, embankment fill consisting of sand and gravel to sand and blast rock was encountered. The thickness of the overall fill deposit ranges from 5.7 m to 6.3 m, with the blast rock zone ranging in thickness from 3.8 m to 5.3 m, located under the sand and gravel to sand fill. The surface of the blast rock was encountered at depths of 0.8 m and 1.5 m below the roadway surface, corresponding to between Elevations 410.2 m and 410.8 m. NW and NQ coring techniques were used to advance the boreholes through the blast rock portions of the borehole. In Borehole UC3-12, a layer of sand and gravel fill was also encountered underlying the blast rock fill at a depth of 5.2 m below the roadway surface corresponding to Elevation 406.6 m.

Underlying about 0.1 m of topsoil fill in Boreholes UC3-1 and UC3-8 and from ground surface in Boreholes UC3-3, UC3-4, UC3-8 and UC3-9, a layer of fill comprised of sand or sand and gravel was encountered. The thickness of the fill layer ranges from 0.2 m to 2.1 m and was encountered from Elevation 411.8 m to 406.0 m. In Borehole UC3-8 a boulder 0.4 m in size was encountered at a depth of 1.0 m depth below the fill and wood/organics were noted in the fill in Borehole UC3-9.

The SPT 'N'-values measured within the fill range between 11 blows to 86 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The grain size distribution of one sample of the sand and gravel fill is shown on Figure A1 in Appendix A.

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

Topsoil/Peat

In Boreholes UC3-5 and UC3-7, a 0.2 m and 0.1 m thick deposit of topsoil was encountered from ground surface at Elevation 409.6 m and 405.8 m, respectively. In Borehole UC3-2, a 0.1 m thick layer of peat was encountered underlying the embankment fill at a depth of 5.8 m below ground surface corresponding to Elevation 405.9 m.

Sand, Gravel, Cobbles and Boulders

A deposit of sand, gravel, cobbles and/or boulders was encountered from ground surface in Boreholes UC3-10 and UC3-11 underlying the fill in Boreholes UC3-1 to UC3-3, UC3-8, UC3-9, UC3-12 and UC3-13 and underlying the topsoil in Borehole UC3-7. The surface of the deposit was encountered from Elevation 406.2 m to 405.1 m. Cobbles and boulders ranging in size from 75 mm to 390 mm were encountered within this deposit and were cored using NW and NQ coring techniques where required to advance the borehole. Borehole UC3-7 was terminated within this deposit after exploring the deposit for 1.7 m.

Where it was possible to conduct a SPT within this deposit, the SPT 'N'-values range from 11 blows to 58 blows per 0.3 m of penetration, indicating that the deposit is compact to very dense in relative density.

The grain size distributions of seven samples of the gravelly sand to sand and gravel portions of this deposit are shown on Figure A2 in Appendix A.



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The natural water content measured on samples of the deposit ranges from about 7 per cent to 14 per cent.

Bedrock/Refusal

Bedrock and refusal to further split spoon advancement was encountered at depths ranging from 0.2 m to 7.7 m below ground surface, between Elevations 411.5 m and 402.8 m and is exposed at Elevation 411.6m. Bedrock was cored in the following boreholes and the surface depths and elevations are presented below.

Borehole No.	Depth to Bedrock Surface (m)	Bedrock/Refusal Surface Elevation (m)	Bedrock Core Length (m)
UC3-1	3.2	404.1	3.0
UC3-2	7.1	404.6	3.1
UC3-3	3.2	403.0	3.3
UC3-9	3.2	402.8	3.2
UC3-10	2.4	403.8	3.0
UC3-11	1.3	404.9	3.0
UC3-12	7.7	404.1	3.0

Note: Borehole UC3-6 was located on a bedrock outcrop

The retrieved bedrock core is described as a fresh to slightly weathered, fine to coarse grained, grey, gneiss, as presented in the Record of Drillhole sheets in Appendix A. Sand seams were noted within the bedrock in Borehole UC3-10 from 3.1 m to 3.8 m depth. Pegmatite sills were noted from depths of 1.7 m to 1.8 m and 3.3 m to 3.4 m in Borehole UC3-11.

The Total Core Recovery (TCR) ranges from 53 per cent to 100 per cent with the majority at 100 per cent. The Rock Quality Designation (RQD) measured on the core samples ranges from 25 per cent to 100 per cent (with majority over 75 per cent), indicating a rock mass of poor to excellent quality, and generally better than fair quality, as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

Laboratory Uniaxial Compressive Strength (UCS) testing was carried out on three selected samples of the recovered bedrock core. The UCS values are presented on the Record of Drillhole sheets in Appendix A and are summarized below and indicate that the bedrock is very strong (R5, 100 MPa < UCS < 250 MPa) in accordance with Table 3.5 of CFEM (2006).

Borehole No.	Depth (m)	Elevation (m)	UCS (MPa)
UC3-1	5.0	402.3	175
UC3-2	9.1	402.6	248
UC3-3	3.8	402.4	214



Refusal to further split-spoon and/or resistance to further casing advancement was encountered in Boreholes UC3-4, UC3-5 and UC3-8, ranging from depths of 0.2 m to 3.3 m below ground surface and ranging in Elevation from 411.5 m to 404.3 m and bedrock is exposed at the location of Borehole UC3-6 at Elevation 411.6 m.

Groundwater Conditions

The water levels observed in Boreholes UC3-1 to UC3-3, UC3-8, UC3-9 to UC3-12 upon completion of drilling were measured between Elevation 406.5 m and 405.5 m. Boreholes UC3-4, UC3-5 and UC3-7 were noted to be dry upon completion of drilling. The inlet (south side) and outlet (north side) creek water levels measured in October 2013 are Elevation 405.9 m and 405.6 m, respectively. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.4 Unknown Creek Culvert, Site 43-234/C

The plan cross-section and profile at Unknown Creek Culvert Site 43-234/C showing the borehole locations and interpreted stratigraphy at approximately STA 11+826 in Airy Township are shown on Drawing B1. The height of the embankment at this location is about 3.5 m and the existing three cell wood box culvert is about 1.9 m high by 5.7 m wide and 27 m long. A total of 13 boreholes and 3 DCPTs were advanced at the culvert site:

- Boreholes UC2-1, UC2-2 and UC2-3 were advanced at the culvert inlet/outlet and midpoint;
- Borehole UC2-4 and UC2-5 were advanced north of the north end of the culvert;
- Boreholes UC2-6 and UC2-7 were advanced south of the south end of the culvert;
- Boreholes UC2-8 to UC2-11 were advanced approximately 50 m away from the culvert along the toes of the embankment slope; and
- Borehole UC2-12 and UC2-13 was advanced through the roadway approximately 8 m east and west of the culvert.

Water

Boreholes UC2-4 to UC2-8 were advanced in the creek and encountered a 0.5 m to 1.4 m deep water column, with the surface of the water ranging from Elevation 411.8 m to 411.0 m.

Embankment Fill

Boreholes UC2-2, UC2-12 and UC2-13 were advanced through the existing roadway and encountered a 100 mm to 150 mm thick layer of asphalt with the roadway surface between Elevations 413.6 m and 413.4 m. Below the asphalt, embankment fill consisting of gravelly sand to sand and gravel, trace to some silt was encountered. The thickness of the overall fill deposit ranges from 1.2 m to 3.6 m. The DCPT advanced adjacent to Borehole UC2-2 encountered refusal within the fill at a depth of 1.7 m, indicative of a possible cobble/boulder.

At the creek bed in Borehole UC2-8, about 1.2 m of gravelly sand fill mixed with peat was encountered at Elevation 410.9 m, corresponding to 0.9 m below the water surface.



The SPT 'N'-values measured within the fill deposit within the embankment range between 7 blows to 81 blows per 0.3 m of penetration, indicating a loose to very dense relative density, however the majority of the values are between 10 blows and 34 blows per 0.3 m of penetration indicating a compact to dense relative density. Two 'N'-values in the fill deposit below the water are 2 blows and 6 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The grain size distribution of a sample of the gravelly sand fill is presented on Figure B1 in Appendix B.

The natural water content measured on samples of the fill ranges from about 4 per cent to 14 per cent.

Peat

A 0.1 m to 3.6 m thick deposit of peat was encountered from ground surface, below the water or underlying the fill in Boreholes UC2-1, UC2-3, UC2-5, UC2-7 and UC2-8, between Elevation 412.4 m and 409.7 m.

The SPT 'N'-values measured within the peat deposit generally range from 0 blows (weight of rods) to 4 blows per 0.3 m of penetration, suggesting a very soft to soft consistency. A SPT 'N'-value of 16 blows per 0.3 m was obtained in the surficial sandy peat deposit encountered in Borehole UC2-1, indicating a compact relative density.

The natural water content measured on samples of the peat deposit ranges from about 42 per cent to 815 per cent.

Sand, Gravel, Cobbles and Boulders

A 0.3 m to 2.2 m thick deposit of sand, gravel, cobbles and/or boulders was encountered from ground surface or underlying the water, embankment fill, or peat deposits in all boreholes except Borehole UC2-11 (bedrock exposed) ranging from Elevation 414.4 m to 406.1 m. Cobbles and boulders ranging in size from 75 mm to 380 mm were encountered within this deposit and were cored using NW and NQ coring techniques where required. A 0.7 m thick layer of silty sand was encountered in Borehole UC2-12, between the embankment fill and the sand, gravel and cobbles deposits.

The SPT 'N'-values measured within this deposit range between 4 blows and 90 blows per 0.3 m of penetration, indicating a loose to very dense relative density, however the majority of the 'N'-values between 10 blows and 47 blows per 0.3 m of penetration indicating a compact to dense relative density. Numerous SPT sampling events were terminated due to hammer bouncing due to the presence of cobbles/boulders in the deposit.

The grain size distribution of five samples of this deposit is shown on Figure B2 in Appendix B.

The natural water content measured on samples of this deposit ranges from about 9 per cent to 11 per cent.

Bedrock/Refusal

Bedrock and refusal to further split spoon or casing advancement was encountered at depths ranging from 0.3 m to 5.9 m below ground surface or creek bottom, ranging between Elevations 414.0 m and 405.0 m, and bedrock is exposed at Elevations 414.5 m.

Bedrock was cored in the following boreholes and the surface depths and elevations are presented below.



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Borehole No.	Depth to Bedrock Surface* (m)	Bedrock/Refusal Surface Elevation (m)	Bedrock Core Length (m)
UC2-1	2.1	410.3	3.4
UC2-2	5.7	407.7	3.1
UC2-3	2.4	409.1	3.5
UC2-4	1.5	408.6	2.9
UC2-7	0.6	409.9	2.3
UC2-12	3.3	410.3	3.6
UC2-13	3.0	410.5	0.6

Note: Borehole UC2-11 was located on a bedrock outcrop.

*Relative to ground surface or creek bottom

The retrieved bedrock core is described as a slightly weathered, fine to very coarse grained, grey, gneiss, as presented in the Record of Drillhole sheets in Appendix B.

The TCR is 100 per cent. The RQD measured on the core samples ranges from 42 per cent to 100 per cent, indicating a rock mass of poor to excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

Laboratory UCS testing was carried out on three selected samples of the recovered bedrock core. The UCS values are presented on the Record of Drillhole sheets in Appendix B and are summarized below and indicate that the bedrock is strong to very strong (R4 to R5, 50 MPa < UCS < 250 MPa) in accordance with Table 3.5 of CFEM (2006).

Borehole No.	Depth (m)	Elevation(m)	UCS (MPa)
UC2-1	4.2	408.2	170
UC2-2	6.2	407.2	220
UC2-3	4.0	407.5	82

Refusal to further split-spoon and/or resistance to further casing advancement was encountered in Boreholes UC2-5, UC2-6 and UC2-8, ranging from depths of 1.6 m to 6.8 m, ranging from Elevation 409.4 m to 405.0 m. In Borehole UC2-9 and UC2-10, refusal to further split spoon advancement was encountered at depths of 0.4 and 0.3 m below ground surface, corresponding to Elevation 414.0 m and 412.6 m, respectively, and bedrock outcrops were observed approximately 5 m east and 5 m west of the boreholes, respectively.

Groundwater Conditions

Boreholes UC2-4, UC2-5, UC2-6, UC2-7 and UC2-8 were advanced from the water surface ranging from Elevation 411.8 m to 411.0 m. The water levels observed in Boreholes UC2-2, UC2-3, UC2-12 and UC2-13 upon completion of drilling were measured between Elevation 412.1 m and 410.4 m. Boreholes UC2-9 and



UC2-10 were noted to be dry upon completion of drilling. The inlet (north side) and outlet (south side) water levels in the creek were measured in September 2013 at Elevation 411.5 m and 411.0 m, respectively. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.5 Unknown Creek Culvert, Site 43-236/C

The plan cross-sections and profile of the Unknown Creek Culvert Site 43-236/C showing the borehole locations and interpreted stratigraphy at approximately STA 11+830 in Sproule Township are shown on Drawing C1. The height of the embankment at this location is about 3.5 m and the existing CSP culvert is about 2.7 m high, 4.3 m wide and 26 m long. A total of 13 boreholes and 2 DCPTs were advanced at the culvert site:

- Boreholes UC1-1 to UC1-3 were advanced along at the culvert inlet/outlet and midpoint;
- Boreholes UC1-4 and UC1-5 were advanced north of the north end of the culvert;
- Boreholes UC1-6 and UC1-7 were advanced south of the south end of the culvert;
- Boreholes UC1-8 to UC1-11 were advanced approximately 50 m away from the culvert along the toes of the embankment slope; and
- Boreholes UC1-12 and UC1-13 were advanced through the roadway within about 5 m to either side of the culvert.

Water

Boreholes UC1-4, UC1-6, UC1-7 and UC1-11 were advanced in the creek and encountered a 0.2 m to 0.8 m deep water column with the surface of the water ranging from Elevation 393.5 m to 393.2 m.

Embankment Fill

A 100 mm to 150 mm thick layer of asphalt was encountered from ground surface in Boreholes UC1-2, UC1-12 and UC1-13. Embankment fill comprised of sand to sand and gravel was encountered underlying the asphalt in Boreholes UC1-2, UC1-12 and UC1-13, from ground surface in Boreholes UC1-1, UC1-3 and underlying a 0.1 m thick layer of topsoil in Borehole UC1-9. The thickness of the fill deposit ranges from 0.6 m to 3.2 m. In Borehole UC1-2, cobbles were encountered at depths between 0.7 m and 2.3 m, ranging in size from 75 mm to 125 mm. In Borehole UC1-12, a 200 mm cobble was encountered at a depth of 2.9 m. NQ coring techniques were required to advance the boreholes through the cobbles.

The SPT 'N'-values measured within the fill deposit range between 2 blows and 68 blows per 0.3 m of penetration, indicating a very loose to very dense relative density, however the majority of the values are in the compact relative density range.

The grain size distributions of three samples of the sand fill are presented on Figure C1 in Appendix C.

The natural water content measured on samples of the fill ranges from about 9 per cent to 11 per cent.



Peat/Topsoil

In Borehole UC1-5 and UC1-10, 0.1 m of topsoil was encountered from ground surface. In Boreholes UC1-6 to UC1-9 and UC1-11, a deposit of black fibrous and/or amorphous peat was encountered from ground surface, beneath the water or below the fill. The top of the peat deposit was encountered between Elevation 394.1 m and 391.0 m and the deposit is between 0.6 m and 5.5 m thick.

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

The natural water content measured on samples of the peat ranges from about 104 per cent to 610 per cent.

Organic Silt to Clayey Organic Silt

In Boreholes UC1-8, UC1-9 and UC1-11, a deposit of brown to grey organic silt to clayey organic silt was encountered underlying the peat deposit. The top of the deposit was encountered between Elevation 391.2 m and 387.0 m and the deposit is between 1.5 m and 3.3 m thick.

The SPT 'N'-values measured within this deposit range between 0 blows (weight of rods) and 2 blows per 0.3 m of penetration, suggesting a very soft consistency. One in situ field vane test was carried out within this deposit and measured an undrained shear strength of about 24 kPa, and a sensitivity calculated to be 2. The field vane test results indicate the deposit has a soft consistency.

Atterberg limits test were carried out on four samples of the organic silt deposit and indicate liquid limits ranging from about 34 per cent to 83 per cent, plastic limits ranging from about 25 per cent to 53 per cent and plasticity indices ranging from about 8 per cent to 30 per cent. The results of the Atterberg limits tests are shown in the plasticity chart on Figure C2 in Appendix C, and indicate the material to be organic silt to clayey organic silt of low to high plasticity.

The grain size distribution of two samples of the organic silt are shown on Figure C3 in Appendix C.

The natural water content measured on samples of the organic silt to clayey organic silt ranges between about 41 per cent and 86 per cent.

Two organic content tests carried out on selected samples of the clayey organic silt portions of the deposit are 3.2 per cent and 4.5 per cent.

Clayey Silt

In Boreholes UC1-9, a deposit of grey, clayey silt trace to some sand was encountered underlying the clayey organic silt. The top of the clayey silt deposit was encountered at Elevation 385.5 m and the deposit is 3.0 m thick.

The SPT 'N'-values measured within this deposit are 0 blows (weight of hammer) and 3 blows per 0.3 m of penetration, suggesting a very soft to soft consistency. One in situ field vane test was carried out within this deposit and measured an undrained shear strength of about 30 kPa, and a sensitivity calculated to be 4. The field vane test results indicate the clayey silt has a firm consistency.



An Atterberg limits test carried out on a sample of the clayey silt deposit and indicate a liquid limit of about 29 per cent, a plastic limit of about 22 per cent and a plasticity index of about 7 per cent. The result of the Atterberg limits test is shown in the plasticity chart on Figure C4 in Appendix C, and indicates the material to be clayey silt of low plasticity.

The grain size distribution of one sample of the clayey silt is shown on Figure C5 in Appendix C.

The natural water content measured on a sample of the clayey silt is about 35 per cent.

Silt to Sand

In Boreholes UC1-1, UC1-3, UC1-5 to UC1-9 and UC1-11, a deposit of brown or grey silt, sandy silt, silt and sand, silty sand or sand was encountered underlying the embankment fill, peat/topsoil, organic silt to clayey organic silt or the clayey silt deposits. The top of the silt to sand deposit was encountered between Elevation 394.6 m and 382.5 m and the thickness of the deposit ranged from 1.3 m to 6.7 m. Borehole UC1-11 was advanced without fully penetrating through the deposit for a thickness of 4.8 m. In Borehole UC1-1, cobbles and/or boulders were inferred from auger resistance between 3.8 m and 4.6 m depth and from 6.1 m to 7.0 m. Silt or silt and sand seams were noted within the sand and gravel deposit, discussed in the following section, in Boreholes UC1-2, UC1-12 and UC1-13.

The SPT 'N'-values measured within this deposit range between 2 blows and 43 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The grain size distributions of ten samples of the silt to sand, including three samples of the silt or silt and sand seams within the sand and gravel deposit discussed in the following section, are shown on Figure C6 in Appendix C.

The natural water content measured on samples of the silt to sand, including the seams within the sand and gravel deposit, ranges from about 11 per cent to 27 per cent.

Atterberg limits tests carried out three samples of the silt or silt and sand portions of the deposit in Boreholes UC1-6, UC1-7 and UC1-12 indicate that these materials are non-plastic.

Sand, Gravel, Cobbles and Boulders

In Boreholes UC1-2, UC1-4 to UC1-10, UC1-12 and UC1-13, a 0.3 m to 10 m thick deposit of sand, gravel, cobbles and/or boulders was encountered below the water or underlying the fill, topsoil or silt to sand deposit, ranging from Elevations 395.2 m to 380.9 m. Cobbles and boulders ranging in size from 75 mm to 1200 mm were encountered and the boreholes through this deposit were cored using NW and NQ coring techniques where required. Boreholes UC1-6 and UC1-8 were terminated after penetrating 1.8 m and 2.3 m into the deposit.

The SPT 'N'-values measured within this deposit range between 3 blows and greater than 100 blows per 0.3 m of penetration, indicating a loose to very dense relative density, with the majority of the deposit having a compact to very dense relative density.

The grain size distributions of eight samples of this deposit are shown on Figure C7 in Appendix C.



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The natural water content measured on samples of the deposit ranges from about 6 per cent to 11 per cent.

Bedrock/Refusal

Bedrock and refusal to further split spoon or auger advancement was encountered at depths ranging from 0.4 m to 13.0 m below ground surface or creek bottom, ranging between elevations 394.9 m and 381.6 m.

Bedrock was cored in the following boreholes and the surface depths and elevations are presented below.

Borehole No.	Depth to Bedrock/Refusal Surface (m)	Bedrock/Refusal Surface Elevation (m)	Bedrock Core Length (m)
UC1-2	10.4	385.5	3.0
UC1-5	3.6	391.1	3.3
UC1-12	11.5	384.5	0.6
UC1-13	13.0	382.9	3.1

In Borehole UC1-3, auger refusal was encountered at a depth of 2.3 m and coring was attempted and terminated at 2.3 m depth due to observations of flush water entering the creek

The retrieved bedrock core is described as a fine to coarse grained, grey, slightly weathered gneiss, as presented in the Record of Drillhole sheets in Appendix C.

The TCR is 100 per cent. The RQD measured on the core samples ranges from 36 per cent to 77 per cent, indicating a rock mass of poor to good quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

Groundwater Conditions

Boreholes UC1-4, UC1-6, UC1-7 and UC1-11 were advanced from the water surface ranging from Elevation 393.2 m and 393.5 m. The water levels observed in Boreholes UC1-1 to UC1-3, UC1-5, UC1-8 to UC1-10, UC1-12 and UC1-13, upon completion of drilling were measured between Elevation 395.1 m and 392.1 m. The water levels at the inlet (north) and outlet south sides of the culvert were measured in September 2013 at Elevation 393.2 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The drilling program was supervised by Messrs. Shane Albert, Gabriel Mathieu, Cody Walter, Adam Core and Ed Savard under the direction of Evan Childerhose P.Eng. This report was prepared by Mr. Adam Core, E.I.T. The technical aspects were reviewed by Mr. André Bom, P.Eng., and Mr. Jorge M. A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this project, carried out a quality control review of the report.



Report Signature Page

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PART B

**FOUNDATION DESIGN REPORT
HIGHWAY 60 CULVERT REPLACEMENTS
UNKNOWN CREEK CULVERTS
SITES 43-232/C, 43-234/C AND 43-236/C
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5198-10-00**



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides an interpretation of the factual geotechnical data obtained during the subsurface investigation and recommendations on the foundation aspects of design of the proposed works. The recommendations provided are intended for the guidance of the design engineer. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the subsurface information provided as it affects their proposed construction methods, costs, equipment selection, scheduling and the like.

6.1 General

Golder has been retained by LEA to provide foundation design recommendations for the replacement of three Unknown Creek culverts, Sites 43-232/C, 43-234/C and 43-236/C crossing Highway 60 in Algonquin Park, Ontario. The details of the three existing culverts addressed in this report are summarized in Table 1. It is understood that:

- the lengths of the new culvert will be generally consistent with those of the existing culvert lengths and the invert level of the new culverts will generally be the same as the existing invert, although the invert elevation may change slightly to address hydraulic requirements;
- a grade raise is not required for the reconstruction of the embankments; and
- the culverts will be replaced in stages under roadway protection measures. Temporary widening of the embankment, benched in the upper portion at the embankment crests, may be required for traffic staging such that detours or modification to the existing embankment slope and lateral extension of the toes are not required.

6.2 Culvert Types

Foundation design recommendations are provided for an open footing culvert and for a box culvert. Table 3 presents a comparison of the two culvert alternatives. From a foundations perspective, a box culvert is recommended for Sites 43-232/C and 43-236/C.

At Site 43-234/C, a box culvert may not be practical due to high bedrock elevation at Elevation 410.3 m at Borehole UC2-1, Elevation 410.3 at Borehole UC2-12 and Elevation 410.5 m at Borehole UC2-13, as the proposed underside of the box culvert would be approximately Elevation 409.7 m. Bedrock excavation to depths of up to at least 0.6 m to 0.8 m would be required over a large footprint of the culvert to facilitate box culvert installation. Hence, an open footing culvert is considered more suitable for Site 43-234/C.



6.3 Design Recommendations for Concrete Culverts

6.3.1 Geotechnical Resistance

Section 6.5 outlines the recommended factored geotechnical axial resistance at Ultimate Limit States (ULS) and the geotechnical axial reaction at Serviceability Limit States (SLS) for 25 mm settlement for design of either a precast concrete box culvert or an open footing culvert, for each individual culvert site. The geotechnical resistances provided are for loads applied perpendicular to the surface of the base of the culverts. Where loads are not applied perpendicular to the base of the culvert, inclination of the loads should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC, 2006) and its Commentary.

The loading on the foundation soils below the culverts and the associated total settlement at the culvert locations will be governed by the design height of the overlying and adjacent embankment fills. As such, it is recommended that the structural engineer exercise caution when utilizing the values of the geotechnical axial resistance at SLS (as provided in Section 6.5) in the design of the culverts and that consideration be given to the sequence and staging of construction. Where embankment widening is not required there will likely be minimal settlement, but where temporary embankment widening is required the post-construction total settlement of the foundation soils will likely be greater than that of the existing embankment and the settlement will vary along the length of the culverts. However, the SLS values as provided may be used in the design for culvert settlement of up to 25 mm.

Table 4 presents a summary of the ULS/SLS axial resistance values based on the assumed culvert sizes identified in Section 6.5 for each individual culvert.

6.3.2 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the base of the concrete box culverts and the new granular fill/bedding, or the cast-in-place open footing on the bedrock or native subsoils, placed following sub-excavation should be calculated in accordance with Section 6.7.5 of the CHBDC. The following summarizes the coefficient of friction for the interface materials for a precast and cast in place culvert.

Interface Materials	Coefficient of Friction
Precast Concrete Box Culvert on Compacted Granular 'B' Type II material	$\tan \delta = 0.45$
Cast-In-Place Concrete on Compacted Granular 'B' Type II or Native Sand and Gravel	$\tan \delta = 0.58$
Cast-in-Place Open Footings on Bedrock	$\tan \delta = 0.70$

Excavation of the bedrock may be required at Sites 43-232/C and 43-234/C to provide for an adequate width of open base to satisfy hydraulic requirements and/or to accommodate the required footing subgrade. Excavation of this hard bedrock within the culvert footprint can be achieved by line drilling and blasting and hydraulic hammer. A Non Standard Special Provision (NSSP) for excavating the bedrock should be included in the Contract Documents; an example NSSP is provided in Appendix D.



Depending on the bedrock surface slope and condition of the bedrock once exposed, doweling of the footing to bedrock may be required to increase the sliding resistance. The horizontal resistance of the dowels is dependent on the strength of the bedrock, grout and steel. For these sites, where the rock mass is as strong or stronger than the concrete, the design of the dowels into the rock may be handled in the same way as the dowel embedment into the concrete for UCS of the grout similar to that of the concrete. The dowels should have a minimum length within fair quality (RQD > 50 per cent) bedrock of 1 m, and the structural strength of the dowels and compressive strength of the grout should not be exceeded. If dowelling into bedrock is adopted at this site, an NSSP should be included in the Contract Documents to specify the installation, materials and testing of the dowels, such as the example provided in Appendix D.

6.3.3 Frost Protection

The estimated frost penetration depth for the Whitney area of Algonquin Park is 1.8 m, as per OPSD 3090.101 (Foundation, Frost Penetration Depths for Southern Ontario).

Box culverts are typically not provided with frost protection where water flows year-round through the culvert. Where the creek freezes, frost penetration may extend to 1.8 m below the invert. As the subsoils below the culvert footprint at each site consist of non-cohesive soil or bedrock at shallow depth, frost protection is not considered necessary.

Spread footings for an open footing concrete culvert should be provided with a minimum of 1.8 m of conventional soil cover for frost protection unless they are founded on bedrock, in which case, frost protection is not required.

6.4 Stability, Settlement and Horizontal Strain

The following sections summarize the methods utilized to: assess embankment stability at the culvert sites; estimate settlement of the foundation soils where the temporary embankment widening is required; and evaluate horizontal strains along the culverts beneath the zone of influence where the existing embankment will be widened for the reconstructed embankment geometry and type of fill material to be used.

Where the existing embankment is temporarily widened at the culvert locations for staging construction, it is anticipated that settlement of the cohesionless founding soils will occur during construction and that horizontal strain along the culvert will not develop. Should the embankment require permanent widening or the existing grade be raised, then stability, settlement and horizontal strain analysis should be carried out and recommendations for mitigation should be provided, as appropriate.

The analyses are based on the construction condition that all organic soils beneath the culvert alignments, including the peat, organic silt and organic clayey silt, will be removed prior to construction as discussed in Section 6.6.3 (including below detour alignments, if required), and that granular fill (i.e., sand and gravel material such as OPSS.PROV.1010 Granular 'B' Type II) will be used for replacement of sub-excavated material.

The piezometric conditions required in the analyses are based on the groundwater levels observed during drilling.



6.4.1 Stability

At Unknown Creek Culvert Sites 43-232/C and 43-234/C, there are no embankment stability issues anticipated due the relatively thin and very dense nature of the sands, gravels, cobbles and boulders deposits overlying bedrock.

The methodology used to evaluate embankment stability at Unknown Creek Culvert Site 43-236/C is described below. The parameters used in the analyses for the culvert and the results of the analyses are discussed in Sections 6.4.1.2 and 6.4.1.3, respectively.

6.4.1.1 Methodology

Limit equilibrium slope stability analyses were performed using the commercially available program GeoStudio 2007 (Version 7.23), produced by Geo-Slope International Ltd., employing the Morgenstern Price method of analysis. For all analyses, the Factor of Safety (FoS) of numerous potential failure surfaces was computed in order to establish the minimum FoS. The FoS is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum FoS of 1.3 is normally adopted for the design of embankment slopes under static conditions for MTO sites. This FoS is considered adequate for the embankments at these sites considering the design requirements and the field data available and is based on deep-seated, global failure surfaces that would affect the operation of the roadway. The stability analyses were performed to check that the target minimum FoS was achieved for the various embankment heights and geometries at the culvert locations.

6.4.1.2 Parameter Selection

The stability analysis for the embankment adjacent to Culvert Site 43-236/C assumes that the widening of the upper portion of the embankment will be constructed with new granular fill (sand and gravel, Granular 'A' or 'B' Type II) having a unit weight of 21 kN/m^3 and an effective friction angle of 35° . The stability of the embankments constructed of granular fill was analyzed using a side slope geometry with slopes at 2 Horizontal to 1 Vertical (2H:1V).

For the subsurface cohesionless soils, the effective stress parameters employed in the analysis were estimated from empirical correlations based on the results of the in situ SPT, in conjunction with engineering judgment based on experience in similar soil conditions.

Culvert	Stratigraphic Unit ¹	γ' (kN/m^3)	Φ' ($^\circ$)
Unknown Creek, Site 43-236/C	New Embankment Fill	21	35
	Silt and Sand, Sand and/or Sand and Gravel	20	30



6.4.1.3 Results of Analysis

The stability analysis performed on the reconstructed embankment geometry at the Site 43-236/C indicates that after completion of construction, the embankment will have a FoS greater than 1.3 for a deep-seated, global failure surface that would impact the operation of the roadway, as shown in Figure C8 in Appendix C.

6.4.2 Settlement

Temporary widening is required to facilitate culvert replacement at all three sites, with single lane traffic switched to cross over one side of the existing culverts and then to the side of the section of permanent culvert to allow for completion of construction of the permanent culverts. Settlement of the foundations soils below the proposed culverts can be expected due to the temporary widening, but the magnitude of settlement is estimated to be less than 25 mm. Should the reconstructed embankment be widened for a permanent condition, or raised relative to the existing embankment grade, settlement analysis will be required and recommendations for mitigation of settlement issues would need to be provided, as appropriate.

It is recommended that consideration be given to the use of OPSS.PROV1010 (Aggregates) Granular 'B' Type I or Type II for embankment reconstruction at the culvert location. Where granular fill will be placed below the water level, Granular 'B' Type II should be used. The material placed below the water level will compress/settle under its self-weight as additional fill is placed over it. The material placed above the water level should be compacted in accordance with OPSS 501 (Compacting). Compression settlement of the fill placed below water and from properly compacted embankment fill above water is expected to occur during construction. It is recommended that the fines content of the Granular 'B' Type II fill used for embankment construction below the water be restricted to a maximum of 5 per cent passing the No. 200 sieve, to reduce the potential for segregation of fines during placement and to reduce the potential post-construction settlement and associated roadway maintenance needs.

6.4.3 Horizontal Strain

Horizontal strain along the culverts is not expected to occur provided the proposed permanent embankment geometry does not change from the current geometry. Should the embankments be widened or raised compared with the existing geometry, a reassessment of the potential magnitude of horizontal strain will be required.

As a result, the culverts can be constructed concurrent with embankment re-construction without the need for any foundation mitigation measures or culvert camber.

6.5 Results of Analysis for Geotechnical Resistances

The geotechnical axial resistances for each of the culverts are presented in the following sections and are also summarized in Table 4 for box culverts and for open footing culverts. Details of the subsurface conditions are summarized for each culvert in the following sections and selected photographs of local site conditions are presented in Appendices A and B for the respective culvert.

Details on the requirements for backfilling and bedding are provided in Section 6.6.1.



6.5.1 Unknown Creek Culvert, Site 43-232/C

The existing 33 m long, three cell, wood box culvert, which is 5.4 m wide by 1.9 m high at about STA 12+158 in Airy Township, will be replaced with a 6 m wide by 2 m high box culvert or open footing culvert. The existing embankment, which is constructed of rock fill, is about approximately 6.0 m high and following culvert replacement the new section of embankment will be re-constructed to the existing grade. Based on the drawings provided by LEA, the invert of the culvert is estimated to be about Elevation 405 m.

Details of the subsurface conditions along the culvert alignment are presented in Section 4.4 and shown on Drawing A1 in Appendix A. The subsoils along the culvert alignment generally consist of a relatively thin and generally dense to very dense layer of sand, gravel, cobbles and boulders underlain by bedrock. While the adjacent embankment is comprised of rock fill, the backfill around and over the replacement culvert should consist of granular fill.

For a box culvert construction, sub-excavation of the organic soil (if encountered) and existing fill and replacement with Granular 'B' Type II will be required below the culvert invert. The factored geotechnical axial resistance at ULS and the geotechnical resistance at SLS (for 25 mm settlement) for a 6 m wide box culvert founded on a granular bedding placed on a properly prepared subgrade comprised of the native non-cohesive soils may be taken as 700 kPa and 350 kPa, respectively. Depending on the bedrock surface elevation along the culvert alignment relative to the culvert invert/bedding elevation (the bedrock surface appears to be higher at Borehole UC3-2 than at the inlet/outlet borehole locations), leveling/lowering of the bedrock may be required to accommodate bedding placement.

If an open footing culvert is selected, the footings should be placed on a level and cleaned bedrock surface with the footing construction and unwatering carried out as discussed in Section 6.6. The factored geotechnical axial resistance at ULS for a 1.2 m wide footing founded on the properly prepared bedrock surface may be taken as 1,000 kPa. The geotechnical reaction at SLS for 25 mm of settlement will be greater than the factored geotechnical axial resistance at ULS since the bedrock is considered to be an unyielding material; as such, ULS conditions will govern for this foundation type.

As the existing embankment will not be raised and the widening of the upper portion of the embankment is only temporary at the location of the replacement culvert, settlement of the foundation soils and horizontal strain along the culvert are not expected to occur and a camber is not necessary.

Based on the above, the replacement culvert can be constructed concurrent with embankment construction, without the need for any additional special foundation mitigation measures.

6.5.2 Unknown Creek Culvert, Site 43-234/C

The existing 27 m long three cell wood box culvert, which is 5.7 m wide by 1.9 m high at about STA 11+826 in Airy Township, will be replaced with a 6 m wide by 2 m high box culvert or open footing culvert. The existing embankment is about 3.5 m high and following culvert replacement the new embankment will be re-constructed with granular fill to the existing grade. Based on the drawings provided by LEA, the invert of the culvert is estimated to be about Elevation 410 m.



Details of the subsurface conditions along the culvert alignment are presented in Section 4.4 and shown on Drawing B1 in Appendix B. The subsoils along the culvert alignment generally consist of a relatively thin and generally dense to very dense layer of sand, gravel and cobbles deposit underlain by bedrock. The adjacent embankment is constructed of granular fill.

For a box culvert construction, sub-excavation of the organic soil (if encountered) and existing fill should be carried out to expose the bedrock surface under the culvert footprint. Where the bedrock surface level is lower than the culvert base the area should be backfilled with Granular 'B' Type II or the culvert founded on bedrock. The factored geotechnical axial resistance at ULS and for a 6 m wide box culvert founded on a granular bedding overlying the bedrock may be taken as 1 MPa. The geotechnical resistance at SLS (for 25 mm settlement) does not apply for a culvert founded on bedrock. Depending on the bedrock surface elevation along the culvert alignment relative to the culvert invert/bedding elevation, leveling/lowering of the bedrock will likely be required to accommodate bedding placement.

If an open footing culvert is selected, the footings should be placed on a level and cleaned bedrock surface with the footing construction and unwatering carried out as discussed in Section 6.6. The factored geotechnical axial resistance at ULS for a 1.2 m wide footing founded on the properly prepared bedrock surface may be taken as 1,000 kPa. The geotechnical reaction at SLS for 25 mm of settlement will be greater than the factored geotechnical axial resistance at ULS, since the bedrock is considered to be an unyielding material; as such, ULS conditions will govern for this foundation type.

As the existing embankment will not be raised and the widening of the upper portion of the embankment is only temporary at the location of the replacement culvert, settlement of the foundation soils and horizontal strain along the culvert are not expected to occur and a camber is not necessary.

Based on the above, the replacement culvert can be constructed concurrent with embankment construction, without the need for any additional special foundation mitigation measures.

6.5.3 Unknown Creek Culvert, Site 43-236/C

The existing 26 m long CSP culvert, which is 4.2 m wide and 2.7 m high at about STA 11+830 in Sproule Township, will be replaced with a 5 m wide by 2.8 m high box culvert or open footing culvert. The existing embankment is about 3.5 m high and following culvert replacement the new embankment will be re-constructed with granular fill to the existing grade. Based on the drawings provided by LEA, the invert of the culvert is estimated to be about Elevation 392.5 m.

Details of the subsurface conditions along the culvert alignment are presented in Section 4.3 and shown on Drawing C1 in Appendix C. The subsoils along the culvert alignment consist of a generally compact silt and sand, sand, sand and gravel deposit. At Borehole UC1-5, to the northeast of the culvert, the depth to bedrock is relatively shallow below ground surface, at Elevation 391.1 m, is inferred to rise to exposed bedrock east of the culvert and north of Highway 60. Further, boreholes advanced for the detour 50 m beyond the culvert alignment generally encountered organic soils up to 8.7 m deep, except to the northeast of the existing culvert where bedrock is exposed.

For a box culvert construction, sub-excavation of the organic soil (if encountered) and existing fill and replacement with Granular 'B' Type II will required below the culvert invert. The factored geotechnical axial



resistance at ULS and the geotechnical reaction at SLS (for 25 mm settlement) for a 4.0 m to 4.5 m wide box culvert founded on granular bedding placed on a properly prepared subgrade comprised of the sand and silt to sand and gravel native non-cohesive soils may be taken as 500 kPa and 100 kPa, respectively.

If an open footing culvert is selected, the footings should be placed at least 1.8 m below the culvert creek bed/invert for protection from frost penetration (approximately Elevation 391 m), such that the footings will be founded on the generally compact silt, sand, gravel subgrade. The factored geotechnical axial resistance at ULS and the geotechnical reaction at SLS (for 25 mm settlement) for a 1.2 m wide footing founded on the properly prepared subgrade may be taken as 400 kPa and 150 kPa, respectively. Leveling/lowering of the bedrock may be required at the northeast end of the culvert to accommodate footing construction.

As the existing embankment will not be raised and the widening of the upper portion of the embankment is only temporary at the location of the replacement culvert, settlement of the foundation soils and horizontal strain along the culvert are not expected to occur and a camber is not necessary.

If detours beyond the culvert alignment are required for traffic staging, sub-excavation of the relatively thick deposits of organic soil will be required.

Based on the above, the replacement culvert can be constructed concurrent with embankment construction, without the need for any additional special foundation mitigation measures.

6.6 Construction Considerations

6.6.1 Bedding and Backfill above Base of Culvert

Precast box culverts should be constructed in accordance with SP 422S01 (Precast Concrete Box Culvert). The box culvert should be constructed on a minimum 300 mm thick layer of OPSS.PROV.1010 (Aggregates) Granular 'B' Type II material for bedding purposes. Bedding for the box culvert could be constructed in either dry or wet conditions as follows:

- Where excavations will be unwatered to allow for construction of the culvert in dry conditions (see Section 6.6.3), the bedding should be placed in lifts not exceeding 300 mm loose thickness, and compacted to at least 95 per cent of the Standard Proctor Maximum Dry Density (SPMDD) of the material as specified in OPSS 501 (Compacting). The structural design of the culvert should take into consideration the conditions for bedding placement and compaction in accordance with the requirements of Section 7.8.3.6 of the CHBDC.
- Alternatively, the culvert could be installed in wet conditions depending on the season of construction and water level at the time of installation. The water level should be lower than the proposed surface of the bedding. In this case, the bedding should consist of Granular 'B' Type II and be nominally compacted by the construction equipment. The design of the culvert should be based on the bedding having achieved a moderate level of compaction – if a degree of compaction is needed for design, a relative density of 90 per cent of the SPMDD should be assumed.

It should be noted that bedding thicknesses will be greater than 300 mm where sub-excavation of organic soils and existing fill is required at specific culvert locations, as noted in Section 6.5.



For open footing culverts, all loose, softened or disturbed subgrade soil and rock should be removed immediately prior to placement of concrete. Construction and inspection of footings should be carried out in accordance with OPSS 902 (Excavating and Backfilling – Structures).

The culverts should be designed for the full overburden stress and appropriate live loads, assuming a fill unit weight of 22 kN/m^3 for Granular 'A' and 21 kN/m^3 for Granular 'B' Type II backfill above and surrounding the culvert.

Prior to placement of the roadway granular subbase and base courses, the final lift of embankment fill should be compacted to 100 per cent of the SPMDD. Inspection and field density testing should be carried out by qualified personnel during fill placement operations to ensure that appropriate materials are used and that adequate levels of compaction have been achieved.

6.6.2 Construction Staging, Temporary Shoring and Excavations

We understand that staged construction is being considered at the three sites for replacement of the culverts.

All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). The fills and granular native soils above the water level are considered to be Type 3 soil and the existing peat and granular soils below the water level are considered to be Type 4 soils. Provisions for traffic control measures should be included in the Contract Documents to maintain the safe operation of Highway 60 during the excavation and backfilling operations. Based on stability analysis of the sections of embankment configuration/geometry proposed for the staging construction period, we recommend that the temporary excavation side slopes during culvert replacement be no steeper than 1.5H:1V and excavation and backfilling operations be completed simultaneously in accordance with OPSS 209 (Embankments over Swamps and Compressible Soils) to at least the culvert invert level.

Given that the roadway embankment at Site 43-232/C is constructed of rock fill and that cobble and boulder size materials could be present at/below the invert, or granular fill at Sites 43-234/C and 43-236/C that contain cobbles/boulders, it will likely not be possible to install conventional shoring (i.e., sheet-pile wall) through these deposits to facilitate replacement of the existing culverts. If conventional shoring is considered, the existing rock fill within the footprint of the shoring should be sub-excavated and replaced with Granular 'B' Type II through which the sheet piles would be driven. Alternatively, a soldier or tube pile and lagging system may be used for support of the excavation provided pre-drilling through the existing rock fill would be completed in advance to allow for pile installation. Between the piles, the rock fill at Site 43-232/C may have to be line-drilled to break up the rock fill into smaller pieces to facilitate lagging installation and to minimize loosening of the embankment rock fill matrix. Further, as cobbles and boulders were encountered in the boreholes within the embankment fill and the granular overburden at Sites 43-234/C and 43-236/C, it will be necessary to remove such obstructions as lagging operations proceed. The temporary excavation support systems should be designed and constructed in accordance with OPSS 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways. The Contractor should be alerted to the presence of cobble and boulder size material rock fill within the embankment at Site 43-232/C and within the granular fill at Sites 43-234/C and 43-236/C and the presence of cobbles and boulders within the native cohesionless soils at all three culvert sites; an example Non-Standard Special Provision (NSSP) (or Notice to Contractor) to be included in the Contract is presented in Appendix D.



New granular fill should be keyed into the existing embankment side slope or cut slopes as per the requirements of OPSD 208.010 (Benching of Earth Slopes) to minimize differential settlement between the existing embankment slopes and the newly placed embankment fill.

6.6.3 Subgrade Preparation and Control of Groundwater and Surface Water

All organic and softened/loosened soils, including the peat, organic silt and organic clayey silt, should be sub-excavated from below the culverts prior to placement of bedding or new fill and below the detour alignments, if required. Granular fill materials should conform to, and placement should be carried out in accordance with, the requirements outlined in OPSS.PROV 206 (Grading).

Creek/ditch flows via the culverts at the time of construction of the replacement culverts will need to be diverted/piped away from the excavation areas during the construction period. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

The subgrade soils along all three culvert alignments are comprised of non-cohesive materials. The non-cohesive materials are generally susceptible to disturbance from construction or foot traffic and/or ponded water or groundwater. In order to limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the subgrade. A sample NSSP to address this requirement is included in Appendix D.

Groundwater flow into the excavation can be expected to occur at all three culvert locations due to the presence of relatively permeable subsoils and the near surface water level observed at the culvert locations. Control of groundwater will be necessary at the culvert sites to allow for excavation and construction to be carried out in dry conditions where applicable. Appropriate dewatering within the excavation will be required to maintain the water level below the base level of the culverts during construction. An NSSP should be included in the Contract to alert the contractor to the potential issues associated with unwatering of the soils at the culvert sites and that the excavation must be unwatered and kept stable during construction; a sample NSSP is included in Appendix D.

Excavations for an open footing culvert will require excavations below the groundwater water level. In this regard, groundwater control will be required and could be in the form of a sheet-pile cut-off wall (i.e. cofferdam) or a temporary box advanced to an appropriate depth and sealed along the bottom by an appropriate means to control groundwater inflow. Cobbles and boulders were encountered in most boreholes drilled at these sites and obstructions to installing a cut-off system should be expected. At these sites, we recommend placement of a tremie concrete plug at the base of the excavation directly below the footing within the sheet-pile cofferdam or temporary box to guard against the basal heave method of failure of subgrade soils where present and to mitigate for the inflow of water as the excavation is unwatered. The tremie concrete plug should have a minimum compressive strength of the same strength as the footings for an open footing culvert. Once the tremie plug is in place, water can be pumped out of the excavation for construction of the footings. It should be noted that at all three culvert sites, the tremie concrete plug forms an integral part of the footing system and it is the tremie concrete plug that will extend to the recommended footing founding elevation and therefore, placement of this tremie concrete plug is not optional for the construction of an open footing culvert.



6.6.4 Erosion Protection

Provision should be made for scour and erosion protection at all three culvert locations. In order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the upstream end of the culvert. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high water level including along the embankment slope. Alternatively, a 0.6 m thick clay blanket may be constructed, extending upstream three times the culvert height and along the adjacent slopes to a height of two times the culvert height or the high water level, whichever is greater.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. As a minimum, rip rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment). Erosion protection for the inlet of the culverts should also follow the standard presented in OPSD 810.010 (Rip Rap Treatment) similar to the outlet but with the rip rap placed up to the toe of slope level, in combination with the cut off measures noted above. Similarly, rip rap should be provided over the full extent of the clay blanket, including the creek side slopes and fill slope over the culvert. Based on the test results for the sulphate in the surface water samples, the sulphate concentrations are less than the criterion for moderate exposure (S-3 as per CSA A23.1-09) and general use hydraulic cement, GU, is suitable.

6.6.5 Analytical Testing for Construction Materials

The results of analytical tests on a sample of creek water taken adjacent to each culvert site are presented in Table 2. The suite of parameters tested is intended to allow the structural engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

6.7 Lateral Earth Pressures for Wing Walls

The lateral earth pressures acting on any wing walls that may be ultimately required at the ends of the culverts will depend on the type and method of placement of backfill materials, the nature of soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the culverts and wing walls. It should be noted that these design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the head/wing walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the requirements of OPSS.PROV1010 (Aggregates) Granular 'A' or Granular 'B' Type II but with less than 5 per cent passing the 200 sieve (0.075 mm) should be used as



backfill behind any head/wing walls. Longitudinal drains and weep holes should be installed behind head/wing walls to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub drains and frost taper for culvert walls and head/wing walls should be in accordance with OPSD 3101.150 (Walls, Abutment, Backfill) and OPSD 3121.150 (Walls, Retaining, Backfill).

- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the head/wing walls, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with OPSS 501 (Compacting). Other surcharge loadings should be accounted for in the design as required.
- For restrained walls, granular fill may be placed either in a zone with the width equal to at least 1.8 m behind the back of the wall (see Figure C6.20(a) of the Commentary to the CHBDC). For unrestrained walls, granular fill should be placed within the wedge shaped zone defined by a line drawn at 1.5H:1V extending up and back from the rear face of the wall (in accordance with Figure C6.20(b) of the Commentary to the CHBDC). The pressures are based on the proposed embankment fill material and the following parameters (unfactored) may be used:

Fill Type	Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular 'A'	22 kN/m ³	0.43	0.27
Granular 'B' Type II	21 kN/m ³	0.43	0.27

The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the Commentary to the CHBDC.

7.0 CLOSURE

This report was prepared by Mr. Adam Core, E.I.T. and Mr. André Bom. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and a Principal with Golder, reviewed the technical aspects of and conducted an independent quality control review of the report.



**FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS
UNKNOWN CREEK CULVERTS, GWP 5198-10-00**

Report Signature Page

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REFERENCES

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

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

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Map Reference Number 32DSW.

Ontario Geological Survey, 1991. Geology of Ontario, 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.

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

ASTM D2573 Standard Test Method for Field Vane Shear Strength Test

Contract Design Estimation and Documentation (CDED):

SP 422S01 Precast Concrete Box Culvert

Commercial Software

GeoStudio (Version 7.23) by Geo-Slope International Ltd.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ontario Provincial Standard Drawings:

OPSD 208.010 Benching of Earth Slopes

OPSD 810.010 Rip-Rap Treatment for Sewer and Culvert Outlets

OPSD 3090.101 Foundation, Frost Penetration Depths for Southern Ontario

OPSD 3101.150 Walls, Abutment, Backfill

OPSD 3121.150 Walls, Retaining, Backfill, Minimum Granular Requirement

Ontario Provincial Standard Specification:

OPSS 209 Construction Specification for Embankments Over Swamps and Compressible Soils

OPSS 501 Construction Specification for Compacting

OPSS 539 Construction Specification for Temporary Protection Systems

OPSS 902 Construction Specification for Excavating and Backfilling – Structures

OPSS 1205 Material Specification for Clay Seal



**FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS
UNKNOWN CREEK CULVERTS, GWP 5198-10-00**

OPSS.PROV 1010

Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Water Resources Act:

Regulation 903

Wells (as amended)



FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS
UNKNOWN CREEK CULVERTS, GWP 5198-10-00

Table 1: Summary of Culvert Details

Culvert Location Highway 60 (Township)	Approximate Existing Embankment Height ¹ (m)	Existing Culvert			Approximate Inlet/Outlet Invert Elevation (m)	Modification to Existing Embankment Geometry	Boreholes	Reference Appendix
		Type	Height x Span (m)	Length (m)				
Unknown Creek, Site 43-232/C, STA 12+158 (Airy)	6.0 (4 m over culvert)	3 Cell Wood Box	1.9 x 5.4	33	405/405	Minor regrading for traffic staging	13 Boreholes 2 DCPTs (UC3-1 to UC3-13)	A
Unknown Creek, Site 43-234/C, STA 11+826 (Airy)	3.5 (1.5 m over culvert)	3 Cell Wood Box	1.9 x 5.7	27	410/410	Minor regrading for traffic staging	13 Boreholes 3 DCPTs (UC2-1 to UC2-13)	B
Unknown Creek, Site 43-236/C, STA 11+830 (Sproule)	3.5 (0.8 m over culvert)	Corrugated Steel Pipe	2.7 x 4.3	26	392.5/392.5	Minor regrading for traffic staging	13 Boreholes 2 DCPTs (UC1-1 to UC1-13)	C

Note: 1. Embankment height is relative to existing ground surface level near toe of embankment adjacent to culvert.

Prepared by: AC
Reviewed by: AB

FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS
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Table 2: Summary of Analytical Testing of Surface Water

Culvert Location Highway 60 (Township)	Parameter (Units, Detection Limit)				
	Chloride (mg/L, 0.2)	Sulphate (mg/L, 1)	Conductivity (µS/cm, 1)	Resistivity (Mohm-cm)	pH
Unknown Creek, Site 43-232/C, STA 12+158 (Airy)	18	3	88	11,000	6.75
Unknown Creek, Site 43-234/C, STA 11+826 (Airy)	11	1	60	17,000	6.44
Unknown Creek, Site 43-236/C, STA 11+830 (Sproule)	67	5	270	3,700	6.85

Notes: 1. Samples obtained September 14, 2013.
2. Analytical testing carried out by Maxam.

Prepared by: AC
Reviewed by: AB



FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS UNKNOWN CREEK CULVERTS, GWP 5198-10-00

Table 3: Evaluation of Culvert Types

Options	Rank	Advantages	Disadvantages	Relative Costs	Risks/Consequences
Box Culvert (concrete)	1 for Sites 43-232/C and 236/C	<ul style="list-style-type: none"> ■ Frost protection generally not required for box culvert. ■ Straightforward and ease of construction. ■ Installation for pre-cast culvert is relatively quick compared with cast-in-place open footing culvert. ■ Dewatering usually not required for culvert bedding as bedding and replacement granular material (Granular 'B' Type II) can be placed below water. 	<ul style="list-style-type: none"> ■ Bedding will be required below the footprint of the box culvert: removal of existing rock fill and replacement with Granular 'B' Type II in the wet is required for bedding placement. ■ Leveling/lowering of bedrock would be required at Site 43-234/C and may be required at Site 43-232/C to accommodate bedding placement due to high elevation of bedrock surface. Not as suitable as an open footing culvert where extensive bedrock excavation is required. ■ Requires soil/granular bed over the invert slab to mimic a natural creek bed. 	<ul style="list-style-type: none"> ■ Less costly than open footing culvert. ■ Additional costs incurred for transportation of pre-cast culvert units. 	<ul style="list-style-type: none"> ■ May require bedrock removal if invert elevation is lowered, incurring additional costs and requiring longer construction period.
	2 for Site 43-234/C				
Open Footing Culvert (concrete)	1 for Site 43-234/C	<ul style="list-style-type: none"> ■ Bedding not required, footings can be founded on native subgrade but concrete has to be placed in-the-dry. ■ An open footing culvert is preferred from an environmental perspective (reduced impact to creek bed). 	<ul style="list-style-type: none"> ■ Deeper excavation for footings required compared with box culvert. ■ Cofferdam likely required to allow for dewatering/unwatering for construction of cast-in-place footings in the dry. Obstructions in the form of cobbles and boulders will make installation of a sheet-pile wall cofferdam difficult and likely require excavation ahead of pile installation. ■ A steel sheet pile cofferdam likely not effective in cutting off groundwater in areas of shallow depth to bedrock or obstruction from boulders: an alternative cut-off system such as temporary box may have to be considered. ■ Frost protection required for culvert footings (deeper founding level). ■ Leveling/lowering of bedrock will likely be required at Sites 43-232/C and 43-234/C to accommodate footing construction depending on bedrock surface elevation. 	<ul style="list-style-type: none"> ■ Additional cost for formwork for concrete placement. ■ Additional cost for cofferdam and dewatering for footing construction in-the-dry. ■ Overall more expensive to construct than a precast concrete box culvert. 	<ul style="list-style-type: none"> ■ Footings may be constructed on bedrock, except that construction may require bedrock removal to accommodate design invert level resulting in increased costs and slower construction.
	2 for Sites 43-232/C and 236/C				

FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS
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Table 4: Summary of Design Parameters for Culvert Construction

Culvert Location Highway 60 (Township)	Approximate Existing Embankment Height ¹ (m)	Preferred Option for Culvert Construction	Estimated Total Settlement for Permanent Culvert ² (mm)	Founding Soil at and Immediately Below ^{3,4}	Geotechnical Axial Resistance				Culvert Strain	
					Box Culvert		Open Footing Culvert		Proposed Culvert Length	Estimated Maximum Joint Opening (mm)
					Factored ULS (kPa)	SLS (for 25 mm Settlement) (kPa)	Factored ULS (kPa)	SLS (for 25 mm Settlement) (kPa)		
Unknown Creek, Site 43-232/C, STA 12+158 (Airy)	6.0	Concurrent with embankment construction	<25	Relatively thin layer of sand, gravel, cobbles over bedrock	700	350	1,000 (leveled, cleaned bedrock)	N/A (leveled cleaned bedrock)	34.2 m	N/A
Unknown Creek, Site 43-234/C, STA 11+826 (Airy)	3.5	Concurrent with embankment construction	<25	Relatively thin layer of sand, gravel, cobbles over bedrock	1,000 (leveled cleaned bedrock)	N/A (leveled cleaned bedrock)	1,000 (leveled cleaned bedrock)	N/A (leveled cleaned bedrock)	22.2 m	N/A
Unknown Creek, Site 43-236/C STA 11+830 (Sproule)	3.5	Concurrent with embankment construction	<25	Sand, Silt, Gravel, Cobbles	500	100	400	150	24 m	N/A

Notes: 1. Embankment height is relative to existing ground surface level near toe of embankment adjacent to culvert.

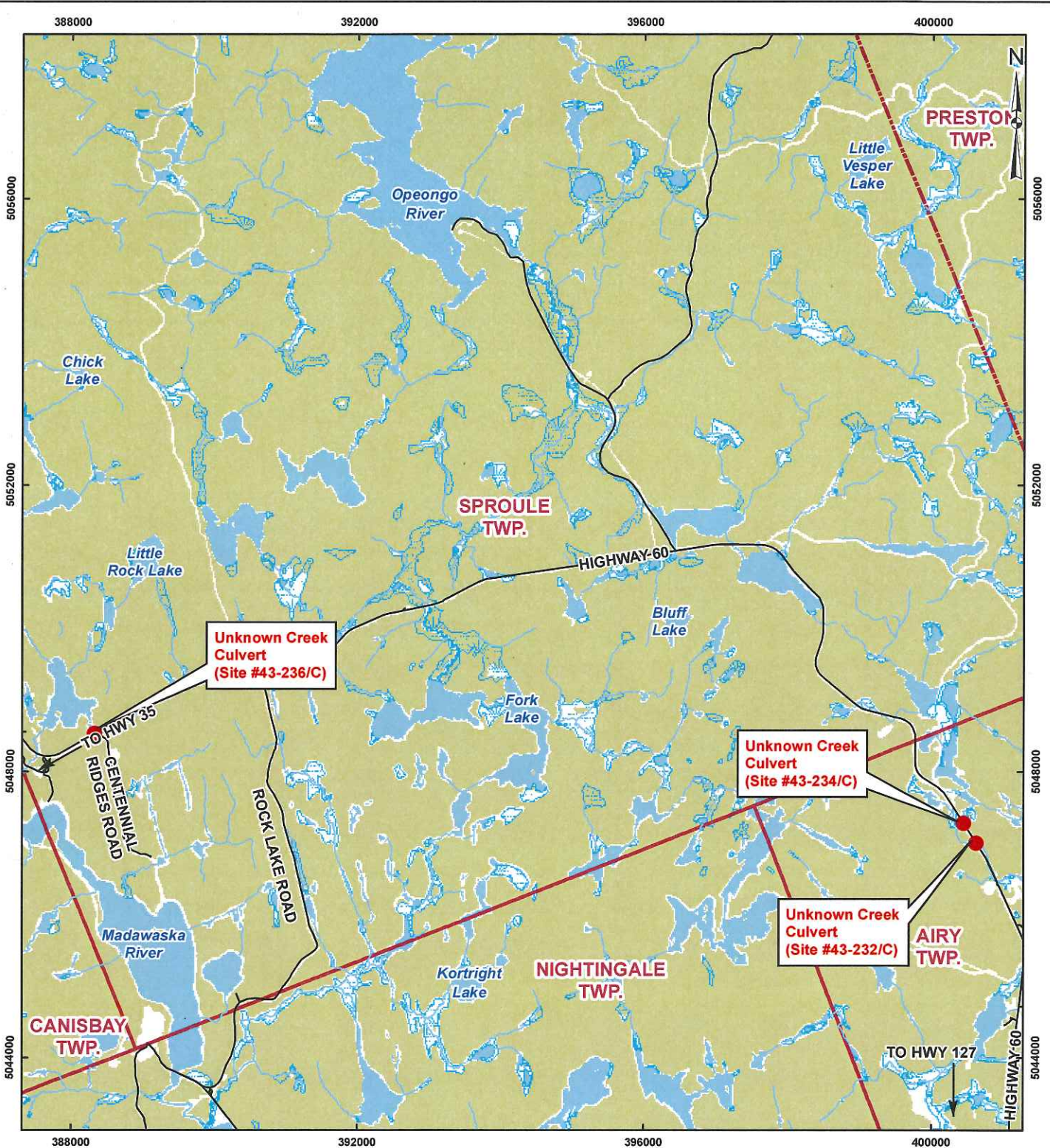
2. Total settlement refers to the immediate settlement of the native soil deposits assuming only minor embankment widening required (no detour).

3. All organic deposits are to be removed prior to culvert construction.

4. Bedding for box culvert should be at least 300 mm thick and consist of Granular 'B' Type II.

Prepared by: AC
Checked by: AB

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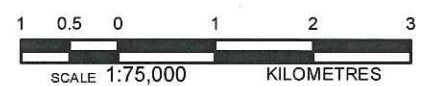


LEGEND

- Site Location
- Roads
- ▭ Twps
- Watercourse
- Waterbody
- Wetland
- Wooded Areas

REFERENCE

Base Data - MNR LIO, obtained 2009
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2012
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 17



PROJECT		UNKNOWN CULVERT REPLACEMENTS ALGONQUIN PARK, ONTARIO	
TITLE		LOCATION PLAN	
 Golder Associates Mississauga, Ontario		PROJECT NO. 13-1191-0003	SCALE AS SHOWN
		DESIGN ME 6 Aug. 2013	REV. 0.0
		GIS RRD Mar. 2014	
		CHECK - - - - -	
REVIEW - - - - -			

FIGURE: 1

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 $= \sigma'_p / \sigma'_{vo}$

(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

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 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

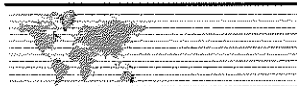
IV. SOIL TESTS

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.

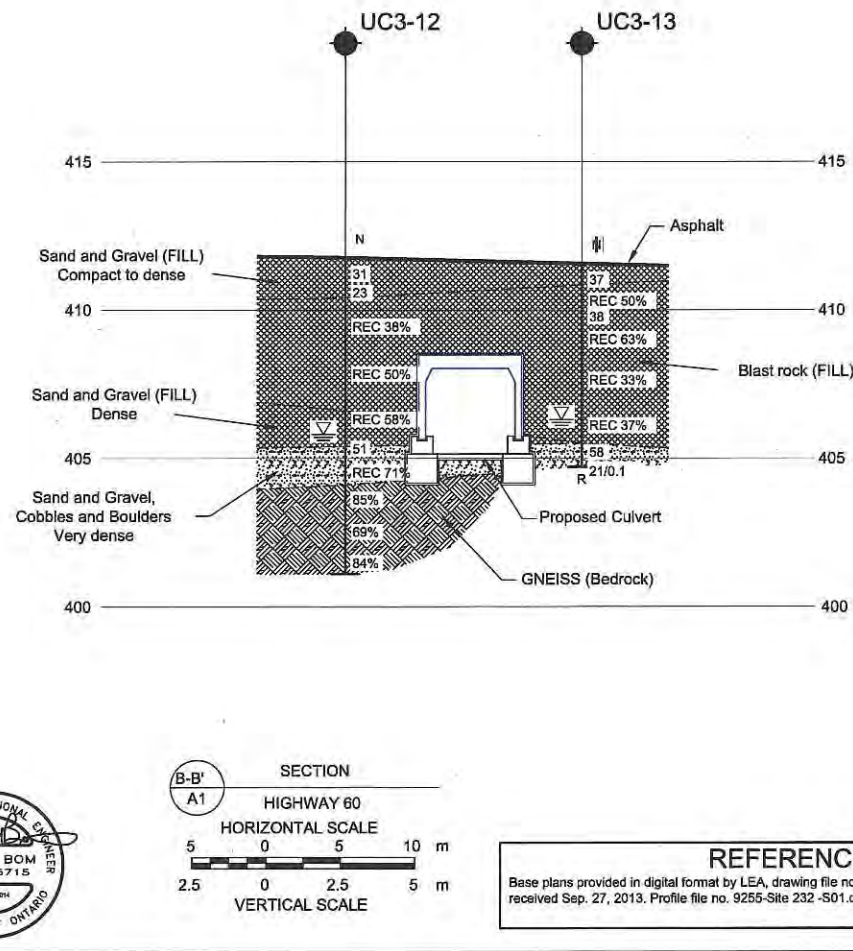
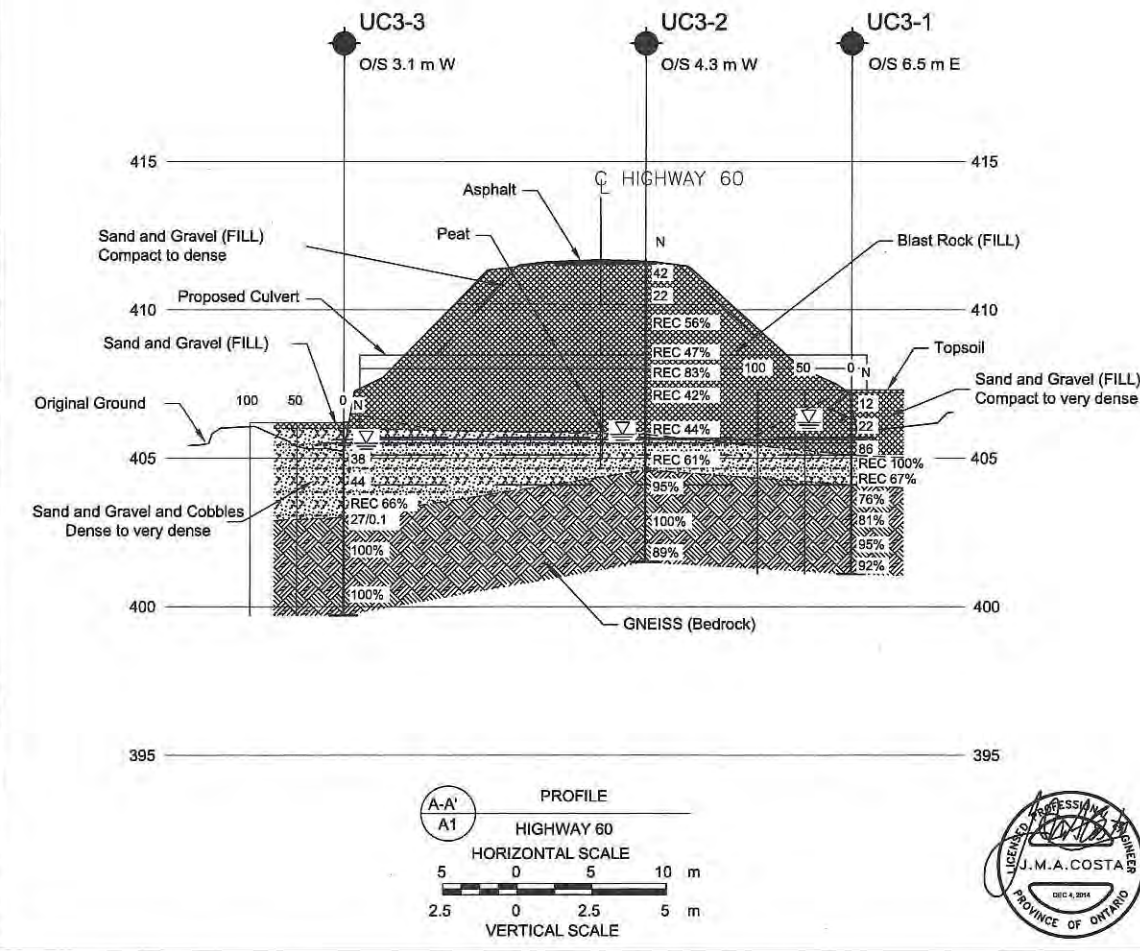
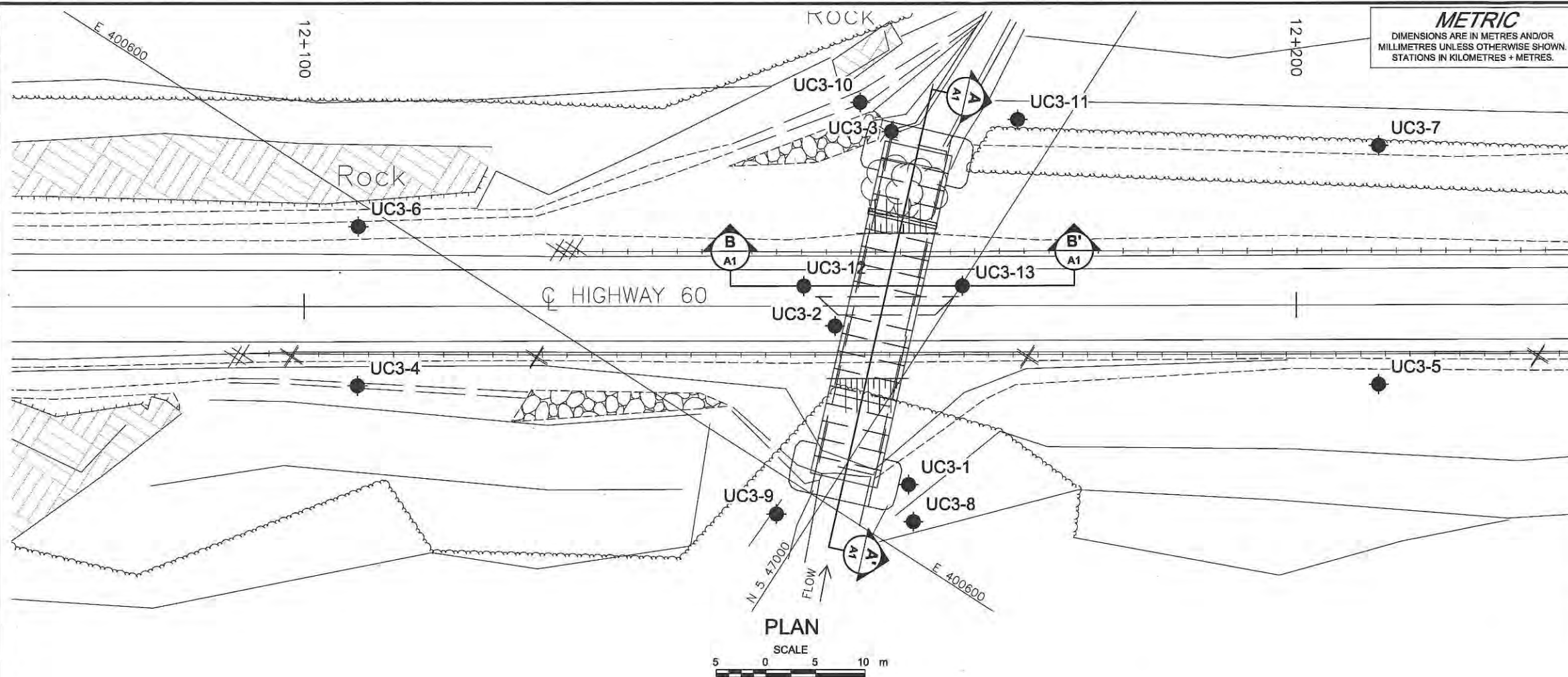
Abbreviations

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	



APPENDIX A

Unknown Creek Culvert, Site 43-232/C (Airy Township)



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

CONT No.
 WP No. 5360-11-01

HIGHWAY 60
 UNKNOWN CREEK CULVERT, SITE 43-232/C
 BOREHOLE LOCATIONS AND SOIL STRATA



Golder Associates Ltd.
 SUDBURY, ONTARIO, CANADA



KEY PLAN
 15 0 15 km

LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
UC3-1	407.3	5046993.6	400606.1
UC3-2	411.7	5047008.5	400615.5
UC3-3	406.2	5047014.3	400635.0
UC3-4	411.8	5047045.7	400584.4
UC3-5	409.6	5046959.2	400640.2
UC3-6	411.6	5047054.3	400597.9
UC3-7	405.8	5046972.2	400660.4
UC3-8	407.6	5046991.2	400603.2
UC3-9	406.0	5047003.2	400596.4
UC3-10	406.2	5047018.5	400635.8
UC3-11	406.2	5047004.2	400642.9
UC3-12	411.8	5047013.3	400617.2
UC3-13	411.6	5046999.9	400625.8

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.

NO.	DATE	BY	REVISION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

REFERENCE

Base plans provided in digital format by LEA, drawing file no. HWY 60 - site 43 232-234.dwg, received Sep. 27, 2013. Profile file no. 9255-Site 232 -501.dwg, received Nov 17, 2014.



PHOTOGRAPHS

Photograph 1: Unknown Creek Culvert, Site 43-232/C - Looking east from culvert (September 2013)



Photograph 2: Unknown Creek Culvert, Site 43-232/C – Looking west from culvert (September 2013)





PHOTOGRAPHS

Photograph 3: Unknown Creek Culvert, Site 43-232/C – Looking North (October 2013)



Photograph 4: Unknown Creek Culvert, Site 43-232/C – Looking South (September 2013)



PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC3-1		1 OF 1 METRIC									
G.W.P. 5198-10-00		LOCATION N 5046993.6, E 400606.1		ORIGINATED BY EHS									
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC									
DATUM GEODETIC		DATE October 19, 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
407.3	GROUND SURFACE						20 40 60 80 100	20 40 60					
0.1	Topsoil (FILL) Sand and gravel, trace to some silt (FILL) Compact to very dense Brown Moist to wet		1	SS	12								
			2	SS	22								
			3	SS	86								
405.1	GRAVEL and COBBLES		-	RC	REC 100%								
2.2	Depth (m) Size (mm)		-	RC	REC 67%								
	2.2 150												
	2.4 75												
404.1	3.2		1	RC	REC 100%								
	GNEISS (BEDROCK)		2	RC	REC 100%								
	Bedrock cored from 3.2 m depth to 6.2 m depth.												
	For coring details see Record of Drillhole UC3-1.		3	RC	REC 100%								
			4	RC	REC 100%								
401.1	6.2												
	END OF BOREHOLE												
	Note:												
	1. Water level 1.1 m below ground surface (Elev. 406.2) upon completion of drilling.												
	2. Advanced DCPT 1 m south, refusal at 1.1 m depth.												

SUD-MTO-001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC3-1

SHEET 1 OF 1

LOCATION: N 5046993.6 ; E 400608.1

DRILLING DATE: October 19, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter Point Load Index (MPa)	RMC -Q/ AVG.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	FLUSH	TOTAL CORE %						SOLID CORE %	B Angle			DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁻⁹				10 ⁻⁸	10 ⁻⁷	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	10 ⁻²	10 ⁻¹																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
		REFER TO PREVIOUS PAGE		404.1 3.2	1	GREY 100%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															</

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC3-2		1 OF 1 METRIC									
G.W.P. 5198-10-00		LOCATION N 5047008.5; E 400615.5		ORIGINATED BY SA									
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC									
DATUM GEODETIC		DATE June 27, 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					
411.7	GROUND SURFACE												
0.1	ASPHALT (100 mm)		1	SS	42								
	Sand and gravel, some silt (FILL) Compact to dense Brown Moist		2	SS	22								
410.2													
1.5	Blast rock (FILL)		-	RC	REC 56%								
			-	RC	REC 47%								
			-	RC	REC 83%								
			-	RC	REC 42%								
405.9			-	RC	REC 44%								
5.9	PEAT												
	SAND and GRAVEL Very dense Grey Wet		-	RC	REC 61%								
404.6													
7.1	GNEISS (BEDROCK)		1	RC	REC 100%								RQD = 95%
	Bedrock cored from 7.1 m depth to 10.2 m depth. For coring details see Record of Drillhole UC3-2.		2	RC	REC 100%								RQD = 100%
			3	RC	REC 100%								RQD = 89%
401.5													
10.2	END OF BOREHOLE												
	Note: 1. Water level 5.9 m below ground surface (Elev. 405.8 m) upon completion of drilling.												

SUD-MTO-001 13-1191-0003.GPJ GAL-MISS.GDT 28/03/14 DATA INPUT:

[illegible]

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC3-3		1 OF 1 METRIC													
G.W.P. 5198-10-00		LOCATION N 5047014.3; E 400635.0		ORIGINATED BY EHS													
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC													
DATUM GEODETIC		DATE October 23, 2013		CHECKED BY AB													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL				
406.2	GROUND SURFACE																
0.0	Sand and gravel (FILL)																
0.2	SAND and GRAVEL, some silt Dense Brown and grey Wet Cobbles at 2.3 m (175 mm) and 2.4 m (125 mm) depth.		1	SS	38												
			2	SS	44												
			-	RC	REC 66%												
403.0	GNEISS (BEDROCK)		3	SS	270.1												
3.2	Bedrock cored from 3.2 m depth to 6.5 m depth. For coring details see Record of Drillhole UC3-3.		1	RC	REC 100%												
			2	RC	REC 100%												
399.7	END OF BOREHOLE																
6.5	Note: 1. Water level at a depth of 0.7 m below ground surface (Elev. 405.5 m) upon completion of drilling. 2. Advanced DCPT 0.5 m west, refusal at 0.8 m depth.																

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 28/03/14 DATA INPUT

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC3-3

SHEET 1 OF 1

LOCATION: N 5047014.3 E 400635.0

DRILLING DATE: October 23, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	RECOVERY	R.Q.D. %	FRACT. INDEX METRES	B Angle °	DISCONTINUITY DATA	TYPE AND SURFACE DESCRIPTION	Jr	Jp	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diameter Point Load Index (MPa)	RMC -Q- AVG	NOTES WATER LEVELS INSTRUMENTATION
		REFER TO PREVIOUS PAGE		403.0															
	NW	GNEISS Grey Fine to coarse grained Fresh Very strong		3.2	1	GREY 100%						JNFORo JNFORo							UCS=214 MPa
4												JNFORo							
5	October 23, 2013 NQ Coring											JNUNRo							
6					2	GREY 100%						JNFORo							
		END OF DRILLHOLE		369.7															
6.5																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 13-1191-0003.GPJ GAL MISS GDT 28/03/14 DATA INPUT:

PROJECT		13-1191-0003				RECORD OF BOREHOLE No UC3-4				1 OF 1		METRIC	
G.W.P.		5198-10-00		LOCATION		N 5047045.7 ; E 400584.4				ORIGINATED BY		GM	
DIST		HWY 60		BOREHOLE TYPE		Portable Equipment				COMPILED BY		AC	
DATUM		GEODETIC		DATE		July 15, 2013				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	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL	
411.8	GROUND SURFACE												
0.0	Sand and gravel, trace organics (FILL)		1	SS	11/0.2								
0.3	Compact Brown Moist												
	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)												
	Notes:												
	1. Borehole dry upon completion of drilling.												
	2. Split spoon sample obtained by driving with a 1/2 weight hammer. SPT N values has been adjusted to the inferred value that would be obtained using a standard weight hammer.												

PROJECT		13-1191-0003				RECORD OF BOREHOLE No UC3-5				1 OF 1		METRIC	
G.W.P.		5198-10-00		LOCATION		N 5046959.2 ; E 400540.2				ORIGINATED BY		GM	
DIST		HWY 60		BOREHOLE TYPE		Portable Equipment				COMPILED BY		AC	
DATUM		GEODETIC		DATE		July 15, 2013				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	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL	
409.6	GROUND SURFACE												
0.0	TOPSOIL		1	SS	3/0.2								
0.2	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)												
	Notes:												
	1. Borehole dry upon completion of drilling.												
	2. Split spoon sample obtained by driving with a 1/2 weight hammer. SPT N values has been adjusted to the inferred value that would be obtained using a standard weight hammer.												

SUD-MTO 002 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT <u>13-1191-0003</u>										RECORD OF BOREHOLE No UC3-6										1 OF 1 METRIC									
G.W.P. <u>5198-10-00</u>					LOCATION <u>N 5047054.3 ; E 400597.9</u>					ORIGINATED BY <u>GM</u>																			
DIST <u> </u> HWY <u>60</u>					BOREHOLE TYPE <u>N/A</u>					COMPILED BY <u>AC</u>																			
DATUM <u>GEODETIC</u>					DATE <u>July 15, 2013</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 (%)															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40	60	20	40	60						
411.6	GROUND SURFACE BEDROCK OUTCROP																												

PROJECT <u>13-1191-0003</u>										RECORD OF BOREHOLE No UC3-7										1 OF 1 METRIC									
G.W.P. <u>5198-10-00</u>					LOCATION <u>N 5046972.2 ; E 400660.4</u>					ORIGINATED BY <u>EHS</u>																			
DIST <u> </u> HWY <u>60</u>					BOREHOLE TYPE <u>Portable Equipment</u>					COMPILED BY <u>AC</u>																			
DATUM <u>GEODETIC</u>					DATE <u>February 7, 2014</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 (%)															
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40	60	20	40	60						
405.8	GROUND SURFACE																												
0.1	Sandy TOPSOIL Gravelly SAND, some silt Very loose to dense Brown Wet		1	SS	3																								
			2	SS	47																								
			3	SS	49																								
404.0	END OF BOREHOLE																												
1.8	Notes: 1. Borehole dry upon completion of drilling. 2. Split spoon samples obtained by driving with a 1/2 weight hammer. SPT N values have been adjusted to the inferred values that would be obtained using a standard weight hammer. 3. Advanced DCPT 1 m west, refusal at 1.2 m.																												

SUD-MTO 002 13-1191-0003.GPJ GAL-MISS.GDT 28/03/14 DATA INPUT:

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC3-8				1 OF 1 METRIC							
G.W.P. 5198-10-00		LOCATION N 5046991.2; E 400603.2		ORIGINATED BY EHS									
DIST _____ HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC									
DATUM GEODETIC		DATE October 19, 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
407.6	GROUND SURFACE						20 40 60 80 100						
0.0	Topsoil (FILL)		1	SS	11								
	Sand and gravel (FILL)		2	SS	50/0.1								
406.6	Compact Brown Moist												
	Boulder (FILL)		-	RC	REC 100%								
406.2													
1.4	SAND and GRAVEL, trace to some silt Compact to dense Brown to grey Wet		3	SS	43								
			4	SS	26								
404.3			5	SS	20/0.1								
3.3	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING) Note: 1. Water level at a depth of 1.1 m below ground surface (Elev. 406.5) upon completion of drilling.												

SUD-MTO-001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14, DATA INPUT:

PROJECT 13-1191-0003			RECORD OF BOREHOLE No UC3-9			1 OF 1 METRIC		
G.W.P. 5198-10-00			LOCATION N 5047003.2, E 400596.4			ORIGINATED BY EHS		
DIST HWY 60			BOREHOLE TYPE NW Casing, NQ Coring			COMPILED BY AC		
DATUM GEODETIC			DATE October 18, 2013			CHECKED BY AB		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
406.0	GROUND SURFACE							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L WATER CONTENT (%) 20 40 60
405.7	Sand, wood, organics (FILL)							
0.3	SAND and GRAVEL, some silt Compact to dense Grey Wet		1	SS	25		405	
			2	SS	32		404	
			3	SS	50		403	○
402.8			4	SS	22/0.2		403	
3.2	GNEISS (BEDROCK) Bedrock cored from 3.2 m depth to 6.4 m depth. For coring details see Record of Drillhole UC3-9.		1	RC	REC 100%		402	
			2	RC	REC 100%		401	
			3	RC	REC 100%		400	
399.6								
6.4	END OF BOREHOLE Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 405.5 m) upon completion of drilling.							
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL 36 46 17 1 RQD = 92% RQD = 83% RQD = 96%								

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC3-9

SHEET 1 OF 1

LOCATION: N 5047003.2; E 400596.4

DRILLING DATE: October 18, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diametral Point Load		RMC Q1 AVG	NOTES WATER LEVELS INSTRUMENTATION	
	FLUSH	TOTAL CORE %						SOLID CORE %	B Angle			DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Js	Jn	10 k, cm/s	10 k, cm/s	10 k, cm/s	10 k, cm/s	N			Q1
		REFER TO PREVIOUS PAGE		402.8 3.2	1	GREY 100%						JNFORo JNFORo												
4	NW October 18, 2013 NQ Coring	GNEISS Grey Fine to coarse grained Fresh			2	GREY 100%						JNFORo JNIRRo JNFORo JNFORo JNFORo JNFORo												
5													JNFORo JNFORo JNFORo JNFORo JNFORo											
6					3	GREY 100%							JNFORo JNFORo JNFORo JNFORo JNFORo											
		END OF DRILLHOLE		399.6 6.4																				
7																								
8																								
9																								
10																								
11																								
12																								
13																								

SUD-RCK 13-1191-0003.GPJ GAL-MISS.GDT 28/03/14 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC3-10				1 OF 1 METRIC	
G.W.P. 5198-10-00		LOCATION N 5047018.5; E 400635.8				ORIGINATED BY EHS	
DIST HWY 60		BOREHOLE TYPE NW Casing, NO Coring				COMPILED BY AC	
DATUM GEODETIC		DATE October 23, 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									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED				WATER CONTENT (%)							
						20 40 60 80 100 20 40 60 80 100				20	40	60	KN/m ³	GR SA SI CL			
406.2	GROUND SURFACE																
0.0	SAND and GRAVEL, some silt, trace organics Compact to dense Brown Moist Cobble at 0.6 m depth.		1	SS	11	▽	406										
			-	RC	REC 100%												
			2	SS	56		405										40 42 16 2
			3	SS	55		404										
403.8	GNEISS (BEDROCK)																
2.4	Bedrock cored from 2.4 m depth to 5.4 m depth. For coring details see Record of Drillhole UC3-10.		1	RC	REC 100%		403									RQD = 93%	
			2	RC	REC 53%		402									RQD = 25%	
			3	RC	REC 92%		401									RQD = 63%	
400.8	END OF BOREHOLE																
5.4	Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 405.7 m) upon completion of drilling.																

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC3-10

SHEET 1 OF 1

LOCATION: N 5047018.5; E 400635.8

DRILLING DATE: October 23, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY			Diameter Point Load Index (MPa)	RMC Q AVG.	NOTES WATER LEVELS INSTRUMENTATION
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	1 m	1 m	1 m							
		REFER TO PREVIOUS PAGE		403.8																							
	NW	GNEISS Grey Fine to coarse grained Slightly weathered		2.4	1	GREY 100%																					
3		Sand seams from 3.1 m depth to 3.8 m depth.			2	BROWN 100%																					
4	October 23, 2013 NQ Coring				3	BROWN 80%																					
5				400.8																							
		END OF DRILLHOLE		5.4																							
6																											
7																											
8																											
9																											
10																											
11																											
12																											

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

SUD-RCK 13-1191-0003.GPJ GAL-MISS.GDT 28/03/14 DATA INPUT:

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC3-11				1 OF 1 METRIC			
G.W.P. 5198-10-00		LOCATION N 5047004.2; E 400642.9				ORIGINATED BY EHS			
DIST _____ HWY 60		BOREHOLE TYPE Excavation by hand shovel and NW Casing, NQ Coring				COMPILED BY AC			
DATUM GEODETIC		DATE October 29, 2013, February 5 and 6, 2014				CHECKED BY AB			
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE		
406.2	GROUND SURFACE								
0.0	SAND, GRAVEL, COBBLES and BOULDERS Brown Moist								
404.9	GNEISS (BEDROCK)		1	RC	REC 100%				RQD = 100%
1.3	Bedrock cored from 1.3 m depth to 4.3 m depth. For coring details see Record of Drillhole UC3-11.		2	RC	REC 100%				RQD = 100%
			3	RC	REC 100%				RQD = 100%
401.9	END OF BOREHOLE								
4.3	Note: 1. On October 29, 2013, excavated using hand shovel to depth of 0.2 m and advanced DCPT 1.5 m east of hand excavation, refusal at 1.1 m. 3. On February 5 and 6, returned to site to core bedrock. 4. Water level at a depth of 0.4 m below ground surface (Elev. 405.8 m) upon completion of drilling.								

SJD-MTO 001 13-1191-0003 GFL GAL/MISS GDT 18/06/14 DATA INPUT:

PROJECT		13-1191-0003		RECORD OF BOREHOLE No UC3-12		1 OF 1 METRIC									
G.W.P.		5198-10-00		LOCATION		N 5047013.3; E 400617.2									
DIST		HWY 60		BOREHOLE TYPE		NW Casing, NQ Coring									
DATUM		GEODETTIC		DATE		October 15, 2013									
						ORIGINATED BY GM									
						COMPILED BY AC									
						CHECKED BY AB									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	WATER CONTENT (%) W _p — W — 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										
411.8	GROUND SURFACE														
0.0	ASPHALT (100 mm)														
0.1	Sand to sand and gravel (FILL) Compact to dense Brown Moist		1	SS	31		411								
			2	SS	23										
410.4	Blast rock (FILL)						410								
1.4			-	RC	REC 38%		409								
			-	RC	REC 50%		408								
			-	RC	REC 58%		407								
406.6	Sand and gravel (FILL) Dense Brown Wet						406								
5.2			3a	SS	51		405							22 57 19 2	
405.4	Gravelly SAND, COBBLES and BOULDERS Grey Wet						405								
6.4	Depth (m) Size (mm) 6.6 360 7.0 390						404								
404.1	GNEISS (BEDROCK)		1	RC	REC 100%		403							RQD = 85%	
7.7	Bedrock cored from 7.7 m depth to 10.7 m depth. For coring details see Record of Drillhole UC3-12.		2	RC	REC 100%		402							RQD = 69%	
			3	RC	REC 100%									RQD = 84%	
401.1	END OF BOREHOLE														
10.7	Note: 1. Water level at a depth of 6.0 m below ground surface (Elev. 405.8m) upon completion of drilling.														

SUD-MTO 001 13-1191-0003.GPJ CAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC3-12

SHEET 1 OF 1

LOCATION: N 5047013.3; E 400617.2

DRILLING DATE: October 15, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: --

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % 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 symbols										BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
								FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY k, cm/s		Diameter Point Load Index (MPa)	RMC Q _i AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
									TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 ⁰	10 ⁻¹	10 ⁻²	10 ⁻³	2	4	10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
																								B Angle			DIPW1 CORE AXIS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

DEPTH SCALE

1 : 50



LOGGED: GM

CHECKED: AB

SUD-RCK 13-1191-0003 GPJ GAL-MISS.GDT 28/03/14 DATA INPUT:

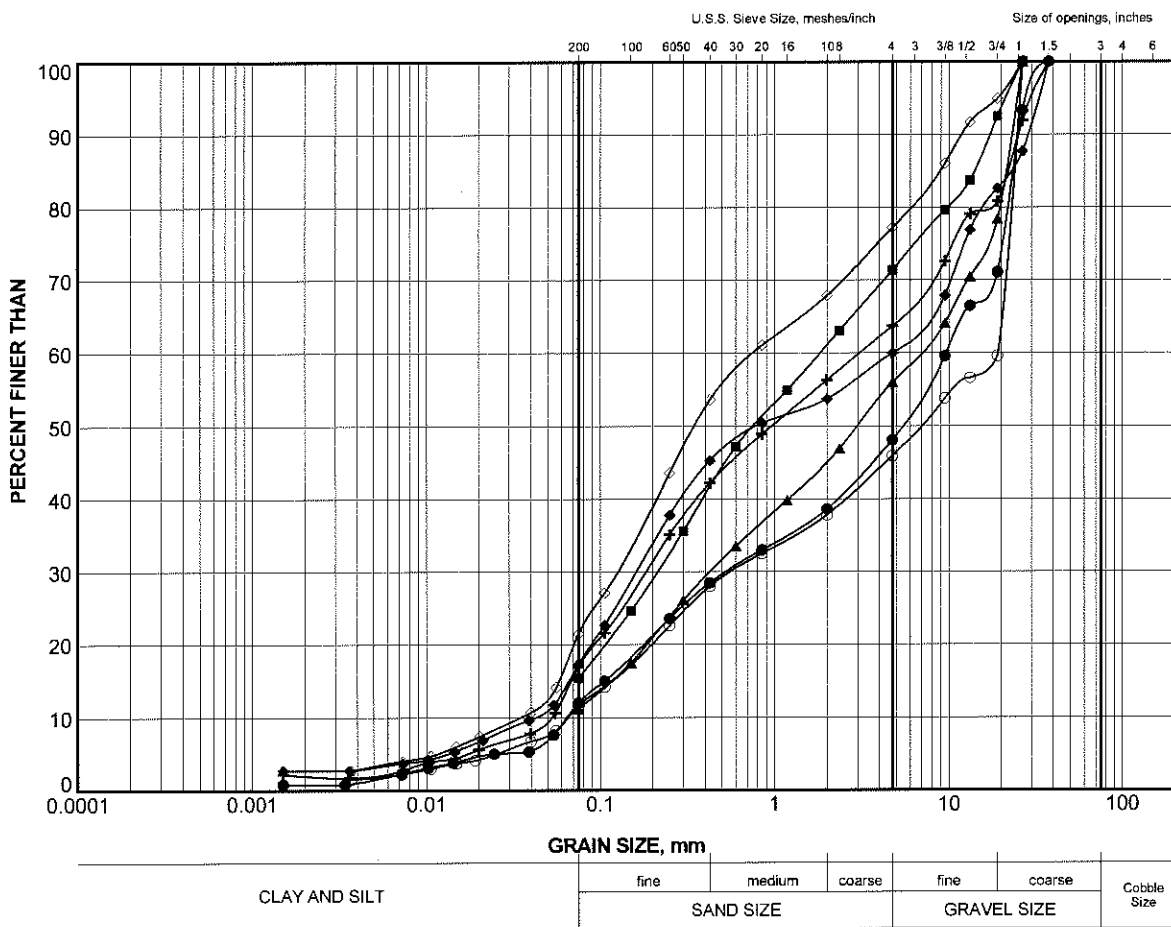
RECORD OF BOREHOLE No UC3-13

1 OF 1 **METRIC**

PROJECT 13-1191-0003 LOCATION N 5046999.9; E 400625.8 ORIGINATED BY GM
 G.W.P. 5198-10-00 DIST HWY 60 BOREHOLE TYPE NW Casing, NQ Coring COMPILED BY AC
 DATUM GEODETIC DATE October 15 and 16, 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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
411.6	GROUND SURFACE														
0.1	ASPHALT (100 mm)														
410.8	Sand and gravel (FILL)		1	SS	37										
0.8	Dense Brown Moist Blast rock (FILL)		-	RC	REC 50%										
			2	SS	38										
			-	RC	REC 63%										
			-	RC	REC 33%										
			-	RC	REC 37%										
405.5															
6.1	SAND and GRAVEL, some silt Very dense Brown Wet		3	SS	58										54 35 11 0
404.7			4	SS	21/0.1										
6.9	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)														
	Note: 1. Water level at a depth of 5.3 m below ground surface (Elev. 406.3 m) upon completion of drilling.														

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 28/03/14 DATA INPUT:



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC3-3	2	404.4
■	UC3-7	3	404.3
▲	UC3-8	4	405.0
+	UC3-9	3	403.4
◆	UC3-10	2	404.9
◇	UC3-12	3b	405.4
○	UC3-13	3	405.2

PROJECT

HIGHWAY 60
UNKNOWN CREEK CULVERT, SITE 43-232/C

TITLE

GRAIN SIZE DISTRIBUTION
GRAVELLY SAND to SAND and GRAVEL



Golder Associates
SUDBURY, ONTARIO

PROJECT No.	13-1191-0003	FILE No.	13-1191-0003.GPJ
DRAWN	TB	Mar 2014	SCALE N/A
CHECK	AB	Mar 2014	REV.
APPR		Mar 2014	

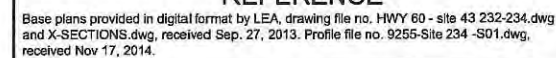
FIGURE A2



FOUNDATION REPORT - HIGHWAY 60 CULVERT REPLACEMENTS UNKNOWN CREEK CULVERTS, GWP 5198-10-00

APPENDIX B

Unknown Creek Culvert, Site 43-234/C (Airy Township)



NO.			REVISION		
Geocres No. 31E-338					
HWY. 60			PROJECT NO. 13-1191-0003		DIST.
SUBM'D. AC		CHKD.	DATE: DEC 2014		SITE: 43-234/C
DRAWN: TB		CHKD. AB	APPD. JMAC		DWG. B1



PHOTOGRAPHS

Photograph 1: Unknown Creek Culvert, Site 43-234/C – Looking West at North end of Culvert
(September 2013)



Photograph 2: Unknown Creek Culvert, Site 43-234/C – Looking East at South end of Culvert
(September 2013)





PHOTOGRAPHS

Photograph 3: Unknown Creek Culvert, Site 43-234/C – Looking North (June 2013)



Photograph 4: Unknown Creek Culvert, Site 43-234/C – Looking South (September 2013)



PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC2-1				1 OF 1 METRIC												
G.W.P. 5198-10-00		LOCATION N 5047286.3; E 400454.2		ORIGINATED BY SA														
DIST _____ HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC														
DATUM GEODETIC		DATE June 25, 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	20	40						60	80	100	20
412.4	GROUND SURFACE																	
0.0	Sandy PEAT		1	SS	16													
411.8	Compact Brown Moist																	
0.6	GRAVEL and COBBLES		2	SS														
	Depth (m) Thickness (mm)		3	RC	REC 63%													
	0.8 150																	
	1.0 90		4	SS	50/0.2													
	1.2 50																	
	1.3 50		5	RC	REC 83%													
410.3	1.4 60																	
2.1	1.5 50																	
	1.7 250																	
	1.95 125																	
	GNEISS (BEDROCK)		1	RC	REC 100%													
	Bedrock cored from 2.1 m to 5.5 m depth.																	
	For coring details see Record of Drillhole UC2-1.		2	RC	REC 100%													
			3	RC	REC 100%													
406.9	END OF BOREHOLE																	
5.5	Note: 1. Water level not recorded after completion of drilling. 2. Advanced DCPT 1 m east, refusal at 1.0 m depth.																	

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

DATUM: GEODETIC

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore

[illegible]

PROJECT		13-1191-0003		RECORD OF BOREHOLE No UC2-2		1 OF 1 METRIC										
G.W.P.		5198-10-00		LOCATION		N 5047289.0; E 400434.6										
DIST		HWY 60		BOREHOLE TYPE		NW Casing, NQ Coring										
DATUM		GEODETIC		DATE		June 26, 2013										
				ORIGINATED BY		GM										
				COMPILED BY		AC										
				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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES						20	40	60	80
413.4	GROUND SURFACE															
0.9	ASPHALT (100 mm) Gravelly sand, trace to some silt (FILL) Loose to very dense Brown Moist to wet		1	SS	81											25 64 (11)
			2	SS	26											
			3	SS	10											
			4	SS	7											
			5	SS	22											
409.7	GRAVEL, COBBLES encountered as follows: Depth (m) Thickness (mm) 3.7 300 4.0 150 4.2 to 5.7 25 to 50		-	RC	REC 67%											
			-	RC	REC 39%											
			-	RC	REC 26%											
407.7	GNEISS (BEDROCK) Bedrock cored from 5.7 m to 8.8 m depth. For coring details see Record of Drillhole UC2-2.		1	RC	REC 100%											RQD = 100%
			2	RC	REC 100%											RQD = 81%
			3	RC	REC 100%											RQD = 47%
404.6	END OF BOREHOLE Note: 1. Water level at a depth of 1.7 m below ground surface (Elev. 411.7 m) upon completion of drilling. 2. Advanced DCPT 1 m east, refusal at 1.6 m depth.															

SUD-MTC 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

SHEET 1 OF 1

DATUM: GEODETIC

DRILLING CONTRACTOR: Landcore

CHECKED: AB

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC2-3				1 OF 1 METRIC																				
G.W.P. 5198-10-00		LOCATION N 5047272.5; E 400430.2				ORIGINATED BY SA																				
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring				COMPILED BY AC																				
DATUM GEODETIC		DATE June 26, 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES						SHEAR STRENGTH kPa		WATER CONTENT (%)											
411.5	GROUND SURFACE																									
0.0	PEAT (Fibrous), some sand		1	SS	52/0.2																					
0.2	Black Moist SAND, GRAVEL, COBBLES		2	RC	REC 26%																					
	<table border="1" style="margin-left: 20px; border-collapse: collapse;"> <thead> <tr> <th>Depth (m)</th> <th>Thickness (mm)</th> </tr> </thead> <tbody> <tr><td>0.2</td><td>300</td></tr> <tr><td>0.5</td><td>150</td></tr> <tr><td>0.7</td><td>200</td></tr> <tr><td>0.9</td><td>100</td></tr> <tr><td>1.0 to 2.2</td><td>50 to 75</td></tr> <tr><td>2.2</td><td>225</td></tr> </tbody> </table>	Depth (m)	Thickness (mm)	0.2	300	0.5	150	0.7	200	0.9	100	1.0 to 2.2	50 to 75	2.2	225											
Depth (m)	Thickness (mm)																									
0.2	300																									
0.5	150																									
0.7	200																									
0.9	100																									
1.0 to 2.2	50 to 75																									
2.2	225																									
409.1	GNEISS (BEDROCK)		3	SS																						
2.4	Bedrock cored from 2.4 m to 5.9 m depth. For coring details see Record of Drillhole UC2-3.		1	RC	REC 100%							RQD = 42%														
			2	RC	REC 100%							RQD = 90%														
			3	RC	REC 100%							RQD = 82%														
405.6	END OF BOREHOLE																									
5.9	Note: 1. Water level at a depth of 1.1 m below ground surface (Elev. 410.4 m) upon completion of drilling. 2. Advanced DCPT 1 m east, refusal at 0.2 m depth.																									

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 08/04/14 DATA INPUT:



PROJECT 13-1191-0003			RECORD OF BOREHOLE No UC2-6			1 OF 1 METRIC											
G.W.P. 5198-10-00			LOCATION N 5047279.8; E 400419.9			ORIGINATED BY CW											
DIST HWY 60			BOREHOLE TYPE NW Casing, Wash Boring			COMPILED BY AC											
DATUM GEODETIC			DATE September 12, 2013			CHECKED BY AB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			
411.0 0.0	WATER SURFACE WATER																
410.2 0.8	Gravelly SAND, some silt Compact Brown Wet		1	SS	17		410									20 59 (21)	
409.4 1.6	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)		2	SS	65/0.1												

SUD-MTD 001 13-1191-0003 GPJ GAL-MISS.GDT 09/04/14 DATA INPUT

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC2-7				1 OF 1 METRIC									
G.W.P. 5198-10-00		LOCATION N 5047269.3; E 400426.3		ORIGINATED BY CW											
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC											
DATUM GEODETIC		DATE September 12, 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
411.0	WATER SURFACE														
0.0	WATER														
410.5															
0.6	PEAT (Fibrous) Black Wet		1	SS	11										
409.9															
1.1	SAND and GRAVEL and COBBLES Compact Brown Wet		1	RC	REC 100%										RQD = 58%
	GNEISS (BEDROCK)														
	Bedrock cored from 1.1 m to 3.4 m depth.														
	For coring details see Record of Drillhole UC2-7.		2	RC	REC 100%										RQD = 75%
407.6															
3.4	END OF BOREHOLE														
	Note: 1. Flush water and sediment observed in creek and stopped coring advancement at 3.4 m below water surface.														

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC2-7

SHEET 1 OF 1

LOCATION: N 5047269.3 ;E 400426.3

DRILLING DATE: September 12, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	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	
						FLUSH % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	B Angle DIP w/ CORE AXIS	DISCONTINUITY DATA	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diameter Point Load Index (MPa)	Q AVG		
							TOTAL CORE %	SOLID CORE %													
		REFER TO PREVIOUS PAGE		409.9																	
	NW September 12, 2013 NO Coring	GNEISS Grey Fine to medium grained Slightly weathered		1.1	1	GREY															
2																					
3					2	GREY															
		END OF DRILLHOLE		407.6																	
3.4																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					

DEPTH SCALE

1 : 50



LOGGED: CW

CHECKED: AB

SUD-RCK 13-1191-0003 GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC2-8		1 OF 1 METRIC														
G.W.P. 5198-10-00		LOCATION N 5047333.5; E 400422.3		ORIGINATED BY EHS														
DIST _____ HWY 60		BOREHOLE TYPE NW Casing, Wash Boring		COMPILED BY AC														
DATUM GEODETIC		DATE October 22, 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			20	40						60	80	100	20
411.8 0.0	WATER SURFACE WATER																	
410.9 0.9	Gravelly sand mixed with peat (FILL) Loose to very loose Brown Wet		1	SS	6													
409.7 2.1	PEAT (Amorphous) Very soft Black Wet		2	SS	2													
408.8 3.0	PEAT (Fibrous) Very soft Black Wet		3	SS	1													
			4	SS	WH													
			5	SS	WR													
			6	SS	1													
406.1 5.7	SAND and GRAVEL, trace silt Compact Grey Wet		7a	SS	WH													
			7b															
			8	SS	10													
405.0 6.8	END OF BOREHOLE REFUSAL TO FURTHER CASING ADVANCEMENT																	

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003										RECORD OF BOREHOLE No UC2-9										1 OF 1		METRIC	
G.W.P. 5198-10-00					LOCATION N 5047247.4 ; E 400473.2					ORIGINATED BY GM													
DIST HWY 60					BOREHOLE TYPE Portable Equipment					COMPILED BY AC													
DATUM GEODETIC					DATE July 15, 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED															
414.4	GROUND SURFACE																						
0.0	SAND and GRAVEL, trace organics		1	SS	13/0.2																		
414.0	Compact Brown Moist																						
0.4	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)																						
Notes: 1. Borehole dry upon completion of drilling. 2. Split spoon sample obtained by driving with a half weight hammer. SPT 'N' value has been adjusted to the inferred values that would be obtained using a standard weight hammer. 3. Bedrock outcrop approximately 5 m east of borehole.																							

PROJECT 13-1191-0003										RECORD OF BOREHOLE No UC2-10										1 OF 1		METRIC	
G.W.P. 5198-10-00					LOCATION N 5047322.8 ; E 400405.6					ORIGINATED BY GM													
DIST HWY 60					BOREHOLE TYPE Portable Equipment					COMPILED BY AC													
DATUM GEODETIC					DATE July 15, 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED															
412.9	GROUND SURFACE																						
0.0	SAND and GRAVEL, trace organics		1	SS	9/0.2																		
412.8	Brown Moist																						
0.3	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)																						
Notes: 1. Borehole dry upon completion of drilling. 2. Split spoon sample obtained by driving with a half weight hammer. SPT 'N' value has been adjusted to the inferred values that would be obtained using a standard weight hammer. 3. Bedrock outcrop approximately 5 m west of borehole.																							

SUD-MTO 002 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:



CSUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

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

PROJECT		RECORD OF BOREHOLE				No UC2-12		1 OF 1		METRIC						
G.W.P. 5198-10-00		LOCATION				N 5047279.9; E 400446.1		ORIGINATED BY GM								
DIST		HWY 60		BOREHOLE TYPE		NW Casing, NQ Coring		COMPILED BY AC								
DATUM GEODETIC		DATE		October 10, 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			20	40	60						80
413.6	GROUND SURFACE															
0.0	ASPHALT (150 mm)															
0.2	Sand to sand and gravel (FILL) Compact to dense Brown Moist		1	SS	31											
412.2			2	SS	13											
1.4	Silty SAND, trace organics (wood fragments), some gravel Compact Brown		3	SS	10											
411.5			-	RC	REC 50%											
2.1	Wet SAND, GRAVEL and COBBLES Very dense Brown Wet		4	SS	90											49 39 12 0
			-	RC	REC 50%											
410.3			5	SS	50/0.2											
3.3	GNEISS (BEDROCK)															
	Bedrock cored from 3.3 m to 6.9 m depth. For coring details see Record of Borehole UC2-12.		1	RC	REC 98%											RQD = 65%
			2	RC	REC 96%											RQD = 92%
			3	RC	REC 100%											RQD = 100%
408.7																
6.9	END OF BOREHOLE															
	Note: 1. Water level at a depth of 1.5 m below ground surface (Elev. 412.1 m) upon completion of drilling.															

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC2-12

SHEET 1 OF 1

LOCATION: N 5047279.9 ; E 400446.1

DRILLING DATE: October 10, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.																NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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SUD-RCK 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

DEPTH SCALE

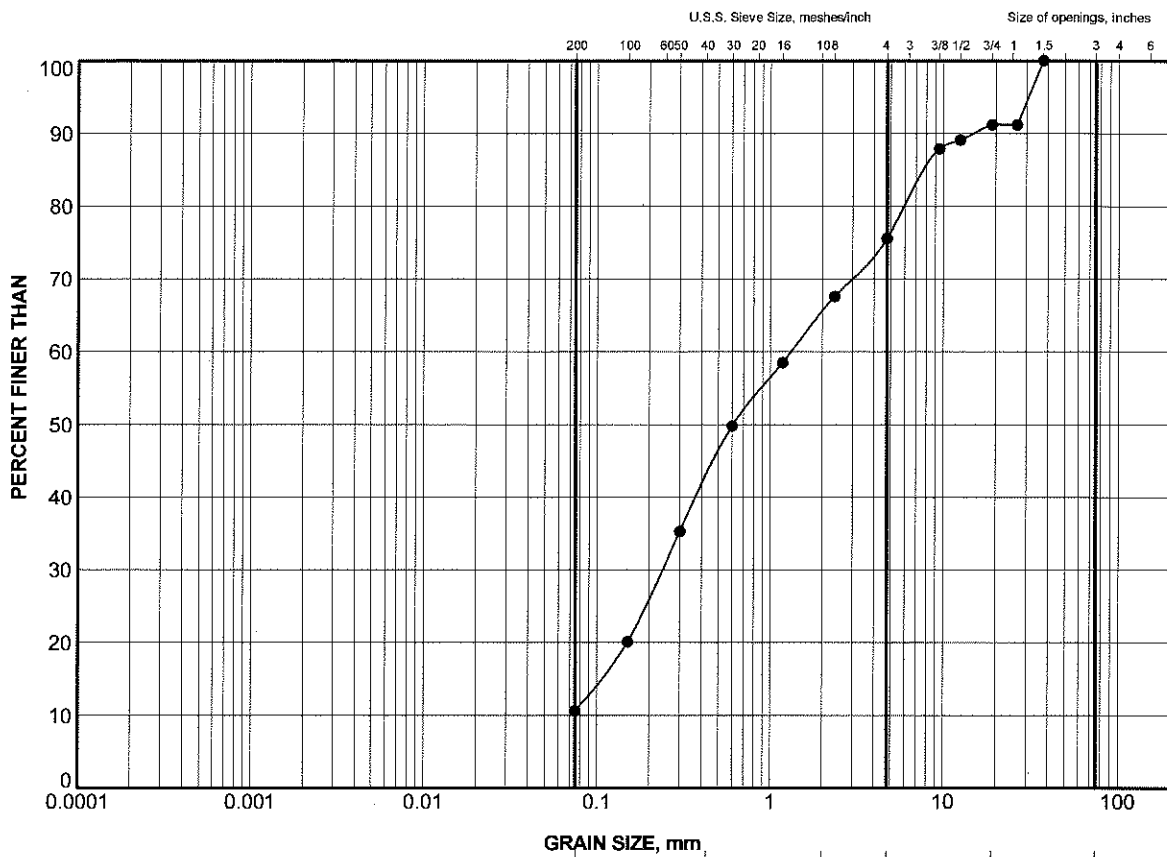
1 : 50



LOGGED: GM

CHECKED: AB


PROJECT		RECORD OF BOREHOLE				No UC2-13		1 OF 1		METRIC				
G.W.P. 5198-10-00		LOCATION		N 5047293.4; E 400437.5				ORIGINATED BY GM						
DIST		HWY 60		BOREHOLE TYPE		NW Casing, NQ Coring				COMPILED BY AC				
DATUM GEODETIC		DATE		October 10, 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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
413.5	GROUND SURFACE													
0.0	ASPHALT (150 mm)													
0.2	Gravelly sand to sand and gravel (FILL) Compact to dense Brown Moist to wet		1	SS	34	413								
			2	SS	21									
			3	SS	12									
411.3														
2.2	SAND and GRAVEL Compact Grey Wet		4	SS	12	411								
410.5														
410.1	GNEISS (BEDROCK)		-	RC	REC 100%									RQD = 100%
3.4	END OF BOREHOLE													
	Note: 1. Water level at a depth of 1.8 m below ground surface (Elev. 411.7 m) upon completion of drilling.													



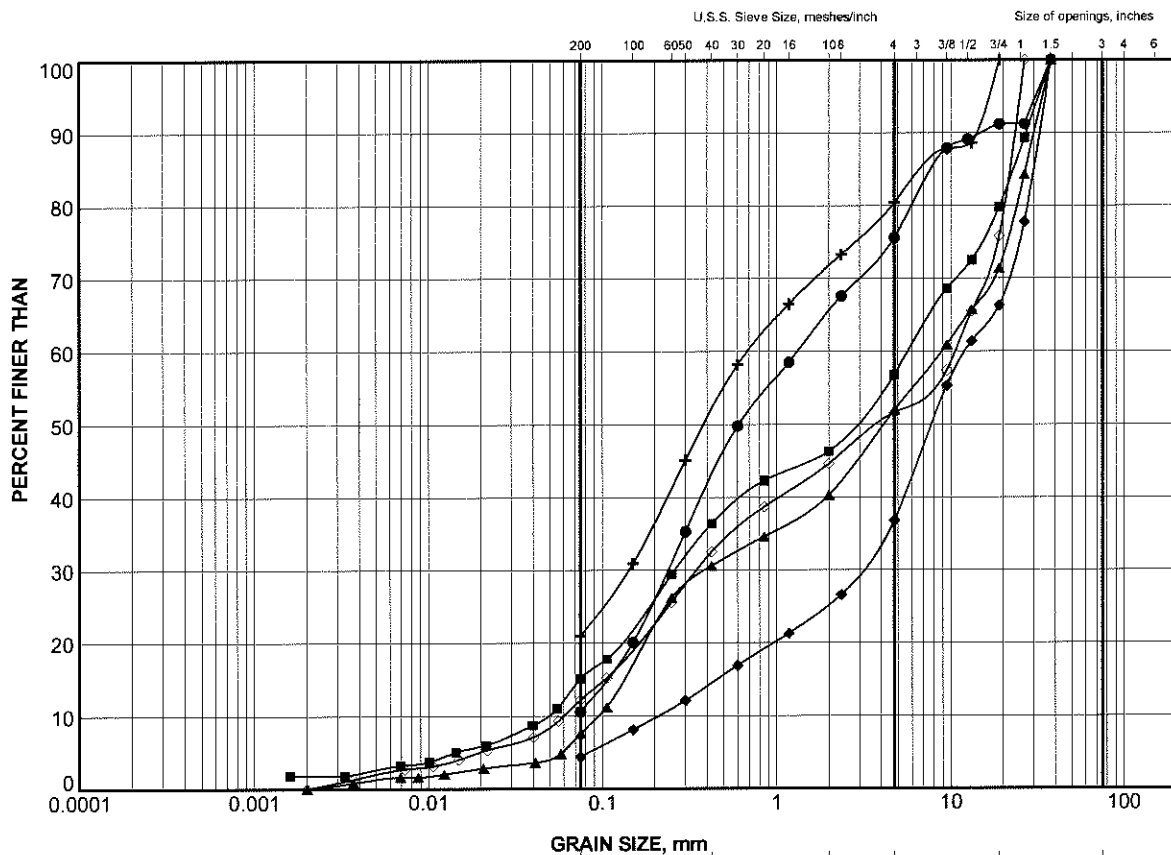
CLAY AND SILT	SAND SIZE, mm.			GRAVEL SIZE, mm.		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC2-2	1	413.1

PROJECT						HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-234/C					
TITLE						GRAIN SIZE DISTRIBUTION GRAVELLY SAND (FILL)					
		PROJECT No.		13-1191-0003		FILE No.		13-1191-0003.GPJ			
		DRAWN	TB	Mar 2014		SCALE	N/A	REV.			
		CHECK	AB	Mar 2014							
		APPR		Mar 2014							
FIGURE B1											


SUD-MTO GSD (NEW) GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC2-2	1	413.1
■	UC2-4	2	408.9
▲	UC2-5	2	408.9
+	UC2-6	1	409.9
◆	UC2-8	8	405.4
◇	UC2-12	4	411.1

PROJECT				
HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-234/C				
TITLE				
GRAIN SIZE DISTRIBUTION GRAVELLY SAND to SAND and GRAVEL				
PROJECT No.		13-1191-0003		FILE No.
DRAWN		TB	Apr 2014	SCALE
CHECK		AB	Apr 2014	N/A
APPR			Apr 2014	REV.
 Golder Associates SUDBURY, ONTARIO		FIGURE B2		

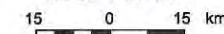
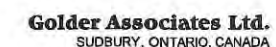




APPENDIX C

Unknown Creek Culvert, Site 43-236/C (Sproule Township)



SHEET



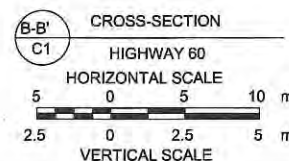
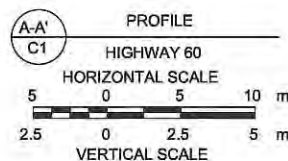
	Borehole
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
REC	Recovery (%)
100%	Rock Quality Designation (RQD)
R	Refusal
	WL upon completion of drilling

No.	ELEVATION	NORTHING	EASTING
UC1-1	394.7	5048533.1	388338.5
UC1-2	395.9	5048539.8	388326.8
UC1-3	395.1	5048547.9	388327.9
UC1-4	393.2	5048547.9	388318.1
UC1-5	394.7	5048552.2	388326.0
UC1-6	393.2	5048528.9	388340.6
UC1-7	393.2	5048537.1	388347.2
UC1-8	394.1	5048497.9	388288.8
UC1-9	394.2	5048524.7	388281.0
UC1-10	395.3	5048576.0	388369.2
UC1-11	393.5	5048553.4	388388.5
UC1-12	396.0	5048536.3	388328.8
UC1-13	395.9	5048541.4	388337.4

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 Contract 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.



Base plans provided in digital format by LEA, drawing file no. HWY 60 - site 43 232-236.dwg and X-SECTIONS.dwg, received Sep. 27, 2013. Profile file no. 9255-Site 236 -S01.dwg, received Nov 17, 2014.

NO.	DATE	BY	REVISION		
Geocres No. 31E-338					
HWY. 60		PROJECT NO. 13-1191-0003			DIST.
SUBMD. AC	CHKD.	DATE: DEC 2014		SITE: 43-236/C	
DRAWN: TB	CHKD. AB	APPD. JMAC		DWG. C1	



PHOTOGRAPHS

Photograph 1: Unknown Creek Culvert, Site 43-236/C – Looking East at South end of Culvert
(September 2013)



Photograph 2: Unknown Creek Culvert, Site 43-236/C – Looking West at North end of Culvert
(September 2013)





PHOTOGRAPHS

Photograph 3: Unknown Creek Culvert Site, 43-236/C – Looking North (June 2013)



Photograph 4: Unknown Creek Culvert Site, 43-236/C – Looking South (June 2013)



PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC1-1		1 OF 1 METRIC								
G.W.P. 5198-10-00		LOCATION N 5048533.1; E 388338.5		ORIGINATED BY SA								
DIST _____ HWY 60		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY AC								
DATUM GEODETIC		DATE June 13, 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					
394.7	GROUND SURFACE											
0.0	Sand and gravel to sand, some silt (FILL) Loose Brown Moist to wet		1	SS	6							
393.3			2	SS	5							
1.4	SAND to SILT and SAND, trace to some gravel, trace clay Very loose to very dense Brown to grey Wet		3	SS	2							
			4	SS	11							
			5	SS	32							
	Cobbles and/or boulders inferred from auger resistance between depths of 3.8 m to 4.6 m and 6.1 m to 7.0 m. Approximately 1.5 m of heave was encountered at 6.1 m depth.		6	SS	11							6 85 (9)
			7	SS	27							
			8	SS	104							1 41 55 3
386.6	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING) Note: 1. Water level at a depth of 1.0 m below ground surface (Elev. 393.7 m) upon completion of drilling. 2. Advanced DCPT 1 m west, refusal at 7.8 m depth.											

SUD-MTO-001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003				RECORD OF BOREHOLE No UC1-2				1 OF 1 METRIC				
G.W.P. 5198-10-00				LOCATION N 5048539.8; E 388326.8				ORIGINATED BY SA				
DIST HWY 60				BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NW Coring				COMPILED BY AC				
DATUM GEODETIC				DATE June 17, 2013				CHECKED BY AB				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W		
395.9	GROUND SURFACE											
0.0	ASPHALT (100 mm)		1	AS	-							
0.7	Sand, some gravel, some silt (FILL) Brown Moist		2	SS	50/0.1							
	Cobbles encountered between 0.7 m and 2.3 m depth, ranging from 75 mm to 125 mm.		3	RC	REC 24%							
393.6			4	SS	50/0.2							
2.3	SAND and GRAVEL, some silt Very dense Brown Wet		5	RC	REC 96%							
	Gravel, cobbles and boulders were encountered as follows:		6	SS	50/0.1							
	Depth (m) Thickness (mm)											
	2.4 1200											
	4.0 100											
	4.2 50											
	4.7 60											
	5.0 100											
	5.3 25											
	5.5 50											
	6.4 75											
			7	RC	REC 16%							
			8	SS	34							
			9	SS	50/0.1							
			10	SS	70							
	Silt and sand seam at 9.8 m depth.		11	RC	REC 33%							
385.5												
10.4	GNEISS (BEDROCK)		1	RC	REC 100%							
	Bedrock cored from 10.4 m to 13.4 m depth.											
	For coring details see Record of Drillhole UC1-2.		2	RC	REC 100%							
382.5												
13.4	END OF BOREHOLE											
	Note: 1. Water level at a depth of 1.8 m below ground surface (Elev. 394.1 m) upon completion of drilling.											

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC1-2

SHEET 1 OF 1

LOCATION: N 5048539.8 ; E 388326.8

DRILLING DATE: June 17, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		FRACT. INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diameter		NOTES WATER LEVELS INSTRUMENTATION				
	NW	June 17, 2013 NQ Coring						FLUSH	TOTAL CORE %		SOLID CORE %	R.Q.D. %	B Angle	DIP W/1 CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s	10 ⁻⁶		10 ⁻⁴	10 ⁻²	Point Load Index (MPa)	RMC -Q ² AVG.
11		REFER TO PREVIOUS PAGE		385.5																					
	NW		GNEISS Grey Fine grained Slightly weathered		10.4	1	GREY 50%							JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo JNIRRo											
12																									
						2	0%						JNIRRo BR												
13														JNIRRo JNIRRo JNIRRo											
			END OF DRILLHOLE		382.5																				
14					13.4																				
15																									
16																									
17																									
18																									
19																									
20																									

SUB-ROCK 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: SA

CHECKED: AB



PROJECT		13-1191-0003		RECORD OF BOREHOLE No UC1-3		1 OF 1 METRIC									
G.W.P.		5198-10-00		LOCATION		N 5048547.9; E 388327.9		ORIGINATED BY		SA					
DIST		HWY 60		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY		AC					
DATUM		GEODETIC		DATE		June 14, 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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
395.1	GROUND SURFACE														
0.0	Sand and gravel, some silt, trace organics (FILL)		1	SS	5										
394.5	Loose Brown Moist														
0.6	SAND to SILT and SAND, some gravel		2	SS	6										
	Loose to compact Brown Moist to wet														
			3	SS	24										
392.8	END OF BOREHOLE AUGER REFUSAL														
2.3	Note: 1. Auger refusal at 1.8 m depth; moved 1 m west and auger refusal at 2.3 m depth. Switched to NW casing and flush water and sediment observed in creek and stopped coring. Moved another 1 m west and auger refusal at 1.5 m; attempted coring and flush water/sediment again observed in creek and stopped coring. 2. Water level at a depth of 1.1 m below ground surface (Elev. 394.0 m) upon completion of drilling. 3. Advanced DCPT 1 m east, refusal at 1.7 m depth.														

SUDATO 001 13-1191-0003 GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC1-4		1 OF 1 METRIC									
G.W.P. 5198-10-00		LOCATION N 5048547.9; E 369318.1		ORIGINATED BY CW									
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC									
DATUM GEODETIC		DATE September 19, 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 Y 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					
393.2	WATER SURFACE												
0.0 392.9	WATER												
0.3	SAND and GRAVEL to Sandy GRAVEL, trace to some silt Loose to dense Brown to grey Wet		1	SS	5								
			2	SS	15								50 45 4 1
			3	SS	6								
			4	SS	9								
			5	SS	32								68 24 7 1
	Cobbles and boulders encountered below 4.0 m depth.		-	RC	REC 100%								
			-	RC	REC 56%								
			-	RC	REC 80%								
			-	RC	REC 41%								
385.8	END OF BOREHOLE												
7.4													

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC1-5		1 OF 1 METRIC						
G.W.P. 5198-10-00		LOCATION N 5048552.2, E 388326.0		ORIGINATED BY EHS						
DIST HWY 60		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring		COMPILED BY AC						
DATUM GEODETIC		DATE October 28, 2013		CHECKED BY AB						
SOIL PROFILE			SAMPLES		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						
394.7	GROUND SURFACE									
0.9	TOPSOIL		1	SS	8					
	SILT and SAND, trace organics Loose to dense Brown Moist to wet		2	SS	43					
393.3										
1.4	SAND and GRAVEL, some silt Dense to very dense Brown Wet		3	SS	34					50 30 19 1
	150 mm cobble encountered at 2.7 m depth.		4	SS	92					
			-	RC	REC 100%					
391.1										
3.6	GNEISS (BEDROCK)		1	RC	REC 100%					RQD = 42%
	Bedrock cored from 3.6 m to 6.9 m depth. For coring details see Record of Drillhole UC1-5.		2	RC	REC 100%					RQD = 65%
			3	RC	REC 100%					RQD = 72%
387.8										
6.9	END OF BOREHOLE									
	Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 393.8 m) upon completion of drilling.									

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC1-5

SHEET 1 OF 1

LOCATION: N 5048552.2 ; E 388326.0

DRILLING DATE: October 28, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY										DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)		RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
								TOTAL CORE %		SOLID CORE %		R.Q.D. %		FRACT. INDEX METRES		B Angle		DIP w.r.t. CORE AXIS		TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k. cm/s		10	10	10	10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
								JN - Joint		BD - Bedding		PL - Planar		PO - Polished		BR - Broken Rock		NOTE: For additional abbreviations refer to list of abbreviations & symbols.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
								FLT - Fault	SHR - Shear	VN - Vein	CJ - Conjugate	FO - Foliation	CO - Contact	OR - Orthogonal	CL - Cleavage	CU - Curved	UN - Undulating	ST - Stepped	IR - Irregular					K - Slickensided	SM - Smooth					Ro - Rough	MB - Mechanical Break																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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SUD-ROK 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

DEPTH SCALE

1: 50



LOGGED: EHS

CHECKED: AB



PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC1-6		1 OF 1 METRIC								
G.W.P. 5198-10-00		LOCATION N 5048528 9; E 388340.6		ORIGINATED BY CW								
DIST HWY 60		BOREHOLE TYPE NW Casing, Wash boring		COMPILED BY AC								
DATUM GEODETIC		DATE September 17, 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					
393.2	WATER SURFACE											
0.0	WATER											
392.6												
0.6	Sandy PEAT, trace gravel Very soft Brown Wet		1	SS	WH							
392.0												
1.2	SILT, trace to some sand Loose Grey Wet		2	SS	5							
			3	SS	8							
389.9												
3.3	SAND and GRAVEL, some silt Loose to compact Grey Wet		4	SS	8							
			5	SS	29							
388.1			6	SS	20/0.2							
5.1	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)											

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE


SUC-MTO 001 13-1191-0003.GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT <u>13-1191-0003</u>		RECORD OF BOREHOLE No UC1-7		1 OF 1 METRIC	
G.W.P. <u>5198-10-00</u>		LOCATION <u>N 5048537.1; E 388347.2</u>		ORIGINATED BY <u>CW</u>	
DIST <u>HWY 60</u>		BOREHOLE TYPE <u>NW Casing, NQ Coring, Wash boring</u>		COMPILED BY <u>AC</u>	
DATUM <u>GEODETIC</u>		DATE <u>September 16 and 17, 2013</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							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED							
393.2	WATER SURFACE						20 40 60 80 100		20 40 60							
0.0	WATER															
392.4																
0.8	PEAT (Amorphous), some sand Very soft Brown Wet		1	SS	WH											
391.8																
1.4	SILT and SAND, trace gravel, trace clay Very loose to compact Grey Wet		2	SS	3											
			3	SS	11											
390.1																
3.1	SAND and GRAVEL to gravelly SAND, some silt Compact to very dense Grey Wet Cobbles encountered from 4.5 m to 4.7 m depth.		4	SS	31											
			5	SS	37/0.2											
			-	RC	REC 100%											
			-	RC	REC 7%											
			6	SS	23											
			7	SS	27											
			8	SS	55											
384.4			9	SS	100/0.2											
8.8	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING)															

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

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

PROJECT 13-1191-0003			RECORD OF BOREHOLE No UC1-8			1 OF 1 METRIC								
G.W.P. 5198-10-00			LOCATION N 5048497.9; E 388288.8			ORIGINATED BY EHS								
DIST HWY 60			BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring			COMPILED BY AC								
DATUM GEODETIC			DATE October 29 and 30, 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									
394.1 0.0	GROUND SURFACE		1	SS	WH		394							
	PEAT (Fibrous) Very soft Black Wet		2	SS	2		393							
			3	SS	WH		392							
391.9 2.2	PEAT (Amorphous) Very soft Black Wet		4	SS	WH		391							
			5	SS	WH		390							
			6	SS	WH		389							
			7	SS	WH		388							
388.6 5.5	ORGANIC SILT, trace sand Very soft Grey Wet		8	SS	WH		387							
			9	SS	2		386							
385.4 8.7	SILT, trace to some sand Compact Grey Wet		10	SS	13		385							
			11	SS	24		384							
383.9 10.2	SAND and GRAVEL, some silt Compact Grey Wet		12	SS	23		383							
381.6 12.5	END OF BOREHOLE SPOON REFUSAL (HAMMER BOUNCING) Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 393.6 m) at beginning of day on October 30, 2013.					382								

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC1-9		1 OF 2 METRIC								
G.W.P. 5198-10-00		LOCATION N 5048524.7; E 388281.0		ORIGINATED BY EHS								
DIST HWY 60		BOREHOLE TYPE 108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY AC								
DATUM GEODETIC		DATE October 29, 2013		CHECKED BY AB								
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT WEIGHT REMARKS & GRAIN SIZE DISTRIBUTION			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL
394.2	GROUND SURFACE											
0.9	Topsoil (FILL) Sand, some gravel, trace to some silt (FILL) Compact Brown Moist to wet		1	SS	15		394					
			2	SS	24		393					
			3	SS	21		392					
			4	SS	20		391					
391.0	PEAT (Fibrous) Very soft Black Wet		5	SS	WH		390					
			6	SS	WH		389					
389.7	PEAT (Amorphous) Very soft Black Wet		7	SS	WH		388					
			8	SS	1		387					
387.0	CLAYEY ORGANIC SILT Very soft Brown Wet		9	SS	WH		386					
							385					
385.5	CLAYEY SILT, trace to some sand Firm Grey Wet		10	SS	WH		384					
							383					
			11	SS	3		382					
382.5	SILT, some clay Compact Grey Wet		12	SS	14		381					
380.9	SAND and GRAVEL, trace silt Very dense Grey Wet		13	SS	100							
380.2												
14.0												

SUD-MTO-001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

Continued Next Page

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



PROJECT		RECORD OF BOREHOLE				No UC1-9		2 OF 2		METRIC			
G.W.P.		LOCATION		N 5048524.7; E 388281.0		ORIGINATED BY		EHS					
DIST		HWY		60		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring		COMPILED BY			
AC										CHECKED BY			
AB													
DATUM		GEODETTIC		DATE		October 29, 2013							
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					
--- CONTINUED FROM PREVIOUS PAGE ---													
END OF BOREHOLE													
Note:													
1. Water level at a depth of 2.1 m below ground surface (Elev. 392.1 m) upon completion of drilling.													

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT <u>13-1191-0003</u>		RECORD OF BOREHOLE No UC1-10				1 OF 1 METRIC							
G.W.P. <u>5198-10-00</u>		LOCATION <u>N 5048576.0; E 388369.2</u>		ORIGINATED BY <u>EHS</u>									
DIST <u>HWY 60</u>		BOREHOLE TYPE <u>Excavation by hand shovel</u>		COMPILED BY <u>AC</u>									
DATUM <u>GEODETIC</u>		DATE <u>October 18, 2013</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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
395.3	GROUND SURFACE						20 40 60 80 100						
0.0	TOPSOIL		1	CS	-	395							
394.9	SAND and GRAVEL												
0.4	Brown Wet END OF BOREHOLE EXPOSED BEDROCK												
Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 395.1 m) upon completion.													

SUD-MTO 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003			RECORD OF BOREHOLE No UC1-11			1 OF 1 METRIC							
G.W.P. 5198-10-00			LOCATION N 5048553.4; E 388388.5			ORIGINATED BY EHS							
DIST HWY 60			BOREHOLE TYPE NW Casing, Wash Boring			COMPILED BY AC							
DATUM GEODETIC			DATE October 17, 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					
393.5	WATER SURFACE												
0.0	WATER												
0.2	PEAT (Fibrous) Very soft Black Wet		1	SS	WH								
			2	SS	WH								
			3	SS	WH								
391.2	Clayey ORGANIC SILT Very soft Brown to grey Wet		4	SS	WH								
			5	SS	WR								
389.7	ORGANIC SILT Very soft Grey Wet		6	SS	WR								
			7	SS	WH								
387.9	SILT, trace to some sand Loose Grey Wet		8	SS	5								
386.3	Silty SAND, some gravel, trace clay Compact Grey Wet		9	SS	13								
			10	SS	21								
383.1	END OF BOREHOLE												
10.4													

SUD-MTC 001 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003		RECORD OF BOREHOLE No UC1-12		1 OF 1 METRIC									
G.W.P. 5198-10-00		LOCATION N 5048536.3; E 388328.8		ORIGINATED BY GM									
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC									
DATUM GEODETIC		DATE October 9 and 10, 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	"N" VALUES	SHEAR STRENGTH kPa					
396.0	GROUND SURFACE												
0.0	ASPHALT (150 mm)												
0.2	Gravelly sand, some silt (FILL) Compact to very dense Brown Moist to wet		1	SS	50								
			2	SS	22								
			3	SS	14								
			4	SS	68								
392.9	A 200 mm cobble was encountered at 2.9 m depth.		-	RC	REC 100%								
3.1	A 325 mm boulder was encountered at 3.2 m depth.		-	RC	REC 100%								
	SAND and GRAVEL, some silt, some organics Loose to very dense Brown to grey Wet		6	SS	5								
	Silt seam at 3.8 m depth.		7	SS	8								
			8	SS	28								
			9	SS	85								
			10	SS	79/0.2								
			11	SS	60/0.1								
384.5	GNEISS (BEDROCK)		-	RC	REC 100%								
11.5													
383.9	END OF BOREHOLE												
12.1	Note: 1. Water level at a depth of 2.3 m below ground surface (Elev. 393.7 m) upon completion of drilling.												

SUD-MTO-001 13-1191-0003.GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003			RECORD OF BOREHOLE No UC1-13			1 OF 2 METRIC							
G.W.P. 5198-10-00			LOCATION N 5048541.4; E 389337.4			ORIGINATED BY GM							
DIST HWY 60			BOREHOLE TYPE NW Casing, NQ Coring			COMPILED BY AC							
DATUM GEODETIC			DATE October 8 and 9, 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
395.9	GROUND SURFACE												
0.0	ASPHALT (150 mm)												
0.2	Sand to sand and gravel, trace to some silt (FILL) Very loose to dense Brown Moist to wet		1	SS	34							4 86 (10)	
			2	SS	12								
			3	SS	10								
			4	SS	2								
392.9													
3.0	SAND and GRAVEL, some silt Compact to very dense Grey Wet Cobbles were encountered between 3.7 m and 4.6 m depth, ranging from 75 mm to 150 mm. Silt and sand seam at 4.9 m depths. Cobbles and boulders were encountered as follows: Depth (m) Thickness (mm) 7.0 350 7.3 90 7.4 190 7.5 75		5	SS	13								
			-	RC	REC 33%								
			6	SS	3							2 57 40 1	
			7	SS	47								
			8	SS	25/0.1								
			-	RC	REC 49%								
			9	SS	12/0.1								
			-	RC	REC 13%								
			10	SS	83							0 62 36 2	
			11	SS	76/0.2								
			12	SS	50/0.1								
382.9													
13.0	GNEISS (BEDROCK) Bedrock cored from 13.0 m to 16.1 m depth. For coring details see Record of Drillhole UC1-13.		1	RC	REC 100%							RQD = 56%	
			2	RC	REC 98%							RQD = 60%	

Continued Next Page

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

SUB-MTO 001 13-1191-0003.GPJ GAL-MISS GDT 09/04/14 DATA INPUT:

PROJECT 13-1191-0003				RECORD OF BOREHOLE No UC1-13				2 OF 2 METRIC					
G.W.P. 5198-10-00		LOCATION N 5048541.4; E 388337.4		ORIGINATED BY GM									
DIST HWY 60		BOREHOLE TYPE NW Casing, NQ Coring		COMPILED BY AC									
DATUM GEODETIC		DATE October 8 and 9, 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 Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100						
379.8		[Hatched Box]	2	RC	REC 98%								RQD = 60%
		[Hatched Box]	3	RC	REC 100%								RQD = 77%
16.1	END OF BOREHOLE Note: 1. Water level at a depth of 2.3 m below ground surface (Elev. 393.6 m) upon completion of drilling.												

SUD-MTO 001 13-1191-0003.GPJ CAL-MISS.GDT 09/04/14 DATA INPUT:

PROJECT: 13-1191-0003

RECORD OF DRILLHOLE: UC1-13

SHEET 1 OF 1

LOCATION: N 5048541.4 ; E 388337.4

DRILLING DATE: October 8 and 9, 2013

DATUM: GEODETIC

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameters		NOTES WATER LEVELS INSTRUMENTATION			
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jm	K _u cm/s	K _u cm/s		K _u cm/s	Point Load Index (MPa)	RMC -Q'- AVG
13	NW October 8 and 9, 2013 NQ Coring	REFER TO PREVIOUS PAGE		382.9																		
		GNEISS Grey Fine grained Slightly weathered		13.0	1	GREY 50%							JNIRRo									
14													JNIRRo									
15					2	GREY 50%							JNIRRo									
16		END OF DRILLHOLE		379.8	3	GREY 50%							JNIRRo									
17				16.1									BR									
18																						
19																						
20																						
21																						
22																						
23																						

DEPTH SCALE

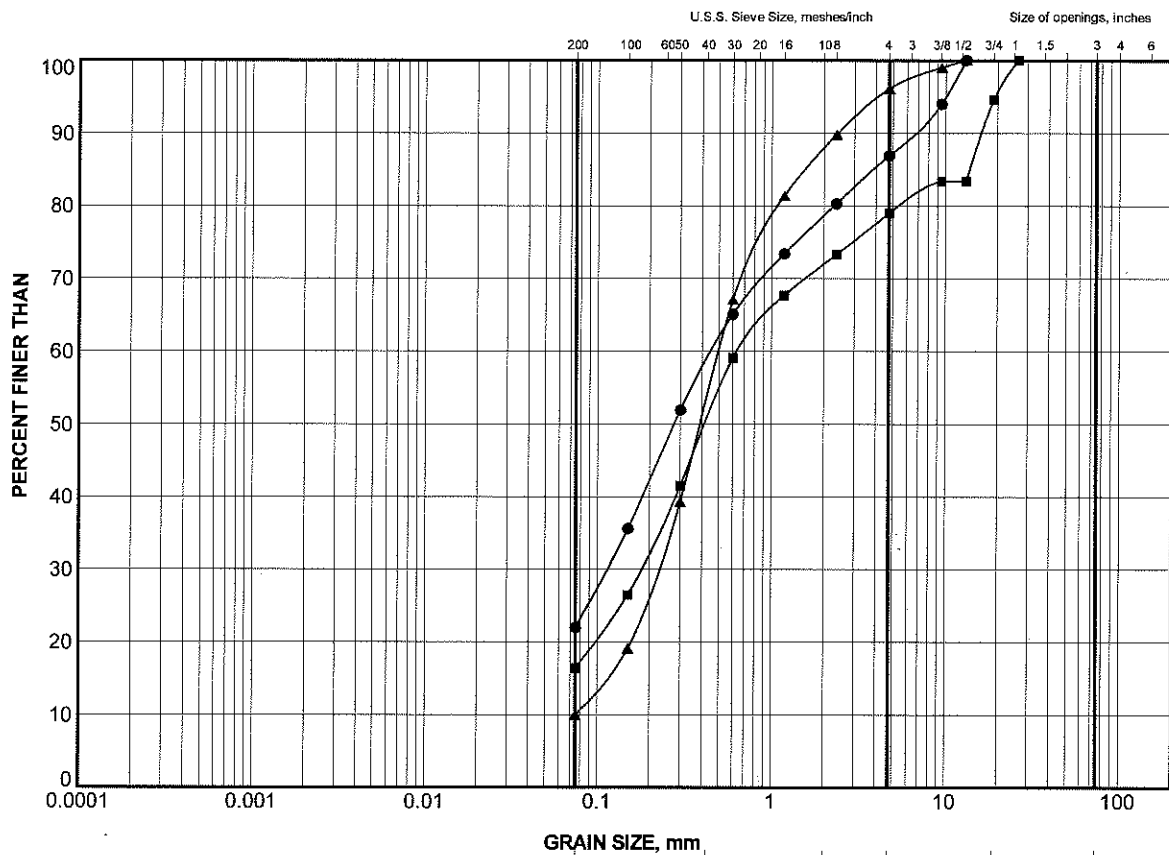
1 : 50



LOGGED: GM

CHECKED: AB

SUD-ROK 13-1191-0003.GPJ GAL-MISS.GDT 09/04/14 DATA INPUT:




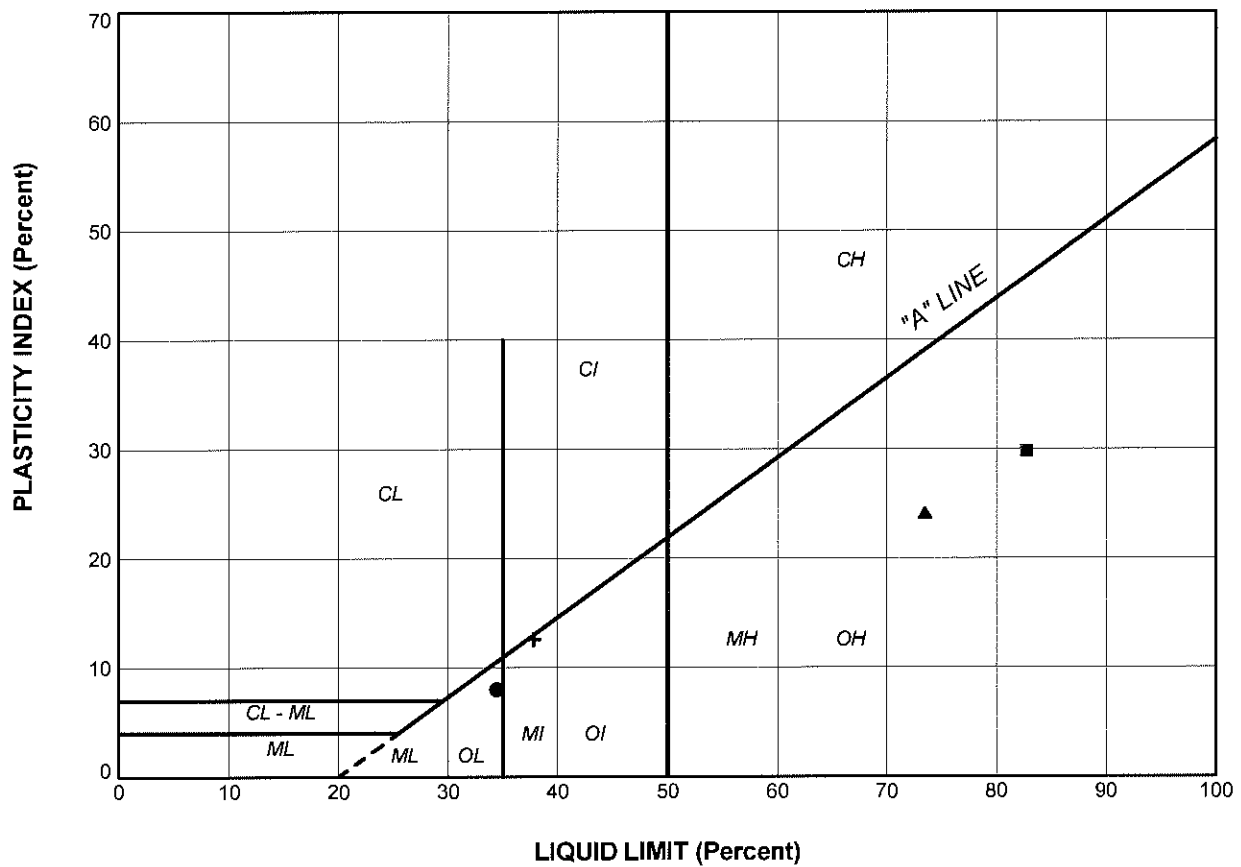
CLAY AND SILT	fine			medium	coarse	fine	coarse	Cobble Size
	SAND SIZE					GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC1-9	3	392.4
■	UC1-12	2	394.9
▲	UC1-13	2	394.8


SUD-MTO GSD (NEW) GLDR_LDN.GDT

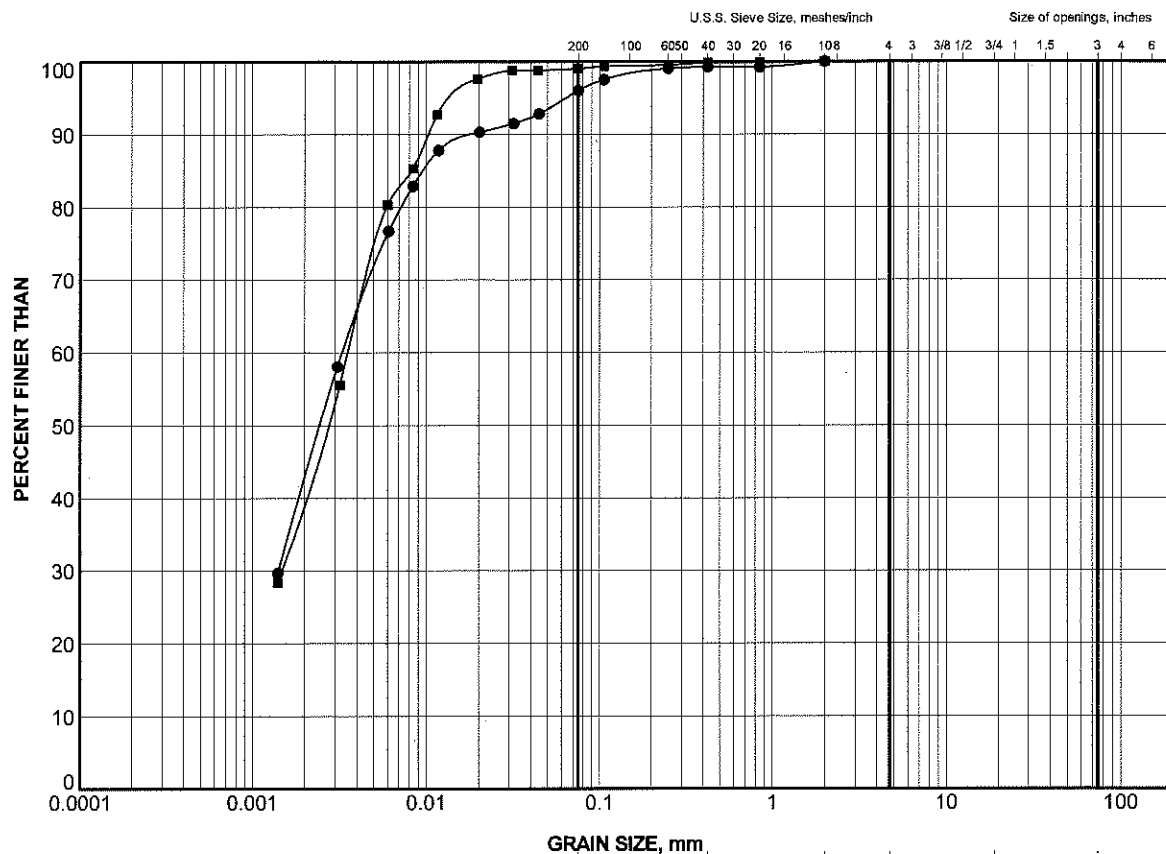
PROJECT					HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C				
TITLE					GRAIN SIZE DISTRIBUTION SAND (FILL)				
 Golder Associates SUDBURY, ONTARIO		PROJECT No.		13-1191-0003		FILE No.		13-1191-0003.GPJ	
		DRAWN	TB	Mar 2014		SCALE	N/A	REV.	
		CHECK	AB	Mar 2014					
		APPR		Mar 2014					
FIGURE C1									



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	UC1-8	8	34.4	26.4	8.0
■	UC1-9	9	82.7	52.9	29.8
▲	UC1-11	4	73.5	49.3	24.2
+	UC1-11	6	37.8	25.2	12.6


PROJECT					
HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C					
TITLE					
PLASTICITY CHART ORGANIC SILT to CLAYEY ORGANIC SILT					
PROJECT No. 13-1191-0003			FILE No. 13-1191-0003.GPJ		
DRAWN	TB	Mar 2014	SCALE	N/A	REV.
CHECK	AB	Mar 2014			
APPR		Mar 2014			
 Golder Associates SUDBURY, ONTARIO			FIGURE C2		



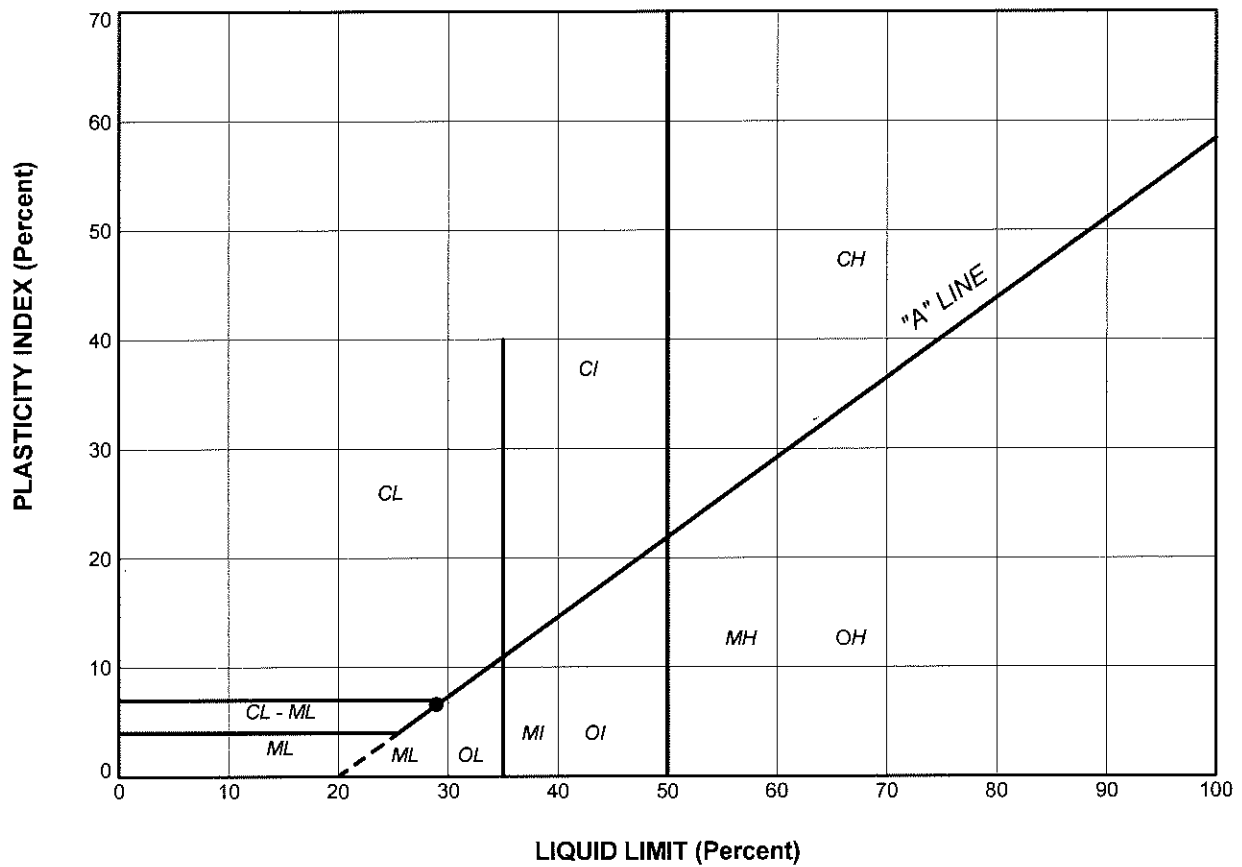
CLAY AND SILT	SAND SIZE				GRAVEL SIZE		Cobble Size
	fine	medium	coarse		fine	coarse	

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC1-8	8	387.7
■	UC1-11	6	389.4

PROJECT						HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C					
TITLE						GRAIN SIZE DISTRIBUTION ORGANIC SILT					
PROJECT No.		13-1191-0003		FILE No.		13-1191-0003.GPJ					
DRAWN	TB	Apr 2014		SCALE	N/A	REV.					
CHECK	AB	Apr 2014									
APPR	JMAC	Apr 2014								FIGURE C3	
 Golder Associates SUDBURY, ONTARIO											

SUD-WTO GSD (NEW) GLDR_LDN.GDT




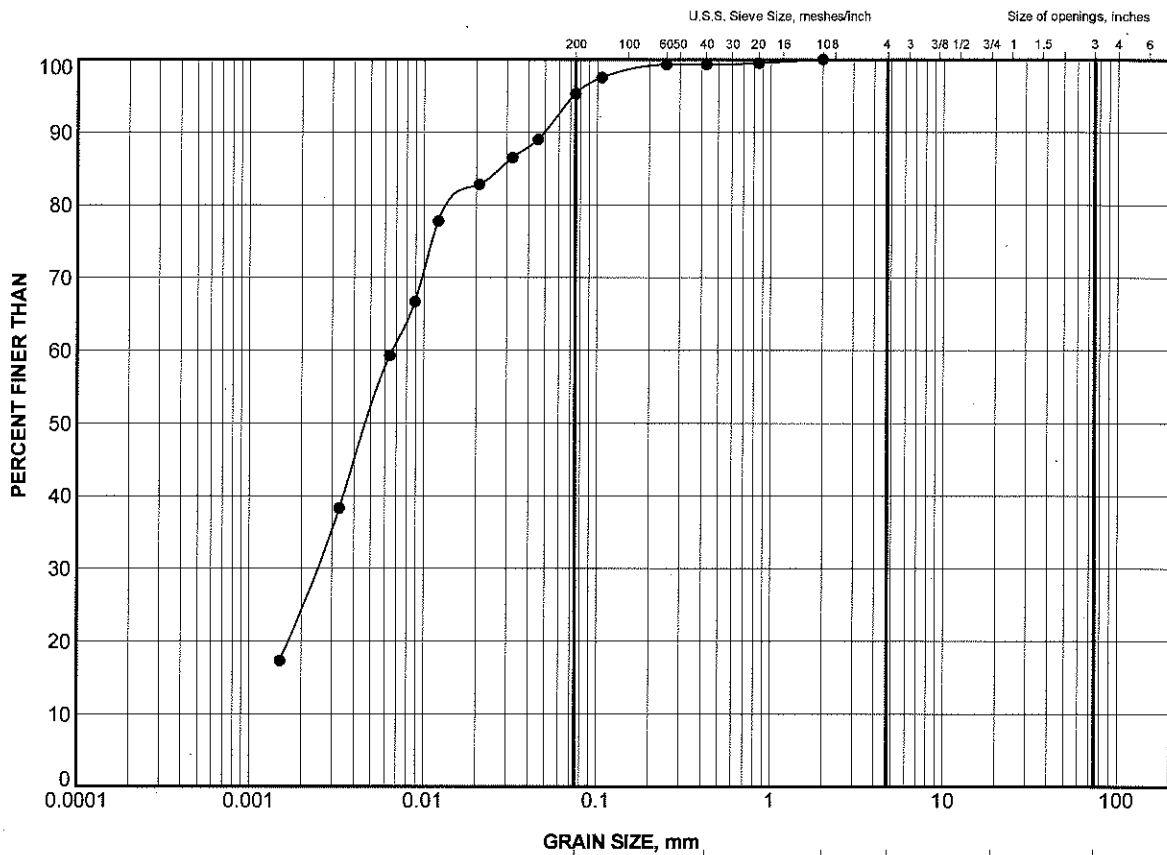
SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	UC1-9	11	28.9	22.3	6.6

PROJECT				
HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C				
TITLE				
PLASTICITY CHART CLAYEY SILT				
PROJECT No. 13-1191-0003		FILE No. 13-1191-0003.GPJ		
DRAWN	TB	Mar 2014	SCALE	N/A
CHECK	AB	Mar 2014	REV.	
APPR		Mar 2014		
 Golder Associates SUDBURY, ONTARIO			FIGURE C4	




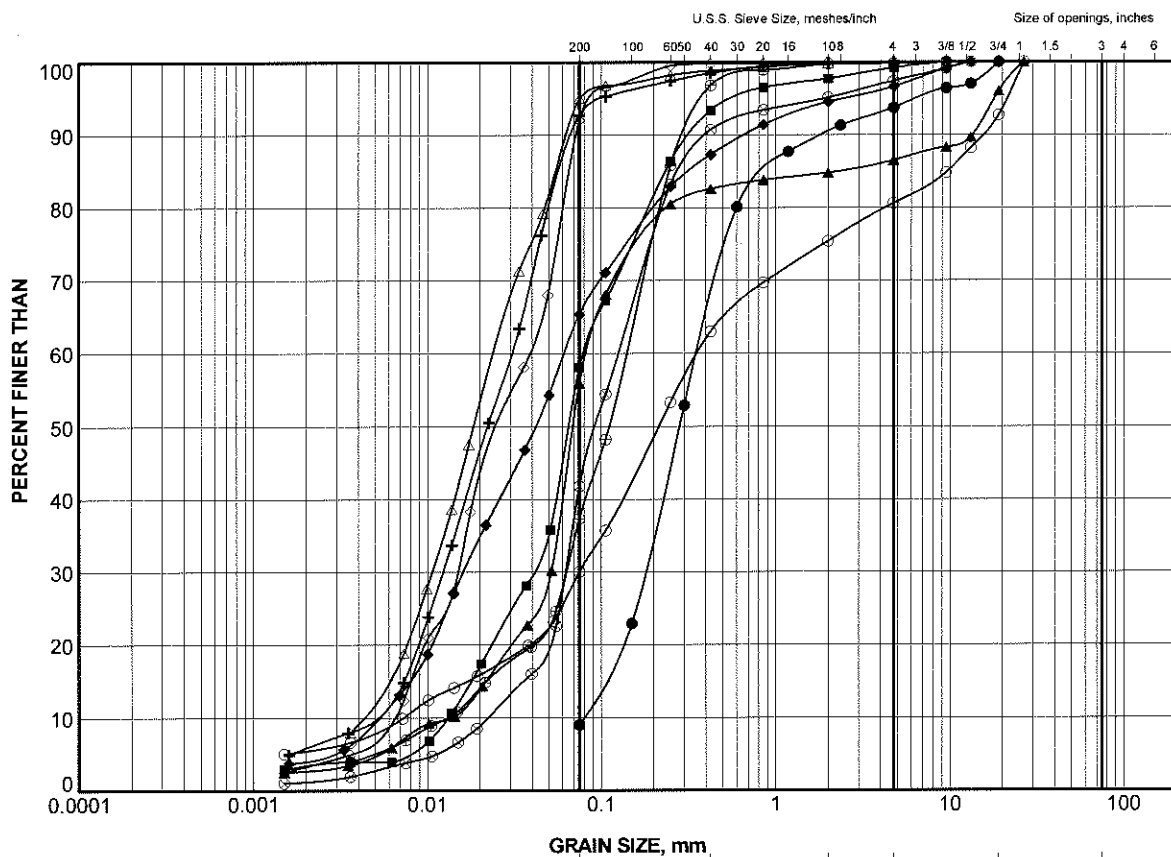
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC1-9	11	383.2

SUD-MTO GSD (NEW) GLDR_LDN.GDT


PROJECT					
HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT					
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 13-1191-0003		FILE No. 13-1191-0003.GPJ	
		DRAWN	TB	Mar 2014	SCALE N/A REV.
		CHECK	AB	Mar 2014	
		APPR		Mar 2014	
FIGURE C5					

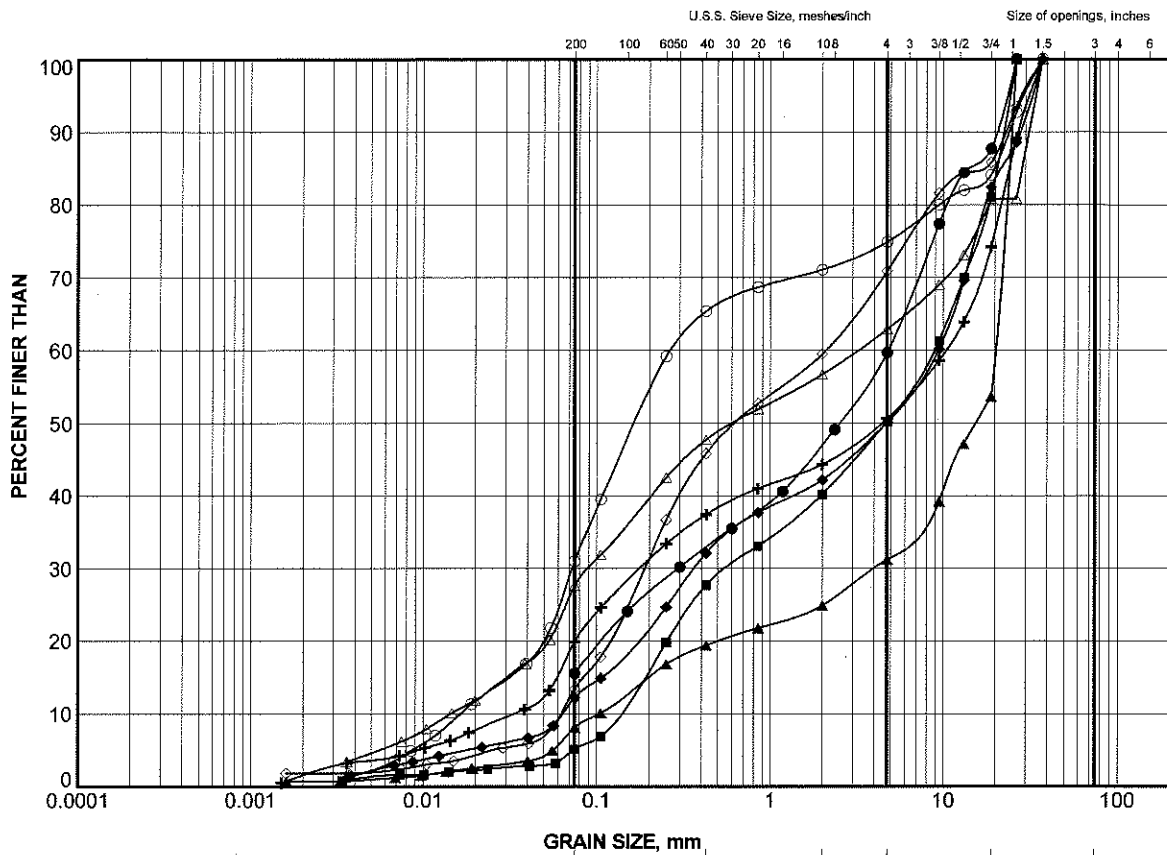


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC1-1	4	392.1
■	UC1-1	8	386.8
▲	UC1-2	10	386.5
+	UC1-6	3	390.5
◆	UC1-7	3	390.5
○	UC1-8	10	384.7
○	UC1-11	10	384.1
△	UC1-12	6	391.9
⊗	UC1-13	6	391.0
⊕	UC1-13	10	386.5


PROJECT			
HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C			
TITLE			
GRAIN SIZE DISTRIBUTION SILT to SAND			
PROJECT No. 13-1191-0003		FILE No. 13-1191-0003.GPJ	
DRAWN TB	Apr 2014	SCALE N/A	REV.
CHECK AB	Apr 2014		
APPR JMAC	Apr 2014	FIGURE C6	
 Golder Associates SUDBURY, ONTARIO			



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

LEGEND

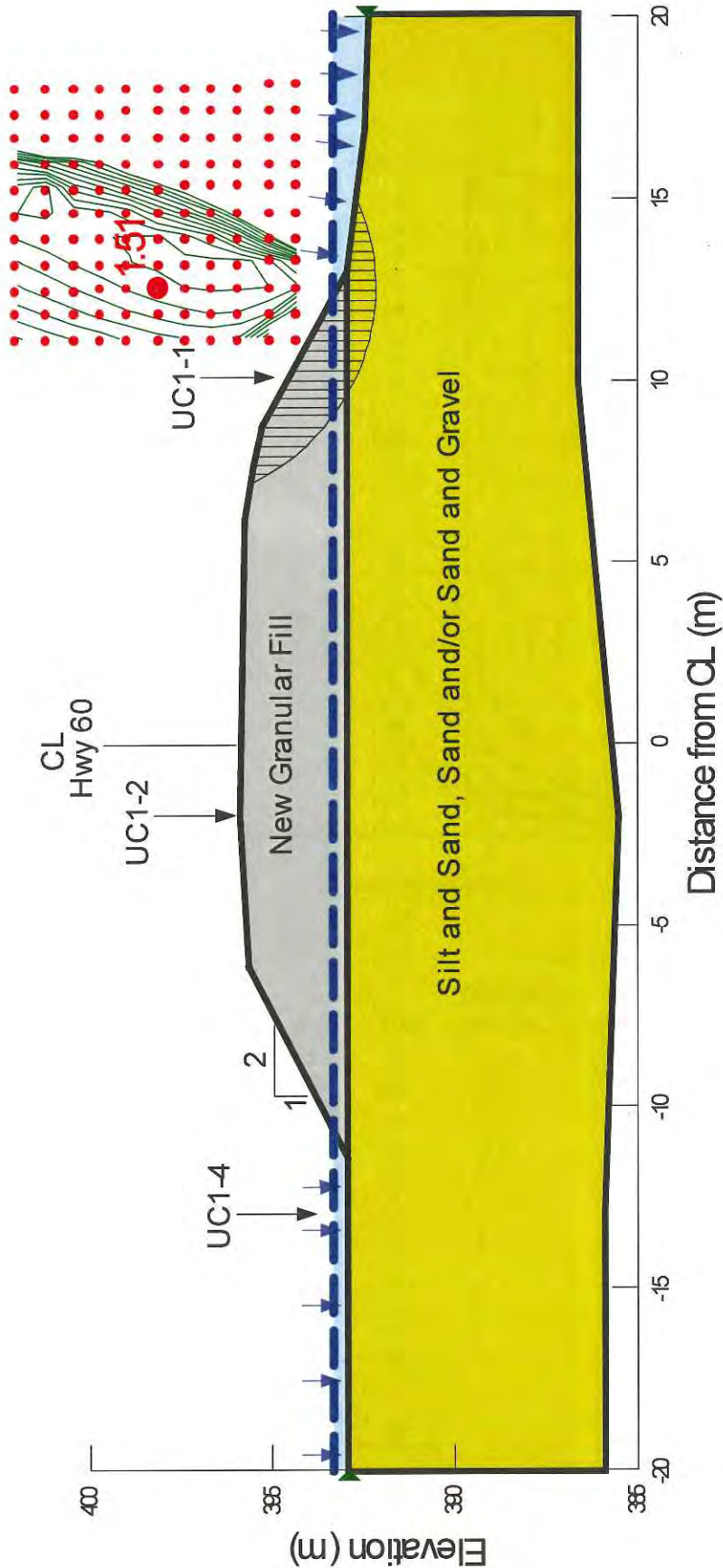
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	UC1-2	8	388.9
■	UC1-4	2	391.8
▲	UC1-4	5	389.5
+	UC1-5	3	392.9
◆	UC1-6	5	388.9
◇	UC1-7	6	386.7
○	UC1-7	9	384.6
△	UC1-12	8	389.6

PROJECT				HIGHWAY 60 UNKNOWN CREEK CULVERT, SITE 43-236/C			
TITLE				GRAIN SIZE DISTRIBUTION SANDY GRAVEL to SAND and GRAVEL			
PROJECT No.		13-1191-0003		FILE No.		13-1191-0003.GPJ	
DRAWN	TB	Apr 2014	SCALE	N/A	REV.		
CHECK	AB	Apr 2014					
APPR	JMAC	Apr 2014					
 Golder Associates SUDBURY, ONTARIO				FIGURE C7			

SUD-MTO GSD (NEW) GLDR_LDN.GDT

New Granular Fill
 Unit Weight: 21 kN/m³
 Phi: 35 °

Silt and Sand, Sand and/or Sand and Gravel
 Unit Weight: 20 kN/m³
 Phi: 30 °



PROJECT

Highway 60 Unknown Creek Culvert, Site 43-236/C

TITLE

**STABILITY ANALYSIS
 EMBANKMENT SOUTH SIDE SLOPE**



PROJECT No. 13-1191-0003	FILE No. —
DESIGN	SCALE AS SHOWN
CADD	REV
CHECK	AB
REVIEW	JMAC
Nov 2014	Nov 2014

FIGURE C8



APPENDIX D

Non-Standard Special Provision

LEVELLING BEDROCK SURFACE - Item No.

Non-Standard Special Provision

Scope of Work

The scope of work for the above-noted Tender Item includes bedrock excavation, which may be necessary at the Unknown Creek Culvert Sites 43-232/C and 43-234/C to provide an appropriate founding surface for the footings.

Construction

Prior to placing concrete for the footings, the bedrock shall be levelled by hydraulic hammer or blasting and line drilling such that the surface of the bedrock is sloping less than 10 degrees throughout the footprint of the footings, or steel dowels should be grouted into bedrock, to satisfy lateral resistance requirements. The exposed bedrock must be cleaned by removing loose debris and rock shatter. The QVE shall review the footing subgrade prior to placing concrete.

Basis of Payment

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

DOWELS INTO ROCK - Item No.

Non-Standard Special Provision

Scope of Work

As part of the work under the above tender item, the Contractor shall include mass concrete as may be required under the footings at Site 43-234/C and 43-242/C.

Construction

Mass concrete shall be of the same strength as the footing concrete and shall be placed in accordance with OPSS 904. All reinforcing steel supplied shall be in accordance with OPSS 1440 (dowel bars conforming to CAN/CSA G30.18, Grade 400).

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

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

Rock Dowel Testing

All proposed testing procedures shall be in general conformance with ASTM D3689-07, ASTM D1143-07 and ASTM D4435-08. Field testing must be carried out in the presence of, and the results reviewed and approved by, the Contract Administrator.

Performance Tests

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

Bridge	Foundation	Number of Dowels for Performance Testing
Site 43-234/C	Footing	2
Site 43-242/C	Footing	2

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

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

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

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

Displacement measurements shall be carried out at each load increment using calibrated displacement gauges capable of measuring movements of 0.0025 cm. Measurements shall be referenced to an independent fixed referenced pint.

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

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

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

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

WORKING SLAB – Item No.

Non-Standard Special Provision

Scope of Work

The subgrade soils for the box culvert foundations may be susceptible to disturbance and loosening from construction traffic and ponded water.

Where precast box culverts are used, if all of the box segments are not placed on the prepared subgrade within four hours of its inspection and approval, a concrete working slab of 20 MPa compressive strength at 28 days with minimum thickness of 100 mm, shall be placed on the foundation subgrade. A minimum 75 mm thick uncompacted levelling pad consisting of Granular 'A' material (OPPS.PROV 1010) or concrete fine aggregate (meeting the grading requirements specified in OPSS.PROV 1002) shall be provided on top of the concrete working slab.

Basis of Payment

Payment at the lump sum contract price for the above tender item includes full compensation for all labour, equipment and material for completion of the work.

END OF SECTION

DEWATERING OF STRUCTURE EXCAVATION - Item No.

Non-Standard Special Provision

Construction of Unknown Creek Culverts, Sites 43-232/C, 43-234/C and 43-236/C will require excavations to extend below the groundwater level. The cohesionless soils that are present below the groundwater table will slough, run, boil or cave into the excavation unless appropriate groundwater controls are in place. The Contractor is to design and install an appropriate excavation protection and dewatering system to enable construction in dry conditions, to prevent disturbance to the founding soils.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

OBSTRUCTIONS

Non-Standard Special Provision

As part of the work for the culvert installation at the Unknown Creek Culverts, Sites 43-232/C, 43-234/C and 43-236/C, the Contactor shall be alerted to the presence of cobble and boulder sizes in the rock fill and granular fill embankments and in the native soil.

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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