



May 9, 2013

FOUNDATION INVESTIGATION REPORT

**Culvert Replacements Rehabilitation of Highway 17
From 0.3 KM west of Highway 94 easterly 12.8 KM
East Ferris and Bonfield Townships, Ontario
Ministry of Transportation, Ontario
GWP 174-98-00**

Submitted to:
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REPORT





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PART A

**FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENTS, REHABILITATION OF HIGHWAY 17
FROM 0.3 KM WEST OF HIGHWAY 94 EASTERLY 12.8 KM
EAST FERRIS AND BONFIELD TOWNSHIPS, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 174-98-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by MMM Group Limited (MMM) on behalf of Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of ten culverts as part of the rehabilitation of Highway 17 in East Ferris Township and Bonfield Township east of North Bay, Ontario. The proposed rehabilitation of Highway 17 extends from 0.3 km west of Highway 94 easterly 12.8 km (to west of Highway 531). The locations of the culverts are shown on the Index Plan, Drawing 1 and summarized in Table 1.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal, dated September 2010. Golder's proposal for foundation engineering services associated with the culverts is contained in Section 6.8 of MMM's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplemental Specialty Quality Control Plan for foundation engineering services for this project, dated January 5, 2011. The drawings showing the proposed culvert alignments were provided to Golder by MMM.

This report addresses the investigation carried out for the ten culverts only. Separate reports will be submitted detailing the foundation investigations for the extension of passing lanes (widening the existing embankment), Kaibuskong River Bridge rehabilitation and the proposed Highway 17/94 Roundabout.

The purpose of this investigation is to establish the subsurface conditions at the locations of the proposed culverts associated with the rehabilitation of Highway 17 by methods of borehole drilling, bedrock coring, in situ testing and laboratory testing on selected soil samples. The boreholes for the culverts were located in the field by Golder, relative to stakes installed by MMM.

2.0 SITE DESCRIPTION

The culverts to be replaced are located along the existing Highway 17 alignment in East Ferris Township and Bonfield Township, extending from approximately 0.6 km east of Highway 94 to 0.6 km west of Highway 531 within the section of Highway 17 to be rehabilitated. The culvert locations and details (size, length, type, etc.) are summarized in Table 1. All of the existing culverts are Corrugated Steel Pipe (CSP) construction except the following two sites:

- Laren Creek at about STA 10+286 in Bonfield Township, which, in addition to a 1.2 m diameter CSP, also includes an approximately 3.0 m wide by 1.6 m high concrete box culvert; and
- Barse Creek at about STA 13+599 in Bonfield Township, which, in addition to a 1.2 m diameter CSP, also includes an approximately 1.8 m wide by 1.6 m high Creosote Timber Culvert (CTC).

In general, the topography of this section of the overall project limits consists of rolling terrain, including sparsely or densely populated treed areas and numerous bedrock outcrops separated by valleys and swamps containing areas of standing water and various types of vegetation and organic soils. The ground surface at the borehole locations advanced within the limits of the study area, including the existing Highway 17 embankment, varies between about Elevation 254 m and 222 m, referenced to Geodetic datum. Section 4 of this report presents a description of the topography in the vicinity of each culvert as well as the condition of the existing culvert based



on the information available from the Preliminary Design Report¹. Selected photographs of the site conditions at the time of the subsurface investigation, or afterwards, at each culvert site are presented in Appendices A to J.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the investigation associated with the proposed replacement of the ten culverts was carried out between March 2 and July 7, 2011, during which period a total of thirty-three (33) boreholes and fifteen (15) Dynamic Cone Penetration Tests (DCPT) were advanced at, or in the immediate vicinity of, the culvert alignments. Table 1 presents a summary of the boreholes and DCPTs advanced for each culvert site and the locations of the boreholes, DCPTs and culvert sites are shown on Drawings A1 to J1 in Appendices A to J, respectively.

The field investigation was carried out using a track mounted CME 55 or portable equipment supplied and operated by Landcore Drilling of Sudbury, Ontario.

The boreholes were advanced through the overburden using 108 mm inside diameter hollow stem augers, or NW or HQ casing with wash boring techniques. 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 automatic hammers on the drill rigs, 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 Record of Borehole sheets where applicable, half weight hammers were used and the SPT 'N' values were corrected, as appropriate. Field vane shear tests were carried out in cohesive soils (strata) for determination of undrained shear strengths (ASTM D2573) using MTO Standard 'N' size vanes. Rock coring was carried out using 'NQ' core barrels to a depth of approximately 3 m beyond auger/casing refusal, where appropriate, and through blast rock fill sections. All open boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903-Wells (as amended).

The boreholes and DCPTs were advanced to depths ranging from 0.5 m to 16.5 m below existing ground surface or water surface, generally penetrating 3 m into competent material, which is defined as material that will provide resistance to settlement or instability of the embankments, or refusal. In general, boreholes were terminated on refusal to further auger, casing and/or split spoon advancement likely on, or in proximity to, the bedrock surface; however, generally one borehole at each culvert location was advanced approximately 3 m deeper than auger/casing refusal to confirm bedrock at these locations.

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 J. As slight artesian conditions were encountered in Borehole C3-1 during drilling, a piezometer was installed to permit monitoring of the groundwater level at this location. The piezometer consists of a 19 mm diameter polyvinyl chloride pipe with a 1.5 m long slotted screen sealed within the sand and gravel deposit underlying the silty clay and silt deposits. The borehole annulus surrounding the piezometer screen was backfilled with sand and the remainder of the borehole was backfilled with bentonite. The piezometer details and water level readings are described on the Record of

¹ Preliminary Design Report for Highway 17 From 0.3 km East of Highway 94, Easterly to 0.2 km West of Highway 531, 12.2 km, North Bay Area, GWP 174-98-00, December 6, 2007, by the Ministry of Transportation, Ontario (MTO)



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Borehole sheets in Appendix I. Where piezometers were not installed, 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 flowing 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.

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 and rock core. The soil samples and rock core 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, Atterberg limits and grain size distribution) was carried out on selected soil samples.

Survey stakes were installed by MMM offset from the Highway 17 centreline prior to the commencement of drilling at the respective sites. The culvert sites as-drilled borehole locations, in stations and offsets, were measured in reference to the applicable stakes installed by MMM and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Borehole elevations were surveyed by a member of our technical staff in reference to the ground surface elevations at applicable stakes installed by MMM. The borehole locations given on the Record of Borehole sheets and shown on Drawings A1 to J1 are positioned relative to 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	Borehole	Location (m)		Ground/Ice/Water Surface Elevation (m)	Borehole/DCPT Depth (m) (Includes Ice/Water)
		Northing	Easting		
STA 16+056 (East Ferris Township)	C10-1/DCPT	5126635.9	320649.8	223.5	5.0/1.8
	C10-2	5126647.6	320663.8	228.5	9.6
	C10-3/DCPT	5126672.0	320665.4	222.5	0.6/0.6
STA 20+261 (East Ferris Township)	C9-1/DCPT	5125899.0	324767.9	234.5	4.5/3.8
	C9-2	5125911.5	324764.8	238.4	9.8
	C9-3	5125928.6	324774.8	235.2	5.2
STA 20+617 (East Ferris Township)	C8-1/DCPT	5125884.5	325117.1	236.5	0.5/1.5
	C8-2	5125897.8	325122.3	242.1	11.4
	C8-3	5125918.8	325132.8	237.7	5.8
STA 21+181 (East Ferris Township)	C7-1/DCPT	5125815.6	325680.6	235.3	2.5/3.2
	C7-2	5125799.1	325676.4	239.9	15.0
	C7-3	5125776.6	325675.0	236.7	11.1
STA 10+286, Laren Creek (Bonfield Township)	C6-2	5125573.4	326852.7	234.0	16.5
	C6-3/DCPT	5125553.0	326852.7	231.6	9.3/9.4
	C6-4	5125590.2	326844.8	231.9	7.7



Culvert Location	Borehole	Location (m)		Ground/Ice/Water Surface Elevation (m)	Borehole/DCPT Depth (m) (Includes Ice/Water)
		Northing	Easting		
STA 13+599, Barse Creek (Bonfield Township)	C5-1/DCPT	5125801.8	330101.7	239.5	2.4/2.5
	C5-2	5125781.8	330095.9	242.2	8.2
	C5-3/DCPT	5125768.5	330100.4	239.5	4.3/4.7
STA 14+063 (Bonfield Township)	C2-1/DCPT	5125749.2	330570.0	236.2	5.2/2.4
	C2-2	5125766.9	330559.9	240.9	7.9
	C2-3/DCPT	5125781.5	330558.2	236.1	1.8/1.3
	C2-3a	5125781.6	330556.2		4.7
STA 14+651 (Bonfield Township)	C1-1	5125765.4	331164.9	238.1	5.8
	C1-2	5125769.4	331164.9	238.2	7.5
	C1-3	5125721.4	331137.1	238.2	1.7
	C1-4	5125719.9	331135.8	238.2	3.0
	C1-5	5125739.4	331152.5	247.2	13.9
	C1-DC1	5125769.2	331168.9	238.2	8.4
	C1-DC2	5125718.3	331134.5	238.1	1.5
	C1-DC3	5125716.8	331133.3	238.1	1.2
STA 14+978 (Bonfield Township)	C3-1	5125683.1	331467.9	249.4	5.6
	C3-2	5125704.9	331478.5	253.9	10.6
	C3-3	5125720.2	331481.2	249.3	6.2
STA 15+400 (Bonfield Township)	C4-1/DCPT	5125573.6	331880.2	234.3	4.4/3.6
	C4-2	5125592.7	331881.4	237.9	8.6
	C4-3/DCPT	5125614.6	331879.5	235.1	3.1/3.1

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on terrain mapping by the Ontario Geological Survey², the overall project site generally consists of rock knobs separated by peat/organic terrain. Towards the east end of the site, in the vicinity of Kaibuskong River, the soils consist of glacio-lacustrine plain silts and sands.

The bedrock in the area typically consists of gneisses of the Powassan or Tilden Lake Domain, both within the Central Gneiss Belt, a subdivision of the Grenville Structural Province, as described in Geology of Ontario, OGS Special Volume 4³.

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 J. The stratigraphic

² Northern Ontario Engineering Geology Terrain Study, Ontario Geological Society, Map 5044.

³ Geology of Ontario, 1991. Ontario Geological Society Special Volume 4, Part 2. Ministry of Northern Development and Mines, Ontario.



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 ten culverts are shown in profile on Drawings A1 to J1. 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 17 alignment is in an east west orientation. Therefore, the directions indicated in the text may differ from those shown on the drawings.

In general, the stratigraphy encountered at the various areas investigated is similar. However, the overburden (soil materials) thickness is variable, ranging from 0.5 m to about 13.2 m. The stratigraphy generally consists of:

- surficial layers of topsoil or peat or embankment fill;
- relatively thin deposits of glacio-lacustrine cohesionless deposits of sand to sand and silt;
- cohesive deposits of glacio-lacustrine mixtures of silt and clay interbedded with silt and sand layers in some areas;
- sand and gravel strata between the cohesive/cohesionless deposits and the inferred bedrock surface; and
- gneiss or granite gneiss bedrock.

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 Culvert at STA 16+056 (East Ferris Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 16+056 in East Ferris Township are shown on Drawing A1. The height of the embankment at this location is about 6 m and the existing CSP culvert is about 35 m long with a diameter of 910 mm. The Preliminary Design Report (PDR) indicates that the bottom of the culvert is rotted. A total of three boreholes and two DCPTs were completed to investigate the subsurface conditions at the culvert location: two boreholes and two companion DCPTs (Boreholes C10-1 and C10-3) were advanced near the ends of the culvert and one borehole (Borehole C10-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area consists of low-lying swamp area with bedrock outcrops and tree areas beyond the swamp limits.

Embankment Fill

Borehole C10-2 was advanced through the existing roadway and encountered a 100 mm thick layer of asphalt with the roadway surface at Elevation 228.5 m. Below the asphalt, the borehole encountered a deposit of fill materials comprised of a 1.0 m thick deposit of sand and gravel to sand, underlain by a 1.2 m thick deposit of



blast rock, underlain by a 2.6 m thick lower deposit of sand to sand and gravel containing trace to some silt, in turn underlain by a 0.3 m thick layer of silty clay.

One SPT 'N'-value in the upper deposit of sand and gravel to sand fill is 56 blows per 0.3 m of penetration, likely high due to the underlying rock fill. SPT 'N'-values measured within the lower sand to sand and gravel fill deposit range from 9 blows to 17 blows per 0.3 m of penetration, suggesting a loose to compact relative density.

The grain size distribution of two samples of the lower deposit of sand to sand and gravel fill is presented on Figure A1 in Appendix A.

The water content of one sample of the granular fill is 9 per cent.

Water

Borehole C10-3 encountered about 0.1 m of ponded water with the surface of the water at Elevation 222.5 m.

Peat

In Borehole C10-1, a 0.9 m thick deposit of peat mixed with sand was encountered from ground surface at Elevation 223.5 m. In Borehole C10-2, a 0.9 m thick deposit of black amorphous peat was encountered below the silty clay fill at a depth of 4.9 m below existing ground surface (Elevation 223.6 m). A deposit of black fibrous peat, approximately 0.6 m thick, was encountered below the water (from ground surface) in Borehole C10-3 at Elevation 222.4 m.

The SPT 'N'-values measured within the peat are between 2 blows and 13 blows per 0.3 m of penetration, suggesting a soft to stiff consistency.

The natural water content measured on a sample of the peat mixed with sand in is about 13 per cent, and on a sample of the peat is about 47 per cent.

Sand and Silt

A deposit of grey sand and silt containing trace to some gravel and trace clay was encountered underlying the peat mixed with sand in Borehole C10-1 and the peat in Borehole C10-2. The top of the sand and silt deposit is at Elevation 222.6 m and Elevation 222.7 m with the thickness of the deposit is about 0.9 m and 0.4 m in Boreholes C10-1 and C10-2, respectively.

Grain size distributions of three samples of the sand and silt deposit are shown on Figure A2 in Appendix A.

The natural water content measured on two samples of this deposit is about 13 per cent and 14 per cent.

Bedrock/Refusal

Bedrock was encountered underlying the sand and silt in Borehole C10-1 and C10-2 at a depth of 1.8 m and 6.2 m below ground/roadway surface corresponding to Elevation 221.7 m. A length of 3.2 m and 3.4 m of



bedrock core to Elevation 222.3 m was recovered in Boreholes C10-1 and C10-2, respectively. Based on a review of the bedrock core samples, the bedrock consists of a fine to medium grained, fresh, pinkish grey granitic gneiss.

The Total Core Recovery (TCR) is 100 per cent for the core samples in Boreholes C10-1 and C10-2 and the Solid Core Recovery (SCR) ranges from about 77 per cent to 100 per cent. RQD values measured on the recovered bedrock core samples in the two boreholes range between 75 per cent and 100 per cent, indicating the rock is of good to excellent quality according to Table 3.10 in CFEM (2006).

Refusal to split-spoon and/or DCPT advancement was encountered in and adjacent to Boreholes C10-1 and C10-3 at depths of 1.8 m and 0.6 m below ground surface, corresponding to Elevation 221.7 m and 221.9 m.

Groundwater Conditions

In Boreholes C10-1 and C10-2, the unstabilized water levels were measured at 0.6 m and 4.2 m below ground surface upon completion of drilling, respectively, corresponding to Elevation 222.9 m and 224.3 m. About 0.1 m of water was observed ponded at Borehole C10-3, corresponding to Elevation 222.5 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.4 Culvert at STA 20+261 (East Ferris Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 20+261 in East Ferris Township are shown on Drawing B1. The height of the embankment at this location is about 5 m and the existing CSP culvert is about 33 m long with a diameter of 760 mm. The PDR indicates that the culvert is sagging and rotted. A total of three boreholes and one DCPT were completed to investigate the subsurface conditions at the culvert location: two boreholes and one DCPT (Boreholes C9-1 and C9-3) were advanced near the ends of the culvert and one borehole (Borehole C9-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area consists of low-lying swamp area with bedrock outcrops and tree areas beyond the swamp limits.

Water

Borehole C9-1 encountered about 0.3 m of ponded water, with the surface of the water at Elevation 234.5 m.

Embankment Fill

Borehole C9-2 was advanced through the existing roadway and encountered a 195 mm thick layer of asphalt, with the roadway surface at Elevation 238.4 m. Below the water (from ground surface) in Borehole C9-1, below the asphalt in Borehole C9-2, and from ground surface in Borehole C9-3, a deposit of sand to sand and gravel fill containing trace to some silt, trace clay was encountered. Cobbles were noted within the fill below a depth of 3.0 m in Borehole C9-2. In Boreholes C9-1, C9-2 and C9-3, the top of sand to sand and gravel fill was encountered between Elevation 238.2 m and 234.2 m and the thickness of the deposit ranges between 1.9 m and 5.0 m.



SPT 'N'-values measured within the fill range from 2 blows to 31 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The grain size distributions of five samples of the fill are presented on Figure B1 in Appendix B.

The water content of five samples of the fill ranges from about 2 per cent to 15 per cent.

Sand and Gravel to Gravel

A deposit of grey gravel or sand and gravel containing trace to some silt was encountered underlying the fill in Boreholes C9-1 and C9-2 at Elevation 231.1 m and 233.2 m, respectively, and the thicknesses of the deposit is 1.1 m and 1.5 m at the respective boreholes.

SPT 'N'-values measured within the gravel or sand and gravel deposit range from 12 blows to 37 blows per 0.3 m of penetration and one value of 15 blows per 0.15 m of penetration, indicating a compact to dense relative density.

A grain size distribution of one sample of the sand and gravel portion of the deposit is shown on Figure B2 in Appendix B.

The natural water content measured on a sample of this deposit is about 12 per cent.

Bedrock/Refusal

Bedrock was encountered underlying the sand and gravel deposit in Borehole C9-2 at a depth of about 6.7 m below ground surface, corresponding to Elevation 231.7 m, and a 3.1 m length of bedrock core was recovered. In Borehole C9-3, bedrock was encountered at a depth of about 1.9 m below ground surface, corresponding to Elevation 233.3 m, and a 3.3 m length of bedrock core was recovered. Based on a review of the bedrock core samples from Borehole C9-2 and C9-3, the bedrock consists of a fine to medium grained, fresh to slightly weathered, pinkish grey gneiss.

The TCR is 100 per cent for all of the core samples and the SCR ranges from about 81 per cent to 97 per cent except in the upper 0.5 m in Borehole C9-3 where the SCR was noted to be 0 per cent. RQD values measured on the recovered bedrock core samples generally range between 56 per cent to 100 per cent, except for the upper 0.5 m in Borehole C9-3 where the RQD was noted to be 0 per cent. Based on the RQD values, the gneiss bedrock is generally of fair to excellent quality according to Table 3.10 in CFEM (2006), except for the upper 0.5 m of Borehole C9-3 which is considered to be very poor quality.

Refusal to split-spoon and DCPT advancement was encountered in and adjacent to Borehole C9-1 at depths of 4.5 m and 3.8 m below ground surface, corresponding to Elevation 230.0 m and 230.7 m, respectively.

Groundwater Conditions

Borehole C9-1 encountered 0.3 m of ponded water at water surface Elevation 234.5 m. The unstabilized water levels observed in Boreholes C9-2 and C9-3 were measured at 3.5 m and 0.8 m below ground surface upon completion of drilling, respectively, corresponding to Elevation 234.9 m and 234.4 m, respectively. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



4.5 Culvert at STA 20+617 (East Ferris Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 20+617 in East Ferris Township are shown on Drawing C1. The height of the embankment at this location is about 6 m and the existing CSP culvert is about 39 m long with a diameter of 760 mm. The PDR indicates that the culvert is sagging and rotted. A total of three boreholes and one DCPT were completed to investigate the subsurface conditions at the culvert location: two boreholes and one DCPT (Boreholes C8-1 and C8-3) were advanced near the ends of the culvert and one borehole (Borehole C8-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area consists of low-lying swamp area with bedrock outcrops and tree areas beyond the swamp limits.

Water

Borehole C8-1 encountered about 0.2 m of ponded water, with the water surface at Elevation 236.5 m.

Embankment Fill

Borehole C8-2 was advanced through the existing roadway and encountered a 230 mm thick layer of asphalt, with the roadway surface at Elevation 242.1 m. Below the water in Borehole C8-1, below the asphalt in Borehole C8-2 and from ground surface in Borehole C8-3, a deposit of sand and gravel to sand fill was encountered with surfaces ranging from Elevation 239.9 m to 236.3 m and ranging in thickness from 0.3 m to 5.6 m. The sand and gravel fill in Borehole C8-3 was noted to be mixed with organics. The deposit of fill in Boreholes C8-2 and C8-3 is comprised of an upper layer of granular material and a lower layer of blast rock about 4.6 m and 0.9 m thick at the respective boreholes.

Two SPT 'N'-values measured within the sand and gravel to sand fill are 1 blow and 6 blows per 0.15 m of penetration, suggesting a very loose to compact relative density.

The grain size distribution of one sample of the sand fill is presented on Figure C1 in Appendix C.

The water content of two samples of the fill is about 4 per cent and 19 per cent.

Peat

A 0.3 m and 0.5 m thick layer of black fibrous or amorphous peat was encountered below the fill in Boreholes C8-2 and C8-3 at Elevation 236.5 m. A 0.7 m thick deposit of cobbles mixed with peat was encountered underlying the peat layer in Borehole C8-2, at Elevation 236.2 m.

One SPT 'N'-value measured within the peat is 9 blows per 0.3 m of penetration, suggesting a stiff consistency.

The natural water content measured on two samples of this layer is about 44 per cent and 94 per cent.



Sand and Gravel

A deposit of grey sand and gravel was encountered below the layer of peat/cobbles mixture in Borehole C8-2 and beneath the peat in Borehole C8-3. Cobbles were inferred from auger advancement/grinding to be present within the sand and gravel deposit in Borehole C8-3. In Boreholes C8-2 and C8-3, the top of this deposit is at Elevation 235.5 m and 236.0 m with thicknesses of 1.7 m and 0.7 m, respectively.

One SPT 'N'-value measured within the sand and gravel is 60 blows per 0.3 m of penetration, indicating a very dense relative density.

A grain size distribution for one selected sample of the sand and gravel deposit is shown on Figure C2 in Appendix C.

The natural water content measured on two samples of this deposit is about 8 per cent and 12 per cent.

Bedrock/Refusal

Bedrock was encountered underlying the sand and gravel deposit in Borehole C8-2 at a depth of about 8.3 m below ground surface, corresponding to Elevation 233.8 m, and a 3.1 m length of bedrock core was recovered. In Borehole C8-3, the bedrock surface was encountered at a depth of about 2.4 m below ground surface, corresponding to Elevation 235.3 m, and a 3.4 m length of bedrock core was recovered. Based on a review of the bedrock core samples from Boreholes C8-2 and C8-3, the bedrock consists of a fine to coarse grained, fresh to slightly weathered, pinkish grey to grey garnetiferous or granitic gneiss.

The TCR is 100 per cent for all of the core samples obtained and the SCR ranges from about 30 per cent to 95 per cent. RQD values measured on the recovered bedrock core samples range from 30 per cent to 100 per cent, indicating the rock is of poor to excellent quality according to Table 3.10 in CFEM (2006).

Refusal to split-spoon and DCPT advancement was encountered in and adjacent to Borehole C8-1 at depths of 0.5 m and 1.5 m below ground surface, corresponding to Elevation 236.0 m and 235.0 m, respectively.

Groundwater Conditions

Borehole C8-1 encountered 0.2 m of ponded water at water surface Elevation 236.5 m. The unstabilized water levels in Boreholes C8-2 and C8-3 were measured at 4.6 m and 0.5 m below ground surface upon completion of drilling, corresponding to Elevation 237.5 m and 237.2 m, respectively. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.6 Culvert at STA 21+181 (East Ferris Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 21+181 in East Ferris Township are shown on Drawing D1. The height of the embankment at this location is about 5 m and the existing CSP culvert is about 34 m long with a diameter of 910 mm. The PDR indicates that the culvert is buried and rusted on the south side and in good condition on the north side. A total of three boreholes and one DCPT were completed to investigate the subsurface conditions at the culvert



location: two boreholes and one DCPT (Boreholes C7-1 and C7-3) were advanced near the ends of the culvert and one borehole (Borehole C7-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area consists of low-lying terrain with moderate tree cover. The culvert conveys a creek flowing northerly.

Embankment Fill

Borehole C7-2 was advanced through the existing roadway shoulder at Elevation 239.9 m and encountered a fill deposit comprised of a 1.6 m thick deposit of sand to sand and gravel containing trace to some silt underlain by a 3.1 m thick deposit of blast rock fill and 0.8 m of sand and gravel containing organics.

SPT 'N'-values measured within the granular fill are between 5 blows and 22 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The grain size distribution of one sample of the granular fill is presented on Figure D1 in Appendix D.

The water content of one sample of the fill is 6 per cent.

Peat

A deposit of black fibrous to amorphous peat was encountered from ground surface in Boreholes C7-1 and C7-3 and below the fill in Borehole C7-2. The top of the peat layer is between Elevation 236.7 m and 234.4 m and the thickness of the deposit is between 0.4 m and 2.5 m.

The SPT 'N'-values measured within the peat are 1 blow per 0.3 m of penetration for the deposit near surface, suggesting a very soft to stiff consistency and 9 blows per 0.3 m of penetration for the layer below the embankment fill, suggesting a stiff consistency.

The natural water content measured on samples of this layer is between 93 per cent and 212 per cent.

Sand and Silt

A 1.4 m thick deposit of grey sand and silt, some gravel and trace clay, cobbles inferred from sampling operation, was encountered at Elevation 236.1 m in Borehole C7-3.

One SPT 'N' value within this layer is 18 blows per 0.3 m of penetration, indicating a compact relative density, whereas another SPT did not penetrate 0.3 m likely due to the presence of cobbles within the layer.

The grain size distribution of one sample of the sand and silt is shown on Figure D2 in Appendix D.

The natural water content measured on a sample of this layer is 18 per cent.

Cobbles and Boulders

A 0.5 m and 0.9 m thick deposit of cobbles and/or boulders was encountered below the peat in Borehole C7-2 at Elevation 234.0 m and below the sand and silt deposit in Borehole C7-3 at Elevation 234.7 m.



Silty Sand to Gravelly Sand

A deposit of brown to grey silty sand to gravelly sand was encountered underlying the deposit of cobbles and/or boulders in Boreholes C7-2 and C7-3 at Elevation 233.5 m and 233.8 m, respectively, and the thicknesses of the deposit is 5.2 m and 5.5 m in the respective boreholes.

The SPT 'N'-values measured within the silty sand to gravelly sand deposit range from 6 blows to 79 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

The grain size distributions of four selected samples of the silty sand to gravelly sand deposit are shown on Figure D3 in Appendix D.

The natural water content measured on three samples of this deposit ranges from about 15 per cent to 23 per cent.

Bedrock/Refusal

Bedrock was encountered underlying the silty sand to gravelly sand deposit in Boreholes C7-2 and C7-3 at a depth of 11.6 m and 8.4 m below ground surface, respectively, corresponding to Elevation 228.3 m. A 3.4 m and 2.7 m length of bedrock core was recovered from the respective boreholes. Based on a review of the bedrock core samples from Boreholes C7-2 and C7-3, the bedrock consists of fine to coarse grained, slightly weathered to fresh, pinkish grey granitic or garnetiferous gneiss.

The TCR is 100 per cent for all of the core samples and the SCR ranges from about 20 per cent to 100 per cent. RQD values measured on the recovered bedrock core samples in Borehole C7-2 range from 72 per cent to 100 per cent indicating the rock is of fair to excellent quality, and in Borehole C7-3 the RQD values range from 21 per cent to 53 per cent indicating the rock is of very poor to fair quality according to Table 3.10 in CFEM (2006).

Refusal to split-spoon and DCPT advancement was encountered in and adjacent to Borehole C7-1 at depths of 2.5 m and 3.2 m below ground surface, corresponding to Elevation 232.8 m and 232.1 m, respectively.

Groundwater Conditions

The unstabilized water levels were measured at 0.1 m and 0.8 m below ground surface upon completion of drilling in Boreholes C7-1 and C7-3, respectively, and at 4.0 m below ground surface in Borehole C7-2, at Elevation 235.2 m and 235.9 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.7 Culvert at STA 10+286, Laren Creek (Bonfield Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at Laren Creek at approximately STA 10+286 in Bonfield Township are shown on Drawing E1 in Appendix E. The height of the embankment at this location is about 3 m. Two culverts are located at this site as follows:



- a 1.2 m diameter and about 32 m long CSP which has undergone minor corrosion as indicated in the PDR; and
- a 3.0 m wide by 1.6 m high concrete box about 31 m long in fair condition with a leaking transverse construction joint about 5 m from the north invert as indicated in the PDR.

A total of three boreholes and one DCPT were completed to investigate the subsurface conditions at this culvert location: two boreholes and a DCPT (Boreholes C6-3 and C6-4) were advanced near the ends of the culvert and one borehole (Borehole C6-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the area of the two culverts consists of relatively level terrain, with a residence on the north side of the highway and relatively dense tree cover on the south side of the highway. The culverts convey Laren Creek flowing northerly under the roadway.

Embankment Fill

Borehole C6-2 was advanced through the roadway embankment and encountered a 175 mm thick layer of asphalt, with the roadway surface at Elevation 234.0 m. Below the asphalt, the borehole encountered a 2.8 m thick deposit of sand and gravel to sand fill containing trace to some silt.

The SPT 'N'-values measured within the fill range from 9 blows to 51 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

The grain size distribution of one sample of the fill is presented on Figure E1 in Appendix E.

The water content of the selected sand fill sample is 4 per cent.

Topsoil

A 0.1 m and 0.2 m thick layer of brown to black topsoil was encountered at ground surface in Boreholes C6-3 and C6-4 at Elevation 231.6 m and 231.9 m, respectively.

Clayey Silt to Silty Clay

A deposit of grey clayey silt to silty clay was encountered below the embankment fill in Borehole C6-2 and underlying the topsoil in Boreholes C6-3 and C6-4. The deposit was noted to consist of alternating seams/varves of silt/silty clay below about Elevation 229 m in Borehole C6-2. The top of the deposit ranges between Elevation 231.8 m and 231.0 m, and the thicknesses of the deposit range between 5.4 m and 6.8 m.

The SPT 'N'-values recorded within this deposit range from 0 blows (weight of rod) to 6 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths ranging from about 13 kPa to 30 kPa. The SPT tests together with the field vane test suggest the deposit is generally soft to firm.

Atterberg limits testing carried out on six samples of the cohesive deposit yielded liquid limits ranging from 30 per cent to 48 per cent, plastic limits ranging from 18 per cent to 24 per cent and plasticity indices ranging



from 12 per cent to 24 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure E2 in Appendix E and indicate that the deposit consists of clayey silt of low plasticity to silty clay of intermediate plasticity.

The natural water content measured on samples of the deposit is between about 35 per cent and 65 per cent. The organic content of the uppermost sample of the clayey silt deposit in Borehole C6-2 is about 3 per cent.

Sandy Silt to Silt

A deposit of grey sandy silt to silt containing trace to some clay was encountered underlying the clayey silt to silty clay deposit in Boreholes C6-2 and C6-3. The top of the sandy silt to silt deposit is at about Elevation 224.9 m and 224.6 m, and the thicknesses of the deposit is about 2.5 m and 2.3 m in the respective boreholes.

The SPT 'N'-values recorded within this deposit range from 0 blows (weight of rods) to 8 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

Atterberg limits testing carried out on one sample of the sandy silt yielded a liquid limit of about 21 per cent, a plastic limit of about 18 per cent and plasticity index of about 3 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure E3 in Appendix E and indicate that the deposit consists of silt.

The grain size distributions of two samples of the sandy silt to silt deposit are shown on Figure E4 in Appendix E.

The natural water content measured on two samples of the silt deposit is 27 per cent.

Gravelly Sand

A deposit of brown or grey gravelly sand trace to some silt was encountered underlying the silt deposit in Borehole C6-2 and underlying the silty clay to clayey silt deposit in Borehole C6-4. Cobbles were inferred from the grinding of the augers to be present within this deposit in Borehole C6-2. The top of the gravelly sand deposit is about Elevation 222.4 m and Elevation 226.4 m, and the thicknesses of the deposit are 1.6 m and 2.2 m in Boreholes C6-2 and C6-4, respectively.

Two SPT 'N'-values recorded within this deposit are 14 blows and 26 blows per 0.3 m of penetration, indicating a compact relative density.

Bedrock/Refusal

Bedrock was encountered underlying the gravelly sand deposit in Borehole C6-2 at a depth of about 13.2 m below ground surface, corresponding to Elevation 220.8 m, and a 3.3 m length of bedrock core was recovered. Based on a review of the bedrock core samples, the bedrock consists of medium to coarse grained, slightly weathered, pinkish grey gneiss.



The TCR is 100 per cent for all of the core samples and the SCR ranges from about 20 per cent to 62 per cent. RQD values measured on the recovered bedrock core samples range from 29 per cent to 74 per cent, indicating the rock is of poor to fair quality according to Table 3.10 in CFEM (2006).

Refusal to split-spoon advancement was encountered in Boreholes C6-3 and C6-4 at depths of 9.3 m and 7.7 m below ground surface, corresponding to Elevation 222.3 m and 224.2 m, respectively, and in the DCPT adjacent to Borehole C6-3 at a depth of 9.4 m below ground surface, Elevation 222.2 m. These refusal depths, while they do not confirm bedrock elevations, may be likely on or in proximity to the bedrock surface.

Groundwater Conditions

Water levels observed in the boreholes upon completion of drilling range from Elevation 231.8 m to 231.3 m, measured at 2.2 m below the ground surface in Borehole C6-2, and at 0.3 m below the ground surface in Boreholes C6-3 and C6-4. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.8 Culvert at STA 13+599, Barse Creek (Bonfield Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at Barse Creek at approximately STA 13+599 in Bonfield Township are shown on Drawing F1. The height of the embankment at this location is about 3 m. Two culverts are located at this site as follows:

- a 1.2 m diameter and about 27 m long CSP, of which the outlet (south) end is not visible on the south side of the embankment as indicated in the PDR; and
- a timber box about 1.8 m wide by 1.6 m high and about 27 m long, which reportedly looks “good” visually but has exceeded its design service life as indicated in the PDR.

A total of three boreholes and two DCPTs were completed to investigate the subsurface conditions in the vicinity of the culvert alignment: two boreholes and two companion DCPTs (Boreholes C5-1 and C5-3) were advanced near the ends of the culvert and one borehole (Borehole C5-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area consists of low-lying terrain, vegetated by relatively moderate to dense tree cover and bedrock exposed to the east along the highway alignment.

Embankment Fill

Borehole C5-2 was advanced through the existing roadway embankment and encountered a 255 mm thick layer of asphalt, with the roadway surface at Elevation 242.2 m. Below the asphalt, the borehole encountered a 3.5 m thick deposit of fill comprised of an upper layer of sand and gravel to sand about 1.2 m thick, a 0.3 m thick layer of blast rock and a lower layer of sand about 2 m thick.



The SPT 'N'-value measured within the upper granular fill (above the blast rock) is 37 blows per 0.3 m of penetration, indicating a dense relative density, and two 'N'-values measured within the lower granular fill (below the blast rock) are 1 blow and 2 blows per 0.3 m of penetration, indicating a very loose relative density.

The grain size distributions of two samples of the sand fill layers are presented on Figure F1 in Appendix F.

The water content of two samples of the fill is 4 per cent and 19 per cent.

Water

Boreholes C5-1 and C5-3 were advanced within the creek and encountered water to a depth of 1.2 m at both locations, with the water surface at Elevation 239.5 m.

Peat

A 0.1 m thick layer of organic material (peat sediment) was encountered on the creek bed, below water, in Borehole C5-3 at Elevation 238.3 m.

Silty Sand to Sandy Silt

A deposit of brown and grey silty sand to sandy silt, trace to some gravel, trace clay was encountered underlying the fill in Borehole C5-2 and underlying the organics in Borehole C5-3. The top of the deposit is at Elevation 238.4 m and 238.2 m and the thickness of the deposit is 1.8 m and 3.0 m in Boreholes C5-2 and C5-3, respectively.

The SPT 'N'-values recorded within this deposit range from 7 blows to 88 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

Grain size distributions of two samples of sand and silt to sandy silt are shown on Figure F2 in Appendix F.

The water content of two samples of this deposit is 14 per cent and 17 per cent.

Gravelly Sand

A deposit of grey gravelly sand with some silt, trace clay was encountered below the water in Borehole C5-1 and below the sand and silt deposit in Borehole C5-2. Cobbles are inferred to be present within this deposit based on observations of augers grinding during borehole advancement. The top of this deposit is at Elevation 238.3 m and 236.6 m in Boreholes C5-1 and C5-2, respectively, and the thickness of the deposit is 1.2 m in Borehole C5-1 and at least 2.6 m in Borehole C5-2, which was terminated within the deposit.

The SPT 'N'-values recorded within this deposit are 81 blows and 90 blows per 0.3 m of penetration indicating a very dense relative density with one value of 50 blows per 0.15 m of penetration, likely as a result of the presence of cobbles within this deposit.

A grain size distribution of two samples of the gravelly sand is shown on Figure F3, in Appendix F.



The natural water content measured on samples of this deposit is about 10 per cent.

Refusal

Refusal to split- spoon advancement was encountered in Boreholes C5-1 and C5-3 and in the DCPT adjacent to Borehole C5-1 at depths of 2.4 m, 4.3 m and 2.5 m, respectively, below water surface (1.2 m and 3.1 m below the creek bed), corresponding to about Elevation 237.1 m and 235.2 m.

Groundwater Conditions

As indicated above, Boreholes C5-1 and C5-3 were advanced from the creek surface and the water level was measured at Elevation 239.5 m. The water level observed in Borehole C5-2 upon completion of drilling is 2.1 m below existing ground surface, corresponding to Elevation 240.1 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.9 Culvert at STA 14+063 (Bonfield Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+063 in Bonfield Township are shown on Drawing G1. The height of the embankment at this location is about 5 m and the existing CSP culvert is about 31 m long with a diameter of 910 mm. The PDR indicates that the culvert is rotted. A total of four boreholes were completed to investigate the subsurface conditions at the culvert location: three boreholes and two companion DCPTs (Boreholes C2-1 and C2-3/3a) were advanced near the ends of the culvert and one borehole (Borehole C2-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area is flat, defined by a low-lying swamp with moderate to densely populated tree areas and bedrocks outcrops exposed beyond the swamp limits.

Embankment Fill

Borehole C2-2 was advanced through the existing roadway embankment and encountered a 220 mm thick layer of asphalt, with the roadway surface at Elevation 240.9 m. Below the asphalt, the borehole encountered a 5.7 m deposit of fill comprised of an upper approximately 0.9 m thick layer of sand and gravel to sand, underlain by a 3.0 m thick layer of blast rock, underlain by a lower approximately 1.8 m thick layer of sand to sand and gravel with some organics. Borehole C2-3 was advanced near the toe of the embankment and encountered an approximately 1.7 m thick layer of sand fill with the ground surface at Elevation 236.1 m.

SPT 'N'-values measured within the sand to sand and gravel fill deposit range from 3 blows to 23 blows per 0.3 m of penetration, suggesting a very loose to compact relative density.

The grain size distributions of two samples of the sand fill are presented on Figure G1 in Appendix G.

The water content of two samples of the fill is 4 per cent and 24 per cent.



Water

Borehole C2-1 encountered approximately 0.1 m of ponded water, with the water surface at Elevation 236.2 m.

Peat

A deposit of black fibrous and/or amorphous peat was encountered below the water in Borehole C2-1 and below the lower deposit on sand to sand and gravel fill in Borehole C2-2. The top of the peat deposit is at Elevation 236.1 m and 235.0 m, and the thickness of the deposit is 1.5 m and 1.3 m in Boreholes C2-1 and C2-2, respectively.

SPT 'N'-values measured within the peat are between 1 blow and 3 blows per 0.3 m of penetration, suggesting a very soft to soft consistency.

The natural water content measured on two samples of this deposit is about 115 per cent and 305 per cent.

Silt

A deposit of grey silt containing trace to some clay, trace sand and trace organics was encountered underlying the peat in Boreholes C2-1 and C2-2. The top of the silt deposit is at about Elevation 234.6 m and 233.7 m, and the thickness of the deposit is 0.5 m and 0.4 m in Boreholes C2-1 and C2-2, respectively.

A grain size distribution for one sample of the silt deposit is shown on Figure G2 in Appendix G.

The natural water content measured on a sample of this deposit is about 50 per cent.

Sand and Gravel

A layer of grey sand and gravel was encountered underlying the silt in Borehole C2-2 and underlying the fill in C2-3. In Boreholes C2-2 and C2-3, the top of this layer is at Elevation 233.3 m and 234.4 m and the thicknesses of the layer are 0.3 m and 0.1 m, respectively.

One SPT 'N'-value recorded within this deposit is 25 blows per 0.3 m of penetration, indicating a compact relative density.

A grain size distribution of one sample of the sand and gravel deposit is shown on Figure G3 in Appendix G.

The natural water content measured on a sample of this deposit is about 11 per cent.

Bedrock/Refusal

Bedrock was encountered in Borehole C2-1 and in the adjacent DCPT at a depth of 2.1 m and 2.4 m below water surface corresponding to Elevation 234.1 m, and 3.1 m of bedrock core was recovered in Borehole C2-1. Refusal was encountered in Borehole C2-3 and in the adjacent DCPT at depths of 1.8 m and 1.3 m below ground surface. To confirm the nature of the refusal condition, Borehole C2-3a was advanced adjacent to the original borehole and bedrock was encountered at a depth of 1.5 m below ground surface (Elevation 234.6 m)



and bedrock was cored for a length of 3.2 m. Based on a review of the bedrock core samples from Borehole C2-1 and Borehole C2-3a, the bedrock consists of a fine to medium grained, fresh, pinkish grey granitic gneiss, and a fine to medium grained, slightly weathered grey to black gneiss, respectively.

The TCR is between 81 per cent and 100 per cent for the core samples recovered and the SCR ranges from approximately 55 per cent to 100 per cent. In Borehole C2-1, RQD values measured on the recovered bedrock core samples are between 91 per cent and 100 per cent indicating the granitic gneiss rock is of excellent quality according to Table 3.10 in CFEM (2006). In Borehole C2-3a, the RQD values are between 44 per cent and 100 per cent indicating the gneiss rock is of poor to excellent quality.

Refusal to further casing penetration was encountered in Borehole C2-2 at a depth of 7.9 m below ground surface, corresponding to Elevation 233.0 m.

Groundwater Conditions

Borehole C2-1 encountered ponded water, with the water surface at Elevation 236.2 m. The unstabilized water level in Borehole C2-2 and Borehole C2-3 was measured at 4.6 m below ground surface and at ground surface upon completion of drilling, corresponding to Elevation 236.3 m and Elevation 236.1 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.10 Culvert at STA 14+651 (Bonfield Township)

The plan and profile along the culvert centreline showing the borehole and DCPT locations and interpreted stratigraphy at approximately STA 14+651 in Bonfield Township are shown on Drawing H1. The height of the embankment at this location is about 10 m and the existing CSP is about 46 m long with a diameter of 910 mm. The PDR indicates that the culvert is rusted on the (inlet) south side of the embankment and not visible on the (outlet) north side of the embankment. A total of five boreholes and three DCPTs were advanced in the vicinity of the culvert to investigate the subsurface conditions at the culvert site: four boreholes and the three DCPTs (Boreholes C1-1 to C1-4 and DCPTs C1-DC1 to C1-DC3) were advanced near the ends of the culvert and one borehole (Borehole C1-5) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area consists of a low-lying swamp with bedrock and tree cover beyond the swamp limits.

Ice

Boreholes C1-3 and C1-4 were advanced from the ice surface at Elevation 238.2 m and the ice was 0.5 m thick.

Embankment Fill

Borehole C1-5 was advanced through the existing roadway embankment and encountered a 260 mm thick layer of asphalt, with the roadway surface at Elevation 247.2 m. Below the asphalt, the borehole encountered a 9.7 m thick deposit of fill comprised of an upper 0.8 m thick layer of sand and gravel to sand, underlain by a 7.7 m thick layer of blast rock, and a lower 1.2 m thick layer of sand. From ground surface in Borehole C1-1 at



Elevation 238.1 m, and below the ice in Borehole C1-3 at Elevation 237.7 m, the boreholes penetrated an approximately 1.1 m and 1.2 m thick layer of fill comprised of sand and gravel to gravelly sand.

SPT 'N'-values measured within the sand and gravel to sand fill range between 1 blow and 12 blows per 0.3 m of penetration, suggesting a very loose to compact relative density.

The grain size distributions of two samples of the granular fill are presented on Figure H1 in Appendix H.

The water content of the fill samples ranges from 16 per cent to 34 per cent.

Peat

A deposit of black fibrous and/or amorphous peat was encountered below the fill in Boreholes C1-1 and C1-5, from ground surface in Borehole C1-2 and below the ice in Borehole C1-4. The top of the peat ranges from Elevation 238.2 m to 237.0 m and the thickness of the deposit is between 0.4 m and 6.4 m.

SPT 'N'-values measured within the peat range from 0 blows (weight of hammer) to 6 blows per 0.3 m of penetration, suggesting a very soft to firm consistency.

The natural water content measured on samples of this deposit ranges from about 86 per cent to 781 per cent. The organic content measured on two samples of this deposit is 24 per cent and 45 per cent.

Sand and Silt

A 0.5 m thick deposit of grey sand and silt containing some gravel, trace clay and trace to some organics was encountered below the peat deposit in Borehole C1-4 at Elevation 237.3 m.

One SPT 'N'-value recorded in this layer is 23 blows per 0.3 m of penetration, indicating a compact relative density.

The grain size distribution for one sample of the sand and silt is shown on Figure H2 in Appendix H.

The water content of the sample of sand and silt is 62 per cent and the organic content in the sample is approximately 3 per cent.

Sand and Gravel

A 0.3 m to 0.5 m thick deposit of grey sand and gravel, containing trace to some silt was encountered underlying the peat in Boreholes C1-1 and C1-2 at Elevation 232.6 m and 231.2 m, respectively.

One SPT 'N'-value recorded within this deposit is 54 blows per 0.3 m indicating a very dense relative density.

Grain size distributions for the two samples of the sand and gravel deposit are shown on Figure H3 in Appendix H.

The natural water content measured on the two samples of this deposit is 10 per cent and 39 per cent.



Bedrock/Refusal

Bedrock was encountered below the sand and silt in Borehole C1-4 and below the peat in Borehole C1-5 at depths of 1.4 m and 10.6 m below ice surface (0.9 m below ground surface) and below the top of the roadway embankment, corresponding to Elevation 236.8 m and Elevation 236.6 m, respectively. Based on a review of the bedrock core samples, the bedrock consists of fine to coarse grained, fresh, grey gneiss.

The TCR is 100 per cent for the core samples from both boreholes and the SCR is between about 88 per cent and 100 per cent. RQD values measured on the recovered bedrock core samples are between 81 per cent and 100 per cent indicating the rock is of good to excellent quality according to Table 3.10 in CFEM (2006).

Refusal to split-spoon advancement was encountered in Boreholes C1-1 to C1-3 at depths ranging from 1.2 m to 7.5 m below ground surface, corresponding to between Elevation 236.5 m and 230.3 m. Refusal to dynamic cone penetration was encountered in DCPTs C1-DC1, C1-DC2 and C1-DC3 at depths ranging from 1.2 m to 8.4 m below ground surface, corresponding to between Elevations 236.9 m and 229.8 m. These refusal depths, while they do not confirm bedrock elevations, in comparison to the bedrock surface elevation encountered in the adjacent boreholes may be likely on or in proximity to the bedrock surface.

Groundwater Conditions

Water levels observed in the boreholes upon completion of drilling range from Elevation 238.4 m to 237.9 m, measured 0.2 m and 0.3 m below the ground surface in Boreholes C1-1 and C1-2, respectively, at the ice surface in Boreholes C1-3 and C1-4 and 8.8 m below the ground surface in Borehole C1-5. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.11 Culvert at STA 14+978 (Bonfield Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 14+978 in Bonfield Township are shown on Drawing I1. The height of the embankment at this location is approximately 5 m and the existing CSP culvert is 33 m long with a diameter of 910 mm. The PDR indicates that the culvert is buried and submerged. A total of three boreholes were completed in the vicinity of the culvert: two boreholes (Boreholes C3-1 and C3-3) were advanced near the ends of the culvert and one borehole (Borehole C3-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the culvert area is flat and consists of a small swamp area with moderate to dense tree cover and bedrock outcrops beyond the edges of the swamp.

Embankment Fill

Borehole C3-2 was advanced through the existing roadway embankment and encountered a 275 mm thick layer of asphalt, with the ground surface at Elevation 253.9 m. Below the asphalt, the borehole encountered a 4.9 m thick deposit of fill, comprised of an upper 1.1 m thick layer of sand and gravel to sand, underlain by a 2.7 m thick layer of blast rock and a lower 1.1 m thick layer of sand.



One SPT 'N'-value measured within the upper layer of sand and gravel to sand fill is 44 blows per 0.3 m of penetration, indicating a dense relative density. One SPT 'N'-value measured within the lower layer of sand fill is 2 blows per 0.3 m of penetration, indicating a very loose relative density.

The grain size distribution of one sample of the upper granular fill is presented on Figure I1 in Appendix I.

The water content of one sample of the upper fill is 3 per cent.

Topsoil

A 0.3 m and 0.4 m thick layer of sandy topsoil was encountered at ground surface in Boreholes C3-1 and C3-3 at Elevation 249.4 m and 249.3 m, respectively.

One SPT 'N'-value measured within this deposit is 0 blows (weight of hammer) per 0.3 m of penetration, indicating a very loose relative density.

Silty Sand to Sand and Silt

A deposit of brown to grey silty sand to sand and silt, some clay was encountered below the sandy topsoil in Boreholes C3-1 and C3-3. The top of this deposit is at Elevation 249.1 m and 248.9 m, and the thicknesses of the deposit are 0.6 m and 1.3 m for Boreholes C3-1 and C3-3, respectively.

Two SPT 'N'-values recorded within this deposit are 4 blows and 9 blows per 0.3 m of penetration, indicating a loose relative density.

A grain size distribution of one sample of the sand and silt deposit is shown on Figure I2 in Appendix I.

The natural water content measured on one sample of this deposit is about 21 per cent.

Clayey Silt to Silty Clay

A deposit of brown to grey clayey silt to silty clay was encountered underlying the roadway embankment fill in Borehole C3-2 and the silty sand to sand and silt deposit in Boreholes C3-1 and C3-3. The top of this deposit is between Elevation 248.7 m and 247.6 m, and the thicknesses of the deposit are between 0.8 m and 1.8 m.

The SPT 'N'-values recorded within this deposit range from 4 blows to 10 blows per 0.3 m of penetration. In situ field vane testing carried out within this stratum measured undrained shear strengths of approximately 23 kPa and 45 kPa. The SPT 'N'-values together with the vane tests indicate that the cohesive deposit has a soft to stiff consistency.

Atterberg limits testing carried out on five samples of the clayey silt to silty clay deposit yielded liquid limits ranging from 27 per cent to 46 per cent, plastic limits ranging from 19 per cent to 21 per cent and plasticity indices ranging from 8 per cent to 26 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure I3 in Appendix I and indicate that the deposit consists of clayey silt of low plasticity to silty clay of intermediate plasticity.



The natural water content measured on samples of the silty clay to clayey silt deposit is between 30 per cent and 40 per cent.

Silt

A deposit of grey silt, trace to some clay and trace sand was encountered below the clayey silt to silty clay deposit in each of the three boreholes. The top of the silt deposit is between Elevation 247.7 m and 245.8 m and the thickness of the deposits ranges between 1.7 m and 2.4 m.

The SPT 'N'-values recorded within the silt deposit range from 3 blows to 11 blows per 0.3 m of penetration, indicating a loose to compact relative density.

Grain size distributions of three samples of the silt deposit are shown on Figure I4 in Appendix I.

The natural water content measured on samples of the silt is between about 27 per cent and 43 per cent.

Sand to Sand and Gravel

A deposit of grey sand to sand and gravel, trace to some silt and trace clay was encountered underlying the silt deposit in each of the boreholes. The top of the sand to sand and gravel deposit is between Elevation 245.3 m and 244.1 m and the thickness of the deposit ranges between 1.0 m and 1.9 m.

The SPT 'N'-values recorded within the sand to sand and gravel deposit range from 7 blows to 27 blows per 0.3 m of penetration, indicating a loose to compact relative density.

Grain size distributions of two samples of this granular deposit are shown on Figure I5 in Appendix I.

The natural water content measured on samples of the sand to sand and gravel deposit is between about 12 per cent and 16 per cent.

Refusal

Refusal to further auger advancement or casing penetration was encountered in each of the boreholes at depths between 5.6 m and 10.6 m below ground surface, between Elevation 243.8 m and 243.1 m.

Groundwater Conditions

The unstabilized water levels in Boreholes C3-2 and C3-3 upon completion of drilling were measured at 4.5 m and 1.5 m below ground surface, respectively, corresponding to Elevation 249.4 m and 247.8 m. In Borehole C3-1, artesian conditions were encountered upon completion of drilling with the water level measured inside the hollow stem augers at approximately 0.6 m above the ground surface. A piezometer was installed in this borehole to permit monitoring of the water levels at later dates. On November 17, 2011, the water level in the piezometer was measured at 1.4 m above ground surface, corresponding to Elevation 250.8 m. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.



4.12 Culvert at STA 15+400 (Bonfield Township)

The plan and profile along the culvert centreline showing the borehole locations and interpreted stratigraphy at approximately STA 15+400 in Bonfield Township are shown on Drawing J1. The height of the embankment at this location is 4 m and the existing CSP culvert is approximately 38 m long with a diameter of 760 mm. The PDR indicates that the culvert is almost full of fill material and the north side is not visible, likely buried under fallen trees. A total of three boreholes and two DCPTs were completed in the vicinity of the culvert: two boreholes and two companion DCPTs (Boreholes C4-1 and C4-3) were advanced near the ends of the culvert and one borehole (Borehole C4-2) was advanced through the roadway embankment near the midpoint of the culvert. In general, the topography in the proposed culvert area consists of downward sloping terrain easterly towards Kaibuskong River and moderate tree cover.

Embankment Fill

Borehole C4-2 was advanced through the existing roadway embankment and encountered a 165 mm thick layer of asphalt with the ground surface at Elevation 237.9 m. Below the asphalt, Borehole C4-2 encountered a 4.2 m thick layer of fill comprised of sand and gravel to sand. Borehole C4-1 was advanced near the south embankment toe and encountered a 0.3 m thick layer of sandy topsoil fill from ground surface at Elevation 234.3 m underlain by a 0.8 m thick layer of sand fill. Borehole C4-3 was advanced near the north embankment toe and encountered a 3.1 m thick layer of sand to sand and gravel fill from ground surface at Elevation 235.1 m. Cobbles were inferred within the fill in Borehole C4-3 at a depth of 0.8 m below ground surface (Elevation 234.3 m) resulting in auger refusal and the borehole was relocated 0.7 m westerly. The bottom of fill in the relocated Borehole C4-3 was defined by refusal to split-spoon advancement at a depth of approximately 3.1 m below ground surface.

SPT 'N'-values measured within the sand and gravel to sand fill in Boreholes C4-1, C4-2 and C4-3 range from 1 blow to 91 blows per 0.3 m of penetration, indicating a very loose to very dense relative density.

The grain size distributions of four samples taken of the sand and gravel to sand fill deposit are presented on Figure J1 in Appendix J.

The natural water content measured on five samples of the fill ranges from about 4 per cent to 15 per cent.

Topsoil/Peat

A 0.6 m thick layer of silty topsoil/peat was encountered below the sand fill in Borehole C4-1 at Elevation 233.2 m.

The natural water content measured on a sample of this deposit is 76 per cent.

Silt to Silty Sand

A 2.7 m thick deposit of grey silt was encountered underlying the silty topsoil/peat in Borehole C4-1 at Elevation 232.6 m and a 4.2 m thick deposit of sandy silt to silty sand was encountered below the fill in Borehole C4-2 at Elevation 233.5 m. The bottom of the deposit in both boreholes was defined by auger refusal.



The SPT 'N'-values recorded within the silt to silty sand deposit range from 4 blows to 37 blows per 0.3 m, indicating a loose to dense relative density.

The grain size distributions of three samples of the silt to silty sand deposit are shown on Figure J2 in Appendix J.

The natural water content measured on samples of this deposit is between 11 per cent and 25 per cent.

Refusal

Refusal to further auger split-spoon and DCPT advancement was encountered between depths of 3.1 m and 8.6 m below ground surface, between Elevation 232.0 m and 228.5 m.

Groundwater Conditions

Water levels in the open boreholes upon completion of drilling range from Elevation 235.1 m to 231.8 m, corresponding to depths between ground surface and 6.1 m below ground surface. Groundwater levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

5.0 CLOSURE

The field personnel supervising the drilling program were Mr. Indulis Dumpis, Mr. Luigi Gianfrancesco, EIT, Mr. Gabriel Mathieu, Mr. Chris Radway and Mr. Ed Savard. This report was prepared by Mr. Matthew Thibeault, EIT. 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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Canadian Highway Bridge Design Code (CHBDC) and Commentary, 2006. CAN/CSA-S6-06 and CSA Special Publication S6.1 06, Canadian Standards Association.

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

Rutledge, P.C. and Gould, J.P., 1973. Movements of Articulated Conduits Under Earth Dams on Compressible Foundations, In: Embankment Dam Engineering – Casagrande Volume. Eds. Hirschfeld, R.C. and Poulos, S.J. John Wiley & Sons, New York.

ASTM International:

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

ASTM D2573 Standard Test Method for Field Vane Shear Test in Cohesive Soil

Commercial Software

GeoStudio (Version 7.17) by Geo-Slope International Ltd.

Settle 3D (Version 2.003) by Rocscience Inc.

Contract Design Estimating and Documentation (CDED):

Special Provision 105S10 Construction Specification for Compacting.

Special Provision 110S13 Material Specification for Aggregates – Base, Subbase, Subgrade and Backfill Material

Special Provision 422.501 Precast Concrete Box Culvert

Special Provision 206S03 Earth Excavation, Grading; Earth Embankment; Rock Excavation, Grading; Rock Embankment

Ministry of Transportation Ontario, Guideline for Rock Fill Settlement and Rock Fill Quantity Estimates, September 2010.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects as amended by O. Reg. 443/09

Ontario Provincial Standard Drawings:

OPSD 202.010 Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment

OPSD 203.030 Embankments Over Swamp, Existing Slopes Maintained

OPSD 208.010 Benching of Earth Slopes



FOUNDATION REPORT - HIGHWAY 17 CULVERT REPLACEMENTS
GWP 174-98-00

OPSD 802.031	Rigid Pipe Bedding, Cover and Backfill, Type 3 Soil - Earth Excavation.
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 810.010	Rip-Rap Treatment for Sewer and Culvert Outlets
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 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS 1002	Material Specification for Aggregates - Concrete
OPSS 1205	Material Specification for Clay Seal

Ontario Water Resources Act:

Ontario Regulation 372/97 Amendment to Ontario Regulation 903



Table 1: Summary of Culvert Details

Culvert Location Highway 17 (Township)	Approximate Existing Embankment Height ¹ (m)	Proposed Culvert ²			Invert Elevations ²		Modification to Existing Embankment Geometry	Boreholes	Reference Appendix
		Type	Diameter or Rise X Span (mm)	Length (m)	South End of Culvert (m)	North End of Culvert (m)			
STA 16+056 (East Ferris)	6	Concrete Pipe	1,800	37	222.7	222.4	Not required	3 Boreholes and 2 DCPTs (C10-1 to C10-3)	A
STA 20+261 (East Ferris)	5	Corrugated Pipe	1,200	36	233.1	233.6	Not required	3 Boreholes and 1 DCPT (C9-1 to C9-3)	B
STA 20+617 (East Ferris)	6	Concrete Pipe	1,200	42	236.4	236.3	Not required	3 Boreholes and 1 DCPT (C8-1 to C8-3)	C
STA 21+181 (East Ferris)	5	Concrete Pipe	1,500	35	235.3	235.0	Not required	3 Boreholes and 1 DCPT (C7-1 to C7-3)	D
STA 10+286 Laren Creek (Bonfield)	3	Existing Concrete Box (no replacement)	3,000 x 1,600	31	231.2	231.0	Not required	3 Boreholes and 1 DCPT (C6-2 to C6-4)	E
		Concrete Box	1,800 x 1,200	32	231.6	231.4			
STA 13+599 Barse Creek (Bonfield)	3	Concrete Box	3,600 x 1,800	31	238.7	238.8	East and Westbound Passing Lane Extensions (Widening 2 m south and 3 m north)	3 Boreholes and 2 DCPTs (C5-1 to C5-3)	F
STA 14+063 (Bonfield)	5	Concrete Pipe	1,200	39	236.5	236.7	Westbound Truck Climbing Lane Extension (Widening 4 m north)	4 Boreholes and 2 DCPTs (C2-1, C2-2, C2-3 and C2-3a)	G
STA 14+651 (Bonfield)	10	Concrete Pipe	1,350	54	237.3	237.1	Westbound Truck Climbing Lane Extension (Widening 4 m north)	5 Boreholes and 3 DCPTs (C1-1 to C1-5 and C1-DC1 to C1-DC3)	H
STA 14+978 (Bonfield)	5	Concrete Pipe	1,000	35	248.9	248.2	Not required	3 Boreholes (C3-1 to C3-3)	I
STA 15+400 (Bonfield)	4	Corrugated Pipe	800	38	234.7	235.2	Not required	3 Boreholes and 2 DCPTs (C4-1 to C4-3)	J

Notes: 1. Embankment height is relative to existing ground surface level near toe of embankment.
2. Culvert information provided by MMM

Prepared by: MT
Checked by: AB



Table 2: Summary of Analytical Testing of Surface Water

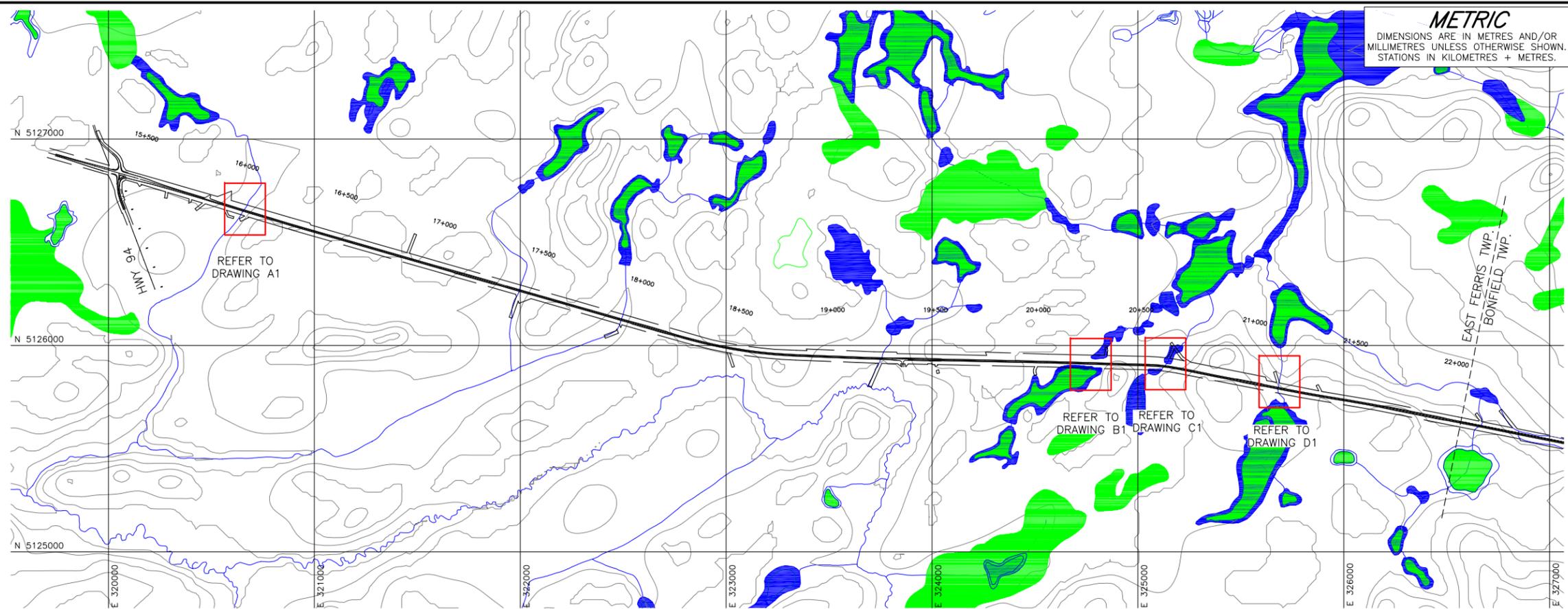
Culvert Location Highway 17 (Township)	Parameter (Units, Detection Limit)				
	Chloride (mg/L, 0.2)	Sulfate (mg/L, 1)	Conductivity (μ S/cm, 1)	Resistivity (Mohm-cm)	pH
STA 16+056 (East Ferris)	39.4	1.2	237	0.0042	6.9
STA 20+261 (East Ferris)	108	<1	411	0.0024	6.4
STA 20+617 (East Ferris)	144	1.5	505	0.0020	6.6
STA 21+181 (East Ferris)	17.6	1.3	106	0.0094	6.8
STA 10+286 Laren Creek (Bonfield)	17.2	1.3	93.2	0.0107	6.6
STA 13+599 Barse Creek (Bonfield)	7.5	<1	66.4	0.0151	6.3
STA 14+063 (Bonfield)	190	10.8	705	0.0014	7.3
STA 14+651 (Bonfield)	45.2	4.9	191	0.0052	6.7
STA 14+978 (Bonfield)	4.2	<1	55.1	0.0181	6.7
STA 15+400 (Bonfield)	20.3	1.8	149	0.0067	7.2

Notes: 1. Samples obtained June 30, 2011.
2. Analytical testing carried out by Testmark Laboratory Ltd.

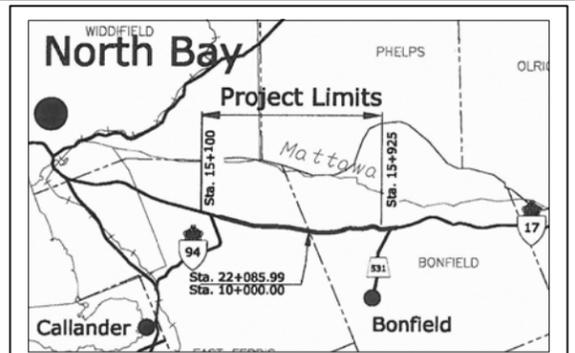
Prepared by: MT
Checked by: AB



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



PLAN



KEY PLAN

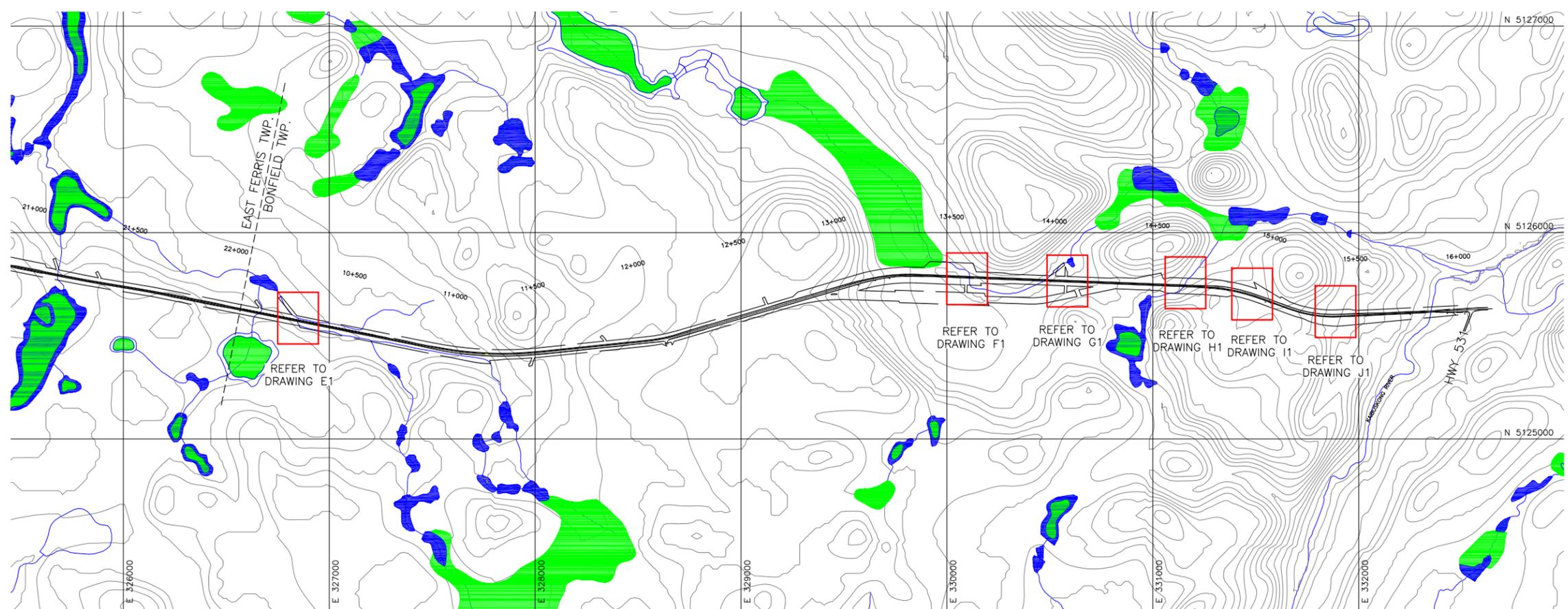
SCALE
5 0 5 km

LEGEND

- Approximate Swamp Limits
- Pond / Open Water
- Contours
- Culvert Location

REFERENCE

Base plans provided in digital format by MPM, drawing file nos. BASE_ALL.dwg and Alignment.dwg received NOV 10, 2011. Keyplan received DEC, 07, 2011.



PLOT DATE: April 17, 2013
 FILENAME: \\s:\s-cad\gwp\Projects\2010\10-1191-0041_MMM_Hwy_17_Bonfield\CAD\Projects\2010\10-1191-0041_MMM_Hwy_17_Bonfield\CAD\101910041M003_Drawing_1.dwg

NO.	DATE	BY	REVISION
Geocres No. 31L-158			
HWY. 17	PROJECT NO. 10-1191-0041		DIST.
SUBM'D.	CHKD. AB	DATE: APR 2013	SITE:
DRAWN: JUL	CHKD.	APPD.	DWG. 1



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

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

Piezo-Cone Penetration Test (CPT)

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

V. MINOR SOIL CONSTITUENTS

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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



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
$\log_{10} x$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

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

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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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



APPENDIX A

Culvert at STA 16+056 – Highway 17 (East Ferris Township)



PHOTOGRAPHS

Photograph 1: Culvert at STA 16+056, Looking West (June 2011)



Photograph 2: Culvert at STA 16+056, Looking South (June 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C10-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5126635.9; E 320649.8</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>June 27, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
							20	40	60	80	100					
223.5	GROUND SURFACE															
0.0	PEAT mixed with sand Soft Brown Moist to wet		1	SS	3											
222.6																
0.9	SAND and SILT, trace to some gravel, trace clay Compact Brown Wet		2	SS	14											13 42 40 5
221.7																
221.7			3	SS	24/0.15											4 58 37 1
1.8	GRANITIC GNEISS (BEDROCK)															
	Bedrock cored from 1.8 m depth to 5.0 m depth. For coring details see Record of Drillhole C10-1.		1	RC	REC 100%											RQD = 75%
			2	RC	REC 100%											
			3	RC	REC 100%											
218.5																
5.0	END OF BOREHOLE															
	Note: 1. Water level at a depth of 0.6 m below ground surface (Elev. 222.9 m) upon completion of drilling. 2. Advanced DCPT 1.0 m east of Borehole C10-1. Refusal at a depth of 1.8 m.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

PROJECT: 10-1191-0041

RECORD OF DRILLHOLE: C10-1

SHEET 1 OF 1

LOCATION: N 5126635.9 ; E 320649.8

DRILLING DATE: June 27, 2011

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 FLUSH	RECOVERY			FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diameter Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION				
							TOTAL CORE %	SOLID CORE %	R.Q.D. %		B Angle	DIP w/EL. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn				k, cm/s	10 ⁰	10 ¹	10 ²
							80	80	80		0	0	0	0	0	0				0	0	0	0
		REFER TO PREVIOUS PAGE		221.7																			
2	NQ Coring June 27, 2011	GRANITIC GNEISS Fine to medium grained Pinkish grey Fresh		1.8																			
		Heavily fractured between 2.7 and 2.8 m depth.																					
3																							
4																							
5		END OF DRILLHOLE		218.5																			
5				5.0																			
6																							
7																							
8																							
9																							
10																							
11																							

SUD-RCK 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: AB

RECORD OF BOREHOLE No C10-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5126647.6; E 320663.8 ORIGINATED BY ID

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 28, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20
228.5	GROUND SURFACE																	
0.0	ASPHALT (100 mm)																	
	Sand and gravel to sand (FILL) Brown Moist																	
227.4	Blast rock (FILL)		1	SS	56													
1.1			2	SS	34/0.15													
226.2																		
2.3	Sand some gravel to sand and gravel, trace to some silt (FILL) Loose to compact Brown Wet		3	SS	9												17	60 (23)
			4	SS	15												39	58 (3)
			5	SS	17													
223.9																		
223.6	Silty clay (FILL) Grey Wet		6	SS	2													
4.9																		
	PEAT (Amorphous) Soft to stiff Brown / black Wet		7a	SS	13													
222.7			7b															
	SAND and SILT, some gravel, trace clay Grey Wet		8	SS	13/0.1												18	43 34 5
222.3																		
6.2	GRANITIC GNEISS (BEDROCK)		1	RC	REC 100%													RQD = 95%
	Bedrock cored from 6.2 m depth to 9.6 m depth.																	
	For coring details see Record of Drillhole C10-2.		2	RC	REC 100%													RQD = 89%
			3	RC	REC 100%													RQD = 100%
218.9	END OF BOREHOLE																	
9.6	Note: 1. Water level at a depth of 4.2 m below ground surface (Elev. 224.3 m) upon completion of drilling.																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

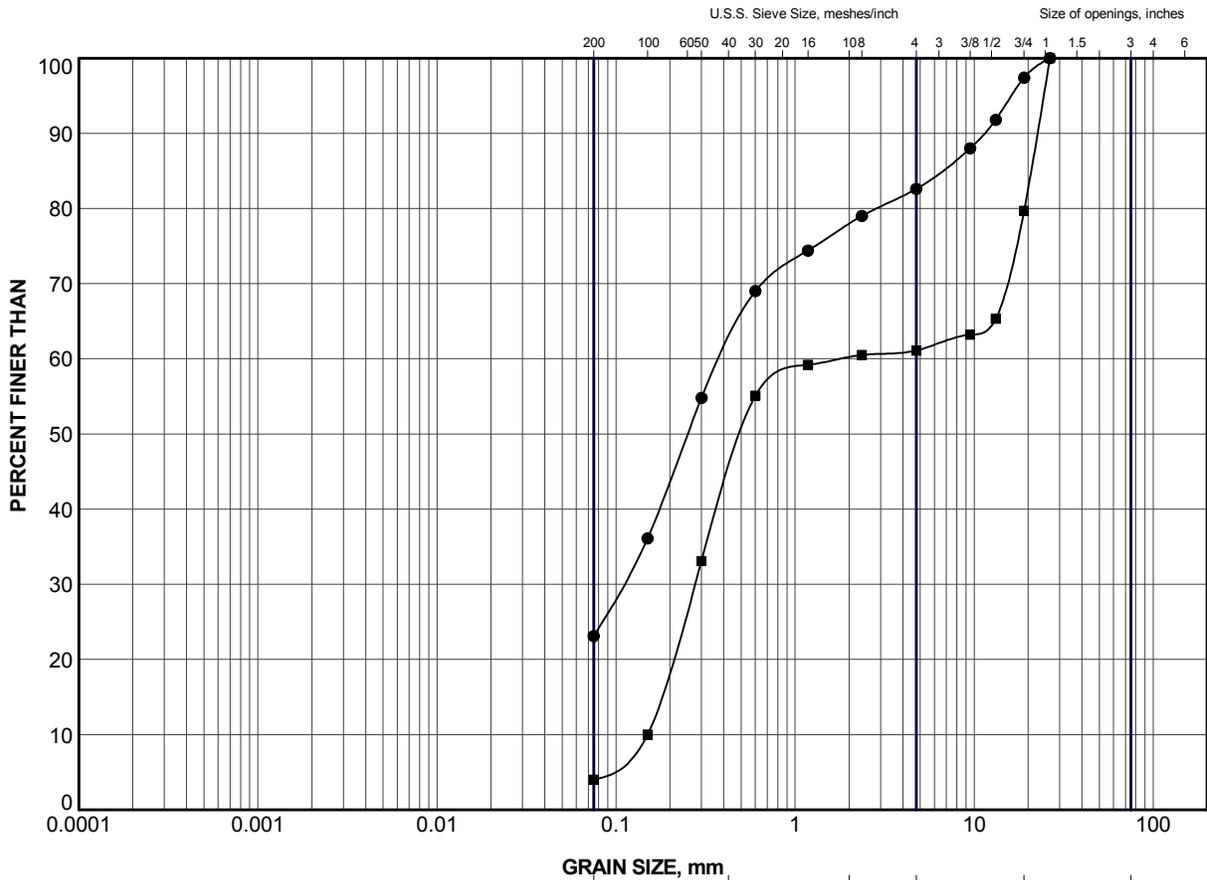
+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C10-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5126672.0; E 320665.4</u>	ORIGINATED BY <u>LG</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>June 15, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W			W _L	GR
222.5	WATER SURFACE																	
0.0	WATER																	
0.1	PEAT (Fibrous)		1	SS	8													
221.9	Stiff Brown Wet																	
0.6	END OF BOREHOLE SPOON REFUSAL																	
Note: 1. Advanced DCPT 0.3 m east of Borehole C10-3. Refusal at a depth of 0.6 m. 2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT 'N' value has been adjusted to the inferred value that would be obtained using a standard weight hammer.																		

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



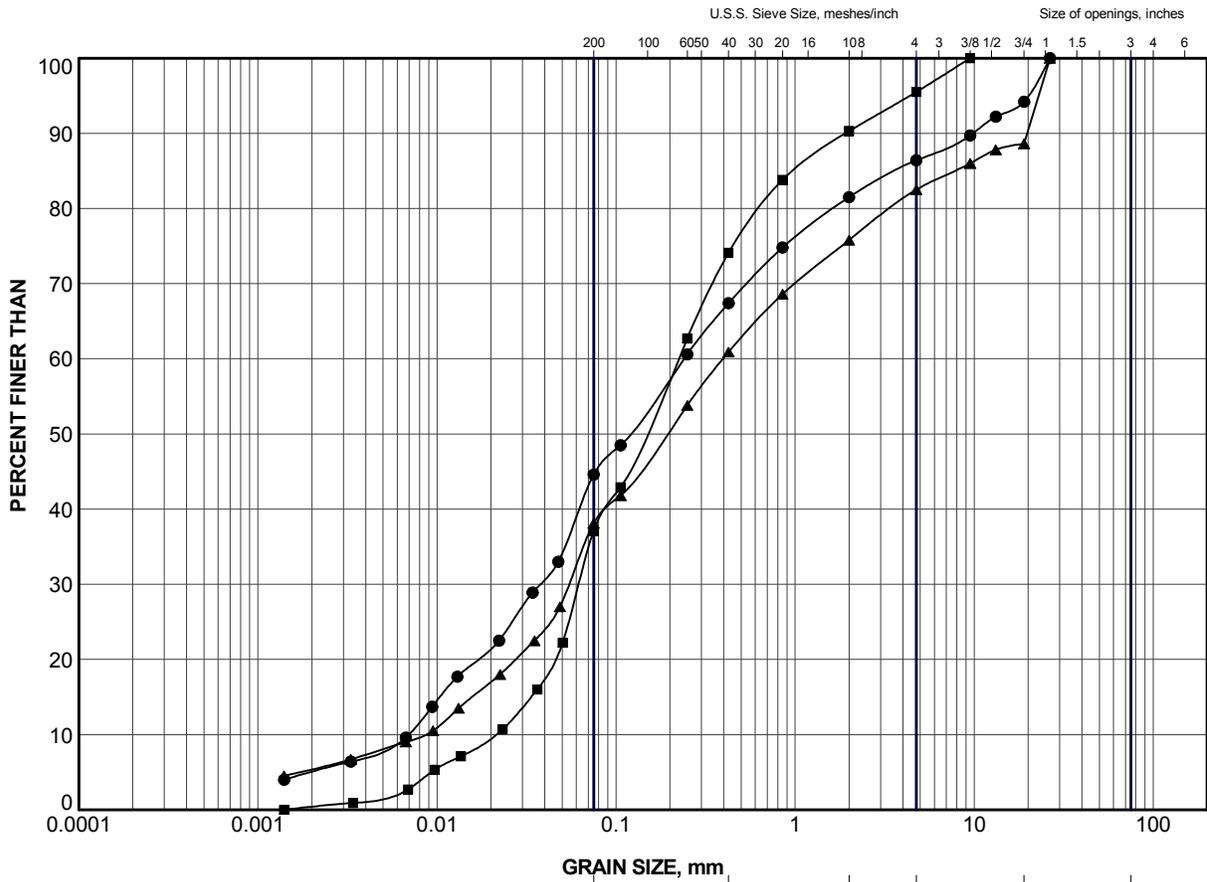
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C10-2	3	225.9
■	C10-2	4	225.1

PROJECT HIGHWAY 17 CULVERT AT STA 16+056						
TITLE GRAIN SIZE DISTRIBUTION SAND TO SAND AND GRAVEL (FILL)						
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE A1	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C10-1	2	222.4
■	C10-1	3	221.8
▲	C10-2	7b	222.6

PROJECT						HIGHWAY 17 CULVERT AT STA 16+056					
TITLE						GRAIN SIZE DISTRIBUTION SAND AND SILT					
PROJECT No.			10-1191-0041			FILE No.			1011910041.GPJ		
DRAWN		J.J.L.		Feb 2012		SCALE		N/A		REV.	
CHECK		A.B.		Feb 2012		APPR		J.M.A.C.		Feb 2012	
 Golder Associates SUDBURY, ONTARIO						FIGURE A2					

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX B

Culvert at STA 20+261 – Highway 17 (East Ferris Township)



PHOTOGRAPHS

Photograph 1: Culvert at STA 20+261, Looking West (November 2011)



Photograph 2: Culvert at STA 20+261, Looking East (November 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C9-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125899.0; E 324767.9</u>	ORIGINATED BY <u>CR</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>July 7, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
234.5	WATER SURFACE															
0.0	WATER															
234.2																
0.3	Sand to sand and gravel, some silt, trace clay (FILL) Very loose to compact Grey Wet		1	SS	2											
			2	SS	21											18 65 14 3
			3	SS	14											
			4	SS	28											36 50 13 1
231.1																
3.4	GRAVEL, trace sand, trace silt Compact Grey to brown Wet		5	SS	12											
			6	SS	15/0.15											
230.0																
4.5	END OF BOREHOLE SPOON REFUSAL Note: 1. Advanced DCPT 1.5 m west of Borehole C9-1. Refusal at a depth of 3.8 m.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C9-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125911.5; E 324764.8 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 16, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W			W _L	GR	SA
238.4	GROUND SURFACE																		
0.0	ASPHALT (195 mm)																		
0.2	Sand to gravelly sand, trace to some silt (FILL) Compact to dense Brown Moist Cobbles encountered below 3.0 m depth. Auger refusal at 3.4 m, switched to NW casing.		1	AS	-														
			2	AS	-														
			3	SS	16														
			4	SS	10														
			5	SS	21														
			6	SS	31														
			7	SS	22														
			8	SS	23														
233.2	SAND and GRAVEL, trace to some silt, cobbles inferred from auger resistance Compact to dense Grey Wet		9	SS	37														
			10	SS	26														
231.7	GNEISS (BEDROCK) Bedrock cored from 6.7 m depth to 9.8 m depth. For coring details see Record of Drillhole C9-2.		1	RC	REC 100%														
			2	RC	REC 100%														
228.6	END OF BOREHOLE																		
9.8	Note: 1. Water level at a depth of 3.5 m below ground surface (Elev. 234.9 m) upon completion of drilling.																		

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C9-3 1 OF 1 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125928.6; E 324774.8 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 17, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)					
							20	40	60	80	100	W _p	W	W _L				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED											
235.2	GROUND SURFACE					235												
0.0	Sand and gravel, trace silt (FILL) Loose Brown Moist to wet	▨	1	SS	5	234						○				40	57	(3)
233.3	GNEISS (BEDROCK)					233												RQD = 0%
1.9	Bedrock cored from 1.9 m depth to 5.2 m depth. For coring details see Record of Drillhole C9-3.	▨	1	RC	REC 100%	232												RQD = 56%
		▨	2	RC	REC 100%	231												RQD = 75%
		▨	3	RC	REC 100%	230												
230.0	END OF BOREHOLE					230												
5.2	Note: 1. Water level at a depth of 0.8 m below ground surface (Elev. 234.4 m) upon completion of drilling.																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

PROJECT: 10-1191-0041

RECORD OF DRILLHOLE: C9-3

SHEET 1 OF 1

LOCATION: N 5125928.6 ; E 324774.8

DRILLING DATE: June 17, 2011

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.	FLUSH	COLOUR % RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY			Diametral 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				k, cm/s	10 ⁰	10 ¹	10 ²
								80	80			0	0	0	0	0	0				0	0	0	0
		REFER TO PREVIOUS PAGE		233.3																				
2	NO Coring June 17, 2011	GNEISS Fine to coarse grained Pinkish grey Slightly weathered		1.9	1	GREY	80%																	
		Heavily fractured between 1.9 m and 2.4 m depth.																						
3		Sand / silt filling in several joints.																						
4					2	GREY	100%																	
5					3	GREY	100%																	
		END OF DRILLHOLE		230.0	5.2																			

SUD-RCK 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

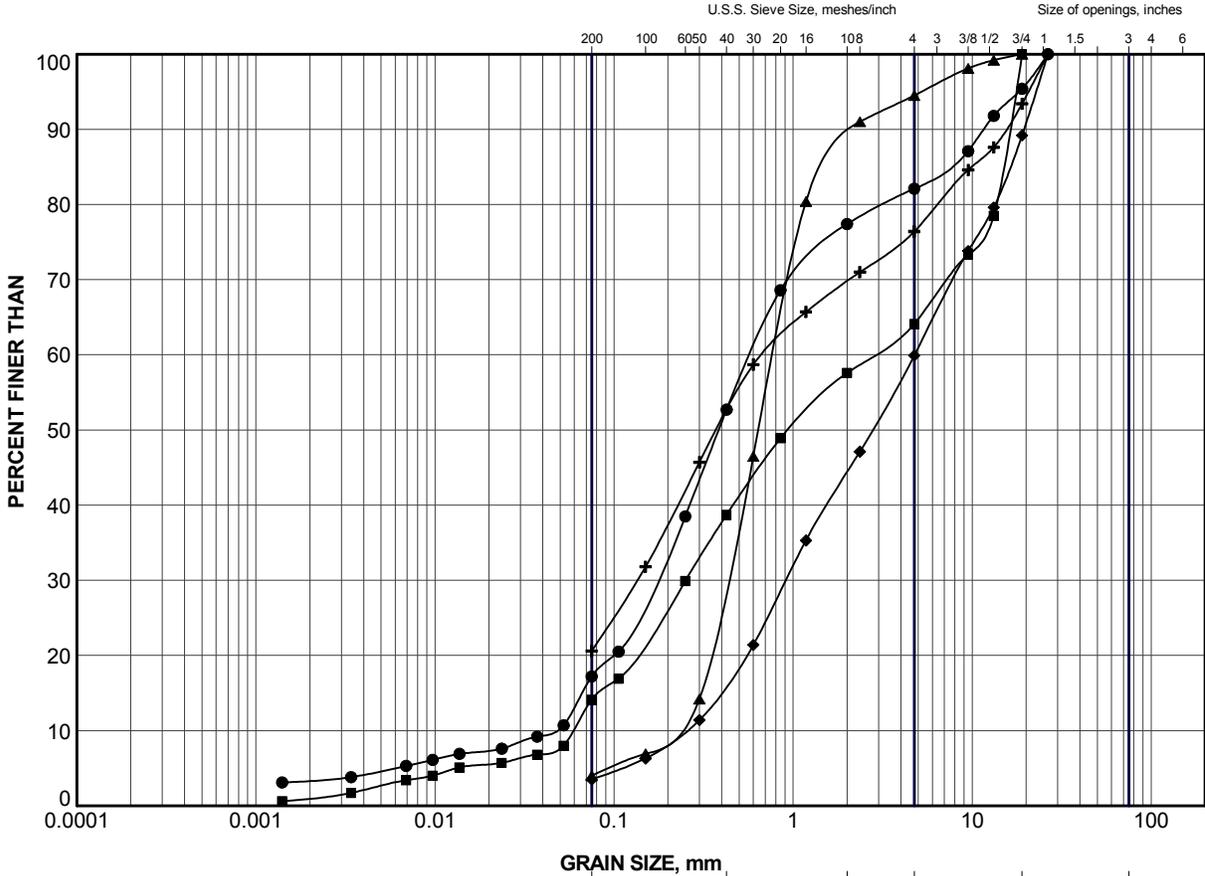
DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB



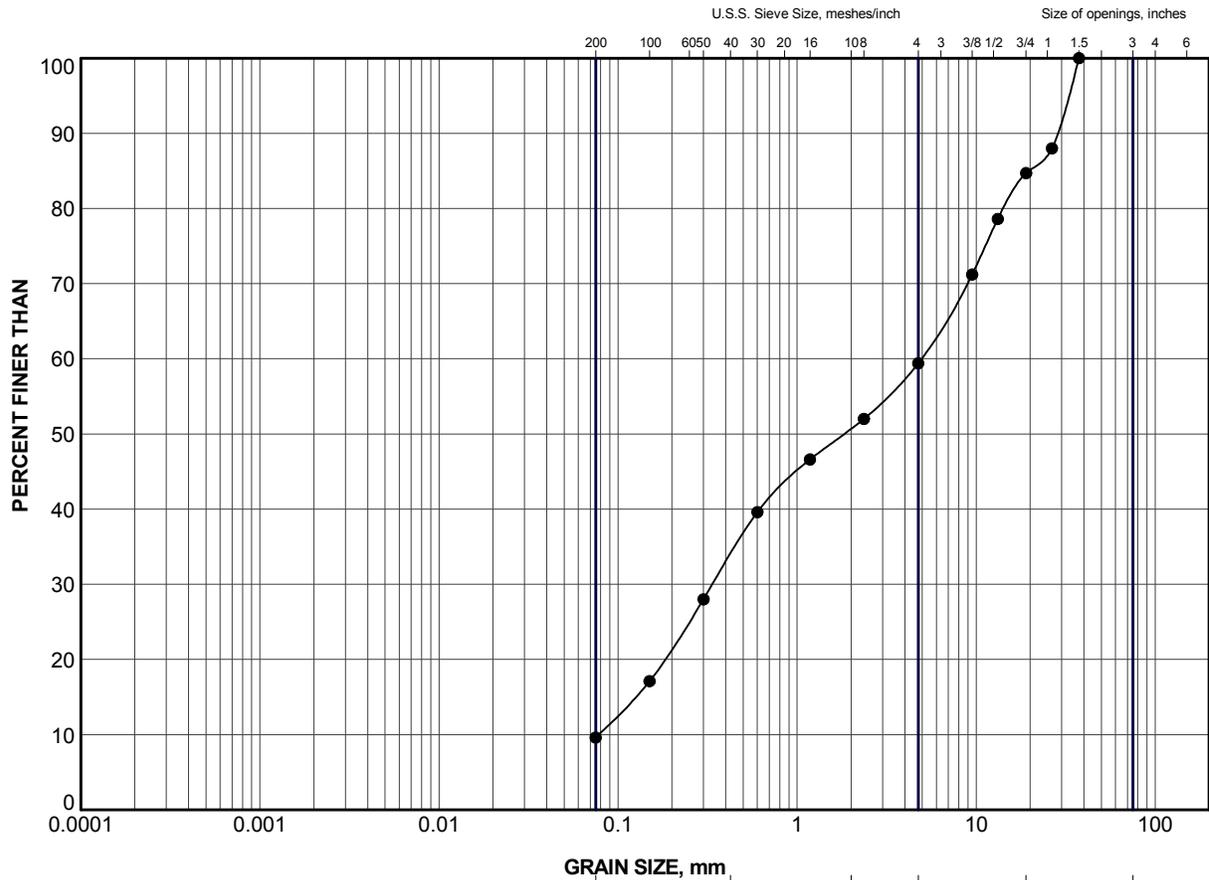
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C9-1	2	233.1
■	C9-1	4	231.6
▲	C9-2	5	235.8
+	C9-2	7	234.3
◆	C9-3	2	234.1

PROJECT HIGHWAY 17 CULVERT AT STA 20+261				
TITLE GRAIN SIZE DISTRIBUTION SAND TO SAND AND GRAVEL (FILL)				
PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
DRAWN	JLL	Feb 2012	SCALE	N/A
CHECK	AB	Feb 2012	FIGURE B1	
APPR	JMAC	Feb 2012		
 Golder Associates SUDBURY, ONTARIO				

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C9-2	10	232.0

PROJECT HIGHWAY 17 CULVERT AT STA 20+261						
TITLE GRAIN SIZE DISTRIBUTION SAND AND GRAVEL						
 Golder Associates SUDBURY, ONTARIO		PROJECT No.	10-1191-0041	FILE No.	1011910041.GPJ	
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE B2	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX C

Culvert at STA 20+617 – Highway 17 (East Ferris Township)

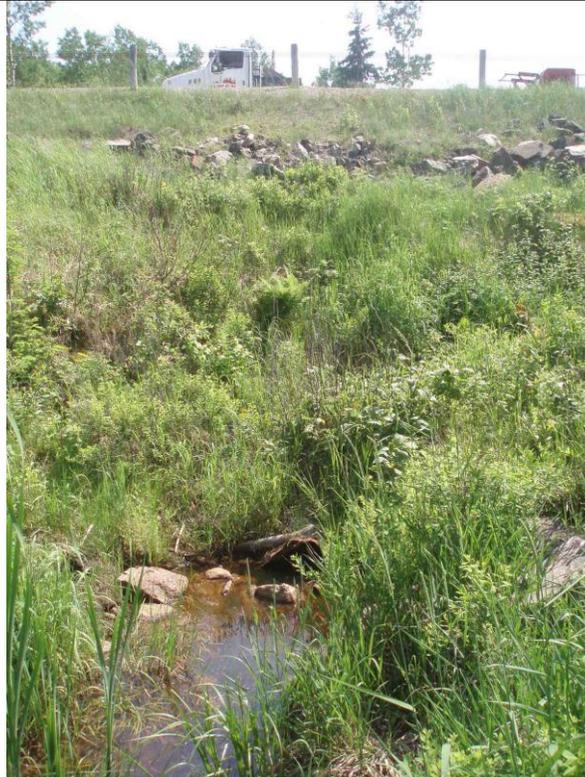


PHOTOGRAPHS

Photograph 1: Culvert at STA 20+617, Looking West (November 2011)



Photograph 2: Culvert at STA 20+617, Looking South (June 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C8-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125884.5; E 325117.1</u>	ORIGINATED BY <u>LG</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>June 15, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W			W _L
						20 40 60 80 100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	WATER CONTENT (%)						
236.5	WATER SURFACE	-----															
0.0	WATER	-----															
236.0	Gravelly sand, trace silt, trace organics (FILL) Compact Brown Wet END OF BOREHOLE SPOON REFUSAL Note: 1. Advanced DCPT 1.0 m south of Borehole C8-1. Refusal at a depth of 1.5 m. 2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT 'N' value has been adjusted to the inferred value that would be obtained using a standard weight hammer.	XXXX	1	SS	6/0.15	236											
0.5																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C8-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125897.8; E 325122.3 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 15, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
242.1	GROUND SURFACE															
0.0	ASPHALT (230 mm)															
0.2	Sand and gravel to sand, trace to some silt (FILL) Brown Moist		1	AS	-											
241.1			2	AS	-											7 86 (7)
1.0	Blast rock (FILL)		3	SS	16											
				RC	REC 13%											
				RC	REC 33%											
236.5			4a	SS	7											
236.2	PEAT (Fibrous) Firm Black Wet		4b													
5.9	COBBLES mixed with peat		5	RC	-											
235.5																
6.6	SAND and GRAVEL, some silt, with cobbles Compact to very dense Grey Wet		6	SS	60											32 49 (19)
233.8																
8.3	GARNETIFEROUS GNEISS (BEDROCK) Bedrock cored from 8.3 m depth to 11.4 m depth. For coring details see Record of Drillhole C8-2.		1	RC	REC 100%											RQD = 63%
			2	RC	REC 100%											RQD = 100%
			3	RC	REC 100%											RQD = 100%
230.7	END OF BOREHOLE															
11.4	Note: 1. Water level at a depth of 4.6 m below ground surface (Elev. 237.5 m) upon completion of drilling.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C8-3 1 OF 1 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125918.8; E 325132.8 ORIGINATED BY ID

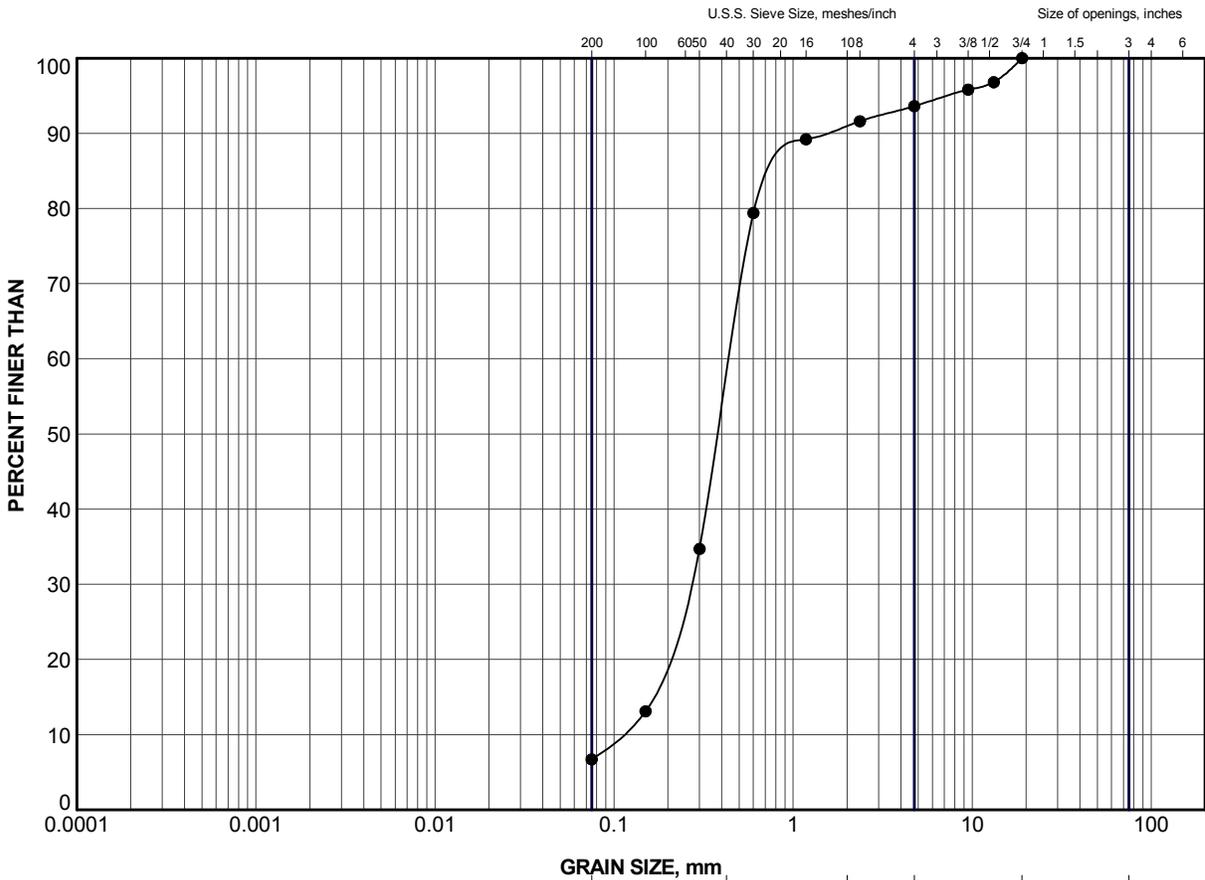
DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 29, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
							20	40	60	80	100					
237.7	GROUND SURFACE															
0.0 237.4	Sand and gravel mixed with organics (FILL)		1	SS	1/0.15											
0.3	Very loose Grey Moist Blast rock (FILL)			RC	-		237									
236.5	PEAT (Amorphous) Stiff Brown / black Wet		2	SS	9											
1.2 236.0						236										
1.7	SAND and GRAVEL, cobbles inferred from auger advance		3	SS	4/0.1											
235.3	Grey Wet			RC	REC 100%	235										RQD = 43%
2.4	GRANITIC GNEISS (BEDROCK)															
	Bedrock cored from 2.4 m depth to 5.8 m depth.		2	RC	REC 100%											RQD = 30%
	For coring details see Record of Drillhole C8-3.															
			3	RC	REC 100%											RQD = 100%
231.9	END OF BOREHOLE															
5.8	Note: 1. Water level at a depth of 0.5 m below ground surface (Elev. 237.2 m) upon completion of drilling.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



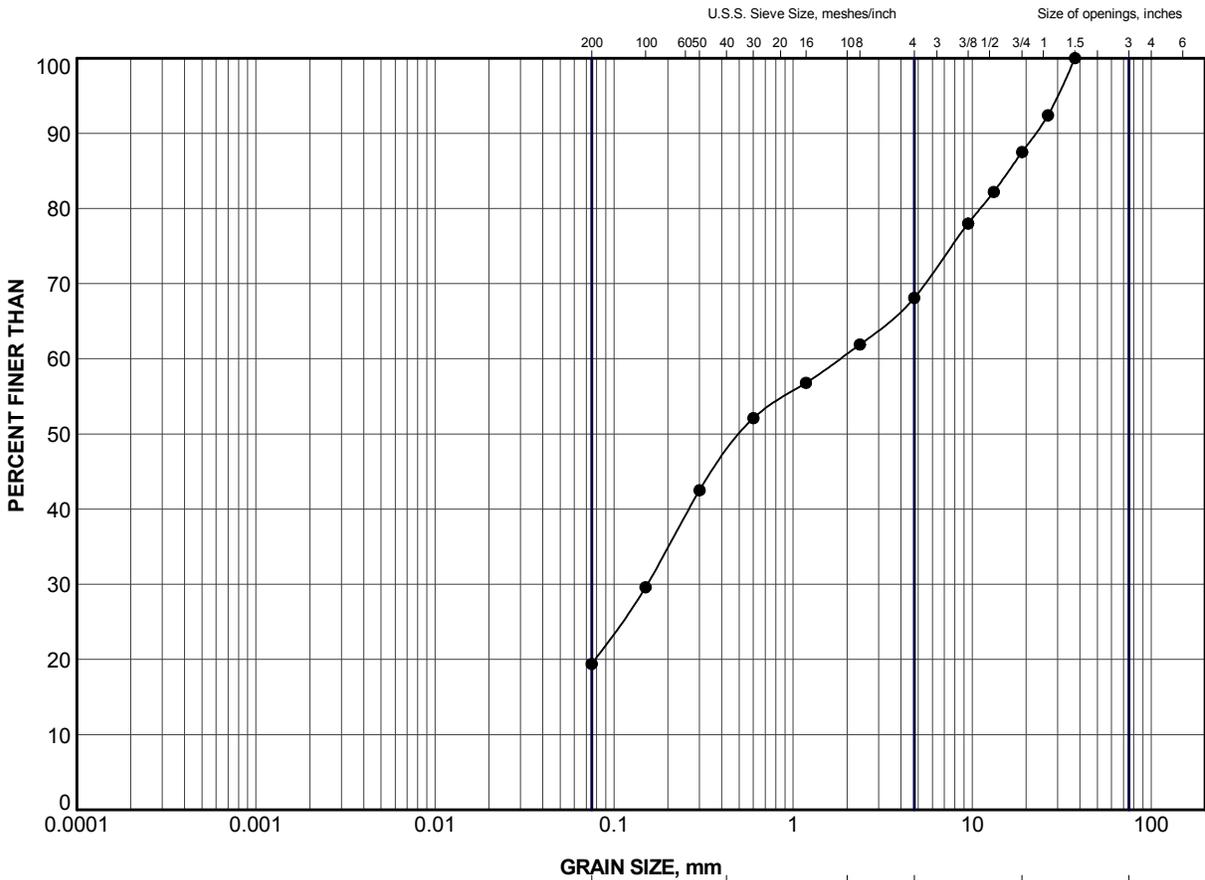
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-2	2	241.4

PROJECT HIGHWAY 17 CULVERT AT STA 20+617					
TITLE GRAIN SIZE DISTRIBUTION SAND (FILL)					
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ	
		DRAWN	JJL	Feb 2012	SCALE N/A
		CHECK	AB	Feb 2012	REV.
		APPR	JMAC	Feb 2012	
FIGURE C1					

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-2	6	234.1

PROJECT HIGHWAY 17 CULVERT AT STA 20+617						
TITLE GRAIN SIZE DISTRIBUTION SAND AND GRAVEL						
 Golder Associates SUDBURY, ONTARIO		PROJECT No.	10-1191-0041	FILE No.	1011910041.GPJ	
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE C2	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX D

Culvert at STA 21+181 – Highway 17 (East Ferris Township)



PHOTOGRAPHS

Photograph 1: Culvert at STA 21+181, Looking West (November 2011)



Photograph 2: Culvert at STA 21+181, Looking North (November 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C7-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125815.6; E 325680.6</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>June 24, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
							20	40	60	80	100					
235.3	GROUND SURFACE															
0.0	PEAT (Fibrous) Very soft Black to brown Wet		1	SS	1											
			2	SS	1											
233.8																
1.5	PEAT (Amorphous) Very soft Black to brown Wet		3	SS	1											
			4	SS	1/0.15											
232.8	END OF BOREHOLE SPOON AND CASING REFUSAL															
2.5	Note: 1. Water level at a depth of 0.1 m below ground surface (Elev. 235.2 m) upon completion of drilling. 2. Advanced DCPT 2.0 m east of Borehole C7-1. Refusal at a depth of 3.2 m.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

RECORD OF BOREHOLE No C7-2 1 OF 2 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125799.1; E 325676.4 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 9, 10, 13 and 14, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
						20	40	60	80	100	20	40	60		GR	SA	SI	CL	
239.9	GROUND SURFACE																		
0.0	Sand and gravel to sand, trace to some silt (FILL) Compact Brown Moist	[Hatched Pattern]	1	SS	22														
			2	SS	10														
238.3			3	SS	13/0.1														
1.6	Blast rock (FILL) Loose	[Hatched Pattern]		RC	REC 33%														
			4	SS	7														
				RC	REC 8%														
235.2			5	SS	5														
4.7	Sand and gravel, containing organics (FILL) Loose Brown / black Wet	[Hatched Pattern]	6a	SS	9														
234.4			6b	SS	9														
5.5	PEAT (Fibrous) Stiff Black Wet	[Wavy Pattern]		RC	REC 88%														
234.0																			
5.9	BOULDERS	[Dotted Pattern]																	
233.5																			
6.4	Silty SAND, trace to some gravel Compact to dense Brown Wet	[Dotted Pattern]	7	SS	16														
			8	SS	20														
			9	SS	36														
			10	SS	13														
	With cobbles and boulders below 10.4 m depth.																		
228.3																			
11.6	GARNETIFEROUS GNEISS (BEDROCK) Bedrock cored from 11.6 m depth to 15.0 m depth. For coring details see Record of Drillhole C7-2.	[Diagonal Hatched Pattern]	1	RC	REC 100%														RQD = 72%
			2	RC	REC 100%														RQD = 98%
			3	RC	REC 100%														RQD = 100%
224.9																			

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

Continued Next Page

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



RECORD OF BOREHOLE No C7-2 2 OF 2 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125799.1; E 325676.4 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 9, 10, 13 and 14, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L			GR	SA
15.0	END OF BOREHOLE Note: 1. Water level at a depth of 4.0 m below ground surface (Elev. 235.9 m) upon completion of drilling.																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C7-3 1 OF 1 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125776.6; E 325675.0 ORIGINATED BY ID

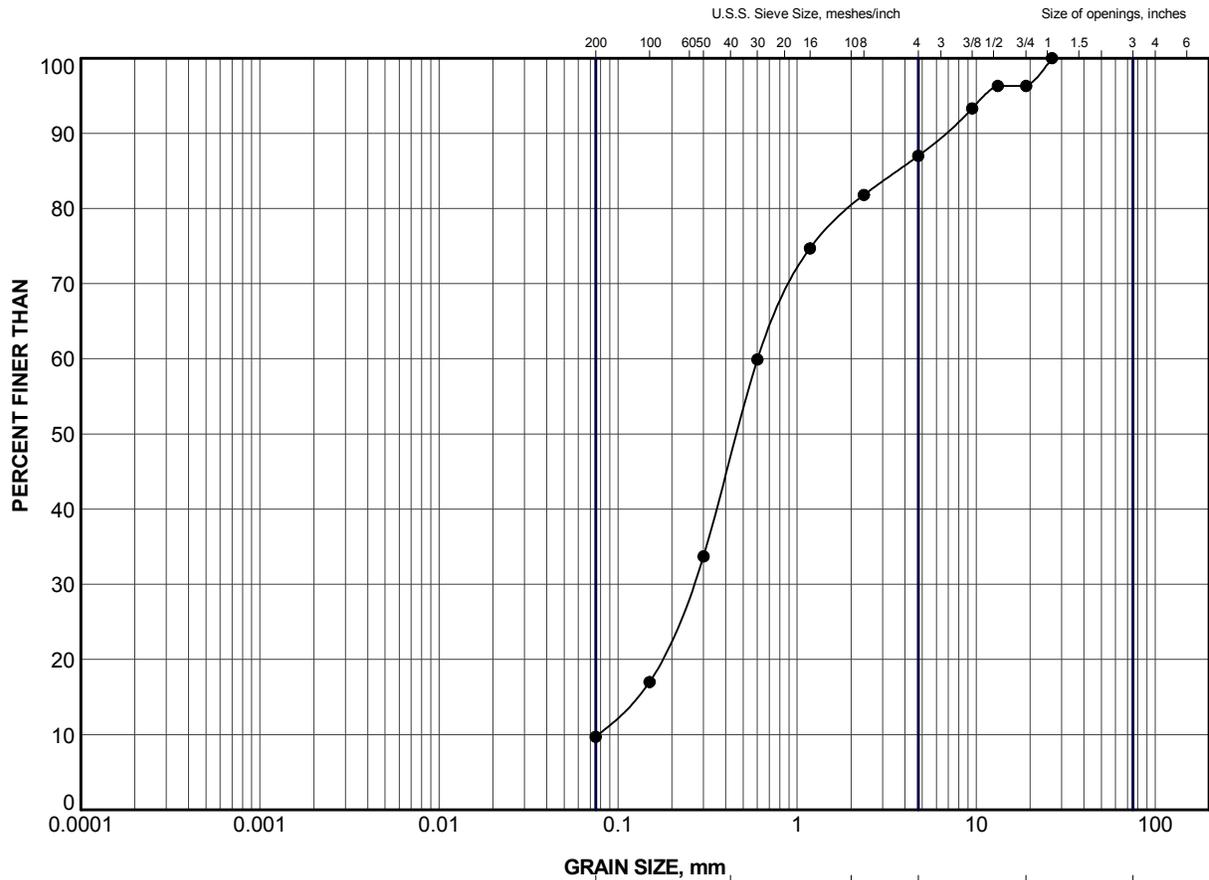
DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 30, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
						20	40	60	80	100	20	40	60		GR	SA	SI	CL	
236.7	GROUND SURFACE																		
0.0	PEAT (Fibrous) Very soft Black to brown Moist		1	SS	1														
236.1																			
0.6	SAND and SILT, some gravel, trace clay, cobbles inferred from auger grinding Compact Grey Wet		2	SS	7/0.15														
234.7																			
2.0	Auger refusal at 1.0 m depth. Switched to casing. COBBLES and BOULDERS		3	SS	18														17 47 33 3
233.8																			
2.9	Gravelly SAND, some silt Loose to very dense Grey to brown Moist to wet																		
			4	SS	8														23 51 26 0
			5	SS	6														
			6	SS	6														26 55 (19)
			7	SS	73														
			8	SS	79														
228.3	GRANITIC GNEISS (BEDROCK)		1	RC	REC 100%														RQD = 21%
8.4	Bedrock cored from 8.4 m depth to 11.1 m depth. For coring details see Record of Drillhole C7-3.		2	RC	REC 100%														RQD = 53%
			3	RC	REC 100%														RQD = 36%
225.6	END OF BOREHOLE																		
11.1	Note: 1. Water level at a depth of 0.8 m below ground surface (Elev. 235.9 m) upon completion of drilling.																		

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



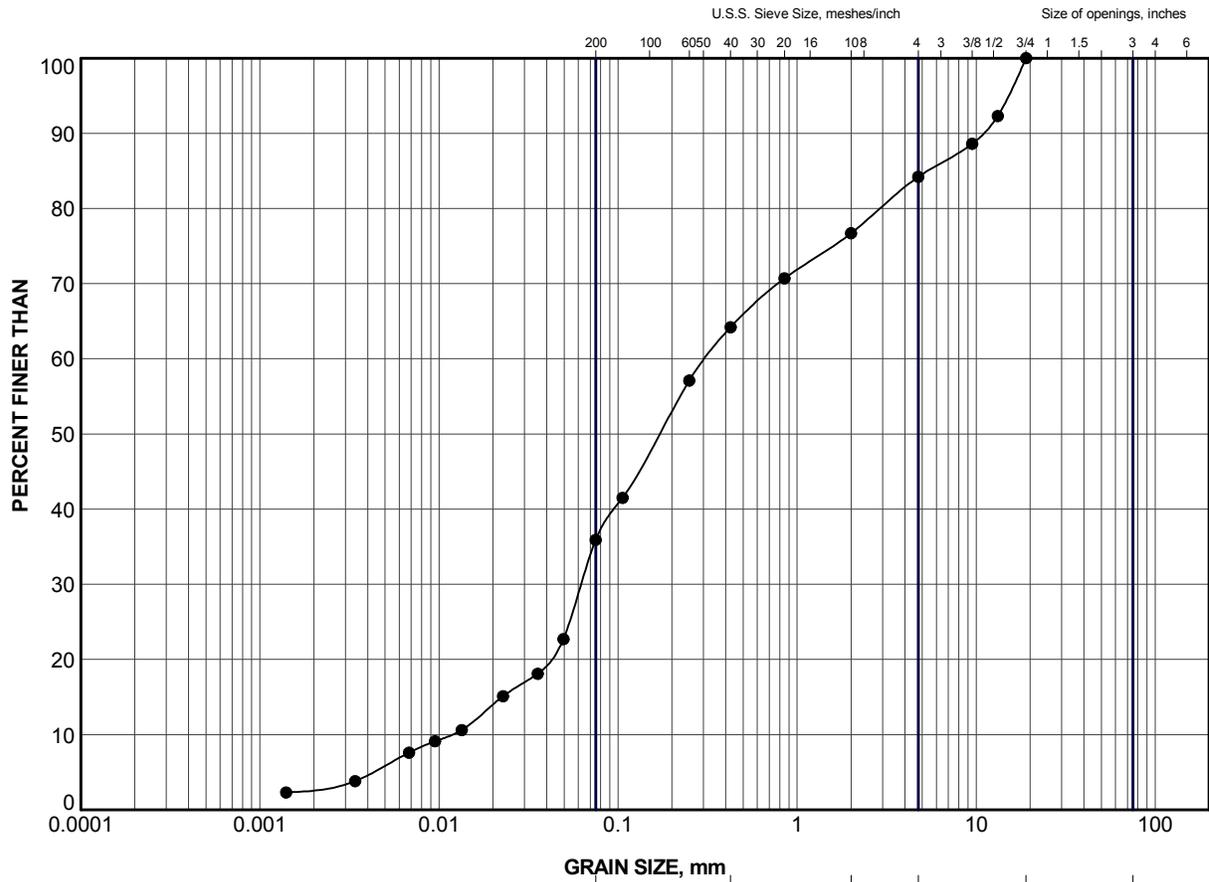
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C7-2	2	238.8

PROJECT HIGHWAY 17 CULVERT AT STA 21+181						
TITLE GRAIN SIZE DISTRIBUTION SAND (FILL)						
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE D1	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



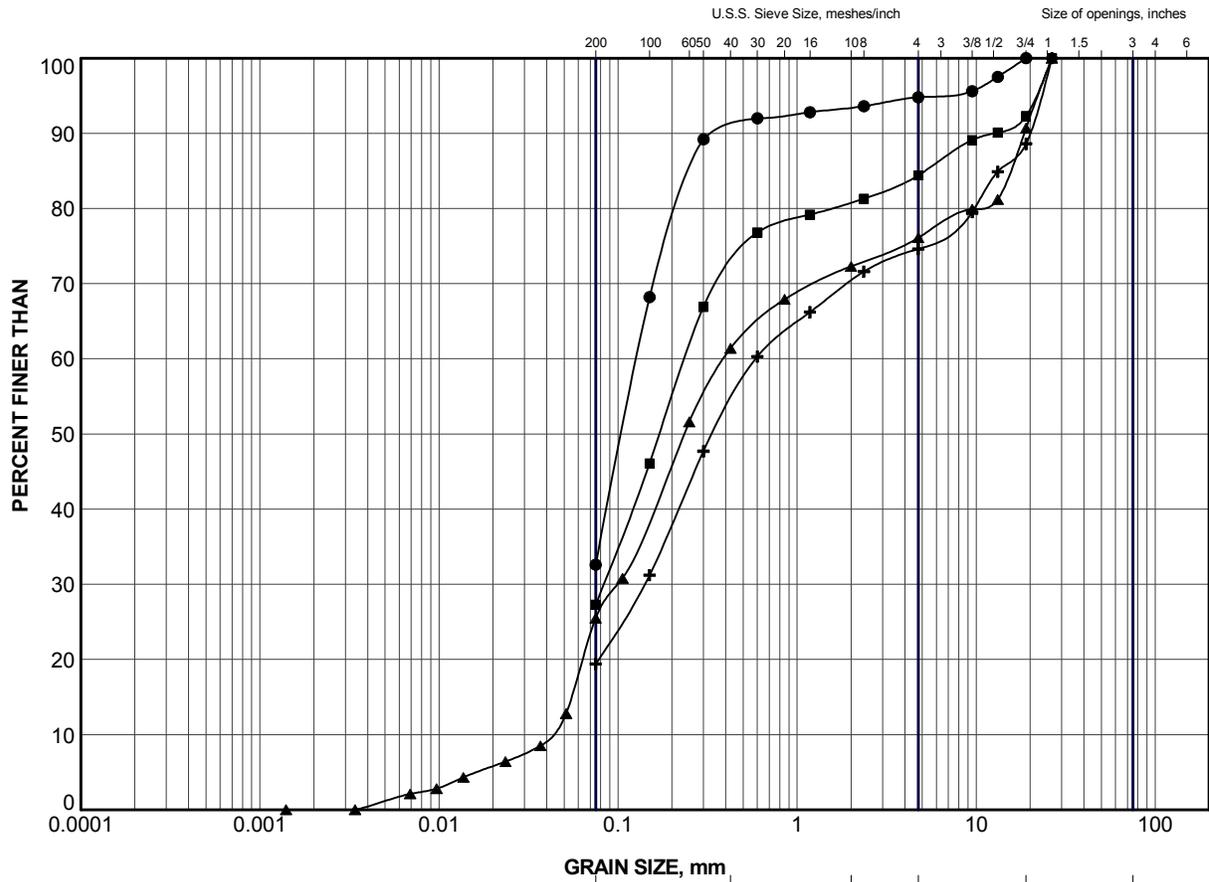
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C7-3	3	234.9

PROJECT						HIGHWAY 17 CULVERT AT STA 21+181					
TITLE						GRAIN SIZE DISTRIBUTION SAND AND SILT					
PROJECT No.		10-1191-0041		FILE No.		1011910041.GPJ					
DRAWN	JJL	Feb 2012		SCALE	N/A	REV.					
CHECK	AB	Feb 2012		FIGURE D2							
APPR	JMAC	Feb 2012									



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C7-2	8	231.9
■	C7-2	10	230.5
▲	C7-3	4	233.3
+	C7-3	6	231.9

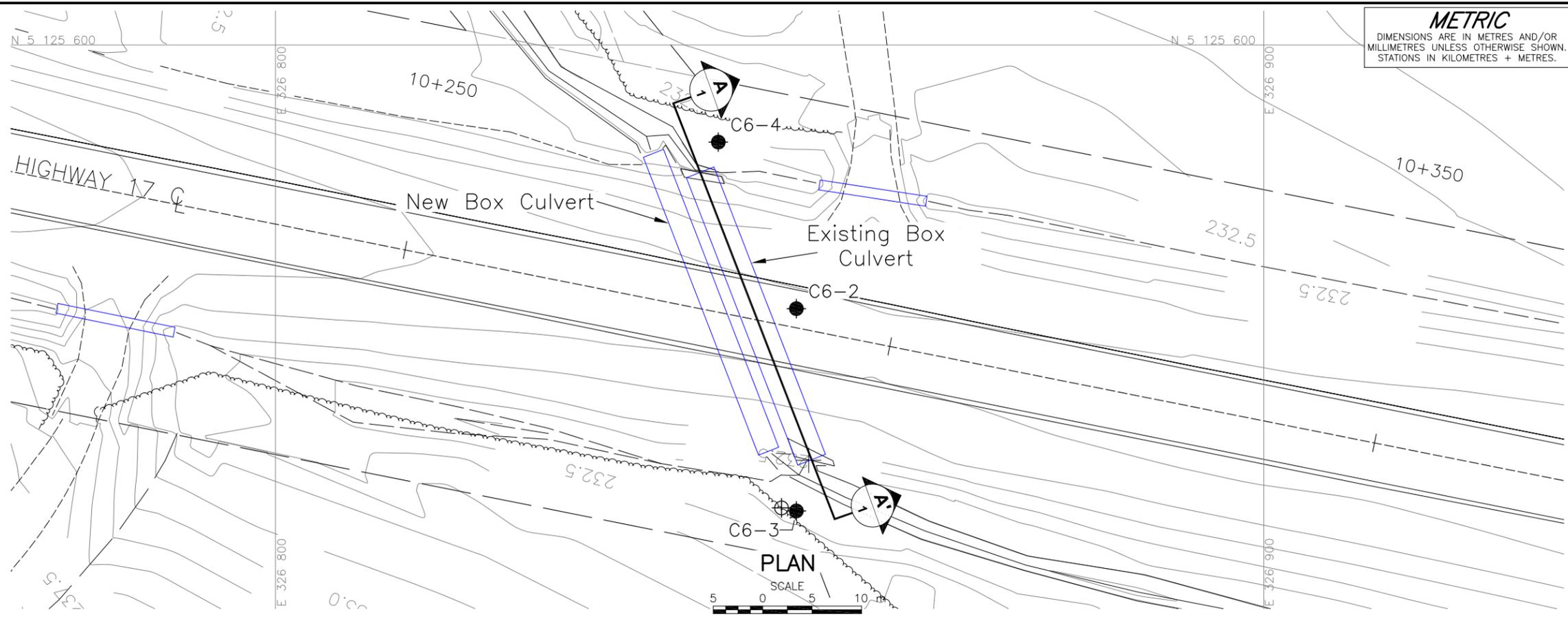
PROJECT HIGHWAY 17 CULVERT AT STA 21+181				
TITLE GRAIN SIZE DISTRIBUTION SILTY SAND TO GRAVELLY SAND				
PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
DRAWN	JJL	Feb 2012	SCALE	N/A
CHECK	AB	Feb 2012	REV.	
APPR	JMAC	Feb 2012	FIGURE D3	
 Golder Associates SUDBURY, ONTARIO				

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX E

Culvert at STA 10+286 – Highway 17 (Bonfield Township)

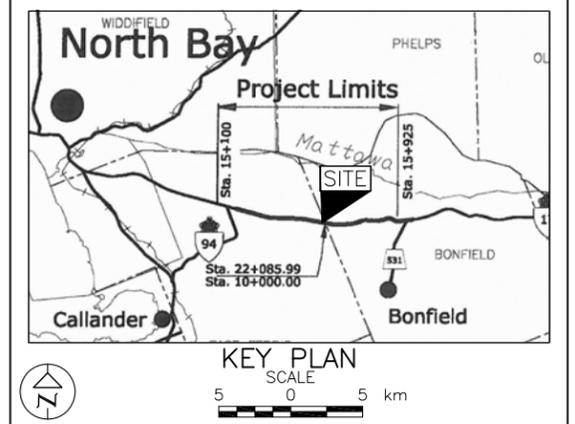


METRIC
 DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. WP No. 5630-04-01

HIGHWAY 17
 CULVERT AT STA 10+286, LAREN CREEK
 BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C6-2	234.0	5125573.4	326852.7
C6-3	231.6	5125553.0	326852.7
C6-4	231.9	5125590.2	326844.8

NOTES

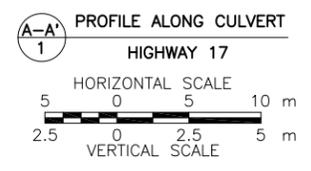
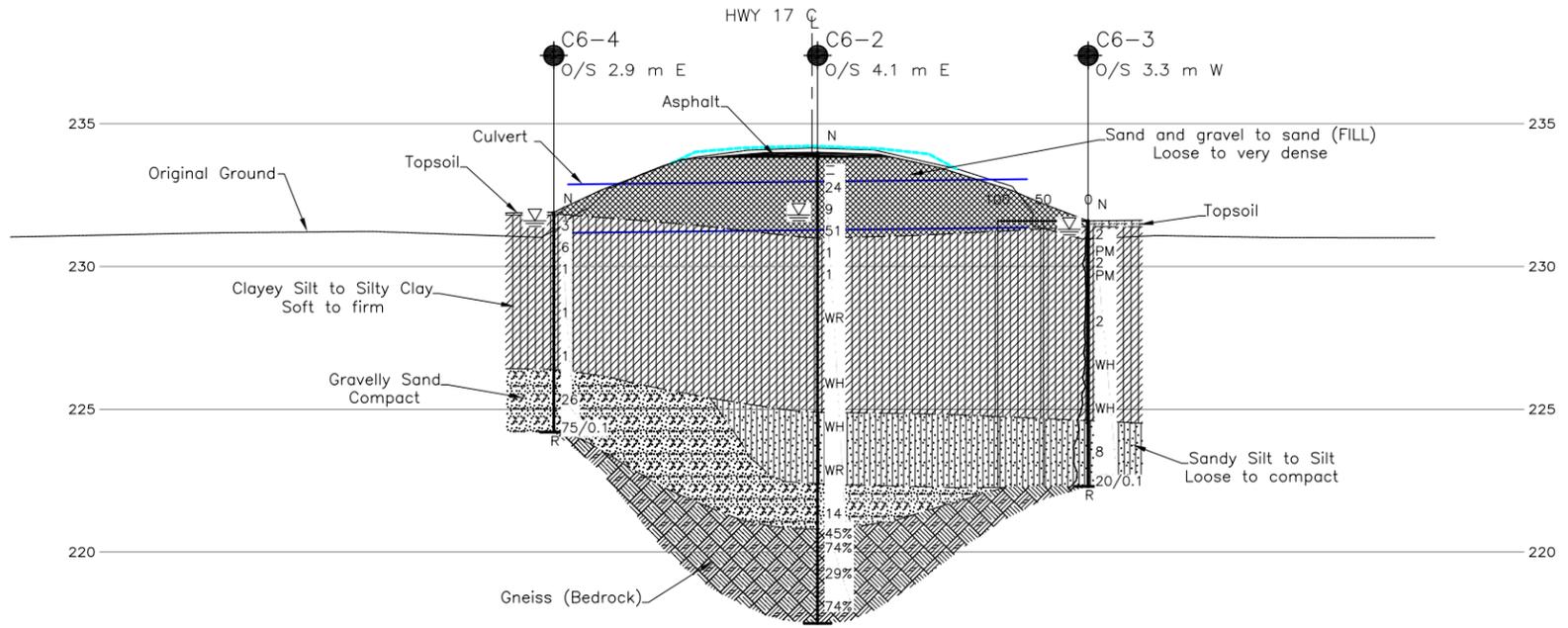
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by MMM, drawing file nos. BASE_ALL.dwg and Alignment.dwg received NOV 10, 2011. Keyplan received DEC 07, 2011, culvert location and profile file CULVERT 21b-GA.dwg received March 5, 2013.



NO.	DATE	BY	REVISION

Geocres No. 31L-158

HWY. 17	PROJECT NO. 10-1191-0041	DIST.
SUBM'D. MT	CHKD. AB	DATE: APR 2013
DRAWN: JJL	CHKD.	APPD. JMAC
		SITE: 43-269
		DWG. E1



PHOTOGRAPHS

Photograph 1: Culvert at STA 10+286, Looking West (November 2011)



Photograph 2: Culvert at STA 10+286, Looking East (June 2011)



RECORD OF BOREHOLE No C6-2 1 OF 2 **METRIC**

PROJECT 10-1191-0041 W.P. 174-98-00 LOCATION N 5125573.4; E 326852.7 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY MT

DATUM Geodetic DATE June 7 and 8, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80	100	20	40	60
234.0	GROUND SURFACE																			
0.0	ASPHALT (175 mm)																			
0.2	Sand and gravel to sand, trace to some silt (FILL) Loose to very dense Brown Moist to wet		1	AS	-															
			2	AS	-															
			3	SS	24															13 80 (7)
			4	SS	9															
			5	SS	51															
231.0	CLAYEY SILT to SILTY CLAY, trace to some organics in samples 6 and 7 Soft to firm Grey Wet		6	SS	1															
			7	SS	1															
			8	SS	WR															
			9	SS	WH															
224.9	SILT, some sand, trace to some clay Very loose Grey Wet		10	SS	WH															
			11	SS	WR															
222.4	Gravelly SAND, trace to some silt, cobbles inferred from auger grinding Compact Brown Wet		12	SS	14															
			13	RC	REC 100%															
220.8	GNEISS (BEDROCK) Bedrock cored from 13.2 m depth to 16.5 m depth. For coring details see Record of Drillhole C6-2.		1	RC	REC 100%															
			2	RC	REC 100%															
			3	RC	REC 100%															

SUD-MTO 001 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

Continued Next Page

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

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C6-2	2 OF 2 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125573.4; E 326852.7</u>	ORIGINATED BY <u>EHS</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>June 7 and 8, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W			W _L	20	40	60	GR	SA
217.5	GNEISS (BEDROCK)			RC	%																	RQD = 29%
	Bedrock cored from 13.2 m depth to 16.5 m depth.																					
	For coring details see Record of Drillhole C6-2.		4	RC	REC 100%																	RQD = 74%
16.5	END OF BOREHOLE																					
	Note: 1. Water level at a depth of 2.2 m below ground surface (Elev. 231.8 m) upon completion of drilling.																					

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

PROJECT: 10-1191-0041

RECORD OF DRILLHOLE: C6-2

SHEET 1 OF 1

LOCATION: N 5125573.4 ;E 326852.7

DRILLING DATE: June 7 and 8, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Drill Rig

DRILLING CONTRACTOR: Landcore

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			Diametral Point Load (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION			
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w/ ZL CORE AXIS	Type and Surface Description	Jr	Ja	Jn				10 ⁰	10 ¹	10 ²
								80 90 95 98 99	80 90 95 98 99			0 10 20 30 40	0 10 20 30 40	0 10 20 30 40									
		REFER TO PREVIOUS PAGE		220.8																			
	NW	GNEISS Medium to coarse grained Slightly weathered Pinkish grey		13.2	1	GREY	100%																
14					2	GREY	100%																
15	8/6/2011 NQ Coring				3	GREY	100%																
16					4	GREY	100%																
		END OF DRILLHOLE		217.5 16.5																			

SUD-RCK 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: EHS

CHECKED: AB

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C6-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125553.0; E 326852.7</u>	ORIGINATED BY <u>CR</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>July 5, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100			W _p
231.6	GROUND SURFACE														
0.0	TOPSOIL														
0.2	Brown Moist SILTY CLAY, trace sand Soft Grey Wet		1	SS	2										
			2	TO	PM										
			3	SS	2										
			4	TO	PM										
			5	SS	2										
			6	SS	WH										
			7	SS	WH										
224.6	Sandy SILT, trace clay Loose to compact Grey Wet		8	SS	8									0 24 70 6	
222.3	END OF BOREHOLE SPOON REFUSAL		9	SS	20/0.1										
9.3	Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 231.3 m) upon completion of drilling. Advanced DCPT 1.5 m west of Borehole C6-3. Refusal at a depth of 9.4 m.														

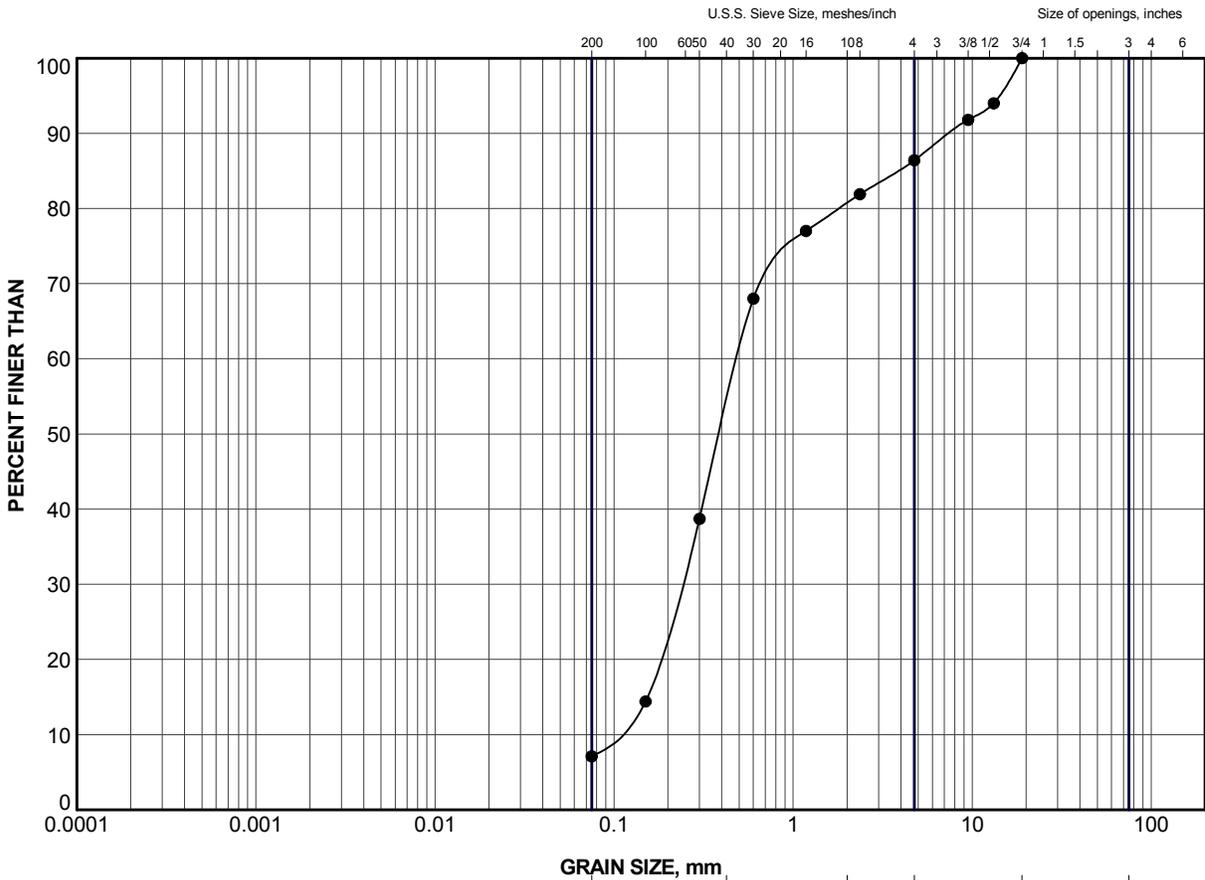
SUD-MTO 001 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

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

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C6-4	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125590.2; E 326844.8</u>	ORIGINATED BY <u>CR</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>July 5, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
						20	40	60	80	100	20	40	60		GR	SA	SI	CL	
231.9	GROUND SURFACE																		
0.0	TOPSOIL Black Moist		1	SS	3														
	CLAYEY SILT to SILTY CLAY, trace sand Very soft to firm Grey Wet		2	SS	6														
			3	SS	1														
			4	SS	1														
			5	SS	1														
226.4	Gravelly SAND Compact Grey Wet		6	SS	26														
224.2	END OF BOREHOLE SPOON REFUSAL		7	SS	750.1														
7.7	Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 231.6 m) upon completion of drilling.																		

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:



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

LEGEND

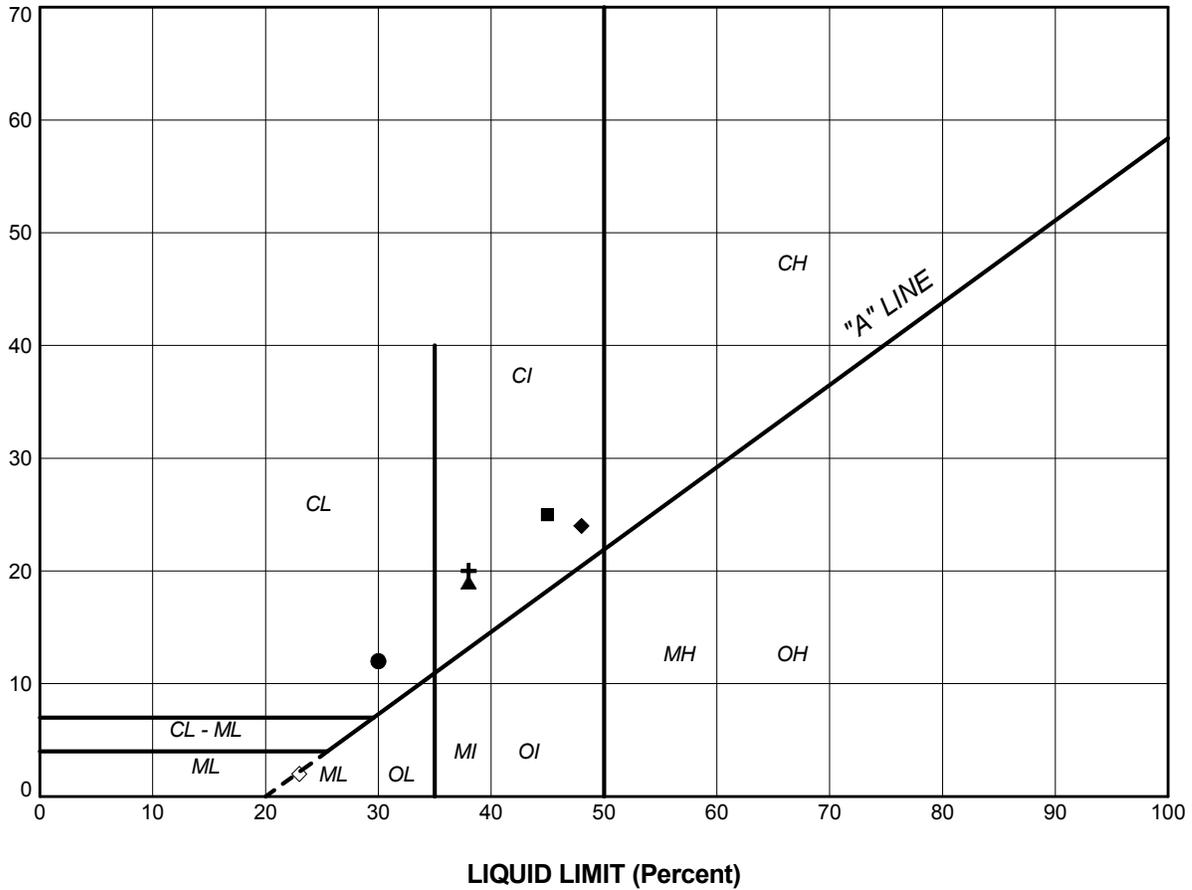
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C6-2	3	232.9

PROJECT HIGHWAY 17 CULVERT AT STA 10+286					
TITLE GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.		10-1191-0041		FILE No. 1011910041.GPJ	
DRAWN	J.J.L.	Feb 2012	SCALE	N/A	REV.
CHECK	A.B.	Feb 2012			
APPR	J.M.A.C.	Feb 2012	FIGURE E1		



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT

PLASTICITY INDEX (Percent)



SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

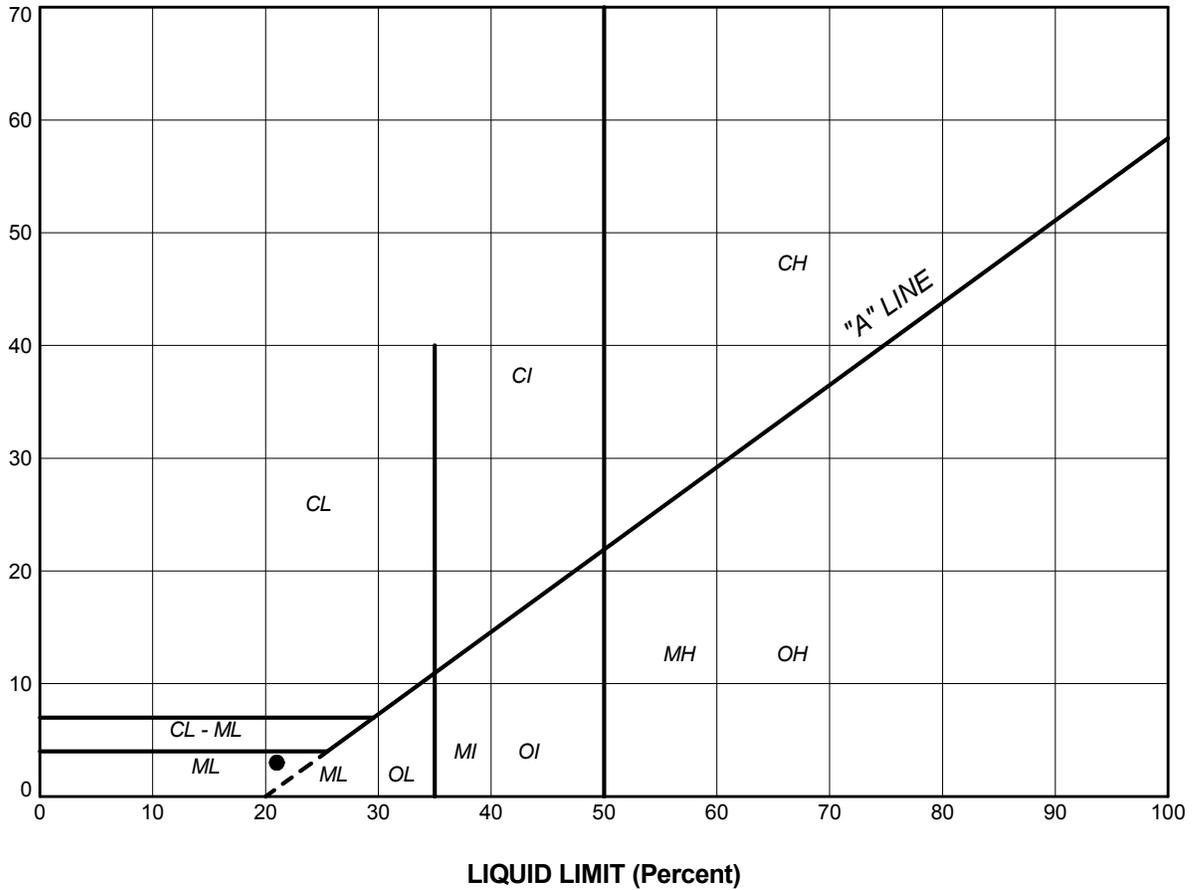
PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C6-2	6	30.0	18.0	12.0
■	C6-2	9	45.0	20.0	25.0
▲	C6-3	3	38.0	19.0	19.0
+	C6-3	5	38.0	18.0	20.0
◆	C6-4	3	48.0	24.0	24.0
◇	C6-4	5	23.0	21.0	2.0

PROJECT					HIGHWAY 17 CULVERT AT STA. 10+286					
TITLE					PLASTICITY CHART CLAYEY SILT TO SILTY CLAY					
PROJECT No. 10-1191-0041			FILE No. 1011910041.GPJ		DRAWN J.J.L. Feb 2012			SCALE N/A		REV.
CHECK AB Feb 2012					APPR JMAC Feb 2012			FIGURE E2		
 Golder Associates SUDBURY, ONTARIO										

PLASTICITY INDEX (Percent)



SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

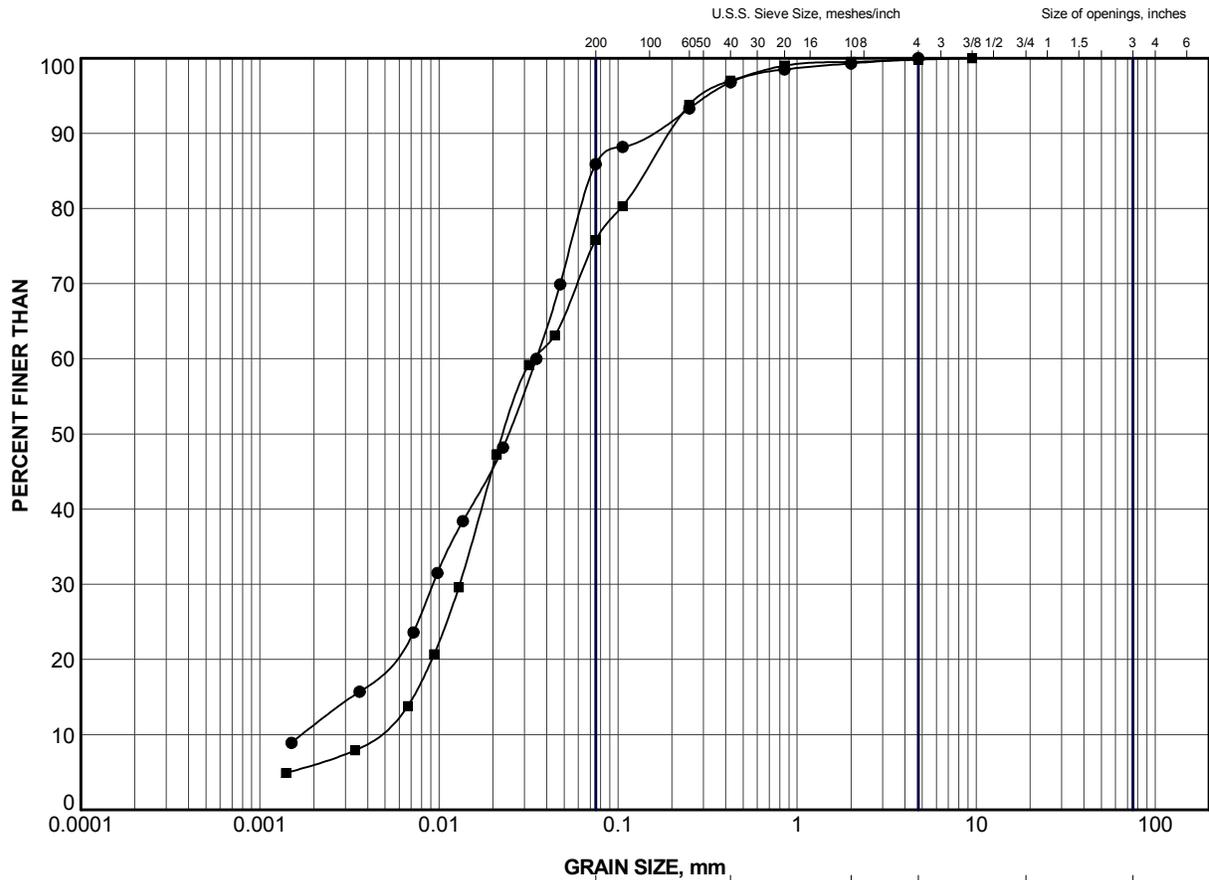
PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C6-3	8	21.0	18.0	3.0

PROJECT					HIGHWAY 17 CULVERT AT STA. 10+286					
TITLE					PLASTICITY CHART SANDY SILT					
PROJECT No. 10-1191-0041			FILE No. 1011910041.GPJ		DRAWN J.J.L. Feb 2012			SCALE N/A		REV.
CHECK AB Feb 2012					APPR JMAC Feb 2012			FIGURE E3		
 Golder Associates SUDBURY, ONTARIO										

SUD-MTO(PL) CULVERTS GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C6-2	11	223.0
■	C6-3	8	223.7

PROJECT HIGHWAY 17 CULVERT AT STA 10+286					
TITLE GRAIN SIZE DISTRIBUTION SILT TO SANDY SILT					
PROJECT No.		10-1191-0041		FILE No. 1011910041.GPJ	
DRAWN	JJL	Feb 2012	SCALE	N/A	REV.
CHECK	AB	Feb 2012	FIGURE E4		
APPR	JMAC	Feb 2012			

Golder Associates
 SUDBURY, ONTARIO

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX F

Culvert at STA 13+599 – Highway 17 (Bonfield Township)



PHOTOGRAPHS

Photograph 1: Culvert at STA 13+599, Looking East (November 2011)



Photograph 2: Culvert at STA 13+599, Looking South (November 2011)



RECORD OF BOREHOLE No C5-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125781.8; E 330095.9 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, Wash Boring COMPILED BY MT

DATUM Geodetic DATE May 17, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	SHEAR STRENGTH kPa			WATER CONTENT (%)
																	GR	SA	SI	CL	
242.2	GROUND SURFACE																				
0.0 241.9	ASPHALT (255 mm)																				
0.3	Sand and gravel to sand, trace silt (FILL) Dense Brown Moist		1	AS	-																
			2	AS	-																2 90 (8)
			3	SS	37																
240.7	Blast rock (FILL)																				
240.4	Sand, trace silt, trace organics (FILL) Very loose Brown Wet		4	SS	2																
1.8			5	SS	1																0 92 (8)
			6	SS	27																
238.4	SAND and SILT, trace to some gravel, trace clay Compact Brown and grey Wet		7	SS	25																
3.8			8	SS	65																
236.6	Gravelly SAND, some silt, trace clay, cobbles inferred Very dense Grey Wet		9	SS	50/0.15																
5.6			10	SS	81																
234.0	END OF BOREHOLE																				
8.2	Note: 1. Water level at a depth of 2.1 m below ground surface (Elev. 240.1 m) upon completion of drilling.																				24 48 (28)

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

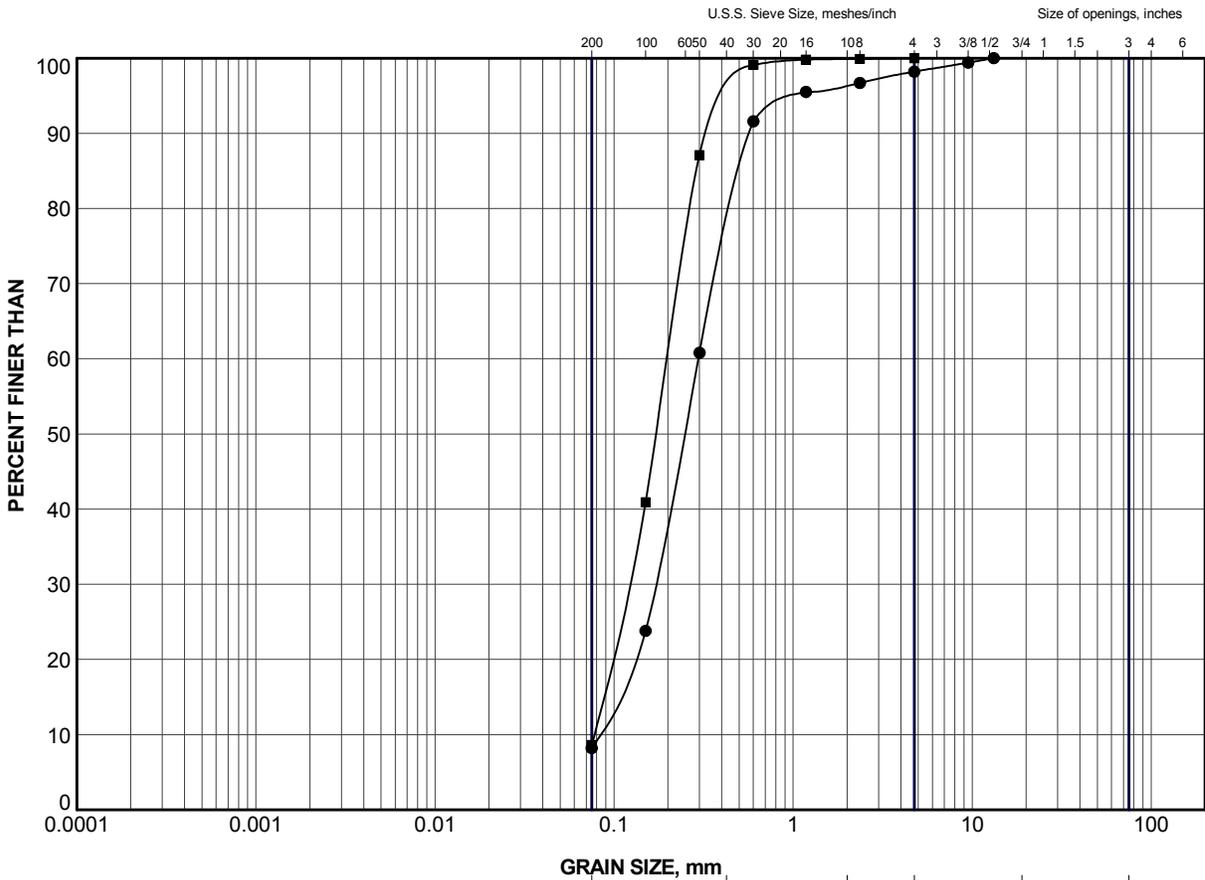
+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C5-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125768.5; E 330100.4</u>	ORIGINATED BY <u>CR</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>MT</u>
DATUM <u>Geodetic</u>	DATE <u>June 28, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			W _p	W
239.5 0.0	WATER SURFACE WATER				▽										
238.3 1.3	PEAT Brown Wet Silty SAND to Sandy SILT, trace clay, with cobbles Loose to very dense Grey Wet	1	SS	7											
		2	SS	81											
		3	SS	74											
		4	SS	88											
235.2 4.3	END OF BOREHOLE SPOON REFUSAL Note: 1. Advanced DCPT 1.0 m west of Borehole C5-3. Refusal at a depth of 4.7 m.														

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



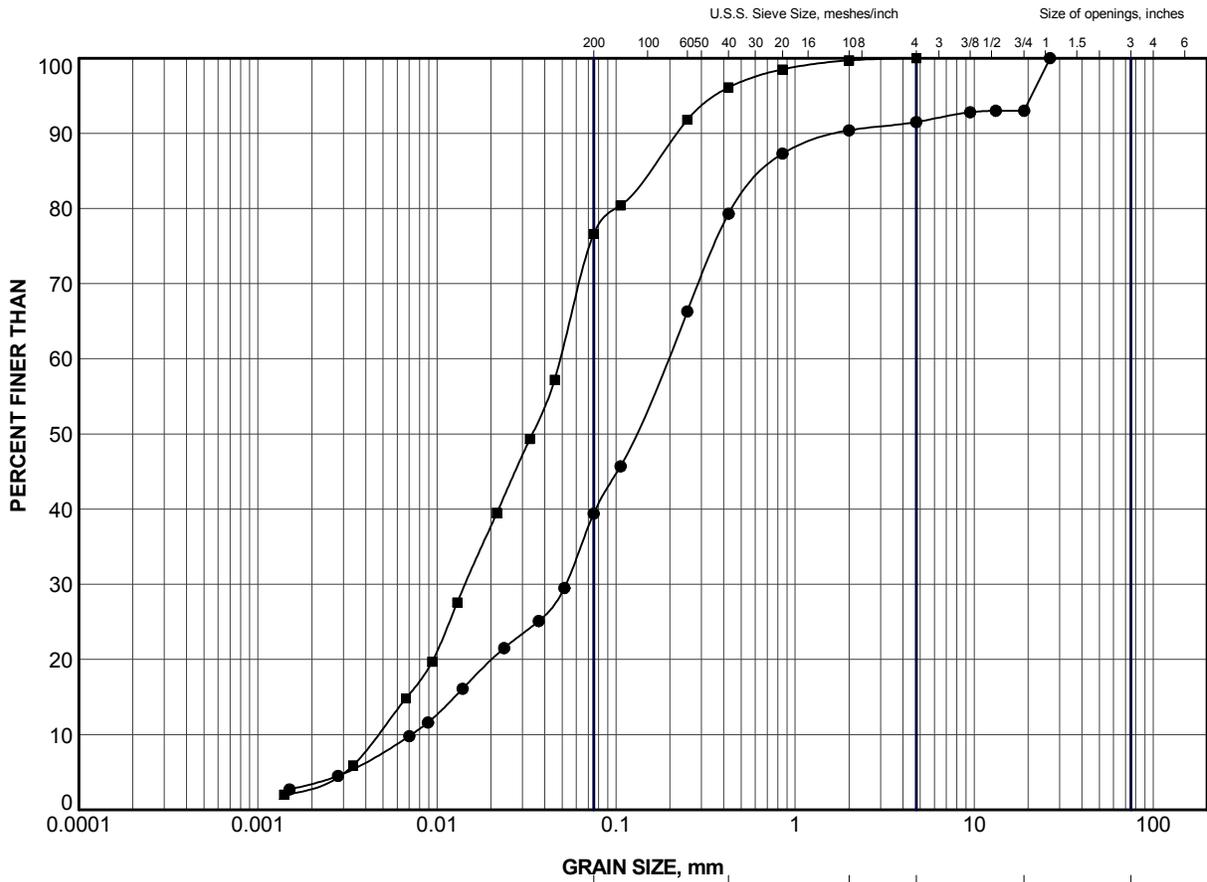
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

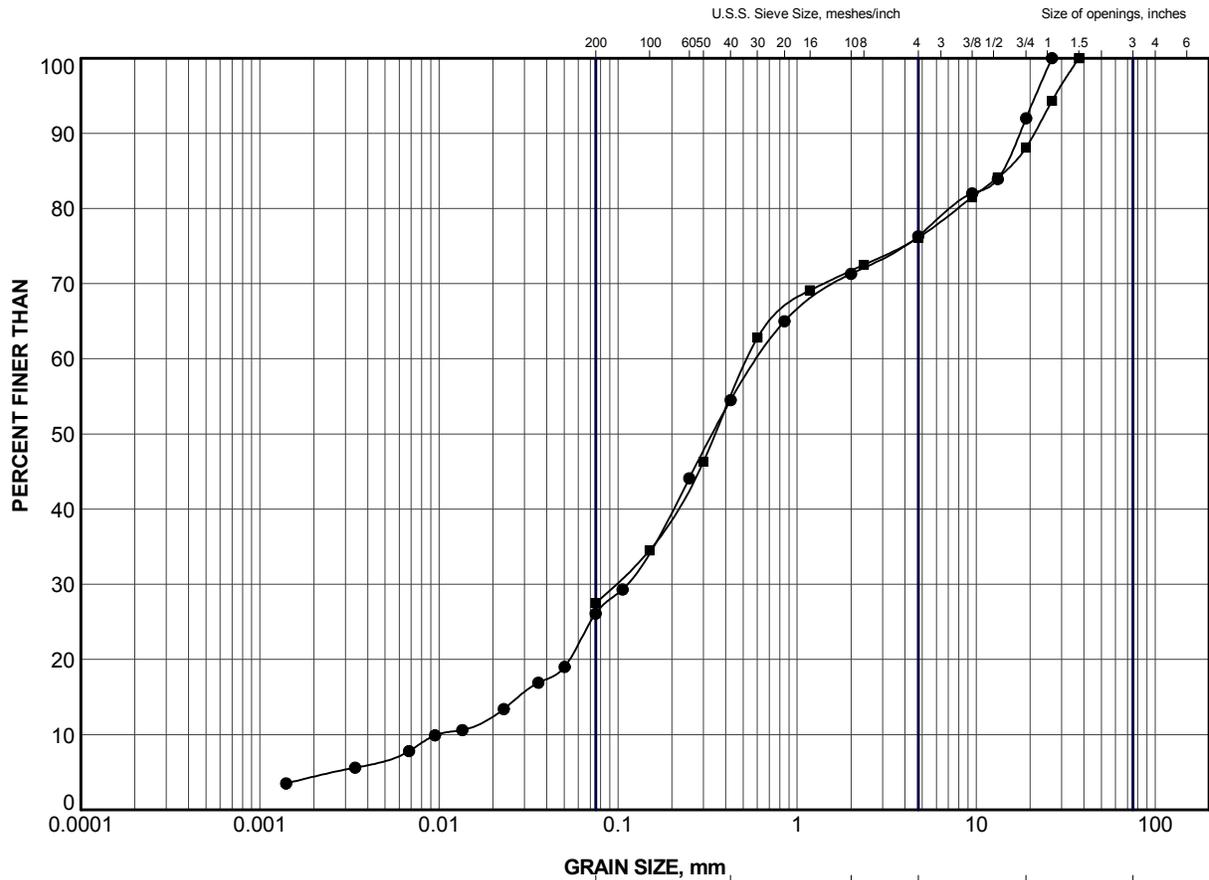
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C5-2	2	241.6
■	C5-2	4	239.6

PROJECT HIGHWAY 17 CULVERT AT STA 13+599						
TITLE GRAIN SIZE DISTRIBUTION SAND (FILL)						
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE F1	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT





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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C5-1	1	237.8
■	C5-2	10	234.3

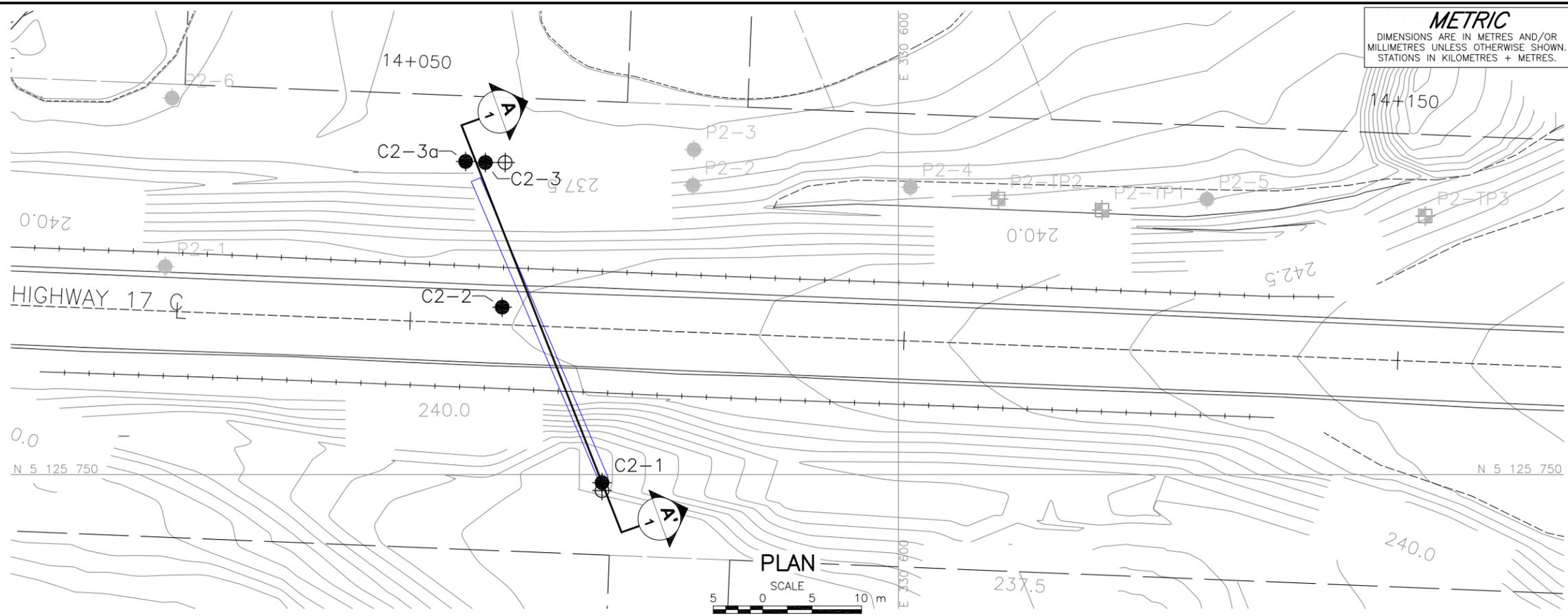
PROJECT HIGHWAY 17 CULVERT AT STA 13+599						
TITLE GRAIN SIZE DISTRIBUTION GRAVELLY SAND						
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE F3	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX G

Culvert at STA 14+063 – Highway 17 (Bonfield Township)

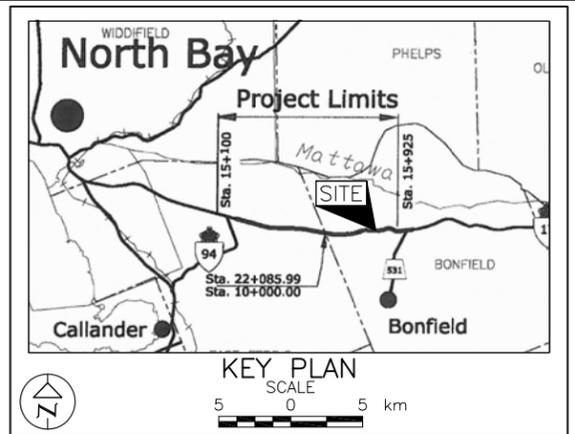


METRIC
 DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. GWP No.174-98-00
 HIGHWAY 17
 CULVERT AT STA 14+063
 BOREHOLE LOCATIONS AND SOIL STRATA



Golden Associates
 SUDBURY, ONTARIO, CANADA
Golden Associates Ltd.
 SUDBURY, ONTARIO, CANADA



LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C2-1	236.2	5125749.2	330570.0
C2-2	240.9	5125766.9	330559.9
C2-3	236.1	5125781.5	330558.2
C2-3a	236.1	5125781.6	330556.2

NOTES

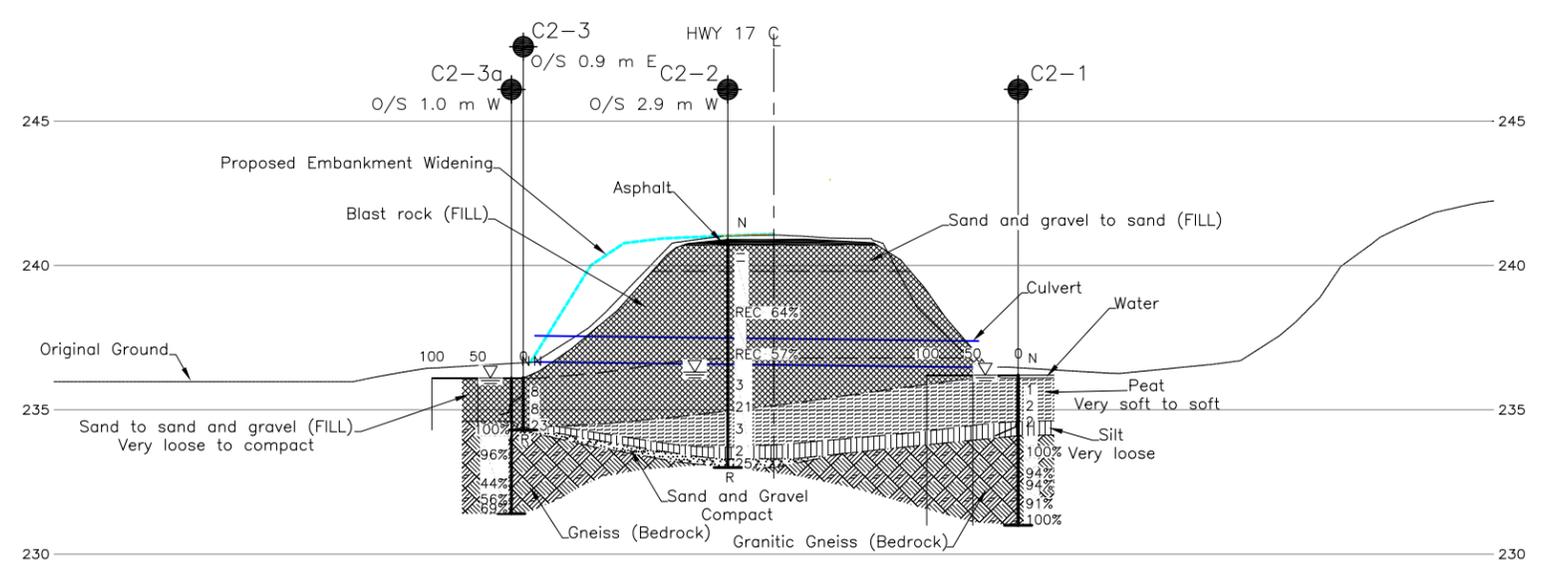
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by MMM, drawing file nos. BASE_ALL.dwg and Alignment.dwg received NOV 10, 2011. Keyplan received DEC 07, 2011. Contours received JAN 4, 2012



PROFILE ALONG CULVERT
 1 HIGHWAY 17
 HORIZONTAL SCALE
 5 0 5 10 m
 2.5 0 2.5 5 m
 VERTICAL SCALE



NO.	DATE	BY	REVISION

Geocres No.31L-158

HWY. 17	PROJECT NO. 10-1191-0041	DIST.
SUBM'D. MT	CHKD. AB	DATE: APR 2013
DRAWN: JJJ	CHKD.	APPD. JMAC
		DWG. G1



PHOTOGRAPHS

Photograph 1: Culvert at STA 14+063, Looking East (May 2011)



Photograph 2: Culvert at STA 14+063, Looking East (May 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C2-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125749.2; E 330570.0</u>	ORIGINATED BY <u>LG</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, NQ Coring</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 25 and 26, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
						20	40	60	80	100	20	40	60		GR	SA	SI	CL	
236.2	WATER SURFACE																		
0.0	WATER																		
	PEAT (Amorphous) Very soft to soft Black Wet		1	SS	1														
			2	SS	2														
234.6			3a	SS	2														
1.6	SILT, trace to some clay, trace sand Grey Wet		3b																
234.1																			
2.1	GRANITIC GNEISS (BEDROCK)																		
	Bedrock cored from 2.1 m depth to 5.2 m depth. For coring details see Record of Drillhole C2-1.		1	RC	REC 100%														RQD = 100%
			2	RC	REC 100%														RQD = 94%
			3	RC	REC 100%														RQD = 94%
			4	RC	REC 100%														RQD = 91%
			5	RC	REC 100%														RQD = 100%
231.0	END OF BOREHOLE																		
5.2	Notes: 1. Refusal at 1.8 m depth at original borehole, moved 1 m south and cored bedrock from 2.1 m depth to 5.2 m depth at new location. 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. Moved 0.8 m south to advance DCPT, refusal at 2.4 m depth.																		

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C2-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125766.9; E 330559.9 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY LG

DATUM Geodetic DATE May 19 and 24, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
240.9	GROUND SURFACE															
0.0	ASPHALT (220 mm)															
0.2	Sand and gravel to sand, trace to some silt (FILL) Brown Moist		1	AS	-											
			2	AS	-											
239.8	Blast rock (FILL)															
1.1				RC	REC 64%											
				RC	REC 57%											
236.8	Sand to sand and gravel, some organics (FILL) Very loose to compact Brown Wet		3	SS	3											
4.1			4	SS	21											
235.0	PEAT (Amorphous / Fibrous) Very soft to soft Brown / black Wet		5	SS	3											
5.9			6	SS	2											
233.7	SILT, trace organics Very loose Grey Wet		7	SS	25											
233.3																
233.0	SAND and GRAVEL, some silt Compact Grey Wet															
7.9																
	END OF BOREHOLE REFUSAL TO FURTHER CASING PENETRATION Note: 1. Water level at a depth of 4.6 m below ground surface (Elev. 236.3 m) upon completion of drilling.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C2-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125781.5; E 330558.2</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 24, 2011</u>	CHECKED BY <u>AB</u>

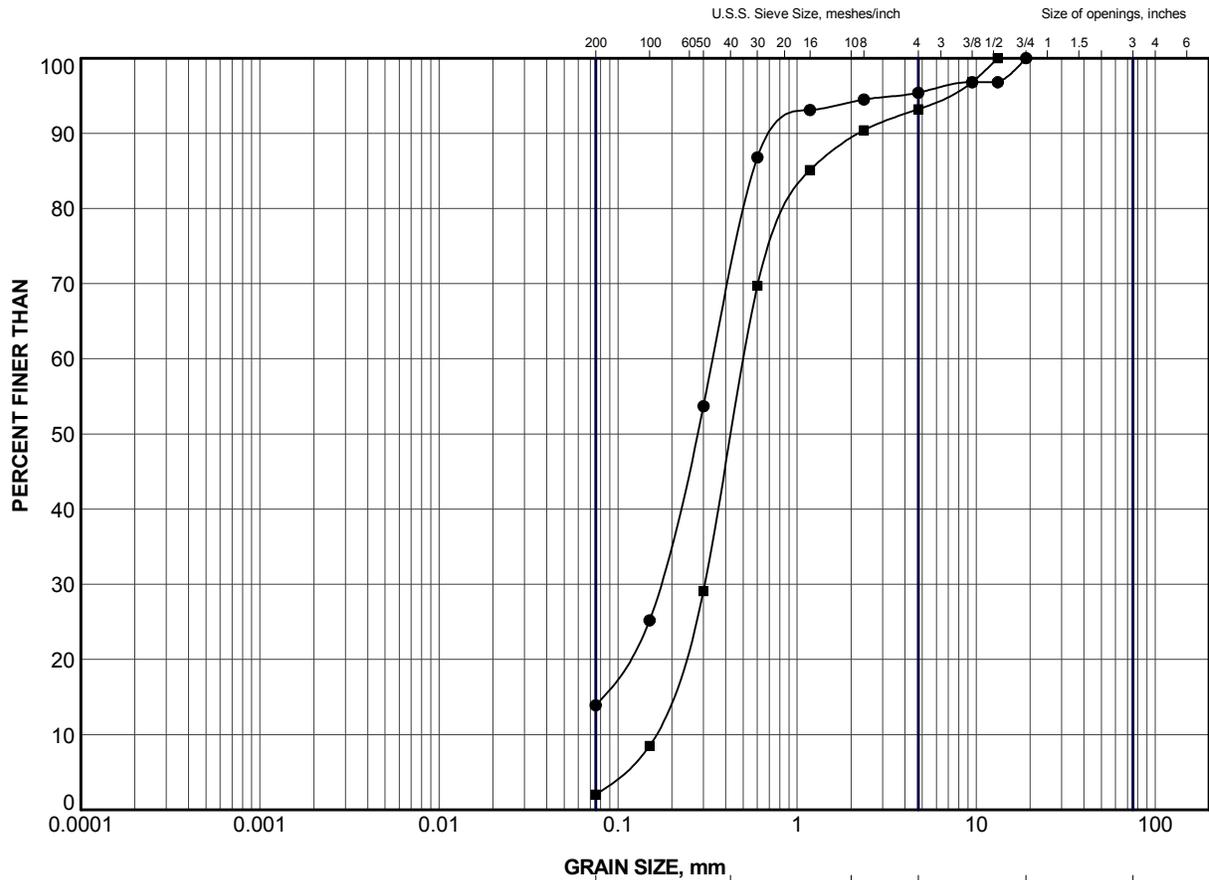
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20
236.1	GROUND SURFACE																	
0.0	Sand, trace gravel, trace silt, trace organics (FILL) Loose to compact Brown Wet		1	SS	8													
			2	SS	8													7 91 (2)
234.4			3	SS	23													
1.8	SAND and GRAVEL Grey Wet END OF BOREHOLE SPOON REFUSAL Note: 1. Water level at ground surface 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. Moved 2 m east to advance DCPT, refusal at 1.3 m depth. 4. Moved 2 m west and cored bedrock. See record of Borehole C2-3a for coring details.																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C2-3a	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125781.6; E 330556.2</u>	ORIGINATED BY <u>LG</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring, NQ Coring</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 25, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)					
							20	40	60	80	100	W _p	W	W _L				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED											
236.1	GROUND SURFACE																	
0.0	For stratigraphic details see Record of Borehole C2-3																	
234.6	1.5		1	RC	REC 100%												RQD = 100%	
	GNEISS (BEDROCK) Bedrock cored from 1.5 m depth to 4.7 m depth. For coring details see Record of Drillhole C2-3b.		2	RC	REC 96%													RQD = 96%
			3	RC	REC 81%													RQD = 44%
			4	RC	REC 100%													RQD = 56%
			5	RC	REC 100%													RQD = 69%
231.4	4.7																	
	END OF BOREHOLE Note: 1. Cored bedrock 2 m west of Borehole C2-3.																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:



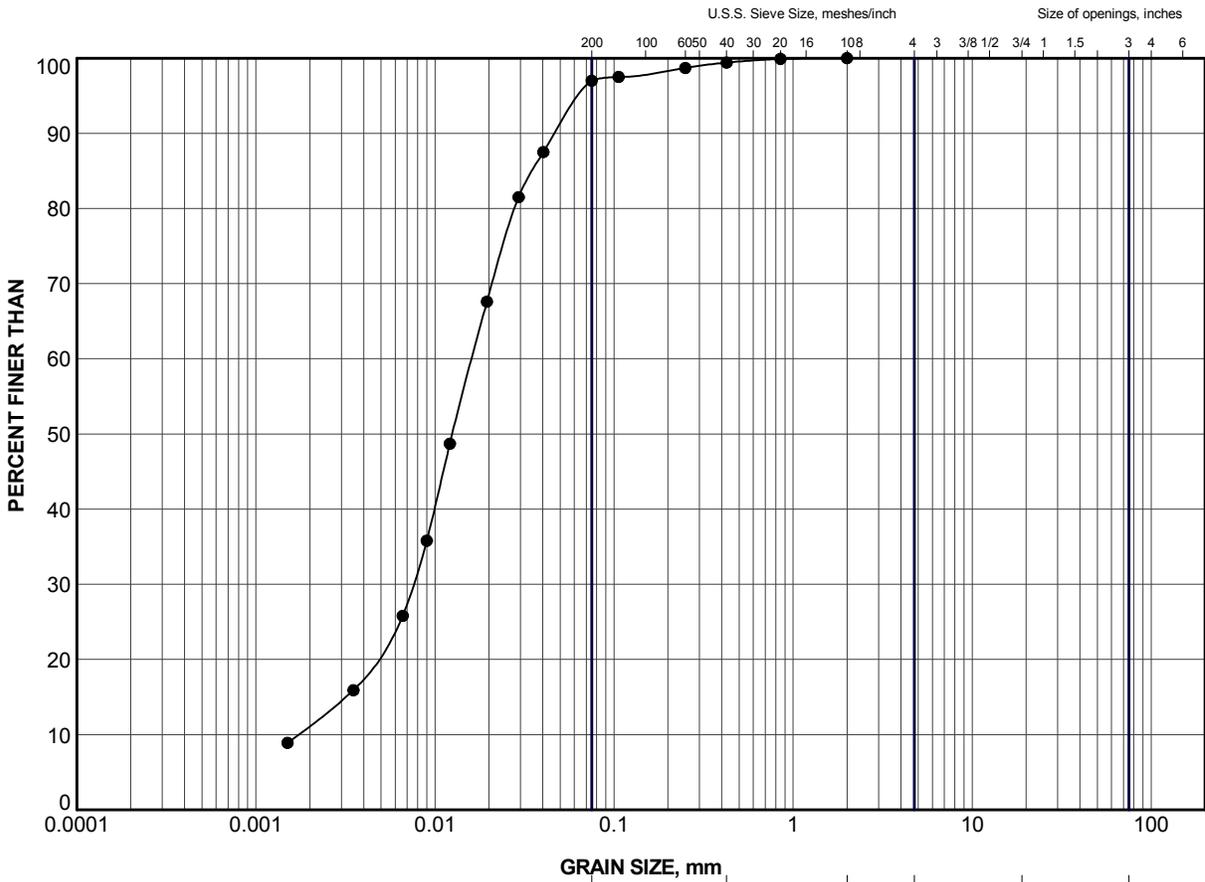
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C2-2	2	240.3
■	C2-3	2	235.2

PROJECT HIGHWAY 17 CULVERT AT STA 14+063							
TITLE GRAIN SIZE DISTRIBUTION SAND (FILL)							
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ			
		DRAWN	JJL	Feb 2012	SCALE	N/A	REV.
		CHECK	AB	Feb 2012	FIGURE G1		
		APPR	JMAC	Feb 2012			

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



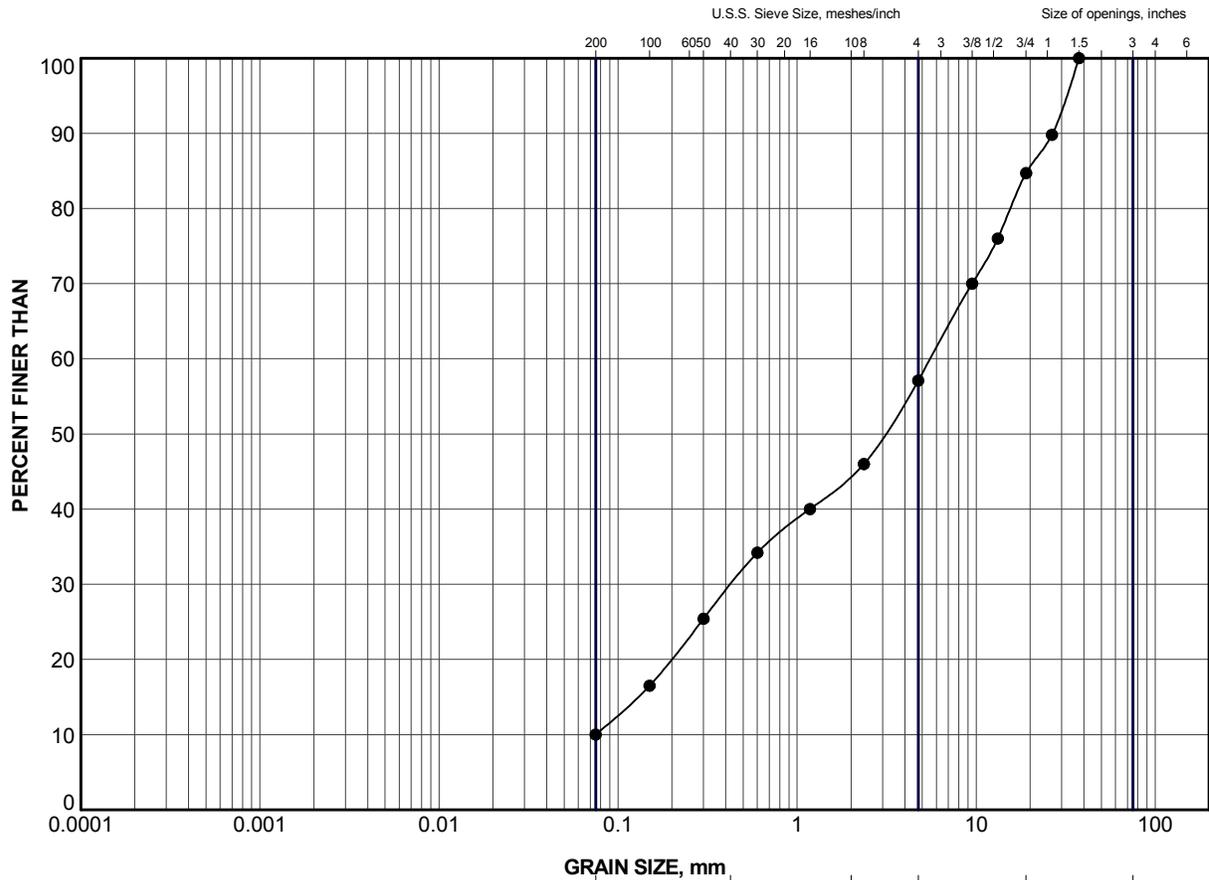
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C2-1	3b	234.5

PROJECT						HIGHWAY 17 CULVERT AT STA 14+063					
TITLE						GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.			10-1191-0041			FILE No.			1011910041.GPJ		
DRAWN	JJL	Feb 2012	SCALE	N/A	REV.						
CHECK	AB	Feb 2012									
APPR	JMAC	Feb 2012	FIGURE G2								



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C2-2	7	233.1

PROJECT					HIGHWAY 17 CULVERT AT STA 14+063				
TITLE					GRAIN SIZE DISTRIBUTION SAND AND GRAVEL				
PROJECT No.		10-1191-0041		FILE No.		1011910041.GPJ			
DRAWN	JJL	Feb 2012		SCALE	N/A	REV.			
CHECK	AB	Feb 2012		FIGURE G3					
APPR	JMAC	Feb 2012							



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX H

Culvert at STA 14+651 – Highway 17 (Bonfield Township)

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

CONT No.
GWP No.174-98-00

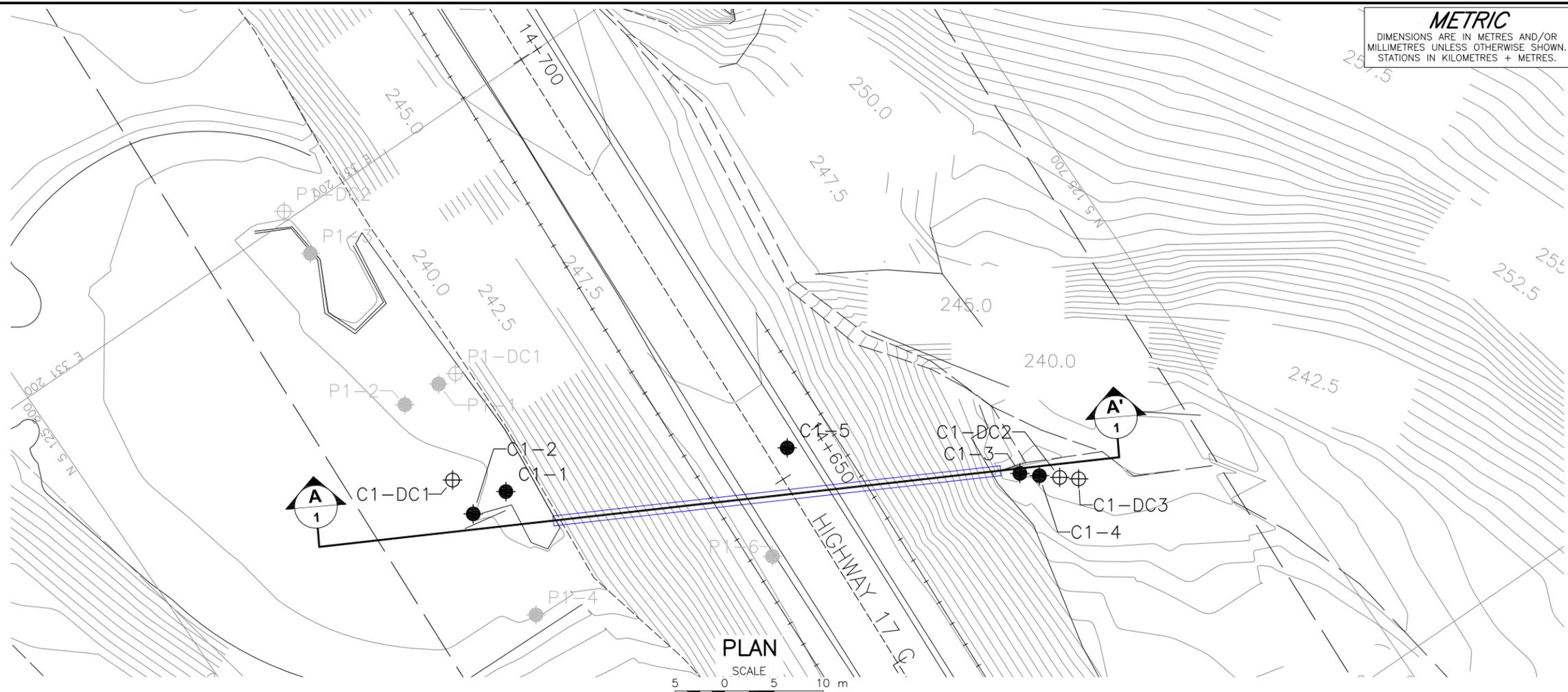
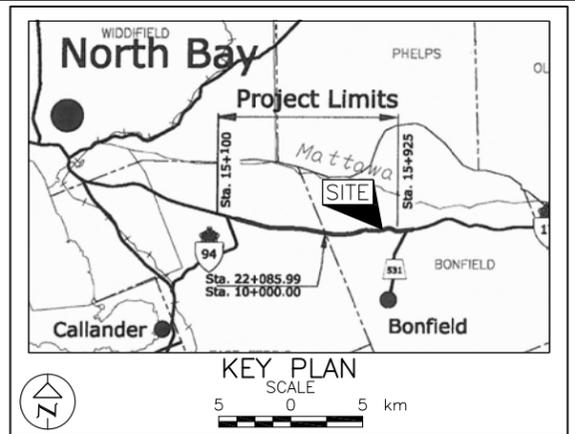


HIGHWAY 17
 CULVERT AT STA 14+651
BOREHOLE LOCATIONS AND SOIL STRATA

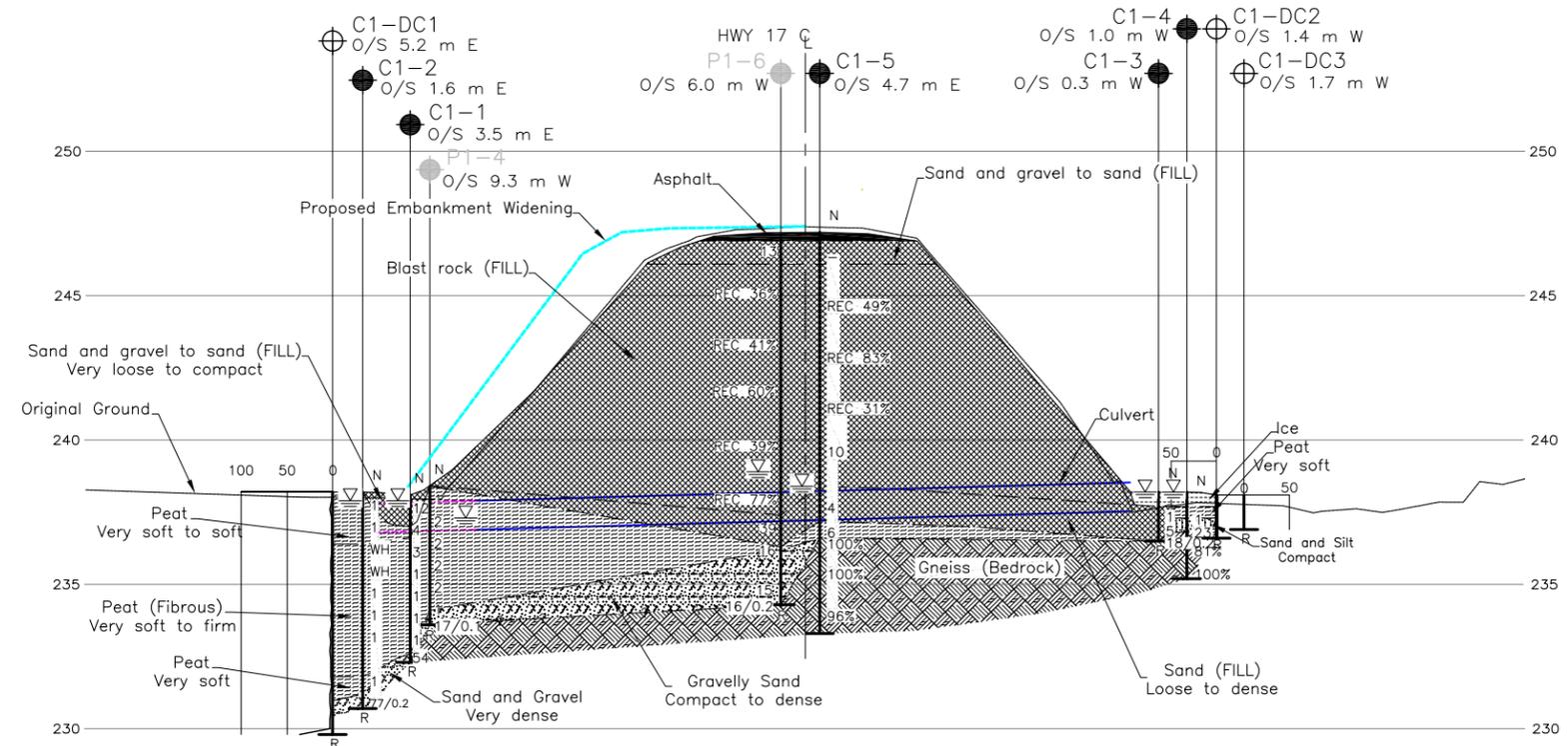
SHEET



Golder Associates Ltd.
 SUDBURY, ONTARIO, CANADA



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



BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C1-1	238.1	5125765.4	331164.9
C1-2	238.2	5125769.4	331164.9
C1-3	238.2	5125721.4	331137.1
C1-4	238.2	5125719.9	331135.8
C1-5	247.2	5125739.4	331152.5
C1-DC1	238.2	5125769.2	331168.9
C1-DC2	238.1	5125718.3	331134.5
C1-DC3	238.1	5125716.8	331133.3
P1-4	238.4	5125769.9	331152.9
P1-6	247.0	5125746.8	331144.3

NOTES

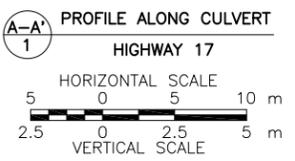
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by MMM, drawing file nos. BASE_ALL.dwg and Alignment.dwg received NOV 10, 2011. Keyplan received DEC 07, 2011.



NO.	DATE	BY	REVISION

Geocres No. 31L-158

HWY. 17	PROJECT NO. 10-1191-0041	DIST.
SUBM'D. MT	CHKD. AB	DATE: APR 2013
DRAWN: JJL	CHKD.	APPD. JMAC
		DWG. H1



PHOTOGRAPHS

Photograph 1: Culvert at STA 14+651, Looking Southwest (May 2011)



Photograph 2: Culvert at STA 14+651, Looking Southeast (March 2011)





PHOTOGRAPHS

Photograph 3: Culvert at STA 14+651, Looking East (May 2011)



Photograph 4: Culvert at STA 14+651, Looking East (May 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C1-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125765.4; E 331164.9</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>March 11 and 12, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)	
						20	40	60	80	100	20	40	60		GR	SA	SI	CL
238.1 0.0	GROUND SURFACE Sand and gravel, trace organics (FILL) Compact Brown Wet		1	SS	12	▽												
237.0	PEAT (Amorphous) Soft Brown / black Wet		2	SS	4													
236.6 1.5	PEAT (Fibrous) Very soft to soft Brown to black Wet		3	SS	3									512.2				
			4	SS	1													
			5	SS	1									780.6				
			6	SS	1													
			7	SS	1													
232.6			8a															
232.3 5.8	SAND and GRAVEL, trace to some silt Very dense Grey Wet END OF BOREHOLE SPOON REFUSAL Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 237.9 m) upon completion of drilling.		8b	SS	54											48	45	(7)

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C1-2	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125769.4; E 331164.9</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>March 2, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100	20	40	60		GR SA SI CL	
238.2	GROUND SURFACE															
0.0	PEAT (Amorphous) Very soft Brown / black Wet		1	SS	1											
			2	SS	1											
236.4	PEAT (Fibrous) Very soft Brown / black Wet		3	SS	WH											
1.8			4	SS	WH											
			5	SS	1											
			6	SS	1											
			7	SS	1											
			8	SS	1											
231.8	PEAT (Amorphous) Very soft Brown / black Wet		9	SS	77/0.2											
6.4																
231.2	SAND and GRAVEL, some silt Very dense Grey Wet															
7.0																
230.7	END OF BOREHOLE SPOON REFUSAL															
7.5																
	Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 237.9 m) upon completion of drilling.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C1-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125721.4; E 331137.1</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>March 4, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80						100	20
238.2	ICE SURFACE																	
0.0	ICE																	
237.7	Sand and gravel to gravelly sand, trace silt, trace to some organics (FILL) Very loose to compact Brown Wet		1	SS	1													
0.5			2	SS	5													
236.5			3	SS	18/0.2													23 74 (3)
1.7	END OF BOREHOLE SPOON REFUSAL Note: 1. Water level at ice surface (Elev. 238.2 m) 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.																	

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C1-4	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125719.9; E 331135.8</u>	ORIGINATED BY <u>ID</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, NW Casing, NQ Coring</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>March 4 and 8, 2011</u>	CHECKED BY <u>AB</u>

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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 (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
238.2	ICE SURFACE																
0.0	ICE						238										
237.7																	
237.3	PEAT (Amorphous) Very soft Brown / black Wet		1a	SS	1												
0.9			1b														
236.8	SAND and SILT, some gravel, trace clay, trace to some organics Compact Grey Wet		2	SS	23		237										12 48 38 2
1.4																	
	GNEISS (BEDROCK)		1	RC	REC 100%		236										RQD = 81%
	Bedrock cored from 1.4 m depth to 3.0 m depth.																
235.2			2	RC	REC 100%												
3.0	For coring details see Record of Drillhole C1-4. END OF BOREHOLE																
	Note: 1. Water level at ice surface (Elev. 238.2 m) upon completion of drilling.																

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

PROJECT: 10-1191-0041

RECORD OF DRILLHOLE: C1-4

SHEET 1 OF 1

LOCATION: N 5125719.9 ; E 331135.8

DRILLING DATE: March 4 and 8, 2011

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Hitti Drill

DRILLING CONTRACTOR: Landcore

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 Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION					
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w/ ZL CORE AXIS	Type and Surface Description	Jr	Ja	Jn				k, cm/s	10 ⁰	10 ¹	10 ²	10 ³
							FLUSH	FLUSH			FLUSH	FLUSH	FLUSH	FLUSH	FLUSH	FLUSH				FLUSH	FLUSH	FLUSH	FLUSH	FLUSH
		REFER TO PREVIOUS PAGE		236.8																				
2	NW NO Coring 04/04/11	GNEISS Fine to medium grained Fresh Grey		1.4	1	GREY 100%	100%	100%	100%										JIR JIR JIR JIR JIR JIR					
3		END OF DRILLHOLE		235.2	2	GREY 100%	100%	100%	100%															
3.0				3.0																				

SUD-RCK 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

DEPTH SCALE

1 : 50



LOGGED: ID

CHECKED: AB

RECORD OF BOREHOLE No C1-5 1 OF 2 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125739.4; E 331152.5 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY LG

DATUM Geodetic DATE May 11, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
						20 40 60 80 100	20 40 60 80 100	20 40 60					GR SA SI CL
247.2	GROUND SURFACE												
0.0 246.9	ASPHALT (260 mm)												
0.3	Sand and gravel to sand, trace silt (FILL) Brown Moist		1	AS	-								
246.1	Blast Rock (FILL)			RC	REC 49%								
1.1				RC	REC 83%								
				RC	REC 31%								
				-	SS 10								
238.4													
8.8	Sand, trace gravel, trace silt (FILL) Loose Brown Wet		2	SS	4							3 91 (6)	
237.2	PEAT (Fibrous) Firm Black Wet		3	SS	6								
236.6	GNEISS (BEDROCK)		1	RC	REC 100%							RQD = 100%	
10.0	Bedrock cored from 10.6 m depth to 13.9 m depth. For coring details see Record of Drillhole C1-5.		2	RC	REC 100%							RQD = 100%	
236.6			3	RC	REC 100%							RQD = 96%	
233.3													
13.9													

SUD-MTO 001 1011910041.GPJ GAL-MISS.GDT 15/03/13 DATA INPUT:

Continued Next Page

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



RECORD OF BOREHOLE No C1-5 2 OF 2 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125739.4; E 331152.5 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY LG

DATUM Geodetic DATE May 11, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					W _p	W	W _L					
--- CONTINUED FROM PREVIOUS PAGE ---								20	40	60	80	100		20	40	60	
	END OF BOREHOLE Note: 1. Water level at a depth of 8.8 m below ground surface (Elev. 238.4 m) upon completion of drilling.																

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



PROJECT 10-1191-0041 **RECORD OF PENETRATION TEST No C1-DC1** 1 OF 1 **METRIC**

W.P. 174-98-00 LOCATION N 5125769.2; E 331168.9 ORIGINATED BY ID

DIST HWY 17 BOREHOLE TYPE DYNAMIC CONE PENETRATION TEST COMPILED BY LG

DATUM Geodetic DATE March 4, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20
238.2 0.0	GROUND SURFACE START OF DCPT					238											
						237											
						236											
						235											
						234											
						233											
						232											
						231											
229.8 8.4	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)					230											

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



PROJECT 10-1191-0041 **RECORD OF PENETRATION TEST No C1-DC2** 1 OF 1 **METRIC**

W.P. 174-98-00 LOCATION N 5125718.3; E 331134.5 ORIGINATED BY ID

DIST HWY 17 BOREHOLE TYPE DYNAMIC CONE PENETRATION TEST COMPILED BY LG

DATUM Geodetic DATE March 4, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
238.1	ICE SURFACE															
0.0	START OF DCPT					238										
236.6						237										
1.5	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)															
	Note: 1. DCPT values 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.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

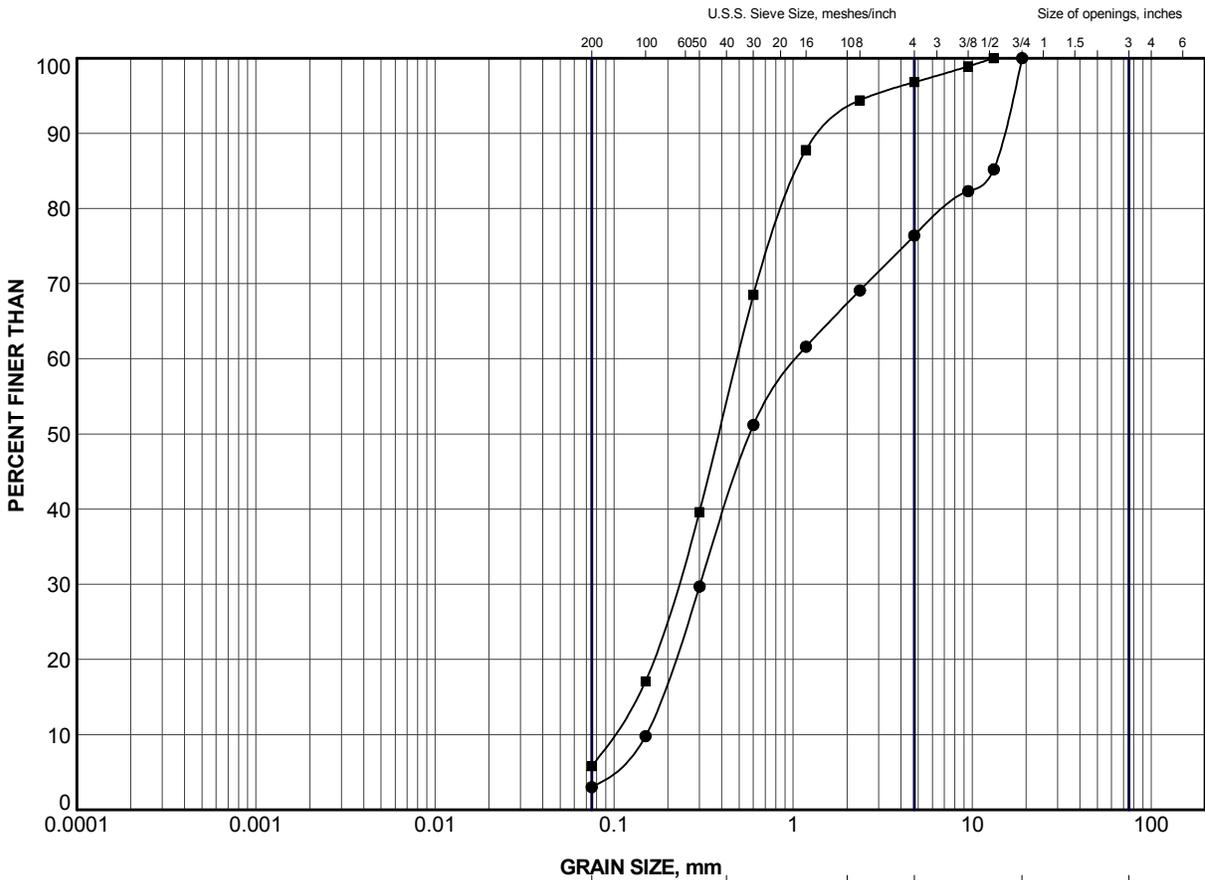


PROJECT 10-1191-0041 **RECORD OF PENETRATION TEST No C1-DC3** 1 OF 1 **METRIC**
W.P. 174-98-00 **LOCATION** N 5125716.8; E 331133.3 **ORIGINATED BY** ID
DIST HWY 17 **BOREHOLE TYPE** DYNAMIC CONE PENETRATION TEST **COMPILED BY** LG
DATUM Geodetic **DATE** March 4, 2011 **CHECKED BY** AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20
238.1	ICE SURFACE																
0.0	START OF DCPT					238											
236.9	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING)					237											
1.2	Note: 1. DCPT values 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.																

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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



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

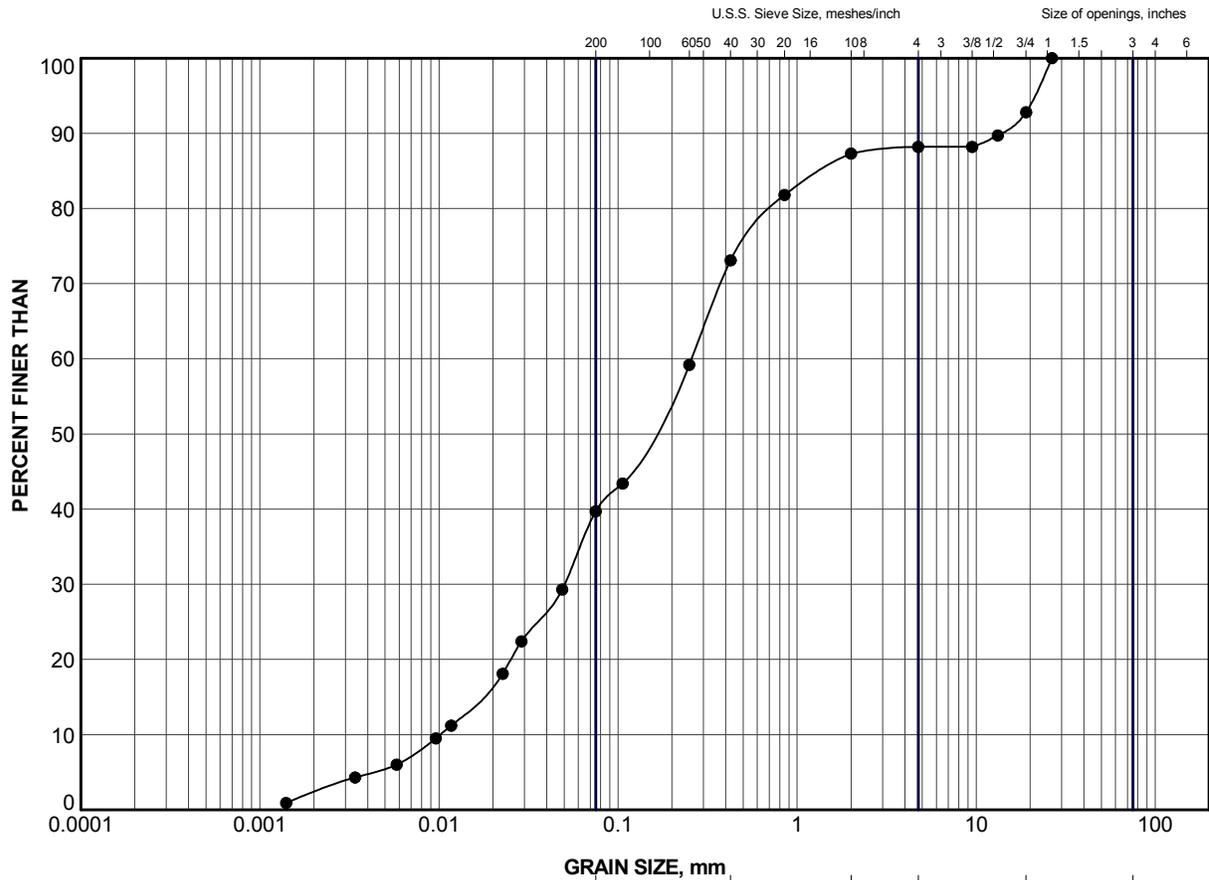
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C1-3	3	236.6
■	C1-5	2	237.8

PROJECT HIGHWAY 17 CULVERT AT STA 14+651				
TITLE GRAIN SIZE DISTRIBUTION GRAVELLY SAND TO SAND (FILL)				
PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
DRAWN	JJL	Feb 2012	SCALE	N/A
CHECK	AB	Feb 2012	REV.	
APPR	JMAC	Feb 2012	FIGURE H1	



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

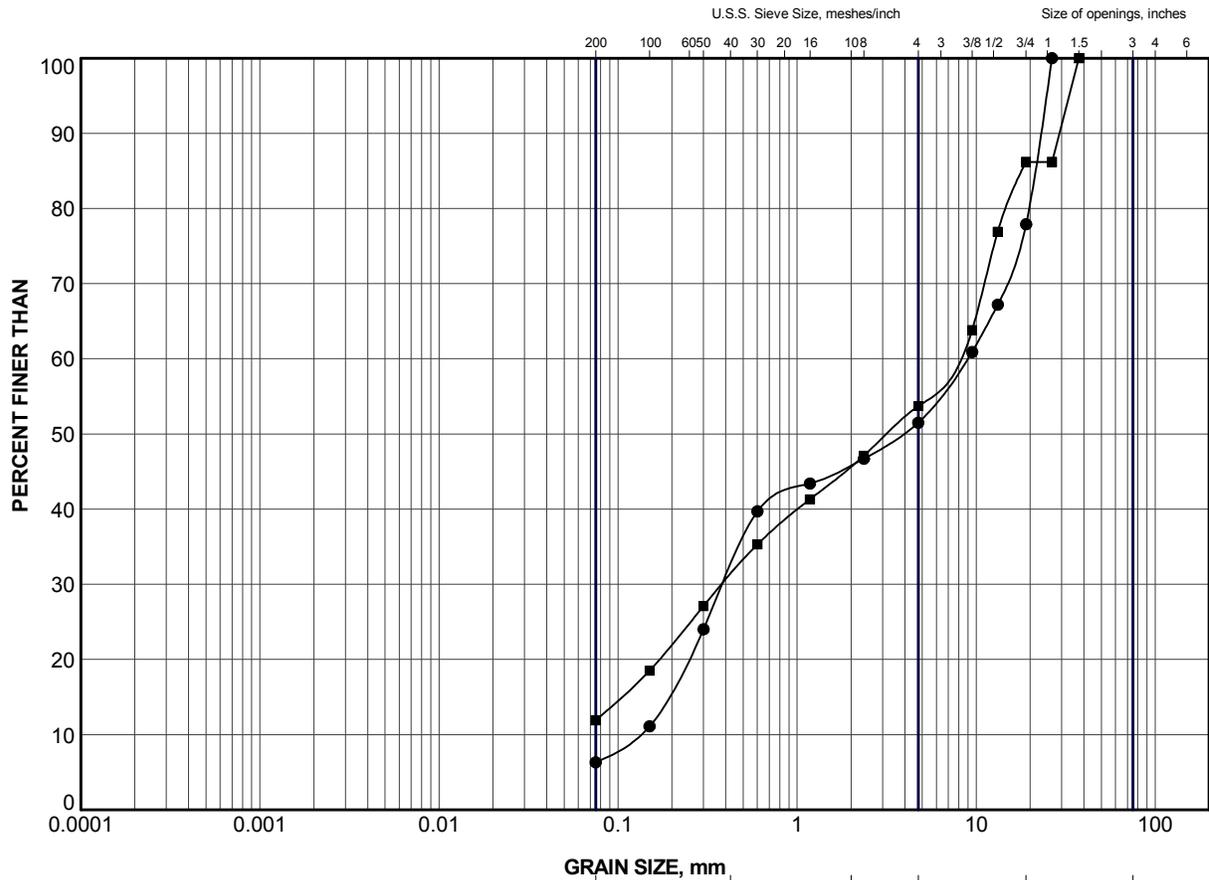
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C1-4	2	237.0

PROJECT					HIGHWAY 17 CULVERT AT STA 14+651				
TITLE					GRAIN SIZE DISTRIBUTION SAND AND SILT				
PROJECT No.		10-1191-0041		FILE No.		1011910041.GPJ			
DRAWN	JJL	Feb 2012	SCALE	N/A	REV.				
CHECK	AB	Feb 2012							
APPR	JMAC	Feb 2012	FIGURE H2						



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C1-1	8b	232.5
■	C1-2	9	230.8

PROJECT HIGHWAY 17 CULVERT AT STA 14+651					
TITLE GRAIN SIZE DISTRIBUTION SAND AND GRAVEL					
PROJECT No.		10-1191-0041		FILE No. 1011910041.GPJ	
DRAWN	JJL	Feb 2012	SCALE	N/A	REV.
CHECK	AB	Feb 2012	FIGURE H3		
APPR	JMAC	Feb 2012			
 Golder Associates SUDBURY, ONTARIO					

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX I

Culvert at STA 14+978 – Highway 17 (Bonfield Township)

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

CONT No.
GWP No.174-98-00

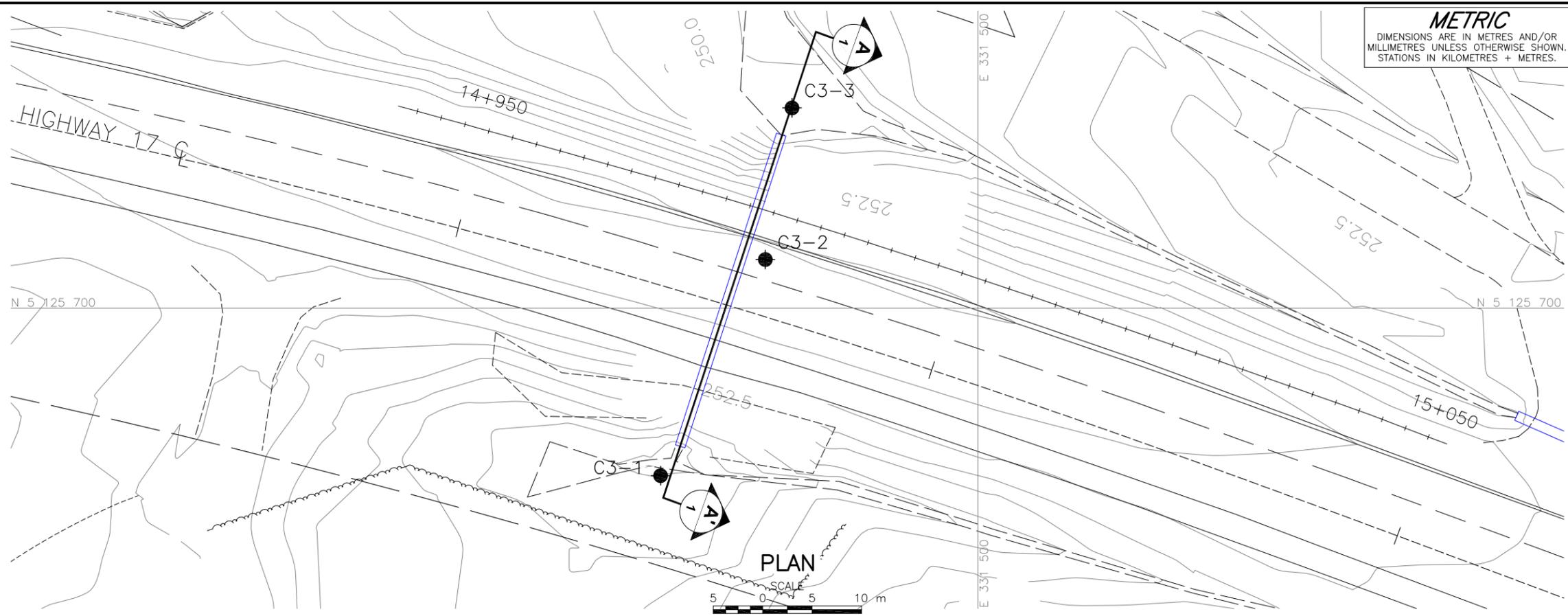
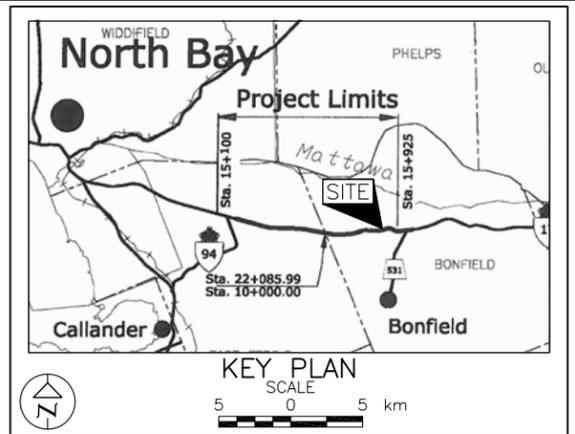


HIGHWAY 17
CULVERT AT STA 14+978
BOREHOLE LOCATIONS AND
SOIL STRATA

SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- Recovery (100%)
- WL in piezometer, measured on NOV 17, 2011
- WL upon completion of drilling
- Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C3-1	249.4	5125683.1	331467.9
C3-2	253.9	5125704.9	331478.5
C3-3	249.3	5125720.2	331481.2

NOTES

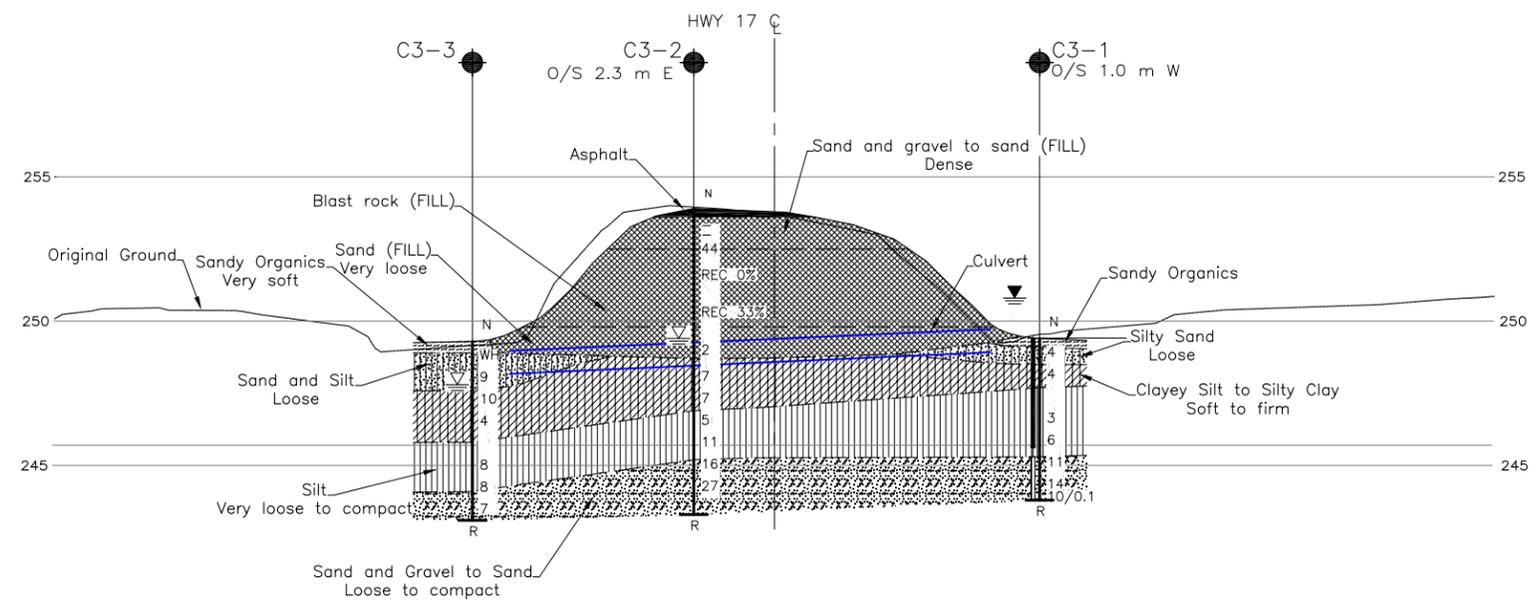
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by MMM, drawing file nos. BASE_ALL.dwg and Alignment.dwg received NOV 10, 2011. Keyplan received DEC 07, 2011. Contours received JAN 4, 2012



NO.	DATE	BY	REVISION

Geocres No. 31L-158

HWY. 17	PROJECT NO. 10-1191-0041	DIST.
SUBM'D. MT	CHKD. AB	DATE: APR 2013
DRAWN: JJJ	CHKD.	APPD. JMAC
		DWG. 11



PHOTOGRAPHS

Photograph 1: Culvert at STA 14+978, Looking West (November 2011)



Photograph 2: Culvert at STA 14+978, Looking North (May 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C3-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125683.1; E 331467.9</u>	ORIGINATED BY <u>EHS</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>108mm ID Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 13 and 16, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
						20	40	60	80	100	20	40	60		GR	SA	SI	CL	
249.4	GROUND SURFACE																		
0.0 249.1	Sandy TOPSOIL Brown/black Wet		1	SS	4														
0.3																			
248.5	Silty SAND Loose Brown to grey Wet		2a																
0.9			2b	SS	4														
247.7	SILTY CLAY Firm Brown to grey Wet																		
1.7																			
247.3	SILT, trace to some clay, trace sand Very loose to compact Brown to grey Wet		3	SS	3														
			4	SS	6														0 3 86 11
245.3	SAND and GRAVEL, some silt, trace clay Compact Grey Wet		5a	SS	11														
4.1			5b																
			6	SS	14														
243.8																			
			7	SS	10/0.1														
5.6	END OF BOREHOLE AUGER REFUSAL																		
	Notes: 1. Water level at 0.6 m above ground surface (Elev. 250.0 m) upon completion of drilling. 2. Water level in piezometer at 1.4 m above ground surface (Elev. 250.8) on November 17, 2011.																		

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

RECORD OF BOREHOLE No C3-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125704.9; E 331478.5 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers, NW Casing, NQ Coring COMPILED BY LG

DATUM Geodetic DATE May 12, 2011 CHECKED BY AB

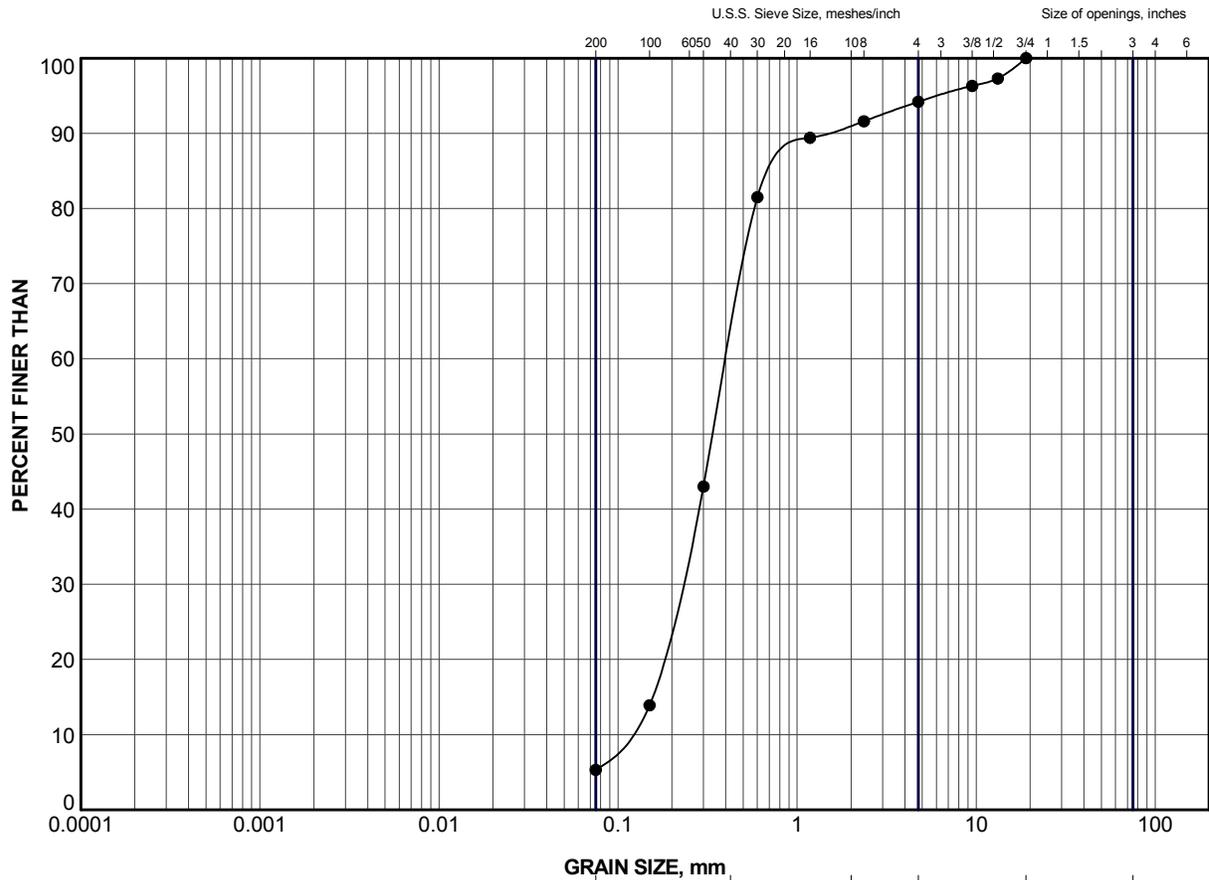
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
253.9	GROUND SURFACE															
0.0	ASPHALT (275 mm)															
253.6																
0.3	Sand and gravel to sand, trace silt (FILL) Dense Brown Moist		1	AS	-											
			2	AS	-											
252.5			3	SS	44											
1.4	Blast rock (FILL)															
				RC	REC 0%											
				RC	REC 33%											
249.8																
4.1	Sand, trace gravel, trace silt (FILL) Very loose Brown Wet		4	SS	2											
248.7																
5.2	SILTY CLAY Firm Brown to grey Wet		5	SS	7											
			6	SS	7											
246.9			7a													
7.0	SILT, some clay, trace sand Loose to compact Grey Wet		7b	SS	5											
			8	SS	11											
245.2			9a	SS	16											
8.7	Gravelly SAND to SAND and GRAVEL, some silt Compact Grey Moist		9b													
			10	SS	27											
243.3																
10.6	END OF BOREHOLE REFUSAL TO FURTHER CASING PENETRATION															
	Note: 1. Water level at a depth of 4.5 m below ground surface (Elev. 249.4 m) upon completion of drilling.															

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C3-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125720.2; E 331481.2</u>	ORIGINATED BY <u>EHS</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>108mm ID Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 18, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W			W _L	GR	SA	SI	CL	
249.3	GROUND SURFACE																					
0.0	Sandy TOPSOIL		1	SS	WH																	
248.9	Very soft Brown / black Moist																					
0.4	SAND and SILT, some clay		2	SS	9														0	43	40	17
	Loose Brown to grey Moist		3a																			
247.6	CLAYEY SILT to SILTY CLAY		3b	SS	10																	
1.7	Soft to firm Brown to grey Wet		4	SS	4																	
245.8	SILT, trace to some clay, trace sand																					
3.5	Loose Grey Wet	5	SS	8																		
		6	SS	8																		
244.1	SAND, trace to some gravel, trace to some silt																					
5.2	Loose Grey Wet	7	SS	7																		
243.1	END OF BOREHOLE AUGER REFUSAL																					
6.2	Note: 1. Water level at a depth of 1.5 m below ground surface (Elev. 247.8 m) upon completion of drilling.																					

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:



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

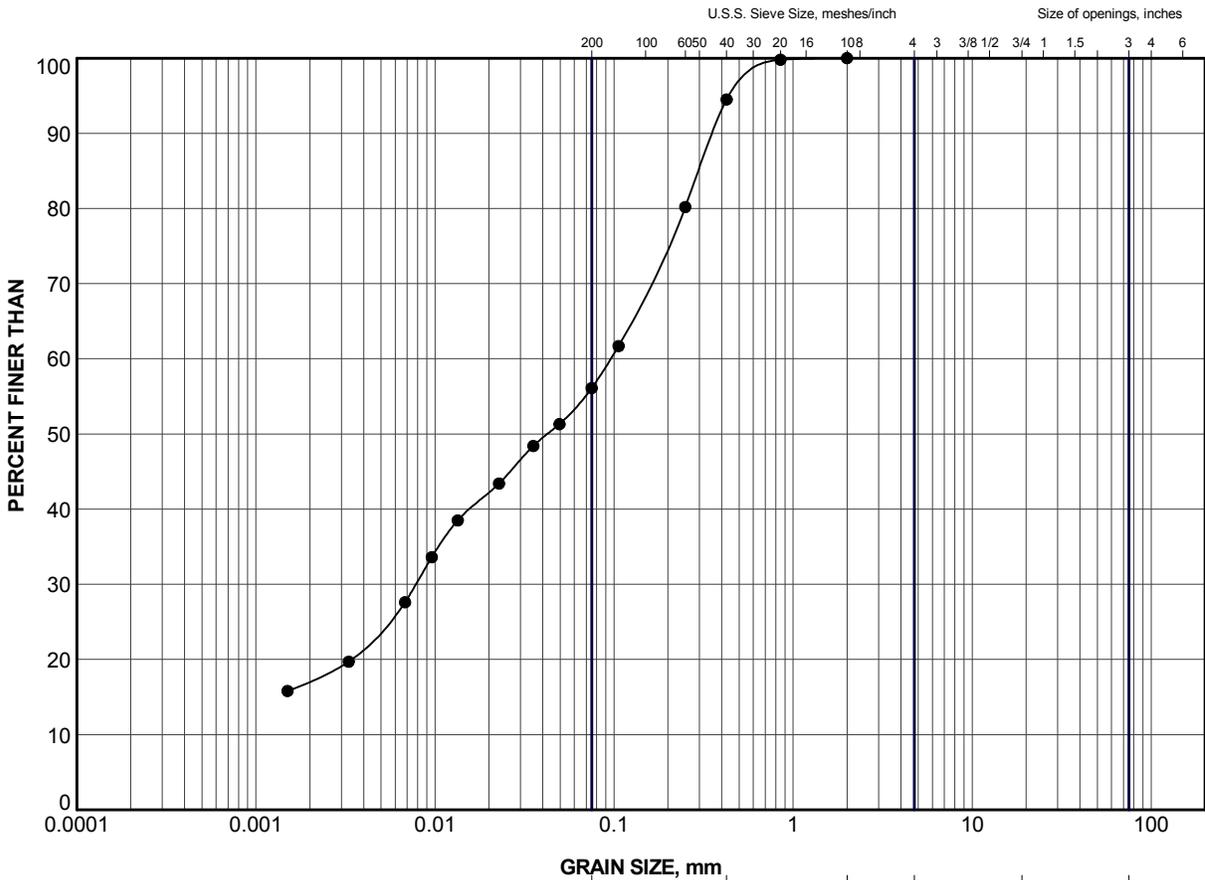
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C3-2	2	253.2

PROJECT HIGHWAY 17 CULVERT AT STA 14+978				
TITLE GRAIN SIZE DISTRIBUTION SAND (FILL)				
PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
DRAWN	JJL	Feb 2012	SCALE	N/A
CHECK	AB	Feb 2012	REV.	
APPR	JMAC	Feb 2012	FIGURE I1	



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

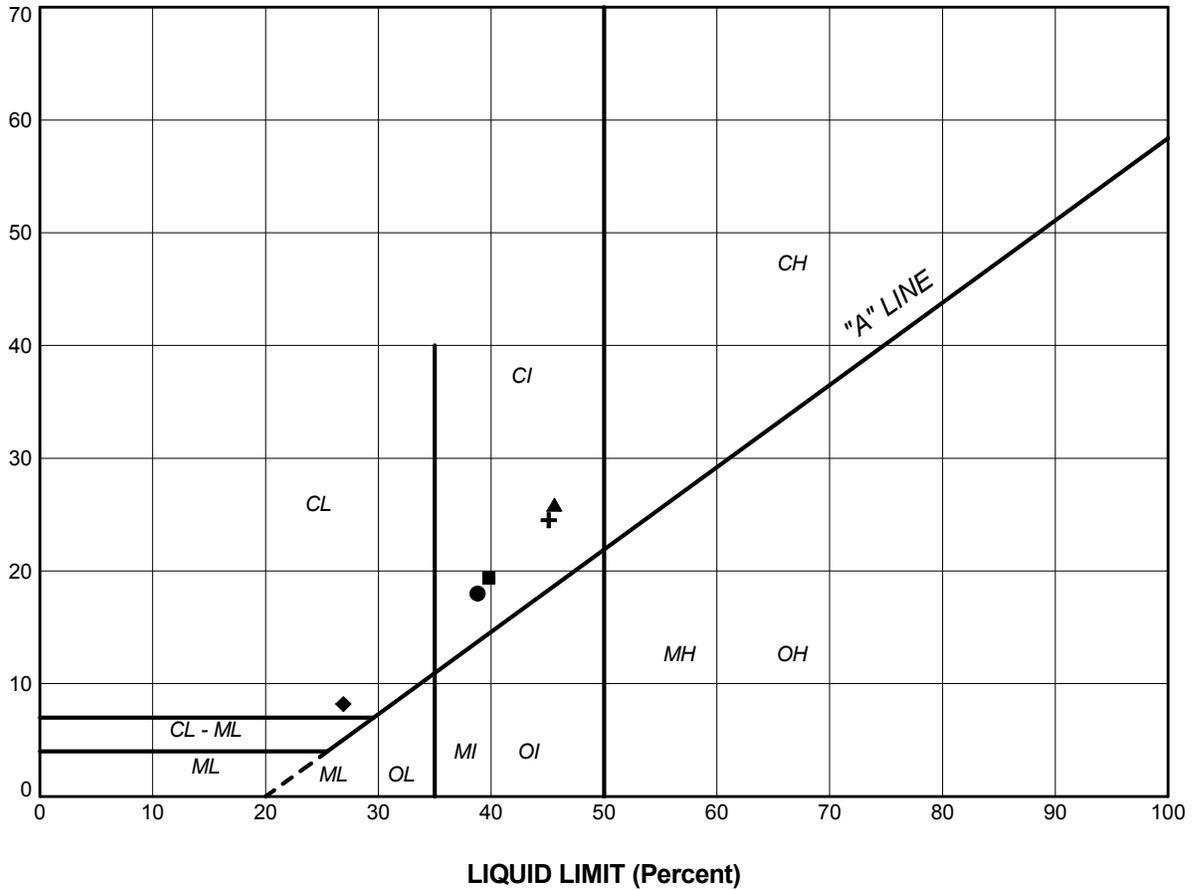
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C3-3	2	248.2

PROJECT HIGHWAY 17 CULVERT AT STA 14+978						
TITLE GRAIN SIZE DISTRIBUTION SAND AND SILT						
 Golder Associates <small>SUDBURY, ONTARIO</small>		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE 12	

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT

PLASTICITY INDEX (Percent)



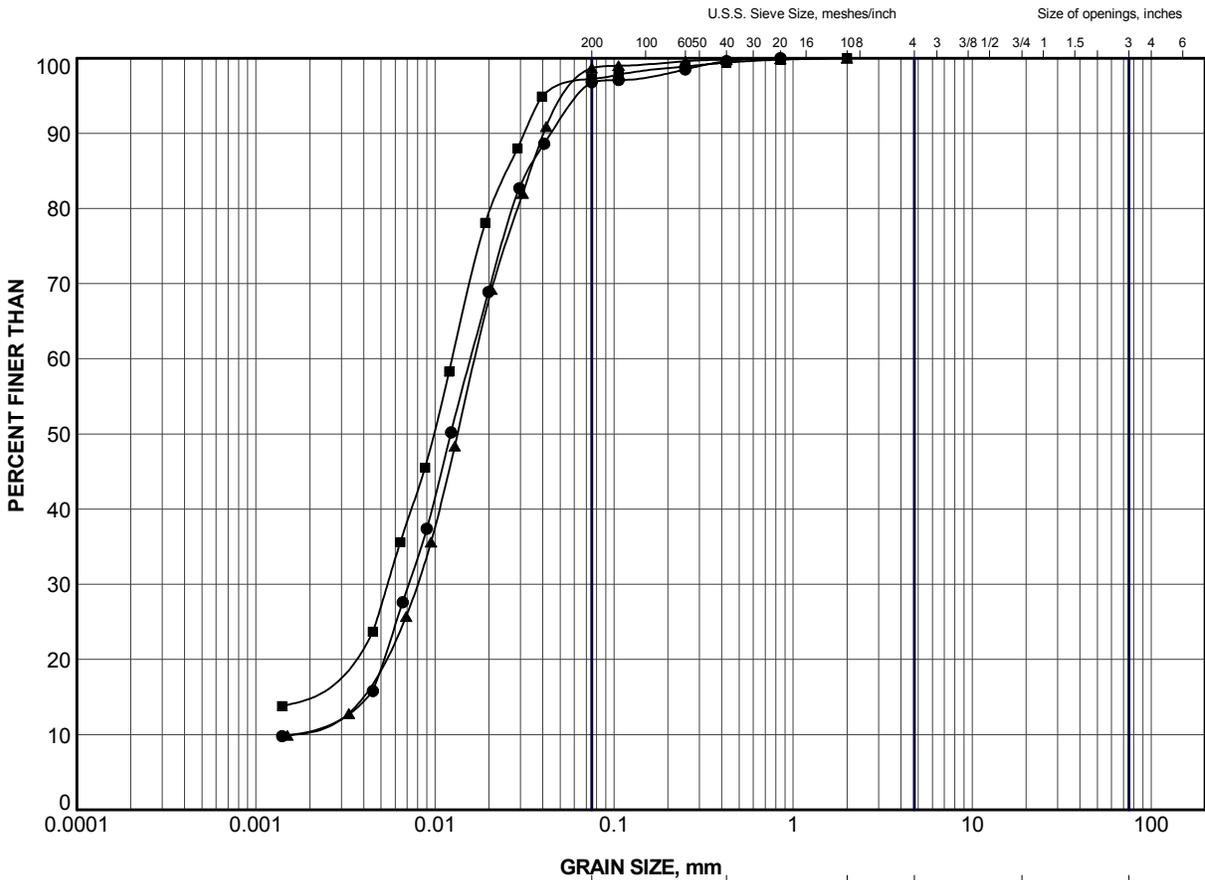
SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C3-1	2b	38.8	20.8	18.0
■	C3-2	5	39.8	20.4	19.4
▲	C3-2	6	45.6	19.7	25.9
+	C3-3	3b	45.1	20.6	24.5
◆	C3-3	4	26.9	18.7	8.2

PROJECT					HIGHWAY 17 CULVERT AT STA. 14+978					
TITLE					PLASTICITY CHART CLAYEY SILT TO SILTY CLAY					
PROJECT No. 10-1191-0041			FILE No. 1011910041.GPJ		DRAWN JLL Feb 2012			SCALE N/A		REV.
CHECK AB Feb 2012			APPR JMAC Feb 2012			FIGURE 13				
 Golder Associates SUDBURY, ONTARIO										



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

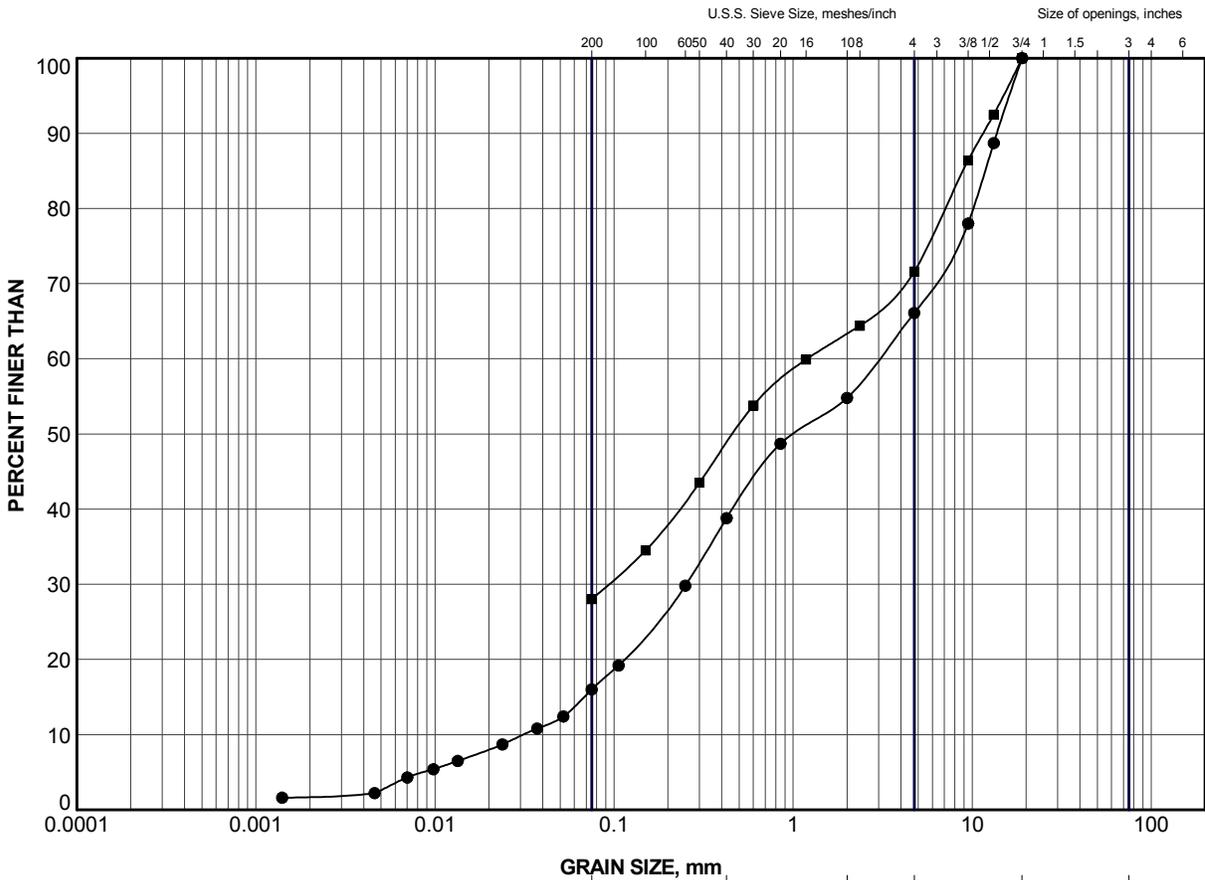
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C3-1	4	246.0
■	C3-2	7b	246.7
▲	C3-3	5	245.2

PROJECT HIGHWAY 17 CULVERT AT STA 14+978				
TITLE GRAIN SIZE DISTRIBUTION SILT				
PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
DRAWN	JJL	Feb 2012	SCALE	N/A
CHECK	AB	Feb 2012	REV.	
APPR	JMAC	Feb 2012	FIGURE 14	



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C3-1	5b	245.1
■	C3-2	9b	245.1

PROJECT HIGHWAY 17 CULVERT AT STA 14+978					
TITLE GRAIN SIZE DISTRIBUTION GRAVELLY SAND TO SAND AND GRAVEL					
PROJECT No.		10-1191-0041		FILE No. 1011910041.GPJ	
DRAWN	JJL	Feb 2012	SCALE	N/A	REV.
CHECK	AB	Feb 2012	FIGURE 15		
APPR	JMAC	Feb 2012			



SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



APPENDIX J

Culvert at STA 15+400 – Highway 17 (Bonfield Township)



PHOTOGRAPHS

Photograph 1: Culvert at STA 15+400, Looking East (May 2011)



PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C4-1	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125573.6; E 331880.2</u>	ORIGINATED BY <u>EHS</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>108mm ID Continuous Flight Hollow Stem Augers</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 18, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80			100
234.3	GROUND SURFACE													
0.0 234.0 0.3	Sandy topsoil (FILL) Very soft Brown / black Moist		1a	SS	2									
233.2	Sand, trace to some gravel, trace silt (FILL) Very loose Brown to grey Moist		2a	SS	1									
1.1 232.6	Silty TOPSOIL / PEAT Black Moist to wet		2b											
1.7	SILT, trace sand, trace to some clay Very loose to dense Grey to brown Wet		3	SS	4									
			4	SS	11									0 4 88 8
			5	SS	14									
			6	SS	25/0.15									
229.9 4.4	END OF BOREHOLE AUGER REFUSAL													
Notes: 1. Water level at a depth of 2.0 m below ground surface (Elev. 232.3 m) upon completion of drilling. 2. Moved 1 m west to advance DCPT, refusal at 5.8 m depth.														

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

RECORD OF BOREHOLE No C4-2 1 OF 1 **METRIC**

PROJECT 10-1191-0041

W.P. 174-98-00 LOCATION N 5125592.7; E 331881.4 ORIGINATED BY EHS

DIST HWY 17 BOREHOLE TYPE 108mm ID Continuous Flight Hollow Stem Augers COMPILED BY LG

DATUM Geodetic DATE May 16, 2011 CHECKED BY AB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100	20	40	60	kN/m ³	GR SA SI CL	
237.9	GROUND SURFACE															
0.0	ASPHALT (165 mm)		1	AS	-											
0.2	Sand and gravel to sand, trace silt (FILL) Compact to dense Brown to grey Moist		2	AS	-						○				13 81 (6)	
			3	SS	16											
			4	SS	30											
			5	SS	39						○				28 54 (18)	
			6	SS	15											
			7	SS	23											
233.5	Sandy SILT to Silty SAND, trace to some gravel, trace clay Compact to dense Grey Moist to wet		8	SS	21						○				0 20 73 7	
4.4																
			9	SS	30											
			10	SS	37						○				11 58 28 3	
229.3	END OF BOREHOLE AUGER REFUSAL															
8.6	Note: 1. Water level at a depth of 6.1 m below ground surface (Elev. 231.8 m) upon completion of drilling.															

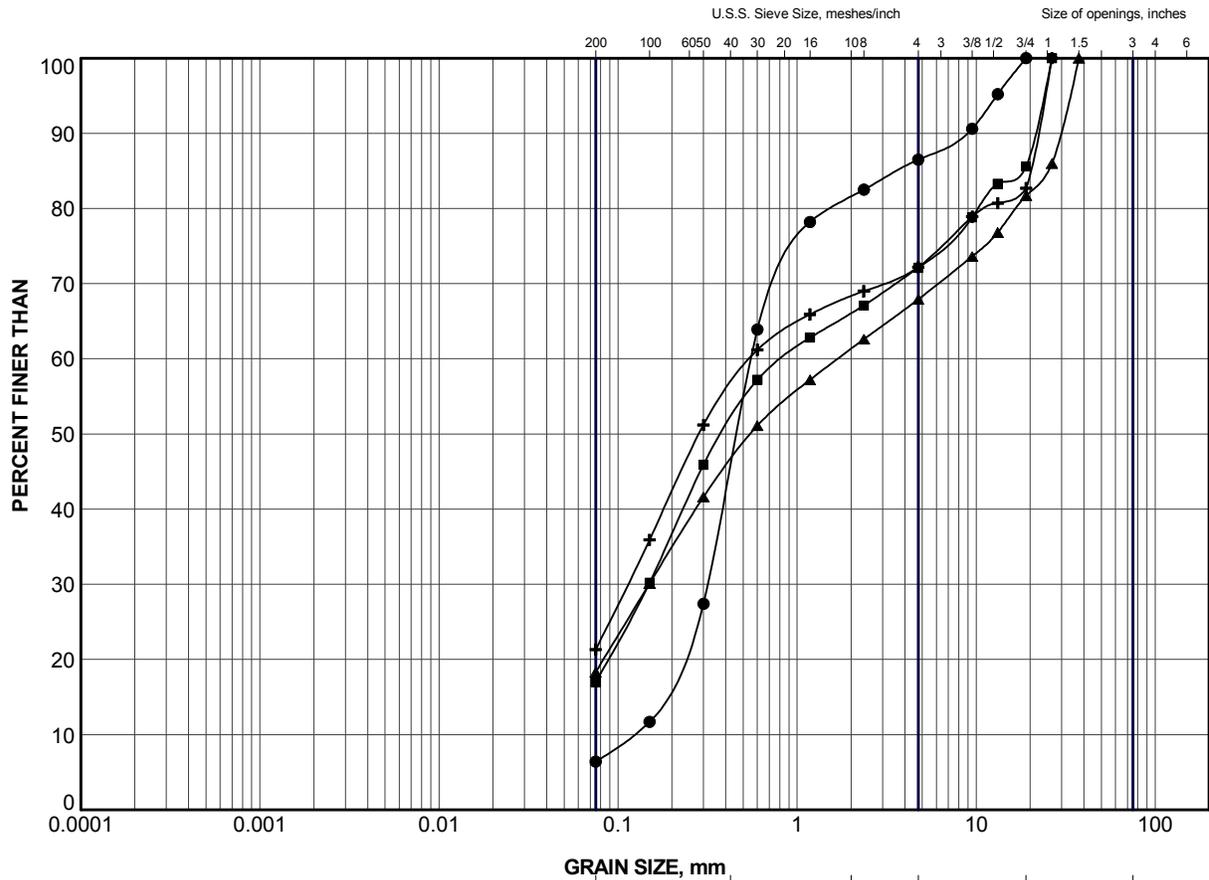
SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:

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

PROJECT <u>10-1191-0041</u>	RECORD OF BOREHOLE No C4-3	1 OF 1 METRIC
W.P. <u>174-98-00</u>	LOCATION <u>N 5125614.6; E 331879.5</u>	ORIGINATED BY <u>LG</u>
DIST <u> </u> HWY <u>17</u>	BOREHOLE TYPE <u>Portable Equipment, HQ Casing, Wash Boring</u>	COMPILED BY <u>LG</u>
DATUM <u>Geodetic</u>	DATE <u>May 30, 2011</u>	CHECKED BY <u>AB</u>

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W			W _L			
							○ UNCONFINED + FIELD VANE					WATER CONTENT (%)								
							● QUICK TRIAXIAL × REMOULDED													
							20 40 60 80 100					20 40 60								
							20 40 60 80 100													
235.1	GROUND SURFACE					235														
0.0	Sand to sand and gravel (FILL) Loose to very dense Brown Moist Containing cobbles and boulders below 0.8 m depth.		1	SS	4	235														
			2	SS	91	234														
			3	SS	53	233						○						32	50	(18)
			4	SS	74	233						○						28	51	(21)
232.0	END OF BOREHOLE SPOON REFUSAL		5	SS	20/0.05	232														
3.1	Note: 1. Water level at ground surface (Elev. 235.1 m) upon completion of drilling. 2. Refusal at 0.8 m at original borehole location, moved 0.7 m west and continued sampling. 3. Moved 1.0 m west to advance DCPT, refusal at 3.1 m depth.																			

SUD-MTO 001 1011910041.GPJ CAL-MISS.GDT 15/03/13 DATA INPUT:



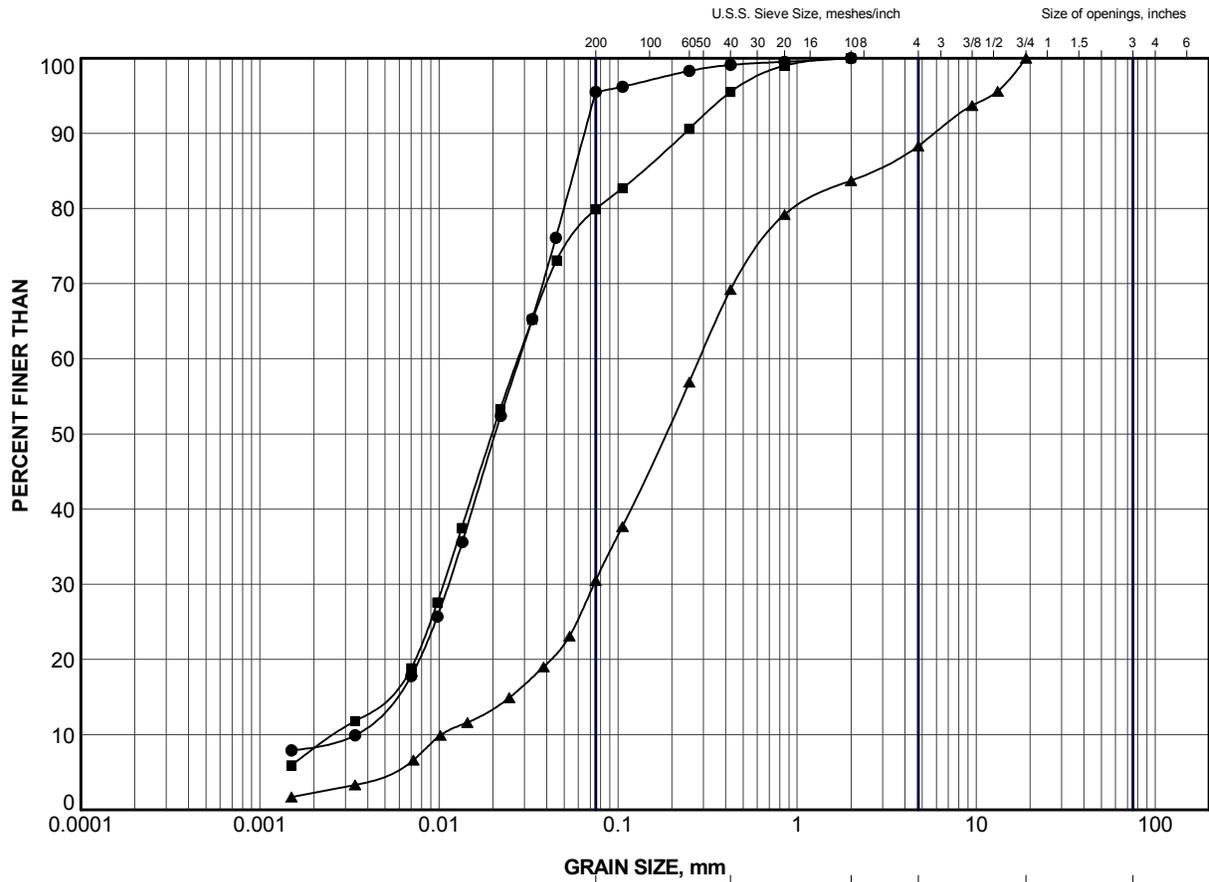
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C4-2	2	237.3
■	C4-2	5	235.3
▲	C4-3	3	233.3
+	C4-3	4	232.5

PROJECT HIGHWAY 17 CULVERT AT STA 15+400					
TITLE GRAIN SIZE DISTRIBUTION SAND AND GRAVEL TO SAND (FILL)					
PROJECT No.		10-1191-0041		FILE No.	1011910041.GPJ
DRAWN	JJL	Feb 2012	SCALE	N/A	REV.
CHECK	AB	Feb 2012	FIGURE J1		
APPR	JMAC	Feb 2012			
 Golder Associates SUDBURY, ONTARIO					

SUD-MTO(GSD)\CULVERTS_GLDR_LDN.GDT



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C4-1	4	231.7
■	C4-2	8	233.0
▲	C4-2	10	230.0

PROJECT HIGHWAY 17 CULVERT AT STA 15+400						
TITLE GRAIN SIZE DISTRIBUTION SILT TO SILTY SAND						
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 10-1191-0041		FILE No. 1011910041.GPJ		
		DRAWN	JJL	Feb 2012	SCALE	N/A
		CHECK	AB	Feb 2012	REV.	
		APPR	JMAC	Feb 2012	FIGURE J2	

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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