



April 6, 2017

FOUNDATION INVESTIGATION REPORT

Centreline Culvert Replacement - Highway 112
STA 21+845, Township of Otto
Ministry of Transportation, Ontario
G.W.P. 5105-12-00; W.P. 5428-15-01

Submitted to:

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REPORT

GEOCRE NO.: 42A-112

Report Number: 1531057-2

Distribution:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by MMM Group Limited (MMM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide Foundation Engineering services for the replacement of the centreline culvert at STA 21+845 on Highway 112 in the Township of Otto, approximately 8 km south of Kirkland Lake, Ontario.

The Terms of Reference and Scope of Work for the foundation investigation are outlined in MTO's Work Order / Assignment #2, dated March 2016. Golder's proposal for the foundation engineering services associated with the culverts is contained in Golder's letter addressed to MMM, dated April 13, 2016. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated May 25, 2016.

This report addresses the investigation carried out for the culvert at STA 21+845 on Highway 112 which has been identified for replacement. The foundation engineering services associated with the other culverts for Work Order / Assignment #2 are presented in separate reports.

2.0 SITE DESCRIPTION

The centreline culvert requiring replacement is located at approximately STA 21+845 on Highway 112 in the Township of Otto, approximately 8 km south of Kirkland Lake, Ontario. The existing culvert is a 910 mm wide by 610 mm high open footing structure covered with up to approximately 6 m of embankment fill. Details of the culvert are also summarized in Table 1 following the text of this report.

In general, the topography in the area of the culvert consists of rolling surface topography with sparsely to densely populated treed areas and numerous bedrock outcrops separated by valleys which generally contain agricultural land or swamps containing slow flowing to standing water, various types of vegetation and organic soils. The developed area directly adjacent to Highway 112 is primarily used for residential purposes and agriculture. The ground surface at the borehole and DCPT locations advanced for the culvert investigation, including through the existing Highway 112 embankment, varies between Elevation 321.5 m and 315.1 m, referenced to Geodetic datum. Figure 1 contains photographs of the ground surface conditions at/near the culvert location.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation associated with the culvert at STA 21+845 was carried out between May 31 and June 3, 2016, during which time a total of six boreholes, three hand excavations and three Dynamic Cone Penetration Test (DCPT) were advanced at, or in the immediate vicinity of, the culvert alignment as summarized in Table 1 and shown on Drawing 1.

The field investigation was carried out using a truck-mounted CME55 drill rig and portable drilling equipment supplied and operated by Landcore Drilling of Sudbury, Ontario. Hand excavations were carried out at selection locations by Golder personnel.

The boreholes drilled by the truck-mounted CME55 drill rig were advanced through the overburden using 152 mm diameter solid stem augers and wash boring techniques using NW size casing. The boreholes completed with the portable equipment were advanced through the overburden using NQ and HQ size casing with wash boring techniques. Boreholes that were completed with rock coring were advanced with an NQ size core barrel. In



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general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m using a 50 mm outside diameter (O.D.) split-spoon sampler operated by an automatic hammer on the drill rig, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Boreholes advanced by portable equipment employed a full-weight hammer lifted manually and dropped from the SPT height.

All open boreholes were backfilled with bentonite upon completion in accordance with R.R.O. 1990, Regulation 903 (Wells) (as amended). The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix A.

A sample of creek water was obtained at the culvert location on June 12, 2016 and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are included in Appendix C.

The fieldwork was observed by members of Golder's 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 the soil and bedrock core samples. The soil and bedrock core samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples 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. One Unconfined Compression (UC) test and six point load strength index tests were carried on selected bedrock core samples. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and presented in the laboratory test figures in Appendix B.

Classification of the rock mass quality of the bedrock with respect to the Rock Quality Designation (RQD) is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM)¹. Classification of the bedrock core samples with respect to strength from point load tests and unconfined compression test is described based on Table 3.5 of CFEM¹. The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W2) and the strength classification of the intact rock mass based on field identification (i.e. strong – R4) are described in accordance with the International Society for Rock Mechanics (ISRM)² standard classification system.

Borehole locations were surveyed in the field relative to a fixed markers on site. The as-drilled borehole locations, in stations and offsets, were measured in reference to the applicable markers and relative to existing site features and were subsequently converted to MTM NAD 83 (Zone 12) coordinates in AutoCAD using base mapping provided by MTO. Borehole elevations were surveyed by a member of our technical staff in reference to the centerline of Highway 112 and the existing culvert, and were subsequently converted to Geodetic elevations using topographic information provided by MTO. The borehole locations, ground surface elevations and drilled depths are summarized below.

¹ Canadian Geotechnical Society. (2006). Canadian Foundation Engineering Manual, 4th Edition.

² International Society for Rock Mechanics Commission on test Methods. (1985). Int. J. Rock Mech. Min. Sci & Geomech. Abstr. Vol 22, No. 2, pp.51-60.



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Culvert Location	Borehole/DCPT	Location		Ground Surface Elevation (m)	Depth (m)
		Northing (m) / Latitude (°)	Easting (m) / Longitude (°)		
STA 21+845 (Township of Otto)	C2-1	532043.7 / 48.069212	376983.6 / -80.031327	316.5	4.6*
	C2-2	5326048.2 / 48.069252	376994.7 / -80.031176	320.1	11.8*
	C2-3	5326057.2 / 48.069330	377010.4 / -80.030965	315.1	5.6*
	C2-4	5326081.9 / 48.069556	376977.3 / -80.031404	321.5	6.8*
	C2-5	5326071.7 / 48.069467	376964.6 / -80.031577	316.2	1.1
	C2-6	5326033.1 / 48.069116	376993.3 / -80.031198	316.9	1.9*
	C2-7 (Hand Excavation)	5326028.6 / 48.069075	376995.5 / -80.031169	318.2	0.1
	C2-8 (Hand Excavation)	5326025.9 / 48.069051	376996.8 / -80.031152	319.6	0.0
	C2-9 (Hand Excavation)	5326064.4 / 48.069396	377009.0 / -80.030982	315.1	0.2
	C2-DCPT-1	5326055.0 / 48.069316	376968.8 / -80.031523	315.6	4.0
	C2-DCPT-2	5326066.4 / 48.069419	376965.1 / -80.031570	315.5	2.8
	C2-DCPT-3	5326076.1 / 48.069506	376962.3 / -80.031607	317.1	1.1

Note: * Includes between 1.6 m and 3.6 m length of bedrock coring.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Highway 112 is located in the Abitibi Uplands physiographic region, within the James region of the Canadian Shield as delineated by the Geomorphic Systems of North America³. The Abitibi Uplands generally slopes towards Hudson Bay and is typically characterized by low broad hills with gently sloping, rolling or undulating topography and subdued relief. This region is underlain by massive, mainly crystalline rocks covered by Quaternary glaciolacustrine, glaciofluvial, and till deposits, as well as more recent organic deposits within the depressions between bedrock knobs⁴.

³ Graf, W. L. (1987). Geomorphic systems of North America. Geological Society of America, Inc.: Boulder, Colorado.

⁴ Ministry of Northern Development and Mines, Ontario (MNDMO). (2016). OGSEarth: Quaternary Geology [Electronic Map]. 1:1,000,000. Retrieved July 28, 2016 from OGSEarth. Queen's Printer for Ontario, 2016.



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Highway 112 crosses four main assemblages or batholiths associated with the southern Abitibi Greenstone Belt⁵: Round Lake Batholith; Catharine-Pacaud assemblage; Boston assemblage and Temiskaming assemblage. The southern end of the highway, where it meets the TransCanada Highway is located within the granodioritic Round Lake Batholith. The highway trends north passing through the Catharine-Pacaud and Boston assemblages, which are characterized by mafic to intermediate grey to green basalt flows with felsic to silicious banding and plagioclase phenocrysts and by metavolcanic to metasedimentary basalts, cherts and conglomerates, respectively. The northern end of Highway 112 contains the Temiskaming assemblage, characterized by clastic metasedimentary rocks, primarily cherts (jasper) and sandstones. This area contains multiple faults and deformations associated within the Larder-Cadillac shear zone which generally runs along Highway 11 in the area where it intersects with Highway 112.

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 and bedrock samples, are presented on the Record of Borehole and Drillhole sheets and the laboratory test sheets in Appendices A and B, respectively. The results of the in situ field testing (i.e. SPT 'N'-values) as presented in the Record of Borehole sheets and in Section 4.3 are uncorrected. The stratigraphic boundaries shown on the Record of Boreholes sheets are inferred from non-continuous sampling, observations of drilling progress and in situ testing and are approximate. 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 stratigraphy at the borehole locations in the culvert area consists of a surficial layer of peat (at the toe of the highway embankment) or embankment fill (within the highway embankment), underlain by deposit of loose silt and sand to sand to sand and gravel, trace organics, which is in turn underlain by deposits of stiff clayey silt and loose silt. The overburden deposits are underlain by granite bedrock. A detailed description of the subsurface conditions at the culvert crossing is provided in the following section 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 21+845

The plan/profiles along the centreline and along the west side of the highway embankment and a cross-section across the highway embankment in the area of the existing culvert at STA 21+845 showing the borehole locations and interpreted stratigraphy are shown on Drawings 1 and 2. The height of the embankment at this location is between about 5 m and 6 m and the existing culvert is about 25 m long. A total of six boreholes, three hand excavations and three DCPT's were completed to investigate the subsurface conditions at the culvert location: three boreholes/hand excavations (Borehole C2-1, C2-3 and C1-9) were advanced near the ends of the existing culvert; one borehole (Borehole C2-2) was advanced through the Highway 112 southbound lane roadway embankment, south of the existing culvert alignment; two boreholes (Boreholes C2-4 and C2-5) and three DCPT's (C2-DCPT-1 to C2-DCPT-3) were advanced north of the existing culvert, west of the centreline of Highway 112

⁵ Jackson, S. L. and Fyon, J. A. (1991). The western Abitibi subprovince in Ontario; in *Geology of Ontario*, Ontario Geological Survey, Special Volume 4, Part 1, p.405-482.



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and at the toe of the embankment; and three boreholes/hand excavations (C2-6 to C2-8) were advanced south of the existing culvert at the west toe of the existing embankment.

4.3.1 Asphalt

An approximately 100 mm thick layer of asphalt was encountered at ground surface in Boreholes C2-2 and C2-4.

4.3.2 Embankment Fill

Embankment fill, approximately 3.5 m and 5.5 m thick was encountered below the asphalt in Boreholes C2-2 and C2-4 at Elevations 320.0 m and 321.4 m, respectively, a 1.1 m thick layer of fill was also encountered at ground surface in Borehole C2-5 at the toe of the embankment at Elevation 316.2 m. Borehole C2-5 was terminated in the fill upon split-spoon refusal (bouncing) on inferred bedrock. The embankment fill consists of a 1.8 m and 1.6 m thick upper layer of gravelly sand to sand and gravel and a 3.7 m and 1.8 m thick layer of rock fill consisting of cobbles ranging in size from 80 mm to 300 mm in diameter, in the respective boreholes. The fill layer at the toe of the embankment consists of sand and gravel. The size of the cobbles/boulders were estimated by coring through areas where the augers encountered refusal.

The SPT 'N'-values measured within the gravelly sand to sand and gravel fill deposit range from 2 blows to 33 blows per 0.3 m of penetration, indicating a very loose to dense relative density. SPT 'N'-values of 100 blows per 0.08 m and 33 blows per 0.2 m of penetration was measured within the gravelly sand fill but are considered not representative of the relative density as the split-spoon sampler was bouncing on the underlying rock fill and inferred bedrock. SPT 'N'-values measured within rock fill are provided on the Record of Borehole sheets; however they may not be representative as the spoon was noted to have been advancing between cobble and boulder size material during the SPT drives..

The natural water contents measured on eight samples of the gravelly sand to sand and gravel fill range from about 3 per cent to 13 per cent.

The results of grain size distribution tests completed on three samples of the sand and gravel to gravelly sand fill are shown on Figure B1 in Appendix B.

4.3.3 Peat

A 0.2 m to 0.8 m thick deposit of peat was encountered at ground surface in Boreholes C2-3, C2-6 and C2-9. The peat typically contains some sand, trace silt and trace gravel. Borehole C2-9 was terminated within the peat deposit due to refusal on the underlying bedrock.

A SPT 'N'-value of 5 blows per 0.3 m of penetration was measured within the peat deposit indicating a loose relative density.

4.3.4 Silt and Sand to Sand and Gravel

A 0.6 m to 1.4 m thick deposit of silt and sand to sand and gravel (comprised of silt and sand, sand, and sand and gravel) was encountered at ground surface (Elevation 316.5 m) in Borehole C2-1, below the embankment fill in



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Borehole C2-2 at a depth of 5.6 m below ground surface (Elevation 314.5 m) and below the peat at a depth of 0.8 m below ground surface (Elevation 314.4 m) in Borehole C2-3. Trace organics were noted to be present within the deposit in Borehole C2-1 and a 0.1 m thick layer of cobbles was encountered underlying the silt and sand deposit.

The SPT 'N'-values measured within the silt and sand to sand and gravel deposit range from 5 blows to 8 blows per 0.3 m of penetration, indicating a loose relative density. A SPT 'N'-value of 100 blows per 0.28 m of penetration was measured in Borehole C2-2, however it may not be representative due to the presence of a cobble.

A natural water content of 22 percent was measured on one sample of the silt and sand.

The result of a grain size distribution test completed on one sample of silt and sand component of the deposit is shown on Figure B2 in Appendix B.

4.3.5 Clayey Silt

A 1.3 m thick deposit of clayey silt was encountered below the sand deposit in Borehole C2-2 at a depth of 6.2 m below ground surface (Elevation 313.9 m). The clayey silt deposit contains trace sand and trace gravel. Silt seams were observed in the clayey silt deposit.

A SPT 'N'-value of 14 blows per 0.3 m of penetration was measured within the clayey silt deposit, suggesting a stiff consistency.

A natural water content of 36 per cent was measured on a sample of the clayey silt.

An Atterberg limits test carried out on a sample of the clayey silt measured a liquid limit of 34 per cent, a plastic limit of 17 per cent and a plasticity index of about 17 per cent. The result of the Atterberg limits test, which is plotted on a plasticity chart on Figure B3 in Appendix B, indicates that the material is a clayey silt of low plasticity.

4.3.6 Silt

A 1.2 m thick deposit of silt was encountered below the clayey silt in Borehole C2-2 at a depth of 7.5 m below ground surface (Elevation 312.6 m). The deposit contains traced sand and trace to some clay. Clayey silt seams were observed in the silt deposit.

A SPT 'N'-value of 6 blows per 0.3 m of penetration was measured within the silt deposit, indicating a loose relative density.

The natural water content measured on one sample of the silt was about 26 per cent.

The results of a grain size distribution test completed on one sample of the silt deposit is shown on Figure B4 in Appendix B.

4.3.7 Bedrock / Refusal

Bedrock was encountered (and cored) in Boreholes C2-1 to C2-4 and C2-6. Refusal to further split-spoon advancement on inferred bedrock was encountered in Borehole C2-5. The bedrock surface was also encountered in two hand excavations (Boreholes C2-7 and C2-8). Refusal to DCPT advancement was encountered in



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C2-DCPT-1 to C2-DCPT-3 on the inferred underlying bedrock. The depths to bedrock and the corresponding bedrock surface elevations are summarized below.

Borehole/DCPT	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
C2-1	1.0	315.5
C2-2	8.7	311.4
C2-3	2.2	312.9
C2-4	3.6	317.9
C2-5	1.1*	316.6*
C2-6	0.3	315.0
C2-7 (Hand Excavation)	0.1	318.1
C2-8 (Hand Excavation)	0.0	319.6
C2-9 (Hand Excavation)	0.2	314.9
C2-DCPT-1	4.0*	311.6*
C2-DCPT-2	2.8*	312.7*
C2-DCPT-3	1.1*	316.0*

Note: * Inferred from refusal to further split-spoon or DCPT advancement.

Based on review of the bedrock core samples, the bedrock consists of coarse grained, non-porous, granite. The bedrock is described as fresh and strong. The bedrock descriptions are shown on the Record of Drillhole sheets in Appendix A and the rock core samples are shown on the photographs in Figures B5A and B5B.

The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 86 per cent and 100 per cent and between 6 per cent and 100 per cent, respectively. The Rock Quality Designation (RQD) based on the borehole data ranges from 24 per cent to 100 per cent, indicating a rock mass of very poor, but generally poor, to excellent quality as per Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006).

An Unconfined Compression (UC) test performed on a core sample of the bedrock from Borehole C2-1 measured an uniaxial compressive strength (UCS) of about 70 MPa. Point load strength index tests were carried out on six selected samples of the bedrock core. The corrected point load strength index values (Is_{50}), for both the axial and diametral tests, range between about 5.0 MPa and 11.0 MPa, as shown in Table B1 in Appendix B.

Based on the laboratory UC and point load index test results, the bedrock is classified as strong (R_4 , $50 \text{ MPa} < \text{UCS} < 100 \text{ MPa}$) to extremely strong (R_6 , $Is_{50} > 10 \text{ MPa}$) as per Table 3.5 of CFEM (2006). The UC test results are presented in Figure B6 in Appendix B.

4.3.8 Groundwater Conditions

Details of the groundwater levels observed in the open boreholes are summarized on the Records of Borehole sheets in Appendix A. A summary of the measured groundwater levels in the open boreholes upon completion of drilling/rock coring are presented below.



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Borehole	Ground Surface Elevation (m)	Depth Below Ground Surface to Water Level (m)	Groundwater Level Elevation (m)	Date	Notes
C2-1	316.5	0.2	316.3	June 1, 2016	Open Borehole
C2-2	320.1	5.6	314.5	May 31, 2016	Open Borehole
C2-3	315.1	0.0	315.1	June 3, 2016	Open Borehole
C2-4	321.5	3.5	318.0	June 1, 2016	Open Borehole
C2-5	316.2	0.0	316.2	June 2, 2016	Open Borehole
C2-6	316.9	Dry	-	June 2, 2016	Open Borehole
C2-7	318.2	Dry	-	June 2, 2016	0.1 m deep Hand Excavation
C2-8	319.6	N/A	N/A	June 2, 2016	Bedrock Outcrop
C2-9	315.1	Dry	-	June 3, 2016	0.2 m deep Hand Excavation

The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

4.3.9 Analytical Testing of Creek Water

Analytical testing was carried out on a sample of creek water taken from the culvert site to assess the corrosivity and concrete degradation potential from the creek water/groundwater for the new culvert structure. The results from the specialist analytical laboratory are presented in Appendix C and are summarised below:

Parameter	Test Result
Water Resistivity	7,900 ohm-cm
Water Conductivity	130 μ mho/cm
Sulphate Concentration	Less than 1.0 mg/L
Chloride Concentration	24 mg/L
Water pH	7.11

5.0 CLOSURE

Messrs. Shane Albert and Dave Marmor, EIT, supervised the borehole investigation program. This report was prepared by Mr. Ted Beadle, P.Eng. and was reviewed by Mr. Pierre-Philippe Levasseur, P.Eng, a senior geotechnical engineer with Golder. Mr. Jorge M.A. Costa, P.Eng., a Senior Consultant to Golder and Designated MTO Foundations Contact, conducted an independent quality control review of this report.



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Report Signature Page

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REFERENCES

Graf, W. L. (1987). *Geomorphic systems of North America*. Geological Society of America, Inc.: Boulder, Colorado.

International Society for Rock Mechanics Commission on test Methods. (1985). *Int. J. Rock Mech. Min. Sci & Geomech. Abstr.* Vol 22, No. 2, pp.51-60.

Jackson, S. L. and Fyon, J. A. (1991). The western Abitibi subprovince in Ontario; *in* *Geology of Ontario*, Ontario Geological Survey, Special Volume 4, Part 1, p.405-482.

Ministry of Northern Development and Mines, Ontario (MNDMO). (2016). *OGSEarth: Quaternary Geology* [Electronic Map]. 1:1,000,000. Retrieved July 28, 2016 from OGSEarth. Queen's Printer for Ontario, 2016.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
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Ontario Water Resources Act:

Ontario Regulation 331/13 Amendment to Revised Regulations of Ontario 1990, Regulation 903



TABLES



FOUNDATION REPORT - CENTRELINE CULVERT REPLACEMENT - HIGHWAY 112 STA 21+845

Table 1: Summary of Existing Culvert Details

Culvert Location (Township)	Culvert ID	Approximate Height of Embankment ¹	Existing Culvert			Approximate Invert Elevation ²		Boreholes	Dynamic Cone Penetration Tests
			Type	Approximate Dimension	Approximate Length	Upstream	Downstream		
STA 21+845 (Otto)	C2	Up to about 6 m	Open Footing	910 mm span by 610 mm high	25.7 m	315.0 m (East End)	314.4 m (West End)	6 Boreholes (C2-1 to C2-6) 3 Hand Excavations (C2-7 to C2-9)	3 DCPTs (C2-DCPT-1 to C2-DCPT-3)

- Notes:
1. Embankment height is relative to existing ground surface level at the toe of embankment adjacent to the culvert.
 2. Culvert invert elevations are estimated based on the Drainage and Hydrology Report for the Replacement of Four Centreline Culverts on Highway 112 and Highway 650, W.P. 5427 15-01, prepared by MMM, dated November 2016.

Prepared By: MCK
Checked By: CN
Reviewed By: JMAC




FIGURES



East side of Highway 112 at STA 21+845 (Township of Otto) Culvert, looking west. June 5, 2016.


REVISION DATE: February 2, 2017 BY: MCK Project: 1531057

PROJECT		Detail Design for Replacement of 3 Centreline Culverts – Highway 112			
		GWP 5105-12-00; WP 5428-15-01			
TITLE		Site Photographs			
		Culvert STA 21+845 (Township of Otto)			
		Highway 112			
		PROJECT No. 1530157		FILE No. ----	
		DESIGN	TWB	Sep 6	SCALE NTS REV.
		CADD	-- --		
		CHECK	PPL	Sep 6	
		REVIEW	JMAC	Sep 6	
					FIGURE 1A



West side of Highway 112 looking south towards Culvert C2 at STA 21+845 (Township of Otto). June 2, 2016.

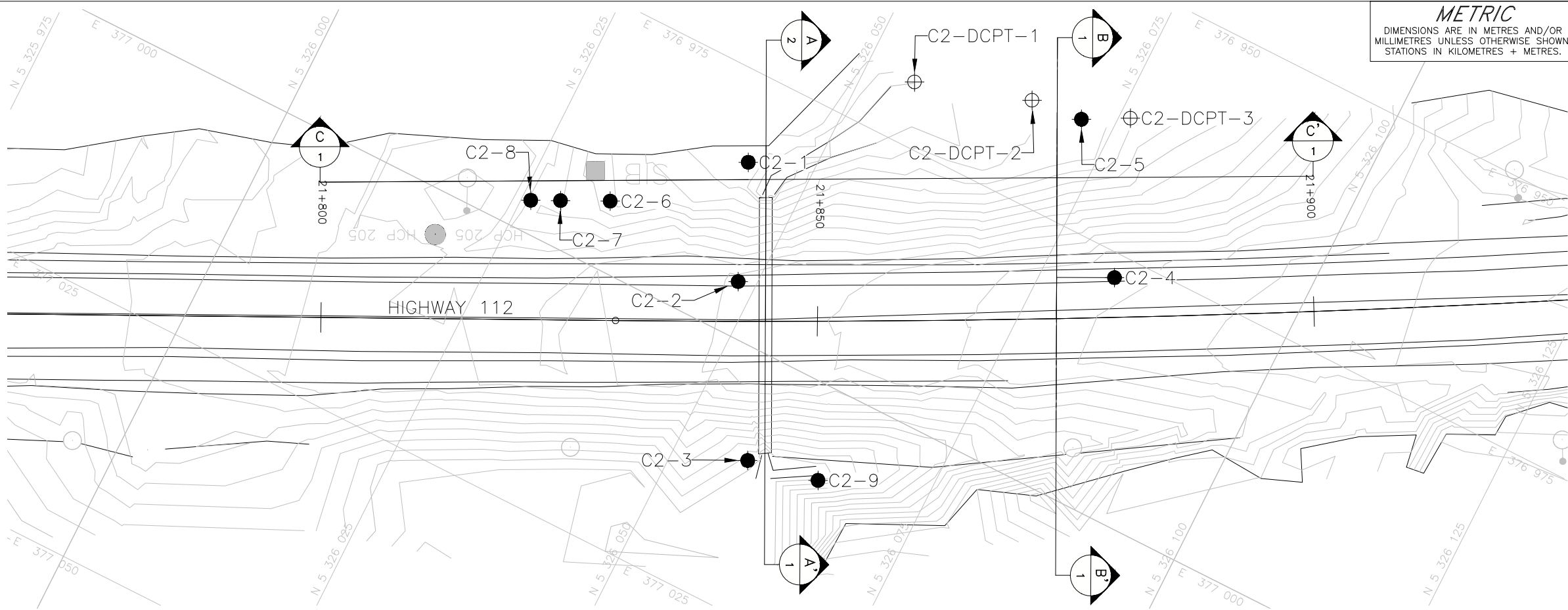
REVISION DATE: February 3, 2017 BY: MCK Project: 1531057

PROJECT		Detail Design for Replacement of 3 Centreline Culverts – Highway 112 GWP 5105-12-00; WP 5428-15-01				
TITLE		Site Photographs Culvert STA 21+845 (Township of Otto) Highway 112				
		PROJECT No. 1530157			FILE No. ----	
		DESIGN	TWB	Sep 6	SCALE	NTS
		CADD	-- --		FIGURE 1B	
		CHECK	PPL	Sep 6		
		REVIEW	JMAC	Sep 6		

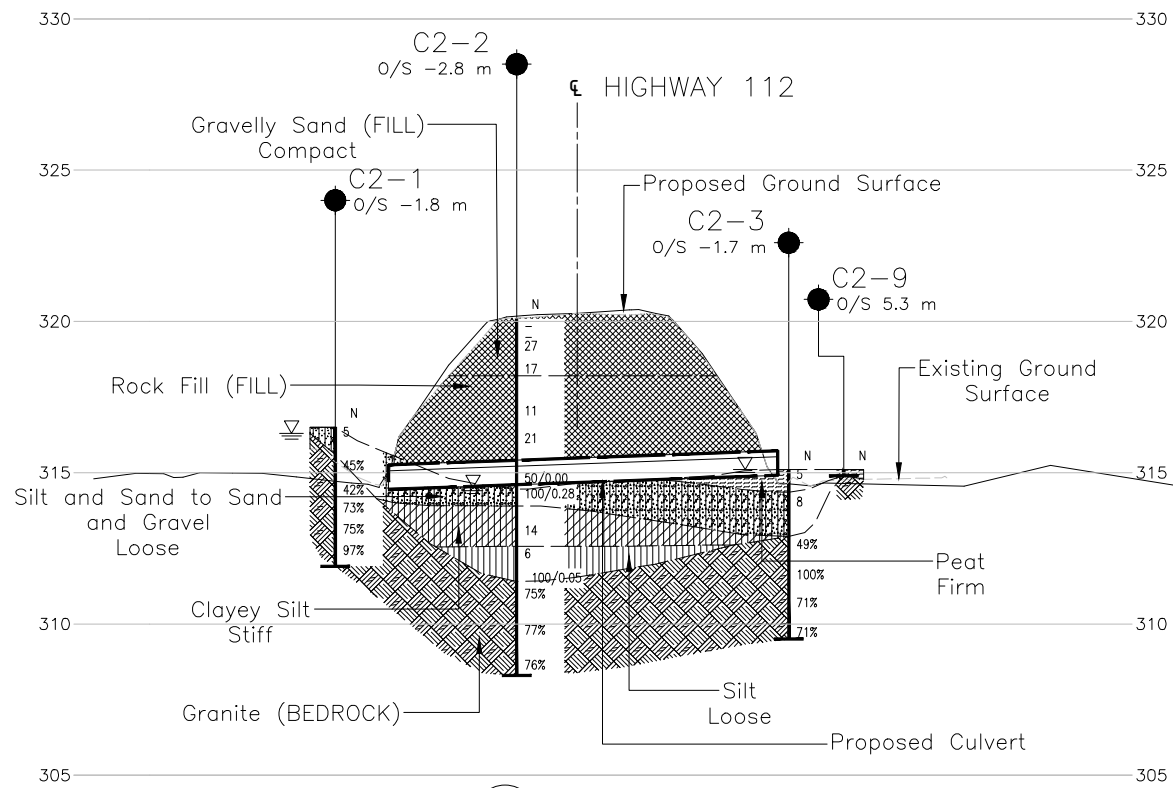


**FOUNDATION REPORT - CENTRELINE CULVERT
REPLACEMENT - HIGHWAY 112 STA 21+845**

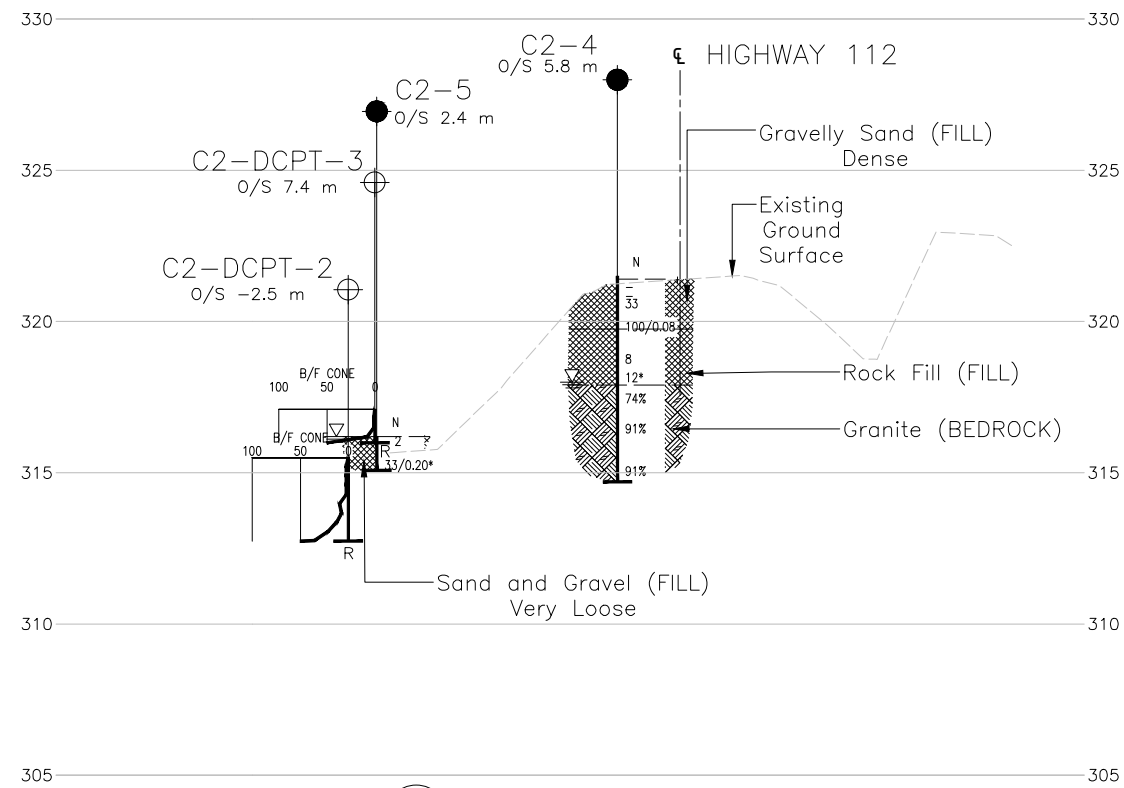
DRAWINGS



PLAN



A-A CULVERT C2
STA. 21+845



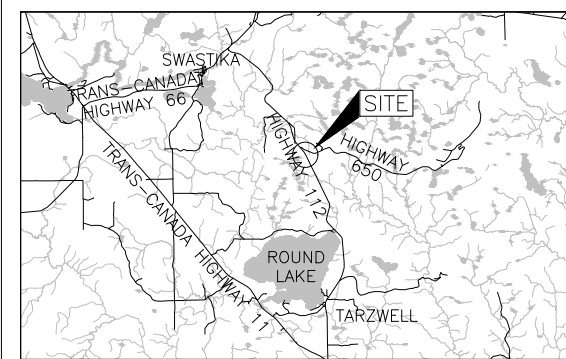
B-B CROSS SECTION
STA. 21+875



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

CONT No. _____
WP No. 5428-15-01

HIGHWAY 112
CULVERTS STA. 21+845
BOREHOLE LOCATIONS AND
SOIL STRATA



KEY PLAN



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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
C2-1	316.5	5326043.7	376983.6
C2-2	320.1	5326048.2	376994.7
C2-3	315.1	5326057.2	377010.4
C2-4	321.5	5326081.9	376977.3
C2-5	316.2	5326071.7	376964.6
C2-6	316.9	5326033.1	376993.3
C2-7	318.2	5326028.6	376995.5
C2-8	319.6	5326025.9	376996.8
C2-9	315.1	5326064.4	377009.0
C2-DCPT-1	315.6	5326055.0	376968.8
C2-DCPT-2	315.5	5326066.4	376965.1
C2-DCPT-3	317.1	5326076.1	376962.3

REFERENCE

Base plan, culvert section and surface data provided in digital format by MTO, drawing file no. "b04490112002.dwg", dated May, 2016, received June 29, 2016. Ground surface section at station 21+875 provided in digital format by MMM, drawing file no. "3216016-007 jh C2 XS-Jan 20, 2017.dwg", dated Jan. 20, 2017, received Jan. 20, 2017.

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.



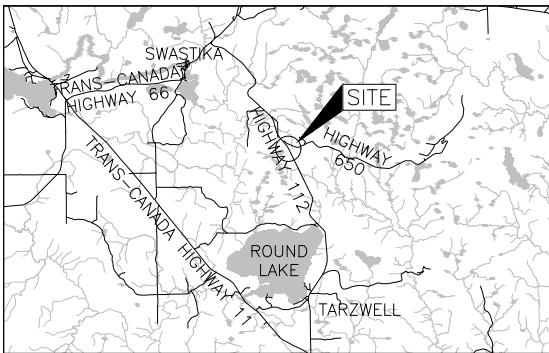
NO.	DATE	BY	REVISION
Geocres No. 42A-112			
HWY. 112	PROJECT NO. 1531057		DIST. .
SUBM'D. TWB	CHKD. TWB	DATE: 4/4/2017	SITE: .
DRAWN: MR	CHKD. CN	APPD. JMAC	DWG. 1

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

CONT No.
WP No. 5428-15-01

HIGHWAY 112
CULVERT STA. 21+845
SOIL STRATA

SHEET



KEY PLAN
SCALE
4 0 4 8 km

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C2-1	316.5	5326043.7	376983.6
C2-2	320.1	5326048.2	376994.7
C2-3	315.1	5326057.2	377010.4
C2-4	321.5	5326081.9	376977.3
C2-5	316.2	5326071.7	376964.6
C2-6	316.9	5326033.1	376993.3
C2-7	318.2	5326028.6	376995.5
C2-8	319.6	5326025.9	376996.8
C2-9	315.1	5326064.4	377009.0
C2-DCPT-1	315.6	5326055.0	376968.8
C2-DCPT-2	315.5	5326066.4	376965.1
C2-DCPT-3	317.1	5326076.1	376962.3

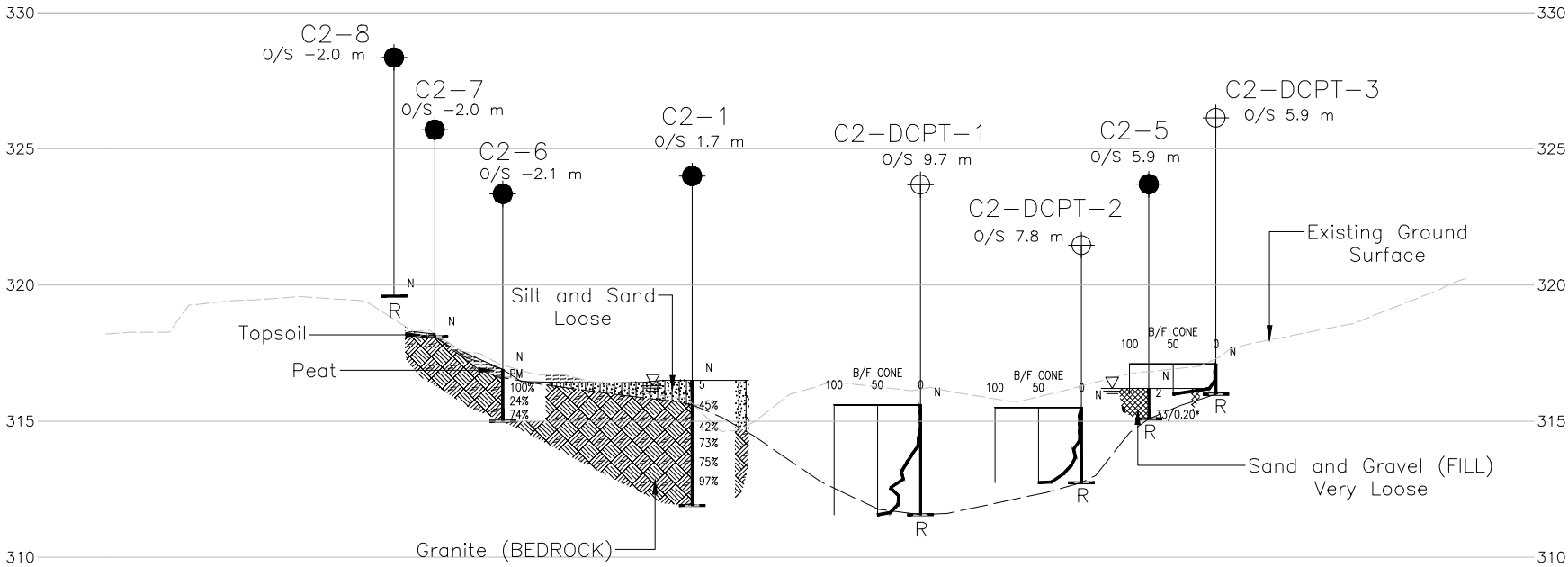
REFERENCE

Base plan, culvert section and surface data provided in digital format by MTO, drawing file no. "b04490112002.dwg", dated May, 2016, received June 29, 2016.

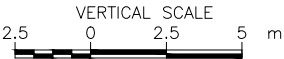
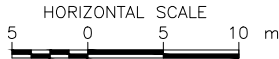
NOTES

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.



C-C
1
PROFILE
STA. 21+800 TO 21+900



NO.	DATE	BY	REVISION
Geocres No. 42A-112			
HWY. 112	PROJECT NO. 1531057		DIST. .
SUBM'D. TWB	CHKD. TWB	DATE: 4/4/2017	SITE: .
DRAWN: MR	CHKD. CN	APPD. JMAC	DWG. 2



APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_{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

Notes: 1
2

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



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERING STATE

Fresh: no visible sign of weathering

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

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

Description and Notes

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

Abbreviations

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

PROJECT		1531057		RECORD OF BOREHOLE No C2-1				SHEET 1 OF 1				METRIC					
W.P.		5428-15-01		LOCATION		N 5326043.7; E 376983.6 MTM ZONE				ORIGINATED BY SA							
DIST		HWY 112		BOREHOLE TYPE		Portable Equipment, HQ Casing (Manual Hammer)				COMPILED BY MR							
DATUM		Geodetic		DATE		June 1, 2016				CHECKED BY MK							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
316.5	GROUND SURFACE																
0.0	SILT and SAND, trace to some clay, trace to some gravel, containing organics and cobbles Loose		1	SS	5											10 48 36 6	
315.6	Brown to grey Moist to wet																
1.0	COBBLES GRANITE (BEDROCK)		1	RC	REC 86%											RQD = 45%	
	Bedrock cored from depths of 0.9 m to 4.6 m.		2	RC	REC 100%											RQD = 42%	
	For bedrock coring details refer to Record of Drillhole C2-1.		3	RC	REC 100%											RQD = 73%	
			4	RC	REC 100%											RQD = 75%	
			5	RC	REC 100%											RQD = 97%	
311.9	END OF BOREHOLE																
4.6	NOTES: 1. Water level in open borehole at a depth of 0.2 m below ground surface (Elev. 316.3 m) upon completion of drilling. 2. Geographic Coordinates: Latitude: 48.069212 Longitude: -80.031327																

PROJECT: 1531057

RECORD OF DRILLHOLE: C2-1

SHEET 1 OF 1

LOCATION: N 5326043.7 ;E 376983.6

DRILLING DATE: June 1, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY				R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG	NOTES			
								TOTAL CORE %	SOLID CORE %	B Angle	DIP w.r.t. CORE AXIS			TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 10 10 10	10 10 10 10								
																				JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage				PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough	MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.

1	NQ RC NW Casing	Continued from Record of Borehole C2-1		315.60	1										UCS = 70.5 MPa	
		COBBLES		0.90												
		Fresh, pink, coarse grained, non-porous, strong GRANITE		1.04												
2																2
3																3
4				4												
5				5												
5		END OF DRILLHOLE		311.90 4.60												
6																
7																
8																
9																
10																

UCS = 70.5 MPa

DEPTH SCALE

1 : 50



LOGGED: SA

CHECKED: MK

PROJECT		1531057		RECORD OF BOREHOLE No C2-2				SHEET 1 OF 1		METRIC						
W.P.		5428-15-01		LOCATION		N 5326048.2; E 376994.7 MTM ZONE		ORIGINATED BY		DM						
DIST		HWY 112		BOREHOLE TYPE		CME 55, 152 mm Diameter Solid Stem Augers, NW Casing		COMPILED BY		MR						
DATUM		Geodetic		DATE		May 31, 2016		CHECKED BY		MK						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
320.1	GROUND SURFACE															
0.9	ASPHALT (100 mm)		1	AS	-											
	Gravelly sand, trace to some silt (FILL)		2	AS	-											
	Compact Brown Moist		3A													
			3B	SS	27											
318.2	Rock fill (FILL)		4	SS	17											
1.9																
			5	SS	11											
			6	SS	21											
			7	SS	50/0.00											
314.5	SAND, some silt		8	SS	100/0.20											
5.6	Brown Wet															
313.9	- cobble at a depth of 5.9 m															
6.2	CLAYEY SILT, trace sand, trace gravel, containing silt seams		9	SS	14											
	Stiff Grey Wet															
312.6	SILT, trace sand, trace to some clay, containing clayey silt seams		10	SS	6											
7.5	Loose Grey Wet															
311.4	GRANITE (BEDROCK)		11		100/0.05											
8.7	Bedrock cored from depths of 8.7 m to 11.8 m.		1	RC	REC 99%											
	For bedrock coring details refer to Record of Drillhole C2-2.		2	RC	REC 100%											
			3	RC	REC 100%											
308.3	END OF BOREHOLE															
11.8	NOTE: 1. Water level in open borehole at a depth of 5.6 m below ground surface (Elev. 314.5 m) upon completion of drilling. 2. Geographic Coordinates: Latitude: 48.069252 Longitude: -80.031176															

PROJECT: 1531057

RECORD OF DRILLHOLE: C2-2

SHEET 1 OF 1

LOCATION: N 5326048.2 ;E 376994.7

DRILLING DATE: May 31, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.																NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25 m	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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9	NQ RC NW Casing	Continued from Record of Borehole C2-2		311.40																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				

DEPTH SCALE

1 : 50



LOGGED: DM

CHECKED: MK

PROJECT		1531057		RECORD OF BOREHOLE No C2-3				SHEET 1 OF 1		METRIC							
W.P.		5428-15-01		LOCATION		N 5326057.2; E 377010.4 MTM ZONE		ORIGINATED BY		SA							
DIST		HWY 112		BOREHOLE TYPE		Portable Equipment, NQ Casing (Manual Hammer)		COMPILED BY		MR							
DATUM		Geodetic		DATE		June 3, 2016		CHECKED BY		MK							
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									
315.1	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT (Fibrous), some sand, trace to some silt Firm Brown Moist to wet		1	SS	5												
314.4																	
0.8	- 280 mm diameter cobble encountered at a depth of 0.6 m SAND and GRAVEL, some silt, containing organics Loose Brown Wet		2	SS	8												
312.9																	
2.2	GRANITE (BEDROCK)																
	Bedrock cored from depths of 2.2 m to 5.6 m. For bedrock coring details refer to Record of Drillhole C2-3.		1	RC	REC 100%												RQD = 49%
			2	RC	REC 100%												RQD = 100%
			3	RC	REC 100%												RQD = 71%
			4	RC	REC 95%												RQD = 71%
309.5	END OF BOREHOLE																
5.6	NOTES: 1. Water level in open borehole at ground surface (Elev. 315.1 m) upon completion of drilling. 2. Geographic Coordinates: Latitude: 48.069330 Longitude: -80.030965																

PROJECT: 1531057

RECORD OF DRILLHOLE: C2-3

SHEET 1 OF 1

LOCATION: N 5326057.2 ;E 377010.4

DRILLING DATE: June 3, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.														NOTES	
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY K, cm/sec			Diametral Point Load Index (MPa)		RMC -Q AVG
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 10 10 10	10 10 10 10			
		Continued from Record of Borehole C2-3		312.90																		
		Fresh, pink, coarse grained, non-porous, strong GRANITE		2.20																		
3					1	100																
					2	100																
4	NQ RC NW Casing				3	100																
5					4	100																
		END OF DRILLHOLE		309.50																		
6				5.60																		
7																						
8																						
9																						
10																						
11																						
12																						

9.3 MPa (Axial)
10.8 MPa

DEPTH SCALE

1 : 50



LOGGED: SA

CHECKED: MK

PROJECT		1531057		RECORD OF BOREHOLE No C2-4				SHEET 1 OF 1		METRIC							
W.P.		5428-15-01		LOCATION		N 5326081.9; E 376977.3 MTM ZONE		ORIGINATED BY		DM							
DIST		HWY 112		BOREHOLE TYPE		CME 55, 152 mm Diameter Solid Stem Augers, NW Casing		COMPILED BY		MR							
DATUM		Geodetic		DATE		June 1, 2016		CHECKED BY		MK							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
321.5	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (100 mm)		1	AS	-												
	Gravelly sand, trace to some silt, trace clay, containing cobbles (FILL)		2	AS	-												
	Dense Brown Moist		3	SS	33												
319.8	Rock fill (FILL)		4	SS	100/0.08*												
1.8																	
			5	SS	8												
			6	SS	12**												
317.9	GRANITE (BEDROCK)																
3.6	Bedrock cored from depths of 3.6 m to 6.8 m. For bedrock coring details refer to Record of Drillhole C2-4.		1	RC	REC 97%												
			2	RC	REC 100%												
			3	RC	REC 100%												
314.7	END OF BOREHOLE																
6.8	NOTES: 1. Water level in open borehole at a depth of 3.5 m below ground surface (Elev. 318.0 m) upon completion of drilling. * N-value may not be representative; split-spoon bouncing on Rock Fill below. ** N-Vaule may not be representative; split-spoon angled due to sloping rock. 2. Geographic Coordinates: Latitude: 48.069556 Longitude: -80.031404																

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PROJECT: 1531057

RECORD OF DRILLHOLE: C2-4

SHEET 1 OF 1

LOCATION: N 5326081.9 ;E 376977.3

DRILLING DATE: June 1, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.														NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
							FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY K, cm/sec				Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	10 10 10 10	10 10 10 10																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
4	NQ RC NW Casing	Continued from Record of Borehole C2-4		317.90																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															</

11.0 MPa
7.1 MPa (Axial)

DEPTH SCALE

1 : 50



LOGGED: DM

CHECKED: MK

PROJECT 1531057		RECORD OF BOREHOLE No C2-5				SHEET 1 OF 1		METRIC								
W.P. 5428-15-01		LOCATION N 5326071.7; E 376964.6 MTM ZONE				ORIGINATED BY SA										
DIST _____ HWY 112		BOREHOLE TYPE Portable Equipment (Manual Hammer)				COMPILED BY MR										
DATUM Geodetic		DATE June 2, 2016				CHECKED BY MK										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
316.2	GROUND SURFACE						20	40	60	80	100	W _p	W	W _L		
0.0	Sand and gravel, trace to some silt, trace clay, containing organics and rootlets (FILL) Very loose Brown Wet		1	SS	2	316										
315.1			2	SS	33/0.20							○				33 53 11 3
1.1	END OF BOREHOLE															
NOTES: 1. Water level in open borehole at a ground surface (Elev. 316.2 m) upon completion of drilling. * Split-spoon bouncing. 2. Geographic Coordinates: Latitude: 48.069467 Longitude: -80.031577																

PROJECT <u>1531057</u>	RECORD OF BOREHOLE No C2-6	SHEET 1 OF 1	METRIC
W.P. <u>5428-15-01</u>	LOCATION <u>N 5326033.1; E 376993.3 MTM ZONE</u>	ORIGINATED BY <u>SA</u>	
DIST <u> </u> HWY <u>112</u>	BOREHOLE TYPE <u>Portable Equipment, HQ Casing (Manual Hammer)</u>	COMPILED BY <u>MR</u>	
DATUM <u>Geodetic</u>	DATE <u>June 2, 2016</u>	CHECKED BY <u>MK</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED								
316.9	GROUND SURFACE																
0.0 316.6 0.3	PEAT (Fibrous), trace gravel, some sand Brown Moist		1	CS	-												
	GRANITE (BEDROCK)		1	RC	REC 100%												RQD = 100%
	Bedrock cored from depths of 0.3 m to 1.9 m.		2	RC	REC 100%												RQD = 24%
	For bedrock coring details refer to Record of Drillhole C2-6.		3	RC	REC 96%												RQD = 74%
315.0 1.9	END OF BOREHOLE																
	NOTE: 1. Geographic Coordinates: Latitude: 48.069116 Longitude: -80.031198																

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PROJECT: 1531057

RECORD OF DRILLHOLE: C2-6

SHEET 1 OF 1

LOCATION: N 5326033.1 ;E 376993.3

DRILLING DATE: June 2, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: Landcore Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	JN - Joint FLT - Fault SH - Shear VN - Vein CJ - Conjugate BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular PO - Polished K - Slickensided SM - Smooth RO - Rough VR - Very Rough MB - Mechanical Break BR - Broken Rock NOTE: For additional abbreviations refer to list of abbreviations & symbols.										NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
									RECOVERY			R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
									TOTAL CORE %	SOLID CORE %				B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja					Jn																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
			Continued from Record of Borehole C2-6		316.60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									


DEPTH SCALE

1 : 50



LOGGED: SA

CHECKED: MK

PROJECT <u>1531057</u>		RECORD OF BOREHOLE No C2-7				SHEET 1 OF 1		METRIC									
W.P. <u>5428-15-01</u>		LOCATION <u>N 5326028.6; E 376995.5 MTM ZONE</u>				ORIGINATED BY <u>SA</u>											
DIST <u> </u> HWY <u>112</u>		BOREHOLE TYPE <u>Hand Excavation</u>				COMPILED BY <u>MR</u>											
DATUM <u>Geodetic</u>		DATE <u>June 2, 2016</u>				CHECKED BY <u>MK</u>											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p	W	W _L	γ	GR SA SI CL
318.2	GROUND SURFACE							20	40	60	80	100	20	40	60	kN/m ³	
0.0	TOPSOIL																
0.1	END OF HAND EXCAVATION REFUSAL TO FURTHER PENETRATION EXPOSED BEDROCK																
	NOTE: 1. Geographic Coordinates: Latitude: 48.069075 Longitude: -80.031169																

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

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_112\02 DATA\GINT\HWY_112.GPJ GAL-GTA.GDT 24/03/17



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

PROJECT		RECORD OF DCPT No C2-DCPT-2				SHEET 1 OF 1		METRIC								
W.P. 1531057		LOCATION N 5326066.4; E 376965.1 MTM ZONE				ORIGINATED BY SA										
DIST _____ HWY 112		BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test (Manual Hammer)				COMPILED BY MR										
DATUM Geodetic		DATE June 2, 2016				CHECKED BY MK										
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								
315.5	GROUND SURFACE						20	40	60	80	100	20	40	60		
0.0	Dynamic Cone Penetration Test (DCPT)															
312.7	END OF DCPT REFUSAL TO FURTHER PENETRATION (50 Blows / 0.02 m) (HAMMER BOUNCING)															
2.8	NOTE: 1. Geographic Coordinates: Latitude: 48.069419 Longitude: -80.031570															

PROJECT <u>1531057</u>		RECORD OF DCPT No C2-DCPT-3		SHEET 1 OF 1		METRIC	
W.P. <u>5428-15-01</u>		LOCATION <u>N 5326076.1; E 376962.3 MTM ZONE</u>		ORIGINATED BY <u>SA</u>			
DIST <u> </u> HWY <u>112</u>		BOREHOLE TYPE <u>Portable Equipment, Dynamic Cone Penetration Test (Manual Hammer)</u>		COMPILED BY <u>MR</u>			
DATUM <u>Geodetic</u>		DATE <u>June 2, 2016</u>		CHECKED BY <u>MK</u>			

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					W _p	W	W _L	WATER CONTENT (%)							
						○ UNCONFINED			+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	20	40	60	80	100		20	40	60	GR
317.1	GROUND SURFACE						317														
0.0	Dynamic Cone Penetration Test (DCPT)																				
316.0							316														
1.1	END OF DCPT REFUSAL TO FURTHER PENETRATION (50 Blows / 0.20 m) (HAMMER BOUNCING) NOTE: NOTE: 1. Geographic Coordinates: Latitude: 48.069506 Longitude: -80.031607																				



APPENDIX B

Geotechnical Laboratory Test Results

TABLE B1
SUMMARY OF POINT LOAD TESTS ON ROCK SAMPLES

PROJECT NO. 1531057						
DATE July, 2016						
Borehole Number	Run Number	Sample Depth (m)	Sample Elevation (m)	Bedrock Description	Test Type	Is (50mm) (MPa)
C2-2	1	8.8	311.3	Granite	Axial	5.0
C2-2	1	9.0	311.1	Granite	Diametral	8.3
C2-3	1	2.8	312.3	Granite	Axial	9.3
C2-3	1	2.9	312.2	Granite	Diametral	10.8
C2-4	1	3.9	317.8	Granite	Diametral	11.0
C2-4	1	4.0	317.7	Granite	Axial	7.1

⁽¹⁾ $Is_{50} \times C$ (actual value will have to be confirmed by UCS testing), from ISRM ("Suggested Methods for Determining Point Load Strength",

International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr.,

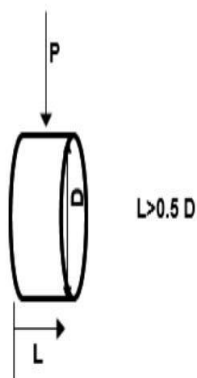
Vol 22, No. 2 1985, pp. 51-60.

⁽²⁾ Actual distance between point load cones at time of failure.

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis

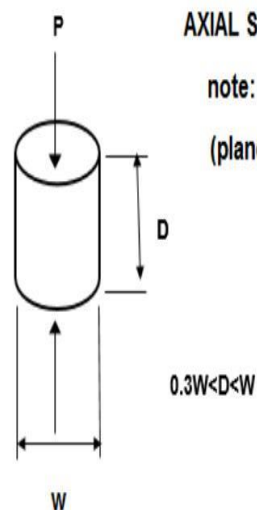
(planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS

note: Axial tests are parallel to core axis

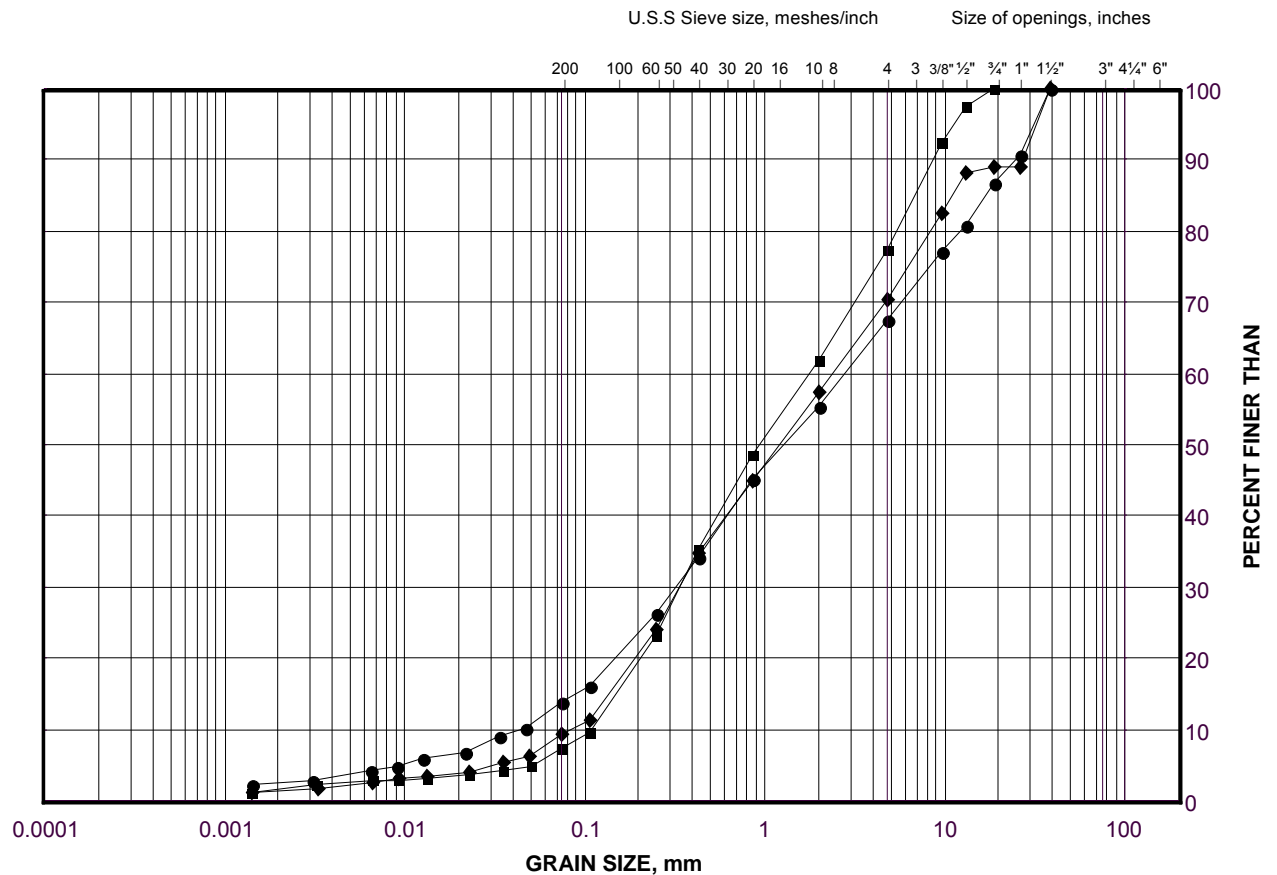
(planes of weakness)



GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sand and Gravel (FILL)

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C2-5	2	315.2
■	C2-2	2	319.4
◆	C2-4	3	320.4

Project Number: 1531057

Checked By: TWB

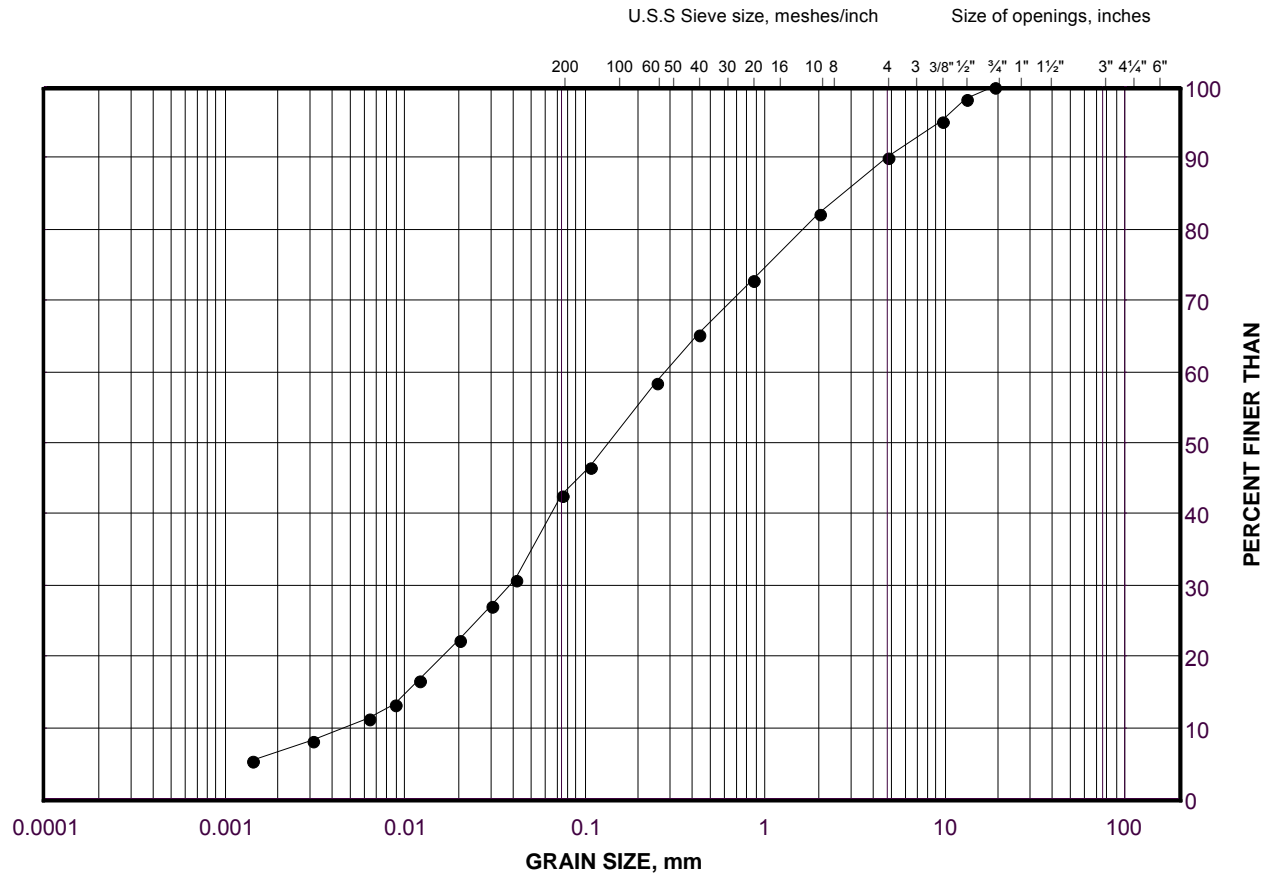
Golder Associates

Date: 17-Aug-16

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B2



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

LEGEND

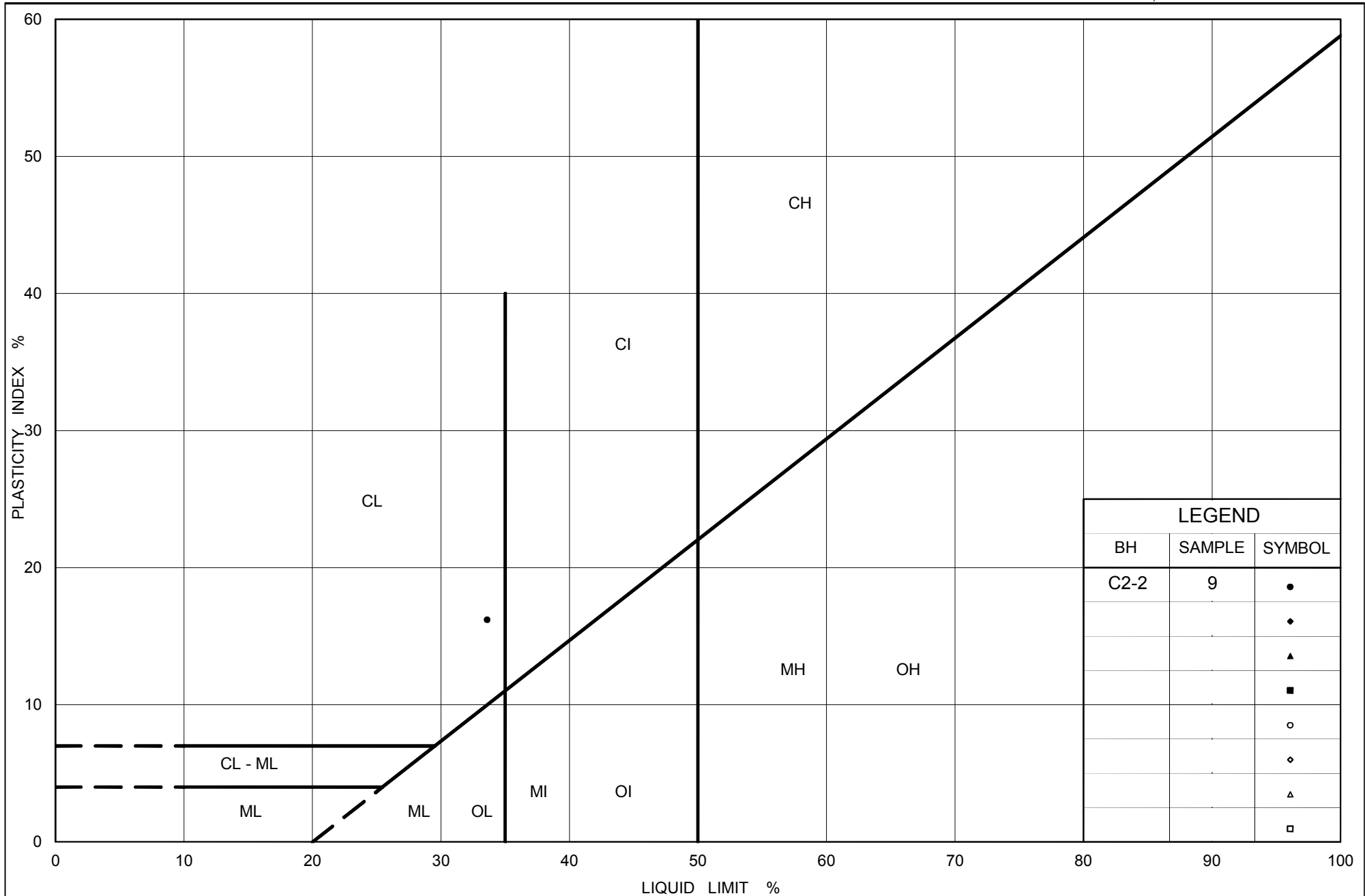
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C2-1	1	316.2

Project Number: 1531057

Checked By: TWB

Golder Associates

Date: 17-Aug-16



LEGEND		
BH	SAMPLE	SYMBOL
C2-2	9	•
		◊
		▲
		■
		◦
		◈
		△
		◻



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Figure No. B3

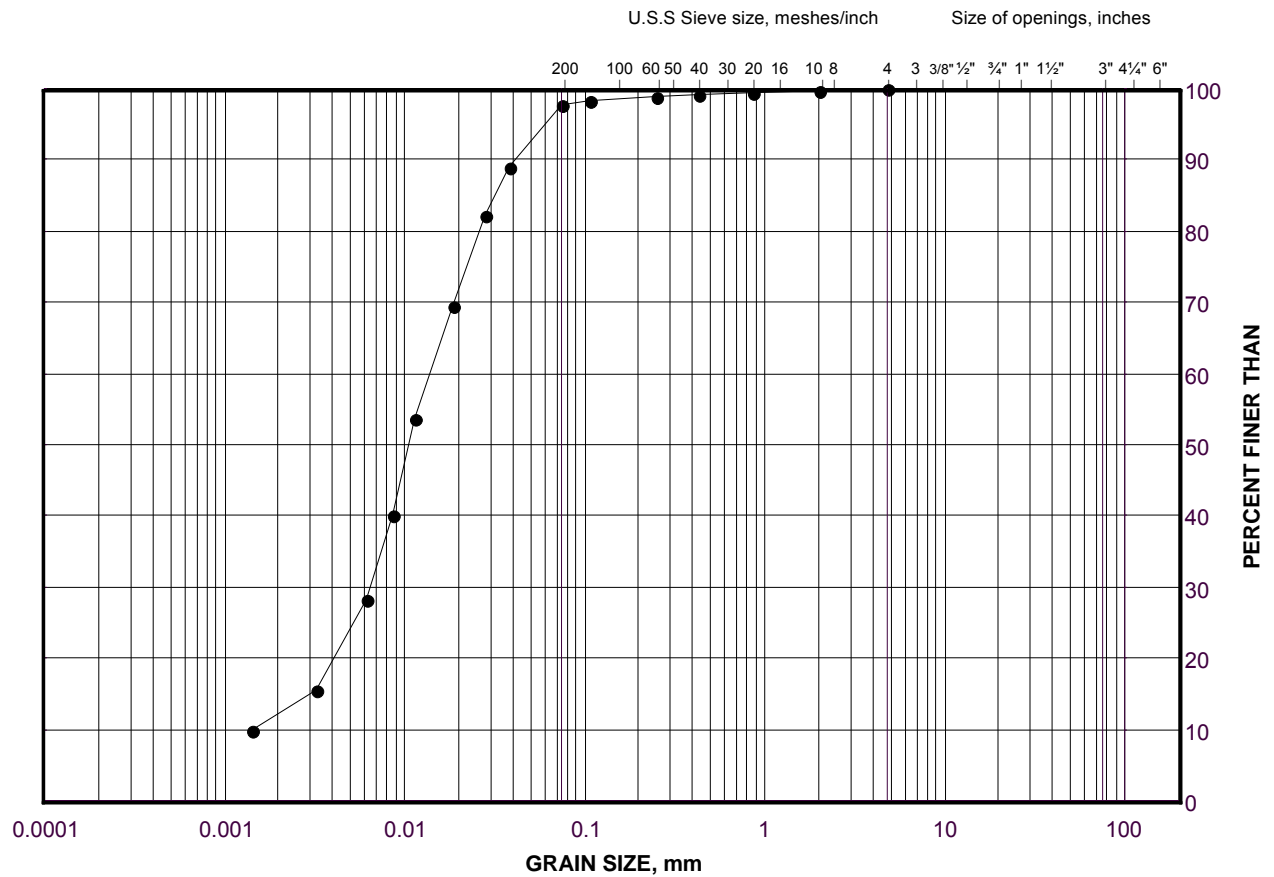
Project No. 1531057

Checked By: TWB

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C2-2	10	312.2

Project Number: 1531057

Checked By: TWB

Golder Associates

Date: 17-Aug-16

Borehole C2-1



Box 1: 0.90 m – 4.60 m

Borehole C2-2

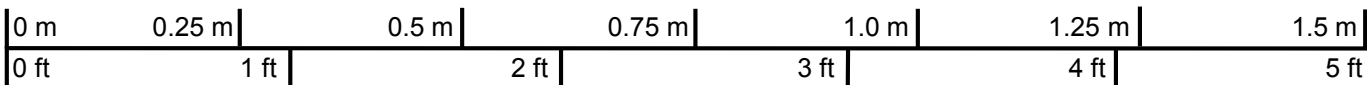


Box 1: 8.70 m – 11.80 m

Borehole C2-3



Box 1: 2.20 m – 5.60 m



Scale

PROJECT **Detail Design for Replacement of 3 Centreline Culverts and 1 Structural Culvert – Highway 112 WP 5428-15-01**

TITLE **Bedrock Core Photographs – Highway 112 Borehole C2-1, C2-2 and C2-3**



PROJECT No. 1531057			FILE No. ----		
DESIGN	TWB	SEP 6	SCALE	NTS	REV.
CADD	--		FIGURE B5A		
CHECK	PPL	SEP 6			
REVIEW	JMAC	SEP 6			

Borehole C2-4

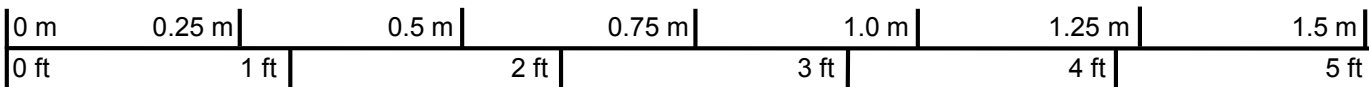


Box 1: 3.60 m – 6.80 m

Borehole C2-6



Box 1: 0.30 m – 1.90 m



Scale

PROJECT **Detail Design for Replacement of 3 Centreline Culverts and 1 Structural Culvert – Highway 112 WP 5428-15-01**

TITLE **Bedrock Core Photographs – Highway 112 Borehole C2-4 and C2-6**



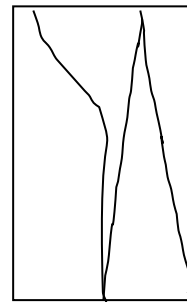
PROJECT No. 1531057			FILE No. ----		
DESIGN	TWB	SEP 6	SCALE	NTS	REV.
CADD	--		FIGURE B5B		
CHECK	PPL	SEP 6			
REVIEW	JMAC	SEP 6			

UNCONFINED COMPRESSION TEST (UC)**Figure B6**

SAMPLE IDENTIFICATION			
PROJECT NUMBER	1531057	RUN NUMBER	Run 2
PROJECT NAME	MMM/5015-E-0003/LV Retainer NE	SAMPLE DEPTH, m	1.65-1.80
BOREHOLE NUMBER	C2-1	DATE:	2016-07-19

TEST CONDITIONS			
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.26

SPECIMEN INFORMATION			
SAMPLE HEIGHT, cm	9.61	WATER CONTENT, (specimen) %	0.15
SAMPLE DIAMETER, cm	4.25	UNIT WEIGHT, kN/m ³	25.40
SAMPLE AREA, cm ²	14.20	DRY UNIT WT., kN/m ³	25.37
SAMPLE VOLUME, cm ³	136.47	SPECIFIC GRAVITY	-
WET WEIGHT, g	353.66	VOID RATIO	-
DRY WEIGHT, g	353.13		

VISUAL INSPECTION**FAILURE SKETCH**

TEST RESULTS			
STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	70.5

REMARKS:

Checked By: MCK

Golder Associates



APPENDIX C

Analytical Test Results

Your Project #: 1531057
Site Location: LV RETAINER NER ASSIGN#2, HWY 112
Your C.O.C. #: 565300-01-01

Attention:Chris Ng

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2016/06/20
Report #: R4035051
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6C1265

Received: 2016/06/13, 11:35

Sample Matrix: Water
Samples Received: 4

Analyses	Date		Date Analyzed	Laboratory Method	Reference
	Quantity	Extracted			
Chloride by Automated Colourimetry	4	N/A	2016/06/16	CAM SOP-00463	EPA 325.2 m
Conductivity	4	N/A	2016/06/16	CAM SOP-00414	SM 22 2510 m
pH	4	N/A	2016/06/16	CAM SOP-00413	SM 4500H+ B m
Resistivity of Water	4	2016/06/14	2016/06/17	CAM SOP-00414	SM 22 2510 m
Sulphate by Automated Colourimetry	4	N/A	2016/06/16	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

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Maxxam Job #: B6C1265
Report Date: 2016/06/20

Golder Associates Ltd
Client Project #: 1531057
Site Location: LV RETAINER NER ASSIGN#2, HWY 112
Sampler Initials: SA

RESULTS OF ANALYSES OF WATER

Maxxam ID		CNJ774	CNJ775	CNJ776	CNJ777			
Sampling Date		2016/06/12 11:00	2016/06/12 10:45	2016/06/12 07:45	2016/06/12 07:40			
COC Number		565300-01-01	565300-01-01	565300-01-01	565300-01-01			
	UNITS	C1	C2	C3	C4	RDL	QC Batch	MDL
Calculated Parameters								
Resistivity	ohm-cm	21000	7900	28000	7000		4538726	
Inorganics								
Conductivity	umho/cm	48	130	36	140	1.0	4541542	0.20
pH	pH	6.72	7.11	7.16	7.46		4541543	
Dissolved Sulphate (SO ₄)	mg/L	<1.0	<1.0	<1.0	<1.0	1.0	4541170	0.10
Dissolved Chloride (Cl)	mg/L	2.0	24	1.3	15	1.0	4541163	0.30
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								

TEST SUMMARY

Maxxam ID: CNJ774
Sample ID: C1
Matrix: Water

Collected: 2016/06/12
Shipped:
Received: 2016/06/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4541163	N/A	2016/06/16	Alina Dobreanu
Conductivity	AT	4541542	N/A	2016/06/16	Yogesh Patel
pH	AT	4541543	N/A	2016/06/16	Yogesh Patel
Resistivity of Water		4538726	2016/06/17	2016/06/17	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4541170	N/A	2016/06/16	Deonarine Ramnarine

Maxxam ID: CNJ775
Sample ID: C2
Matrix: Water

Collected: 2016/06/12
Shipped:
Received: 2016/06/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4541163	N/A	2016/06/16	Alina Dobreanu
Conductivity	AT	4541542	N/A	2016/06/16	Yogesh Patel
pH	AT	4541543	N/A	2016/06/16	Yogesh Patel
Resistivity of Water		4538726	2016/06/17	2016/06/17	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4541170	N/A	2016/06/16	Deonarine Ramnarine

Maxxam ID: CNJ776
Sample ID: C3
Matrix: Water

Collected: 2016/06/12
Shipped:
Received: 2016/06/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4541163	N/A	2016/06/16	Alina Dobreanu
Conductivity	AT	4541542	N/A	2016/06/16	Yogesh Patel
pH	AT	4541543	N/A	2016/06/16	Yogesh Patel
Resistivity of Water		4538726	2016/06/17	2016/06/17	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4541170	N/A	2016/06/16	Deonarine Ramnarine

Maxxam ID: CNJ777
Sample ID: C4
Matrix: Water

Collected: 2016/06/12
Shipped:
Received: 2016/06/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride by Automated Colourimetry	KONE	4541163	N/A	2016/06/16	Alina Dobreanu
Conductivity	AT	4541542	N/A	2016/06/16	Yogesh Patel
pH	AT	4541543	N/A	2016/06/16	Yogesh Patel
Resistivity of Water		4538726	2016/06/17	2016/06/17	Automated Statchk
Sulphate by Automated Colourimetry	KONE	4541170	N/A	2016/06/16	Deonarine Ramnarine

Maxxam Job #: B6C1265
Report Date: 2016/06/20

Golder Associates Ltd
Client Project #: 1531057
Site Location: LV RETAINER NER ASSIGN#2, HWY 112
Sampler Initials: SA

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	9.3°C
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Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1531057
Site Location: LV RETAINER NER ASSIGN#2, HWY 112
Sampler Initials: SA

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4541163	Dissolved Chloride (Cl)	2016/06/16	NC	80 - 120	101	80 - 120	<1.0	mg/L	0.024	20
4541170	Dissolved Sulphate (SO4)	2016/06/16	NC	75 - 125	104	80 - 120	<1.0	mg/L	4.3	20
4541542	Conductivity	2016/06/16			102	85 - 115	<1.0	umho/cm	1.9	25
4541543	pH	2016/06/16			101	98 - 103			1.2	N/A

N/A = Not Applicable

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Services

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INVOICE TO: Company Name: #1326 Golder Associates Ltd Attention: Central Acct: 1112, 1113, 1118 Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 Tel: (905) 567-4444 Fax: (905) 567-6561 Email: Catherine_Guido@golder.com, Rachel_Benjamin@gol			REPORT TO: Company Name: _____ Attention: _____ Address: _____ Tel: _____ Fax: _____ Email: _____			PROJECT INFORMATION: Quotation #: B52596 P.O. #: _____ Project: 1531057 Project Name: LV Retainer NER Assign #2 Site #: HWY 112 Sampled By: S.A. + D.M.			Laboratory Use Only: Maxxam Job #: _____ Bottle Order #: _____ COC #: _____ Project Manager: _____ Ema Gitej					
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY						ANALYSIS REQUESTED (PLEASE BE SPECIFIC)								
Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____			Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA Municipality _____ <input type="checkbox"/> PWQO <input type="checkbox"/> Other _____			Special Instructions _____			Field Filtered (please circle): Metals / Hg / Cr-VI Chloride & Sulphate Conductivity, Resistivity and pH			Turnaround Time (TAT) Required: Please provide advance notice for rush projects Regular (Standard) TAT: (will be applied if Rush TAT is not specified) Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details. <input checked="" type="checkbox"/>		
Include Criteria on Certificate of Analysis (Y/N)? _____						Job Specific Rush TAT (if applies to entire submission) Date Required: _____ Time Required: _____ Rush Confirmation Number: _____ (call lab for #)								
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix								# of Bottles	Comments	
1	C1	June 12/16	11:00AM	Surface Water								1	small puddle (~3" deep) NOT Flowing	
2	C2	June 12/16	10:45AM	"								1		
3	C3	June 12/16	7:50AM	"								1		
4	C4	June 12/16	7:40AM	"								1		
5														
6														
7														
8														
9														
10														

Received in Sudbury

13-Jun-16 11:35
 Ema Gitej

 B6C1265
 GK1 ENV-1107

* RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)		Time		RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)		Time		# jars used and not submitted		Laboratory Use Only	
 Shane Albert		16/06/13		11:35am		 Bradley Frappier		16/06/13		11:35				Time Sensitive: _____ Temperature (°C) on Receipt: 9, 10, 9°C Custody Seal: Present <input type="checkbox"/> Intact <input checked="" type="checkbox"/>	
<small>* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS. SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM. White: Maxxam Yellow: Client</small>															

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