REPORT

April 6, 2017

FOUNDATION INVESTIGATION REPORT

Centreline Culvert Replacement - Highway 112
STA 13+234, Township of Pacaud
Ministry of Transportation, Ontario
G.W.P. 5105-12-00; W.P. 5428-15-01

Submitted to:
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GEOCRES NO. 42A-113

Report Number: 1531057-1

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Table of Contents

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 the centreline culvert at STA 13+234 on Highway 112 in the Township of Pacaud, approximately 16 km south of Kirkland Lake, Ontario.

The Terms of Reference and the 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 13+234 on Highway 112 which has been identified for replacement. The foundation investigation 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 13+234 on Highway 112 in the Township of Pacaud, approximately 16 km south of Kirkland Lake, Ontario. The existing culvert is a 910 mm wide by 610 mm high by 30.5 m long open footing culvert covered with approximately 5.5 m and 3 m of embankment fill on the west side and east side of the highway, respectively. 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 293.3 m and 288.7 m, referenced to Geodetic datum. Figure 1 contains photographs of the culvert location.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation associated with the culvert at STA 13+234 was carried out on May 30 and 31, 2016, during which time a total of three boreholes and one Dynamic Cone Penetration Test (DCPT) were advanced at, or in the immediate vicinity of the culvert alignment, as summarized in Table 1 and as shown on Drawing 1.

The field investigation was carried out using a truck-mounted CME55 drill rig and portable drilling equipment which were supplied and operated by Landcore Drilling of Sudbury, Ontario.

The borehole drilled by the truck-mounted CME55 drill rig was advanced through the overburden using 152 mm diameter solid stem augers and wash boring techniques. The boreholes completed by 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 sized core barrel. In 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. In situ field vane testing, using a MTO standard "N''-vane (ASTM D2573), was carried out in the cohesive soils, where appropriate, to measure the undrained shear strength of the deposit.

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 samples. The soil 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. Point Load tests and an Unconfined Compressive Strength test were carried out on selected specimen of the rock core samples. The results of the laboratory testing are summarized on the Record of Borehole and Drillhole 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 CFEM[1]. 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 from existing site features and were subsequently converted into MTM NAD 83 (Zone 12) coordinates in AutoCAD. 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.

Culvert Location	Borehole / DCPT	Location		Ground Surface Elevation (m)	Depth of Borehole / DCPT (m)
		Northing (m) / Latitude (º)	Easting (m) / Longitude (º)		
STA 13+234 (Township of Pacaud)	C1-1	5,318,327.9 / 47.999704	378,035.1 / -80.018537	288.7	7.2
	C1-2	5,318,321.6 / 47.999645	378,048.7 / -80.018355	293.3	14.9*
	C1-3	5,318,318.3 / 47.999613	378,071.3 / -80.018053	290.2	4.6*
	DCPT 1-1	5,318,325.1 / 47.999678	378,034.1 / -80.018550	288.7	7.7

Note: * Includes between 1.4 m and 3.3 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 Canadian Shield as delineated by the *Geomorphic Systems of North America*[3]. 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 knobs[4].

Highway 112 crosses four main assemblages, or batholiths associated with the southern Abitibi Greenstone Belt[5]: 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 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.

[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.

[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.

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 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 at the culvert site consists of surficial layers of organic silt and clayey silt trace organics, or embankment fill, underlain by a deposit of firm to very stiff silty clay to clay. The silty clay to clay deposit is underlain by a deposit of compact silt and sand to silty sand, which is in turn underlain by a deposit of very dense sand and gravel in places. The overburden deposits are underlain by porphyritic basalt 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 13+234

The plan and profile along the centreline of the existing culvert at STA 13+234 showing the borehole locations and interpreted stratigraphy are shown on Drawing 1. The height of the embankment at the culvert location is about 5.5 m on the west side of the highway and 3 m on the east side of the highway and the existing culvert is about 30.5 m long. A total of three boreholes and one DCPT were completed to investigate the subsurface conditions at the culvert location: two boreholes (Borehole C1-1 and C1-3) and one DCPT (DCPT C1-DCPT-1) were advanced near the ends of the existing culvert; and one borehole (Borehole C1-2) was advanced through the Highway 112 southbound lane highway embankment, south of the existing culvert alignment.

4.3.1 Asphalt

An approximately 100 mm layer of asphalt was encountered at ground surface in Borehole C1-2.

4.3.2 Embankment Fill

Embankment fill approximately 4.4 m thick was encountered below the asphalt in Borehole C1-2 at Elevation 293.2 m. The embankment fill consists of an upper 1.8 m thick layer of sand and gravel, and a lower 0.3 m thick layer of sand, some gravel, some silt containing cobbles, underlain by a 2.3 m thick deposit of cohesive fill comprised of layers/zones of sandy clayey silt, silt and sand and silty clay, trace gravel.

The SPT 'N'-values measured within the non-cohesive portion of the fill deposit are between 43 blows and 49 blows per 0.3 m of penetration, indicating a dense relative density. The SPT 'N'-values measured within the portion of the cohesive fill deposit range between 4 blows and 20 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The natural water content measured on a sample of the non-cohesive fill is about 1 per cent. The natural water content measured on two samples of the cohesive fill are about 19 per cent.

The result of a grain size distribution test completed on one sample of the silt and sand fill is shown on Figure B1 in Appendix B.

An Atterberg limits test carried out on a sample of the cohesive fill measured a liquid limit of about 37 per cent and a plastic limit of about 16 per cent, corresponding to a plasticity index of about 21 per cent. The result of the Atterberg limits test is shown on the plasticity chart on Figure B2 in Appendix B and indicates that the cohesive fill is classified as a silty clay of intermediate plasticity.

4.3.3 Organic Silt

A 0.3 m thick deposit of organic silt was encountered at ground surface in Borehole C1-1. The organic silt layer contains some sand, trace gravel, trace clay, roots and rootlets.

A SPT 'N'-value of 8 blows per 0.3 m of penetration was measured within the organic silt deposit, suggesting a firm consistency.

4.3.4 Clayey Silt to Clay

A 2.1 m to 4.7 m thick deposit of clayey silt to silty clay to clay, trace sand, trace organics was encountered between Elevations 290.2 m and 288.4 m, at ground surface in Borehole C1-3, underlying the organic silt in Borehole C1-1 and below the embankment fill in Borehole C1-2.

The measured SPT 'N'-values within the clayey silt to clay deposit range from 5 blows to 24 blows per 0.3 m of penetration. Field vane tests carried out in a borehole adjacent to Borehole C1-1 and in Borehole C1-2 measured undrained shear strengths ranging from about 65 kPa to greater than 96 kPa and sensitivities between 2 and 5. The SPT 'N'-values together with the field vane undrained shear strength results indicate that the deposit has a firm to very stiff consistency.

The natural water contents measured on four samples of the clayey silt to clay deposit range from about 26 per cent to 41 per cent.

The result of a grain size distribution test completed on a sample of clay is shown on Figure B3.

Atterberg limits tests were carried out on three samples of the cohesive portion of the deposit and measured liquid limits ranging from 38 per cent to 57 per cent, plastic limits ranging from 19 per cent to 22 per cent and plasticity indices ranging from 19 per cent to 36 per cent. The test results, which are plotted on a plasticity chart on Figure B4 in Appendix B, indicate that portions of the cohesive deposit are classified as a silty clay of intermediate plasticity to clay of high plasticity.

4.3.5 Silt and Sand to Silty Sand

A deposit of silt and sand to silty sand was encountered below the clayey silt to clay deposit at all borehole locations. The surface of the deposit was encountered between Elevations 288.1 m and 283.7 m and the thickness of the deposit ranges from 1.1 m to 2.9 m. Cobbles were inferred at a depth of 9.1 m and 2.7 m

(Elevations 284.2 m and 287.5 m, respectively) by the grinding of the casing as it advanced through the deposit in Boreholes C1-2 and C1-3. Borehole C1-1 was terminated in the silt and sand deposit at a depth of 7.2 m below ground surface (Elevation 281.5 m) after encountering refusal to further split spoon advancement.

The measured SPT 'N'-values within the silt and sand to silty sand deposit range from 18 blows to 38 blows per 0.3 m of penetration, indicating a compact to dense relative density. SPT 'N'-values of 25 blows per 0.15 m of penetration and 40 blows per 0.27 m of penetration were measured within the silt and sand to silty sand deposit but these values are not considered to be representative of the deposits relative density as the split-spoon sampler was bouncing on inferred cobbles, boulders or bedrock.

The natural water contents measured on three samples of the silt and sand to silty sand deposit range from about 17 per cent to about 22 per cent.

The results of grain size distribution testing completed on two samples of the silt and sand portion of the deposit are shown on Figure B5.

4.3.6 Sand and Gravel

A 1.4 m thick deposit of sand and gravel, trace silt was encountered below the silt and sand deposit in Borehole C1-2 at a depth of 10.2 m below ground surface, corresponding to Elevation 283.1 m. Cobbles were inferred within the deposit below a depth of 11.0 m (Elevation 282.3 m) by the grinding of the casing as it advanced through the deposit.

A SPT 'N'-value of 62 blows per 0.3 m of penetration was measured within the sand and gravel deposit, indicating a very dense relative density.

The natural water content measured on one sample of the sand and gravel was about 7 per cent.

4.3.7 Bedrock / Refusal

Bedrock was encountered in Boreholes C1-2 and C1-3 at depths of 11.6 m and 3.2 m below ground surface, respectively, corresponding to Elevations 281.7 m and 287.0 m. Refusal to DCPT advancement was encountered in the borehole adjacent to Borehole C1-1 and in C1-DCPT-1 at a depth of 7.2 m and 7.7 m, respectively corresponding to Elevations 281.5 m and 281.0 m.

Based on review of the bedrock core samples, the bedrock consists of fine grained porphyritic basalt with coarse grained quartz and feldspar clasts. The bedrock is fresh and very 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 on Figure B6.

The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are between 93 per cent and 100 per cent and between 62 per cent and 100 per cent, respectively. The Rock Quality Designation (RQD) based on the borehole data ranges from 62 per cent to 100 per cent, indicating a rock mass of fair to excellent quality.

Point load strength index tests were carried out on selected samples of the bedrock core. The corrected point load strength index values (Is_{50}) presented in Table B1 and on the Drillhole sheet in Appendix B are 15 MPa and 12 MPa for the axial and diametral tests, respectively.

An Unconfined Compression (UC) test performed on a core sample of the bedrock from Borehole C1-3 measured a uniaxial compressive strength (UCS) of 120 MPa as presented in Figure B7. Based on the laboratory Point Load strength index and the UC test, the bedrock is classified as very strong (R5, 100 MPa < UCS < 250 MPa) to extremely strong (R6 > 250 MPa).

4.3.8 Groundwater Conditions

The water level was measured in Boreholes C1-1 to C1-3 upon completion of drilling operations at depths of 0.8 m and 8.0 m below ground surface, ranging from Elevations 289.4 m to 285.3 m. 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	21,000 ohm-cm
Water Conductivity	48 μmho/cm
Sulphate Concentration	Less than 1.0 mg/L
Chloride Concentration	2.0 mg/L
Water pH	6.72

5.0 CLOSURE

Messrs. Shane Albert and Dave Marmor, EIT, supervised the borehole investigation program. This report was prepared by Ms. Madison C. Kennedy, B.A.Sc., and was reviewed by Mr. Christopher Ng, P.Eng., a senior geotechnical engineer and an Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with Golder and Designated MTO Foundations Contact, conducted an independent quality control review of this report.

Report Signature Page

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MCK/CN/JMAC/aj/mck/rb

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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

Ontario Water Resources Act:

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

TABLES

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 13+234 (Pacaud)	C1	Up to about 5.5 m	Open Footing	910 mm span by 610 mm high	30.5 m	289.9 m (East End)	287.9 m (West End)	3 Boreholes (C1-1 to C1-3)	1 DCPT (C1-DCPT-1)

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 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 13+234 (Township of Pacaud) Culvert Inlet, looking west. May 31, 2016.

PROJECT **Detail Design for Replacement of 3 Centreline Culverts – Highway 112**
GWP 5105-12-00; WP 5428-15-01

TITLE **Site Photographs**
Culvert STA 13+234 (Township of Pacaud)
Highway 112

Golder Associates

PROJECT No. 1530157			FILE No. ----		
DESIGN	MCK	Aug16	SCALE	NTS	REV.
CADD	-- --		**FIGURE 1A**		
CHECK	CN	Aug 16			
REVIEW	JMAC	Aug 16			

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

West side of Highway 112 at STA 13+234 (Township of Pacaud) Culvert Outlet, looking east. June 1, 2016.

PROJECT **Detail Design for Replacement of 3 Centreline Culverts – Highway 112**
GWP 5105-12-00; WP 5428-15-01

TITLE **Site Photographs**
Culvert STA 13+234 (Township of Pacaud)
Highway 112

Golder Associates

PROJECT No. 1530157			FILE No. ----		
DESIGN	MCK	Aug16	SCALE	NTS	REV.
CADD	-- --		**FIGURE 1B**		
CHECK	CN	Aug 16			
REVIEW	JMAC	Aug 16			

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

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

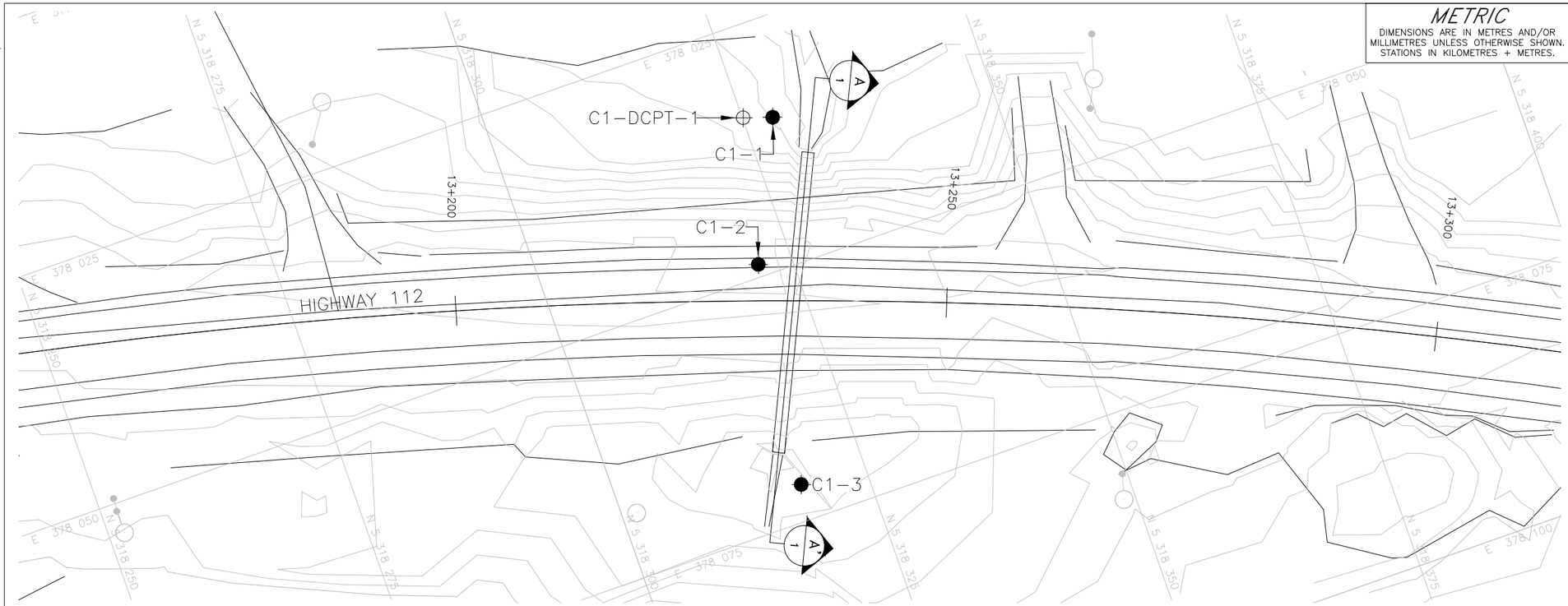
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5428-15-01

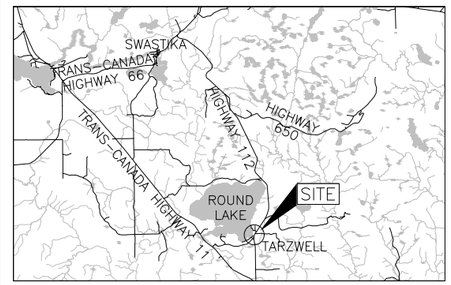
SHEET

HIGHWAY 112
CULVERT STA. 13+234
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates



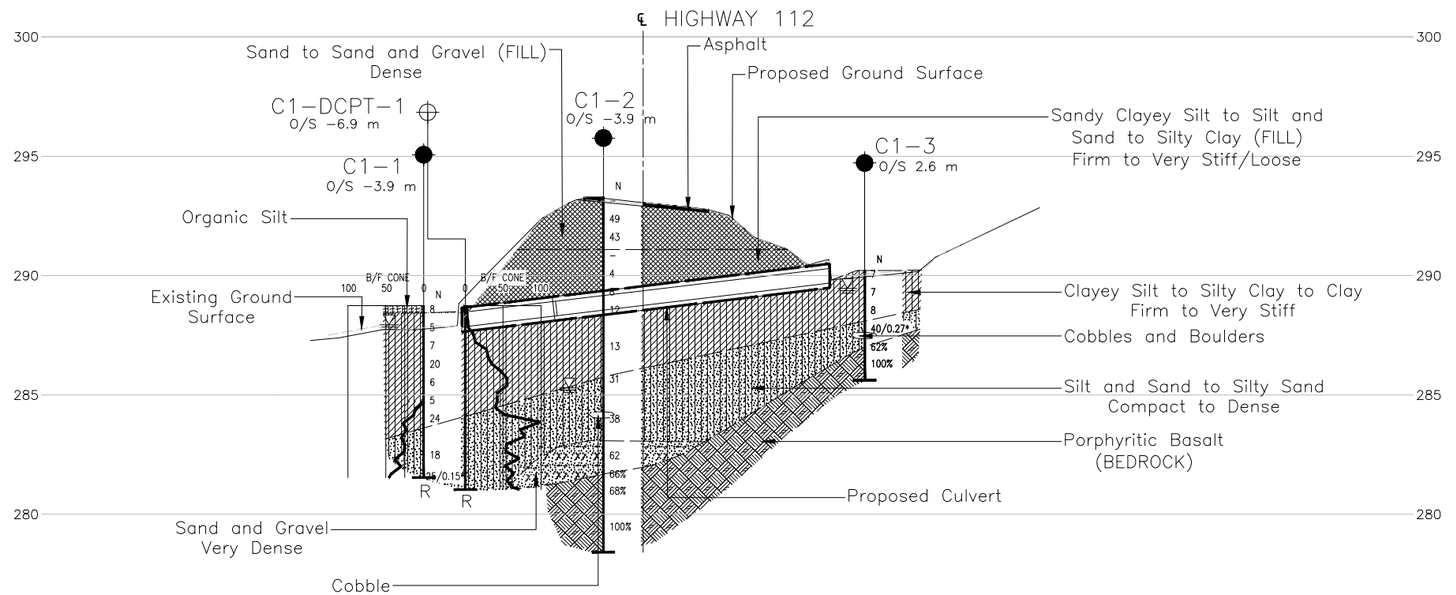
PLAN
SCALE
5 0 5 10 m



KEY PLAN
SCALE
4 0 4 8 km

LEGEND

- Borehole – Current Investigation
- Dynamic Cone Penetration Test
- 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



A-A / 1 CULVERT C1
STA. 13+234

HORIZONTAL SCALE
5 0 5 10 m

VERTICAL SCALE
2.5 0 2.5 5 m

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C1-1	288.7	5318327.9	378035.1
C1-2	293.3	5318321.6	378048.7
C1-3	290.2	5318318.3	378071.3
C1-DCPT-1	288.7	5318325.1	378034.1

NOTES

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

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

REFERENCE

Base plan, culvert section and surface data provided in digital format by MTO, drawing file no. "b07590112001.dwg", dated May, 2016, received June 29, 2016. Key plan data obtained from MNRF 2016.

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA Apr. 04, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER C.C. NG 100086170 Apr. 04, 2017 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 42A-113

HWY. 112	PROJECT NO. 1531057		DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: 4/4/2017	SITE: .
DRAWN: MR	CHKD. CN	APPD. JMAC	DWG. 1

PLOT DATE: April 4, 2017
FILENAME: S:\Clients\MTO\Hwy_112\09_PRO\1531057_MMAGroup_CulvReplac\4D_PROD\0001_C1_Foundation\1531057-0001-BC-0001.dwg

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

2 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, 60º 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 cm^2 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 / Relative Density	N 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	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.

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

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)

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

Solid Core Recovery (SCR)

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

Rock Quality Designation (RQD)

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

DISCONTINUITY DATA

Fracture Index

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

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} 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		

Golder Associates

RECORD OF BOREHOLE No C1-1

SHEET 1 OF 1 **METRIC**

PROJECT 1531057 | W.P. 5428-15-01 | LOCATION N 5318327.9; E 378035.1 MTM ZONE | ORIGINATED BY SA

DIST | HWY 112 | BOREHOLE TYPE Portable Equipment, HQ Casing, DCPT (Manual Hammer) | COMPILED BY MR

DATUM Geodetic | DATE May 30, 2016 | CHECKED BY TWB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.7	GROUND SURFACE										
0.0 / 288.4	Organic SILT, some sand, trace gravel, trace clay, trace roots and rootlets		1A 1B	SS	8						
0.3	Firm Dark brown Moist					▽					
	SILTY CLAY to CLAY, trace sand, silt laminations throughout Firm to very stiff Brown Moist		2	SS	5		288				0 2 25 73
			3	SS	7		287	5 2			
			4	SS	20		286	>96			
			5	SS	6						
			6	SS	5		285				
283.7			7	SS	24		284				
5.0	SILT and SAND, trace clay Compact Grey Wet						283				
			8	SS	18		282				0 61 38 1
281.5			9	SS	25/0.15*						
7.2	END OF BOREHOLE SPLIT-SPOON REFUSAL										

NOTE:

1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 287.9 m) upon completion of drilling.

2. An additional borehole was advanced about 1.0 m South of Borehole C1-1 to obtain a Shelby Sample, carry out vanes and a DCPT to confirm depth of refusal. DCPT refusal at a depth of 7.2 m, 50 blows for less than 0.01 m of penetration.

* Split-Spoon Bouncing

3. Geographic Coordinates:

Latitiude: 47.999704
Longitude: -80.018537

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No C1-2

SHEET 1 OF 2

METRIC

PROJECT 1531057

W.P. 5428-15-01 LOCATION N 5318321.6; E 378048.7 MTM ZONE ORIGINATED BY DM

DIST HWY 112 BOREHOLE TYPE CME 55, 152 mm Diameter Solid Stem Augers, NW Casing, Wash bore COMPILED BY MR

DATUM Geodetic DATE May 30, 2016 CHECKED BY TWB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
293.3	GROUND SURFACE										
0.0	ASPHALT (100 mm)		1	AS	-		293				
0.1	Sand and gravel, some cobbles (FILL) Dense Brown Moist		2	SS	49			○			
291.4			3A	SS	43		292				
291.1	Sand, some gravel, some silt, some cobbles (FILL)		3B								
2.2	Dense Brown Moist		4	SS	20		291				
290.3	Sandy clayey silt (FILL)										
3.0	Very stiff Brown Moist		5	SS	4		290		○		9 40 47 4
289.6	Silt and sand, trace gravel (FILL)										
3.7	Loose Brown Moist		6	SS	8		289		⊢○⊣		
288.8	Silty clay with sand, trace gravel, trace organics (FILL)										
4.5	Firm Grey Moist		7	SS	12				⊢○⊣		
	CLAY, trace sand, trace organics Stiff Grey Moist						288	+ >96			
			8	SS	13		287				
286.0											
7.3	SILT and SAND, trace to some gravel Dense Grey Wet		9	SS	31	▽	286		○		
	- Casing grinding at a depth of 9.1 m on inferred cobble		10	SS	38		285				0 47 45 8
283.1							284		○		
10.2	SAND and GRAVEL, trace silt Very dense Grey Wet		11	SS	62		283				
	- Casing grinding between depths of 11.4 m and 11.6 m								○		
281.7							282				
11.6	PORPHYRITIC BASALT (BEDROCK)		1	RC	REC 100%						RQD = 66%
	Bedrock cored from depths of 11.6 m to 14.9 m. For bedrock coring details refer to Record of Drillhole C1-2.		2	RC	REC 100%		281				RQD = 68%
			3	RC	REC 100%		280				RQD = 100%
278.4							279				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No C1-2

SHEET 2 OF 2 **METRIC**

PROJECT 1531057
W.P. 5428-15-01 LOCATION N 5318321.6; E 378048.7 MTM ZONE ORIGINATED BY DM
DIST HWY 112 BOREHOLE TYPE CME 55, 152 mm Diameter Solid Stem Augers, NW Casing, Wash bore COMPILED BY MR
DATUM Geodetic DATE May 30, 2016 CHECKED BY TWB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
14.9	END OF BOREHOLE NOTE: 1. Water level in open borehole at 8.0 m below ground surface (Elev. 285.3 m) upon completion of drilling. 2. Geographic Coordinates: Latitiude: 47.999645 Longitude: -80.018355										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT: 1531057

RECORD OF DRILLHOLE: C1-2

SHEET 1 OF 1

LOCATION: N 5318321.6 ;E 378048.7

DRILLING DATE: May 30, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55, NQ Coring

DRILLING CONTRACTOR: Landcore Drilling Inc.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		GROUND SURFACE		281.69																
12	NW Casing	Fresh, massive, grey, fined grained matrix with medium to coarse grained white quartz and feldspar porphyries, non-porous, very strong PORPHYRITIC BASALT		11.60	1															15.0 MPa (Axial) 11.7 MPa
13	NQ RC May 30, 2016				2															
14					3															
				278.41																
15		END OF DRILLHOLE		14.88																
16																				
17																				
18																				
19																				
20																				
21																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DM
CHECKED: TWB

GTA-RCK 018 S:\CLIENTS\MTO\HWY_112\02_DATA\GINT\HWY_112.GPJ GAL-MISS.GDT 24/03/17

Golder Associates

RECORD OF BOREHOLE No C1-3

SHEET 1 OF 1 **METRIC**

PROJECT 1531057
W.P. 5428-15-01
DIST HWY 112
DATUM Geodetic
LOCATION N 5318318.3; E 378071.3 MTM ZONE
BOREHOLE TYPE Portable Equipment, HQ Casing (Manual Hammer)
DATE May 31, 2016
ORIGINATED BY SA
COMPILED BY MR
CHECKED BY TWB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
290.2	GROUND SURFACE										
0.0 / 289.6	CLAYEY SILT, trace to some peat, trace gravel, trace organics Firm Grey/brown Moist		1	SS	7	▽	290				
0.6	SILTY CLAY with silt laminations Firm Grey/brown Moist		2	SS	7						
288.1			3	SS	8		289				
2.1	Silty SAND, trace to some gravel Compact Grey Wet		4	SS	40/0.27*		288				
287.0	- Cobbles and boulders below 2.7 m										
3.2	PORPHYRITIC BASALT (BEDROCK) Bedrock cored from depths of 3.2 m to 4.6 m. For bedrock coring details refer to Record of Drillhole C1-3.		1	RC	REC 100%		287				RQD = 62%
285.6			2	RC	REC 93%		286				RQD = 100%
4.6	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 0.8 m below ground surface (Elev. 289.4 m) upon completion of drilling.

* Split-Spoon Bouncing

2. Geographic Coordinates:

Latitiude: 47.999613
Longitude: -80.018053

$+^3, \times^3$: Numbers refer to Sensitivity
$\circ^{3\%}$ STRAIN AT FAILURE

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

PROJECT: 1531057

RECORD OF DRILLHOLE: C1-3

SHEET 1 OF 1

LOCATION: N 5318318.3 ;E 378071.3

DRILLING DATE: May 31, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment, NQ Coring

DRILLING CONTRACTOR: Landcore Drilling Inc.

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.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN (FLUSH)	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES
		GROUND SURFACE		287.02																
4	NW Casing; NQ RC; May 31, 2016	Fresh, massive, grey, fined grained matrix with medium to coarse grained white quartz and feldspar porphyries, non-porous, very strong PORPHYRITIC BASALT		3.20	1	100														UC = 120 MPa
					2	100														
				285.62																
		END OF DRILLHOLE		4.60																
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SA
CHECKED: TWB

GTA-RCK 018 S:\CLIENTS\MTO\HWY_112\02_DATA\GINT\HWY_112.GPJ GAL-MISS.GDT 24/03/17

Golder Associates

RECORD OF DCPT No C1-DCPT-1

SHEET 1 OF 1

METRIC

PROJECT 1531057

W.P. 5428-15-01 LOCATION N 5318325.1; E 378034.1 MTM ZONE ORIGINATED BY SA

DIST HWY 112 BOREHOLE TYPE Portable Equipment, Dynamic Cone Penetration Test (Manual Hammer) COMPILED BY MR

DATUM Geodetic DATE May 30, 2016 CHECKED BY MCK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.7	GROUND SURFACE							20 40 60 80 100	20 40 60		
0.0	Dynamic Cone Penetration Test (DCPT)						288 287 286 285 284 283 282				
281.0											
7.7	END OF DCPT REFUSAL TO FURTHER PENETRATION (71 Blows / 0.08 m) (HAMMER BOUNCING) NOTE: 1. Geographic Coordinates: Latitiude: 47.999678 Longitude: -80.018550										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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)
C1-2	1	11.8	281.5	Porphyritic Basalt	Axial	15.0
C1-2	1	11.9	281.4	Porphyritic Basalt	Diametral	11.7

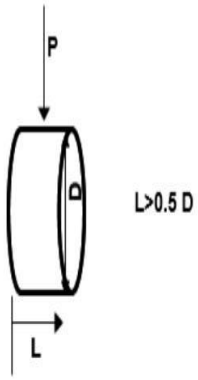
(1) Is_{50} x C (actual value will have to be confirmed by UCS testing), from ISRM ("Suggested Methods for Determining Point Load Strength",
International Society for Rock Mechanics Commission on Testing Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr.,
Vol 22, No. 2 1985, pp. 51-60.

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

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis

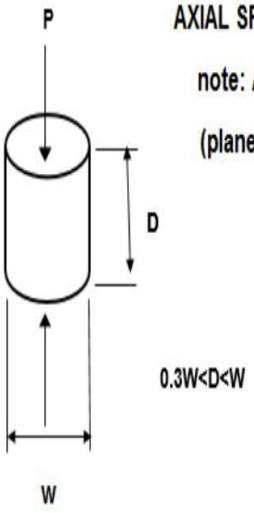
(planes of weakness)



AXIAL SPECIMEN SHAPE REQUIREMENTS

note: Axial tests are parallel to core axis

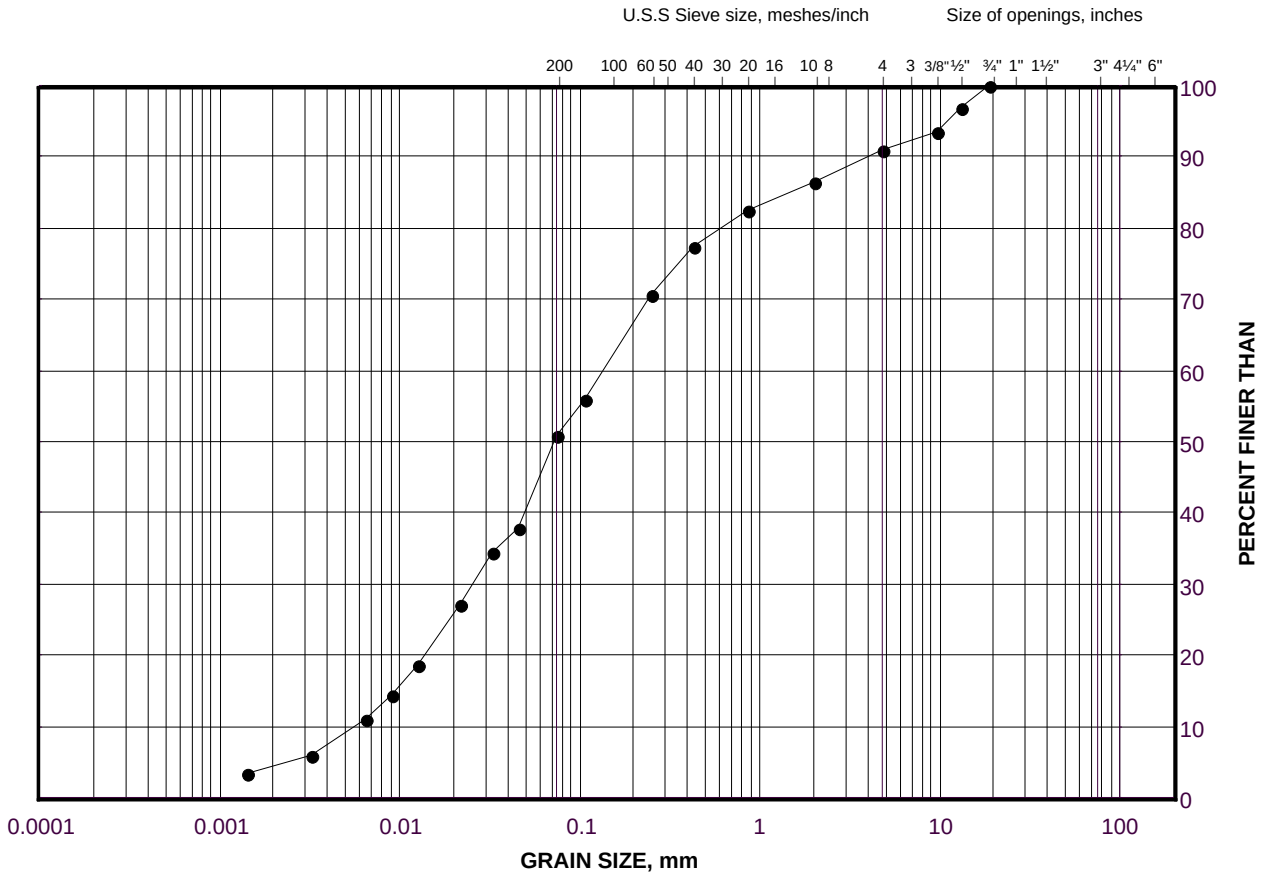
(planes of weakness)



GRAIN SIZE DISTRIBUTION

Silt and Sand (FILL)

FIGURE B1



LEGEND

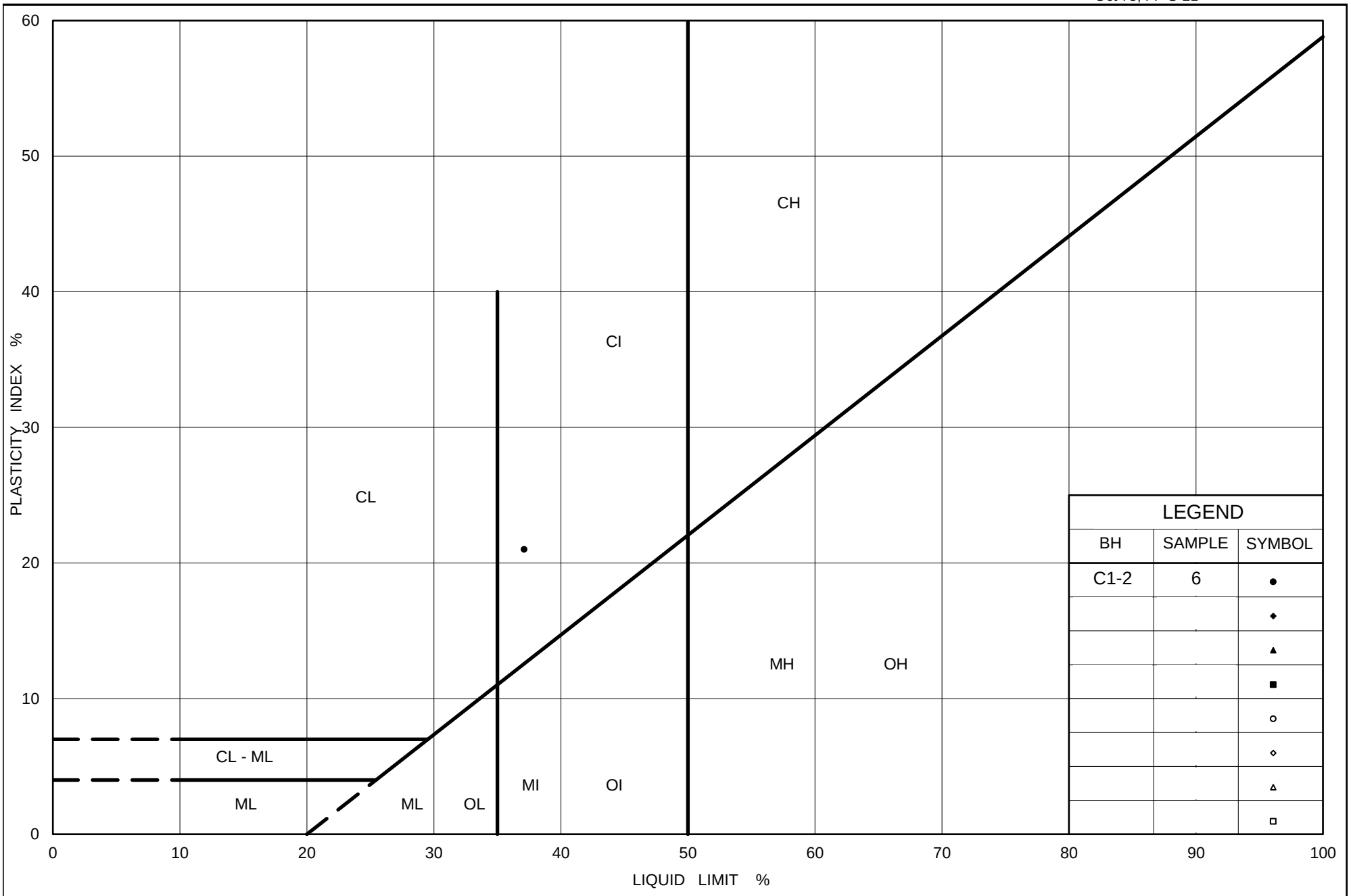
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C1-2	5	289.9

Project Number: 1531057

Checked By: CN

Golder Associates

Date: 11-Aug-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay (FILL)

Figure No. B2

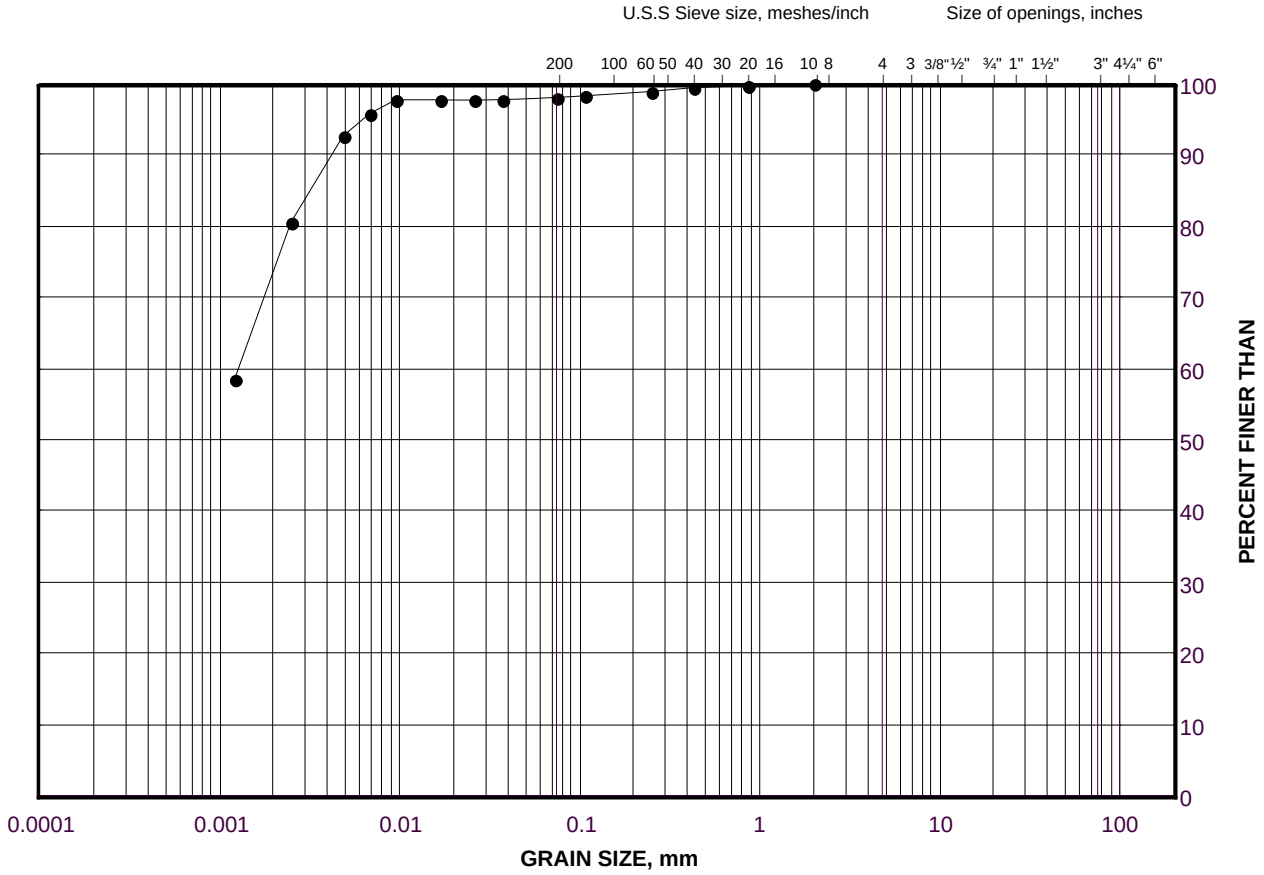
Project No. 1531057

Checked By: CN

GRAIN SIZE DISTRIBUTION

Clay

FIGURE B3



LEGEND

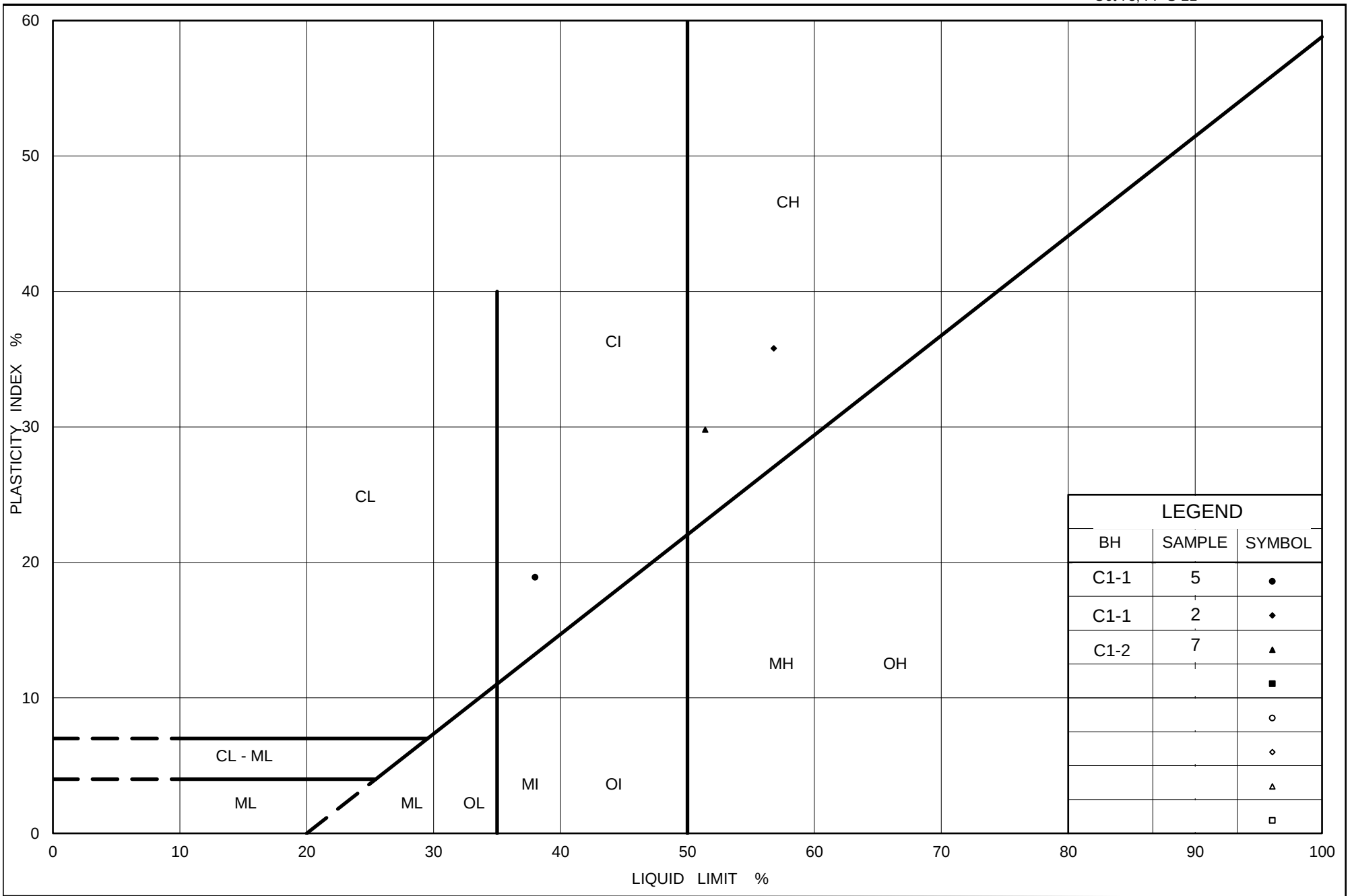
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C1-1	2	287.6

Project Number: 1531057

Checked By: CN

Golder Associates

Date: 11-Aug-16



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay to Clay

Figure No. B4

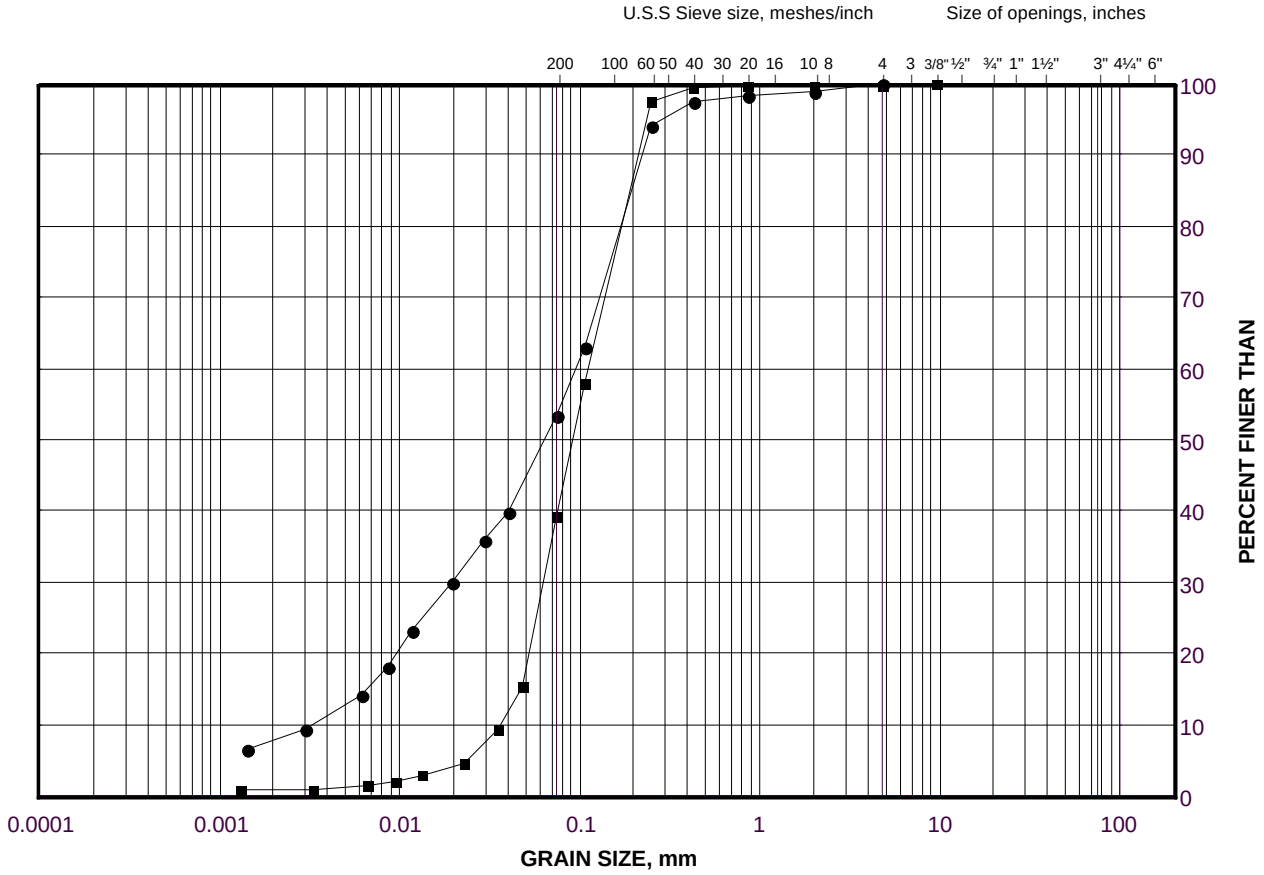
Project No. 1531057

Checked By: CN

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C1-2	10	283.8
■	C1-1	8	282.3

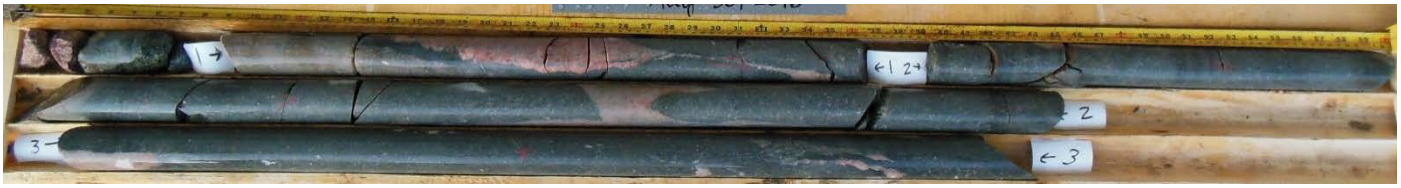
Project Number: 1531057

Checked By: CN

Golder Associates

Date: 29-Jul-16

Borehole C1-2



Box 1: 11.60 m – 14.88 m

Borehole C1-3

Box 1: 3.20 m – 4.60 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT: **Detail Design for Replacement of Centreline Culvert– Highway 112 WP 5427-15-01**

TITLE: **Bedrock Core Photographs – Highway 112 Borehole C1-2 and C1-3**

Golder Associates

PROJECT No. 1531057			FILE No. ----		
DESIGN	MCK	AUG 16	SCALE	NTS	REV.
CADD	-- --		**FIGURE B6**		
CHECK	CN	AUG 16			
REVIEW	JMAC	AUG 16			

REVISION DATE: August 9, 2016 BY: MCK Project: 1531057

UNCONFINED COMPRESSION TEST (UC)

ASTM D7012

Figure B7

SAMPLE IDENTIFICATION

PROJECT NUMBER	1531057	SAMPLE NUMBER	Run 1
PROJECT NAME	MMM/5015-E-0003/LV Retainer NE	SAMPLE DEPTH, m	3.53-3.68
BOREHOLE NUMBER	C1-3	DATE:	2016-07-19

TEST CONDITIONS

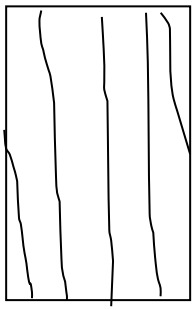
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.21

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	9.39	WATER CONTENT, (specimen) %	0.04
SAMPLE DIAMETER, cm	4.26	UNIT WEIGHT, kN/m^3	26.76
SAMPLE AREA, cm^2	14.24	DRY UNIT WT., kN/m^3	26.75
SAMPLE VOLUME, cm^3	133.73	SPECIFIC GRAVITY	-
WET WEIGHT, g	365.02	VOID RATIO	-
DRY WEIGHT, g	364.87		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	120.3

REMARKS:

Checked By: CN

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	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
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

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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 (SO4)	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

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

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

TEST SUMMARY

Maxxam ID: CNJ774 **Collected:** 2016/06/12
Sample ID: C1 **Shipped:**
Matrix: Water **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 **Collected:** 2016/06/12
Sample ID: C2 **Shipped:**
Matrix: Water **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 **Collected:** 2016/06/12
Sample ID: C3 **Shipped:**
Matrix: Water **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 **Collected:** 2016/06/12
Sample ID: C4 **Shipped:**
Matrix: Water **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

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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

GENERAL COMMENTS

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

Package 1	9.3°C

Results relate only to the items tested.

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

QUALITY ASSURANCE REPORT

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

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% 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).

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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

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

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B52596	Maxxam Job #:	Bottle Order #:
Attention:	Central Acct:1112, 1113, 1118	Attention:		P.O. #:			565300
Address:	6925 Century Ave Suite 100	Address:		Project:	1531057	COC #:	Project Manager:
	Mississauga ON L5N 7K2			Project Name:	LV Retainer NER Assign#2 HWY112	C#565300-01-01	Ema Gitej
Tel:	(905) 567-4444 Fax (905) 567-6561	Tel:	Fax:	Site #:			
Email:	Catherine_Guiao@golder.com, Rachel_Benjamin@gol	Email:		Sampled By:	S.A + D.M		

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)	Other Regulations	Special Instructions
☐ Table 1 ☐ Res/Park ☐ Medium/Fine	☐ CCME ☐ Sanitary Sewer Bylaw	
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ Reg 558 ☐ Storm Sewer Bylaw	
☐ Table 3 ☐ Agri/Other ☐ For RSC	☐ MISA Municipality ____	
☐ Table ___	☐ PWQO	
	☐ Other ____	
Include Criteria on Certificate of Analysis (Y/N)? ____		

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.

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	Field Filtered (please circle): Metals / Hg / Cr VI	Chloride & Sulphate	Conductivity, Resistivity and pH	# of Bottles	Comments
1		C1	June 13/16	11:00AM	Surface Water		X	X	1	*small puddle (~3" deep) NOT Flowing
2		C2	June 13/16	10:45AM	"		X	X	1	
3		C3	June 13/16	7:50AM	"		X	X	1	
4		C4	June 13/16	7:40AM	"		X	X	1	
5										
6										
7										
8										
9										
10										

13-Jun-16 11:35
Ema Gitej
B6C1265
GK1 ENV-1107

Received in Sudbury

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date (YY/MM/DD)	Time	# jars used and not submitted
Shane Albert	16/06/13	11:35am	B_F — Bradley Frappier	2016/06/13	11:35	
			MUSRAT MAZ	2016/06/14	11:00	

Laboratory Use Only				
Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
	9.10, 9°C	Present		✓
		Intact		

* 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

Maxxam Analytics International Corporation o/a Maxxam Analytics

2/5/4

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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