REPORT

January 10, 2019

FOUNDATION INVESTIGATION REPORT

STRUCTURAL BUNDLE - 11 STRUCTURES ON HIGHWAYS 129, 532 AND 556
HIGHWAY 556 - SILVER CREEK CULVERT REPLACEMENT, 25.9 KM EAST OF HIGHWAY 17 (SITE NO. 38S-0039/C0)
HODGINS TOWNSHIP, ALGOMA DISTRICT, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5378-11-00 ; WP 5307-14-01

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Golder Associates

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PART A

FOUNDATION INVESTIGATION REPORT
STRUCTURAL BUNDLE – 1 STRUCTURE ON HIGHWAY 556
HIGHWAY 556 – SILVER CREEK CULVERT REPLACEMENT, 25.9 KM EAST OF HIGHWAY 17 (SITE NO. 38S-0039/C0)
HODGINS TOWNSHIP, ALGOMA DISTRICT, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5378-11-00 ; WP 5307-14-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detail design of the replacement of a culvert on Highway 556 (Site No. 38S-0039/C0) in the Hodgins Township, Algoma District, Ontario.

The purpose of the field investigation is to establish the subsurface conditions at the location of the proposed replacement culvert by methods of borehole drilling, in-situ testing and laboratory testing on selected soil samples.

This report summarizes the factual results of field and laboratory work (including field investigation procedures, borehole stratigraphy, and geotechnical and analytical laboratory test results) as well as a description of the interpreted soil and groundwater conditions at the Silver Creek culvert site.

The Terms of Reference and Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal dated May 2016 (Agreement No. 5016-E-0029) as well as change request letter dated April 24, 2018 which was approved by MTO on June 11, 2018 (Change Order No. C05016E0029001). Golder's proposal for foundation engineering services is contained in Section 17.8 of AECOM's Technical Proposal for this assignment.

2.0 PROJECT AND SITE DESCRIPTION

2.1 Project Description

The existing culvert at the site conveys the Silver Creek under Highway 556 in south to north direction. The culvert was constructed in 1976, but there are no records of the culvert being rehabilitated since that time. It is understood that the existing culvert underwent a structural assessment in 2015 and was identified as being in fair structural condition with minor deterioration of several elements, and more significant deterioration of the structural steel coatings. It is understood that the culvert is to be replaced with a new concrete box culvert.

2.2 Site Description

The site of the proposed culvert replacement is located about 25.9 km east of Highway 17 in the Hodgins Township, Algoma District, Ontario, at approximately Station 12+254.

The existing Silver Creek culvert consist of a Structural Plate Corrugated Steel Pipe Arch (SPCSPA) culvert with a span of approximately 3.9 m and measuring about 22.1 m in length. The fill above the obvert of the culvert ranges in thickness from about 0.4 m (near the edges of the highway embankment) to about 1.0 m (near the travelled portion of highway). Concrete cut-off walls surrounding the open ends of the culvert are located at the inlet and outlet of the culvert. The culvert location is shown on Drawing 1 and on Photographs 1 and 2 (on the following page).

The Silver Creek at the location of the culvert is generally less than 5 m wide and flows in a northly direction. At the time of the investigation, the creek was relatively shallow (less than 0.1 m deep) near the inlet of the culvert, however, the creek was deeper near the outlet where an approximately 2 m deep and 10 m wide scour pool was located. The downstream end of Silver Creek flows into the Goulais River about 120 m north of the culvert.

Highway 556 at the location of the culvert consists of an approximately 3.5 m to 4 m high earth fill embankment (with rock fill/rip-rap protection along the face of the slopes near the culvert) and carries one lane of traffic in each direction. The travelled portion of the highway consists of an asphalt surface which is at approximately Elevation 195.4 m in the vicinity of the existing culvert.

Photograph 1: Inlet of the existing Silver Creek Culvert on the south side of Highway 556 (looking north/downstream)

Photograph 2: Outlet of the existing culvert on the north side of Highway 556 (looking southwest)

Roadway entrances to residential properties are located on the north side of Highway 556, immediately west and approximately 30 m east of the culvert, as well as on the south side of Highway 556, approximately 55 m east of the culvert. Overhead electrical transmission lines run along the highway on the south side of Highway 556 (i.e., immediately above the inlet). The overhead lines also cross the highway about 15 m west and about 50 m east of the culvert.

The topography of the area in the immediate vicinity of the culverts is relatively flat to undulating and is located within the Goulais River valley.

3.0 FIELD INVESTIGATION PROCEDURES

The fieldwork at the site was carried out over five days between August 14 and August 18, 2018, during which time three boreholes (designated as Boreholes SCC-01 to SCC-03) were advanced near the existing culvert. Boreholes SCC-01 and SCC-03 were advanced near the inlet and outlet of the existing culvert, respectively. Borehole SCC-02 was advanced through the Highway 556 embankment on the eastbound lane.

The subsurface soil conditions encountered in the boreholes are shown in detail on the Records of Boreholes in Appendix A. Lists of abbreviations and symbols are also provided in Appendix A to assist in the interpretation of the borehole records. The locations of the as-drilled boreholes are shown in plan on Drawing 1.

The boreholes were advanced using portable drilling equipment and a truck-mounted drill rig. Boreholes SCC-01 and SCC-03 were advanced using portable drilling equipment comprised of a tripod and a cathead. Borehole SCC-01 was advanced near the inlet with the equipment set up on the existing ground/creek bed, where the creek water level was relatively shallow (i.e., less than about 0.1 m deep); and Borehole SCC-03 was advanced near the outlet (i.e., within the scour pool) on a drilling platform. The portable drilling equipment was supplied and operated by Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario. These two boreholes were advanced through the overburden using 'BW' casing with wash boring techniques. Borehole SCC-02 was advanced using a CME-75 truck-mounted drill rig supplied and operated by Landcore Drilling Inc. of Chelmsford, Ontario. The borehole was advanced using 210 mm outer diameter, continuous flight, hollow-stem augers.

In the two boreholes advanced near the inlet and outlet of the culvert, the soil samples were generally obtained at intervals of depth of about 0.75 m within about 2 m to 3 m below the creek bed followed by sampling at intervals of depth of about 1.5 m; while in the one borehole advanced on Highway 556, the soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m. All soil samples were collected using a 50 mm outer diameter split-spoon sampler driven by a manual hammer (within Boreholes SCC-01 and SCC-03 advanced using the portable drilling equipment) or an automatic hammer (within Borehole SCC-02 advanced using the truck-mounted drill rig) in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*). Field vane shear tests were carried out in the cohesive soils encountered in Boreholes SCC-01 and SCC-03 for assessment of undrained shear strengths (ASTM D2573, *Standard Test Method for Field Vane Shear Strength Test in Cohesive Soil*) using an MTO Standard 'B'-size vane given the smaller diameter of the boreholes advanced by portable equipment. Dynamic Cone Penetration Tests (DCPTs) were also carried out in all boreholes following the soil sampling operation.

The boreholes, including the DCPTs, were advanced to depths ranging between about 16.8 m and 26.8 m below existing ground or water surface. Upon completion of drilling operations, the boreholes were backfilled to or to near ground surface with bentonite grout, in accordance with Ontario Regulation 903 (as amended); and Borehole SCC-02 was capped with cold patch asphalt.

Prior to commencement of field work, Golder arranged for the clearance of underground utilities/services. The field work was observed on a full-time basis by a member of Golder's engineering staff who monitored the drilling and sampling operations and logged the boreholes in the field. The soil samples were transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual/tactile examination and geotechnical laboratory testing.

Geotechnical index testing (i.e., water content, Atterberg limits and grain size distribution) was carried out on selected soil samples. The results of the geotechnical laboratory testing are summarized on the borehole records in Appendix A and the results of the geotechnical testing are provided in Appendix B. All of the laboratory tests were carried out in accordance with MTO Laboratory and/or ASTM Standards, as appropriate.

One soil sample was selected from Borehole SCC-02 for corrosivity testing. The selected soil sample was submitted, under chain-of-custody procedures, to Maxxam Analytics of Mississauga, Ontario (a Standards Council of Canada accredited laboratory) for analysis of a suite of corrosivity parameters including pH, sulphate, sulphide, chloride and resistivity/conductivity.

Temporary benchmarks were established and surveyed near the existing Silver Creek culvert by Callon Dietz Inc. prior to the drilling crews mobilizing to site. Upon completion of drilling operations, borehole offsets and corresponding ground surface elevation differences were recorded and tied-in to the surveyed benchmark locations to determine the as-drilled borehole locations and ground surface elevations. The borehole survey information, including northing and easting coordinates (presented in the MTM NAD83 Zone 13 and latitude/longitude coordinate systems) and the ground surface elevations (referenced to Geodetic datum), are provided on the borehole records in Appendix A, presented on Drawing 1, and summarized below.

Borehole No.	Approximate Location	Coordinates (MTM NAD83 Zone 13)		Ground / Water [1] Surface Elevation	Borehole Depth [4]
		Northing (Latitude)	Easting (Longitude)		
SCC-01	Inlet of culvert; south of Highway 556	5178620.4 m (46.747135°)	298978.8 m (-84.076192°)	192.3 m [2]	17.1 m [5]
SCC-02	Eastbound lane of Highway 556, east of the culvert	5178634.4 m (46.747261°)	298984.7 m (-84.076115°)	195.5 m [3]	26.8 m [5]
SCC-03	Outlet of culvert; north of Highway 556	5178649.4 m (46.747396°)	298985.9 m (-84.076099°)	191.8 m [2]	16.8 m [5]

Notes:
1. Water surface refers to the top of the water in the Silver Creek at the time of the investigation.
2. Boreholes SCC-01 and SCC-03 were advanced using portable drilling equipment near the inlet and outlet of the culvert, respectively.
3. Borehole SCC-02 was advanced using a truck-mounted drill rig through the Highway 556 embankment.
4. The borehole depth includes the depth of DCPT penetration carried out at the bottom of each open borehole.
5. The termination depth of Boreholes SCC-01 and SCC-03 was measured from the water surface in the Silver Creek. The water depth in the creek at the time of drilling was measured at about 0.1 m and 2.1 m in the respective boreholes.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)[1] mapping, the Silver Creek culvert site is located within a valley train consisting primarily of gravelly and sandy soils which “are mainly confined to the larger river valleys and usually occur as flat, terraced landforms” (McQuay, 1980). The granular deposits are variable in

1 Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41KNE, Study Number 91.

thickness and are generally underlain by varved silt and clay to glacial till and bedrock. The valley train is bordered by bedrock knobs.

Based on geological mapping developed by the Ontario Ministry of Northern Development and Mines (MNDM)[2], the site is underlain by bedrock from the gneissic tonalite suite of rocks comprised of tonalite to granodiorite (foliated to gneissic) with minor supracrustal inclusions.

4.2 Overview of Local Subsurface Conditions

The subsurface soil and groundwater conditions encountered in the boreholes advanced at this site, together with the results of the in-situ and geotechnical/analytical laboratory testing, are presented on the borehole records (provided in Appendix A) and the laboratory test figures/sheets (provided in Appendices B and C). The results of the in-situ field tests (i.e., SPT 'N'-values and field vane undrained shear strengths) as presented on the borehole records are uncorrected, and the 'N'-values are based on SPT sampling procedures carried out with a manual hammer at the locations of Boreholes SCC-01 and SCC-03 and an automatic hammer at the location of Borehole SCC-02.

The stratigraphic boundaries shown on the borehole records and on the soil strata profile (i.e., Drawing 1) are inferred from observations of drilling progress, generally non-continuous sampling and in-situ testing, and therefore represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the Silver Creek culvert site consists of embankment fill (associated with Highway 556) or water (associated with Silver Creek) underlain by an extensive deposit of varved silt to clayey silt and silty clay to clay. In places, cobbles and boulders are present on the creek bed.

Detailed descriptions of the subsurface conditions encountered in the boreholes at this site are provided in the following subsections.

4.2.1 Water

Water was encountered above the creek bed in Boreholes SCC-01 and SCC-03 which were advanced in the Silver Creek near the inlet and outlet of the existing culvert, respectively. The water surface elevation and water depth at each borehole location is summarized below.

Borehole Designation	Approximate Location	Water Surface Elevation	Approximate Water Depth
SCC-01	About 4 m south of culvert inlet	192.3 m	0.1 m
SCC-03	About 4 m north of culvert outlet	191.8 m	2.1 m

As noted above, cobbles and boulders were observed on/above the creek bed near the inlets and outlets of the culvert, especially along the creek leading up to the inlet (refer to Photograph 3 below) and north of the scour pool near the outlet (refer to Photograph 4 on the following page), although cobbles and boulders are also visible around and at the bottom of the scour pool.

2 Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2544.

Photograph 3: Cobbles and boulders near the inlet and along the creek (looking south/downstream from top of Highway 556)

Photograph 4: Cobbles and boulders around and at the bottom of the scour pool as well as along the creek north of the scour pool (looking north/upstream from top of Highway 556)

4.2.2 Asphalt

An approximately 50 mm thick layer of asphalt was encountered in Borehole SCC-02 which was advanced through the Highway 556 embankment on the eastbound lane (east of the existing culvert). The top of the asphalt layer is at about Elevation 195.5 m.

4.2.3 Sandy Gravel to Gravelly Sand (Fill)

An approximately 3.9 m thick layer of sandy gravel to gravelly sand fill associated with the Highway 556 embankment was encountered below the asphalt in Borehole SCC-02 at about Elevation 195.4 m and a 2.2 m thick layer sandy gravel fill was encountered below the creek bed Borehole SCC-01 at about Elevation 192.2 m. The fill encountered in Borehole SCC-01 (advanced near the inlet) contains cobbles and boulders; while the granular fill encountered in Boreholes SCC-02 contains cobbles and rock fragments (see Photograph 5). It is further noted that difficult auger advancement was noted between depths of about 0.1 m and 2.3 m below existing ground surface in Borehole SCC-02.

Photograph 5: Cobbles and rock fragments – auger sample recovered from the upper portion of the embankment fill (in Borehole SCC-02) where difficulty with auger advancement was encountered.

The SPT 'N'-values measured within the fill range from 8 blows per 0.3 m of penetration to 50 blows for 0.15 m of penetration, indicating a loose to very dense state of compactness. The lower SPT "N"-values (i.e., 8 blows and 24 blows per 0.3 m) were encountered near the lower portion of the fill in Boreholes SCC-01 and SCC-02, respectively.

The water content measured on a sample of the gravelly sand recovered from Borehole SCC-02 is approximately 9%.

It is noted that is was not possible to schedule grain size distribution laboratory tests on the fill materials due to poor sample recovery during Standard Penetration Testing which is attributed to the gravelly/cobbley nature of the fill encountered at the site.

4.2.4 Varved Silt to Clayey Silt and Silty Clay to Clay

An extensive varved deposit comprised of silt to clayey silt laminae and silty clay to clay laminae was encountered underlying the sandy gravel fill in Borehole SCC-01, underlying the gravelly sand fill in Borehole SCC-02, and at the creek bed in Borehole SCC-03. The varved nature of the cohesive deposit is shown on Photograph 6 (on the

following page); however, it is difficult to distinguish/classify the different types of laminae based on a visual inspection.

Photograph 6: Silt to clayey silt laminae (light grey colour) and silty clay laminae (dark grey colour)

The top of the varved deposit ranges between about Elevations 191.6 m and 189.7 m. All three boreholes were terminated within this deposit between about Elevations 182.6 m and 179.7 m. The thickness of the sampled portion of the varved cohesive deposit ranges from approximately 7.5 m to 11.9 m. DCPTs were also carried out at the bottom of each open borehole (i.e., below the last collected soil sample). The DCPTs were terminated at elevations ranging between about 175.2 m and 168.7 m. The blow counts (from the DCPTs) at these elevations generally range between 20 blows and 40 blows per 0.3 m of penetration.

The SPT 'N'-values measured within the varved cohesive deposit range between 0 blows (weight of hammer) and 12 blows per 0.3 m of penetration. In-situ vane tests carried out within this deposit measured undrained shear strength ranging from about 80 kPa to greater than 136 kPa. The sensitivity (defined as the quotient between the undisturbed shear strength and the remoulded shear strength) ranges between about 1 and 5, but typically varies from 2 to 4. The in-situ field vane test results indicate that the varved deposit has a predominantly stiff to very stiff consistency. However, given the presence of generally stronger/stiffer silt to clayey silt laminae, the measured undrained shear strengths may not be representative of the operative shear strength of the varved deposit or of the weaker silty clay to clay laminae.

The water content measured on 21 samples of this deposit ranges between about 45% and 52%. An organic content test carried out on a sample recovered from the upper portion of the varved cohesive deposit from Borehole SCC-03 is approximately 1.9% (by weight).

The results of grain size distribution tests carried out on six samples of the varved silt to clayey silt and silty clay to clay deposit are shown on Figure B1 in Appendix B. Atterberg limits tests were carried out on ten samples of the varved clay deposit. The tests measured liquid limits between about 36% and 51%, plastic limits between about 21% and 23%, and plasticity indices between about 16% and 27%. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B2 in Appendix B, and indicate that the soil is classified as silty clay of intermediate plasticity to clay of high plasticity. The results also suggest that the soil consists predominantly of silty clay, but this may not be a true representation of the overall varved deposit. These results can be attributed

to the difficulty in attempting to separate the two types of laminae for laboratory testing purposes. The silt to clayey silt laminae, which were identified in the field and the laboratory based on tactile examination, have been mixed with portions of the more plastic laminae, yielding 'average' Atterberg limits indicative of a cohesive material of intermediate plasticity.

4.3 Groundwater Conditions

Given the presence of the Silver Creek, the groundwater level is anticipated to be at or near the creek surface. The water level in Borehole SCC-02 (advanced from the top of the Highway 556 embankment) was noted to be at a depth of about 3.5 m below existing highway surface, corresponding to approximately Elevation 192.0 m, upon completion of drilling which is similar to the elevation of the surface of the adjacent creek. Boreholes SCC-01 and SCC-03 were advanced using wash-boring techniques, which introduced water into the boreholes.

The water level surveyed at the surface of the Silver Creek during the field investigation is at about Elevation 192.3 m at the location of Borehole SCC-01 (i.e., near the inlet) and at about Elevation 191.8 m at the location of Borehole SCC-03 (i.e., near the outlet).

The water level in the creek and the degree of saturation of the embankment fill (or the potential presence of a perched water table within the fill) is subject to seasonal fluctuations and precipitation events. Water levels in the creek and within the fill are expected to be higher during wet seasons and sustained periods of precipitation.

4.4 Analytical Testing of Soil

One soil sample was selected from Borehole SCC-02 (advanced through the highway embankment) and submitted to Maxxam Analytics Ontario for corrosivity testing. The analytical laboratory test results are provided on the Certificates of Analysis presented in Appendix C, and summarized below.

Borehole Designation	Sample No.	Average Approx. Sample Depth [2] (m)	Average Approx. Sample Elevation (m)	Material Type	Resistivity (ohm·cm)	Conductivity (µmho/cm)	pH	Chloride (Cl) Content (ppm or µg/g)	Sulphate (SO_4) Content (ppm or µg/g)
SCC-02 [1]	SA 4	3.9	191.6	Varved Silt to Clayey Silt and Silty Clay to Clay	5,800	171	8.6	<20 [1]	<20 [1]

Note:
1. The sulphate and chloride concentrations measured on samples recovered from Borehole SCC-02 are below the reportable detection limit of 20 µg/g.

It is noted that the sulphide concentration measured on the soil sample recovered from Borehole SCC-02 and was also analyzed and is less than 0.55 µg/g (i.e., below the reportable detection limit of 55 µg/g).

5.0 CLOSURE

The field work for this investigation was supervised by members of Golder's engineering staff. The Foundation Investigation Report was prepared by Ms. Alysha Kobylinski, B.A.Sc. and reviewed by Mr. Tomasz Zalucki, P.Eng., a geotechnical engineer at Golder. Mr. Paul Dittrich, P.Eng., a Principal and MTO Foundations Designated Contact for Golder, conducted an independent quality control review of the report.

Report Signature Page

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https://golderassociates.sharepoint.com/sites/14262g/deliverables/03-draft fidr/silver creek culvert/1670846-12-rpt-revb-silver creek culvert draft fidr-20181121.docx

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McQuay, D.F. 1980. Sault Ste. Marie Area (NTS 41K/NE), District of Algoma; Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 91, 21p. Accompanied by Maps 5012 and 5013, Scale 1:100000.

Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41KNE, Study Number 91.

Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2544.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D2573	Standard Test Method for Field Vane Shear Strength Test in Cohesive Soil

Ontario Regulations:

R.R.O 1990, Regulation 903	Wells, under Ontario Water Resources Act, R.S.O. 1990, c. O.40

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

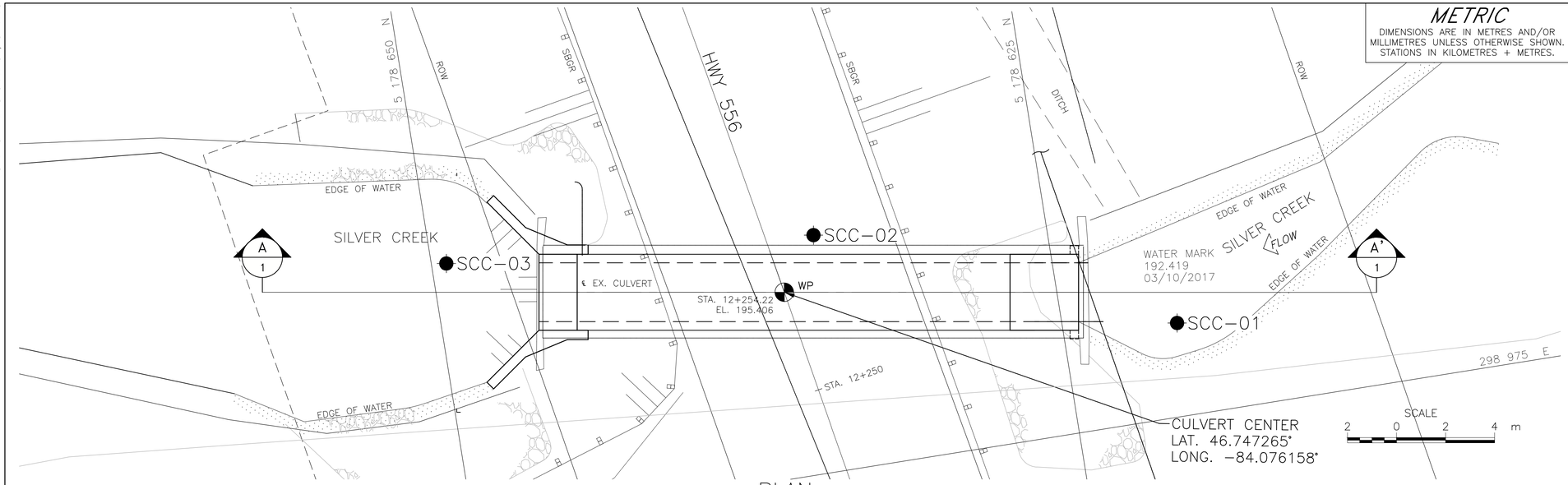
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5307-14-01

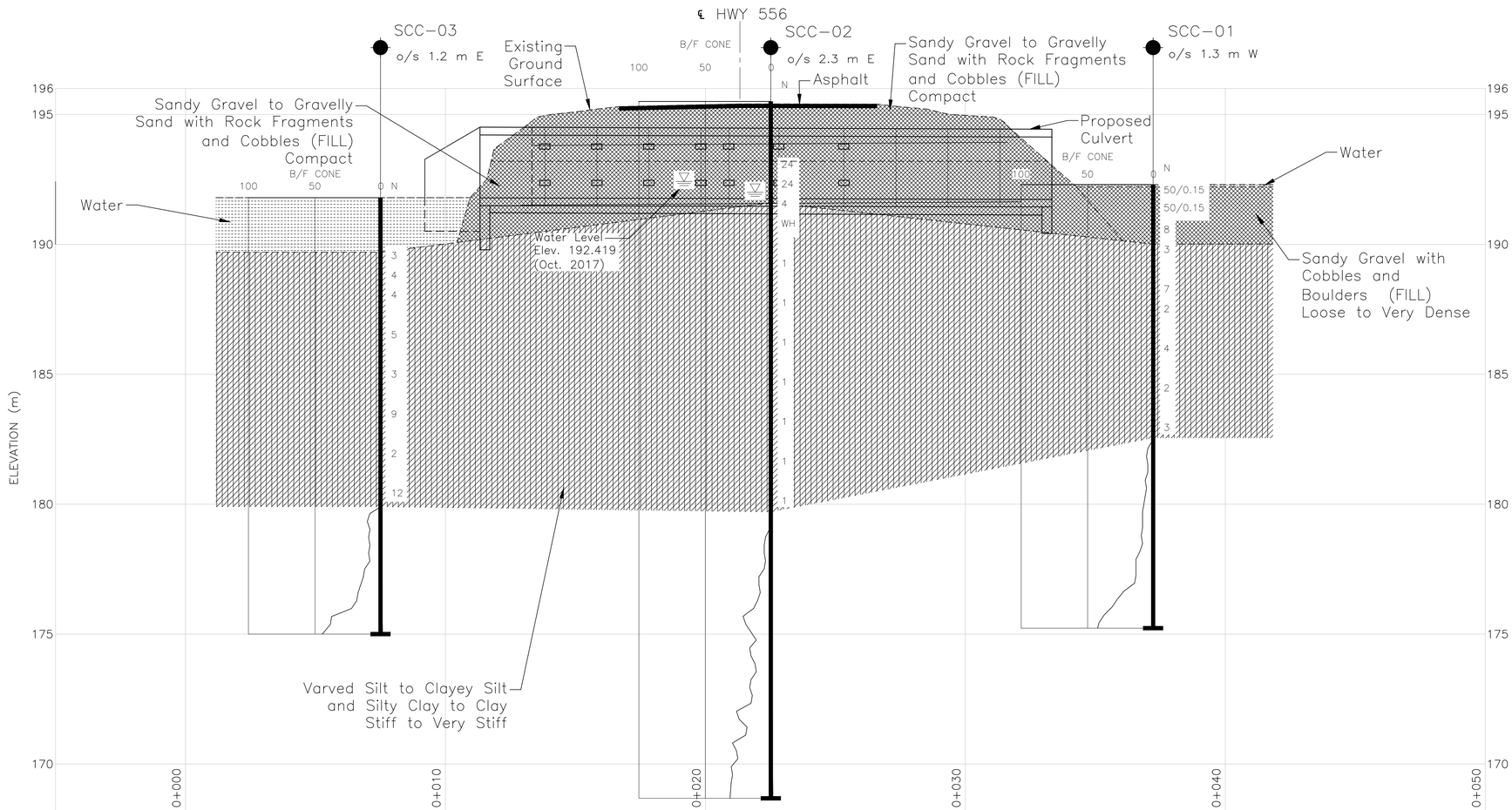
SHEET

HIGHWAY 556
SILVER CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates

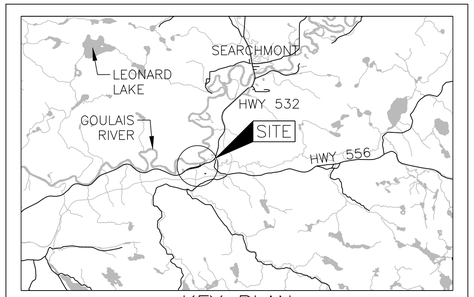


PLAN



A-A
1
CULVERT PROFILE

SCALE
2 0 2 4 m



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 13)

No.	ELEVATION	NORTHING	EASTING
SCC-01	192.3	5178620.4	298978.8
SCC-02	195.5	5178634.4	298984.7
SCC-03	191.8	5178649.4	298985.9

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 plans provided in digital format by AECOM, drawing file no. 60546679-S100.dwg, received AUG 24, 2018.

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NO.	DATE	BY	REVISION

Geocres No. 41K-113

HWY. 556	PROJECT NO. 1670846		DIST. ALGOMA
SUBM'D. AK	CHKD. TZ	DATE: 1/11/2019	SITE: 38S-0039/C0
DRAWN: TR	CHKD. JPD	APPD. JPD	DWG. 1

PLOT DATE: January 11, 2019
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APPENDIX A

Records of Borehole Sheets

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 (Cohesionless) Soils

Compactness Condition	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

GOLDER

RECORD OF BOREHOLE No SCC-01

SHEET 1 OF 2

METRIC

PROJECT 1670846

G.W.P. 5307-14-01

LOCATION N 5178620.4; E 298978.8 MTM NAD 83 ZONE 13 (LAT. 46.747135; LONG. -84.076192)

ORIGINATED BY MB

DIST ALGOMA HWY 556

BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing

COMPILED BY AK

DATUM Geodetic

DATE August 16 to 18, 2018

CHECKED BY TZ

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
192.3	WATER SURFACE											
0.0	WATER (80 mm)											
0.1	Sandy gravel with cobbles and boulders (FILL) Loose to very dense Grey and red Wet		1	SS	50/0.15		192					
			2	SS	50/0.15							
			3	SS	8		191					
190.0												
2.3	Varved SILT to CLAYEY SILT and SILTY CLAY to CLAY, trace sand Stiff to very stiff Grey Wet		4	SS	3		190					0 5 49 46
							189		3.1			
			6	SS	7		188					0 4 57 39
			7	SS	2							
							187		3.1			
			8	SS	4		186					
							185		3.3			
			9	SS	2		184					
									4.9			
			10	SS	3		183					
182.6												
9.8	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						182					
							181					
							180					
							179					
							178					

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

○3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No SCC-01

SHEET 2 OF 2

METRIC

PROJECT 1670846

G.W.P. 5307-14-01 LOCATION N 5178620.4; E 298978.8 MTM NAD 83 ZONE 13 (LAT. 46.747135; LONG. -84.076192) ORIGINATED BY MB

DIST ALGOMA HWY 556 BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing COMPILED BY AK

DATUM Geodetic DATE August 16 to 18, 2018 CHECKED BY TZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100; ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	w_P w w_L; 20 40 60	γ kN/m³	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
175.2	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						177 176				
17.1	END OF DCPT NOTE: 1. Borehole SCC-01 advanced in Silver Creek near the inlet (south side of Highway 556) of the existing culvert.										

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

GOLDER

RECORD OF BOREHOLE No SCC-02

SHEET 1 OF 2

METRIC

PROJECT 1670846

G.W.P. 5307-14-01

LOCATION N 5178634.4; E 298984.7 MTM NAD 83 ZONE 13 (LAT. 46.747261; LONG. -84.076115)

ORIGINATED BY LJS

DIST ALGOMA HWY 556

BOREHOLE TYPE 210 mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY AK

DATUM Geodetic

DATE August 15, 2018

CHECKED BY TZ

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
195.5	GROUND SURFACE										
0.0	ASPHALT (50 mm)										
0.1	Sandy gravel with rock fragments and cobbles (FILL) Compact Brown Moist to wet		1	SS	24		195				
							194				
							193				
192.5											
3.0	Gravelly sand, trace silt (FILL) Compact Brown Wet		2	SS	24	▽	192		○		
191.6											
3.9	Varved SILT to CLAYEY SILT and SILTY CLAY to CLAY, trace to some sand Stiff to very stiff Grey Wet		3A 3B	SS	4		191		○		
			4	SS	WH				○		
							190				
			5	SS	1		189		○		0 7 53 40
							188				
			6	SS	1				○		
							187				
			7	SS	1		186		○		
							185				
			8	SS	1				○		0 11 51 38
							184				
			9	SS	1		183				
							182				
			10	SS	1				○		
							181				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No SCC-02

SHEET 2 OF 2

METRIC

PROJECT 1670846

G.W.P. 5307-14-01

LOCATION N 5178634.4; E 298984.7 MTM NAD 83 ZONE 13 (LAT. 46.747261; LONG. -84.076115)

ORIGINATED BY LJS

DIST ALGOMA HWY 556

BOREHOLE TYPE 210 mm O.D. Continuous Flight Hollow Stem Augers

COMPILED BY AK

DATUM Geodetic

DATE August 15, 2018

CHECKED BY TZ

SOIL PROFILE			SAMPLES			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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
179.7			11	SS	1		180				
15.8	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						179 178 177 176 175 174 173 172 171 170 169				
168.7											
26.8	END OF DCPT NOTES: 1. Borehole SCC-02 advanced on the eastbound lane of Highway 556, east of the existing culvert. 2. Water level measured at a depth of about 3.5 m below ground surface (Elev. 192.0 m) upon completion of drilling. 3. Consisting of varved clay estimated based on comparison of index testing and field vane testing in adjacent boreholes SCC-01 and SCC-03.										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No SCC-03

SHEET 1 OF 2

METRIC

PROJECT 1670846

G.W.P. 5307-14-01

LOCATION N 5178649.4; E 298985.9 MTM NAD 83 ZONE 13 (LAT. 46.747396; LONG. -84.076099)

ORIGINATED BY MB

DIST ALGOMA HWY 556

BOREHOLE TYPE Portable Equipment - Eash Boring; BW Casing

COMPILED BY AK

DATUM Geodetic

DATE August 14 to 16, 2018

CHECKED BY TZ

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
191.8	WATER SURFACE										
0.0	WATER										
189.7											
2.1	Varved SILT to CLAYEY SILT and SILTY CLAY to CLAY, trace to some sand Stiff to very stiff Grey Wet - Organics encountered between depths of about 2.1 m and 2.8 m (between about Elev. 189.7 m and 189.0 m)		1	SS	3		191			OC=1.9%	
			2	SS	4		190				
			3	SS	4		189				
							188				
							187	2.1, 2.2			
			4	SS	5		186				0 5 52 43
							185	4.0			
			5	SS	3		184	1.6			
			6	SS	9		183				
							182	1.0			
			7	SS	2		181				0 7 57 36
			8	SS	12		180				
179.9							179				
11.9	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						178				
							177				

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No SCC-03

SHEET 2 OF 2

METRIC

PROJECT 1670846

G.W.P. 5307-14-01

LOCATION N 5178649.4; E 298985.9 MTM NAD 83 ZONE 13 (LAT. 46.747396; LONG. -84.076099)

ORIGINATED BY MB

DIST ALGOMA HWY 556

BOREHOLE TYPE Portable Equipment - Eash Boring; BW Casing

COMPILED BY AK

DATUM Geodetic

DATE August 14 to 16, 2018

CHECKED BY TZ

SOIL PROFILE			SAMPLES			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
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
175.0	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						176 175				
16.8	END OF DCPT NOTE: 1. Borehole SCC-03 advanced in Silver Creek near the outlet (north side of Highway 556) of the existing culvert.										

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

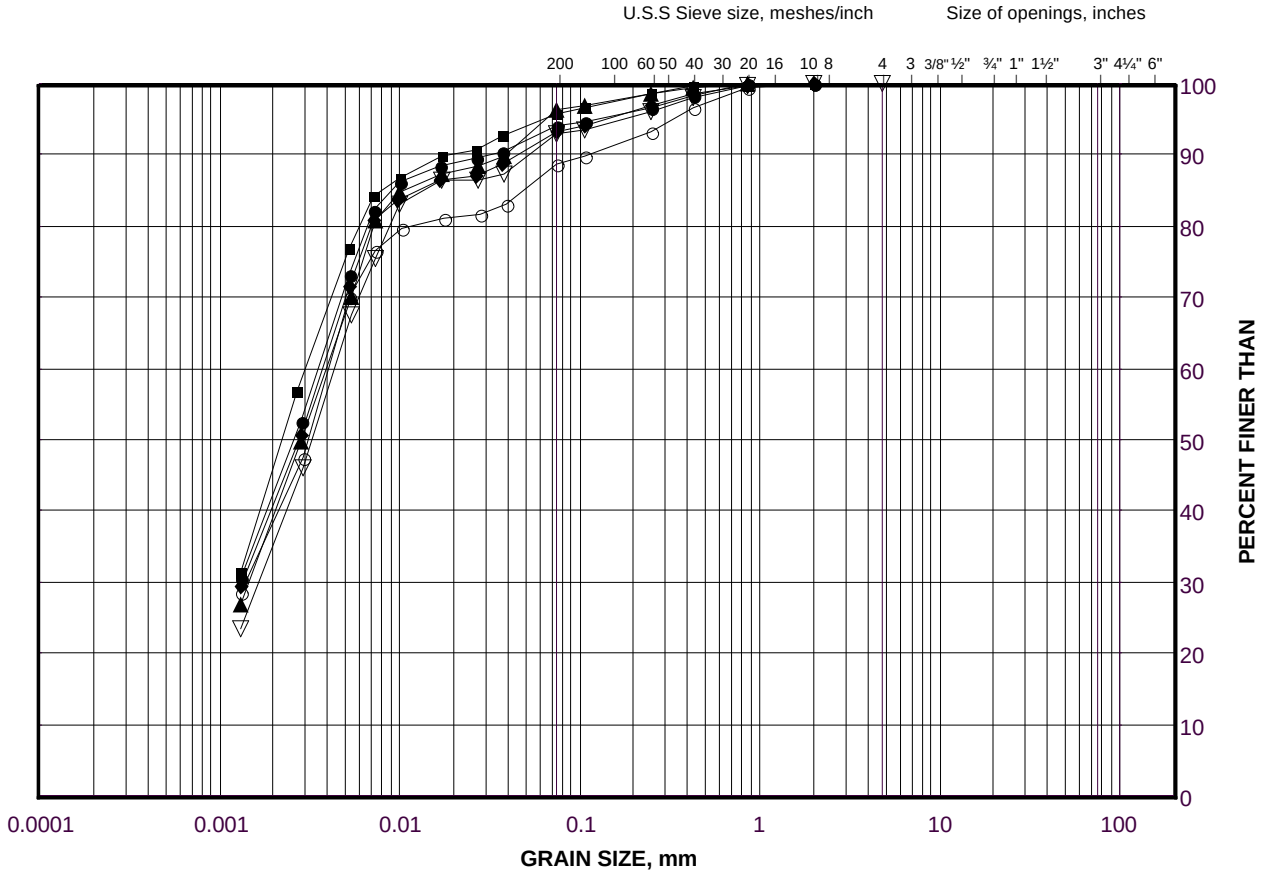
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Varved Silt to Clayey Silt and Silty Clay to Clay

FIGURE B1



LEGEND

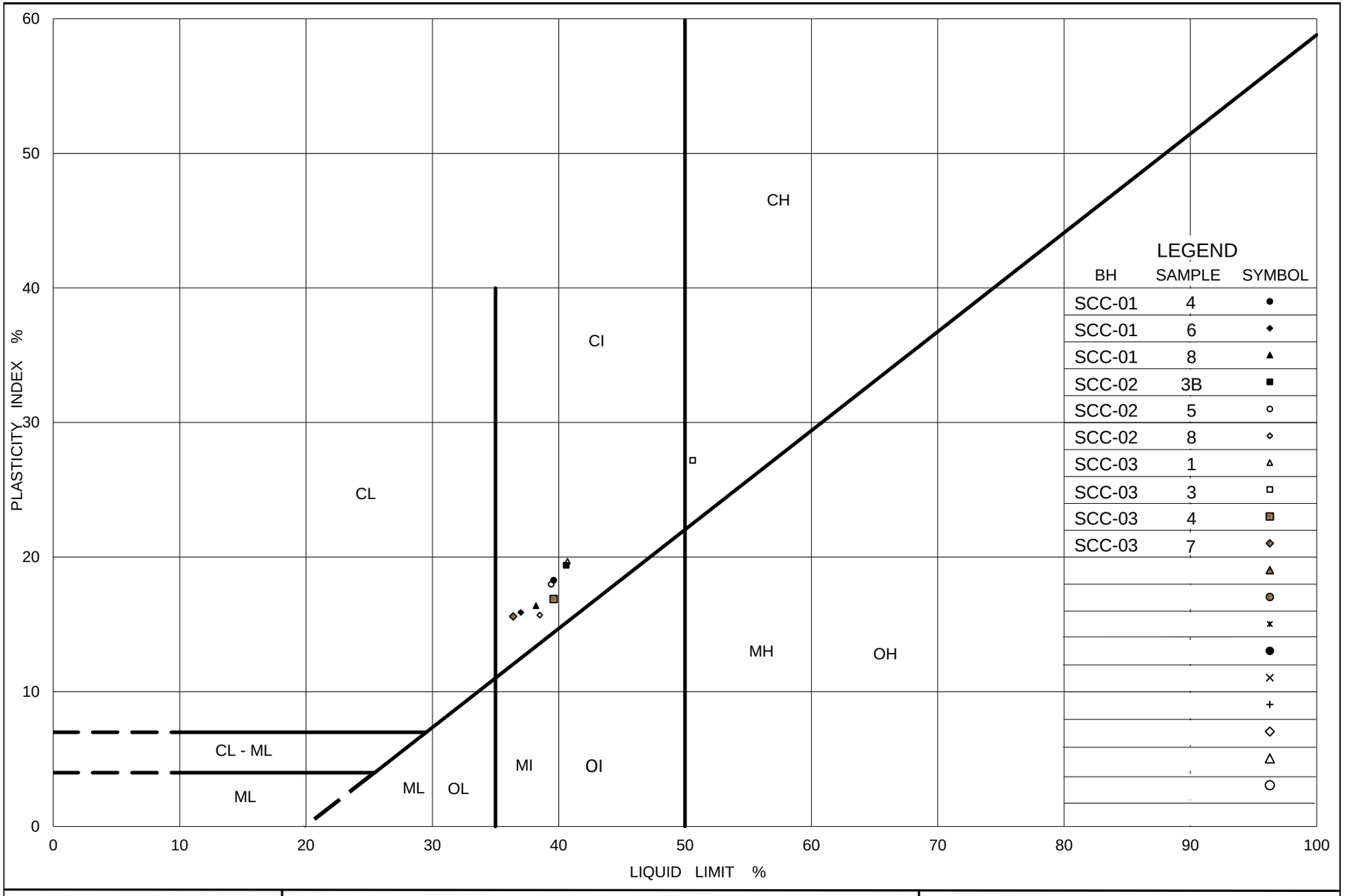
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	SCC-03	4	186.3
■	SCC-01	4	189.6
◆	SCC-02	5	189.1
▲	SCC-01	6	188.1
▽	SCC-03	7	181.8
❍	SCC-02	8	184.5

Project Number:1670846

Checked By: TZ

Golder Associates

Date: 09-Oct-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Varved Silty Clay to Clay

Figure No. B2

Project No. 1670846

Checked By: TZ

APPENDIX C

Analytical Laboratory Test Results

Maxxam
A Bureau Veritas Group Company

Your Project #: 1670846
Your C.O.C. #: 384711-01-01

Attention: Tom Zalucki

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

Report Date: 2018/09/11
Report #: R5394328
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8M3564
Received: 2018/08/29, 12:17

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	1	N/A	2018/09/04	CAM SOP-00463	EPA 325.2 m
Conductivity	1	N/A	2018/09/04	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2018/09/04	2018/09/04	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2018/08/30	2018/09/04	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	N/A	2018/09/04	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

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

Your Project #: 1670846
Your C.O.C. #: 384711-01-01

Attention: Tom Zalucki

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

Report Date: 2018/09/11
Report #: R5394328
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8M3564
Received: 2018/08/29, 12:17

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 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 #: B8M3564
Report Date: 2018/09/11

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: ML

SOIL CORROSIVITY PACKAGE (SOIL)

Maxxam ID		HPJ678			HPJ678		
Sampling Date		2018/08/15 14:00			2018/08/15 14:00		
COC Number		384711-01-01			384711-01-01		
	UNITS	SCC-02 SA4	RDL	QC Batch	SCC-02 SA4 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	5800		5707341			
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	5712194			
Conductivity	umho/cm	171	2	5712636	174	2	5712636
Available (CaCl2) pH	pH	8.56		5712501			
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	5712195	<20	20	5712195

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

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Maxxam Job #: B8M3564
Report Date: 2018/09/11

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: ML

TEST SUMMARY

Maxxam ID: HPJ678
Sample ID: SCC-02 SA4
Matrix: Soil

Collected: 2018/08/15
Shipped:
Received: 2018/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5712194	N/A	2018/09/04	Deonarine Ramnarine
Conductivity	AT	5712636	N/A	2018/09/04	Tahir Anwar
pH CaCl2 EXTRACT	AT	5712501	2018/09/04	2018/09/04	Gnana Thomas
Resistivity of Soil		5707341	2018/09/04	2018/09/04	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5712195	N/A	2018/09/04	Alina Dobreanu

Maxxam ID: HPJ678 Dup
Sample ID: SCC-02 SA4
Matrix: Soil

Collected: 2018/08/15
Shipped:
Received: 2018/08/29

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	5712636	N/A	2018/09/04	Tahir Anwar
Sulphate (20:1 Extract)	KONE/EC	5712195	N/A	2018/09/04	Alina Dobreanu

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 #: B8M3564
Report Date: 2018/09/11

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: ML

GENERAL COMMENTS

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

Package 1	1.7°C

Results relate only to the items tested.

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 #: B8M3564
Report Date: 2018/09/11

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: ML

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5712194	Soluble (20:1) Chloride (Cl-)	2018/09/04	NC	70 - 130	102	70 - 130	<20	ug/g	0.52	35
5712195	Soluble (20:1) Sulphate (SO4)	2018/09/04	99	70 - 130	96	70 - 130	<20	ug/g	NC	35
5712501	Available (CaCl2) pH	2018/09/04			101	97 - 103			0.13	N/A
5712636	Conductivity	2018/09/04			103	90 - 110	<2	umho/cm	1.9	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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 spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

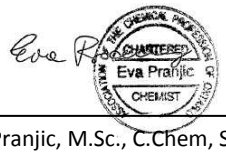
Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B8M3564
Report Date: 2018/09/11

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: ML

VALIDATION SIGNATURE PAGE

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



Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

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29-Aug-18 12:17
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Maxxam

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5779 www.maxxam.ca

CHAIN OF CUS

Page of

Lab Use Only:

BOTTLE ORDER #: 384711

PROJECT MANAGER: Mathura Thirukkumaran

C#384711-01-01

INVOICE INFORMATION:		REPORT INFORMATION (if differs from invoice):		PROJECT INFORMATION:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	~~B70976~~
Contact Name:	Central Accounting: 1111	Contact Name:	Tom Zalucki	P.O. #:	
Address:	6925 Century Avenue Suite # 100	Address:		Project #:	1670846
	Mississauga ON L5N 7K2			Project Name:	
Phone:	(905)567-4444 Fax: (905)567-6561	Phone:	905 567 4444 Fax:	Site #:	
Email:	~~Jennifer_lee@golder.com~~, ~~maxxam@golder.com~~, AP_CustomerService@golder.com	Email:	tzalucki@golder.com	Sampled By:	

Regulation 153 (2011)
- [ ] Table 1 [ ] Res/Park [ ] Medium/Fine
- [ ] Table 2 [ ] Ind/Comm [ ] Coarse
- [ ] Table 3 [ ] Agri/Other
- [ ] Table ___ [ ] For RSC

Other Regulations
- [ ] CCME [ ] Sanitary Sewer Bylaw
- [ ] Reg. 558 [ ] Storm Sewer Bylaw
- [ ] MISA Municipality ___
- [ ] PWQO
- [ ] Other ___

SPECIAL INSTRUCTIONS

Include Criteria on Certificate of Analysis (Y/N)? ___

Note: For MOE regulated drinking water samples - please use the Drinking Water Chain of Custody Form

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (Please be specific):

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	Regulated Drinking Water? (Y/N)	Metals Field Filtered? (Y/N)	Chloride & SO4 (201 extract)	Conductivity/ Resistivity	pH CaCl2 EXTRACT	Sulphide (Maxxam)	# of Bottles	Comments
1		SCC-02 SA 4	Aug 15, 2018	2pm	Soil			X	X	X	X	2	
2													
3													
4													
5													
6													
7													
8													
9													
10													

*RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time:	# Jars Used and Not Submitted
Martin Legroulx	18/08/29	10 am	GURUINDER SINGH	2018/08/29	12:17	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal Present	Yes	No
	2/1/2	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.

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

Your Project #: Campobello job# B8M3564

Attention: EMA GITEJ

MAXXAM ANALYTICS
CAMPOBELLO
6740 CAMPOBELLO ROAD
MISSISSAUGA, ON
CANADA L5N 2L8

Report Date: 2018/09/10
Report #: R2616906
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B874287
Received: 2018/08/31, 12:13

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Sulphide in Soil	1	2018/09/04	2018/09/10	BBY6SOP-00052,	EPA-821-R-91-100 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

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

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: Campobello job# B8M3564

Attention: EMA GITEJ

MAXXAM ANALYTICS
CAMPOBELLO
6740 CAMPOBELLO ROAD
MISSISSAUGA, ON
CANADA L5N 2L8

Report Date: 2018/09/10
Report #: R2616906
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B874287
Received: 2018/08/31, 12:13

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Namita Sahni, Burnaby Project Manager
Email: NSahni@maxxam.ca
Phone# (604)639-2614
==========
This report has been generated and distributed using a secure automated process.
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Maxxam Job #: B874287
Report Date: 2018/09/10

MAXXAM ANALYTICS
Client Project #: Campobello job# B8M3564
Sampler Initials: ML

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		UF1080		UF1080		
Sampling Date		2018/08/15 14:00		2018/08/15 14:00		
	UNITS	**SCC-02 SA4**	**RDL**	**SCC-02 SA4 Lab-Dup**	**RDL**	**QC Batch**
MISCELLANEOUS						
Sulphide	ug/g	<0.70 (1)	0.70	<0.55	0.55	9128307

RDL = Reportable Detection Limit

Lab-Dup = Laboratory Initiated Duplicate

(1) Matrix spike exceeds acceptance limits due to matrix interference. Re-analysis yields similar results.

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Maxxam Job #: B874287
Report Date: 2018/09/10

MAXXAM ANALYTICS
Client Project #: Campobello job# B8M3564
Sampler Initials: ML

TEST SUMMARY

Maxxam ID: UF1080
Sample ID: SCC-02 SA4
Matrix: Soil

Collected: 2018/08/15
Shipped:
Received: 2018/08/31

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphide in Soil	SPEC	9128307	2018/09/04	2018/09/10	Faisal Khater

Maxxam ID: UF1080 Dup
Sample ID: SCC-02 SA4
Matrix: Soil

Collected: 2018/08/15
Shipped:
Received: 2018/08/31

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphide in Soil	SPEC	9128307	2018/09/04	2018/09/10	Faisal Khater

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Maxxam Job #: B874287
Report Date: 2018/09/10

MAXXAM ANALYTICS
Client Project #: Campobello job# B8M3564
Sampler Initials: ML

GENERAL COMMENTS

Sample UF1080 [SCC-02 SA4] : Sample analyzed past method specified hold time for Moisture. Sample received past method specified hold time for Moisture. Sample analyzed past method specified hold time for Sulphide in Soil. Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised. Sample received past method specified hold time for Sulphide in Soil. Sample received past method specified hold time for Sulphide in Soil.

Results relate only to the items tested.

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Maxxam Job #: B874287
Report Date: 2018/09/10

QUALITY ASSURANCE REPORT

MAXXAM ANALYTICS
Client Project #: Campobello job# B8M3564
Sampler Initials: ML

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9128307	Sulphide	2018/09/10	56 (1,2)	75 - 125	96	75 - 125	<0.50	ug/g	NC (3)	30

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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 (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(2) Matrix Spike Parent ID [UF1080-01]

(3) Duplicate Parent ID [UF1080-01]

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Maxxam Job #: B874287
Report Date: 2018/09/10

MAXXAM ANALYTICS
Client Project #: Campobello job# B8M3564
Sampler Initials: ML

VALIDATION SIGNATURE PAGE

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

Andy Lu, Ph.D., P.Chem., Scientific Specialist

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