



April 19, 2017

FOUNDATION INVESTIGATION REPORT

Blake Creek Culvert Replacement - Site No. 46-490

Highway 17, STA 11+970, Lorne Township,
Sudbury, Ontario GWP 5173-12-00

Submitted to:

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario
L3T 0A1



GEOCREs No.: 411-349

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Distribution:

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REPORT



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FOUNDATION REPORT HIGHWAY 17 BLAKE CREEK CULVERT REPLACEMENT

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 Blake Creek Culvert (Site No. 46-490), located at about STA 11+970 on Highway 17 in Lorne Township, District Sudbury, approximately 19 km east of Espanola, Ontario.

The purpose of this investigation is to establish the subsurface conditions at the replacement culvert location, by borehole drilling and in situ and laboratory testing on selected soil samples. The investigation area is shown on the Key Plan on Drawing 1.

2.0 SITE DESCRIPTION

The existing culvert is a 6.1 m wide by 1.8 m high open footing rigid frame structure under approximately 2 m of embankment fill cover. The embankment fill is about 5 m high above the surrounding topography, which is primarily low-lying. Visual inspection of the culvert, by others, suggests that the culvert has experienced settlement of about 0.8 m at the midspan which is consistent with consolidation settlement over time. However, there are no reported culvert settlement problems or recent pavement re-grading works. The highway in this area exhibits a sag in the vertical profile that is understood to be approximately equal to the amount of settlement observed within the culvert, which has not been corrected in past pavement rehabilitation events.

In general, the topography in the area of the culvert consists of rolling terrain with sparsely populated treed areas, lakes, and areas of standing water/swamps. Blake Creek flows in a south-north direction at the location of the culvert, traversing under the highway. The ground surface varies between Elevation 212 m at the highway road grade to about Elevations 209 m to 208 m at the north and south toe of the embankment at the borehole locations, respectively.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation at Blake Creek culvert was carried out between August 18 and 24, 2016, during which time a total of 3 boreholes (designated as BH16-1 to BH16-3) were advanced in proximity to the culvert alignment. In addition, Dynamic Cone Penetration Tests (DCPTs) were advanced from the bottom of Boreholes 16-2 and 16-3.

The boreholes were advanced using a CME 75 truck-mounted drill rig, supplied and operated by Landcore Drilling of Sudbury, Ontario. The boreholes were advanced through the overburden using either nominal 152 mm diameter solid stem augers, 165 mm outside diameter hollow stem augers or NW casing with wash boring in the case of Borehole 16-1. In general, soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Samples of the cohesive soils were obtained using 76 mm O.D. thin walled Shelby Tubes (ASTM D1587) for relatively undisturbed samples. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573) using MTO Standard 'N' size vanes.

The groundwater level in the open boreholes was observed during the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled with cementitious bentonite grout upon completion in accordance with Ontario Regulation 903 Wells (as amended).



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The fieldwork for this foundation investigation was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground utilities present in the area, observed 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 with care to Golder's Sudbury geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Classification testing (water content, Atterberg limits and grain size distribution) and consolidation testing was carried out on selected soil samples. All of the laboratory tests were carried out to MTO Laboratory Standards and/or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and presented in the laboratory test figures provided in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed in the field by Golder technical staff, referenced to the highway centerline and existing culvert and were subsequently converted into MTM NAD 83 (Zone 12) coordinates for the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MMM. The borehole locations in the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole	Location (m)		Ground Surface Elevation (m)	Depth of Borehole / DCPT (m)
	Northing	Easting		
16-1	5,131,900.2	263,096.6	209.1	23.0
16-2	5,131,874.8	263,099.1	212.0	13.4 / 22.6
16-3	5,131,861.7	263,077.6	208.4	10.7 / 26.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This area of Highway 17 is located in the Penokean Hills physiographic region, within the Canadian Shield, as described in *The Geomorphic Systems of North America* by Graf (1987)¹. The Penokean Hills are typically characterized by low-grade metamorphic rocks, with the ranges of hills resulting from differential erosion of faulted or gently folded strata. This region is underlain by bedrock comprised of mainly undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift (MNDM, 2016)². Based on geological mapping by the Ministry of Natural Resources (Map 2542)³, the site is underlain by rocks of the Paleoproterozoic Era belonging to the Huronian Supergroup and Elliot Lake Group consisting of conglomerate, wacke, arkose, quartz arenite, argillite, limestone and dolostone. Areas of mafic and related intrusive rocks comprised of diabase sills, dykes and related granophyre are also present in the vicinity of the site. There are localized areas of glaciolacustrine deposits of silt and clay, with minor sand layers.

¹ Graf, W. L. 1987. *Geomorphic systems of North America*. Geological Society of America, Inc.: Boulder, Colorado.

² The Ministry of Natural Development and Mines, Ontario, 2016. OGSEarth: Quaternary Geology [Electronic Map] 1:1,000,000.

³ Ministry of Natural Resources. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey - Map 2542



4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of the in situ field tests (i.e., SPT 'N' values and undrained shear strengths from field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The detailed results of geotechnical laboratory testing are contained in Appendix B. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt and sand and gravel embankment fill or surficial sandy silt to silt and sand deposits at the embankment toes underlain by an extensive deposit of soft to stiff silty clay to clay. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

4.2.1 Topsoil/Asphalt

A 0.1 m and 0.4 m thick layer of topsoil was encountered in Boreholes 16-1 and 16-3, respectively. A 0.1 m thick layer of asphalt was encountered in Borehole 16-2 constituting the roadway pavement.

4.2.2 Fill

A deposit of non-cohesive fill comprised of sand, trace silt to gravelly sand to sand and gravel, trace to some silt was encountered below the topsoil or asphalt layers in all boreholes. The fill in Borehole 16-1 contains trace organics. The top of this fill layer varied between Elevation 211.9 m and 208 m, and the thickness of the deposit ranges from 0.5 m to 3.9 m being thickest beneath the road surface.

The SPT 'N'-values measured with the fill deposit range from 5 to 42 blows per 0.3 m of penetration, indicating a very loose to dense relative density.

The natural water content measured on three samples of the fill deposit ranges from about 2 per cent to 6 per cent with one value of 27 percent, likely associated with the organics within the overlying topsoil in Borehole 16-3. The result of a grain size distribution test completed on one sample of the sand and gravel fill is shown on Figure B1 in Appendix B.

4.2.3 Sandy Silt to Silt and Sand

A deposit of sandy silt to silt and sand, trace organics, was encountered below the fill in Boreholes 16-1 and 16-3, located at the toes of the embankment. The surface of the deposit is at Elevations 208.2 m to 207.5 m and the thickness of the deposit is 1.1 m to 0.6 m, in the respective boreholes.

The SPT 'N'-values measured within the silty sand to silt and sand deposit range from 3 to 4 blows per 0.3 m of penetration, indicating a very loose relative density.

The natural water content measured on one sample of the sandy silt to silt and sand deposit was 32 per cent. One sample yielded a non-plastic Atterberg limit test result.



4.2.4 Clayey Silt to Clay

A cohesive deposit was encountered in all boreholes below the fill or silty sand to silt and sand deposit. The deposit is comprised of a 1.5 m to 1.1 m thick upper stratum of clayey silt, trace to with sand in Boreholes 16-2 and 16-3, respectively, and of silty clay to clay below the clayey silt and below the sandy silt in Borehole 16-1. Trace organics was encountered in the clayey silt portion of the deposit in Borehole 16-2 below the embankment fill. The lower 0.6 m of the deposit in Borehole 16-1 is also comprised of clayey silt. The surface of the cohesive deposit ranges from Elevation 208.0 m to 206.9 m, and the thickness of the deposit is 20.4 m in Borehole 16-1 where it was fully penetrated, and may be about 18.6 m as inferred from the DCPT in Borehole 16-2 and 25.3 m as inferred from the DCPT in Borehole 16-3.

The SPT 'N'-values measured within the clayey silt portion of the cohesive deposit are 2 blows and 6 blows per 0.3 m of penetration; one in situ field vane test in the clayey silt stratum measured and undrained shear strength greater than 96 kPa. The results of the SPT and field vane test suggest that the clayey silt stratum is soft to stiff in consistency. The SPT 'N'-values measured within the silty clay to clay deposit are 0 blows (weight of hammer) per 0.3 m of penetration. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 20 kPa to 58 kPa, and the sensitivity is calculated to range from about 2 to 7. The field vane tests results indicate that the silty clay to clay has a soft to stiff consistency.

The natural water content measured on seventeen samples of the cohesive deposit ranges from about 17 per cent to about 67 per cent, with the average natural water content being approximately 53 percent. The grain size distributions of six samples of this cohesive deposit are shown on Figures B2A and B2B in Appendix B.

Atterberg limits tests were completed on nine samples of the cohesive deposit. The results of two Atterberg limits tests on samples from the upper zone of clayey silt indicate liquid limits of about 23 per cent and 30 per cent, plastic limits of about 16 per cent and 20 per cent, corresponding to plasticity indices of about 7 per cent and 10 per cent. The results of these Atterberg limits tests are shown on the plasticity chart on Figures B3A and B3B in Appendix B, and indicates that material/zone is classified as clayey silt of low plasticity. The remaining seven Atterberg limits tests were performed on the silty clay to clay portion of the cohesive deposit and indicate liquid limits ranging from about 43 per cent to 57 per cent, plastic limits ranging from about 20 per cent to 24 per cent and plasticity indices ranging from about 19 per cent to 34 per cent. The results of these Atterberg limits tests are shown on the plasticity chart on Figure B3B in Appendix B, and indicate that the material is classified as silty clay of intermediate plasticity to clay of high plasticity.

Laboratory consolidation tests were carried out on four specimens of the silty clay to clay portion of the cohesive deposit obtained from Shelby tube samples in all three boreholes. Preconsolidation pressures ranging between 100 kPa and 145 kPa were estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. Bulk unit weights ranging of about 15.9 kN/m³ to 17.3 kN/m³ and a specific gravity between 2.75 and 2.77 were measured on the consolidation test specimens. Details of the test results are shown on Figure B6 to B7 in Appendix B and the test results are summarized below.



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Borehole Sample No.	Sample Depth/ Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	c_v (cm ² /s)	e_o
16-1 SA 8	9.2 m / 199.9 m	60	135	75	2.2	0.65	0.05	3.1×10^{-3}	1.77
16-2 SA 8	8.0 m / 204.0 m	100	100	0	1	0.26	0.04	7.0×10^{-4}	1.41
16-2 SA 11	12.4 m / 199.6 m	140	145	5	1	0.34	0.04	2.2×10^{-3}	1.32
16-3 SA 5	4.8 m / 203.6 m	75	140	65	1.9	0.64	0.06	3.5×10^{-3}	1.79

Note: For the stress range between effective overburden stress and the embankment stress (due to a 4 m high embankment) that is $30 \text{ kPa} \leq \sigma_v' \leq 285 \text{ kPa}$

where: σ_{vo}' is the effective overburden stress in kPa

σ_p' is the preconsolidation stress in kPa

OCR is overconsolidation ratio

C_c is the compression index

C_r is the recompression index

e_o is initial void ratio

c_v is the coefficient of consolidation in cm²/s

4.2.5 Silt and Sand

A 0.6 m thick deposit of silt and sand, some gravel, trace clay was encountered below the clayey silt stratum in Borehole 16-1 at Elevation 186.7 m. One SPT test attempted within this deposit resulted in the split spoon bouncing after 15 blows and no penetration.

4.2.6 Groundwater Conditions

In general, the recovered soil samples were described as wet. Borehole 16-1 was drilled on the north side of the embankment and encountered a water level at ground surface (Elevation 209.1 m) upon completion of drilling. Boreholes 16-2 and 16-3 encountered a water level at depths of 11.9 m and 7.6 m below ground surface, respectively, corresponding to Elevations 200.1 m and 200.8 m, upon completion of drilling. The groundwater levels are not stabilized and should be expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is higher during the wet seasons and thereafter periods of heavy precipitation.

4.2.7 Analytical Testing

The results of an analytical test on a sample of the silty sand taken from Borehole 16-1 and a sample of the upper portion of the cohesive deposit was taken from Borehole 16-3 are provided in Appendix C. The suite of parameters tested include pH, sulphate, sulphide, chloride, resistivity, and conductivity.



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5.0 CLOSURE

The foundation investigation program was supervised by Mr. Adam Core, P.Eng., and Mr. Imran Khalid, B.A.Sc. This report was prepared by Ms. Alysha Kobylinski, B.A.Sc., and the technical aspects were reviewed by Sarah E. M. Poot, P.Eng., a senior geotechnical engineer and an Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant of Golder and Designated MTO Foundations Contact conducted an independent quality control review of this report.

GOLDER ASSOCIATES LTD.

Alysha Kobylinski

Alysha Kobylinski, B.A.Sc.
Geotechnical Engineering Analyst



Sarah E. M. Poot, P. Eng.
Associate, Geotechnical Engineer

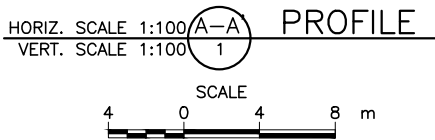
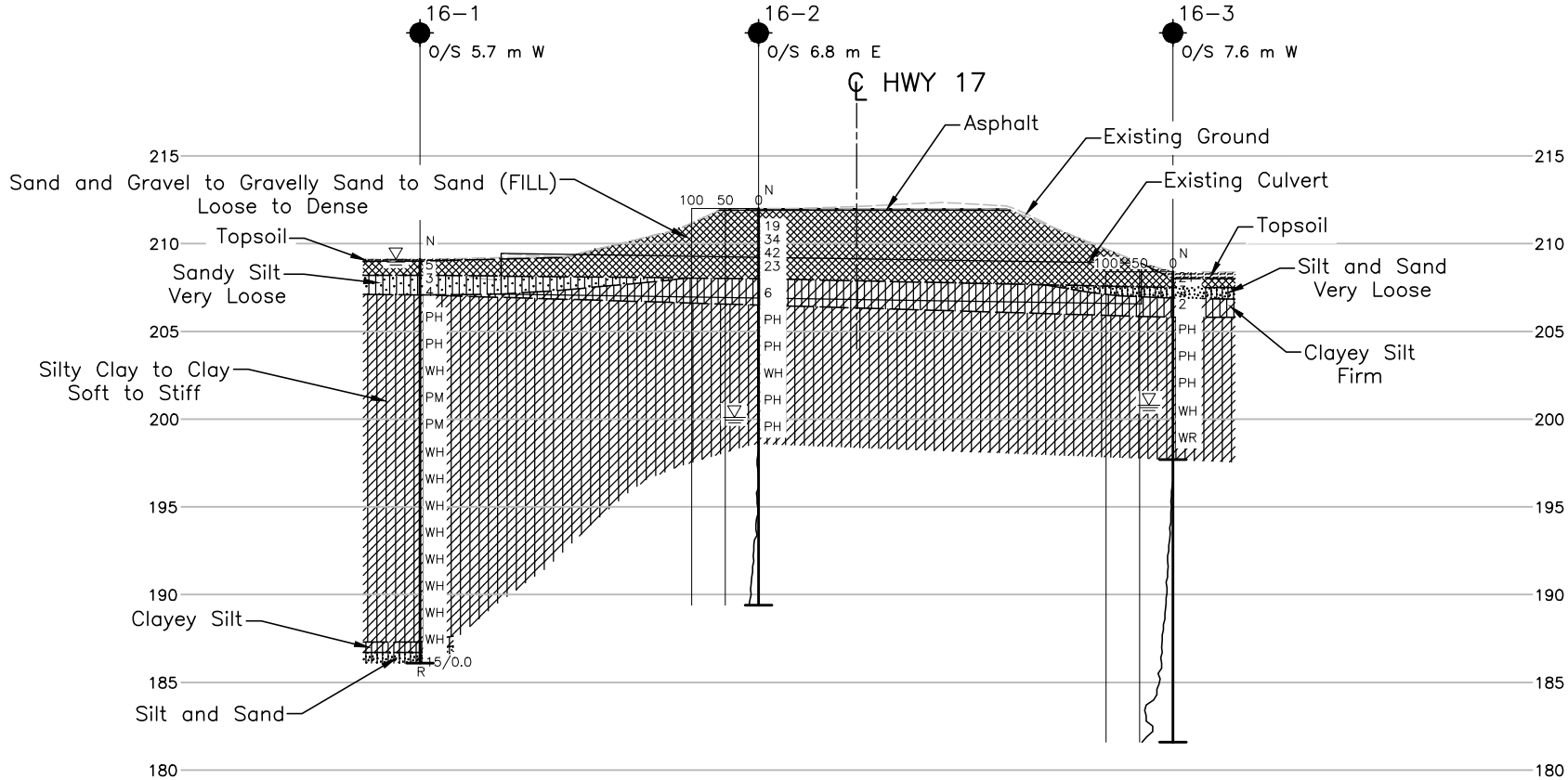
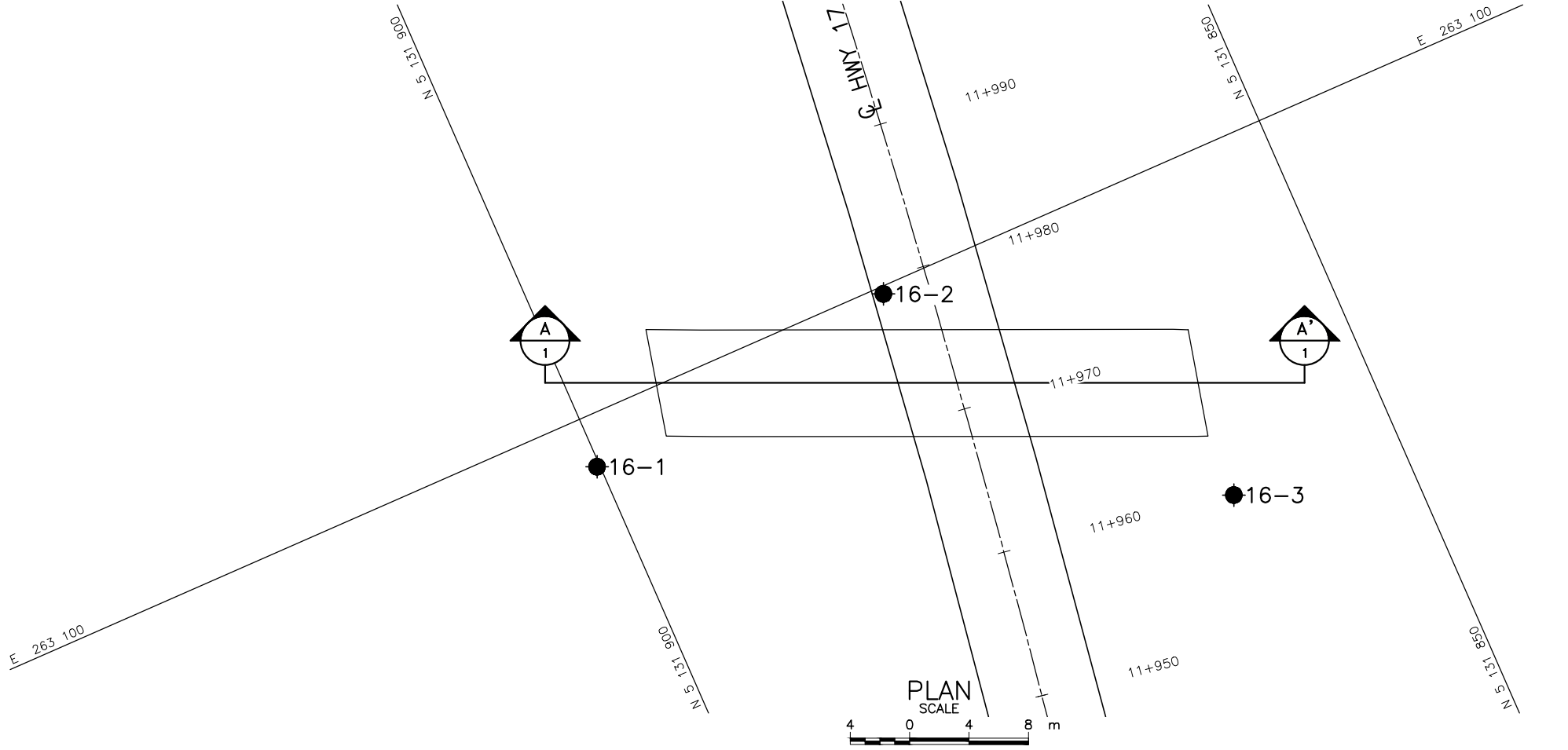


Jorge M. A. Costa, P. Eng.
Designated MTO Foundations Contact, Senior Consultant

ACK/SEMP/JMAC/nh

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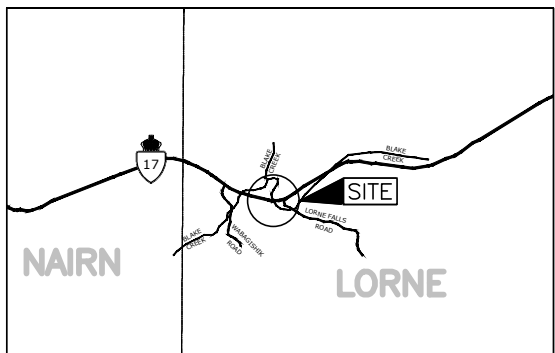
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. 1
GWP No. 5173-12-00



BLAKE CREEK CULVERT
HIGHWAY 17
BOREHOLE LOCATIONS AND SOIL
STRATA

SHEET



KEY PLAN
N.T.S.

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
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
16-1	209.1	5131900.2	263096.6
16-2	212.0	5131877.9	263099.5
16-3	208.4	5131861.7	263077.6

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by MMM, drawing file nos. Hwy 17 Existing Topo Blake Creek, received JULY 05, 2016. Key Plan received NOV 04, 2016.



NO.	DATE	BY	REVISION
1	3/22/2017	JJL/TB	1
Geocres No. 411-349			
HWY. 17	PROJECT NO. 1535723	DIST. SUDBURY	
SUBM'D.	CHKD. ARV/ACK	DATE: 3/22/2017	SITE: 46-490
DRAWN: JJL/TB	CHKD. SEMP	APPD. JMAC	DWG. 1



APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

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



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 (DCPT); N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

SUD-MTO 001 MTM ZN INC LAT/LONG 1535723 HWY17.GPJ GAL-MISS.GDT 29/11/16 DATA INPUT:

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

2 OF 3 **METRIC**

CHECKED BY ARV

Continued Next Page

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

PROJECT <u>1535723</u>		RECORD OF BOREHOLE No 16-1		3 OF 3 METRIC	
G.W.P. <u>5173-12-00</u>		LOCATION <u>N 5131900.2; E 263096.6 MTM ZONE 12 (LAT. 46.32554; LONG. -81.5416)</u>		ORIGINATED BY <u>AC</u>	
DIST <u>SUDBURY</u> HWY <u>17</u>		BOREHOLE TYPE <u>Power Auger with Solid Stem Augers to 3.0 m, then NW Casing with Wash Boring</u>		COMPILED BY <u>ACK</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 23 and 24, 2016</u>		CHECKED BY <u>ARV</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		GR	SA	SI	CL	
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE	REMOULDED	WATER CONTENT (%)							
	END OF BOREHOLE SPLIT-SPOON REFUSAL																				
	Notes: 1. Water level at ground surface (Elev. 209.1 m) upon completion of drilling.																				

SUD-MTO 001 MTM ZN INC LAT/LONG 1535723 HWY17.GPJ GAL-MISS.GDT 29/11/16 DATA INPUT:

PROJECT 1535723		RECORD OF BOREHOLE No 16-2		1 OF 2 METRIC	
G.W.P. 5173-12-00		LOCATION N 5131877.9; E 263099.5 MTM ZONE 12 (LAT. 46.32531; LONG. -81.5416)		ORIGINATED BY AC	
DIST SUDBURY HWY 17		BOREHOLE TYPE Power Auger with 165 mm O.D. Continuous Flight Hollow Stem Augers		COMPILED BY ACK	
DATUM GEODETIC		DATE August 18, 2016		CHECKED BY ARV	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)							
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED		w _p	w	w _L					
212.0	GROUND SURFACE																	
0.0	ASPHALT (115 mm)																	
0.1	Sand and gravel, trace to some silt (FILL) Compact to dense Brown Moist		1	CS	-													
			2	SS	19													
			3	SS	34													
			4	SS	42													
			5	SS	23													
208.0																		
4.0	CLAYEY SILT with SAND, trace gravel, trace organics Firm Grey Wet		6	SS	6													
206.5																		
5.5	SILTY CLAY to CLAY Firm to stiff Grey Wet		7	SS	PH													
			8	TO	PH													
			9	SS	WH													
			10	TO	PH													

SUD-MTO 001 MTM ZN INC LAT/LONG 1535723 HWY17.GPJ GAL-MISS.GDT 29/11/16 DATA INPUT:

Continued Next Page

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

PROJECT 1535723		RECORD OF BOREHOLE No 16-2				2 OF 2 METRIC							
G.W.P. 5173-12-00		LOCATION N 5131877.9; E 263099.5 MTM ZONE 12 (LAT. 46.32531; LONG. -81.5416)				ORIGINATED BY AC							
DIST SUDBURY HWY 17		BOREHOLE TYPE Power Auger with 165 mm O.D. Continuous Flight Hollow Stem Augers				COMPILED BY ACK							
DATUM GEODETIC		DATE August 18, 2016				CHECKED BY ARV							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L				
	--- CONTINUED FROM PREVIOUS PAGE ---												
198.6	SILTY CLAY to CLAY Firm to stiff Grey Wet		11	TO	PH			199	2 + 3			17.3	
13.4	END OF BOREHOLE START OF DCPT							198					
								197					
								196					
								195					
								194					
								193					
								192					
								191					
								190					
189.4	END OF DCPT Notes: 1. Water level at a depth of 11.9 m below ground surface (Elev. 200.1 m) upon completion of drilling.												

SUD-MTO 001 MTM ZN INC LAT/LONG 1535723 HWY17.GPJ GAL-MISS.GDT 29/11/16 DATA INPUT:

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

PROJECT <u>1535723</u>		RECORD OF BOREHOLE No 16-3		2 OF 3 METRIC	
G.W.P. <u>5173-12-00</u>		LOCATION <u>N 5131861.7; E 263077.6 MTM ZONE 12 (LAT. 46.32519; LONG. -81.5418)</u>		ORIGINATED BY <u>AC</u>	
DIST <u>SUDBURY</u> HWY <u>17</u>		BOREHOLE TYPE <u>Power Auger with 165 mm O.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>ACK</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 24, 2016</u>		CHECKED BY <u>ARV</u>	


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			W _p	W	W _L		GR	SA	SI	CL	
								○ UNCONFINED	+	FIELD VANE									
	--- CONTINUED FROM PREVIOUS PAGE ---						● QUICK TRIAXIAL	×	REMOULDED	WATER CONTENT (%)									
							20	40	60	80	100	20	40	60					
													</						

SUD-MTO 001 MTM ZN INC LAT/LONG 1535723_HWY17.GPJ GAL-MISS.GDT 29/11/16 DATA INPUT:

Continued Next Page

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

PROJECT <u>1535723</u>		RECORD OF BOREHOLE No 16-3		3 OF 3 METRIC	
G.W.P. <u>5173-12-00</u>		LOCATION <u>N 5131861.7; E 263077.6 MTM ZONE 12 (LAT. 46.32519; LONG. -81.5418)</u>		ORIGINATED BY <u>AC</u>	
DIST <u>SUDBURY</u> HWY <u>17</u>		BOREHOLE TYPE <u>Power Auger with 165 mm O.D. Continuous Flight Hollow Stem Augers</u>		COMPILED BY <u>ACK</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 24, 2016</u>		CHECKED BY <u>ARV</u>	

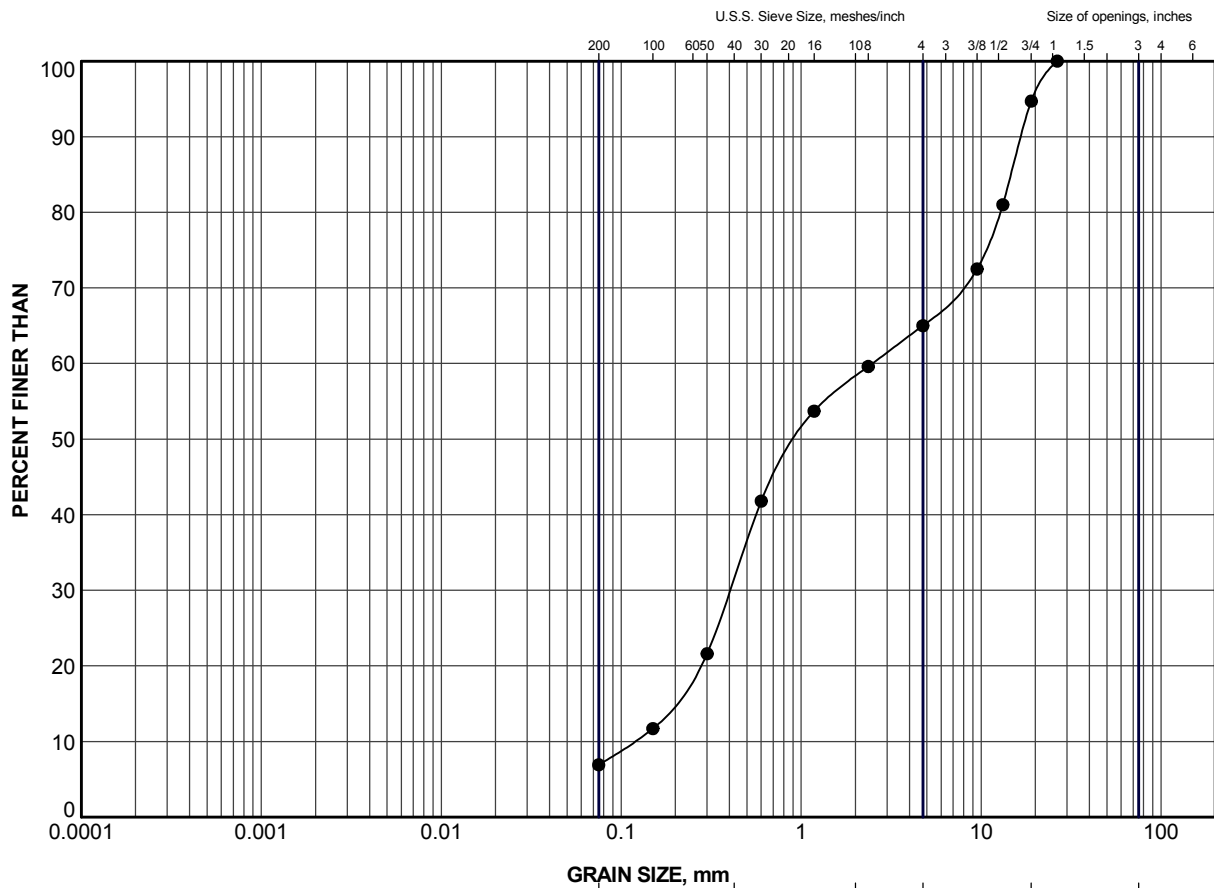
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)								
								20 40 60 80 100			w _p w w _L								
--- CONTINUED FROM PREVIOUS PAGE ---							UNCONFINED + FIELD VANE QUICK TRIAXIAL x REMOULDED												
181.6 26.8	END OF DCPT Notes: 1. Water level at a depth of 7.6 m below ground surface (Elev. 200.8 m) upon completion of drilling.						184 183 182												

SUD-MTO 001 MTM ZN INC LAT/LONG 1535723 HWY17.GPJ GAL-MISS.GDT 29/11/16 DATA INPUT:



APPENDIX B

Laboratory Test Results



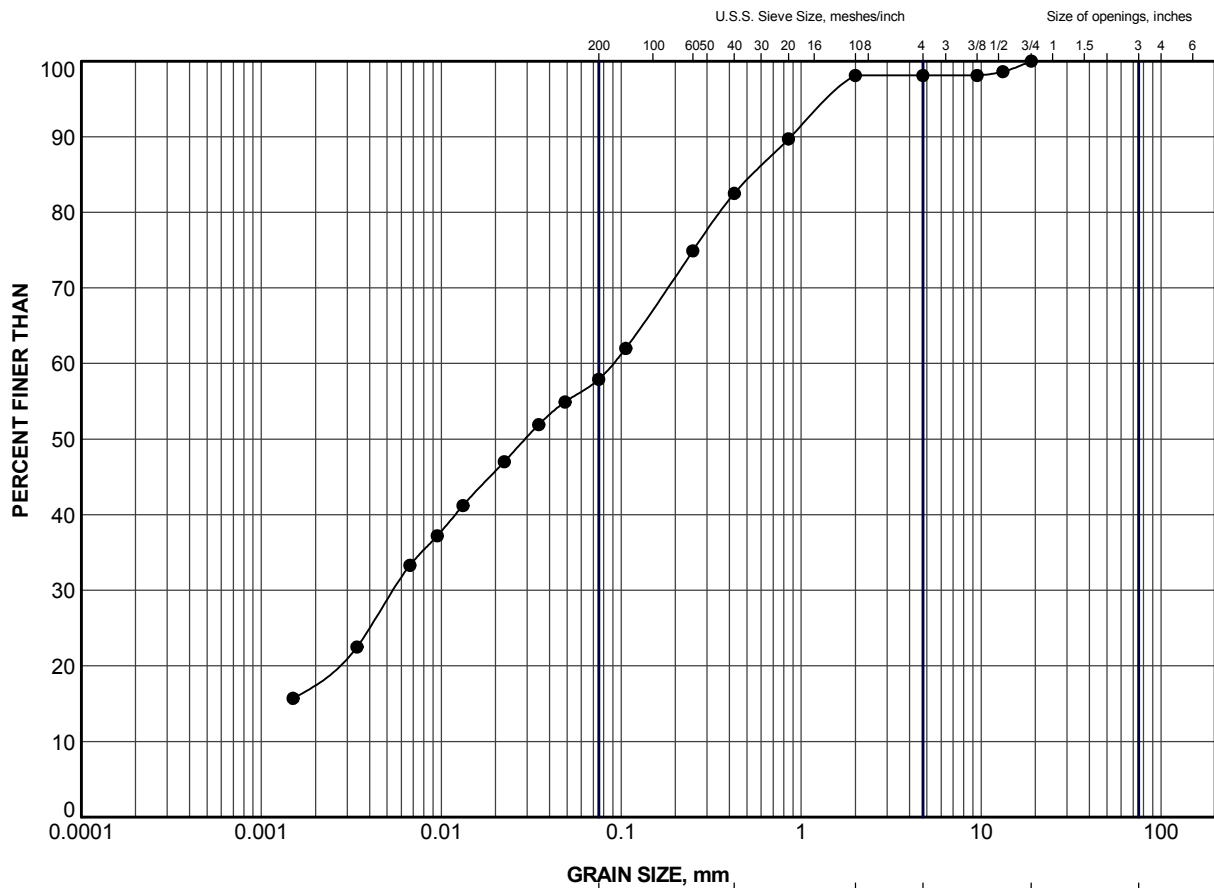
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	16-2	4	209.5

PROJECT					
HIGHWAY 17 Blake Creek Culvert					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and GRAVEL (FILL)					
PROJECT No.		1535723		FILE No. 1535723_HWY17.GPJ	
DRAWN	JJL	Nov 2016	SCALE	N/A	REV.
CHECK	ARV	Nov 2016			
APPR	SEMP	Nov 2016			
			FIGURE B1		




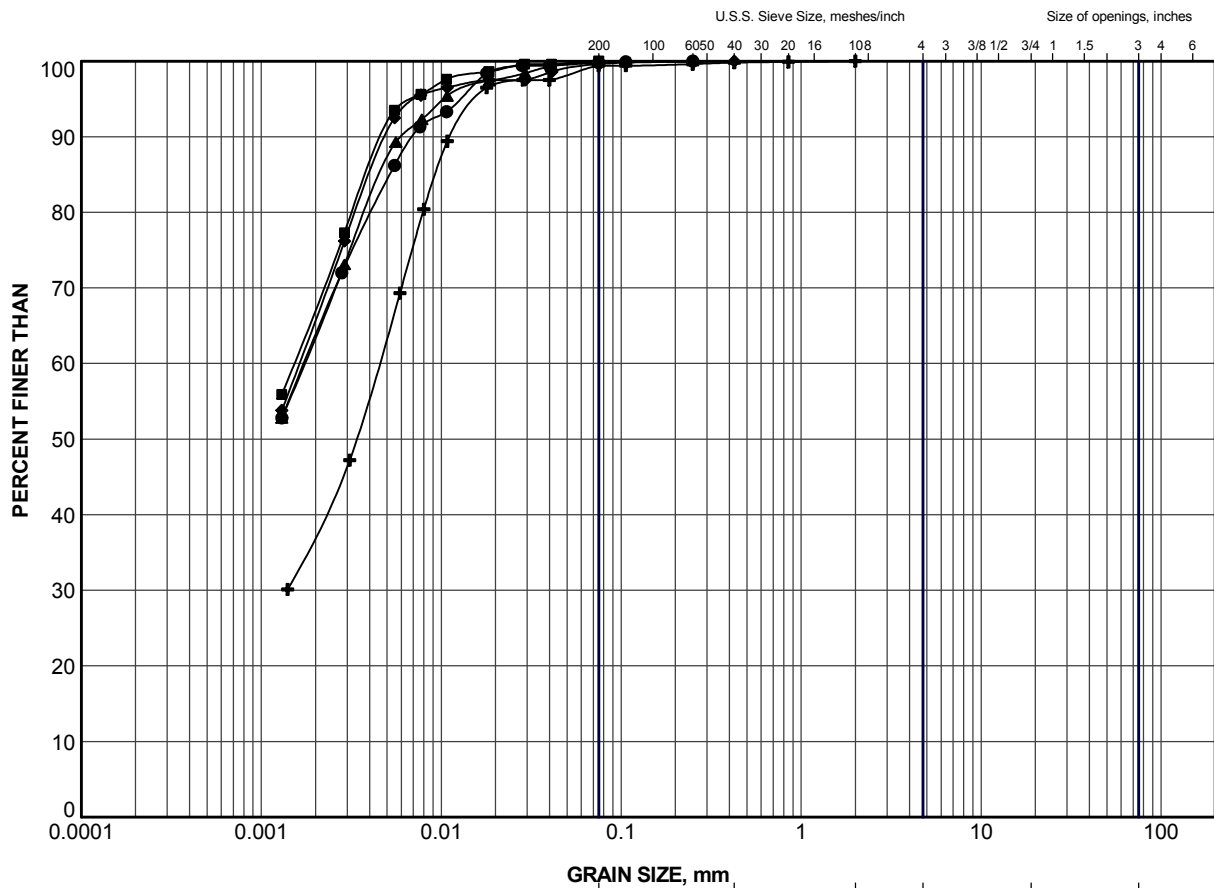


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	16-2	6	207.2

PROJECT						HIGHWAY 17 Blake Creek Culvert					
TITLE						GRAIN SIZE DISTRIBUTION CLAYEY SILT to CLAYEY					
PROJECT No.				1535723		FILE No.				1535723_HWY17.GPJ	
DRAWN		JJL		Nov 2016		SCALE		N/A		REV.	
CHECK		ARV		Nov 2016							
APPR		SEMP		Nov 2016							
 Golder Associates SUDBURY, ONTARIO						FIGURE B2A					



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	16-1	6	202.7
■	16-1	10	196.6
▲	16-2	9	202.6
+	16-3	3	206.6
◆	16-3	8	199.0

PROJECT

HIGHWAY 17
Blake Creek Culvert

TITLE

GRAIN SIZE DISTRIBUTION

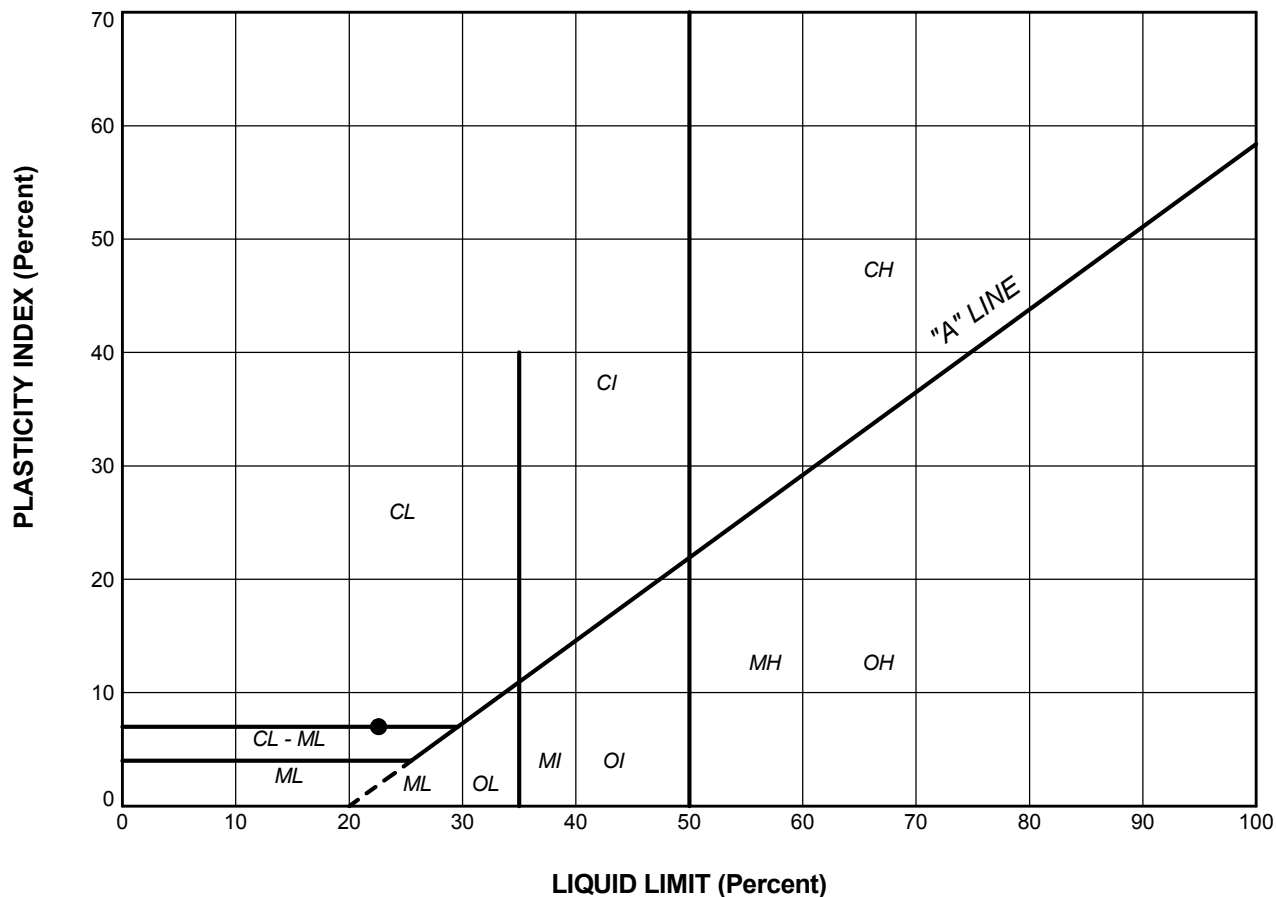
CLAYEY SILT to CLAY



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Associates**
SUDBURY, ONTARIO

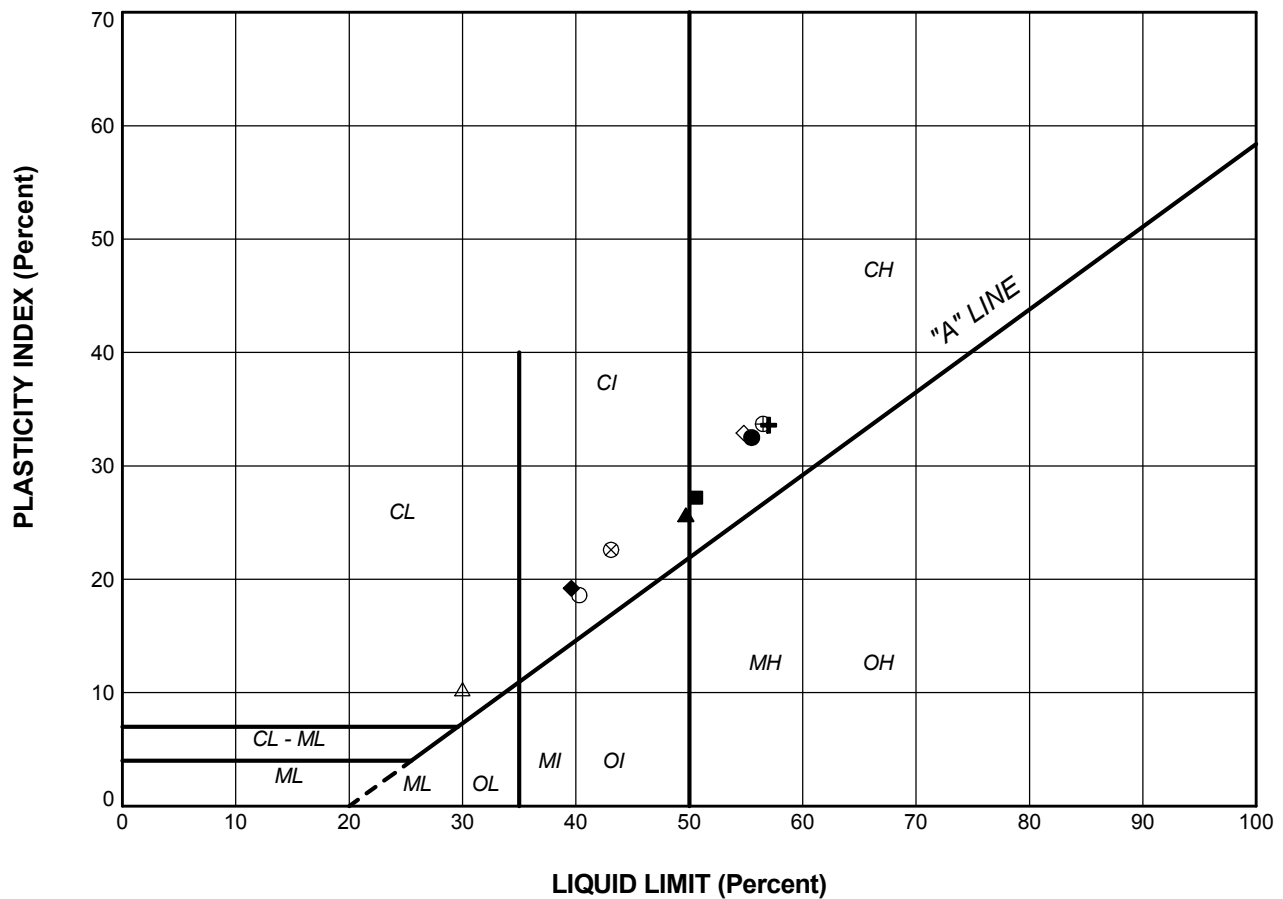
PROJECT No. 1535723		FILE No. 1535723_HWY17.GPJ	
DRAWN	JJL	Nov 2016	SCALE N/A
CHECK	ARV	Nov 2016	REV.
APPR	SEMP	Nov 2016	

FIGURE B2B




PROJECT					
HIGHWAY 17 Blake Creek Culvert					
TITLE					
PLASTICITY CHART CLAYEY SILT with SAND					
PROJECT No. 1535723			FILE No. 1535723_HWY17.GPJ		
DRAWN	JJL	Nov 2016	SCALE	N/A	REV.
CHECK	ARV	Nov 2016	FIGURE B3A		
APPR	SEMP	Nov 2016			





LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	16-1	6	55.5	23.0	32.5
■	16-1	8	50.6	23.4	27.2
▲	16-1	10	49.7	24.0	25.7
⊕	16-1	12	57.0	23.4	33.6
◆	16-2	8	39.6	20.4	19.2
◇	16-2	9	54.8	21.9	32.9
○	16-2	11	40.3	21.7	18.6
△	16-3	3	30.0	19.7	10.3
⊗	16-3	5	43.1	20.5	22.6
⊕	16-3	8	56.5	22.8	33.7

PROJECT					HIGHWAY 17 Blake Creek Culvert				
TITLE					PLASTICITY CHART CLAYEY SILT to CLAY				
PROJECT No.			1535723		FILE No.			1535723_HWY17.GPJ	
DRAWN	JJL	Nov 2016	SCALE	N/A	REV.				
CHECK	ARV	Nov 2016							
APPR	SEMP	Nov 2016							
 Golder Associates SUDBURY, ONTARIO			FIGURE B3B						

CONSOLIDATION TEST SUMMARY
Highway 17 STA 11+970 Blake Creek Culvert

FIGURE B4
Page 1 of 4

SAMPLE IDENTIFICATION

Project Number	1535723	Sample Number	8
Borehole Number	16-1	Sample Depth, m	9.17

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	9/19/16		
Date Completed	10/4/16		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.52	Unit Weight, kN/m3	16.150
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m3	9.790
Area, cm2	31.74	Specific Gravity, measured	2.768
Volume, cm3	80.06	Solids Height, cm	0.910
Water Content, %	64.96	Volume of Solids, cm3	28.873
Wet Mass, g	131.84	Volume of Voids, cm3	51.186
Dry Mass, g	79.92	Degree of Saturation, %	101.435

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0	2.522	1.773	2.522				
4	2.521	1.772	2.521	93	0.0145	1.03E-04	1.46E-07
13	2.520	1.770	2.520	135	0.0100	4.94E-05	4.83E-08
31	2.514	1.764	2.517	470	0.0029	1.22E-04	3.43E-08
66	2.503	1.752	2.509	240	0.0056	1.23E-04	6.72E-08
137	2.452	1.696	2.478	1500	0.0009	2.88E-04	2.45E-08
277	2.180	1.397	2.316	5415	0.0002	7.68E-04	1.58E-08
558	2.037	1.240	2.109	2160	0.0004	2.02E-04	8.64E-09
1118	1.938	1.131	1.988	1058	0.0008	7.01E-05	5.43E-09
558	1.947	1.141	1.943				
137	1.980	1.177	1.964				
31	2.016	1.217	1.998				
4	2.048	1.252	2.032				

Note:
k calculated using cv based on t₉₀ values.

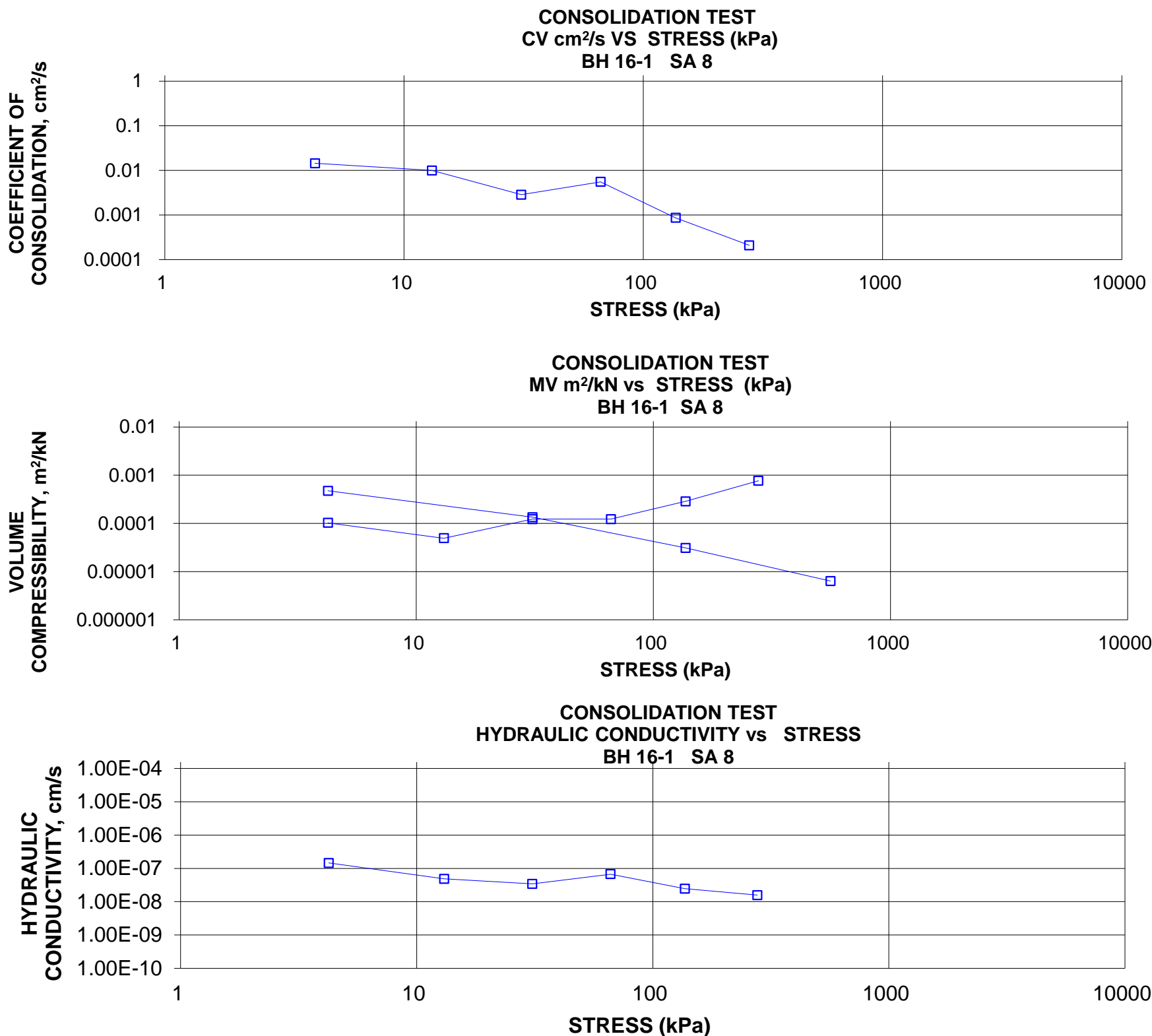
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

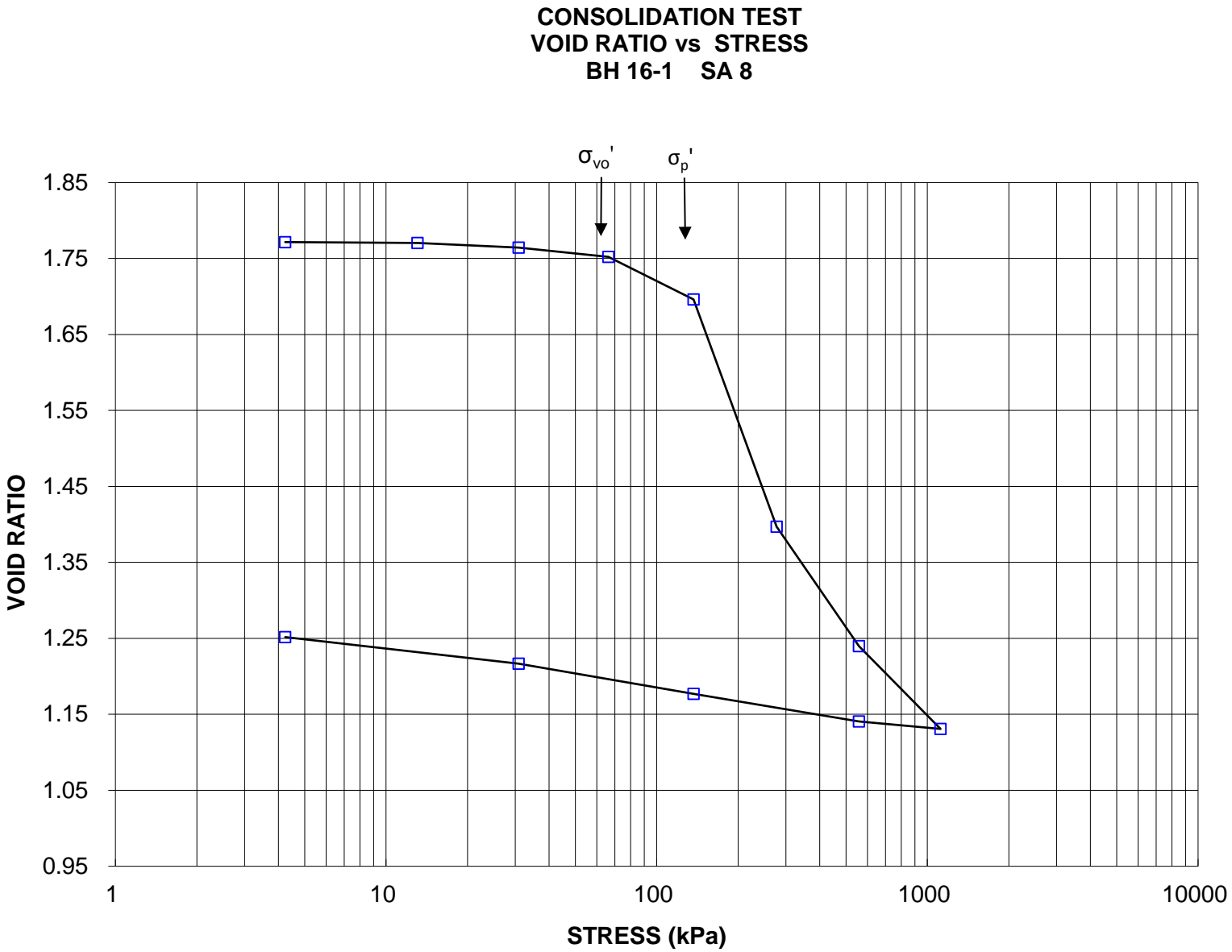
Sample Height, cm	2.05	Unit Weight, kN/m3	16.66
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m3	12.06
Area, cm2	31.74	Specific Gravity, measured	2.77
Volume, cm3	65.01	Solids Height, cm	0.910
Water Content, %	38.18	Volume of Solids, cm 3	28.87
Wet Mass, g	110.43	Volume of Voids, cm 3	36.14
Dry Mass, g	79.92		

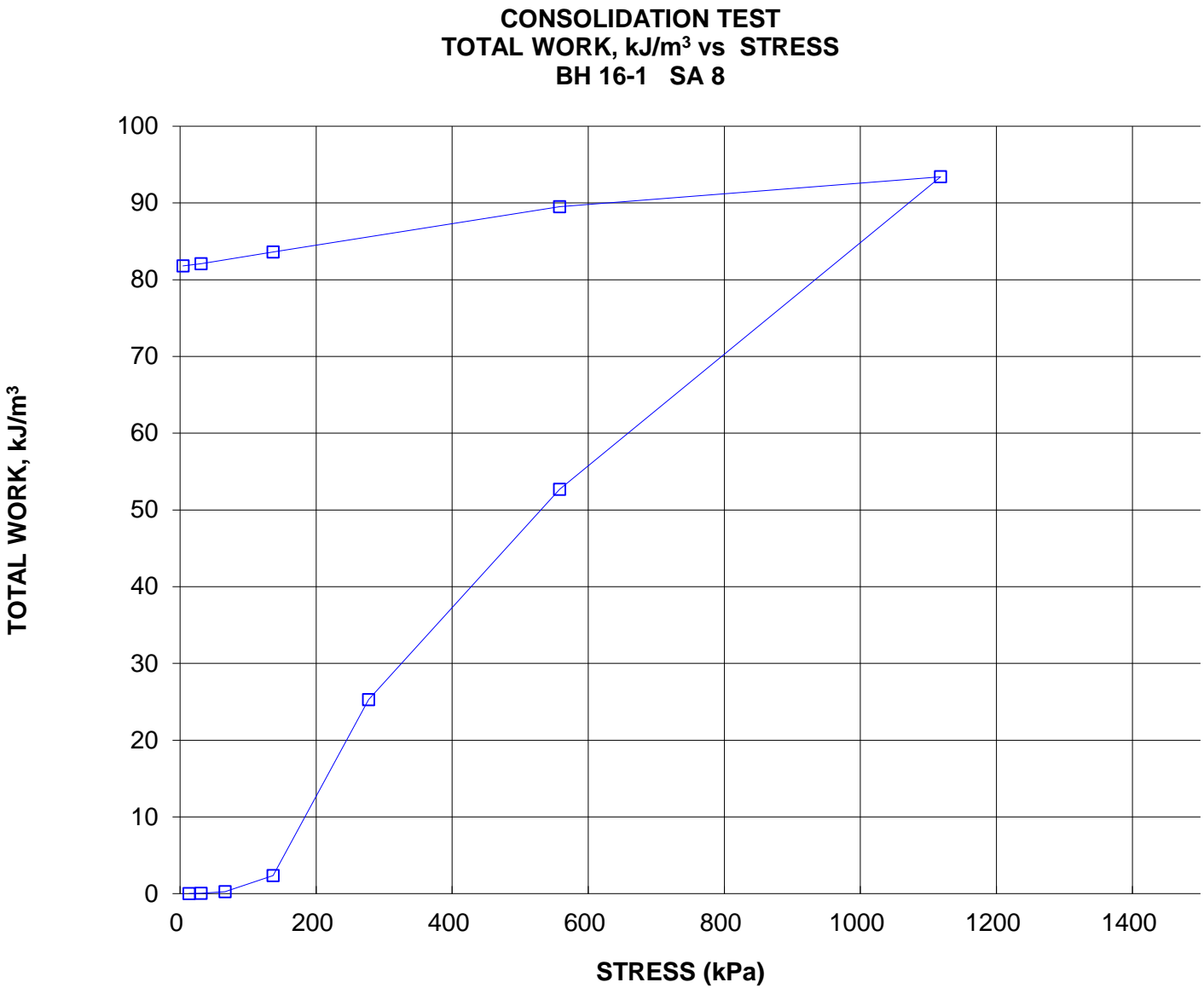
Prepared By: TG

Golder Associates

Checked By: MT







CONSOLIDATION TEST SUMMARY**Highway 17 STA 11+970 BH 16-2 SA 8****FIGURE B5****Page 1 of 4****SAMPLE IDENTIFICATION**

Project Number:	1535723	Sample Number:	8
Borehole Number:	16-2	Sample Depth, m:	8.02

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	9/9/16		
Date Completed	9/19/16		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.522	Unit Weight, kN/m ³	17.05
Sample Diameter, cm	6.358	Drv Unit Weight, kN/m ³	11.22
Area, cm ²	31.74	Specific Gravity, Measured	2.756
Volume, cm ³	80.06	Solids Height, cm	1.047
Water Content, %	51.95	Volume of Solids, cm ³	33.24
Wet Mass, g	139.20	Volume of Voids, cm ³	46.82
Dry Mass, g	91.61		

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0	2.522	1.408	2.522				
4	2.513	1.400	2.518	3840	3.50E-04	8.23E-04	2.82E-08
13	2.504	1.391	2.509	540	2.47E-03	4.20E-04	1.02E-07
31	2.486	1.374	2.495	2018	6.54E-04	4.04E-04	2.59E-08
66	2.455	1.344	2.470	1500	8.62E-04	3.45E-04	2.92E-08
137	2.392	1.285	2.424	2160	5.76E-04	3.53E-04	2.00E-08
277	2.289	1.186	2.341	2381	4.88E-04	2.92E-04	1.39E-08
558	2.217	1.117	2.253	1441			
1117	2.145	1.048	2.181	437			
558	2.154	1.057	2.149				
137	2.188	1.089	2.171				
31	2.225	1.125	2.206				
4	2.250	1.149	2.237				

Note:

k calculated using cv based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	2.25	Unit Weight, kN/m ³	16.96
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m ³	12.58
Area, cm ²	31.74	Specific Gravity, measured	2.76
Volume, cm ³	71.43	Solids Height, cm	1.047
Water Content, %	34.83	Volume of Solids, cm ³	33.24
Wet Mass, g	123.52	Volume of Voids, cm ³	38.19
Dry Mass, g	91.61		

Prepared By: TG

Golder Associates

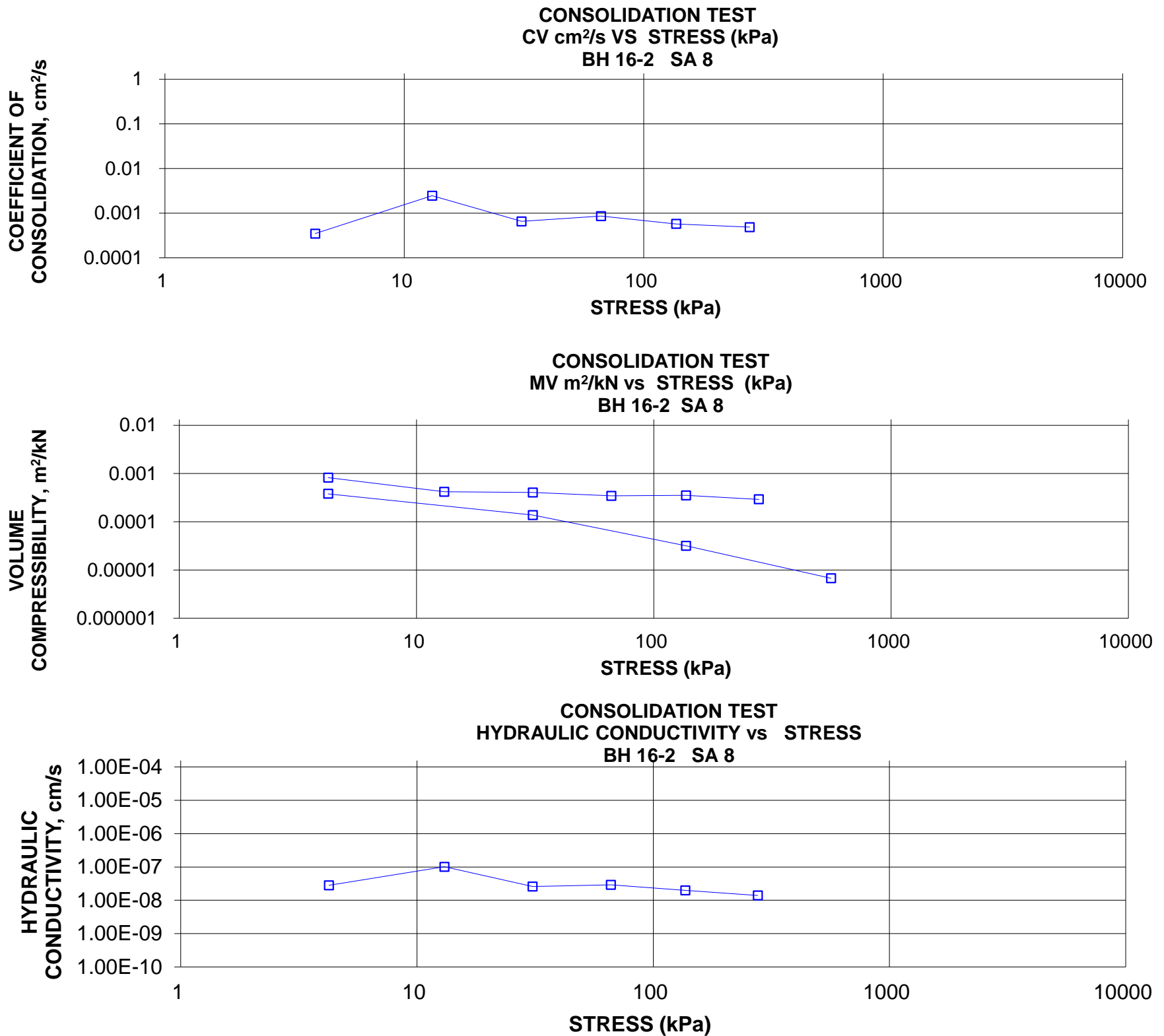
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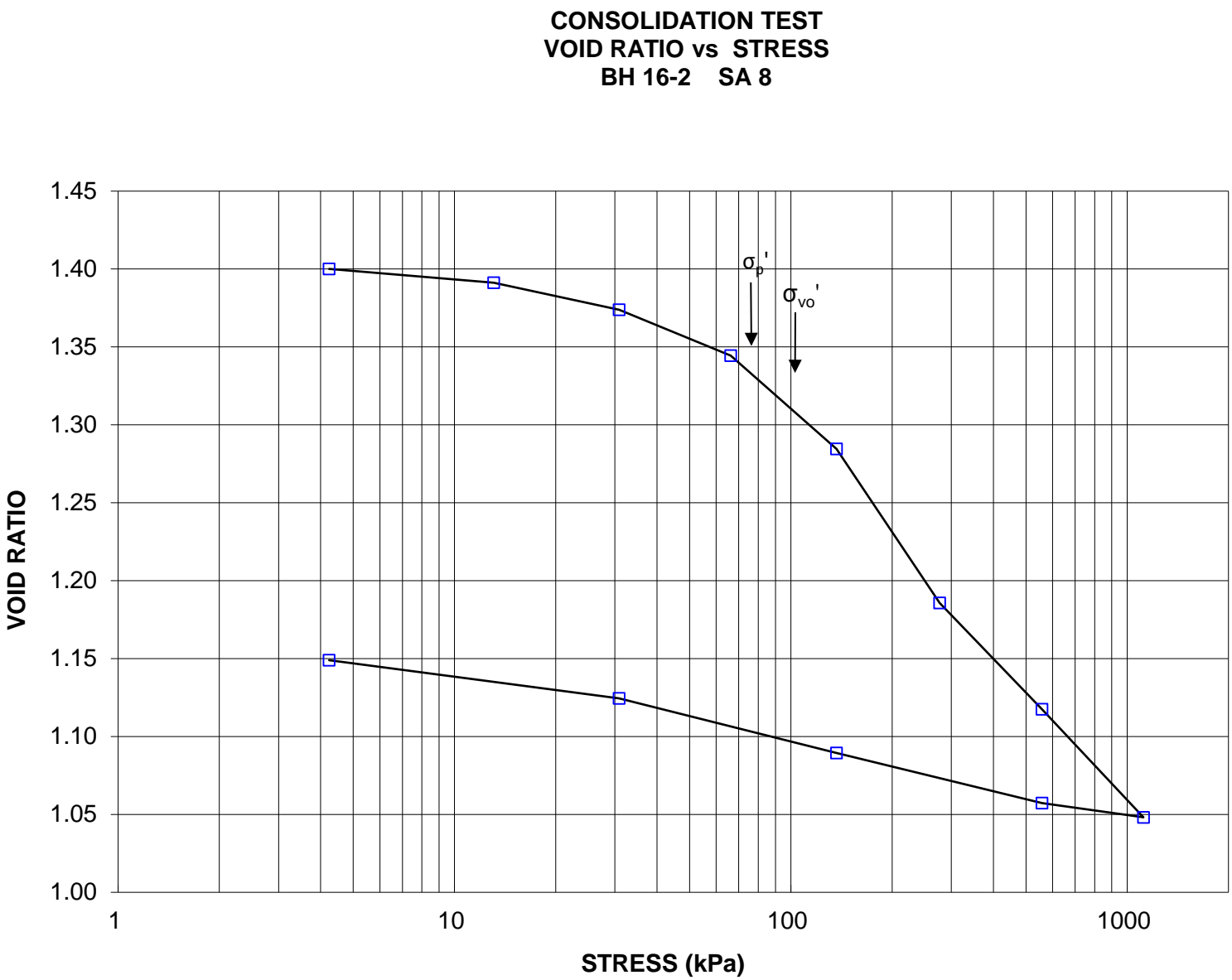
CONSOLIDATION TEST SUMMARY

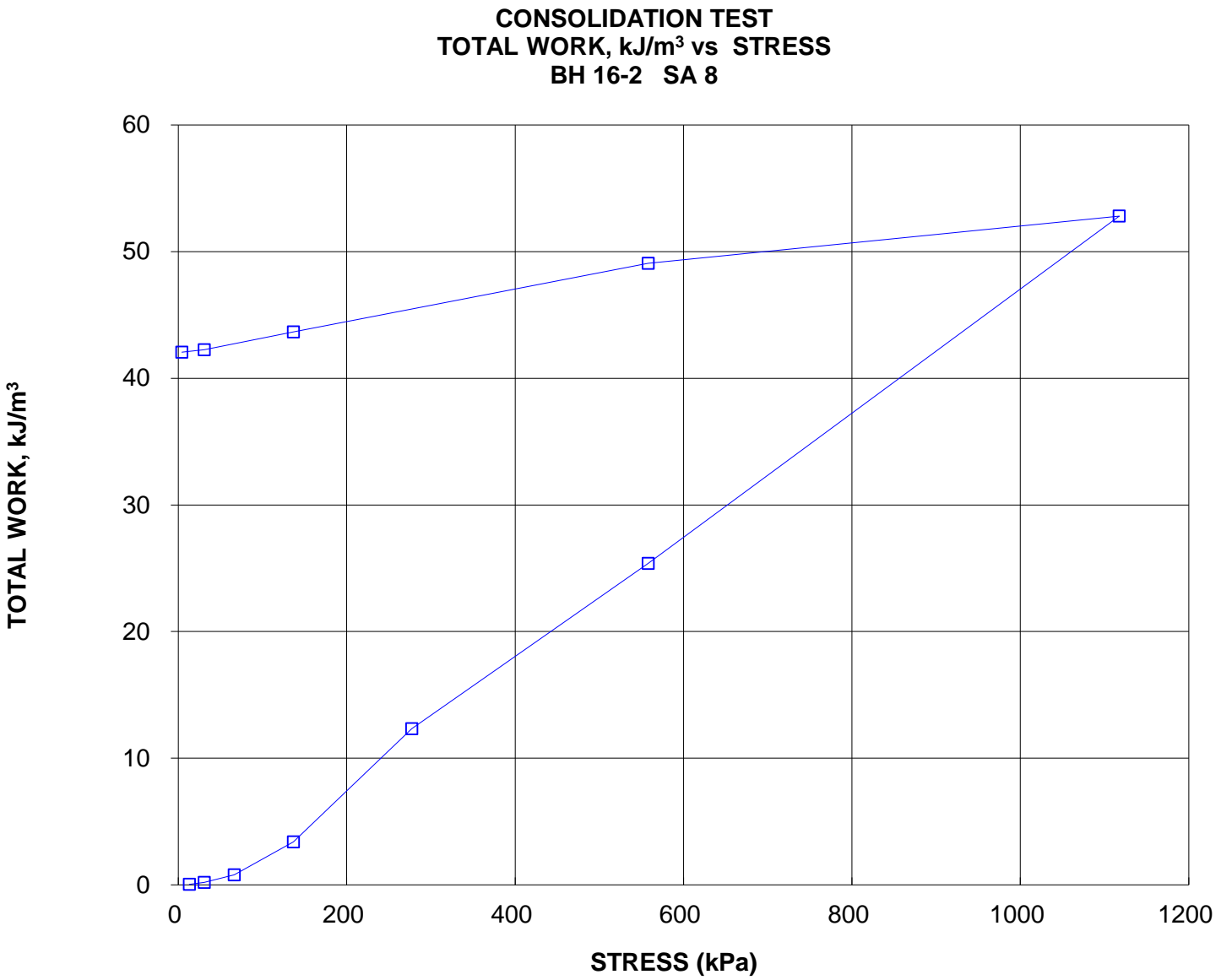
Highway 17 STA 11+970 BH 16-2 SA 8

FIGURE B5

Page 2 of 4







CONSOLIDATION TEST SUMMARY

Highway 17 STA 11+970 Blake Creek Culvert

FIGURE B6
Page 1 of 4

SAMPLE IDENTIFICATION

Project Number	1535723	Sample Number	11
Borehole Number	16-2	Sample Depth, m	12.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	9/19/16		
Date Completed	10/4/16		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m3	17.28
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m3	11.71
Area, cm2	31.74	Specific Gravity, measured	2.77
Volume, cm3	80.75	Solids Height, cm	1.097
Water Content, %	47.54	Volume of Solids, cm3	34.82
Wet Mass, g	142.30	Volume of Voids, cm3	45.93
Dry Mass, g	96.45	Degree of Saturation, %	99.8

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0	2.544	1.319	2.544				
9	2.538	1.313	2.541	614	0.0022	2.90E-04	6.34E-08
18	2.532	1.308	2.535	540	0.0025	2.32E-04	5.74E-08
35	2.521	1.298	2.527	540	0.0025	2.51E-04	6.17E-08
69	2.502	1.281	2.512	614	0.0022	2.22E-04	4.74E-08
143	2.455	1.238	2.478	676	0.0019	2.53E-04	4.78E-08
285	2.345	1.137	2.400	2160	0.0006	3.04E-04	1.68E-08
570	2.246	1.047	2.295	866	0.0013	1.37E-04	1.72E-08
1140	2.158	0.967	2.202	540	0.0019	6.07E-05	1.13E-08
570	2.166	0.975	2.162				
143	2.195	1.001	2.181				
35	2.228	1.031	2.212				
9	2.260	1.060	2.244				

Note:
k calculated using cv based on t₉₀ values.

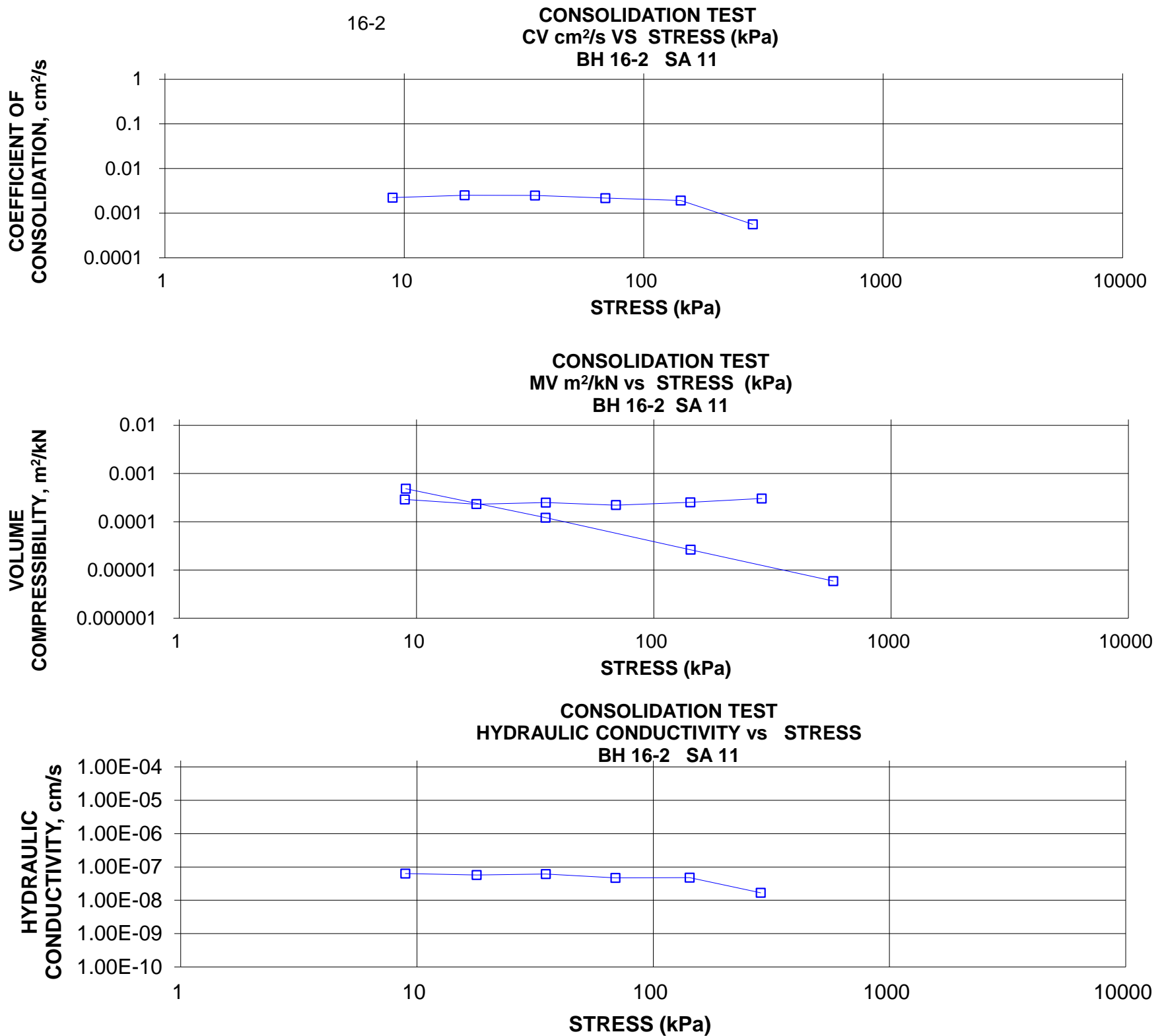
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

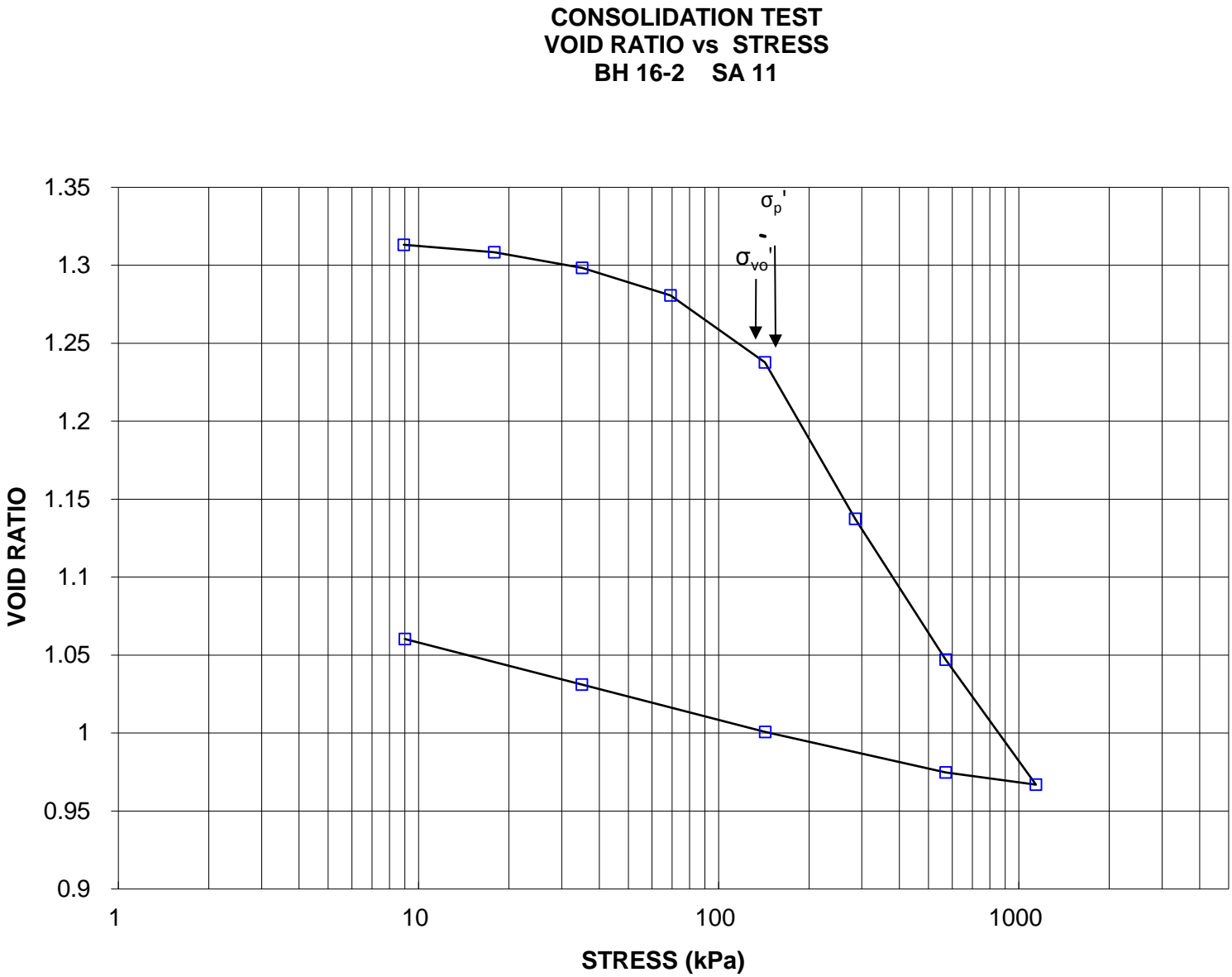
Sample Height, cm	2.26	Unit Weight, kN/m3	17.65
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m3	13.18
Area, cm2	31.74	Specific Gravity, measured	2.77
Volume, cm3	71.74	Solids Height, cm	1.097
Water Content, %	33.84	Volume of Solids, cm 3	34.82
Wet Mass, g	129.09	Volume of Voids, cm 3	36.92
Dry Mass, g	96.45		

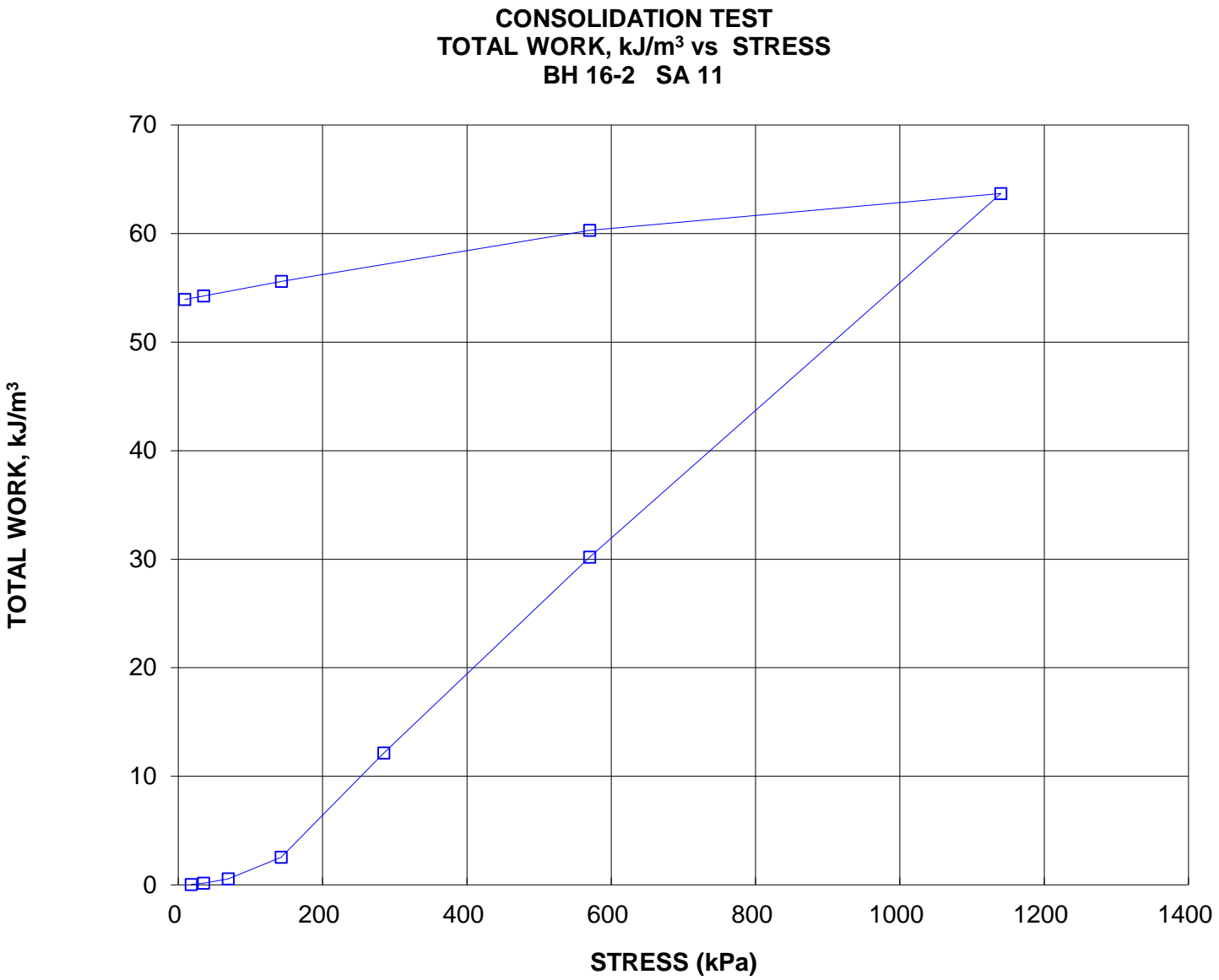
Prepared By: TG

Golder Associates

Checked By: MT







CONSOLIDATION TEST SUMMARY **Highway 17 STA 11+970 Blake Creek Culvert**

FIGURE B7
Page 1 of 4

SAMPLE IDENTIFICATION

Project Number	1535723	Sample Number	5
Borehole Number	16-3	Sample Depth, m	4.80

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	9/9/16		
Date Completed	9/19/16		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m3	15.92
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m3	9.66
Area, cm2	31.74	Specific Gravity, measured	2.75
Volume, cm3	80.75	Solids Height, cm	0.913
Water Content, %	64.85	Volume of Solids, cm3	28.98
Wet Mass, g	131.12	Volume of Voids, cm3	51.78
Dry Mass, g	79.54	Degree of Saturation, %	99.6

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0	2.544	1.787	2.544				
9	2.540	1.782	2.542	317	4.32E-03	1.94E-04	8.19E-08
18	2.536	1.778	2.538	290	4.70E-03	1.69E-04	7.80E-08
35	2.523	1.763	2.529	735	1.85E-03	3.01E-04	5.45E-08
69	2.504	1.742	2.513	290	4.61E-03	2.21E-04	9.97E-08
143	2.483	1.719	2.493	317	4.16E-03	1.12E-04	4.58E-08
285	2.175	1.382	2.329	4438	2.59E-04	8.50E-04	2.16E-08
570	2.065	1.262	2.120	1750			
1140	1.974	1.163	2.020	1561			
570	1.985	1.174	1.980				
143	2.021	1.213	2.003				
35	2.063	1.260	2.042				
9	2.091	1.291	2.077				

Note:
k calculated using cv based on t₉₀ values.

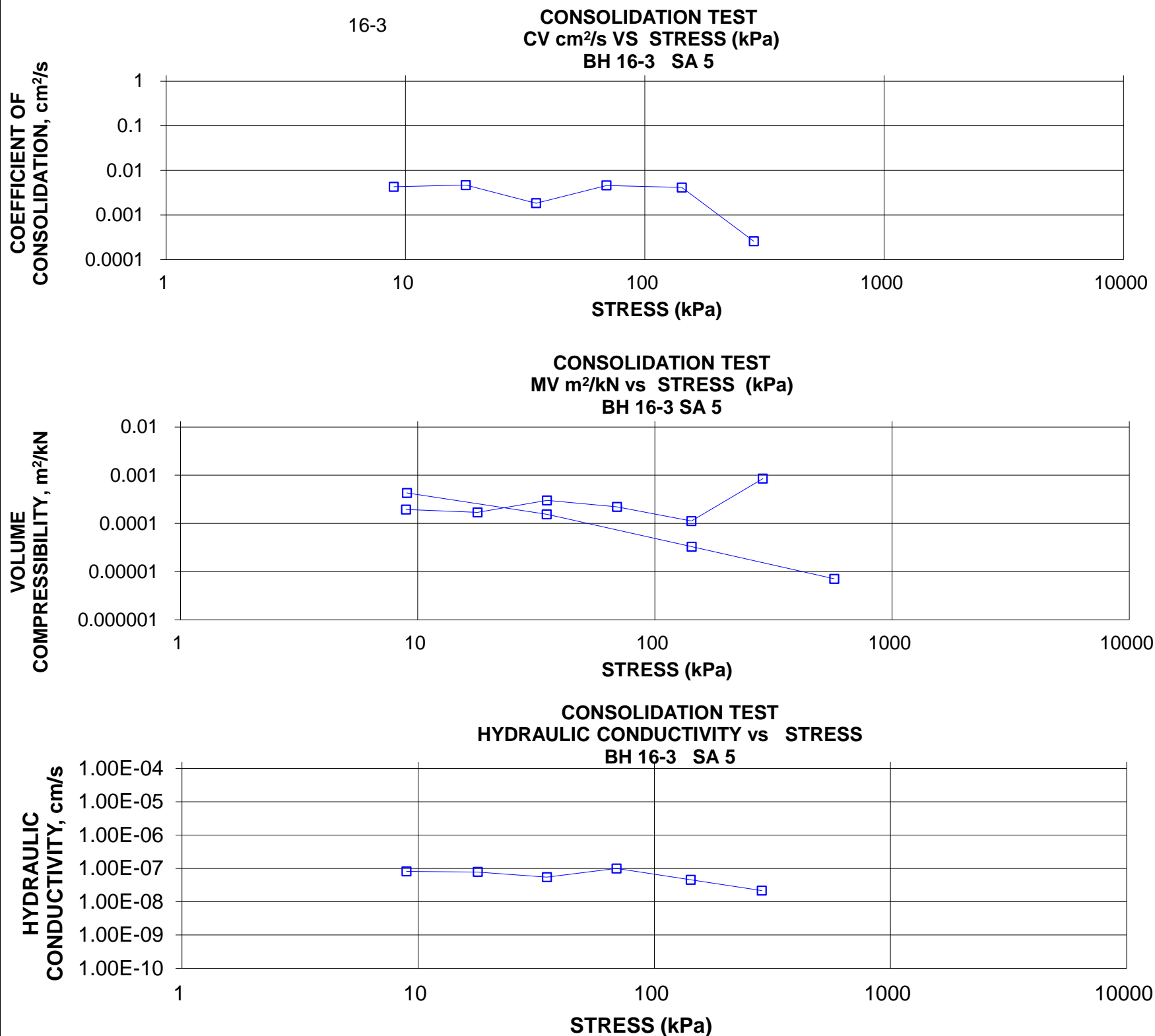
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

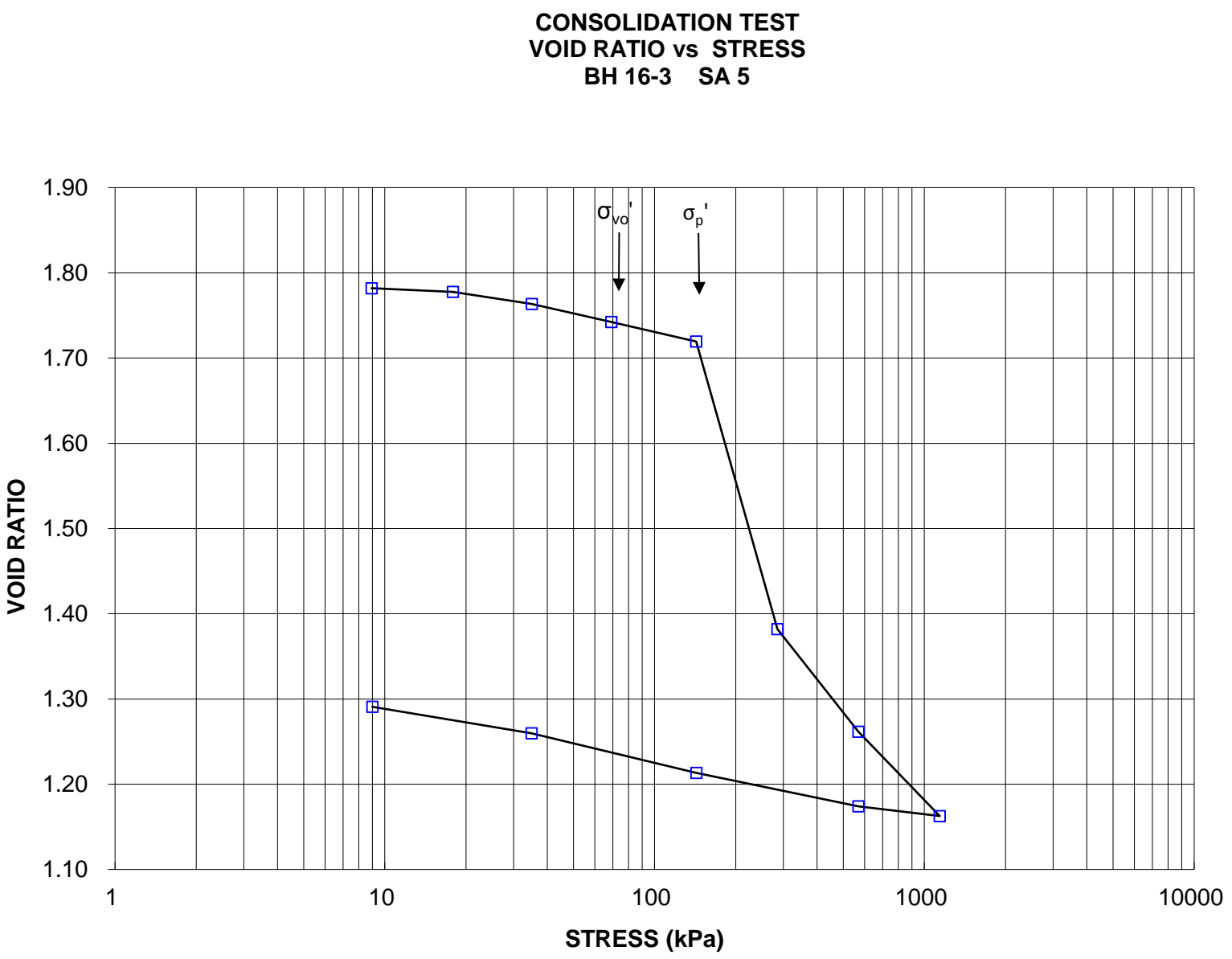
Sample Height, cm	2.09	Unit Weight, kN/m3	16.36
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m3	11.75
Area, cm2	31.74	Specific Gravity, measured	2.75
Volume, cm3	66.38	Solids Height, cm	0.913
Water Content, %	39.21	Volume of Solids, cm 3	28.98
Wet Mass, g	110.73	Volume of Voids, cm 3	37.40
Dry Mass, g	79.54		

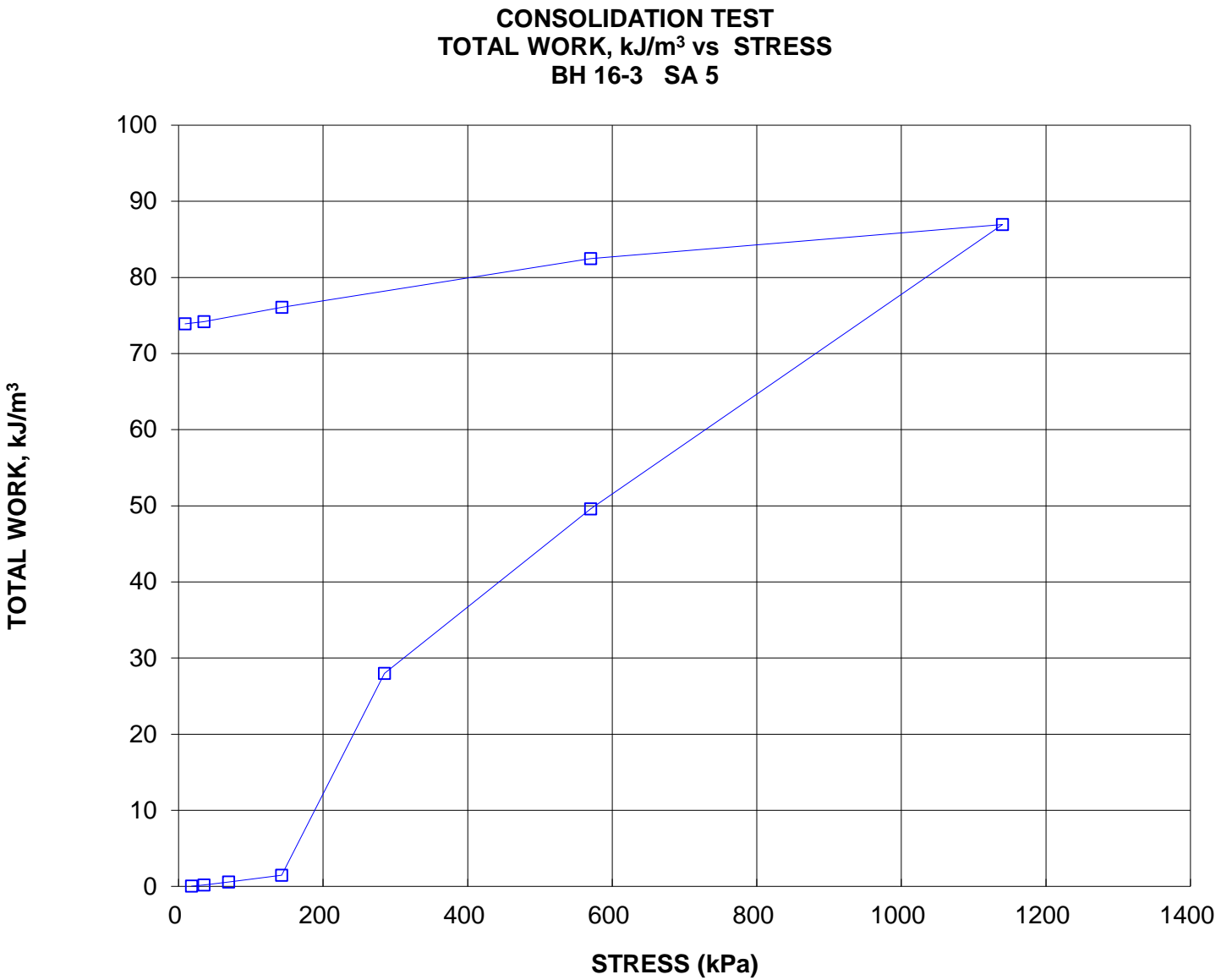
Prepared By: TG

Golder Associates

Checked By: MT









**FOUNDATION REPORT
HIGHWAY 17 BLAKE CREEK CULVERT REPLACEMENT**

APPENDIX C

Analytical Test Results

Your P.O. #: 1535723
Your Project #: 1535723
Site Location: BLAKE CREEK CULVERT
Your C.O.C. #: NA

Attention:Adam Core

Golder Associates Ltd
33 Mackenzie Street
Suite 100
Sudbury, ON
Canada P3C 4Y1

Report Date: 2016/09/30
Report #: R4185473
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6I2210

Received: 2016/08/25, 09:09

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	2	N/A	2016/08/31	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2016/08/31	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2016/08/30	2016/08/30	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2016/08/26	2016/08/31	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	2	N/A	2016/08/31	CAM SOP-00464	EPA 375.4 m
Oxidation-Reduction Potential (1, 2)	2	2016/08/29	2016/09/30	SLA SOP-00101	In house

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.

- (1) This test was performed by Maxxam Sladeview Petrochemical
(2) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode.

Encryption Key



Ema Gitej
30 Sep 2016 10:06:50 -04:00

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.

RESULTS OF ANALYSES OF SOIL

Maxxam ID		CYO660	CYO661	CYO661		
Sampling Date		2016/08/23 10:00	2016/08/24 12:00	2016/08/24 12:00		
COC Number		NA	NA	NA		
	UNITS	16-1 SA#2B 3'-4.5'	16-3 SA#3 5'-7'	16-3 SA#3 5'-7' Lab-Dup	RDL	QC Batch
Calculated Parameters						
Resistivity	ohm-cm	1900	1200			4636743
Inorganics						
Soluble (20:1) Chloride (Cl)	ug/g	200	400		20	4640865
Conductivity	umho/cm	537	831	757	2	4641008
Available (CaCl2) pH	pH	7.26	7.43			4639135
Soluble (20:1) Sulphate (SO4)	ug/g	ND	ND		20	4640868
Subcontracted Analysis						
Oxidation-Reduction Potential	mV	+160	+132	+132		4639029
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate ND = Not detected						

Maxxam Job #: B6I2210
Report Date: 2016/09/30

Golder Associates Ltd
Client Project #: 1535723
Site Location: BLAKE CREEK CULVERT
Your P.O. #: 1535723
Sampler Initials: AC

TEST SUMMARY

Maxxam ID: CYO660
Sample ID: 16-1 SA#2B 3'-4.5'
Matrix: Soil

Collected: 2016/08/23
Shipped:
Received: 2016/08/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4640865	N/A	2016/08/31	Deonarine Ramnarine
Conductivity	AT	4641008	N/A	2016/08/31	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4639135	2016/08/30	2016/08/30	Neil Dassanayake
Resistivity of Soil		4636743	2016/08/31	2016/08/31	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4640868	N/A	2016/08/31	Deonarine Ramnarine
Oxidation-Reduction Potential	PH	4639029	2016/08/29	2016/09/30	Grace Sison

Maxxam ID: CYO661
Sample ID: 16-3 SA#3 5'-7'
Matrix: Soil

Collected: 2016/08/24
Shipped:
Received: 2016/08/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4640865	N/A	2016/08/31	Deonarine Ramnarine
Conductivity	AT	4641008	N/A	2016/08/31	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4639135	2016/08/30	2016/08/30	Neil Dassanayake
Resistivity of Soil		4636743	2016/08/31	2016/08/31	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4640868	N/A	2016/08/31	Deonarine Ramnarine
Oxidation-Reduction Potential	PH	4639029	2016/08/29	2016/09/30	Grace Sison

Maxxam ID: CYO661 Dup
Sample ID: 16-3 SA#3 5'-7'
Matrix: Soil

Collected: 2016/08/24
Shipped:
Received: 2016/08/25

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	4641008	N/A	2016/08/31	Neil Dassanayake
Oxidation-Reduction Potential	PH	4639029	2016/08/29		Grace Sison

GENERAL COMMENTS

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

Package 1	7.7°C
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Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1535723
Site Location: BLAKE CREEK CULVERT
Your P.O. #: 1535723
Sampler Initials: AC

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD		QC Standard	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
4639029	Oxidation-Reduction Potential						+109	mV	0	20	+247	238 - 248
4639135	Available (CaCl2) pH	2016/08/30			98	97 - 103			1.6	N/A		
4640865	Soluble (20:1) Chloride (Cl)	2016/08/31	104	70 - 130	104	70 - 130	ND, RDL=20	ug/g	NC	35		
4640868	Soluble (20:1) Sulphate (SO4)	2016/08/31	NC	70 - 130	110	70 - 130	ND, RDL=20	ug/g	NC	35		
4641008	Conductivity	2016/08/31			100	90 - 110	ND,RDL=2	umho/cm	9.3	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.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

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).

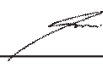

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

VALIDATION SIGNATURE PAGE

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




Eva Pranjić, M.Sc., C.Chem, Scientific Specialist

Grace Sison, B.Sc., C.Chem, Senior Project Manager - Petroleum Division

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.

CHAIN OF CUSTODY RECORD

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required	
Company Name: <u>Golder Associates</u>		Company Name:		Quotation #: <u>1535723</u>		<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses	
Contact Name: <u>Adam Core</u>		Contact Name:		P.O. #/AFER: <u>1535723</u>		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
Address: <u>33 Mackenzie St</u>		Address:		Project #: <u>1535723</u>		Rush TAT (Surcharges will be applied)	
City: <u>Sudbury</u>		City:		Site Location: <u>Blake Creek Culvert</u>		<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days	
Phone: <u>705-524-1641</u> Fax: <u>705-524-1091</u>		Phone: Fax:		Site #:		Date Required:	
Email: <u>Adam.Core@golder.com</u>		Email:		Sampled By:		Rush Confirmation #:	
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY							
Regulation 153		Other Regulations		Analysis Requested		LABORATORY USE ONLY	
<input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other <input type="checkbox"/> Table <input type="checkbox"/> FOR RSC (PLEASE CIRCLE) Y / N		<input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> PWQO Region <input type="checkbox"/> Other (Specify) <input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED)		REFER TO BACK OF COC REG 153 METALS & INORGANICS REG 153 METALS (Hg, Cr VI, ICPIMS Metals, HWS - B) Corrosivity Package		CUSTODY SEAL Y / N Present Intact COOLING MEDIA PRESENT: <input checked="" type="checkbox"/> Y / N COMMENTS	
Include Criteria on Certificate of Analysis: Y / N							
SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM							
SAMPLE IDENTIFICATION		DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / Cr VI	HOLD - DO NOT ANALYZE
1	16-1 SA#2B 3'-4.5'	2016/08/23	10:00am	Soil			
2	16-3 SA#3 5'-7'	2016/08/24	12:00am	Soil			
3		labelled 2016/12/16 10:00am jwr					
4							
5							
6							
7							
8							
9							
10							
RELINQUISHED BY: (Signature/Print)		DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)		DATE: (YYYY/MM/DD)	TIME: (HH:MM)
<u>Adam Core</u>		2016/08/25	9:09am	<u>Adam Core</u>		2016/08/25	9:09
				<u>Adam Core</u>		2016/08/26	09:23

25-Aug-16 09:09

Ema Gitej



B612210

KP7 ENV-1115

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.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
100, Scotia Court
Whitby, Ontario, L1N 8Y6
Canada
T: +1 (905) 723 2727

