



December 19, 2013

FOUNDATION INVESTIGATION REPORT

**CULVERT AT STATION 14+510 (BC4)
REALIGNMENT OF HIGHWAY 66 AT VIRGINIATOWN FROM 10.6 KM EAST OF
HIGHWAY 624 EASTERLY 3.4 KM
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5091-07-00**

Submitted to:
McCormick Rankin Corporation
A Member of MMM Group Limited
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8



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REPORT





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PART A

FOUNDATION INVESTIGATION REPORT

CULVERT AT STATION 14+510 (BC4)

REALIGNMENT OF HIGHWAY 66 AT VIRGINIATOWN

FROM 10.6 KM EAST OF HIGHWAY 624 EASTERLY 3.4 KM

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5091-07-00



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (MRC), a member of MMM Group Limited (MMM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the proposed Culvert BC4, crossing the proposed Highway 66 realignment at STA 14+510. The proposed work is part of the overall Highway 66 realignment from 10.6 km east of Highway 624 easterly 3.4 km. The foundation engineering components within the overall project limits include the engineering of: high fill embankments and embankments over swamps; a deep cut section; as well as a number of culverts. The proposed Culvert BC4 is located about 12.5 km east of Highway 624 within the Swamp Crossing H6/H7. The general location of the proposed Culvert BC4 is shown on the Key Plan on Drawing 1.

This report addresses the investigation carried out for the proposed Culvert BC4 only. Separate reports address the foundation investigations for the remaining culverts, swamp crossing/high fill areas and deep cut section.

The purpose of this investigation is to establish the subsurface conditions along the proposed culvert alignment by methods of borehole drilling, rock coring, in situ testing and laboratory testing on selected samples. The centreline of the proposed Highway 66 realignment was staked in the field by MRC and the foundation investigation was carried out at Culvert BC4, as defined in the Terms of Reference. The investigation area is shown in plan on Drawing 1.

2.0 SITE DESCRIPTION

The new Highway 66 alignment is oriented generally in an east-west direction within the Township of McGarry. The proposed culvert will be up to 35 m long extending across the proposed realigned Highway 66 at about STA 14+510. The land in the vicinity of Culvert BC4 is used for recreation.

In general, the topography in the vicinity of Culvert BC4 consists of a low-lying swamp area. The area is densely populated with trees and has open water ponded as a result of beaver dams. Multiple ATV trails are located near the proposed culvert. The ground surface within the limits of the culvert alignment varies between about Elevation 304 m and Elevation 305 m. A detailed description of the subsurface conditions along the culvert alignment is presented in Section 4.0.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The investigation for Culvert BC4 crossing the realigned Highway 66 was carried out between November 14 and 18, 2012, during which time a total of three boreholes were advanced along the proposed culvert alignment. The locations of the boreholes are shown on Drawing 1 and are provided on the Record of Borehole sheets in Appendix A.

The field investigation was carried out using portable drilling equipment supplied and operated by Landcore Drilling of Sudbury, Ontario. The portable equipment was set up on a floating raft to facilitate drilling in areas of open water. The boreholes were advanced through the overburden using 'NW' casing with wash boring techniques. In general, soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by a cathead hammer, and carried out in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, Standard Test Method for Standard



Penetration Test). The portable equipment employed full-weight hammers, dropped from the standard SPT height. Samples of the cohesive soils were obtained at selected locations/depths using 76 mm O.D. thin-walled 'Shelby' tubes (ASTM D1587, Standard Practice for Thin-Walled Tube Sampling) for relatively undisturbed samples. Field vane shear tests were carried out in cohesive soils for assessment of undrained shear strengths (ASTM D2573, Standard Test Method for Field Vane Strength Shear Test) using MTO Standard 'N' size vanes. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 Wells (as amended).

A dynamic cone penetration test (DCPT) was advanced from the bottom of two of the boreholes and extended to refusal. The boreholes were advanced to depths ranging between 13.6 m and 18.7 m below existing ground surface (excluding the ponded water), including the DCPTs driven from the bottom of two of the boreholes.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations and are described on the Record of Borehole sheets provided in Appendix A.

The fieldwork was observed by a member of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples. In addition, one-dimensional consolidation (oedometer) tests were carried out on select samples of the cohesive deposit. The results of the laboratory testing on samples from the culvert boreholes are included in Appendix B.

The proposed centreline of the new highway alignment was staked in the field by MRC prior to drilling. The as-drilled borehole locations, in stations and offsets, were measured in reference to the centreline alignment and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. Static water elevations at the borehole locations were surveyed at the time of drilling by a member of our technical staff in reference to the ground surface elevations at temporary benchmarks, which were installed by MRC prior to the commencement of fieldwork. The borehole locations given 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 as follows:

Borehole	Location (MTM NAD 83)		Water/Ground Surface Elevation (m)	Borehole/DCPT Depth Below Ground Surface (m)
	Northing	Easting		
BC4-1	5334678.1	410115.3	305.2/305.0	15.5/18.7
BC4-2	5334695.8	410109.4	304.8/304.1	13.6
BC4-3	5334660.4	410121.2	305.2/304.9	14.3/15.5



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

In the Quaternary Period, the Virginiatown area was encompassed by glacial Lakes Barlow and Ojibway. In areas of more turbulent waters in these lakes, coarse grained sediments of sand and gravel were deposited. In the calmer portions of the glacial lakes fine grained sediments, consisting primarily of varved clay, were deposited. After Lakes Barlow and Ojibway receded, organic materials were deposited. In the Kirkland Lake area the organic deposits are usually found as fens, bogs and swamps containing varying thicknesses of organics and are often encountered in glaciolacustrine plains (overlying the sand and gravel or clay), along creeks and streams and in bedrock basins. (Baker, 1985)¹

Based on NOEGTS² Mapping, the subsoils in the vicinity of the Highway 66 realignment generally consist of till deposited as a ground moraine. A primarily clay/clayey glaciolacustrine deposit is located further than 1 km north of the realignment. The soils along the Highway 66 realignment consist of variable deposits of organic materials, lacustrine sand, silt and clay and till.

Published literature indicates that the site is located in the Abitibi Subprovince of the Superior Province (OGS, 1991)³. The Abitibi Subprovince contains rocks of up to 2.75 Ga in age, is about 800 km by 300 km in area and lies within the southern portion of the Superior Province. Bedrock in this subprovince consists primarily of zones of mafic to intermediate metavolcanic rocks and metasedimentary rocks.

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the attached Record of Borehole sheets and the soil laboratory test sheets provided in Appendices A and B. The results of the in situ field tests (i.e., SPT 'N'-values and undrained shear strengths from the field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of in situ testing. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The inferred soil stratigraphy based on the result of the boreholes is shown in profile on Drawing 1. The orientation (i.e., north, south, east, west) stated in the text of the report is typically referenced to project north and/or up-chainage (along the proposed Highway 66 alignment). For purposes of this report, Highway 66 is oriented east-west.

In general, the subsurface conditions encountered at the site consist of peat at the ground surface underlain by a deposit of very soft to firm clayey silt to clay. The cohesive deposit is underlain by a deposit of very loose to dense silt which is in turn underlain by a layer of gravelly sand at one borehole location and dense gravelly sand.

¹ C.L. Baker, 1985. Quaternary Geology of the Kirkland Lake Area, Districts of Cochrane and Timiskaming; Ontario Geological Survey.

² Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Map Reference Number 32DSW.

³ Ontario Geological Survey, 1991. Geology of Ontario, Special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.



Detailed descriptions of the subsurface conditions along the investigated culvert alignment are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

4.2.1 Peat

A 0.2 m to 0.7 m thick deposit of amorphous to fibrous peat was encountered below the ponded water at between pond bottom Elevations 305.0 m to 304.1 m.

One SPT 'N'-value measured within the peat is 1 blow per 0.3 m of penetration, suggesting a very soft relative density.

The natural water content measured on one sample of the peat is 93 per cent.

4.2.2 Clayey Silt to Clay

A cohesive deposit consisting of an upper zone of clayey silt, a middle zone of silty clay to clay and transitioning to a lower zone of clayey silt was encountered underlying the peat in the three boreholes. The total thickness of the deposit ranges between 8.5 m and 9.9 m and the surface of the deposit was encountered between Elevations 304.6 m and 303.9 m.

The upper zone is comprised of layered, grey to brown clayey silt and is between 1.2 m and 2.3 m thick. The middle zone is comprised of grey silty clay to clay and is between 6.1 m and 7.3 m thick. This portion of the deposit was noted to be irregularly varved with clayey silt/clay varves between 1 mm and 25 mm thick as observed in the Shelby tube samples. The lower zone is comprised of grey, wet clayey silt and is about 1.5 m thick in the two boreholes encountered. Silt seams/interlayers (i.e., varves) were encountered within the cohesive deposit, between Elevations 297.8 m and 296.3 m in Borehole BC4-1, between Elevations 302.7 m and 300.0 m and between Elevations 298.5 m and 295.4 m in Borehole BC4-2, and between Elevations 297.7 m and 296.2 m in Borehole BC4-3.

4.2.2.1 Clayey Silt

The SPT 'N'-values measured within the clayey silt portion of the deposit range from 1 blow to 4 blows per 0.3 m of penetration. In situ field vane tests carried out within the upper portion of the deposit measured undrained shear strengths of 26 kPa and 34 kPa, and the sensitivity is calculated to be 9 and 18, respectively. The field vane tests results indicate that the clayey silt portion of the deposit has a firm consistency.

The natural water content measured on three samples of this portion of the deposit range from about 26 per cent to 33 per cent.

A grain size distribution test completed on one sample of the clayey silt deposit is shown on Figure B1 in Appendix B.

Atterberg limits test were carried out on three samples of the upper clayey silt portion of the deposit and measured liquid limits ranging from about 28 per cent to 31 per cent, plastic limits of about 18 per cent and plasticity indices ranging from about 11 per cent to 13 per cent. The results of the Atterberg limits tests are



shown on the plasticity chart on Figure B2 in Appendix B and indicate that the material is classified as a clayey silt of low plasticity.

4.2.2.2 Silty Clay to Clay

The SPT 'N'-values measured within the silty clay to clay portion of the deposit range are 0 blows (weight of hammer) or 1 blow per 0.3 m of penetration. In situ field vane tests carried out within this portion of the deposit measured undrained shear strengths ranging between 20 kPa and 39 kPa, and the sensitivity is calculated to range from 3 to 13. The field vane tests results indicate that the silty clay to clay portion of the deposit has a soft to firm consistency.

The natural water content measured on eight selected samples of this portion of the deposit ranges from about 45 per cent to 70 per cent.

The results of grain size distribution tests completed on three samples of the silty clay to clay portion of the deposit are shown on Figure B3 in Appendix B.

Atterberg limits test were carried out on eight samples of the silty clay to clay portion of the deposit and measured liquid limits ranging from about 37 per cent to 57 per cent, plastic limits ranging from about 20 per cent to 25 per cent and plasticity indices ranging from about 17 per cent to 32 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B4 in Appendix B and indicate that the material is classified as a silty clay of intermediate plasticity to clay of high plasticity.

Laboratory consolidation tests were carried out on three specimens of the silty clay to clay deposit obtained from Shelby tube samples in Borehole BC4-1. Preconsolidation pressures ranging between 92 kPa to 134 kPa were estimated from the void ratio versus logarithmic pressure plot and from the total work versus pressure plot. Bulk unit weights ranging from 16.1 kN/m³ to 16.6 kN/m³ and a specific gravity between about 2.74 and 2.76 were measured on the consolidation test specimens. Details of the test results are shown on Figure B5 to B7 in Appendix B, and the test results are summarized below.

Borehole Sample No.	Sample Depth / Elevation	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	OCR	C_c	C_r	e_o	c_v^* (cm ² /s)
Borehole BC4-1 Sample 4	3.4 m / 301.8 m	18	125	107	6.9	1.04	0.04	1.87	1.4×10^{-2}
Borehole BC4-1 Sample 5	4.9 m / 300.3 m	30	92	62	3.1	0.68	0.05	1.74	1.3×10^{-2}
Borehole BC4-1 Sample 6	6.4 m / 298.8 m	40	134	94	3.4	0.90	0.05	1.62	1.6×10^{-2}

*For stress range between approximately effective overburden stress and final stress due to 3 m high embankment, that is $30 \text{ kPa} \leq \sigma_v' \leq 140 \text{ kPa}$

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
OCR is overconsolidation ratio
 e_o is initial void ratio
 C_c is the compression index
 C_r is the recompression index
 c_v is the coefficient of consolidation in cm²/s



4.2.2.3 Clayey Silt

The SPT 'N'-values recorded within the lower clayey silt portion of the deposit are 1 blow per 0.3 m of penetration. One in situ field vane test carried out within the lower portion of the deposit measured an undrained shear strength of 37 kPa, and the sensitivity is calculated to be 7. The field vane test result indicates that the clayey silt deposit has a firm consistency.

The natural water content measured on one sample of this deposit is 36 per cent.

An Atterberg limits test carried out on one sample of the clayey silt deposit measured a liquid limit of about 29 per cent, the plastic limit of about 20 per cent and a plasticity index of about 9 per cent. The results of the Atterberg limits test are shown on the plasticity chart on Figure B2 in Appendix B and indicate the material is classified as a clayey silt of low plasticity.

4.2.3 Silt

A deposit of grey, wet silt, 4.1 m to 4.9 m thick was encountered underlying the cohesive deposit in all the boreholes. The surface of this deposit was encountered between Elevation 295.4 m and 294.7 m.

The SPT 'N'-values measured within the silt deposit range from 4 blows to 35 blows per 0.3 m of penetration, indicating a very loose to dense relative density. Borehole BC4-2 was terminated within this deposit on refusal to further split spoon and casing advancement.

The natural water content measured on three samples of this deposit ranges from about 27 per cent to 29 per cent.

The results of grain size distribution tests completed on three samples of the silt deposit are shown on Figure B8 in Appendix B. An Atterberg limits test on one sample of the silt deposit indicates this material to be non-plastic.

4.2.4 Gravelly Sand

A 0.9 m thick deposit of grey, wet gravelly sand, some silt, trace clay was encountered below the silt deposit in Borehole BC4-1. The surface of this deposit was encountered at Elevation 290.4 m.

One SPT 'N'-value measured within the gravelly sand deposit is 40 blows per 0.3 m of penetration, indicating a dense relative density.

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

A grain size distribution test completed on one sample of the gravelly sand deposit is shown on Figure B9 in Appendix B.

4.2.5 Refusal

Dynamic Cone Penetration Tests (DCPTs) were advanced from the bottom of Boreholes BC4-1 and BC4-3. The bedrock surface at the boreholes and DCPTs is inferred by refusal to further split-spoon, casing advancement or dynamic cone penetration between depths of about 13.6 m to 18.7 m below the ground surface, corresponding to between Elevation 290.5 m and 286.3 m.



4.3 Groundwater Conditions

Groundwater levels were measured in the open boreholes during and upon completion of drilling. Between 0.2 m and 0.7 m of standing water was encountered over the ground surface in the boreholes.

The ponded water elevation as encountered at the borehole locations may not be representative of groundwater levels and both the surface water level and groundwater elevations will vary depending on seasonal fluctuations, precipitation, local soil permeability, and, in the case of the ponded water, on the condition of the beaver dams.

5.0 CLOSURE

The drilling program was supervised by Mr. Gabriel Mathieu. This report was prepared by Mr. Matt Thibeault, EIT and reviewed by Ms. Sarah Coyne, P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.



Report Signature Page

GOLDER ASSOCIATES LTD.

Matt Thibeault

Matt Thibeault, EIT
Geotechnical Engineering Intern



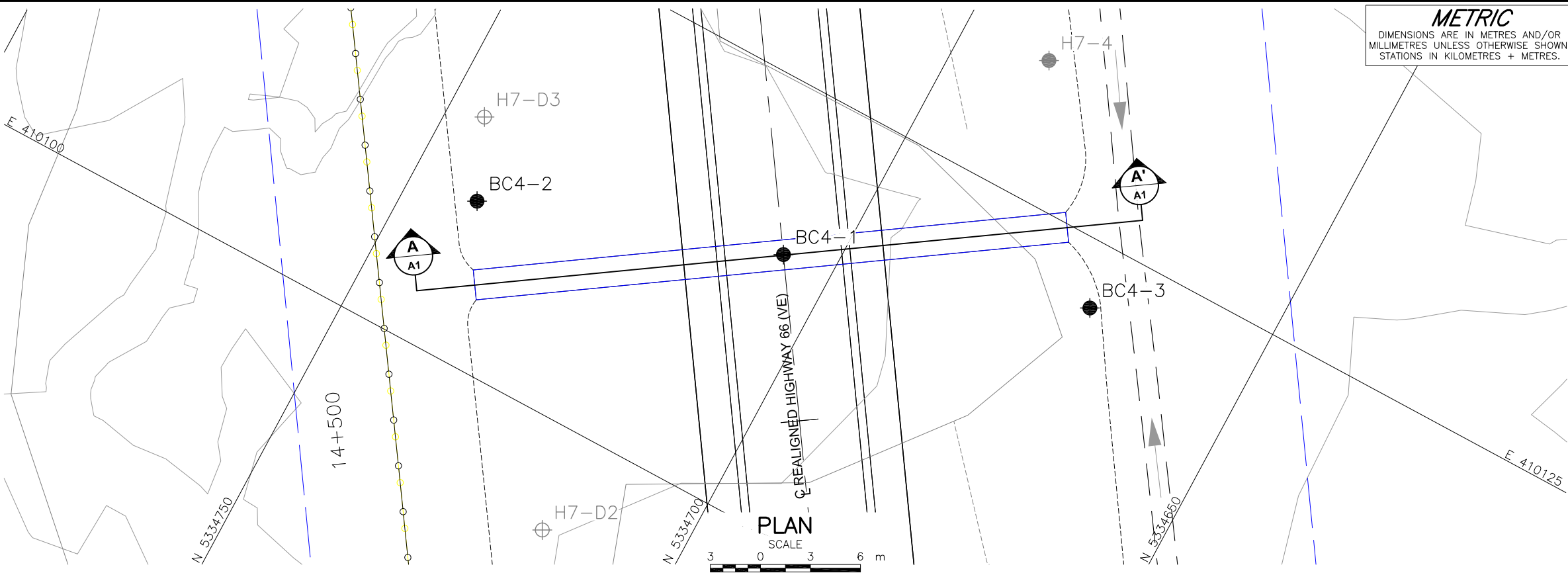
Sarah E.M. Coyne, P. Eng.
Senior Geotechnical Engineer, Associate



Jorge M.A. Costa, P. Eng.
Designated MTO Contact, Principal

MT/SEMC/JMAC/kp

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

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GWP No. 5091-07-00

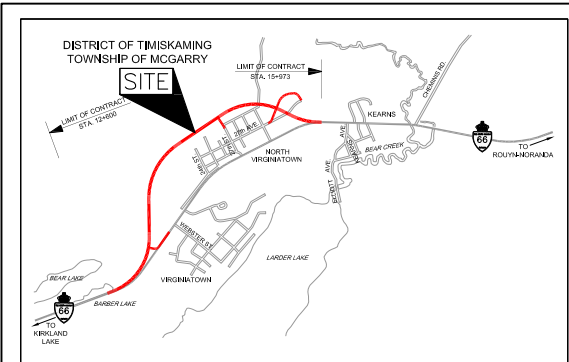


HIGHWAY 66
CULVERT AT STA 14+510
BOREHOLE LOCATIONS AND
SOIL STRATA

SHEET



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN
SCALE
700 0 700 m

LEGEND

- Borehole
- ⊕ Dynamic Cone Penetration Test
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- R Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BC4-1	305.2	5334678.1	410115.3
BC4-2	304.8	5334695.8	410109.4
BC4-3	305.2	5334660.4	410121.2

NOTES

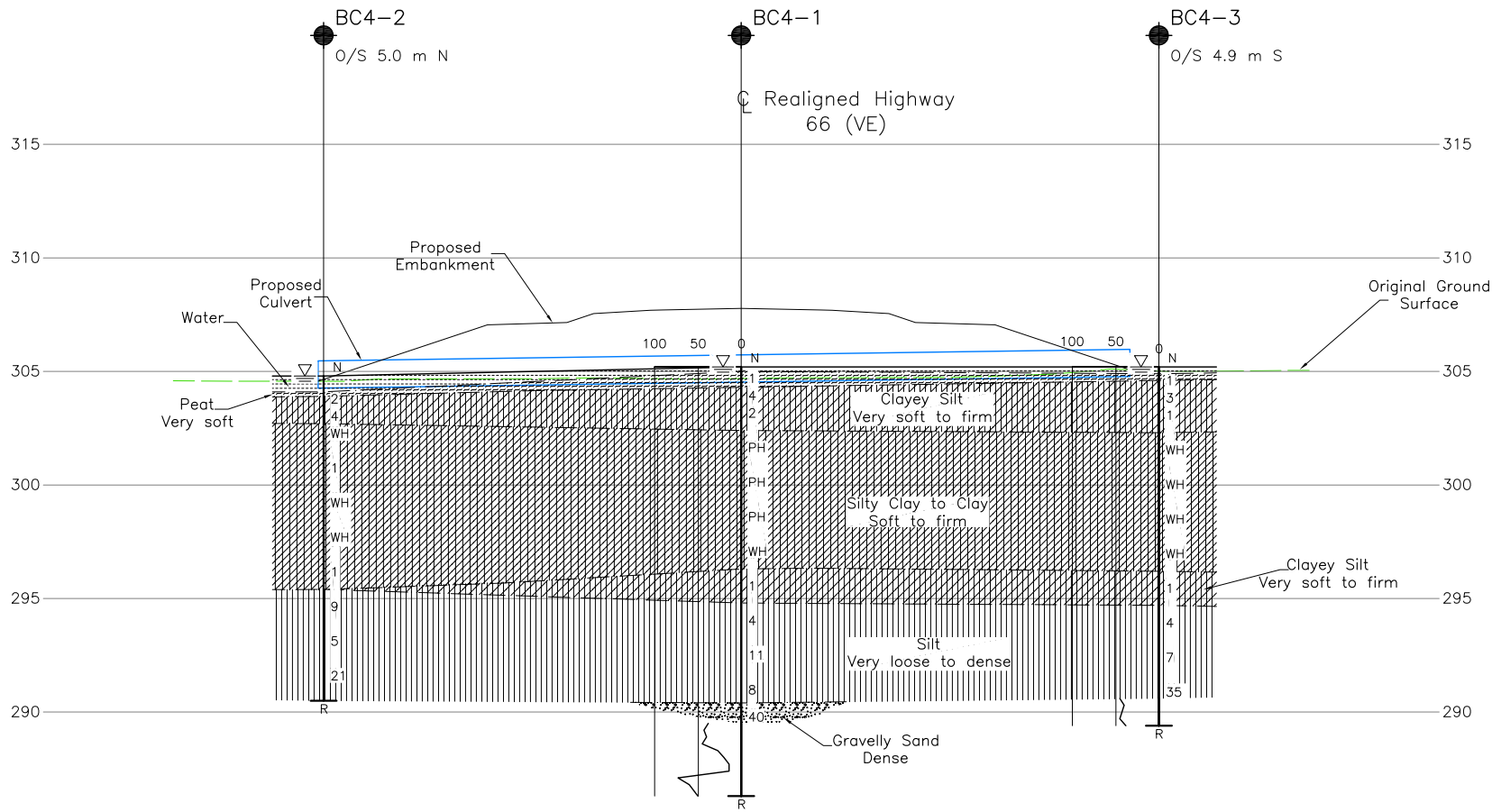
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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

REFERENCE

Base plans provided in digital format by MMM, drawing file nos. H3211009D16 ROLL PLAN-ULTIMATE and PDR.dwg, received DEC 3, 2012. Keyplan drawing file nos. H3211009G02 received JAN 24, 2013.



CULVERT AT STA 14+510
HIGHWAY 66
HORIZONTAL SCALE
3 0 3 6 m
VERTICAL SCALE
3 0 3 6 m



NO.	DATE	BY	REVISION
Geocres No. 32D-18			
HWY. 66	PROJECT NO. 10-1191-0044		DIST.
SUBM'D. MT	CHKD.	DATE: DEC 2013	SITE:
DRAWN: JJJ	CHKD. SEMC	APPD. JMAC	DWG. 1



APPENDIX A

Highway 66 Realignment, Virginiatown – Culvert at STA 14+510 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; 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

PROJECT 10-1191-0044			RECORD OF BOREHOLE No BC4-1			1 OF 2 METRIC						
G.W.P. 5091-07-00			LOCATION N 5334678.1; E 410115.3			ORIGINATED BY GM						
DIST _____ HWY 66			BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring			COMPILED BY MT						
DATUM GEODETIC			DATE November 16, 2012			CHECKED BY SEMC						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	γ	GR SA SI CL
305.2	WATER SURFACE											
0.0	WATER											
0.2	PEAT (Amorphous) Very soft Black Moist		1	SS	1		305					
304.3												
0.9	CLAYEY SILT, layered Firm Brown Wet		2	SS	4		304					
			3	SS	2		303					0 1 70 29
302.4												
2.8	CLAY Soft to firm Grey Wet Clayey silt / silt and clay irregular varves between 1 mm and 25 mm thick noted in Shelby tubes samples 4, 5 and 6.		4	TO	PH		302				16.1	0 2 33 65
			5	TO	PH		301					
							300				16.2	
							299					
			6	TO	PH		298				16.6	0 5 39 56
							297					
			7	SS	WH		296					
296.3												
8.9	CLAYEY SILT Very soft Grey Wet		8	SS	1		295					
294.8							294					
10.4	SILT, trace to some clay Very loose to compact Grey Wet		9	SS	4		293					
			10	SS	11		292					0 0 88 12
			11	SS	8		291					
290.4												
14.8												

SUD-MTO 001 10-1191-0044SUD.GPJ GAL-MISS.GDT 19/12/13 DATA INPUT:

Continued Next Page

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

PROJECT <u>10-1191-0044</u>				RECORD OF BOREHOLE No BC4-1				2 OF 2 METRIC									
G.W.P. <u>5091-07-00</u>				LOCATION <u>N 5334678.1; E 410115.3</u>				ORIGINATED BY <u>GM</u>									
DIST <u> </u> HWY <u>66</u>				BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>				COMPILED BY <u>MT</u>									
DATUM <u>GEODETIC</u>				DATE <u>November 16, 2012</u>				CHECKED BY <u>SEMC</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)					
							20	40	60	80	100						
289.5	Gravelly SAND, some silt, trace clay Dense Grey Wet		12	SS	40		290										26 59 13 2
15.7	END OF BOREHOLE START OF DCPT						289										
							288										
							287										
286.3	END OF DCPT REFUSAL TO FURTHER PENETRATION 50 BLOWS / 0.08 m (HAMMER BOUNCING)																
18.9																	

SUD-MTO 001 10-1191-0044SUD.GPJ GAL-MISS.GDT 19/12/13 DATA INPUT:

PROJECT		10-1191-0044		RECORD OF BOREHOLE No BC4-2		1 OF 2 METRIC																
G.W.P.		5091-07-00		LOCATION		N 5334695.8; E 410109.4																
DIST		HWY 66		BOREHOLE TYPE		Portable Equipment, NW Casing, Wash Boring																
DATUM		GEODETIC		DATE		November 14, 2012																
						ORIGINATED BY GM																
						COMPILED BY MT																
						CHECKED BY SEMC																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
304.8	0.0	WATER SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L 20 40 60			kN/m ³					
		WATER																				
304.1		PEAT (Amorphous)		1a				304														
0.9		CLAYEY SILT, layered Soft Brown Wet		1b	SS	2								—								
302.7				2	SS	4		303														
2.1		SILTY CLAY to CLAY Firm Grey Wet		3	SS	WH		302						—								
		Silt seams encountered between 2.1 and 4.8 m depth.						301	4 +													
				4	SS	1		300	8 +													
				5	SS	WH		299						—			○			0 0 43 57		
		Silt seams encountered between 6.3 and 9.4 m depth.						298	8 +													
				6	SS	WH		297	7 +													
				7	SS	1		296						—			○					
295.4	9.4	SILT, some clay Loose to compact Grey Wet		8	SS	9		295						○						NP 0 0 87 13		
				9	SS	5		294														
				10	SS	21		293														
								292														
								291														
290.5	14.3	Spoon attempted at 14.3 m depth, bouncing.																				

SUD-MTO 001 10-1191-0044SUD.GPJ GAL-MISS.GDT 19/12/13 DATA INPUT:

Continued Next Page

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

PROJECT <u>10-1191-0044</u>		RECORD OF BOREHOLE No BC4-2				2 OF 2 METRIC										
G.W.P. <u>5091-07-00</u>		LOCATION <u>N 5334695.8; E 410109.4</u>				ORIGINATED BY <u>GM</u>										
DIST <u> </u> HWY <u>66</u>		BOREHOLE TYPE <u>Portable Equipment, NW Casing, Wash Boring</u>				COMPILED BY <u>MT</u>										
DATUM <u>GEODETIC</u>		DATE <u>November 14, 2012</u>				CHECKED BY <u>SEMC</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
	END OF BOREHOLE SPOON REFUSAL AND REFUSAL TO FURTHER CASING ADVANCEMENT (HAMMER BOUNCING)															

SUD-MTO 001 10-1191-0044SUD.GPJ GAL-MISS.GDT 19/12/13 DATA INPUT:

PROJECT 10-1191-0044			RECORD OF BOREHOLE No BC4-3			1 OF 2 METRIC															
G.W.P. 5091-07-00			LOCATION N 5334660.4; E 410121.2			ORIGINATED BY GM															
DIST _____ HWY 66			BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring			COMPILED BY MT															
DATUM GEODETIC			DATE November 17 and 18, 2012			CHECKED BY SEMC															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ					
305.2	WATER SURFACE							20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60	kN/m ³	GR SA SI CL								
0.0	WATER						305														
304.9	PEAT (Fibrous)		1	SS	1		304														
304.6	CLAYEY SILT, layered Very soft to firm Grey to brown Wet		2	SS	3		303														
0.6	Trace organics above 0.9 m depth.		3	SS	1		302														
302.3	SILTY CLAY Soft to firm Grey Wet		4	SS	WH		301														
2.9			5	SS	WH		300														
			6	SS	WH		299														
			7	SS	WH		298														
	Silt seams encountered between 7.5 m and 9.0 m depth.		8	SS	1		297														
296.2	CLAYEY SILT Firm Grey Wet		9	SS	4		296														
9.0			10	SS	7		295														
294.7	SILT, trace to some clay Loose to dense Grey Wet		11	SS	35		294														
10.5							293														
							292														
290.6	END OF BOREHOLE START OF DCPT						291														
14.6																					

SUD-MTO 001 10-1191-0044SUD.GPJ GAL-MISS.GDT 19/12/13 DATA INPUT:

Continued Next Page

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

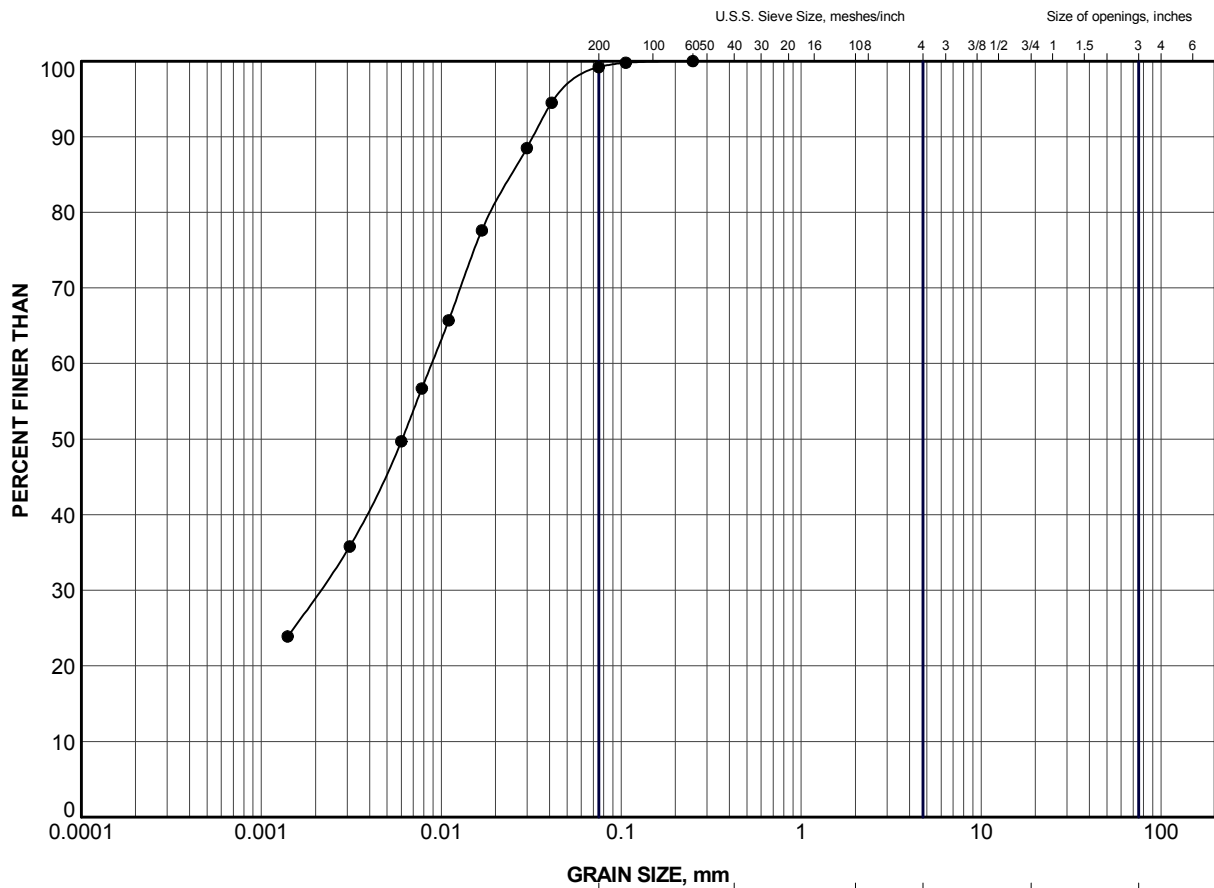


+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE



APPENDIX B


Highway 66 Realignment, Virginiatown – Culvert at STA 14+510 Laboratory Test Results

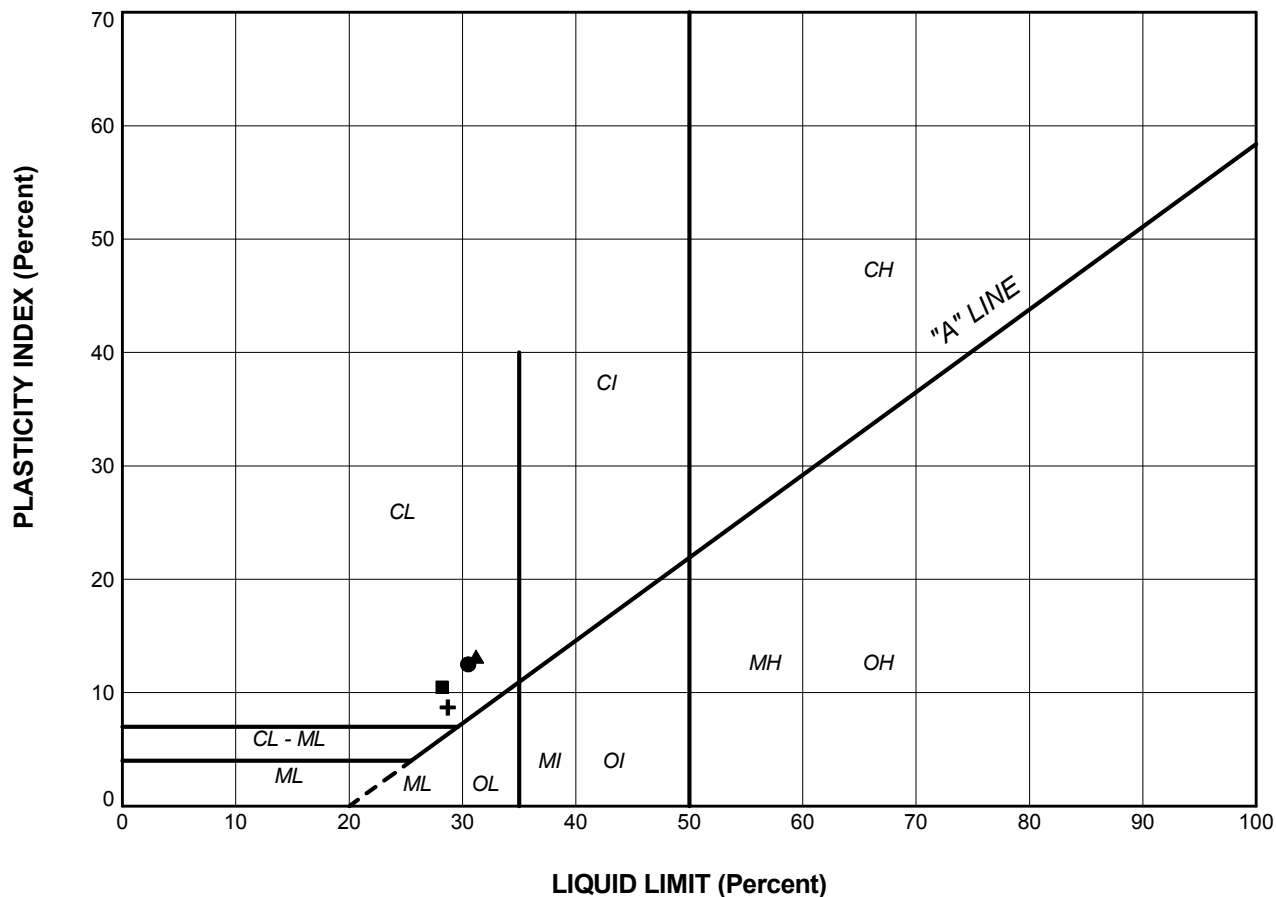


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC4-1	3	303.2

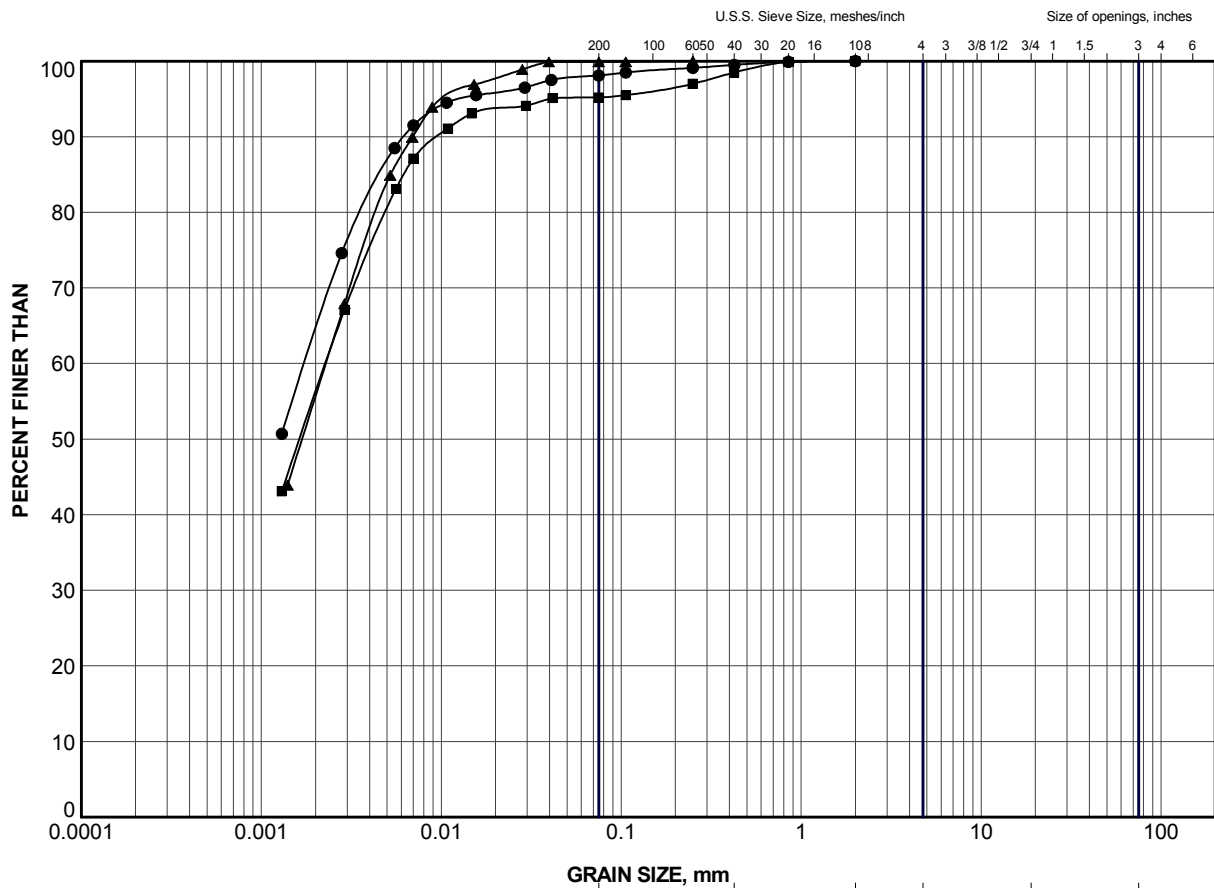
PROJECT					
HIGHWAY 66 - CULVERT BC4 STA 14+510					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT					
PROJECT No.		10-1191-0044		FILE No. 10-1191-0044C.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	SEMC	Dec 2013			
APPR	JMAC	Dec 2013			
 Golder Associates SUDBURY, ONTARIO			FIGURE B1		



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BC4-1	3	30.5	18.0	12.5
■	BC4-2	1b	28.2	17.7	10.5
▲	BC4-3	3	31.2	18.0	13.2
+	BC4-3	8	28.7	20.0	8.7

PROJECT						HIGHWAY 66 - CULVERT BC4 STA 14+510					
TITLE						PLASTICITY CHART CLAYEY SILT					
PROJECT No.			10-1191-0044			FILE No.			10-1191-0044C.GPJ		
DRAWN		TB		Dec 2013		SCALE		N/A		REV.	
CHECK		SEMC		Dec 2013							
APPR		JMAC		Dec 2013							
 Golder Associates SUDBURY, ONTARIO						FIGURE B2					



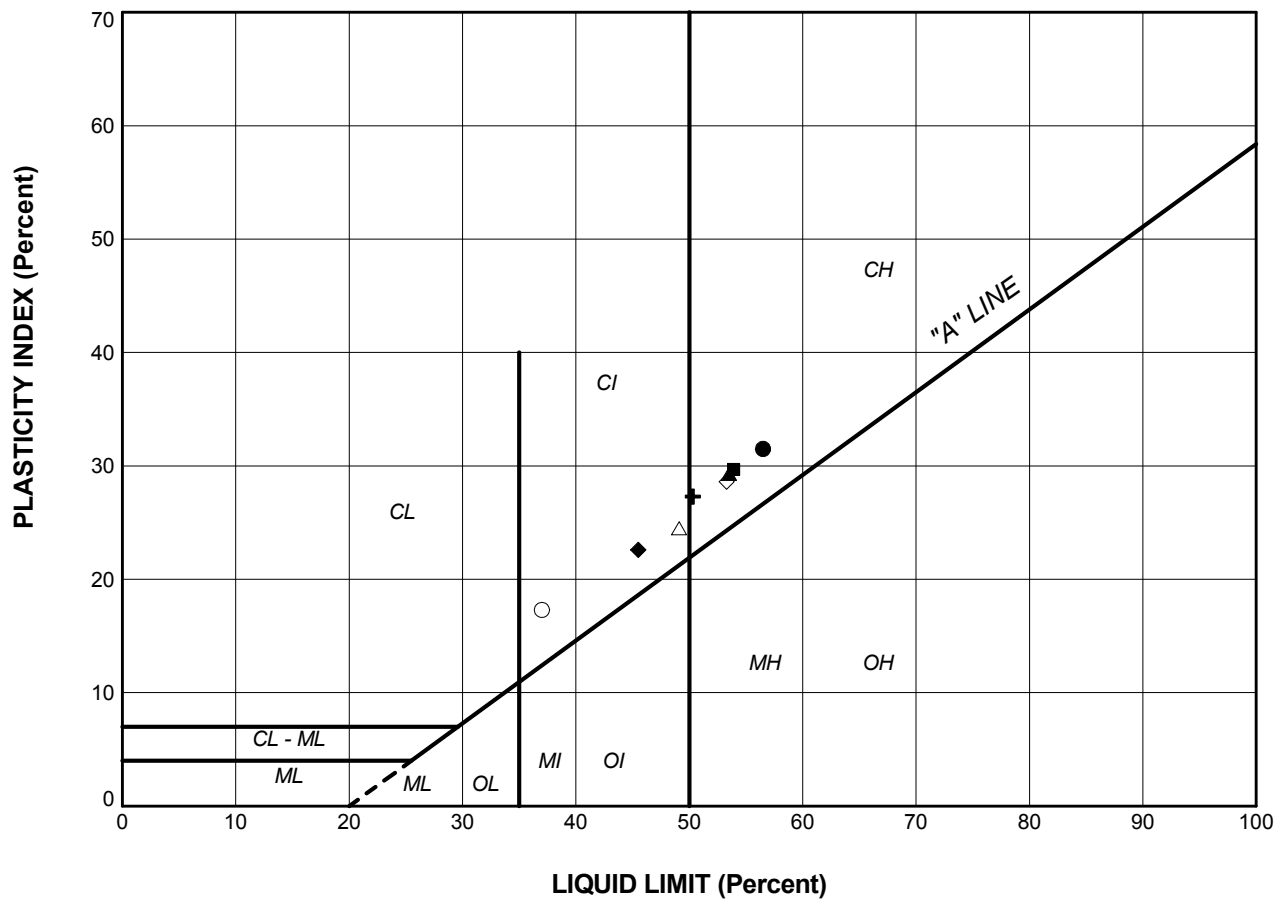
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC4-1	4	301.8
■	BC4-1	6	298.7
▲	BC4-2	5	299.2

PROJECT					
HIGHWAY 66 - CULVERT BC4 STA 14+510					
TITLE					
GRAIN SIZE DISTRIBUTION CLAY					
PROJECT No.		10-1191-0044		FILE No. 10-1191-0044C.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	SEMC	Dec 2013	FIGURE B3		
APPR	JMAC	Dec 2013			






SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BC4-1	4	56.5	25.0	31.5
■	BC4-1	5	53.9	24.2	29.7
▲	BC4-1	6	53.5	24.2	29.3
+	BC4-1	7	50.3	23.0	27.3
◆	BC4-2	3	45.5	22.9	22.6
◇	BC4-2	5	53.3	24.7	28.6
○	BC4-2	7	37.0	19.7	17.3
△	BC4-3	5	49.1	24.6	24.5

PROJECT					HIGHWAY 66 - CULVERT BC4 STA 14+510				
TITLE					PLASTICITY CHART SILTY CLAY to CLAY				
PROJECT No.			10-1191-0044		FILE No.			10-1191-0044C.GPJ	
DRAWN	TB	Dec 2013		SCALE	N/A		REV.		
CHECK	SEMC	Dec 2013		FIGURE B4					
APPR	JMAC	Dec 2013							
 Golder Associates SUDBURY, ONTARIO									

CONSOLIDATION TEST SUMMARY**FIGURE B5**

Pg. 1 of 4

SAMPLE IDENTIFICATION

Project Number: 10-1191-0044

Sample Number: 4

Borehole Number: BC4-1

Sample Depth, m: 3.4

TEST CONDITIONS

Test Type Standard

Load Duration, hr 24

Oedometer Number 2

Date Started Dec. 12/12

Date Completed Dec. 26/12

SAMPLE DIMENSIONS AND PROPERTIES - INITIALSample Height, cm 2.526 Unit Weight, kN/m³ 16.11Sample Diameter, cm 6.351 Dry Unit Weight, kN/m³ 9.37Area, cm² 31.68 Specific Gravity, Measured 2.74Volume, cm³ 80.02 Solids Height, cm 0.880Water Content, % 72.04 Volume of Solids, cm³ 27.87Wet Mass, g 131.47 Volume of Voids, cm³ 52.15

Dry Mass, g 76.42

TEST COMPUTATIONS

Pressure	Primary	Corr.		Average					Total
kPa	Consolidation	Height	Void	Height	t ₉₀	cv.	mv	k	Work
		cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s	kJ/m3
0	0	2.526	1.871	2.526					
4	0.02	2.524	1.869	2.525	60	0.0225	1.96E-04	4.33E-07	0.002
13	0.03	2.521	1.865	2.522	73	0.0186	1.38E-04	2.51E-07	0.012
31	0.04	2.516	1.860	2.519	60	0.0224	9.78E-05	2.15E-07	0.051
66	0.09	2.508	1.850	2.512	86	0.0155	9.85E-05	1.49E-07	0.221
137	0.41	2.467	1.804	2.487	505	0.0026	2.29E-04	5.83E-08	1.867
277	2.64	2.203	1.504	2.335	1500	0.0008	7.44E-04	5.62E-08	24.007
558	1.13	2.090	1.375	2.146	694	0.0014	1.60E-04	2.20E-08	45.480
1117	0.88	2.002	1.275	2.046	406	0.0022	6.23E-05	1.33E-08	80.756
558	-0.08	2.010	1.285	2.006					
137	-0.29	2.039	1.318	2.024					
31	-0.36	2.075	1.358	2.057					
4	-0.31	2.105	1.393	2.090					

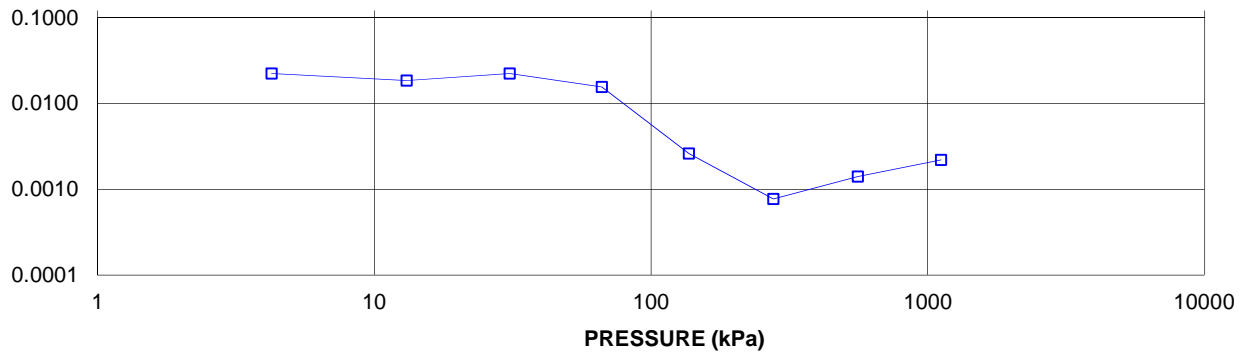
Note:

k calculated using α based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**Sample Height, cm 2.105 Unit Weight, kN/m³ 15.89Sample Diameter, cm 6.35 Dry Unit Weight, kN/m³ 11.24Area, cm² 31.68 Specific Gravity, Measured 2.74Volume, cm³ 66.70 Solids Height, cm 0.880Water Content, % 41.39 Volume of Solids, cm³ 27.87Wet Mass, g 108.05 Volume of Voids, cm³ 38.83

Dry Mass, g 76.42

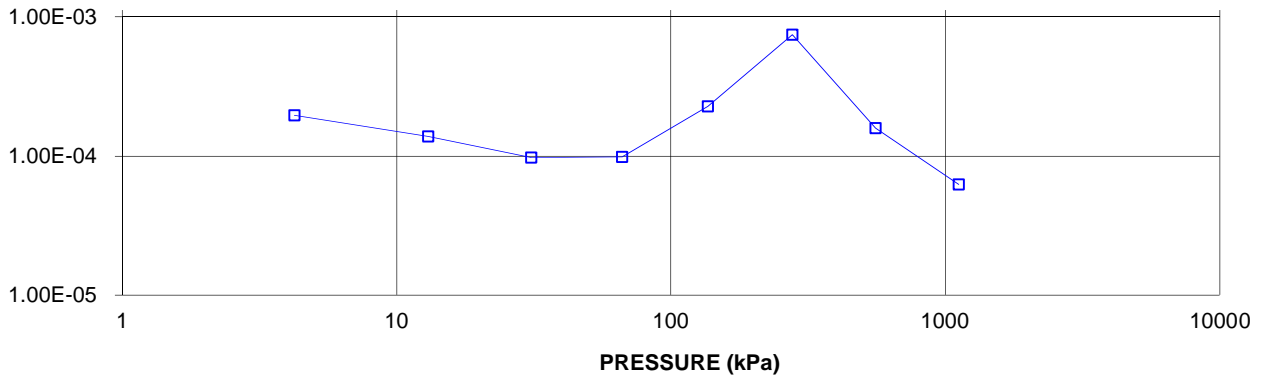
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH BC4-1 Sa 4



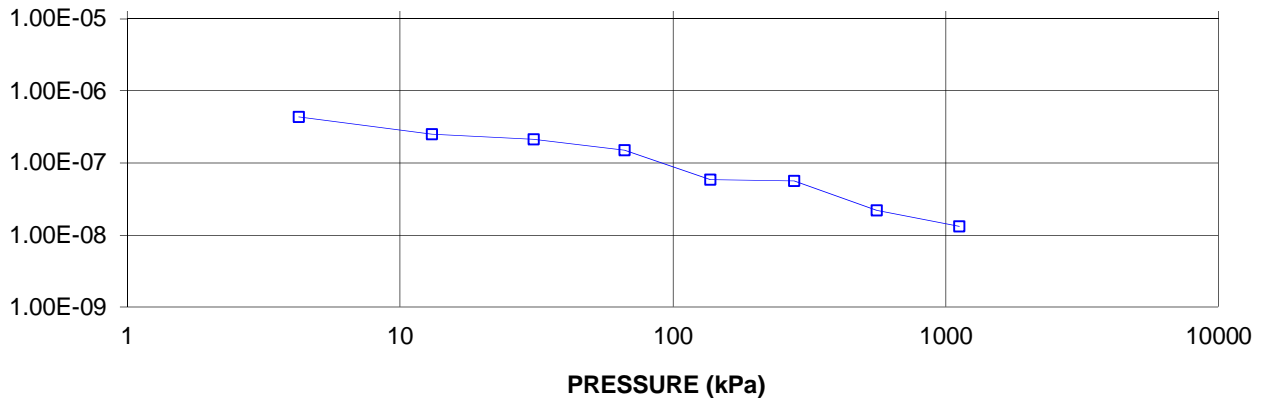
VOLUME COMPRESSIBILITY, m²/kN

CONSOLIDATION TEST
MV m²/kN vs PRESSURE (kPa)
BH BC4-1 Sa 4



HYDRAULIC CONDUCTIVITY,
cm/s

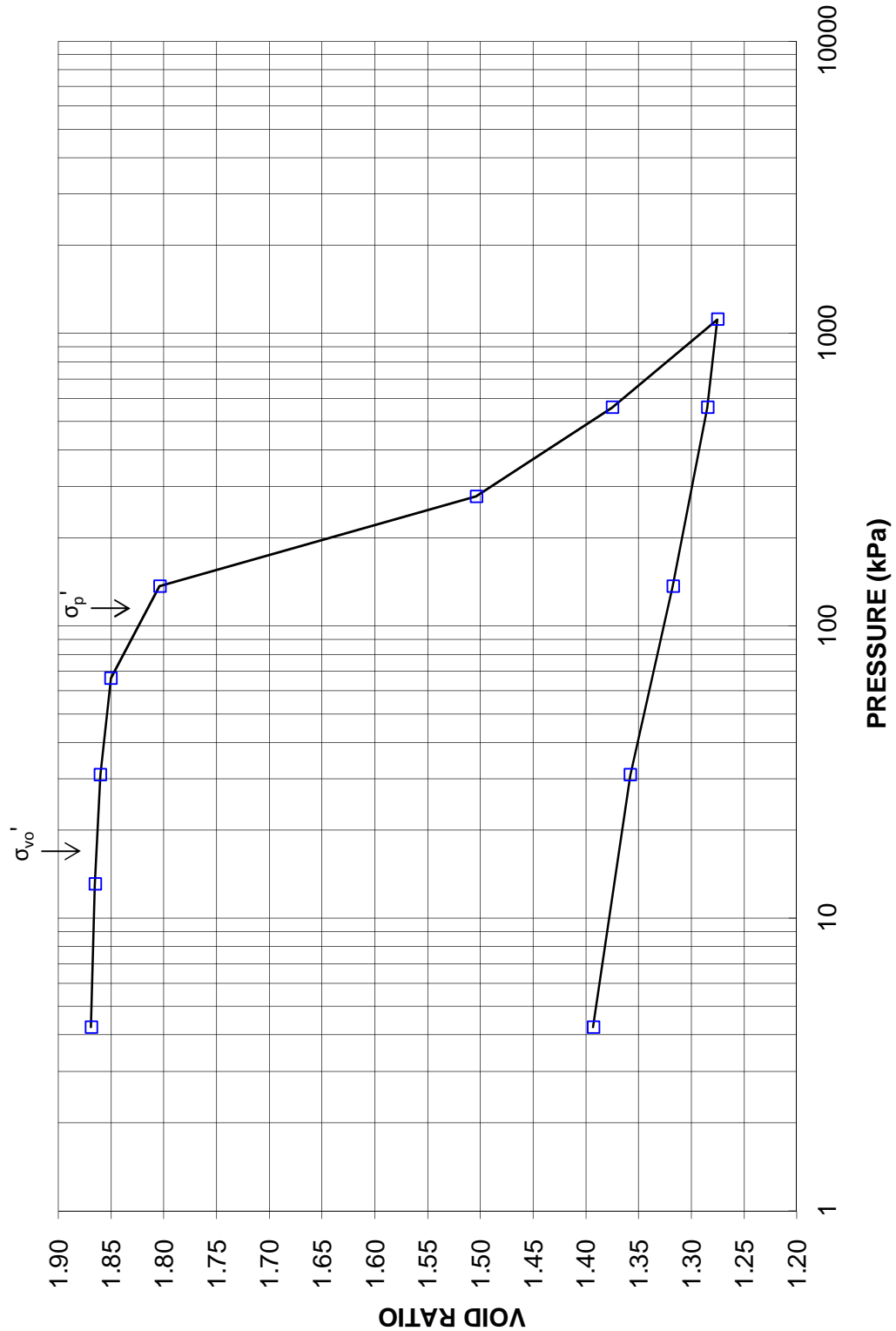
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH BC4-1 Sa 4



CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE

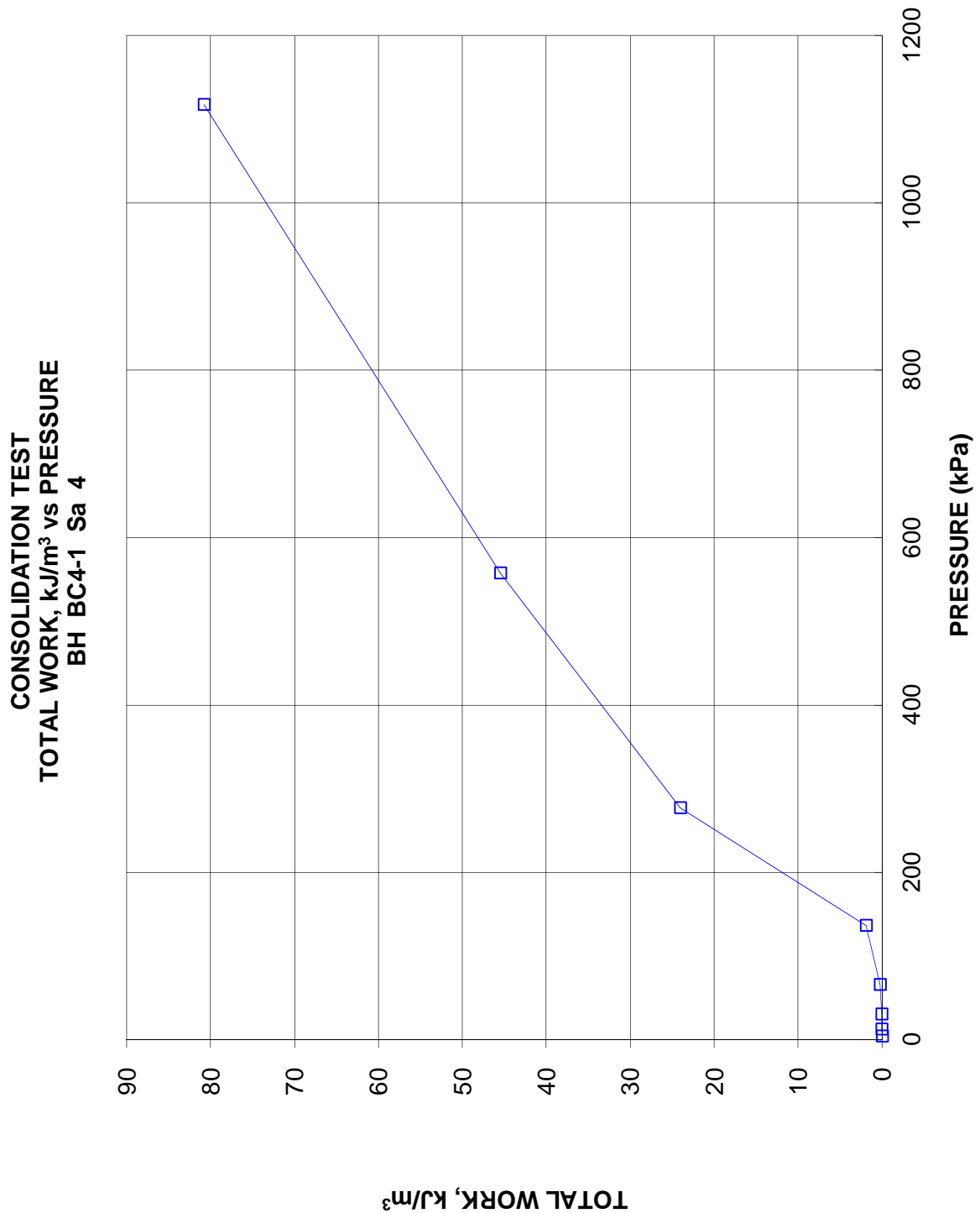
FIGURE B5
Pg. 3 of 4

CONSOLIDATION TEST
VOID RATIO VS PRESSURE
BH BC4-1 Sa 4



**CONSOLIDATION TEST
TOTAL WORK VS PRESSURE**

FIGURE B5
Pg. 4 of 4



CONSOLIDATION TEST SUMMARY**FIGURE B6****Pg. 1 of 4****SAMPLE IDENTIFICATION**

Project Number:	10-1191-0044	Sample Number:	5
Borehole Number:	BC4-1	Sample Depth, m:	4.9

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	Nov. 28/12		
Date Completed	Dec. 11/12		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.526	Unit Weight, kN/m ³	16.24
Sample Diameter, cm	6.351	Dry Unit Weight, kN/m ³	9.81
Area, cm ²	31.68	Specific Gravity, Measured	2.74
Volume, cm ³	80.02	Solids Height, cm	0.923
Water Content, %	65.50	Volume of Solids, cm ³	29.25
Wet Mass, g	132.48	Volume of Voids, cm ³	50.77
Dry Mass, g	80.05	Degree of Saturation, %	103.3

TEST COMPUTATIONS

Pressure kPa	Primary Consolidation	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s	Total Work kJ/m ³
0	0	2.526	1.736	2.526					
4	0.02	2.524	1.734	2.525	86	0.0156	2.05E-04	3.15E-07	0.002
13	0.02	2.521	1.731	2.523	60	0.0225	1.08E-04	2.39E-07	0.010
31	0.05	2.516	1.725	2.519	60	0.0224	1.17E-04	2.58E-07	0.056
66	0.11	2.505	1.714	2.511	86	0.0155	1.19E-04	1.81E-07	0.262
137	1.20	2.386	1.584	2.445	1622	0.0008	6.75E-04	5.17E-08	5.116
277	1.80	2.205	1.388	2.295	1109	0.0010	5.08E-04	5.01E-08	20.762
558	0.89	2.116	1.292	2.161	375	0.0026	1.26E-04	3.25E-08	37.632
1117	1.41	1.975	1.139	2.046	194	0.0046	9.96E-05	4.46E-08	93.368
558	-0.15	1.991	1.156	1.983					
137	-0.29	2.020	1.188	2.005					
31	-0.31	2.050	1.221	2.035					
4	-0.27	2.078	1.250	2.064					

Note:

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

Sample Height, cm	2.078	Unit Weight, kN/m ³	16.38
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	11.93
Area, cm ²	31.68	Specific Gravity, Measured	2.74
Volume, cm ³	65.82	Solids Height, cm	0.923
Water Content, %	37.31	Volume of Solids, cm ³	29.25
Wet Mass, g	109.92	Volume of Voids, cm ³	36.57
Dry Mass, g	80.05		

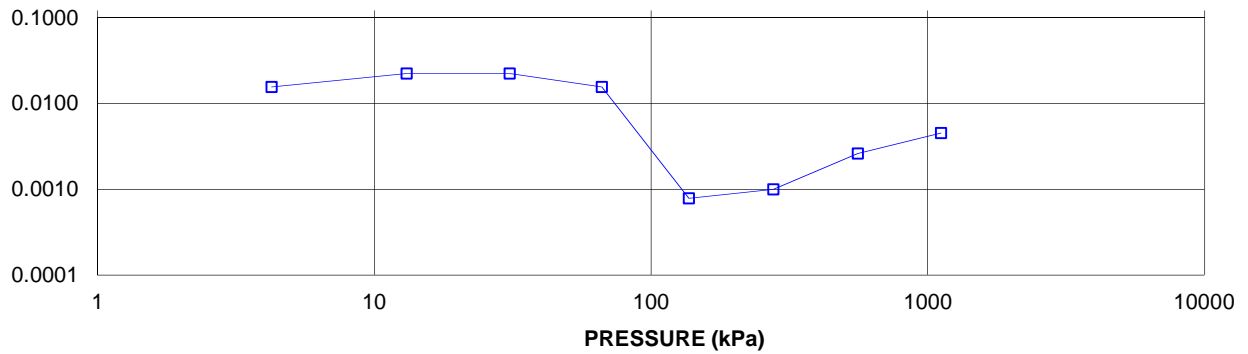
CONSOLIDATION TEST SUMMARY

FIGURE B6

Pg. 2 of 4

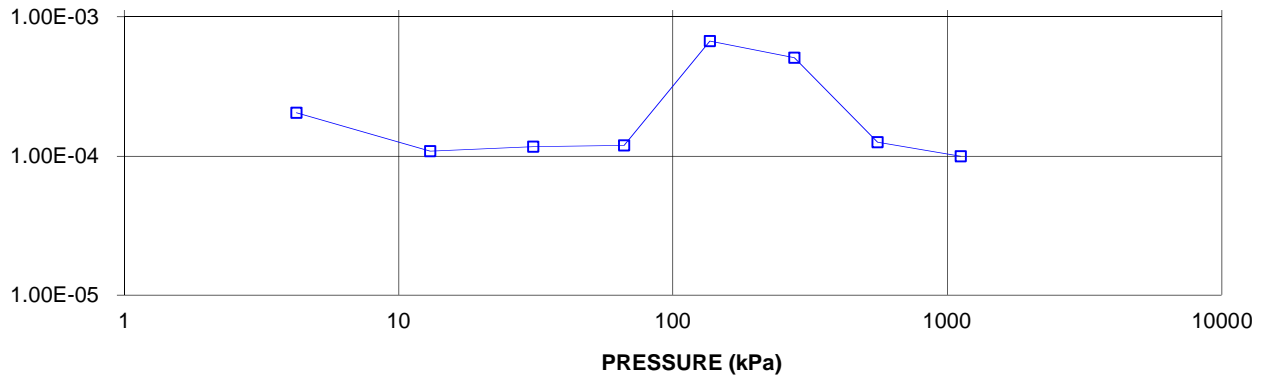
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS PRESSURE (kPa)
BH BC4-1 Sa 5



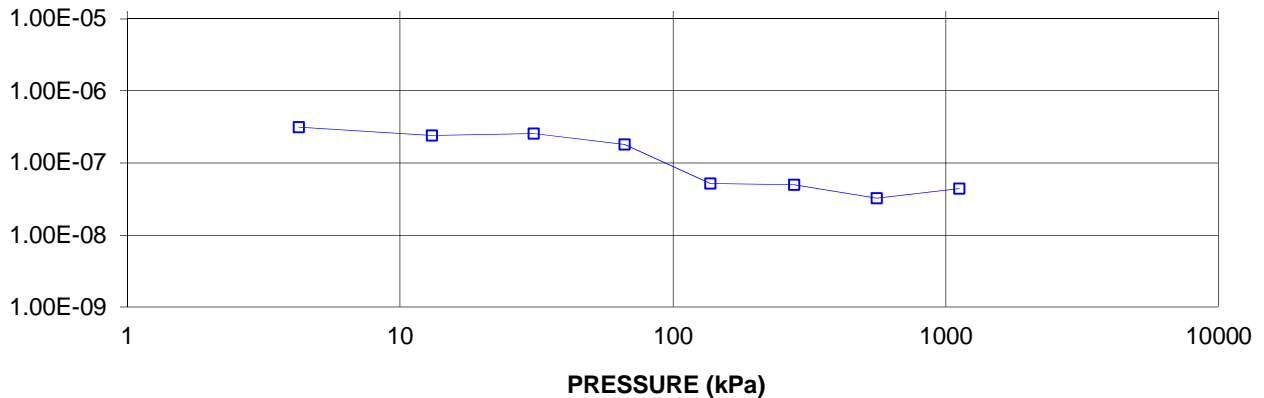
VOLUME COMPRESSIBILITY, m²/kN

CONSOLIDATION TEST
MV m²/kN vs PRESSURE (kPa)
BH BC4-1 Sa 5



HYDRAULIC CONDUCTIVITY,
cm/s

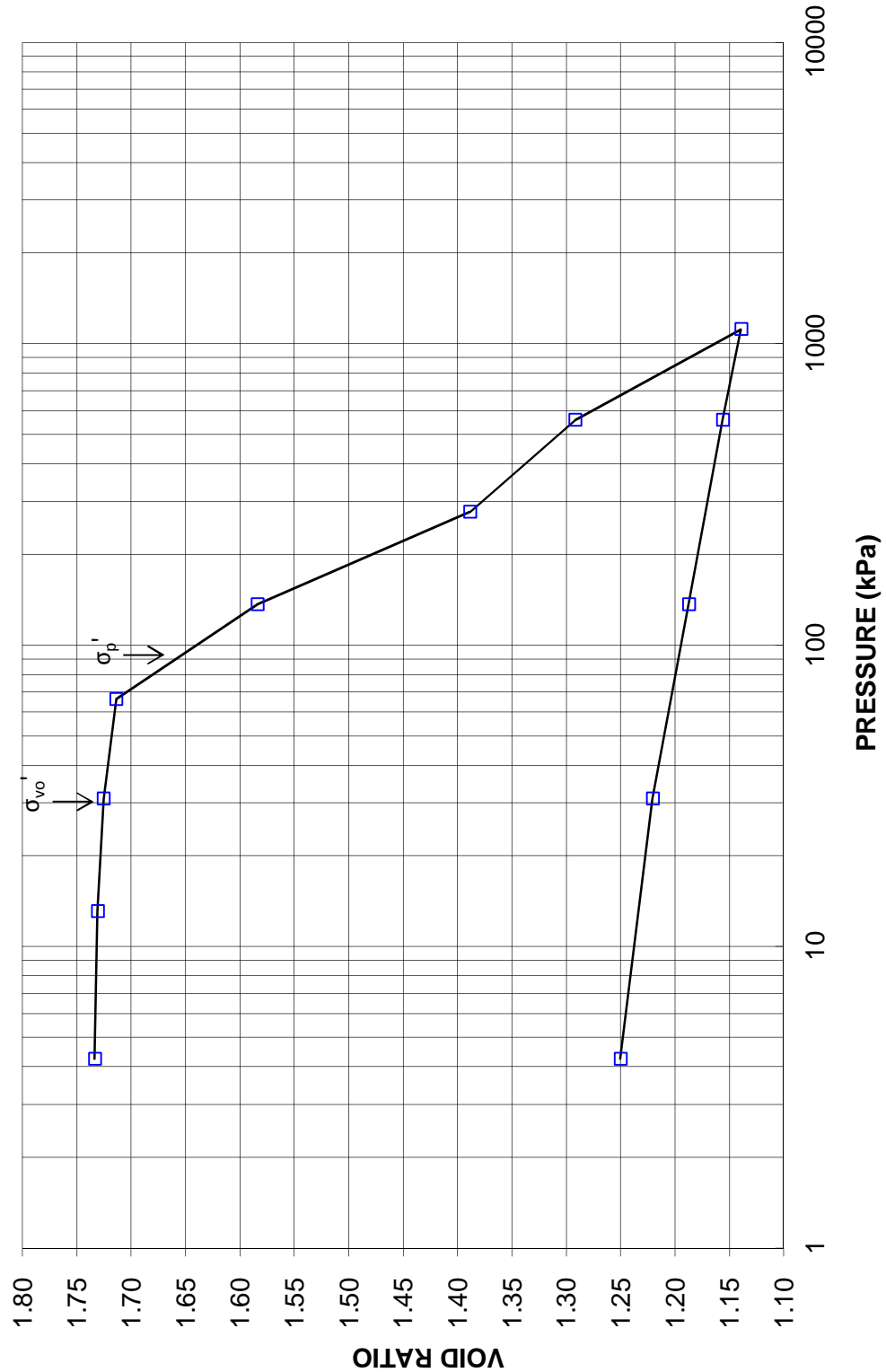
CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
BH BC4-1 Sa 5



**CONSOLIDATION TEST
VOID RATIO VS LOG PRESSURE**

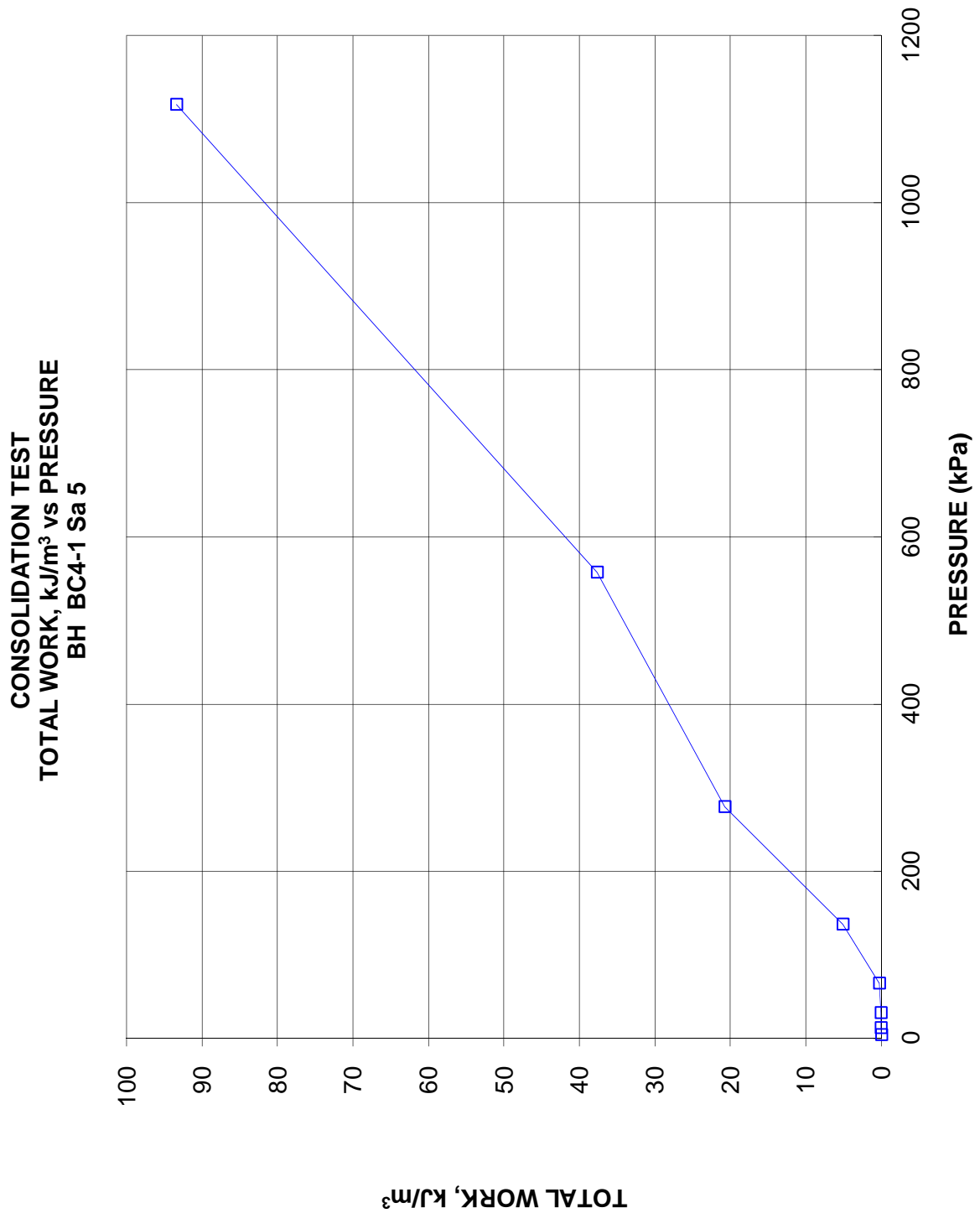
FIGURE B6
Pg. 3 of 4

**CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH BC4-1Sa 5**



**CONSOLIDATION TEST
TOTAL WORK VS PRESSURE**

FIGURE B6
Pg. 4 of 4



CONSOLIDATION TEST SUMMARY**FIGURE B7****Pg. 1 of 4****SAMPLE IDENTIFICATION**

Project Number	10-1191-0044	Sample Number	6
Borehole Number	BC4-1	Sample Depth, m	6.4

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	Dec. 12/12		
Date Completed	Dec. 26/12		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.544	Unit Weight, kN/m ³	16.63
Sample Diameter, cm	6.353	Dry Unit Weight, kN/m ³	10.32
Area, cm ²	31.70	Specific Gravity, measure	2.76
Volume, cm ³	80.64	Solids Height, cm	0.971
Water Content, %	61.04	Volume of Solids, cm ³	30.78
Wet Mass, g	136.71	Volume of Voids, cm ³	49.86
Dry Mass, g	84.89		

TEST COMPUTATIONS

Pressure kPa	Primary Consolidation	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s	Total Work kJ/m ³
0	0.00	2.544	1.620	2.544					
9	0.06	2.538	1.614	2.541	118	0.01164	2.42E-04	2.76E-07	0.010
18	0.04	2.535	1.611	2.536	101	0.01345	1.55E-04	2.62E-07	0.032
35	0.06	2.528	1.604	2.532	60	0.02265	1.43E-04	3.18E-07	0.097
69	0.10	2.519	1.594	2.524	60	0.02250	1.14E-04	2.52E-07	0.301
143	0.35	2.483	1.558	2.501	317	0.00418	1.88E-04	7.71E-08	1.781
285	2.53	2.230	1.297	2.357	960	0.00123	6.99E-04	8.40E-08	23.559
570	1.10	2.120	1.184	2.175	614	0.00163	1.51E-04	2.42E-08	44.653
1140	0.72	2.049	1.110	2.085	290	0.00317	4.94E-05	1.54E-08	73.486
570	-0.06	2.055	1.116	2.052					
143	-0.24	2.079	1.141	2.067					
35	-0.30	2.109	1.172	2.094					
9	-0.26	2.135	1.199	2.122					

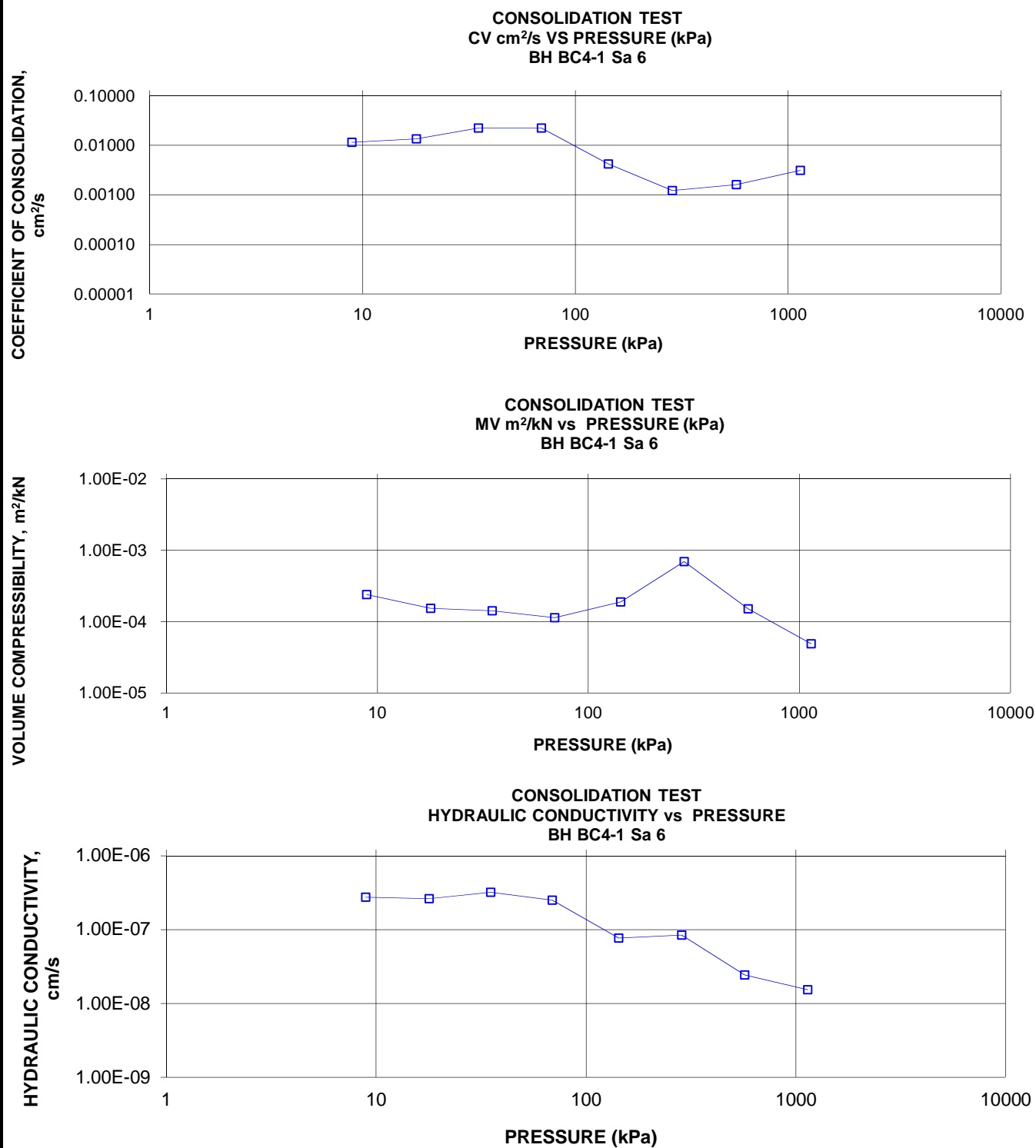
Note:

k calculated using α based on t_{90} values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	2.135	Unit Weight, kN/m ³	16.96
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	12.30
Area, cm ²	31.70	Specific Gravity, measure	2.76
Volume, cm ³	67.69	Solids Height, cm	0.971
Water Content, %	37.94	Volume of Solids, cm ³	30.78
Wet Mass, g	117.10	Volume of Voids, cm ³	36.91
Dry Mass, g	84.89		

CONSOLIDATION TEST SUMMARY

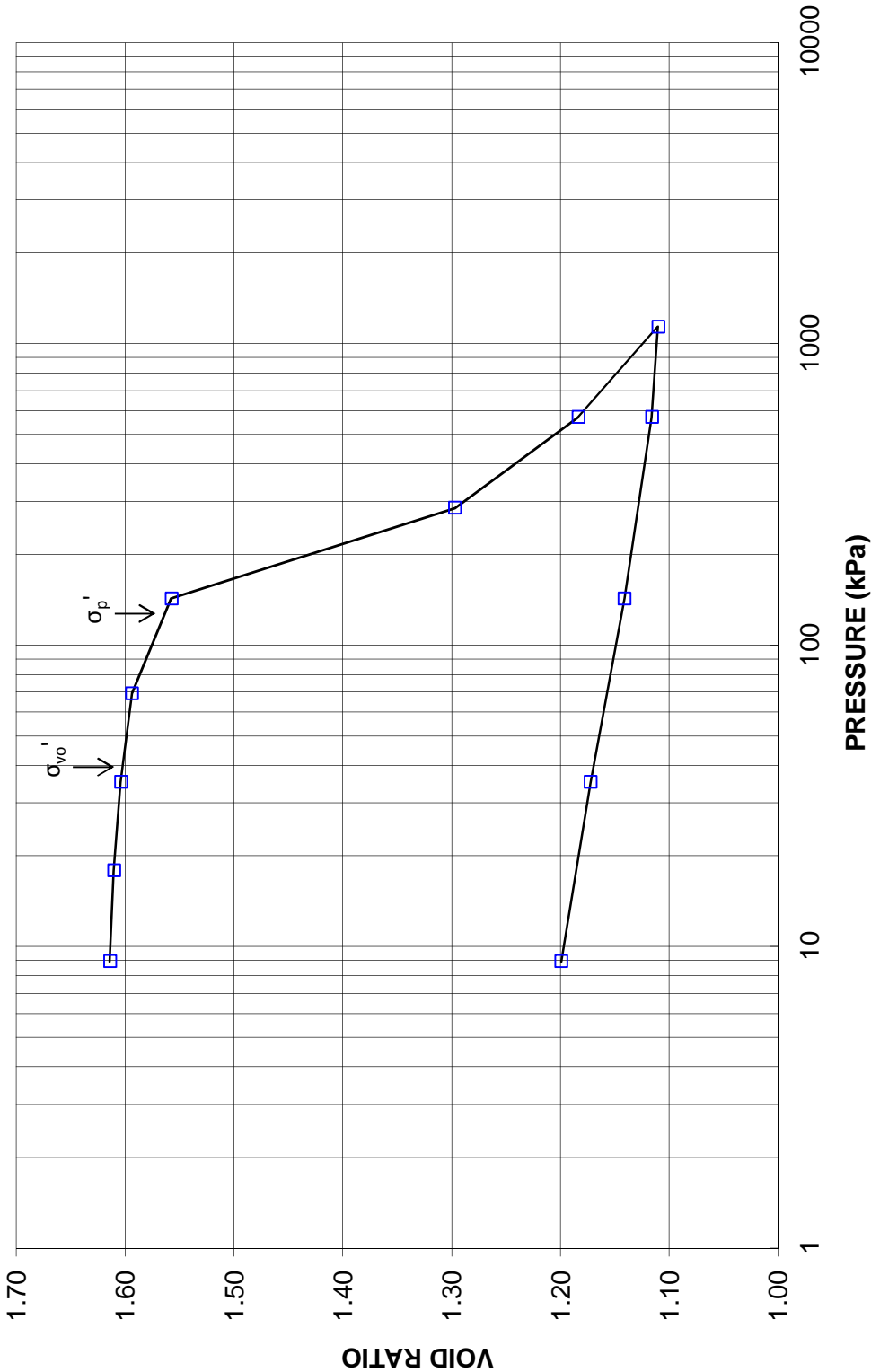
FIGURE B7
Pg. 2 of 4



CONSOLIDATION TEST VOID RATIO VS LOG PRESSURE

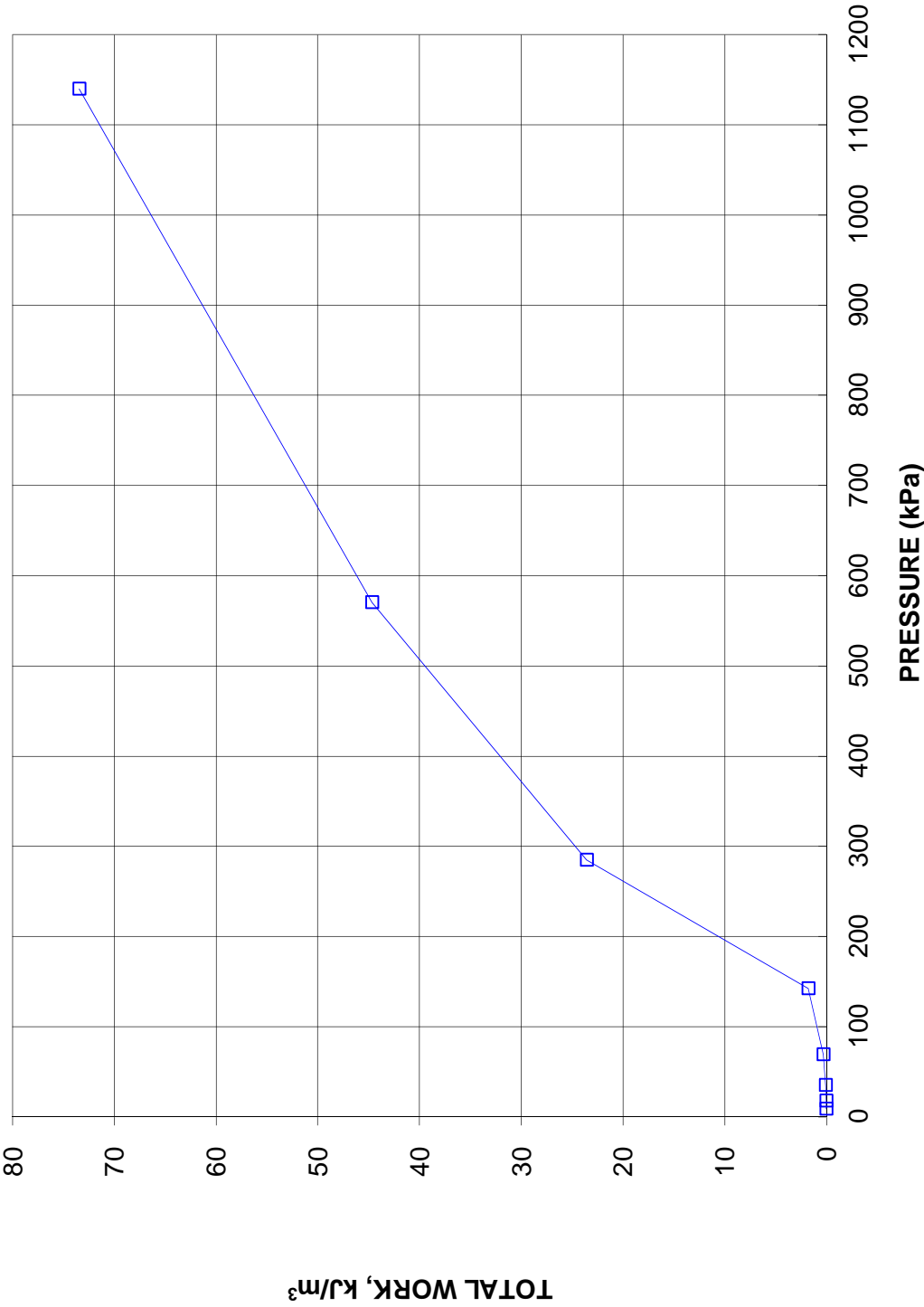
FIGURE B7
Pg. 3 of 4

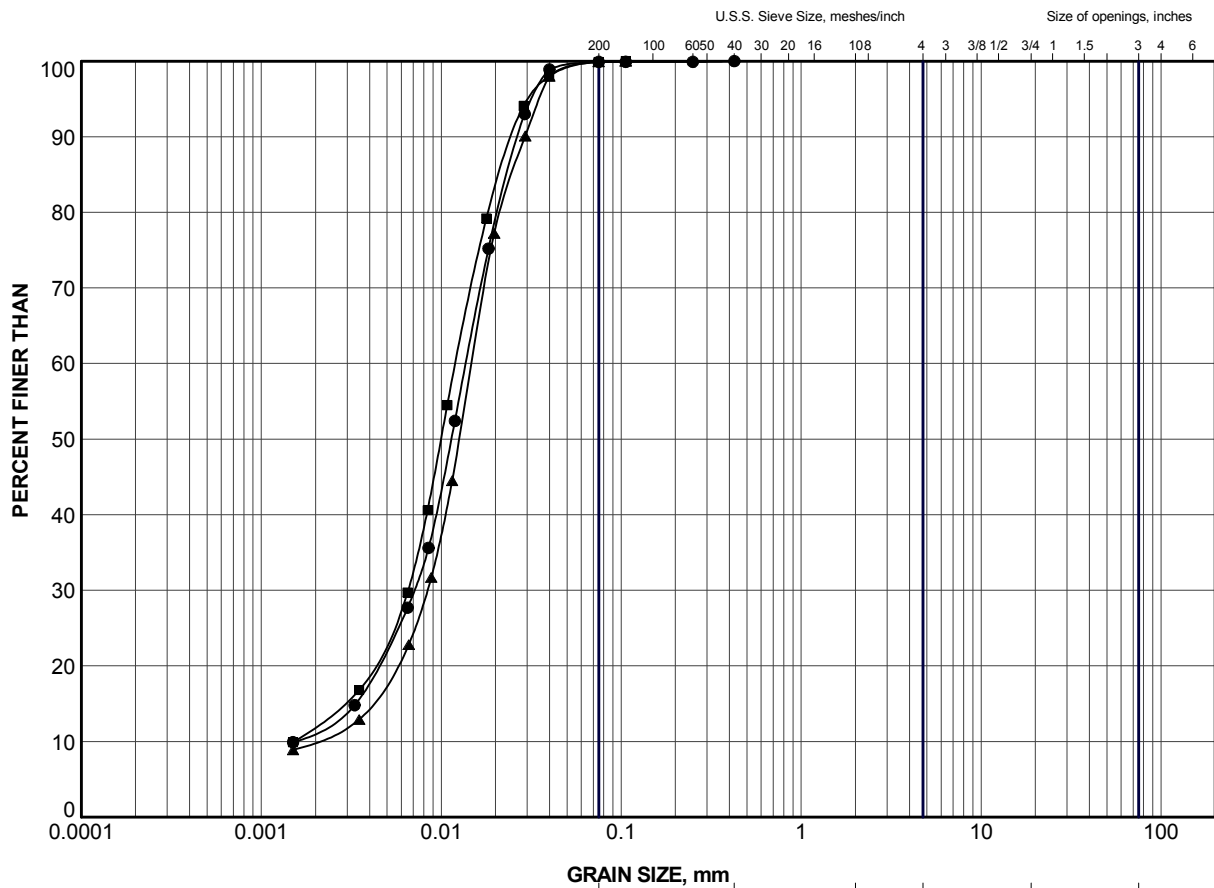
CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH BC4-1 Sa 6



**CONSOLIDATION TEST
TOTAL WORK VS PRESSURE**

**CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs PRESSURE
BH BC4-1 Sa 6**





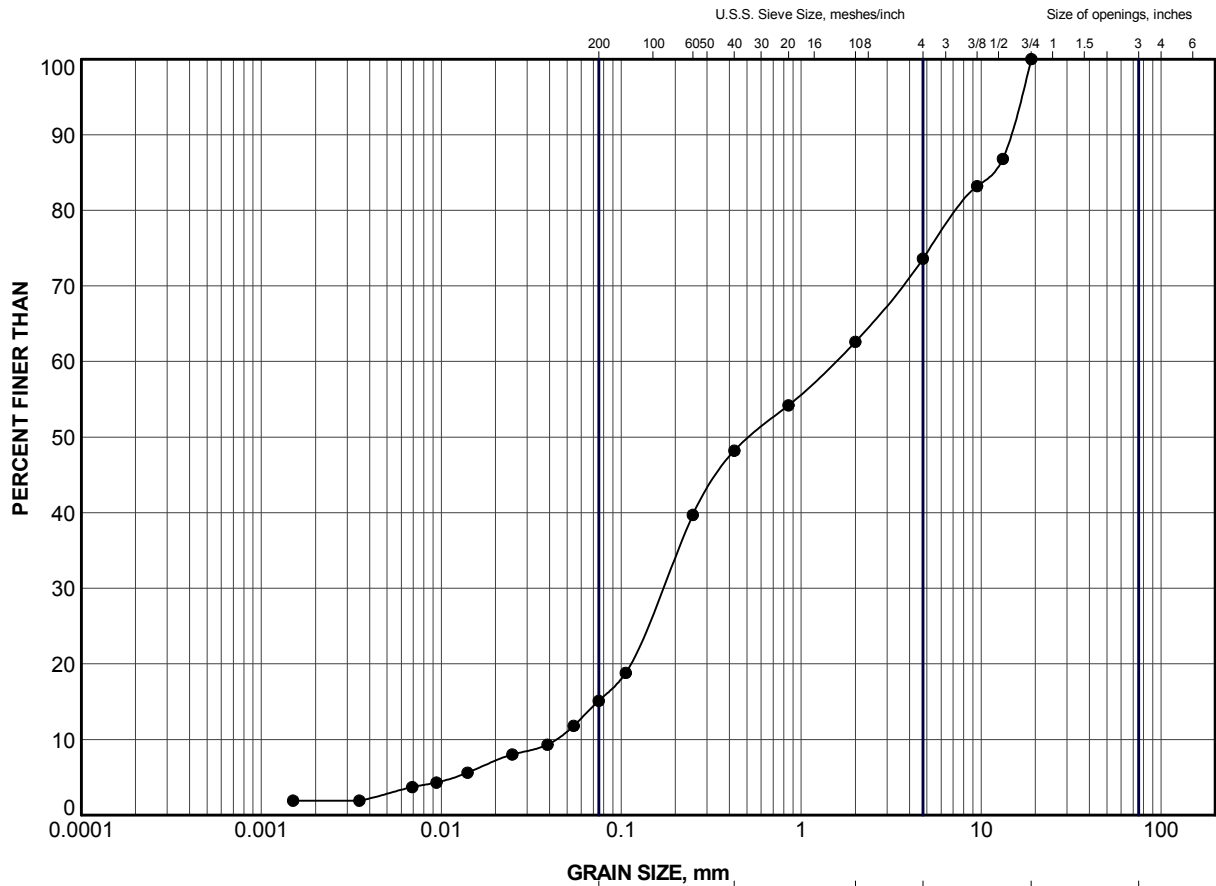
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC4-1	10	292.7
■	BC4-2	8	294.7
▲	BC4-3	10	292.4


PROJECT					
HIGHWAY 66 - CULVERT BC4 STA 14+510					
TITLE					
GRAIN SIZE DISTRIBUTION SILT					
PROJECT No.		10-1191-0044		FILE No. 10-1191-0044C.GPJ	
DRAWN	TB	Dec 2013	SCALE	N/A	REV.
CHECK	SEMC	Dec 2013	FIGURE B8		
APPR	JMAC	Dec 2013			





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

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BC4-1	12	289.8

PROJECT					
HIGHWAY 66 - CULVERT BC4 STA 14+510					
TITLE					
GRAIN SIZE DISTRIBUTION GRAVELLY SAND					
		PROJECT No.		10-1191-0044	
		FILE No.		10-1191-0044C.GPJ	
		DRAWN	TB	Dec 2013	SCALE N/A
		CHECK	SEMC	Dec 2013	REV.
		APPR	JMAC	Dec 2013	
FIGURE B9					

SUD-MTO GSD GLDR_LDN.GDT

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

