

**Golder Associates Ltd.**

2390 Argentia Road  
Mississauga, Ontario, Canada L5N 5Z7  
Telephone: (905) 567-4444  
Fax: (905) 567-6561



**REPORT ON**

**FOUNDATION INVESTIGATION  
MOOSE HORN CREEK CULVERT REPLACEMENT  
HIGHWAY 624  
DISTRICT TIMISKAMING, NEW LISKEARD AREA  
G.W.P. 5259-03-00  
MINISTRY OF TRANSPORTATION, ONTARIO**

Submitted to:

Morrison Hershfield Ltd.  
Suite 600, 235 Yorkland Blvd.  
Toronto, Ontario  
M2J 1T1

GEOCREs NO: 31M-67

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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Ltd. (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the Moose Horn Creek culvert replacement at Highway 624 in the District Timiskaming, New Liskeard area, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P41-1580, dated September 2004, that forms part of the Consultant's Agreement (P.O. Number 5005-A-000420). This report addresses the proposed culvert replacement at Moose Horn Creek as part of the Highway 624 Culvert Replacement at Benson Creek and Moose Horn Creek project. The foundation investigation and design for the two culvert replacement sites is provided in two separate reports. The work was carried out in accordance with the Quality Control Plan for this project dated February 7, 2005.

The purpose of this investigation is to establish the subsurface conditions at the proposed structure by borehole drilling, dynamic cone penetration testing, in situ testing and laboratory testing on selected samples. The general arrangement drawing for the culvert replacement at Moose Horn Creek across Highway 624 was provided to Golder by Morrison Hershfield on June 7, 2005.

## **2.0 SITE DESCRIPTION**

The site is located on Highway 624, approximately 7 km north of Blanche River Bridge (about 12 km north of the intersection with Highway 11) in the Township of Hearst, District Timiskaming, New Liskeard area, Ontario (see key plan on Contract Drawings). The existing highway has two lanes, one lane each for northbound and southbound traffic.

The site generally consists of rolling hills with forest and swamp areas located on both sides of the existing highway. The existing timber culvert is located in a low-lying valley that allows passage of Moose Horn Creek from the east side to the west side of the highway.

The existing Highway 624 grade ranges from about Elevation 246 m to 250 m within the project limits. The existing culvert invert is at about Elevation 237 m, resulting in a fill embankment height of up to 9 m in some areas. The existing embankment side slopes are graded at about 2H (horizontal):1V (vertical) and are covered with mature trees and vegetation on both the east and west side of the highway.

A private residence and driveway is located southwest of the existing culvert location. Stormwater drainage ditches are present on both the east and west sides of the existing highway that direct surface water to culverts and/or natural drainage paths that lead to Moose Horn Creek.

### **3.0 INVESTIGATION PROCEDURES**

#### **3.1 Foundation Investigation**

The field work for this culvert investigation was carried out between February 28 and April 7, 2005 during which time six (6) boreholes, numbering 05-201 to 05-206 (inclusive), and four (4) Dynamic Cone Penetration Tests, numbering DCPT-10, DCPT-20, DCPT-30 and DCPT30A, were advanced at approximately the locations shown in plan on the Contract Drawings.

The field investigation was carried out using a track-mounted CME 55 drill rig and portable tri-pod drilling equipment supplied and operated by Marathon Drilling Inc. of Ottawa, Ontario. The tri-pod drilling equipment was used to advance boreholes and DCPTs from the top of the ice surface at Moose Horn Creek and at locations where conventional drill rigs could not gain access. All of the boreholes were advanced using either 108 mm inside diameter (I.D.) continuous flight hollow stem augers or B-size casing. Soil samples were obtained at intervals ranging from 0.75 m to 3.0 m in depth, using a 50 mm outer diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. Field vane shear tests using an MTO 'N' vane or a 'B' vane were carried out in the cohesive soils. Shelby tube samples were taken in the cohesive soils at selected locations/depth in order to carry out specialized laboratory consolidation testing and further soil classification.

The boreholes were advanced to depths ranging from 12.5 m to 25.0 m below the existing ground surface. The DCPTs were advanced to depths ranging from 4.7 m to 27.4 m below the existing ground/ice surface and were terminated on effective refusal. The groundwater conditions in the open boreholes were observed during the drilling operations and one piezometer was installed in a selected borehole (BH05-203) to permit monitoring of the groundwater level at this location. The piezometer consisted of 25 mm outside diameter PVC tubing with a 3 m long slotted tip that is sealed at a selected depth within the borehole. The boreholes and piezometer were backfilled with bentonite according to Ontario Regulation 128/03. The installation details and water level readings are described on the Record of Borehole sheets that follow the text of this report.

The field work was supervised by members of our technical staff, who located the boreholes, arranged for the clearance of underground services, supervised 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 Mississauga geotechnical laboratory where the samples underwent further detailed 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 select samples. Specialized laboratory consolidation testing was carried out on one sample from Borehole 05-201 and laboratory organic content testing was carried out on one sample from Borehole 05-204.

The boreholes were located in the field, relative to local benchmarks identified on the site plan provided by Morrison Hershfield, by Golder personnel prior to drilling operations. Upon completion of the fieldwork, the elevations of the completed boreholes were surveyed by Golder personnel relative to benchmark geodetic datum elevations provided by Morrison Hershfield and the final borehole locations were converted to MTO Station and Offset relative to the existing Highway 624 centreline.

## **4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

From published geologic information, the site is located in the physiographic region known as the Abitibi Uplands that form the easternmost part of the Canadian Shield (Ontario Geological Society (OGS), 1991. "Geology of Ontario, Special Volume 4, Part I"). The terrain is comprised largely of metavolcanic and minor metasedimentary rocks. Bostock (1970) in OGS (1991) describes the Abitibi Uplands as a rocky landscape, scattered with lakes and large areas that are mantled by deposits from Pleistocene glaciation consisting of the lacustrine clays and former shorelines of proglacial lakes. Landforms typically include outwash channels, tills and moraines. The local physiography is generally characterized by variable overburden materials and an irregular, variable bedrock surface with rock outcrops.

### **4.2 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 given on the attached Record of Borehole sheets and in Appendix A following the text of this report.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests (SPTs). 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 results of the boreholes at the culvert replacement location is shown on the Contract Drawings.

In general, the subsoils at the site consist of a surficial layer of fill (i.e. the existing highway embankment) comprised of silty sand and gravel to silt and sand. The upper fill zone consisted of silty sand and gravel containing cobbles and boulders and transitioned to a lower fill zone that consisted of silt and sand containing pockets of silty clay and organics. Underlying the fill, a thin layer of silt and sand containing organics was encountered, underlain by a deposit of varved silty clay. A deposit of sand to silty sand was present below the varved clay; all of the boreholes were terminated within this deposit.

#### **4.2.1 Asphalt**

Asphalt was encountered at ground surface in Boreholes 05-201 to 05-203 (i.e. the boreholes put down along the existing Highway 624). The asphalt thickness ranged from about 25 mm to

125 mm. In Borehole 05-203, two thin asphalt layers were separated by an approximately 75 mm thick layer of silty sand and gravel fill.

#### **4.2.2 Embankment Fill**

Embankment fill consisting of sand and gravel, silty sand and gravel, silty sand, silt and sand, or re-worked silty clay was encountered below the asphalt (i.e. near the embankment centreline) in Boreholes 05-201, 05-202, 05-203 and below the ice in the ditch, near the embankment midslope in Borehole 05-206. The upper embankment fill consisted predominantly of silty sand and gravel containing cobbles and boulders to a depth of about 2 m to 3 m below the road surface. Below a depth of about 3 m from the road surface, the lower embankment fill consisted predominantly of silt and sand containing pockets of silty clay and organics. The top of the fill along the embankment centreline was encountered between Elevation 245.9 m and Elevation 250.3 m and ranged from about 2.1 m to 9.1 m in thickness.

Standard Penetration Testing (SPT) 'N' values recorded within the embankment fill ranged between 0 (i.e. weight of hammer) and greater than 50 blows per 0.1 m of penetration. The upper embankment fill 'N' values ranged between 36 blows per 0.3 m of penetration and greater than 50 blows per 0.1 m of penetration, indicating a dense to very dense state of packing. The higher blow counts may be attributed to the presence of cobbles and boulders and/or frozen ground which was measured to penetrate up to 2.1 m in depth at the time of the investigation. The lower embankment fill 'N' values ranged between 0 (i.e. weight of hammer) and 9 blows per 0.3 m of penetration, indicating a very loose to loose relative density or very soft to stiff consistency.

Natural water contents measured on samples of the embankment fill ranged between 2 and 36 percent. The natural water contents measured on the upper fill typically ranged between 2 and 20 percent and the lower fill typically ranged between 12 and 36 percent. Grain size distribution curves for selected samples of the upper sand and gravel fill and the lower sand and silt fill are shown on Figures A1 and A2, respectively, in Appendix A.

#### **4.2.3 Ice and Water**

Ice and/or water were encountered at surface in Boreholes 05-204, 05-205 and 05-206 (i.e. the boreholes put down on or near the Moose Horn Creek ice surface). The top of the ice surface at Moose Horn Creek was at Elevation 236.8 m and 236.9 m at Boreholes 05-204 and 05-205, respectively. At Borehole 05-206 the ice surface along a drainage path on the mid-slope of the embankment was at Elevation 240.2 m. The ice thickness was measured to range from about 0.2 m to 0.6 m thick. Open water was encountered below the ice surface in Borehole 05-204 and the total ice/water thickness from the top of the ice surface was about 0.9 m.



#### **4.2.4 Sandy Silt**

Underlying the embankment fill, a layer of sandy silt was encountered in Borehole 05-202. The sandy silt layer contained interlayers of clayey silt and sand seams. The top of the sandy silt layer was encountered at about Elevation 248.2 and was approximately 0.8 m thick.

A Standard Penetration Testing (SPT) 'N' value recorded within this layer was 4 blows per 0.3 m of penetration, indicating a very loose to loose relative density.

The natural water content measured on a sample of the sandy silt layer was 20 percent.

#### **4.2.5 Organic Silt and Sand / Silty Sand with Organics**

A layer of organic silt and sand to silty sand with organics and wood fragments was encountered surficially (i.e. below the ice and/or water) in Boreholes 05-204 and 05-205, and below the embankment fill in Borehole 05-201. The top of this layer was encountered at depths of about 0.2 m and 0.9 m below the ice surface and 9.2 m below the ground surface, corresponding to between Elevations 235.9 m and 236.8 m. The large range in depths to the top of this layer is due to the fact that Borehole 05-201 was advanced from the roadway, whereas Boreholes 05-204 and 05-205 were advanced from the creek level. The thickness of the organic silt and sand to silty sand layer varied between 0.8 m and 1.3 m.

Standard Penetration Testing (SPT) 'N' values recorded within this layer typically ranged between 0 (i.e. weight of hammer) and 2 blows per 0.3 m of penetration, indicating a very loose relative density. An SPT 'N' value of 15 was recorded within this layer in Borehole 05-201, indicating a compact relative density under the maximum height of existing embankment fill.

The natural water content measured on samples of the organic silt and sand to silty sand containing organics layer ranged between 22 and 57 percent. A grain size distribution curve for a selected sample of the organic silt and sand is shown on Figures A3 in Appendix A. A laboratory organic content measured on a sample of the organic silt and sand was 6.5 %.

#### **4.2.6 Varved Silty Clay to Clay**

A deposit of varved silty clay to clay was encountered below the embankment fill, sandy silt, and silty sand with organics in all of the boreholes. In Borehole 05-202, a thin layer of clayey silt (approximately 1 m thick) containing sand seams was encountered above the varved silty clay. The varved silty clay consisted of alternating grey and dark grey silty clay and clay layers and contained occasional fine sand seams. The top of the varved silty clay and clay deposit was encountered at depths ranging between about 1.5 m and 10.2 m below ground or ice surface,

corresponding to between Elevations 235.1 m and 247.4 m. The thickness of this deposit varied between 2.6 m and 18.0 m.

Standard Penetration Testing (SPT) 'N' values recorded within the varved silty clay to clay ranged between 1 and 6 blows per 0.3 m of penetration, indicating a very soft to firm consistency.

The results of field vane tests for the undrained shear strength of the varved silty clay to clay are summarized on Figure 1, which show a comparison of the strengths measured at the bottom of the valley with those measured at the sides/top of the valley. Based on the field vane tests, the shear strength of the varved silty clay deposit ranges from 20 kPa to 85 kPa (indicating a soft to stiff consistency) at the bottom of the valley and from 35 kPa to greater than 95 kPa (indicating a firm to stiff consistency) on the top and sides of the valley. The sensitivity of the varved silty clay deposit, estimated from the field vane tests, ranges from 2.3 to 7.0, implying the varved silty clay in this area is medium sensitive to sensitive based on the classification system provided in CFEM (1992). A summary of the sensitivity results is given on Figure 2.

The natural water content measured on samples of the varved silty clay deposit ranged between 35 and 52 percent, with an average of 45 percent. The water contents were near the liquid limit value. Grain size distribution curves for two selected samples of the varved silty clay deposit are shown on Figure A4 in Appendix A.

The results of Atterberg Limits testing carried out on selected samples of the varved silty clay deposit are illustrated on the plasticity chart on Figure A5 in Appendix A. The test results are summarized in the following table which indicates that the varved silty clay has intermediate to high plasticity.

<i>Borehole</i>	<i>Sample</i>	<i>Elevation (m)</i>	<i>Liquid Limit (%)</i>	<i>Plastic Limit (%)</i>	<i>Plasticity Index (%)</i>
05-201	11	233.8-233.3	47	21	26
05-202	7	244.3-243.7	52	20	32
05-202	11	238.8-237.6	55	21	34
05-203	5	244.3-243.7	57	22	35
05-203	7	241.7-241.1	48	21	27
05-203	11	235.6-235.0	47	21	26
05-204	3	233.8-233.1	40	20	20
05-205	3	235.4-234.8	43	21	22
05-205	4	233.8-233.4	41	20	21
05-206	5	237.2-236.5	52	27	25
05-206	7	234.1-233.5	39	20	19
Average	-	-	47	21	26

Laboratory consolidation testing was carried out on a specimen of the varved silty clay obtained from a Shelby tube sample. The results are summarized in the table below:

<i>Borehole and Sample No.</i>	<i>Elevation (m)</i>	<i><math>\sigma_{vo}'^*</math> (kPa)</i>	<i><math>\sigma_p'</math> (kPa)</i>	<i><math>\sigma_p' - \sigma_{vo}'</math> (kPa)</i>	<i>OCR</i>	<i><math>e_o</math></i>	<i><math>C_r</math></i>	<i><math>C_c</math></i>	<i><math>c_v^{**}</math> (cm<sup>2</sup>/s)</i>
05-201, Sa#11	233.8-233.3	216	230	14	1.1	1.26	0.070	0.52	$5.9 \times 10^{-3}$

Notes: \* Assumed water level at Elev. 237m (i.e. Moose Horn Creek water level)

\*\* For stress range of  $200 \leq \sigma_v' \leq 250$  kPa

where:  $\sigma_{vo}'$  is the effective overburden pressure in kPa  
 $\sigma_p'$  is the preconsolidation pressure in kPa  
OCR is overconsolidation ratio  
 $e_o$  is initial void ratio  
 $C_c$  is the compression index (based on void ratio)  
 $C_r$  is the recompression index  
 $c_v$  is the coefficient of consolidation in cm<sup>2</sup>/s

The varved silty clay sample used for the consolidation test (i.e. BH 05-201, Sa#11) was located below the centreline of the existing embankment and is considered to be near normally consolidated under the embankment loading. At the culvert ends, the varved silty clay is considered to be slightly preconsolidated under the low embankment loading based on the results of in-situ and laboratory testing.

The bulk unit weight measured on one sample of the varved silty clay produced a value of about 17.4 kN/m<sup>3</sup>. A specific gravity of 2.73 was measured on one sample of the varved silty clay.

#### 4.2.7 Silty Sand, Silt and Sand, Sand

Beneath the varved silty clay, interlayers of silty sand, silt and sand, and sand containing trace to some clay was encountered in all of the boreholes. The top of the silty sand, silt, and sand deposit was encountered at depths ranging from about 4.3 m to 21.0 m, corresponding to elevations ranging from 229.4 m to 233.2 m. All of the boreholes were terminated within this deposit at depths ranging from 12.5 m to 25.0 m (Elevations ranging from 215.1 m to 225.4 m), resulting in a measured layer thickness of between about 4.3 m and greater than 16.6 m. A DCPT was advanced from the bottom of Borehole 05-201 until effective refusal was reached at a depth of 27.4 m (Elevation 218.5 m) within the inferred granular deposit. DCPT-20, DCPT-30 and DCPT-30A were terminated upon effective refusal (as defined by greater than 100 blows per 0.3 m of cone penetration) within the inferred granular deposit at depths ranging from 4.7 m to 9.5 m (Elevation 227.5 m to Elevation 232.2 m).

Standard Penetration Testing (SPT) 'N' values recorded within the silty sand, silt, and sand deposit ranged between 1 and 79 blows per 0.3 m of penetration, but typically between 7 and 50 blows indicating a loose to dense relative density, typically compact. The lower 'N' values may be attributed to some base heave of the saturated sand at the bottom of the borehole during sampling operations.

The natural water content measured on samples of the silty sand, sand and silt deposit ranged between 3 and 28 percent. Grain size distribution curves for selected samples of the silty sand, silt and sand, and sand deposit are shown on Figure A6 in Appendix A.

#### 4.2.8 Groundwater Conditions

The water levels were noted in the open boreholes after the drilling operations. A piezometer was installed in Borehole 05-203. The piezometer was sealed into the silty sand to sand deposit, below the varved silty clay. Details of the piezometer installation are shown on the Record of Borehole Sheet following the text of this report. The water levels in the piezometer and open boreholes upon completion of drilling are summarized in the table below:

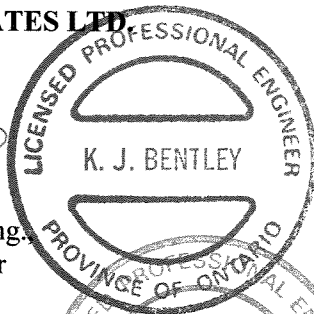
<i>Borehole</i>	<i>Installation</i>	<i>Ground Surface Elevation (m)</i>	<i>Depth to Water Level (m)</i>	<i>Water Level Elevation (m)</i>	<i>Date</i>
05-201	Open Borehole	246.0	4.6	241.4	March 1, 2005
05-202	Open Borehole	250.4	2.4	248.0	March 2, 2005
05-203	Piezometer	247.8	17.3	230.5	March 29, 2005
05-204	Open Borehole	236.8	0	236.8	March 28, 2005
05-205	Open Borehole	236.9	0	236.9	March 28, 2005
05-206	Open Borehole	240.2	4.0	236.2	March 30, 2005

As shown on the table above, the water levels encountered in the boreholes ranged from Elevation 248.0 m to 230.5 m. The water encountered at the higher elevations (i.e. Elevation

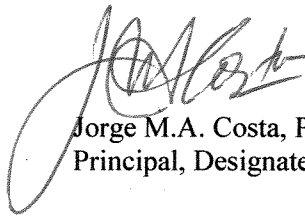
241.4 m and 248 m) in Boreholes 05-201 and 05-202 is believed to represent perched water levels in the roadway embankment fills. The water encountered at between about Elevation 236 m and 237 m in Boreholes 05-204 to 05-206 is representative of the surface level of Moose Horn Creek at the bottom of the valley. The water level measured at Elevation 230.5 m in the piezometer in Borehole 05-203 represents the deeper groundwater conditions within the sandy silt to sand and silt deposit at the site. It should be noted that the water levels in the area of the culvert depend on the recent rainfall and snowmelt conditions. It should also be emphasized that groundwater levels in the area are subject to seasonal fluctuations.

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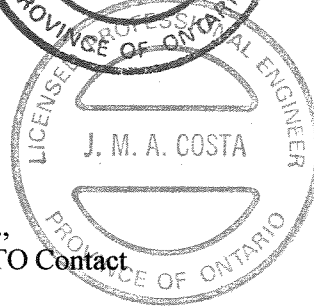
Kevin J. Bentley, P.Eng.,  
Geotechnical Engineer



J. Paul Dittrich, P.Eng.,  
Associate



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



KJB/JPD/FJH/JMAC/sm

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## 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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

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

### 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.)

#### Consistency

	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

#### (b) Cohesive Soils

#### 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.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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.

### 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

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

## LIST OF SYMBOLS

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

### I. General

$\pi$	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
F	factor of safety
V	volume
W	weight

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is $\rho$ . Unit weight symbol is $\gamma$ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

#### (a) Index Properties (continued)

w	water content
$w_L$	liquid limit
$w_p$	plastic limit
$I_p$	plasticity index = $(w - w_p)$
$w_s$	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)

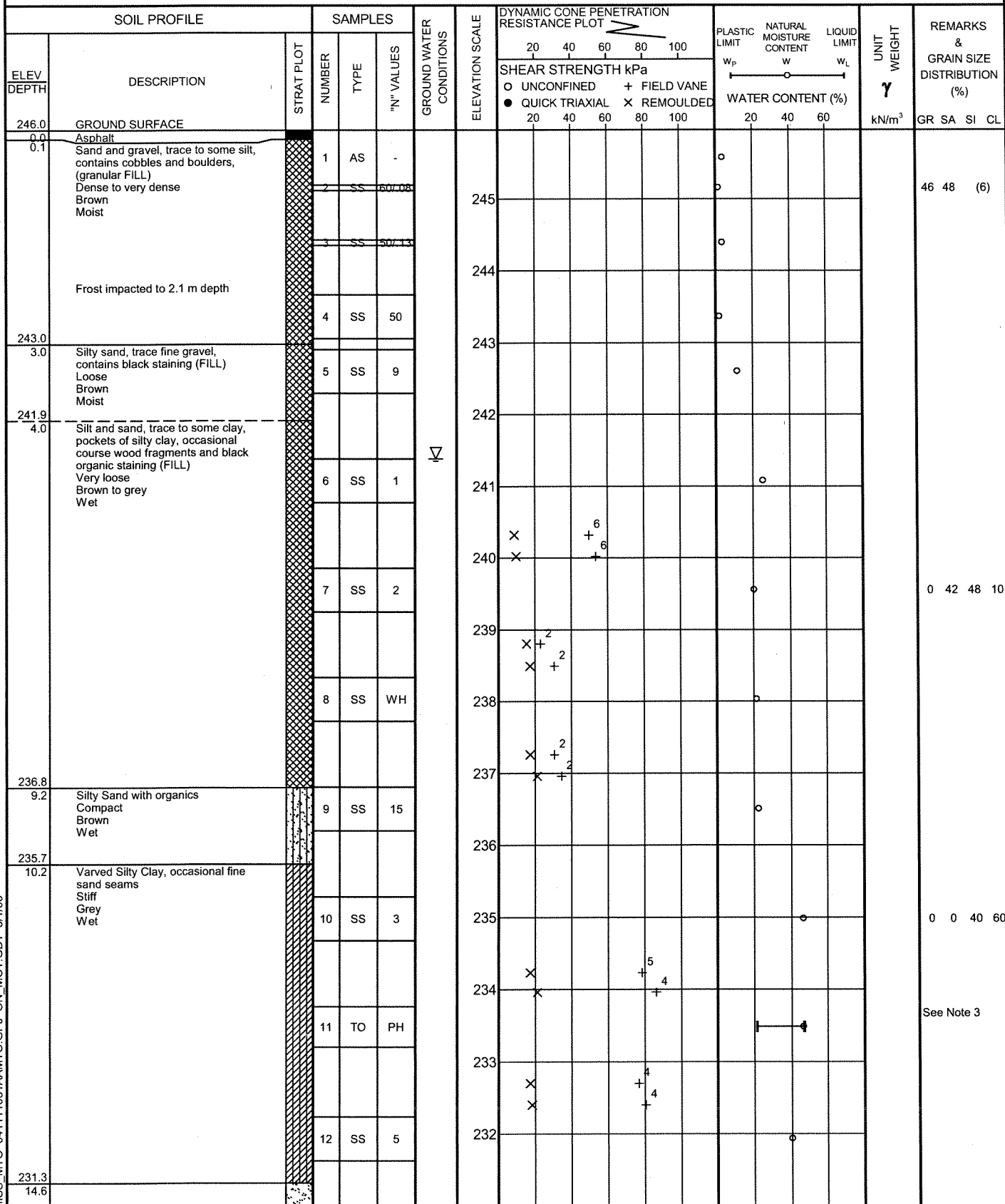
$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_a$	coefficient of secondary consolidation
$m_v$	coefficient of volume change
$c_v$	coefficient of consolidation
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

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

- Notes: 1  $\tau = c' + \sigma' \tan \phi'$   
2 Shear strength = (Compressive strength)/2

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-201</b>		1 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 17+050, Offset 2.0 m Right</u>		ORIGINATED BY <u>CR</u>	
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>1-Mar-2005</u>		CHECKED BY <u>KJB</u>	



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

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+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-202</b>		1 OF 2		<b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 16+883, Offset 2.5 m Left</u>				ORIGINATED BY <u>CR</u>	
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>				COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>2-Mar-2005</u>				CHECKED BY <u>KJB</u>	



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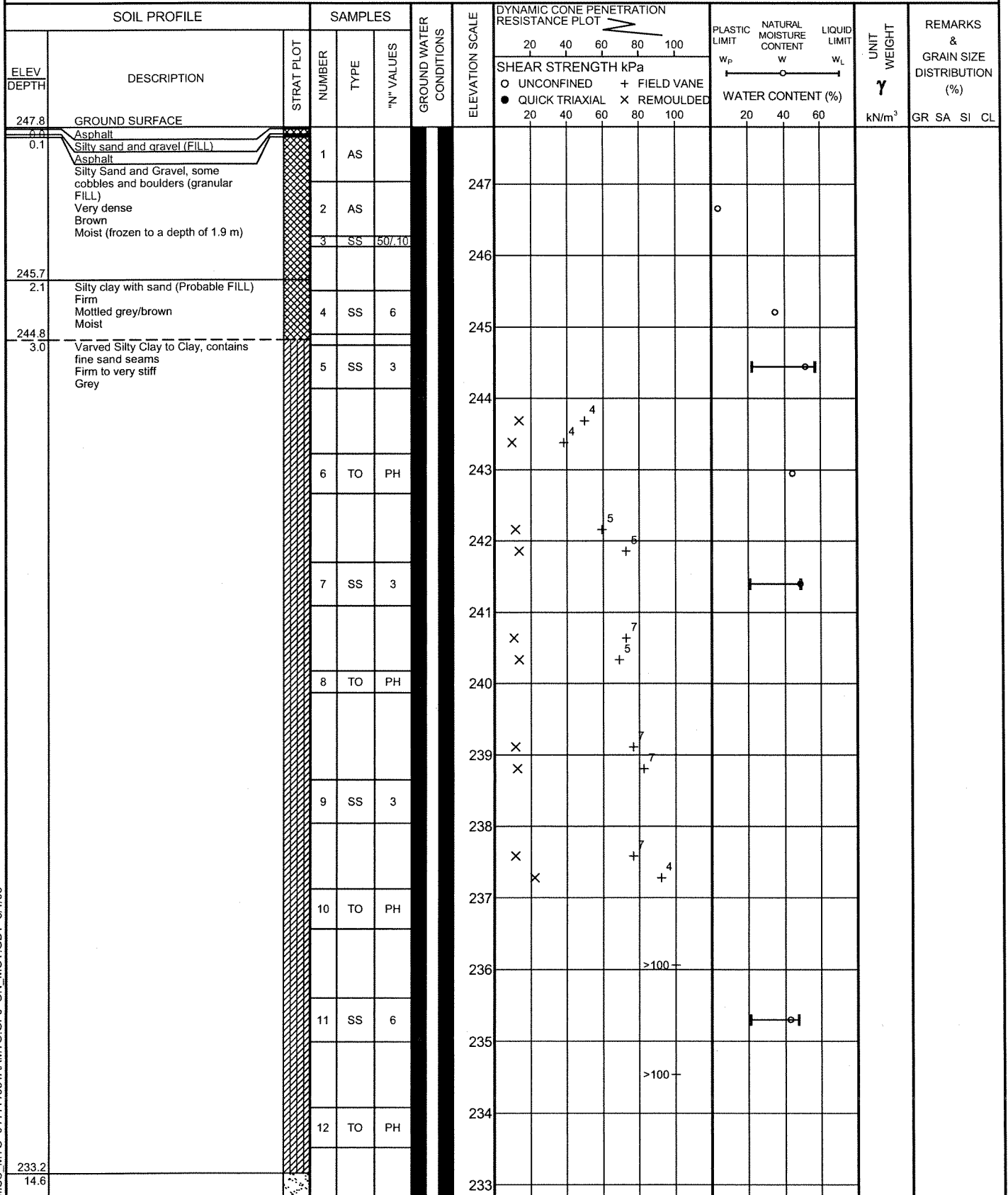
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-202</b>		2 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 16+883, Offset 2.5 m Left</u>		ORIGINATED BY <u>CR</u>	
DIST <u>HWY 624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>2-Mar-2005</u>		CHECKED BY <u>KJB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT		UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W			W <sub>L</sub>
								○ UNCONFINED	+ FIELD VANE					
— CONTINUED FROM PREVIOUS PAGE —								20 40 60 80 100						
	Varved Silty Clay to Clay, contains fine sand seams Firm to very stiff Grey		13	SS	6	235								
						234								
						233								
						232								
						231								
229.4			14	TO	PH	230								
21.0	Sand Compact to very dense Grey Moist to wet		15	SS	79	229								
						228								
						227								
						226								
						16	SS	22						
225.4														
25.0	End of Borehole  Note:  1. Water level in open borehole at 2.4 m depth below ground surface upon completion of drilling.													

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PROJECT <u>04-1111-051</u>		<b>RECORD OF BOREHOLE No 05-203</b>		1 OF 2 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 17+131, Offset 2.0 m Left</u>		ORIGINATED BY <u>CR</u>	
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Power Augering using 108 mm ID Hollow Stem Augers</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>03-Mar-2005</u>		CHECKED BY <u>KJB</u>	



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

PROJECT 04-1111-051

# RECORD OF BOREHOLE No 05-203

2 OF 2 METRIC

W.P. 5259-03-00

LOCATION Station 17+131, Offset 2.0 m Left

ORIGINATED BY CR

DIST HWY 624

BOREHOLE TYPE Power Augering using 108 mm ID Hollow Stem Augers

COMPILED BY JDR

DATUM Geodetic

DATE 03-Mar-2005

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
	— CONTINUED FROM PREVIOUS PAGE —							20 40 60 80 100		w <sub>p</sub> — w — w <sub>L</sub>				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						
								20 40 60 80 100		20 40 60				

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 04-1111-051		<b>RECORD OF BOREHOLE No 05-204</b>		2 OF 2 <b>METRIC</b>	
W.P. 5259-03-00		LOCATION Station 17+040, Offset 20.5 m Right		ORIGINATED BY CR	
DIST HWY 624		BOREHOLE TYPE Portable Power Augering using 'B' Casing		COMPILED BY JDR	
DATUM Geodetic		DATE 28-Mar-2005		CHECKED BY KJB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
	— CONTINUED FROM PREVIOUS PAGE —																	
	Notes:  1. Borehole caved to a depth of 7.9 m upon completion of drilling.  2. Water level in caved borehole at ground surface upon completion of drilling (i.e. ice surface).  3. Borehole advanced using portable drilling equipment with a half-weight hammer. The SPT"N" values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.																	

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PROJECT 04-1111-051

**RECORD OF BOREHOLE No 05-205**

1 OF 2 **METRIC**

W.P. 5259-03-00

LOCATION Station 17+054, Offset 24.0 m Left

ORIGINATED BY CR

DIST HWY 624

BOREHOLE TYPE Portable Power Augering using 'B' Casing

COMPILED BY JDR

DATUM Geodetic

DATE 06-Apr-2005

CHECKED BY KJB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa								WATER CONTENT (%)			
236.9	ICE SURFACE						20	40	60	80	100				GR	SA	SI	CL
0.0	Ice																	
0.2	Silty Sand with organics Very loose Grey to dark brown Wet		1	SS	WH													
235.4			2	SS	2													
1.5	Varved Silty Clay, contains sand seams Firm to stiff Grey		3	SS	2													
			4	SS	1													
			5	SS	6													
231.7																		
5.2	Sand, trace to some silt, trace clay Compact Grey Wet		6	SS	16													
			7	SS	14													
229.3																		
7.6	Silty Sand Loose to compact Grey Wet		8	SS	7													
			9	SS	23													
			10	SS	16													
225.2																		
11.7	Silt and Sand, trace clay Loose to compact Grey Wet		11	SS	10													
223.6																		
13.3	Silty Sand Compact Grey Wet		12	SS	13													
								</										



PROJECT 04-1111-051		<b>RECORD OF BOREHOLE No 05-205</b>		2 OF 2 <b>METRIC</b>	
W.P. 5259-03-00		LOCATION Station 17+054, Offset 24.0 m Left		ORIGINATED BY CR	
DIST HWY 624		BOREHOLE TYPE Portable Power Augering using 'B' Casing		COMPILED BY JDR	
DATUM Geodetic		DATE 06-Apr-2005		CHECKED BY KJB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
								<div><div></div><div>20406080100</div></div> <div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x REMOULDED</div>					<div><div></div><div>204060</div></div> <div>W<sub>P</sub> W W<sub>L</sub></div>					
— CONTINUED FROM PREVIOUS PAGE —																		
221.7 15.2	Sand, some silt, trace clay, contains silty sand seams Dense to very dense Grey Wet		13	SS	50												0 79 19 2	
			14	SS	46													
215.1 21.8	End of Borehole		15	SS	37													
	Notes:  1. Borehole caved to a depth of 11.6 m upon completion of drilling.  2. Water level in caved borehole at ground surface upon completion of drilling (i.e. ice surface).  3. Borehole advanced using portable drilling equipment with a half-weight hammer. The SPT"N" values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.																	

PROJECT 04-1111-051			RECORD OF BOREHOLE No 05-206			1 OF 2 METRIC			
W.P. 5259-03-00			LOCATION Station 17+056, Offset 19.5 m Right			ORIGINATED BY CR			
DIST HWY 624			BOREHOLE TYPE Portable Power Augering using 'B' Casing			COMPILED BY JDR			
DATUM Geodetic			DATE 30-Mar-2005			CHECKED BY KJB			
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED 20 40 60 80 100 PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%) 20 40 60 UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
240.2	ICE SURFACE						240		
0.0	Ice						239.9		
0.3	Silty sand with organics, trace to some clay, trace gravel, contains cobbles (FILL) Very loose to loose Grey Wet		1	SS	3		239		
238.7			2	SS	4		238		
1.5	Silty clay, trace gravel, trace sand, trace organics (FILL) Very soft to soft Grey/brown (mottled)		3	SS	2		237		
238.1			4	SS	3		236		
2.1	Varved Silty Clay to Clay, contains some fine sand seams Soft to stiff Grey		5	SS	2		235		
			6	SS	2		234		
			7	SS	2		233		
232.6			8	SS	23		232		
7.6	Silty Sand, trace clay, contains sand seams Compact to very dense Grey Wet		9	SS	31		231		
			10	SS	33		230		
			11	SS	44		229		
			12	SS	57		228		
							227		
							226		

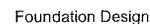
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+ 3 X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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PROJECT 04-1111-051			RECORD OF BOREHOLE No 05-206			2 OF 2 METRIC							
W.P. 5259-03-00			LOCATION Station 17+056, Offset 19.5 m Right			ORIGINATED BY CR							
DIST HWY 624			BOREHOLE TYPE Portable Power Augering using 'B' Casing			COMPILED BY JDR							
DATUM Geodetic			DATE 30-Mar-2005			CHECKED BY KJB							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	GR SA SI CL
— CONTINUED FROM PREVIOUS PAGE —													
221.9	Silty Sand, trace clay, contains sand seams Compact to very dense Grey Wet		13	SS	27		225						
221.3	Silt and Sand, trace to some clay Compact Grey Wet		14	SS	23		224						0 47 47 6
18.9	End of Borehole						223						
	Notes:  1. Borehole caved to a depth of 11.9 m upon completion of drilling.  2. Water level in caved borehole at 4.0 m depth upon completion of drilling.  3. Borehole advanced using portable drilling equipment with a half-weight hammer. The SPT "N" values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.						222						

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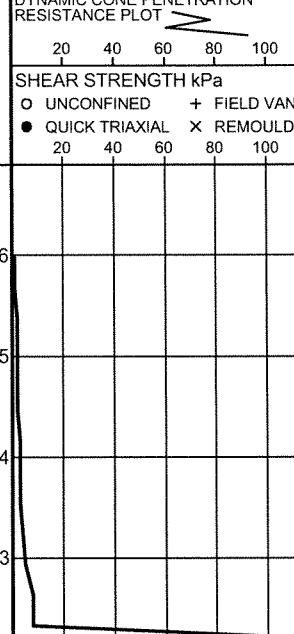


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT <u>04-1111-051</u>		<b>RECORD OF PENETRATION TEST No DCPT-20</b>		1 OF 1 <b>METRIC</b>	
W.P. <u>5259-03-00</u>		LOCATION <u>Station 17+051, Offset 24.0 m Left</u>		ORIGINATED BY <u>CR</u>	
DIST <u>          </u> HWY <u>624</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>		COMPILED BY <u>JDR</u>	
DATUM <u>Geodetic</u>		DATE <u>07-Apr-2005</u>		CHECKED BY <u>KJB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
237.0	GROUND SURFACE													
0.0	Snow/Ice													
236.7														
0.3	Start of Dynamic Cone Penetration Test at 0.3 m depth													
							236							
							235							
							234							
							233							
							232							
							231							
							230							
							229							
							228							
227.5	End of DCPT													
9.5	Notes:  1. DCPT rods sank 0.9 m under weight of hammer.  2. DCPT advanced using portable drilling equipment with a half-weight hammer. The dynamic cone penetration resistance values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.							Refusal - 80 blows/0.1 m						

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PROJECT <u>04-1111-051</u>		RECORD OF PENETRATION TEST <b>No DCPT-30</b>				1 OF 1 <b>METRIC</b>				
W.P. <u>5259-03-00</u>		LOCATION <u>Station 17+043, Offset 20.5 m Right</u>				ORIGINATED BY <u>CR</u>				
DIST <u>        </u> HWY <u>624</u>		BOREHOLE TYPE <u>Dynamic Cone Penetration Test</u>				COMPILED BY <u>JDR</u>				
DATUM <u>Geodetic</u>		DATE <u>30- Mar-2005</u>				CHECKED BY <u>KJB</u>				
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT $w_p$ NATURAL MOISTURE CONTENT $w$ LIQUID LIMIT $w_L$ WATER CONTENT (%)	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
236.9	GROUND SURFACE									
0.0	Ice									
236.4	Water									
0.6	Start of Dynamic Cone Penetration Test at 0.6 m depth									
232.2	End of DCPT									
4.7	Note:  1. DCPT advanced using portable drilling equipment with a half-weight hammer. The dynamic cone penetration resistance values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.									

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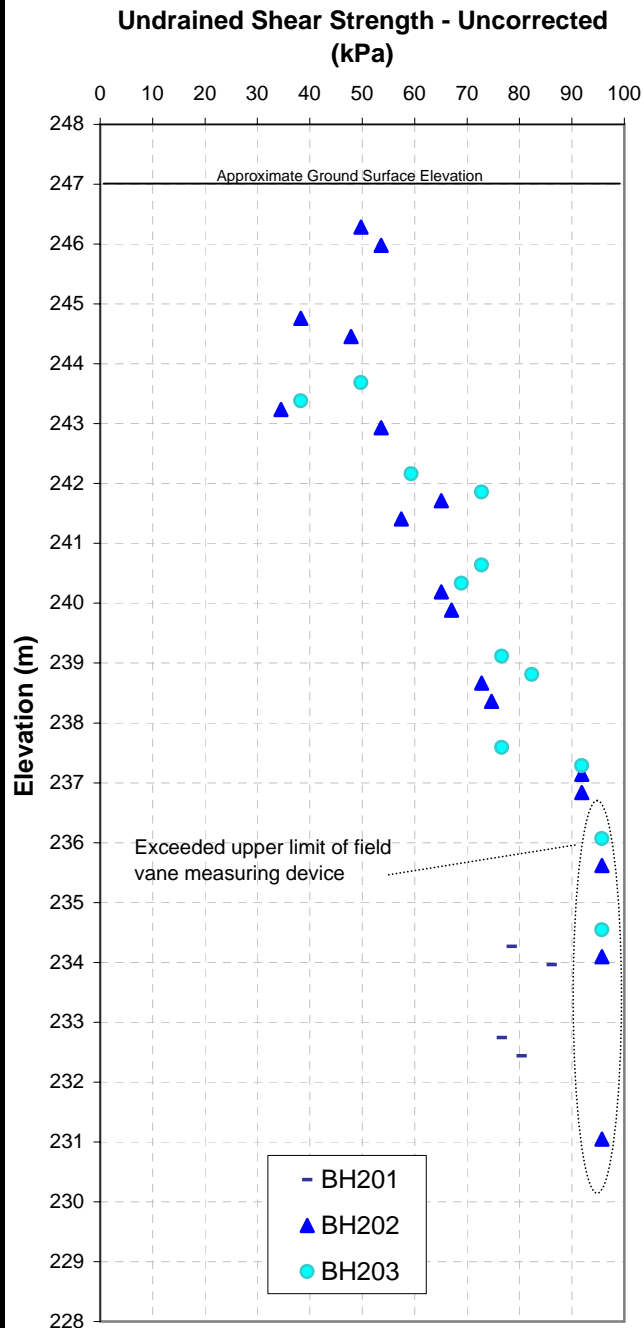
PROJECT		RECORD OF PENETRATION TEST No DCPT-30A				1 OF 1		METRIC					
W.P.		LOCATION				ORIGINATED BY							
DIST		BOREHOLE TYPE				COMPILED BY							
DATUM		DATE				CHECKED BY							
04-1111-051		Station 17+043, Offset 21.5 m Right				CR							
5259-03-00		Dynamic Cone Penetration Test				JDR							
Geodetic		30-Mar-2005				KJB							
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	GR SA SI CL
236.9	GROUND SURFACE							20 40 60 80 100					
0.0	Ice							20 40 60 80 100					
236.3	Start of Dynamic Cone Penetration Test at 0.6 m depth							20 40 60 80 100					
0.6								20 40 60 80 100					
233.2	End of DCPT							20 40 60 80 100					
4.7	Note: 1. DCPT advanced using portable drilling equipment with a half-weight hammer. The dynamic cone penetration resistance values have been adjusted on this log to reflect the values that would be obtained using a standard-weight hammer.							20 40 60 80 100					

# Summary of Field Vane Test Results

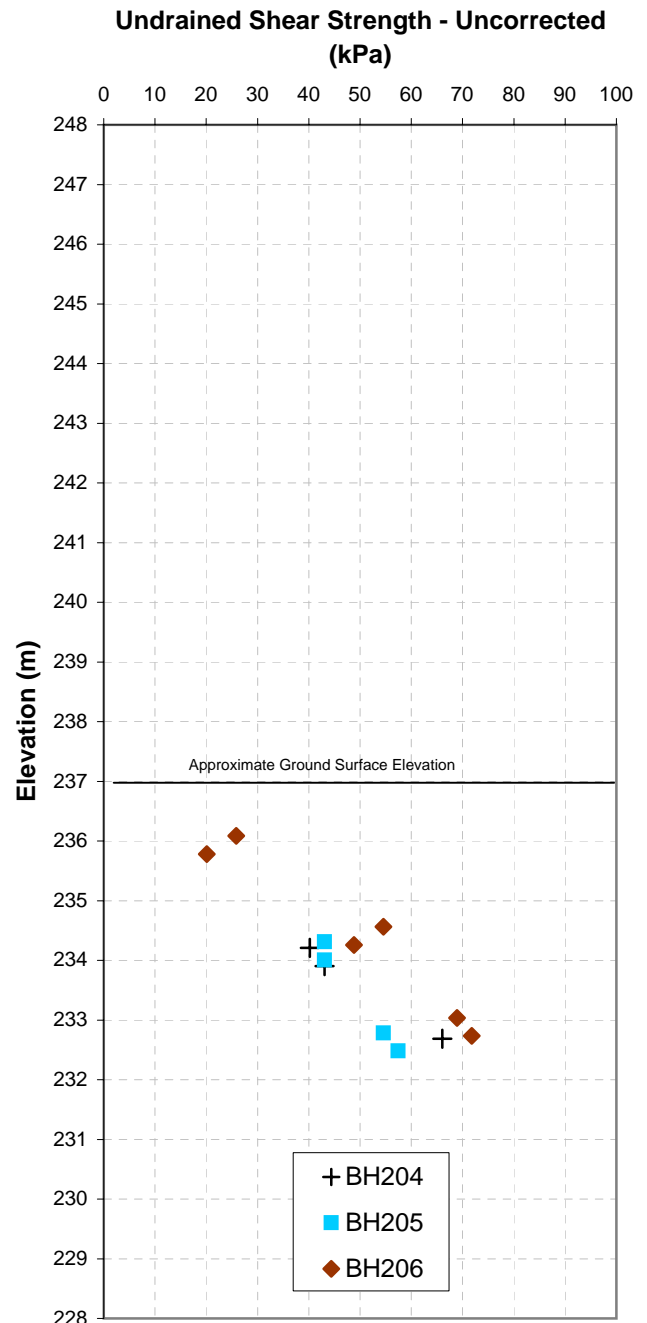
Varved Silty Clay to Clay  
Moose Horn Creek - Highway 624

FIGURE 1

## Top / Sides of Valley



## Bottom of Valley



WP No. 5259-03-00  
Date: 1-Aug-05  
Project: 04-1111-051A

Drawn by: KJB  
Checked by: JPD

Golder Associates

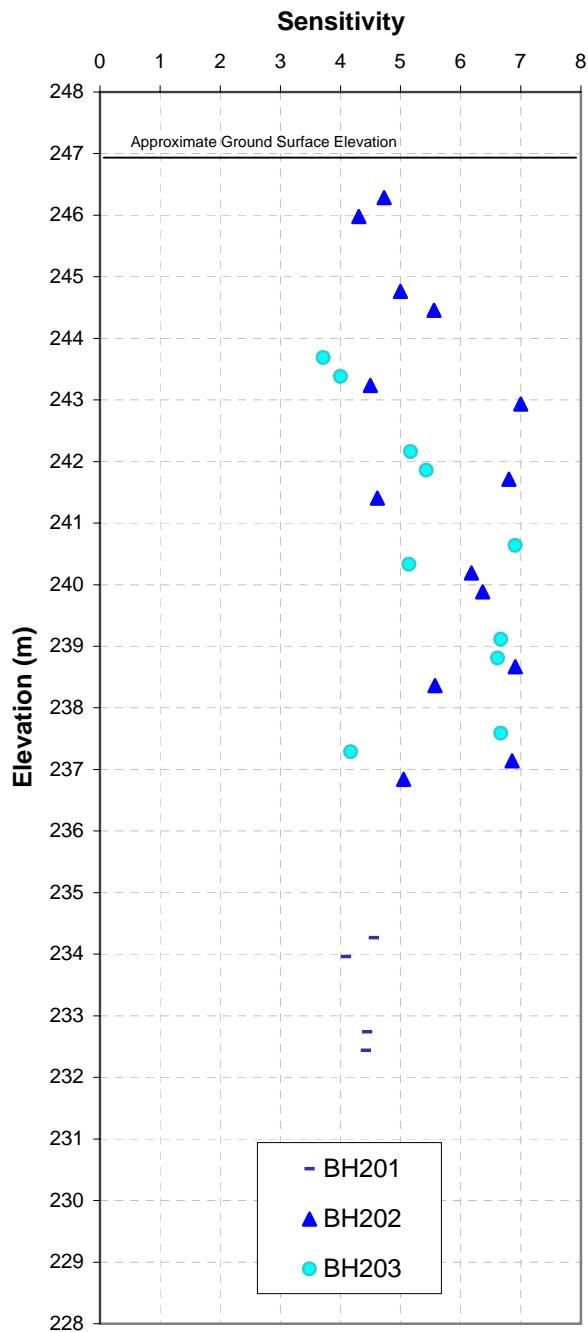


## Summary of Sensitivity Results

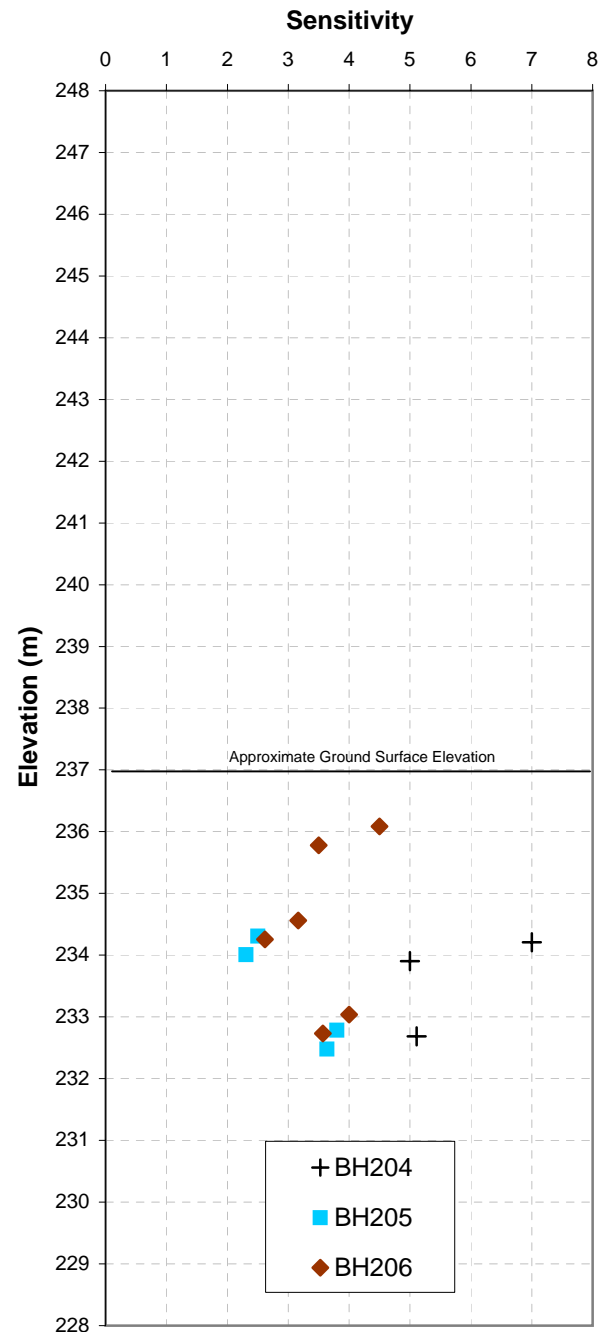
Varved Silty Clay to Clay  
Moose Horn Creek - Highway 624

**FIGURE 2**

### Top / Sides of Valley



### Bottom of Valley



WP No. 5259-03-00  
Date: 1-Aug-05  
Project: 04-1111-051A

Drawn by: KJB  
Checked by: JPD

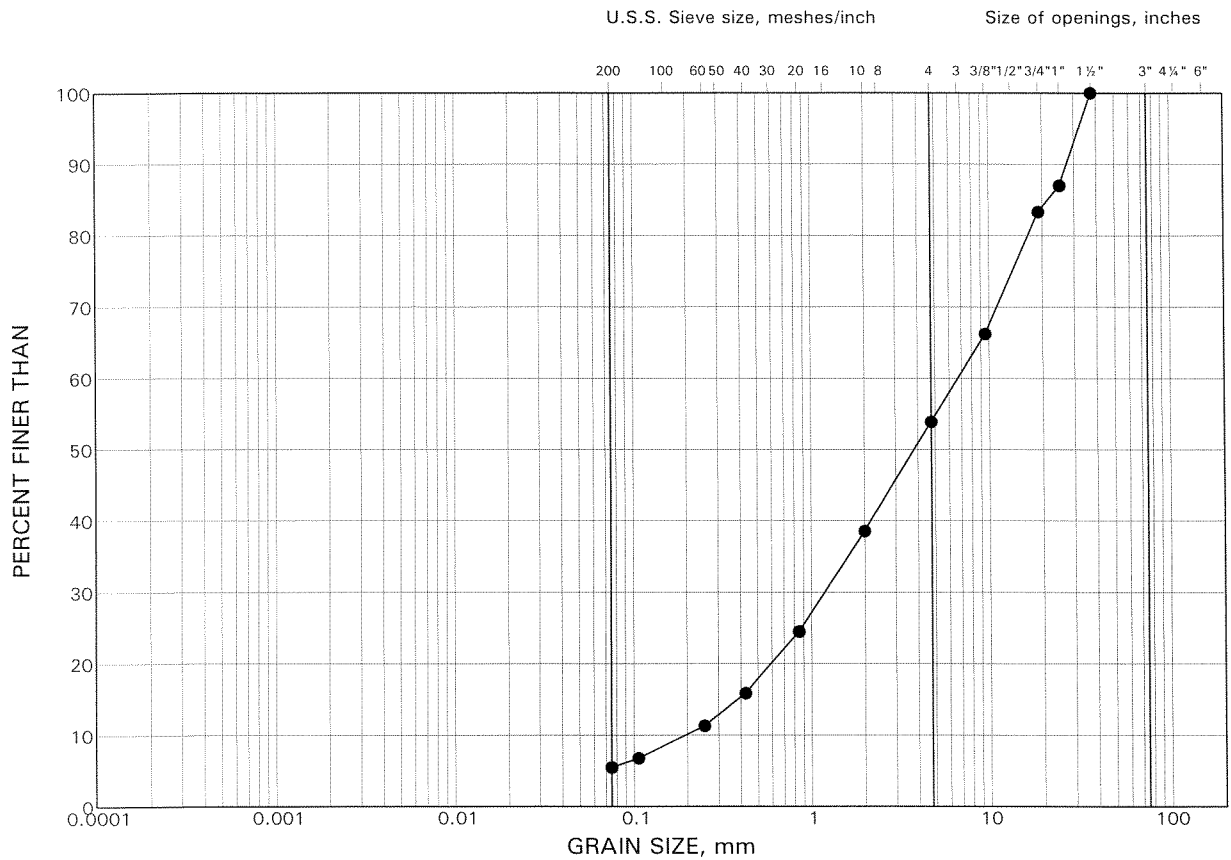
**Golder Associates**

**APPENDIX A**  
**LABORATORY TEST DATA**

# GRAIN SIZE DISTRIBUTION

## Sand and Gravel (Fill)

FIGURE A1



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

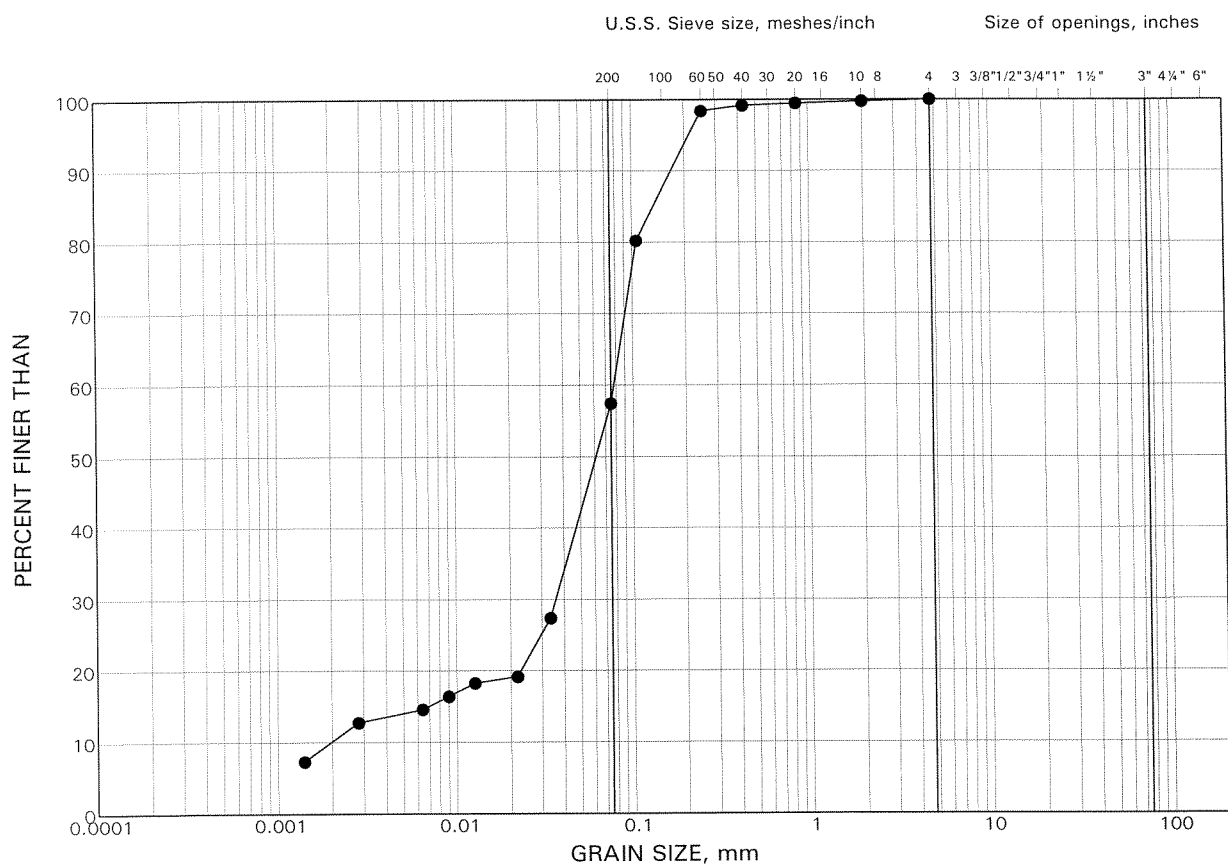
### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	05-201	2	244.4

# GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE A2



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

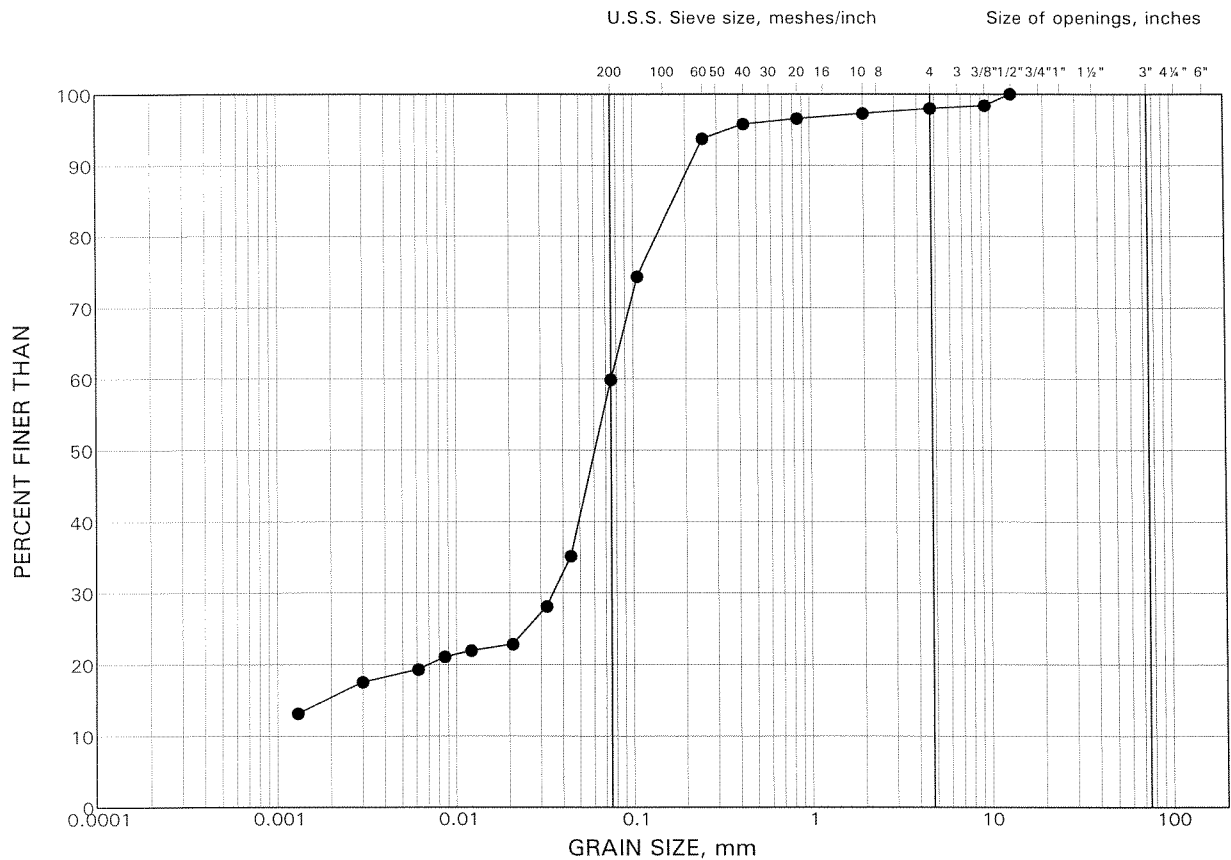
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	05-201	7	239.5

# GRAIN SIZE DISTRIBUTION

Organic Silt and Sand

FIGURE A3



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

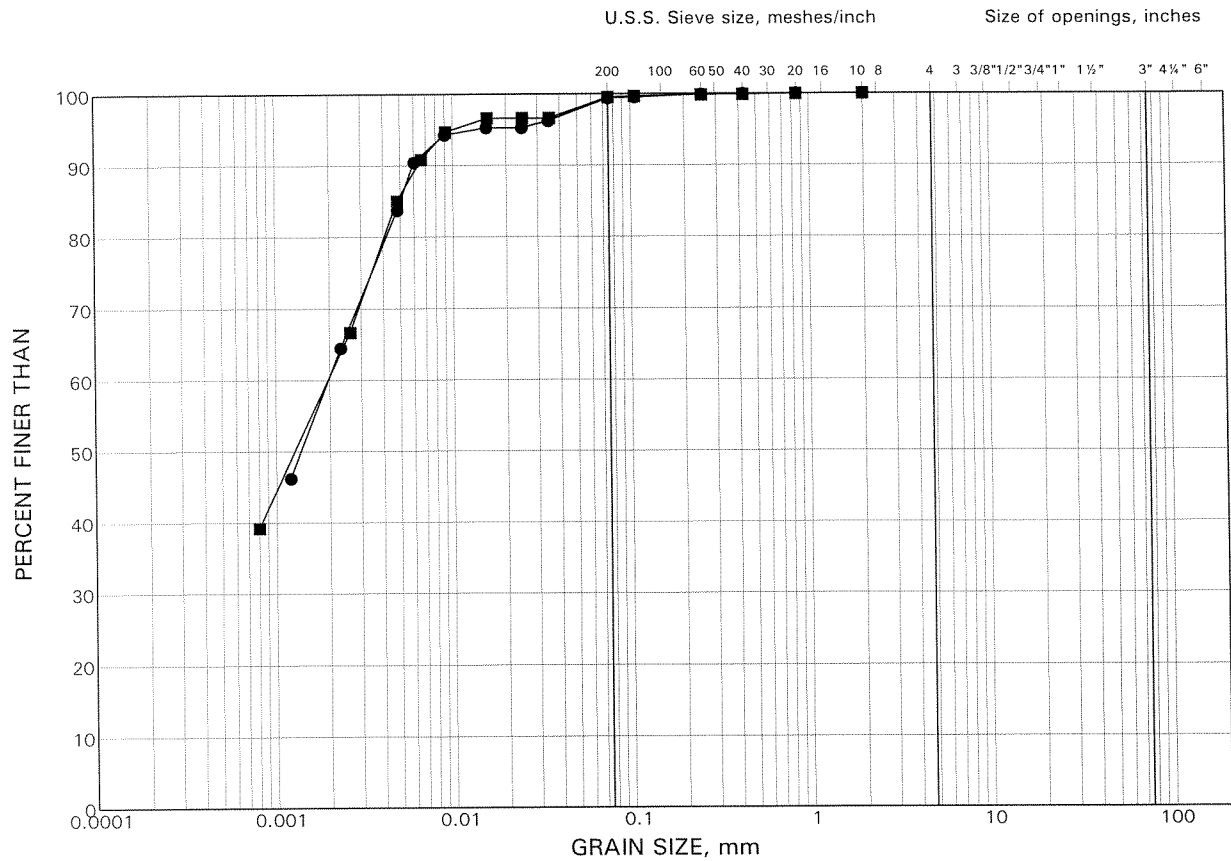
## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	05-204	1	235.5

# GRAIN SIZE DISTRIBUTION

Varved Silty Clay

FIGURE A4



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	05-201	10	235.0
■	05-205	4	233.5

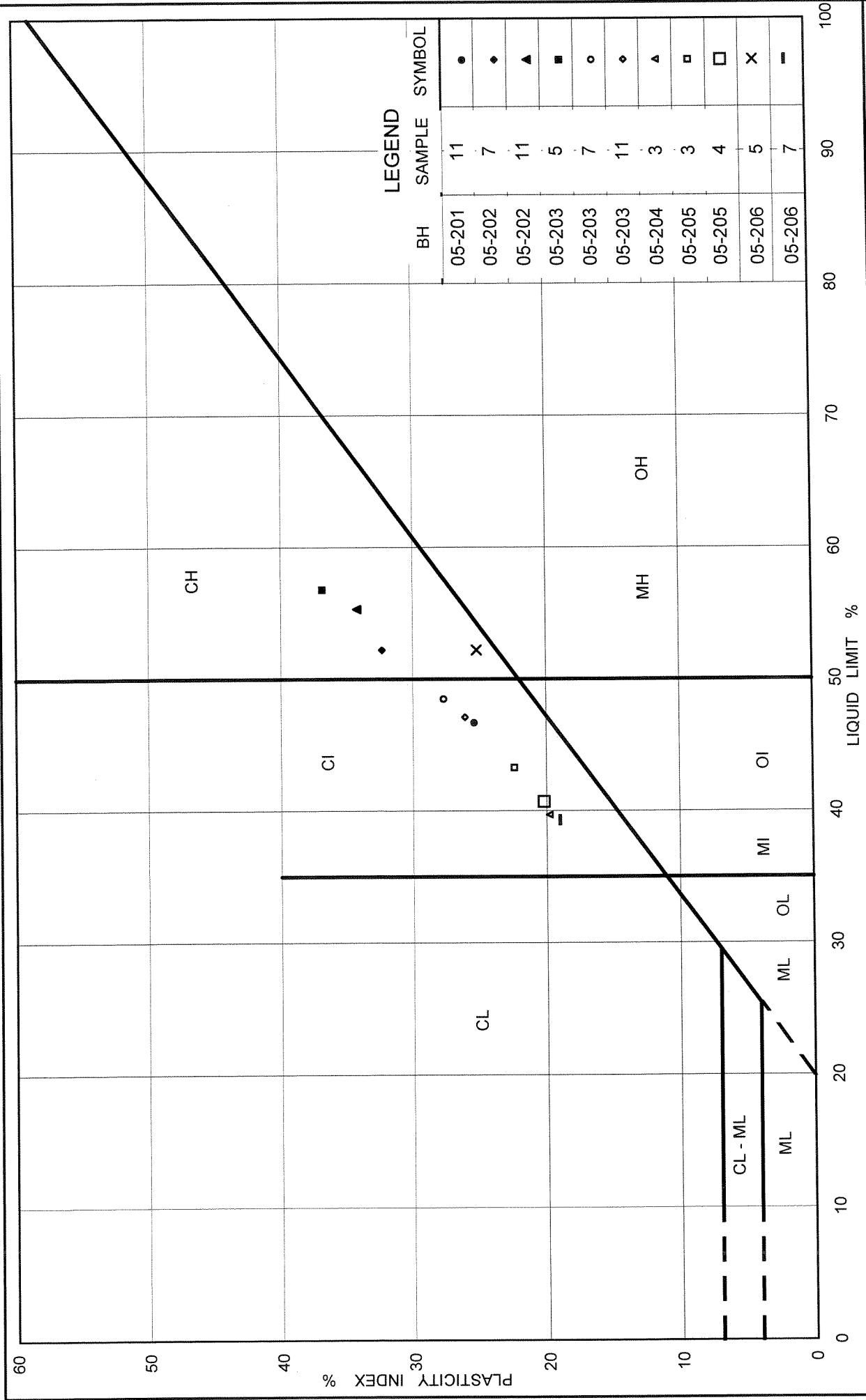


FIG No. A5

**PLASTICITY CHART**  
Varved Silty Clay to Clay

Ministry of Transportation

Project No. 04-1111-051A

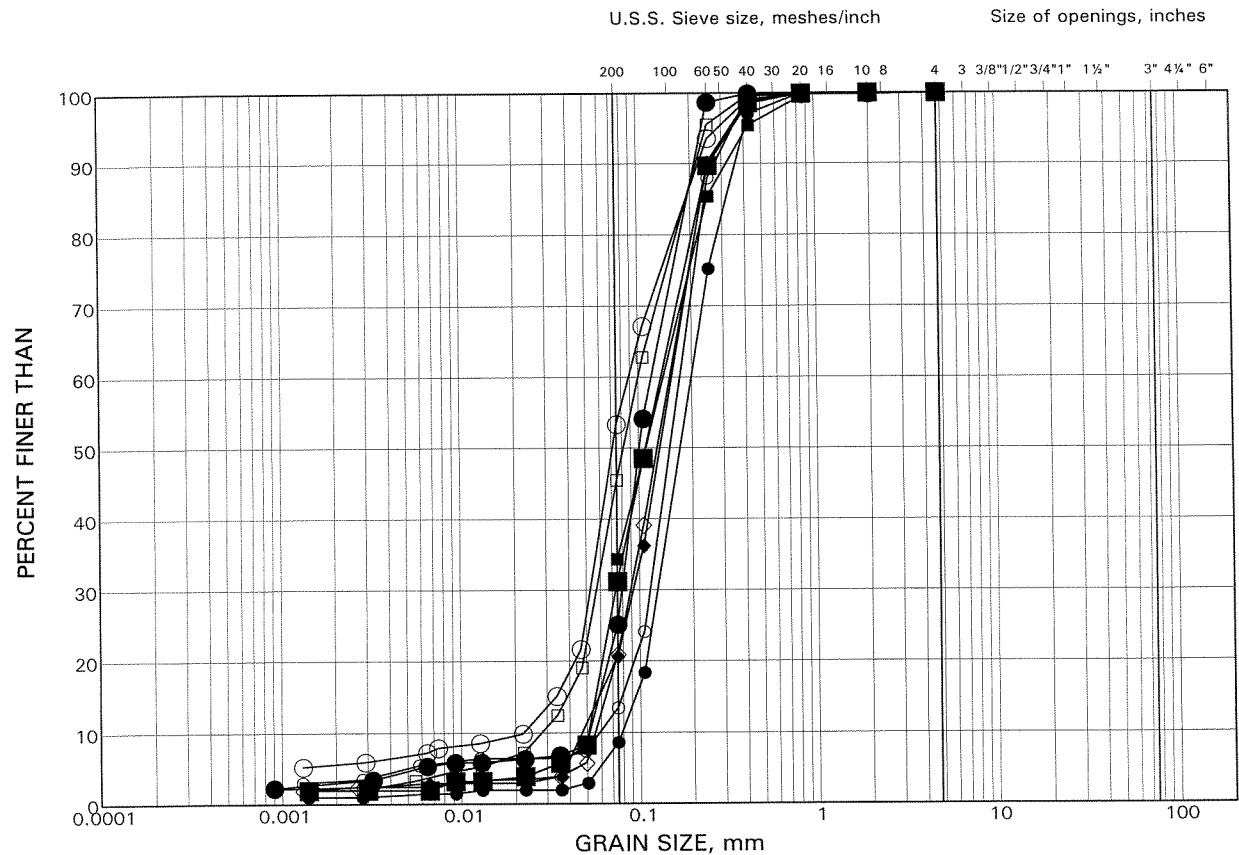


Ontario

# GRAIN SIZE DISTRIBUTION

Silty Sand, Silt and Sand, Sand

FIGURE A6



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

## LEGEND

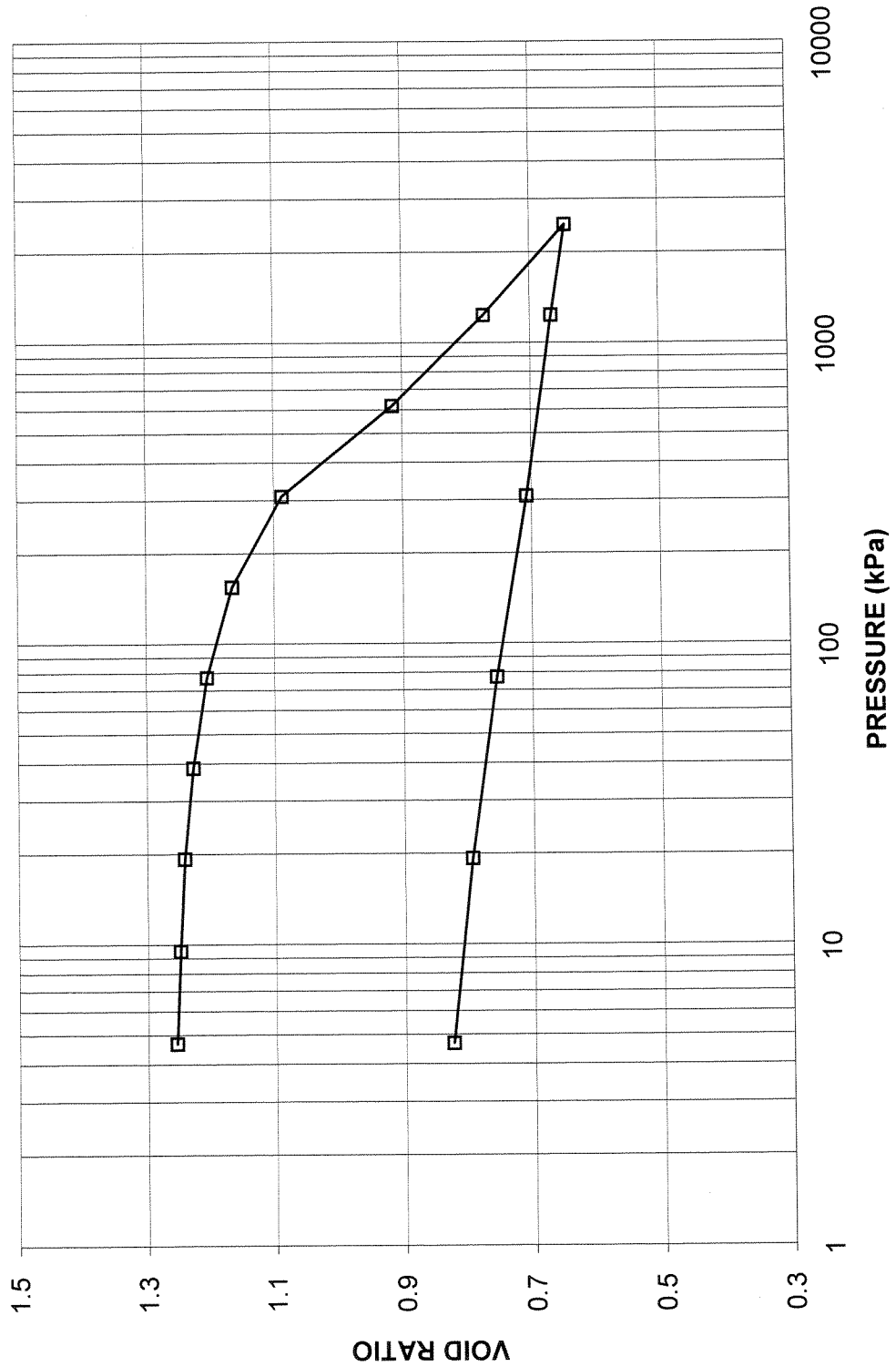
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	05-201	13	230.5
■	05-201	15	224.3
◆	05-204	8	225.8
○	05-205	7	230.5
□	05-205	11	224.4
◇	05-205	13	221.5
●	05-206	8	232.3
■	05-206	11	227.7
○	05-206	14	221.6



CONSOLIDATION TEST  
VOID RATIO VS. PRESSURE

FIGURE A7

CONSOLIDATION TEST  
VOID RATIO vs PRESSURE  
BH 05-201 SA 11



**CONSOLIDATION TEST  
TOTAL WORK VS. PRESSURE**

**FIGURE A8**

**CONSOLIDATION TEST  
TOTAL WORK,  $\text{kJ/m}^3$  vs PRESSURE  
BH 05-201 SA 11**

