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**FOUNDATION INVESTIGATION REPORT  
CULVERT 18  
HIGHWAY 7 TWINNING FROM 0.7 KM WEST  
OF JINKINSON ROAD WESTERLY 10.5 KM TO  
2.5 KM WEST OF ASHTON STATION ROAD  
W.P. 251-99-00**

Submitted to:

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## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Marshall Macklin Monaghan (MMM) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the twinning of Highway 7 from two to four lanes in the former West Carleton Township which is now part of the City of Ottawa, and in Beckwith Township in Lanark County. The section of Highway 7 included in this assignment (W.P. 251-99-00) extends from 0.7 km west of Jinkinson Road westerly for 10.5 km, to 2.5 km west of Ashton Station Road, and includes service roads to accommodate future construction on Highway 7.

This report addresses the proposed new Culvert 18, to be located on the new North Service Road at approximately Station 11+700, to permit the North Service Road to cross over a tributary to Lavallee Creek.

## **2.0 SITE DESCRIPTION**

The proposed Culvert 18 site, at the crossing of the new North Service Road over the Lavallee Creek tributary for the North Service Road, is located approximately 1.7 km east of Carleton Place and 180 m east of Lavallee Creek, in Beckwith Township in Lanark County. The North Service Road is to be located approximately 20 m south of the existing Trans-Canada Trail (former rail right-of-way) at the proposed tributary crossing location.

At the Culvert 18 site, the Lavallee Creek tributary is oriented approximately north-south, and flows in a northerly direction. Immediately west and east of the creek, the topography consists of relatively flat farm land that slopes gently downward toward the creek flood plain. The ground surface within the creek flood plain is at about Elevation 125.5 m, and the creek bed at the culvert site is at approximately Elevation 125.1 m. The creek flood plain consists of grass-covered marsh land; frozen standing water was observed throughout the flood plain at the time of the investigation in February 2007. The creek was also frozen at the time of investigation, with about 0.3 m of ice and water present above the creek bed.

### **3.0 INVESTIGATION PROCEDURES**

The field work for this subsurface investigation was carried out between February 13 and 15, 2007. Two boreholes (Boreholes 07-1 and 07-2) were drilled at the locations shown on the Borehole Location and Soil Strata drawing contained in the Contract Documents. The boreholes were located as close as possible to the proposed culvert location given the flooding and partial freezing conditions at the time of the investigation: Borehole 07-1 was located outside of the creek flood plain on the creek bank immediately west of the proposed culvert location, while Borehole 07-2 was located within the creek floodplain adjacent to the southeast end of the proposed culvert. These two boreholes were supplemented with a hand augerhole (Borehole 07-3) located within the flooded area at the centre of the proposed culvert alignment, and advanced using a combination of hand auger and ice auger drilling equipment; this borehole was advanced to assess the presence of organic/alluvial soils at the creek bed.

Boreholes 07-1 and 07-2 were advanced using a track-mounted drill rig, supplied and operated by Marathon Drilling Company Ltd. of Ottawa, Ontario. These boreholes were advanced to practical refusal to augering at depths of 7.7 m and 7.8 m below the existing ground/ice surface; Borehole 07-1 was advanced a further 2.3 m into the bedrock using NQ-size coring equipment. Samples of the overburden were obtained at 0.75 m to 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. In situ vane testing was carried out within the cohesive deposits using an N-sized vane. Relatively undisturbed, 75-millimetre diameter thin-walled Shelby tube (ASTM D1587) samples of the silty clay were retrieved using a fixed piston sampler. The boreholes were sealed at their base using bentonite pellets in accordance with Ontario Regulation 903, then backfilled with the native clayey soils, and the site conditions were restored following completion of the work.

Borehole 07-3 was advanced to a depth of 1.8 m below the ice surface. The soils recovered on the augers were classified by visual and tactile examination.

The field work was supervised on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labelled containers and transported to Golder's laboratories in Ottawa and Mississauga for further examination and laboratory testing. Index and classification tests consisting of water content determinations, Atterberg limits testing and grain size distribution analyses were carried out on selected soil samples at the Ottawa laboratory. An oedometer (consolidation) test was carried out on one sample of the clay deposit in the Mississauga laboratory.

The borehole locations were determined by Golder relative to existing site features. The borehole ground surface elevations were also determined by Golder and referenced to the elevation of boreholes from Golder's previous investigation for the North Service Road bridge over Lavallee

Creek, to the west of this site. The borehole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to Geodetic datum, are summarized in the following table and are shown on the Borehole Location and Soil Strata drawing contained in the Contract Documents.

<b><i>Borehole Number</i></b>	<b><i>Borehole Location</i></b>	<b><i>MTM NAD83 Northing (m)</i></b>	<b><i>MTM NAD83 Easting (m)</i></b>	<b><i>Ground Surface Elevation (m)</i></b>
07-1	West of culvert alignment	5,000,924.7	335,572.7	126.2
07-2	East of culvert alignment	5,000,928.1	335,605.8	125.8
07-3	Centre of culvert alignment	5,000,928.2	335,596.6	125.7

## **4.0 SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Regional Geological Conditions**

The study area for this assignment lies within the Smith Falls Limestone Plain, as delineated in *The Physiography of Southern Ontario*<sup>1</sup>, that lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Smiths Falls Limestone Plain is characterized by shallow overburden deposits overlying sedimentary bedrock consisting of limestones, dolostones, sandstones and shales. The shallow overburden soils are typically between 1 m and 3 m in thickness and are commonly comprised of sandy to gravelly till derived from the Precambrian Shield to the north, overlain by glaciofluvial sediments that consist of layered sands and gravels. In the vicinity of Carleton Place, clay has been deposited within depressions in the bedrock that have been caused by faulting. Large areas of the plain are covered with peat and muck, due to poor drainage as a consequence of the relatively flat topography and shallow depth to bedrock.<sup>1</sup>

### **4.2 Site Stratigraphy**

As part of the subsurface investigation at this site, two boreholes and one hand augerhole were advanced in the area of the proposed Culvert 18. The borehole locations, ground surface elevations and an interpreted stratigraphic profile are shown on the Borehole Location and Soil Strata drawing contained in the Contract Documents.

The detailed subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets and Figures 1 to 6. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

In general, the soils encountered at the site consist of topsoil and surficial organic-containing deposits of silty clay and clayey with thicknesses of about 0.9 m to 1.1 m, over an approximately 6.1 m to 7.2 m thick deposit of clay. The upper 1.5 m to 2.7 m of the clay deposit has been weathered to a grey-brown crust, while the underlying, unweathered portion of the deposit is grey in colour. Below a depth of about 7.3 m to 7.5 m, the silty clay is underlain by about 0.3 m of sandy silt till. The till is, in turn, underlain by dolomitic limestone bedrock that was encountered between about 7.7 m and 7.8 m depth (at approximately Elevations 118.2 m to 118.4 m, respectively).

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<sup>1</sup> Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### **4.2.1 Topsoil**

About 300 mm of topsoil was encountered immediately below the ground surface in Borehole 07-1, which is located on the creek bank just west of the proposed culvert location.

#### **4.2.2 Organic-Containing Clayey Silt to Silty Clay**

A surficial deposit consisting of clayey silt and/or silty clay containing organic matter was encountered immediately below the creek bed/flood plain in Boreholes 07-2 and 07-3. Traces of shells were also noted in this deposit in Borehole 07-3. The deposit is about 0.9 m to 1.1 m in thickness, with its base encountered at Elevations 124.4 m and 124.6 m. The organic content of one sample of the alluvium was measured to be 4 per cent.

#### **4.2.3 Clay**

The topsoil and surficial clayey silt to silty clay, where present, are underlain by a clay deposit that is between 6.1 m and 7.2 m in thickness as encountered in Boreholes 07-2 and 07-1, respectively. The surface of the clay deposit was encountered between Elevations 124.4 m and 124.6 m within the creek channel and flood plain (Boreholes 07-2 and 07-3), and at about Elevation 125.9 m in Borehole 07-1 on the west bank of the creek.

At Boreholes 07-1 and 07-2, the upper 1.5 m to 2.7 m of the clay deposit has been weathered to a grey-brown crust. The measured SPT “N” values in this portion of the deposit ranged from 5 to 10 blows per 0.3 m of penetration, while in situ vane testing measured undrained shear strengths of greater than 96 kPa; these test results indicate that the weathered clay crust has a very stiff consistency. The result of a grain size distribution test on one sample of the weathered clay crust is shown on Figure 1. Atterberg limit testing on two selected samples of the weathered clay crust measured plastic limits of 23 and 26 per cent, liquid limits of 51 and 55 per cent, and plasticity indices of 28 and 29 per cent. These results, which are summarized on a plasticity chart on Figure 2, confirm that this material is generally a clay of high plasticity.

The clay below the depth of weathering is grey. The measured SPT “N” values within the unweathered grey clay range from 5 to 9 blows per 0.3 m of penetration, while in situ vane testing carried out in Boreholes 07-1 and 07-2 measured undrained shear strengths of greater than 96 kPa. These results indicate that the unweathered grey clay has a very stiff consistency. The result of a grain size distribution test on one sample of the unweathered clay is shown on Figure 3. Atterberg limit testing was carried out on five selected samples of the grey clay measured plastic limits of 21 to 24 per cent, liquid limits of 49 to 57 per cent, and plasticity indices of 28 to 34 per cent.



These results, which are plotted on a plasticity chart on Figure 4, confirm that this material is a clay of high plasticity.

Oedometer consolidation testing was carried out on one sample of the grey clay obtained just below the depth of weathering. The results of that testing, which are provided on Figures 5A to 5D and summarized in the table below, indicate that this material is overconsolidated, with a preconsolidation pressure about 430 kPa and an overconsolidation ratio of approximately 12 in the upper portion of the unweathered material.

Borehole/ Sample Number	Sample Depth/Elev. (m)	Unit Weight (kN/m <sup>3</sup> )	$\sigma_p'$ (kPa)	$\sigma_{vo}'$ (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	Cc	Cr	e <sub>o</sub>	OCR	Cv
07-2 / 3	3.1 / 122.7	17.2	430	35	395	0.41	0.055	0.96	12	0.02

**Notes:**

- $\sigma_p'$  - Apparent preconsolidation pressure
- $\sigma_{vo}'$  - Computed existing vertical effective stress
- Cc - Compression index
- Cr - Recompression index
- e<sub>o</sub> - Initial void ratio
- OCR - Overconsolidation ratio
- Cv - Coefficient of consolidation

#### 4.2.4 Sandy Silt Till

A 0.1 m to 0.3 m thick layer of glacial till was encountered below the clay deposit in Boreholes 07-1 and 07-2. The surface of this till deposit was encountered between Elevations 118.5 m and 118.7 m in these boreholes.

Based on local experience and observations of the drilling resistance, the glacial till consists of a heterogeneous mixture of gravel and cobbles in a matrix of sandy silt, containing trace clay; the result of a grain size distribution test conducted on one sample of the sandy silt till is shown on Figure 6. Due to the limited thickness of this deposit at the site, only limited standard penetration testing could be carried out before sampler refusal was encountered on the bedrock surface.

#### 4.2.5 Dolomitic Limestone Bedrock

Dolomitic bedrock, containing interbeds of sandstone, underlies the till deposit at this site, with the surface of the bedrock encountered between Elevations 118.2 m and 118.4 m. The bedrock was confirmed by coring for 2.3 m in Borehole 07-1.

The dolomitic limestone bedrock at the site is fresh, medium strong, and very thinly to medium bedded. The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples were approximately 62 and 73 percent, indicating that the bedrock is of fair quality. The

discontinuities observed in the rock core are typically horizontal to sub-horizontal, associated with the bedding planes, although minor sub-vertical jointing was also observed. A description of some of the terms used in the description of the bedrock samples from this site is provided on the *Lithological and Geotechnical Rock Description Terminology* sheet which precedes the Record of Borehole sheets included with this report.

### **4.3 Groundwater Conditions**


The water level in Borehole 07-1, located on the bank at the edge of the floodplain, was at a depth of 0.7 m (Elevation 125.5 m) during drilling. The floodplain was submerged at the time of the investigation, with the ice level at about Elevation 125.8 m.

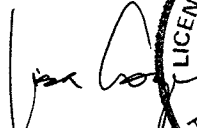
The groundwater and surface water levels are expected to fluctuate seasonally, and are expected to be higher during wet periods of the year.

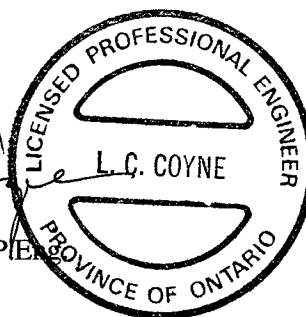
## 5.0 CLOSURE

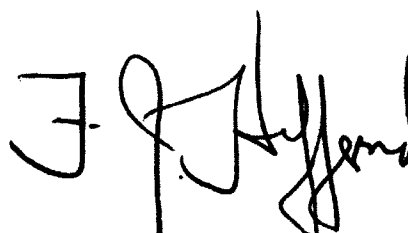
This Foundation Investigation Report was prepared by Ms. Susan Trickey, EIT, and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fintan Heffernan, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of the report.


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SAT/LCC/FJH/sat/lcc

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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

	<u>kPa</u>	<u>psf</u>
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

$c_u, s_u$

#### 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 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
$SO_4$	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 = $(w_l - w_p)$
$w_s$	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
$C_a$	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

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

**Fresh:** no visible sign of weathering.

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

## BEDDING THICKNESS

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

## JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	> 3 m
Wide	1 - 3 m
Moderately close	0.3 - 1 m
Close	50 - 300 mm
Very close	< 50 mm

## GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 - 60 mm
Medium Grained	60 microns - 2 mm
Fine Grained	2 - 60 microns
Very Fine Grained	< 2 microns

Note: \* Grains > 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery

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

### Solid Core Recovery (SCR)

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

### Rock Quality Designation (RQD)

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

## DISCONTINUITY DATA

### Fracture Index

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

### Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

### Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

### Abbreviations

B - Bedding	P - Polished
FO - Foliation/Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane/Zone	R - Ridged/Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
MF - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	

# RECORD OF BOREHOLE No 07-1

1 OF 1 **METRIC**

PROJECT 04-1111-007-6000

W.P. 251-99-00

LOCATION N 5000924.7; E 335572.7

ORIGINATED BY P.A.H.

DIST HWY 7

BOREHOLE TYPE Power Auger 108mm I.D. Hollow Stem

COMPILED BY J.M.

DATUM Geodetic

DATE Feb. 13/14, 2007

CHECKED BY S.A.T.

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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X REMOULDED	WATER CONTENT (%)					
126.2	GROUND SURFACE													
126.0	TOPSOIL													
0.3	CLAY (Weathered Crust) Very stiff Grey brown Moist to wet		1	SS	7									
			2	SS	10									
			3	SS	7									
123.1	CLAY Very stiff Grey Wet		4	SS	7									
3.1			5	SS	9									
			6	TP	PH									
118.7	Sandy SILT, some gravel, trace to some clay (TILL) Grey Wet		7	SS	>100									
118.4	Dolomitic limestone (BEDROCK) Fresh Very thinly to medium bedded Grey Medium strong		8	NQ RC	REC 100%									
7.8	Bedrock cored between 7.8m 10.15m depth. For bedrock coring details refer to Record of Drillhole 07-1.		9	NQ RC	REC 100%									
116.0	End of Borehole													
10.2	Note: Water level in open borehole at a depth of 0.7 m (Elevation 125.5 m) on completion of deilling.													

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

MIS-MTO 001 04-1111-007-6000 GPJ GAL-MISS.GDT 5/8/07

PROJECT: 04-1111-007-6000

## RECORD OF DRILLHOLE: 07-1

SHEET 1 OF 1

LOCATION: N 5000924.7; E 335572.7

DRILLING DATE: Feb. 13/14, 2007

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	PENETRATION RATE mm/min	COLOUR % RETURN	FLUSH	JN - Joint FLT - Fault SHR- Shear VN - Vein CU - Conjugate	BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break	BR - Broken Rock	NOTE: For additional abbreviations refer to list of abbreviations & symbols.	DISCONTINUITY DATA												HYDRAULIC CONDUCTIVITY				Diameter Point Load Index (MPa)	RMC -Q- AVG	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
				DEPTH (m)											RECOVERY			R Q.D. %	FRACT INDEX PER 0.3 m	B Angle DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	Jc	Jo	Jp	Js	Jt	Ju				Jv	Jw	Jx	Jy	Jz	K, cm/sec																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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8		ROCK SURFACE		118.39																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		</



**RECORD OF BOREHOLE No 07-2**

1 OF 1 **METRIC**

PROJECT 04-1111-007-6000

W.P. 251-99-00

LOCATION N 5000928.1; E 335605.8

ORIGINATED BY P.A.H.

DIST HWY 7

BOREHOLE TYPE Power Auger 108mm I.D. Hollow Stem

COMPILED BY J.M.

DATUM Geodetic

DATE

CHECKED BY S.A.T.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL   LIQUID LIMIT   MOISTURE   LIMIT CONTENT   CONTENT   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 ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED		WATER CONTENT (%) w <sub>p</sub> w   w <sub>L</sub>				
125.8	GROUND SURFACE							20   40   60   80   100		25   50   75				
0.0	ICE													
0.4	WATER													
124.6	Clayey silt and silty clay, some organic matter (ALLUVIUM) Grey brown to dark grey Wet		1	SS	1		125							
1.2	CLAY (Weathered Crust) Very stiff Grey brown Wet		2	SS	5		124						0   0   33   67	
123.1	CLAY Very stiff Grey Wet						123							
2.7			3	TP	PH		122							
							121							
			4	SS	5		120							
							119							
118.5														
118.2	Sandy SILT, some gravel, trace to some clay (TILL) Grey Wet		6	SS	>100									
7.7	End of Borehole Auger Refusal Probable Bedrock													

MIS-MTO 001 04-1111-007-6000.GPJ GAL-MISS.GDT 5/8/07

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

**RECORD OF BOREHOLE No 07-3**

1 OF 1 **METRIC**

PROJECT 04-1111-007-6000

W.P. 251-99-00

LOCATION N 5000928.2; E 335596.6

ORIGINATED BY P.A.H.

DIST HWY 7

BOREHOLE TYPE Hand Auger

COMPILED BY J.M.

DATUM Geodetic

DATE \_\_\_\_\_

CHECKED BY S.A.T.

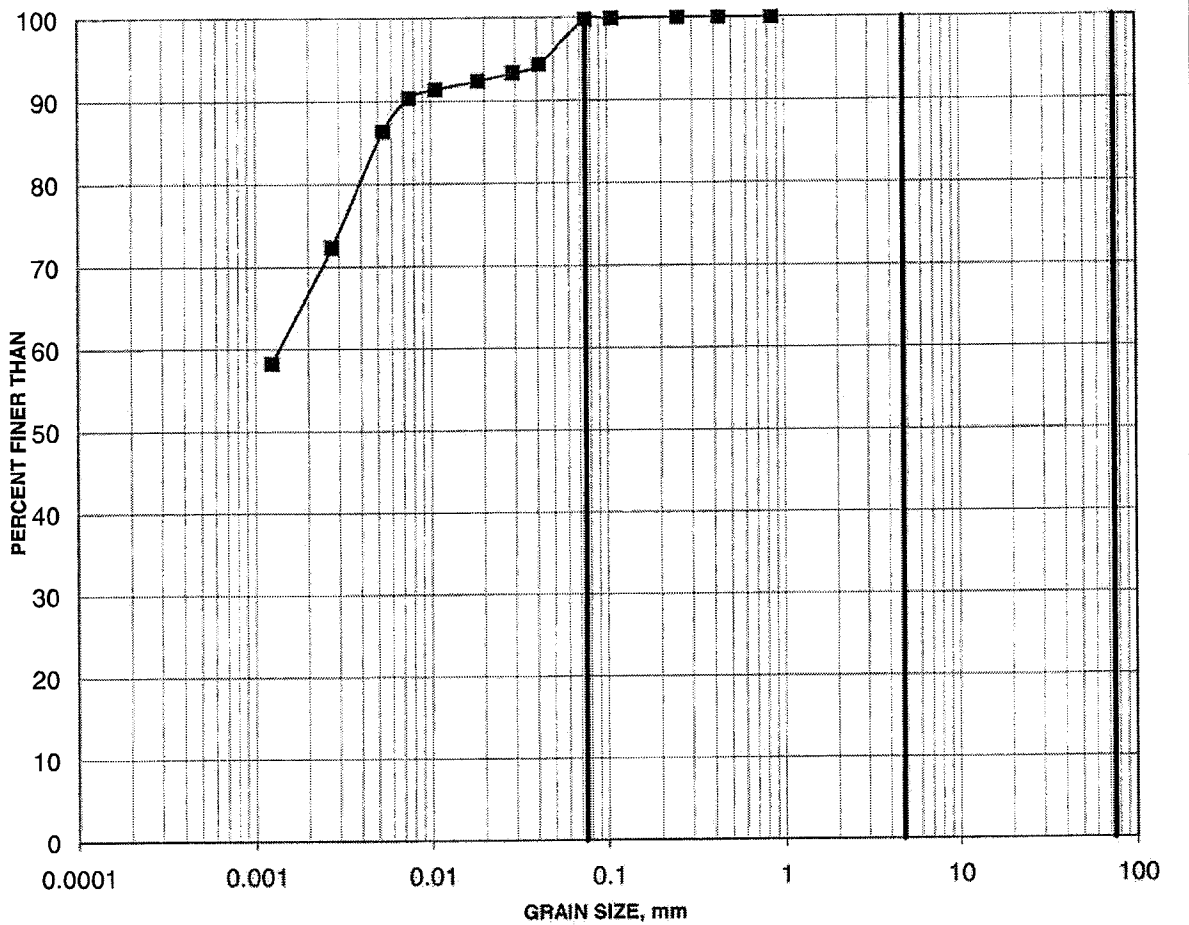
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
125.7	GROUND SURFACE							20	40	60	80	100						
0.0	ICE																	
	WATER																	
0.5	ORGANIC Material		1	A.S.	-		125											
	Silty clay, some organic matter, trace shells (ALLUVIUM)																	
124.4	Dark grey																	
	Wet																	
1.4	CLAY						124											
123.9	Very stiff																	
	Grey-brown																	
1.8	End of Augerhole																	

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

# GRAIN SIZE DISTRIBUTION TEST RESULTS

## Weathered Clay Crust

FIGURE 1



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

Borehole	Sample	Depth (m)
07-2	2	1.37-1.98

Received:

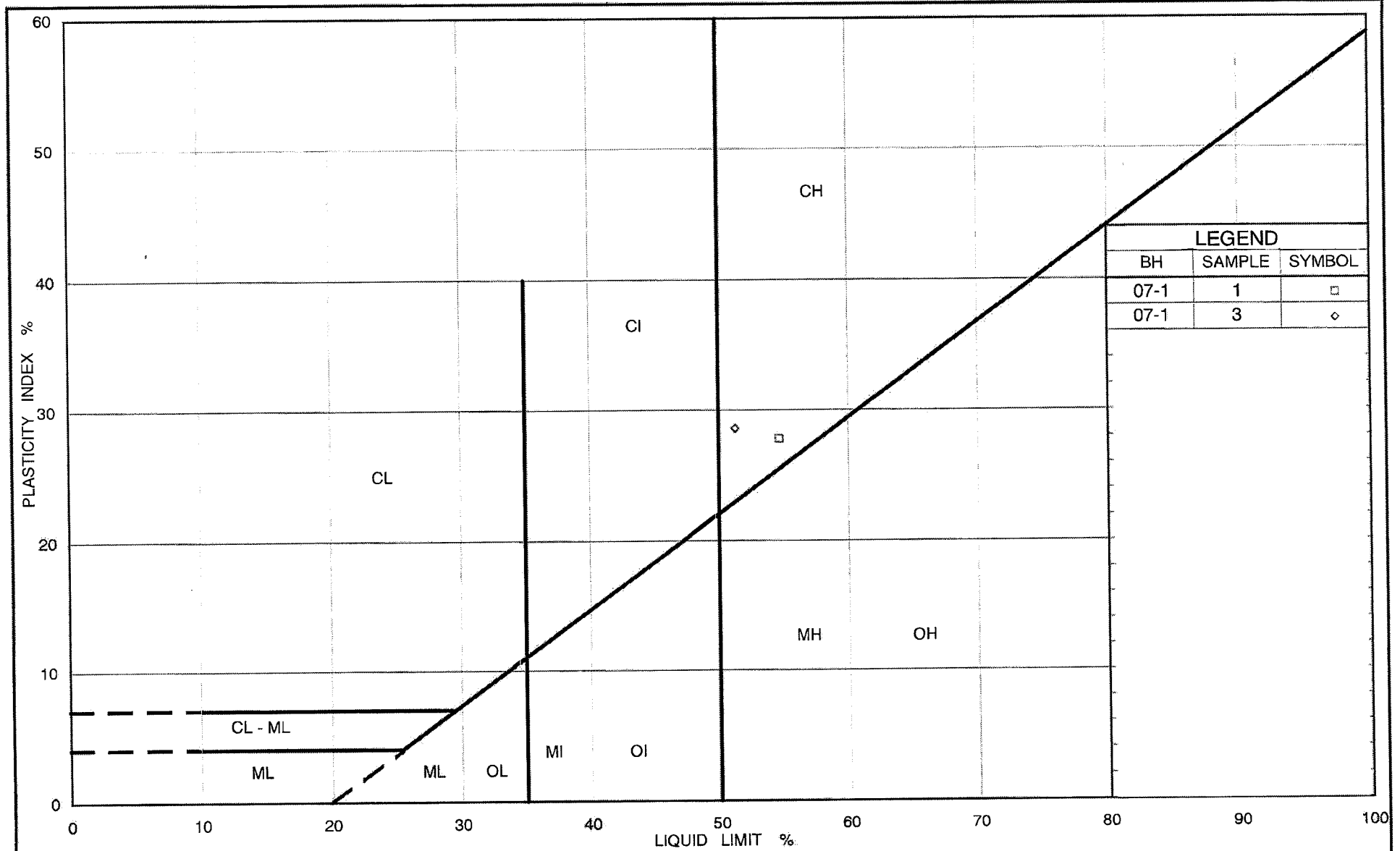
Project: 041111007

Golder Associates

9-May-07

Created by: MaD

Checked by: BaJ



Ministry of Transportation

Ontario

## PLASTICITY CHART Weathered Clay

FIGURE 2

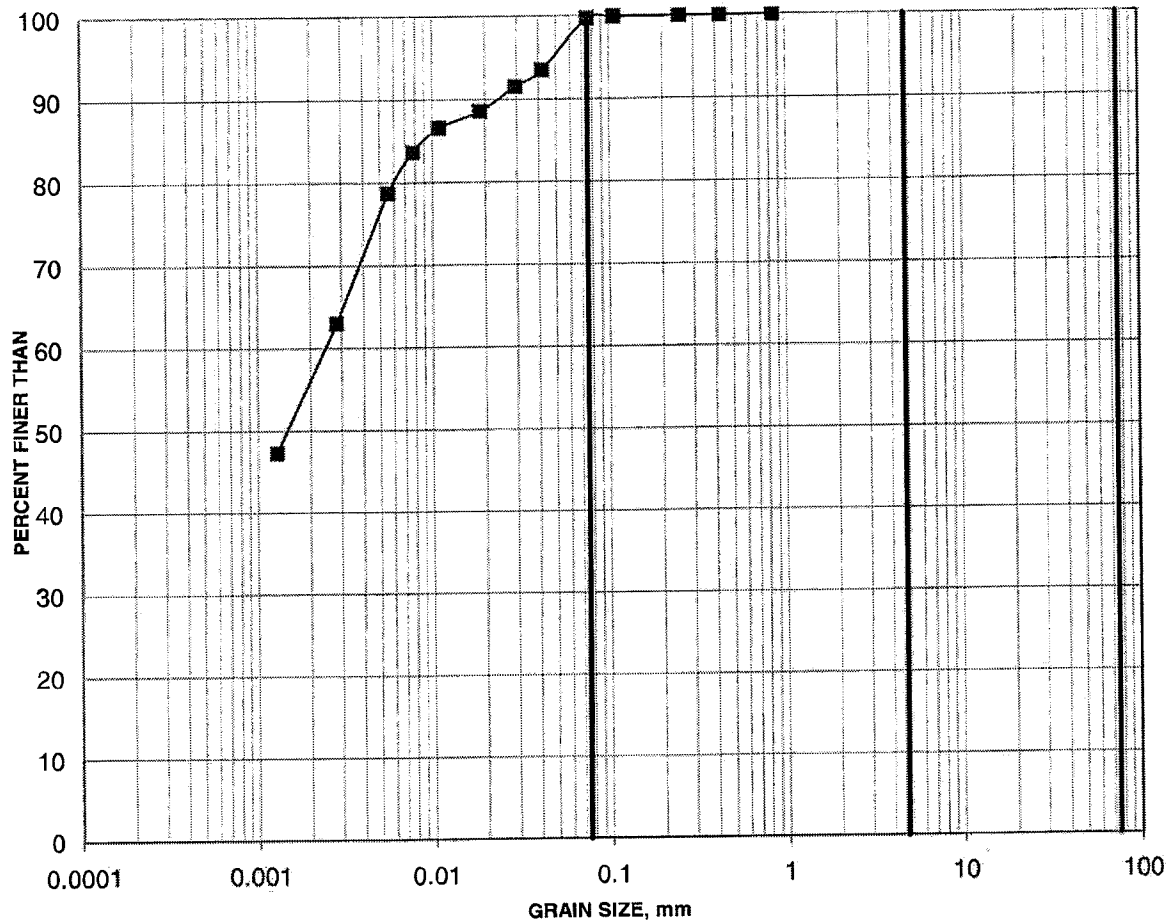
Project No. 041-111007

Checked By: SAT

# GRAIN SIZE DISTRIBUTION TEST RESULTS

## Unweathered Clay

FIGURE 3



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

Borehole	Sample	Depth (m)
07-1	4	3.05-3.66

Received:

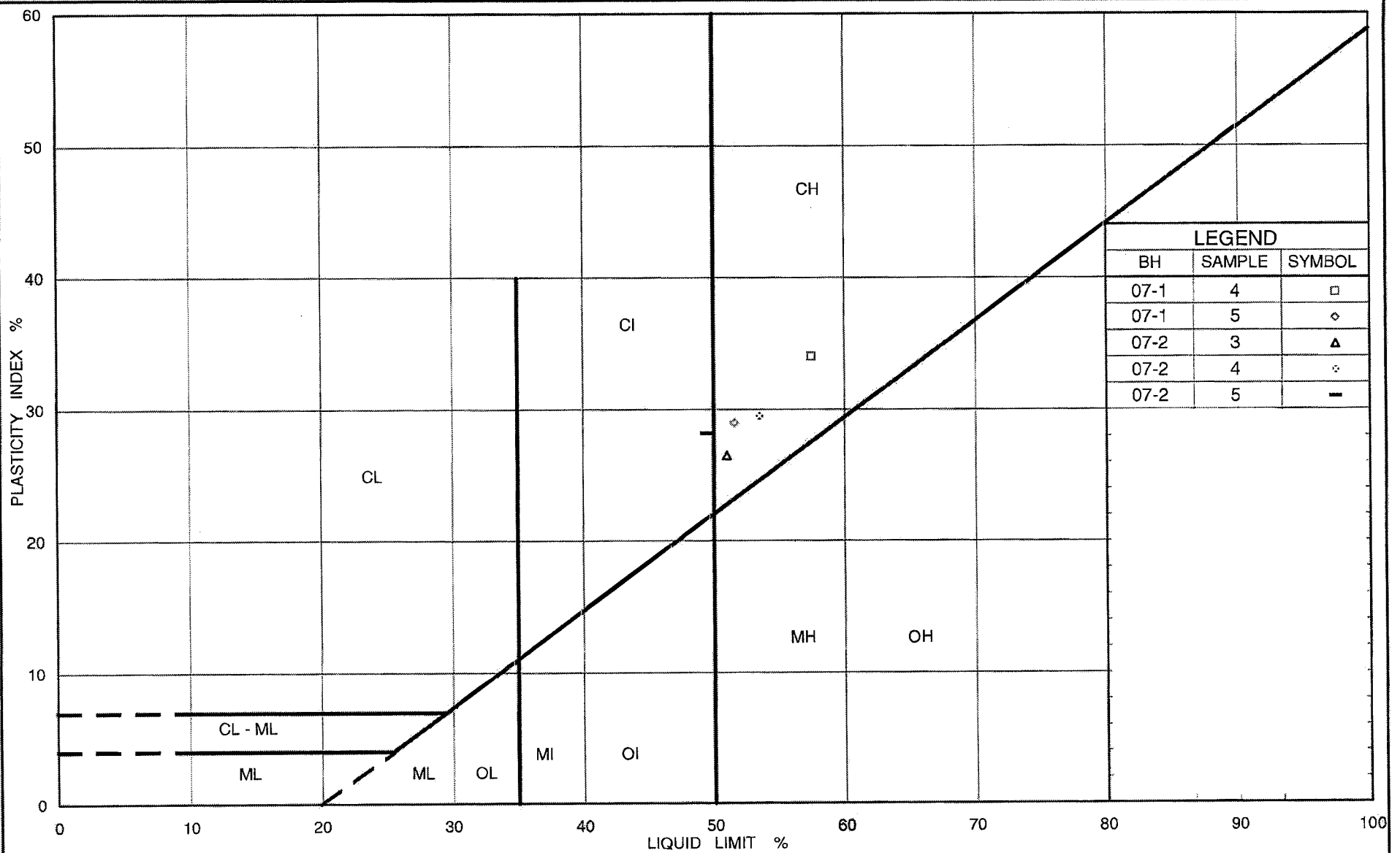
Project: 041111007

Golder Associates

9-May-07

Created by: MaD

Checked by: BaJ



Ontario

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# PLASTICITY CHART Unweathered Clay

FIGURE 4

Project No. 041-111007

Checked By: SAT

# **CONSOLIDATION TEST RESULTS** **UNWEATHERED CLAY**

**FIGURE 5A**

## **SAMPLE IDENTIFICATION**

Project Number	04-1111-007	Sample Number	3
Borehole Number	07-2	Sample Depth, m	2.9-3.35

## **TEST CONDITIONS**

Test Type	Standard	Load Duration, hr	24
Oedometer Number	7		
Date Started	02/25/2007		
Date Completed	03/07/2007		

## **SAMPLE DIMENSIONS AND PROPERTIES - INITIAL**

Sample Height, cm	1.90	Unit Weight, kN/m <sup>3</sup>	18.67
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m <sup>3</sup>	13.87
Area, cm <sup>2</sup>	31.39	Specific Gravity, measured	2.77
Volume, cm <sup>3</sup>	59.64	Solids Height, cm	0.970
Water Content, %	34.59	Volume of Solids, cm <sup>3</sup>	30.45
Wet Mass, g	113.53	Volume of Voids, cm <sup>3</sup>	29.19
Dry Mass, g	84.35	Degree of Saturation, %	100.0

## **TEST COMPUTATIONS**

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t <sub>90</sub> sec	cv. cm <sup>2</sup> /s	mv m <sup>2</sup> /kN	k cm/s
0.00	1.900	0.959	1.900				
4.87	1.899	0.958	1.900	2	3.82E-01	1.08E-04	4.05E-06
9.47	1.894	0.952	1.897	13	5.87E-02	5.72E-04	3.29E-06
19.67	1.887	0.945	1.891	38	1.99E-02	3.61E-04	7.06E-07
39.23	1.881	0.939	1.884	30	2.51E-02	1.61E-04	3.97E-07
78.07	1.871	0.929	1.876	30	2.49E-02	1.36E-04	3.30E-07
156.16	1.855	0.912	1.863	53	1.39E-02	1.08E-04	1.47E-07
311.72	1.831	0.887	1.843	21	3.43E-02	8.12E-05	2.73E-07
623.59	1.776	0.831	1.804	41	1.68E-02	9.28E-05	1.53E-07
1247.92	1.679	0.731	1.728	41	1.54E-02	8.18E-05	1.24E-07
2496.15	1.565	0.613	1.622	32	1.74E-02	4.81E-05	8.21E-08
1247.92	1.577	0.626	1.571				
311.72	1.609	0.659	1.593				
78.07	1.648	0.699	1.629				
19.69	1.686	0.738	1.667				
4.87	1.714	0.767	1.700				

Note:

k calculated using cv based on t<sub>90</sub> values.

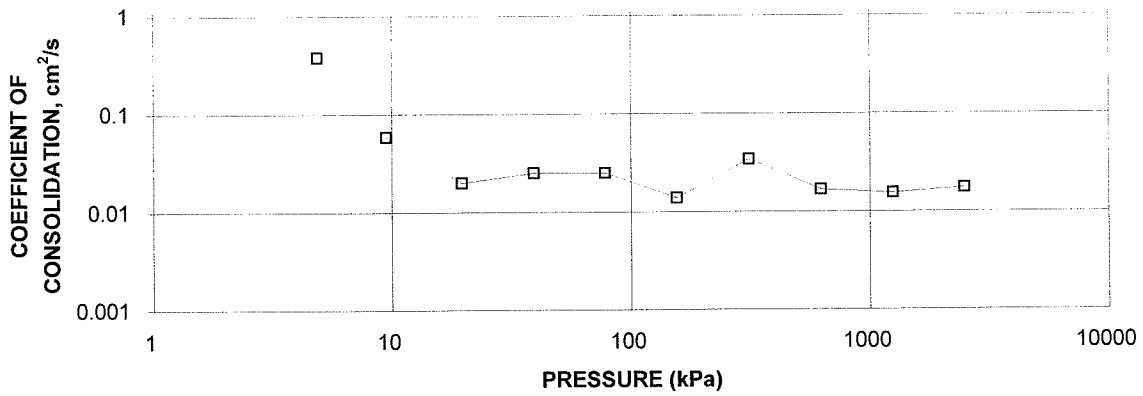
## **SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

Sample Height, cm	1.71	Unit Weight, kN/m <sup>3</sup>	20.28
Sample Diameter, cm	6.32	Dry Unit Weight, kN/m <sup>3</sup>	15.37
Area, cm <sup>2</sup>	31.39	Specific Gravity, measured	2.77
Volume, cm <sup>3</sup>	53.80	Solids Height, cm	0.970
Water Content, %	31.90	Volume of Solids, cm <sup>3</sup>	30.45
Wet Mass, g	111.26	Volume of Voids, cm <sup>3</sup>	23.35
Dry Mass, g	84.35		

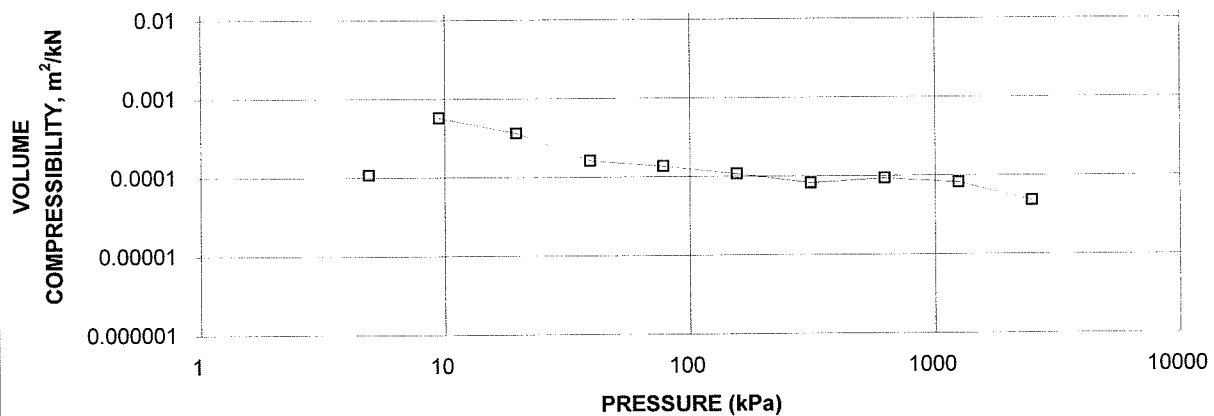
# CONSOLIDATION TEST RESULTS UNWEATHERED CLAY

FIGURE 5B

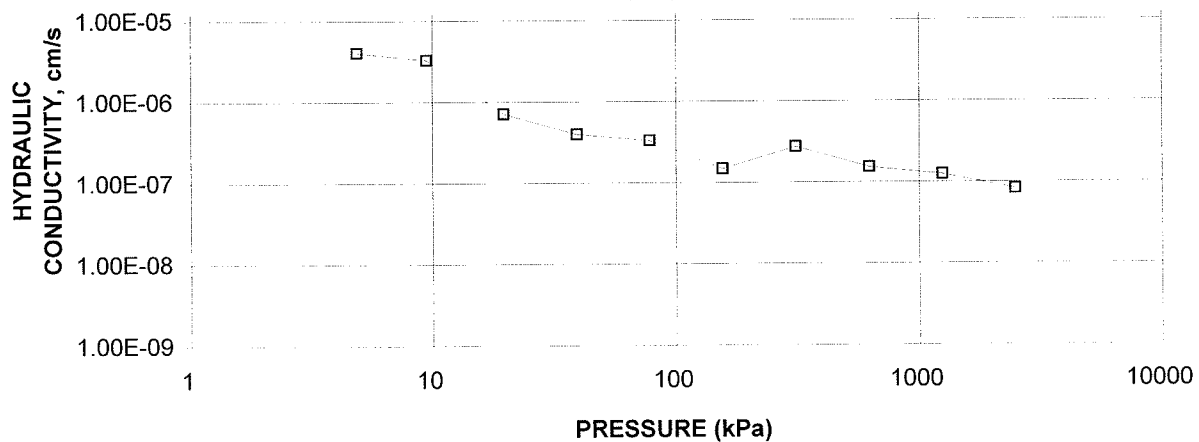
CONSOLIDATION TEST  
CV cm<sup>2</sup>/s VS PRESSURE (kPa)  
BH 07-2 SA 3



CONSOLIDATION TEST  
MV m<sup>2</sup>/kN vs PRESSURE (kPa)  
BH 07-2 SA 3



CONSOLIDATION TEST  
HYDRAULIC CONDUCTIVITY vs PRESSURE  
BH 07-2 SA 3

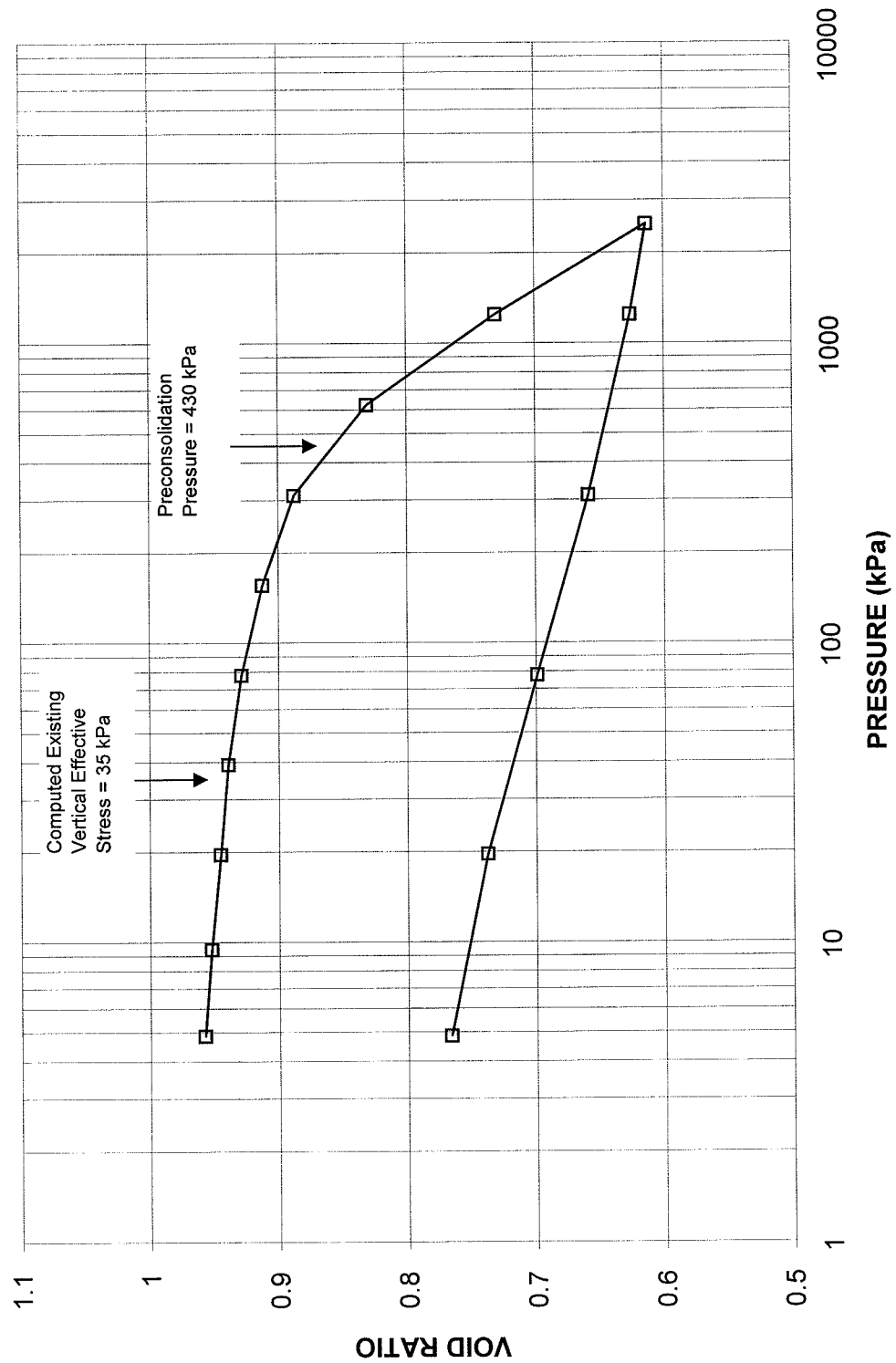




**CONSOLIDATION TEST RESULTS  
UNWEATHERED CLAY**

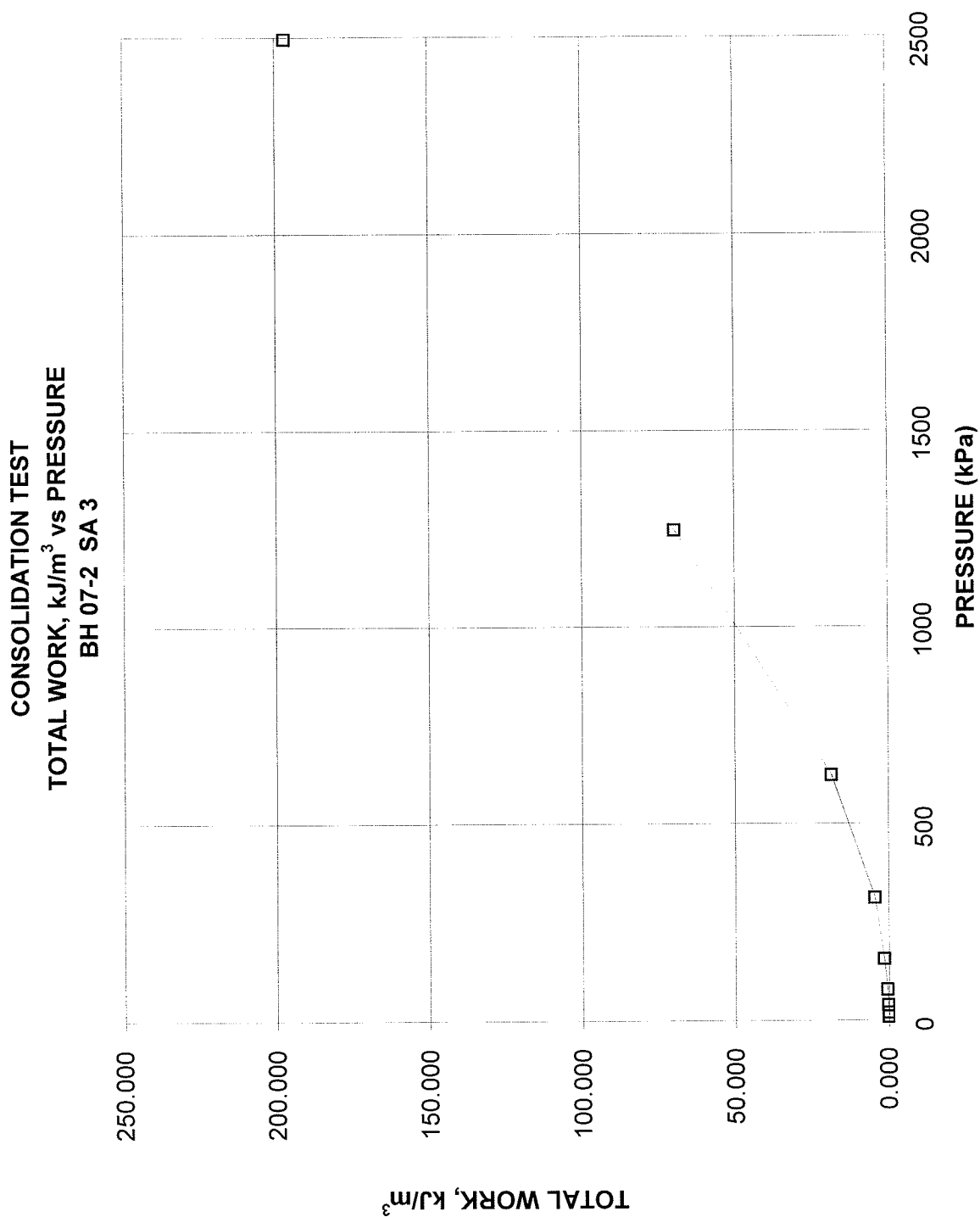
**FIGURE 5C**

**CONSOLIDATION TEST  
VOID RATIO vs PRESSURE  
BH 07-2 SA 3**



# CONSOLIDATION TEST RESULTS UNWEATHERED CLAY

FIGURE 5D



Project No. 04-1111-007

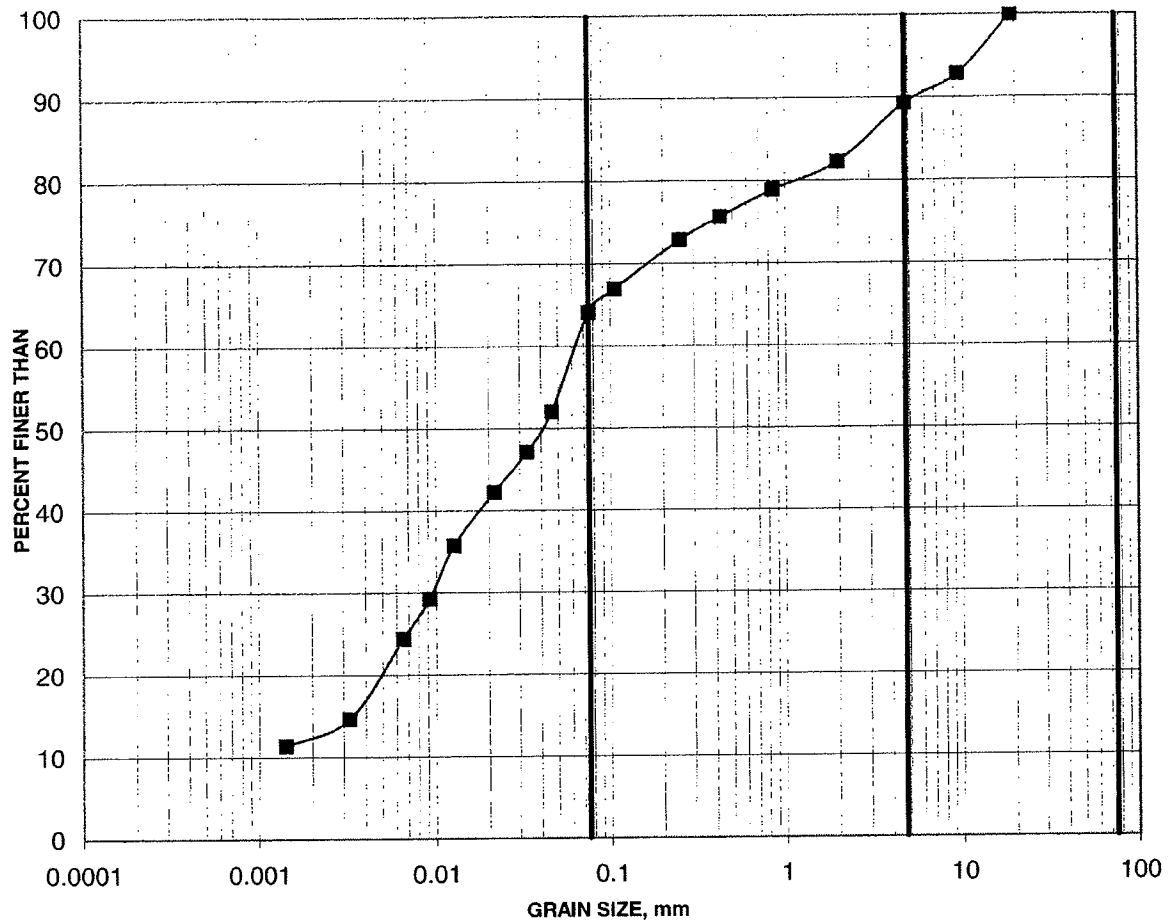
Golder Associates

Prepared By: LFG

Checked By: MM

# GRAIN SIZE DISTRIBUTION Sandy Silt Till

FIGURE 6



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

Borehole	Sample	Depth (m)
—■— 07-1	7	7.62-7.80

Received:

Project: 041111007

Golder Associates

17-May-07

Created by: MaD

Checked by: BaJ