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REPORT ON

FOUNDATION INVESTIGATION
PEDESTRIAN SUBWAY CROSSING STRUCTURE
G.W.P. 275-99-00, HIGHWAY 406 TWINNING
FROM 2.2 KM NORTH OF REGIONAL ROAD 20 TO
0.2 KM NORTH OF PORT ROBINSON ROAD
CITY OF THOROLD, CENTRAL REGION

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the twinning of Highway 406 in the City of Thorold, Regional Municipality of Niagara. The project includes a new bridge structure and interchange at Regional Road 20, a pedestrian subway at the abandoned CN Rail, culvert extensions and high fill areas. The limits of the project extend from 0.2 km north of Port Robinson Road northerly to 2.2 km north of Regional Road 20.

This report addresses the proposed pedestrian subway structure at the abandoned CN Rail crossing. A foundation investigation was carried out to determine the subsurface conditions at the proposed pedestrian subway location by drilling a limited number of boreholes, and carrying out in-situ testing and laboratory testing on selected samples.

The work was carried out in accordance with Golder Associates' Quality Control Plan for Foundation Design Services, dated August 2002. A General Arrangement plan for the pedestrian subway structure was provided to Golder by Morrison Hershfield in December 2002.

The subsurface information found in the following report prepared by the MTO was utilized in the preparation of this report to supplement the subsurface data obtained during the current investigation:

- Foundation Design Report titled "C.N.R. Overhead at Hwy 406", W.P. 167-66-01, Site 34-210, District 4, Hamilton, dated August 1980. GEOCRES No. 30M3-176.

2.0 SITE DESCRIPTION

The site is located in the City of Thorold, Regional Municipality of Niagara, with the proposed subway structure located about 65 m to the south of the existing bridge structure that carries Highway 406 over the C.N. Rail corridor. After C.N. abandoned the rail line, the City of Thorold transformed the corridor into a recreational trail. The existing Highway 406 is carried over the abandoned section of the C.N. Rail line via a three-span pre-cast concrete girder bridge that was constructed under Contract 69-137. The existing embankment is up to about 9 m high and, based on the contours shown on the topographic map, the side slopes are inclined at about 2 horizontal to 1 vertical (2H:1V). In this area, Highway 406 is presently a two lane, undivided highway with a posted speed limit of 80 km/hr.

The topography of the general area is characterized by low relief. In addition to the many wet sloughs that cover the plain as a result of poor drainage, several shallow watercourses traverse the area with direct surface drainage into several parallel streams that include Twenty Mile Creek, Forty Mile Creek and the Welland River. These watercourses are carried beneath the existing Highway 406 within the project limits with rigid frame, open footing concrete culverts that range in size from 1.2 m by 1.2 m to 2.5 m by 1.5 m.

The land within the project limits is mainly used for agricultural purposes. The perimeter of the open fields typically hold stands of mature trees. Long grass and occasional bushes cover the highway right-of-ways within the project limits.

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out on October 31, 2002 and January 14, 2003. On October 31, 2002 two (2) boreholes, numbered Boreholes P-1 and P1-A, were advanced near the east limit of the proposed subway structure. Borehole P-1 was extended into the bedrock (total depth of about 15 m) and Borehole P-1A was advanced to about 8 m depth for the purpose of collecting Shelby tube samples. Borehole P-2 was advanced near the centreline of the proposed structure to a depth of about 13 m depth on January 14, 2003. The information obtained in these boreholes was supplemented with the information obtained during the previous MTO investigation at the site. It should be noted that the numbers for the previous boreholes have been modified to reflect the year (i.e. 1980) in which they were drilled (e.g. Borehole 1 from the previous investigation designated as Borehole 80-1A herein). The previous information includes five (5) boreholes, labelled Boreholes 80-1A, and 80-3A to 80-6A inclusive.

The current boreholes were advanced with a track-mounted CME-75 drill rig equipped with an automatic hammer using 114 mm diameter solid stem augers supplied and operated by GeoEnvironmental Ltd. of Milton, Ontario. In the boreholes, overburden samples 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. Undisturbed samples of the clayey material were collected using 73 mm diameter Shelby Tube samplers. Field vane testing was also carried out in order to measure the in-situ, undrained shear strength of the subsoils. Bedrock was cored in NQ size in Borehole P-1. The groundwater conditions in the open boreholes were observed throughout the drilling operations, and a piezometer was installed in each of Boreholes P-1 and P-2 to permit monitoring of the groundwater level at these locations. The piezometers consist of a 25 mm outside diameter pipe with a 0.3 m long slotted tip that is sealed at a selected depth within the boreholes. The boreholes were backfilled to ground surface with bentonite mixed with soil cuttings.

The field work was supervised on a full-time basis by a member of our engineering staff who cleared the area of buried utilities, located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, and logged the boreholes. The soil samples and bedrock core were identified in the field, placed in labelled containers (split-spoon samples), and boxes (bedrock core), and transported to our laboratory in Mississauga for further examination and testing. The Shelby tubes were labelled and the ends waxed in the field to preserve the moisture of the samples. Index and classification tests consisting of grain size analyses, Atterberg limits tests and water content determinations were carried out on selected soil samples. One-dimensional consolidation (oedometer) tests were carried out on two selected samples of the clayey deposit. Point load tests were also carried out on selected sections of the recovered core.

The borehole locations were established relative to the staked alignment of the pedestrian subway structure. The as-drilled borehole locations and elevations were surveyed by Callon Dietz Inc. of London, Ontario. It is understood that the northing and easting coordinates are referenced to the MTM coordinate system and that the elevations are referenced to Geodetic

Datum. Borehole P-2 was drilled after the surveying was complete and this borehole location was referenced to a station and offset relative to the proposed median of Highway 406. The borehole locations for the current and previous investigations are shown on Drawing 1, except for Borehole 80-1A which is located about 10 m to the south of Borehole 80-4A.

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Site Geology

From published literature, the site is located within the physiographic region known as the Haldimand Clay Plain ("The Physiography of Southern Ontario", 3rd Edition, Chapman and Putnam, 1984). This region was submerged by glacial Lake Warren and as such much of the subsoil is comprised of stratified lacustrine silts and clays. In some areas the stratified clay overlies clayey till while in other areas the subsoil is represented by an interlayered / intermixed deposit of lacustrine silt / clay and till. The overburden is generally less than about 20 m thick, with a trend of increasing thickness towards Lake Erie. The underlying bedrock consists of a succession of Paleozoic beds dipping slightly southward under Lake Erie. Dolostone is the predominate type of rock within the plain with softer, shaley rock found in the southwest area of the plain.

4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil and bedrock samples, are given on the attached Record of Borehole and Corehole sheets and on Figures 1 to 9 following the text of this report. The stratigraphic boundaries shown on the borehole and corehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil and bedrock conditions will vary between and beyond the borehole / corehole locations.

In summary, the subsoils at the site consist of a surficial layer of topsoil and organics underlain by an upper deposit of silty clay, which in turn is underlain by clayey silt with occasional silty clay to silt seams / layers. A deposit of silty clay with sand and gravel was encountered beneath the clayey silt in two of the previous boreholes. The clayey silt / silty clay deposits overlie dolomite bedrock. The aquifer in the bedrock controls the primary groundwater level; the water level measured in the piezometer installed in Borehole P-1 was at about 7.5 m depth (Elevation 173.5 m) and 2.3 m depth (Elevation 178.7 m) about 2 weeks and 3 months, respectively, after its installation. The water level was measured in the piezometer installed in Borehole P-2 at 5.1 m depth (El. 177.1 m) about 2 weeks after installation. The groundwater was also measured in the open hole in Borehole 80-1A (located about 10 m south of Borehole 80-4A) at about 7 m depth (Elevation 174 m) about 3 days after completion of drilling.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections. The locations and elevations of the current and previous boreholes are shown on the attached Drawing 1. The Record of Borehole Sheets for the previous investigation at the site are included in Appendix A.

4.2.1 Topsoil / Organics

A layer of topsoil was encountered surficially in all boreholes. The topsoil is generally about 0.1 m to 0.2 m thick at the borehole locations. In Borehole 80-5A, the topsoil layer is underlain by organic material with a combined total thickness of about 1 m at this borehole location. It should be noted that Borehole 80-5A was put down immediately to the east of a small surface pond.

4.2.2 Silty Clay Fill

A layer of silty clay fill was encountered below the topsoil in Borehole P-2. A trace of sand and gravel were noted within the fill. Standard Penetration Testing (SPT) carried out within the fill measured 'N' values of 4 blows and 7 blows per 0.3 m of penetration indicating a stiff consistency.

The silty clay fill is 1.3 m thick at the location of Borehole P-2 and extends to Elevation 180.8 m. It is likely that the fill was placed during the construction of the existing embankment for Highway 406.

4.2.3 Upper Silty Clay

A deposit of reddish brown / grey silty clay, trace sand and gravel was encountered below the topsoil / organics in all the boreholes. The deposit is typically weathered throughout its 2 m to 4 m thickness where oxidation staining and fissuring were noted in the samples. A grain size distribution curve of a selected sample of the silty clay is shown on Figure 1.

Standard Penetration Testing (SPT) measured 'N' values ranging from 8 blows to 37 blows per 0.3 m of penetration, which indicates a stiff to hard consistency. In general, the upper silty clay is very stiff to hard as a result of weathering that has formed a crust. Field vane testing was attempted within the deposit; however, it was found that the vane could not be turned. This indicates that the undrained shear strength exceeds 96 kPa (i.e. the upper limit of shear strength measurement of the vane). The results of the unconfined shear strength testing carried out on selected samples from this stratum as part of the previous investigation measured shear strengths of 287 kPa to 156 kPa, with a general trend of decreasing strength with depth throughout the deposit.

Atterberg Limits testing conducted on two selected samples obtained from this stratum show liquid limits (w_L) of about 39 percent and 52 percent and plasticity indices (I_P) of about 18 percent and 29 percent. The results of the Atterberg limits testing carried out on samples of this deposit as part of the previous investigation show liquid limits (w_L) ranging from about 34 percent to 48 percent and plasticity indices (I_P) ranging from about 18 percent to 26 percent. The results of the Atterberg Limits testing classify the soil in this stratum as an inorganic silty clay of intermediate to high plasticity. The results of the current Atterberg Limits testing are

shown plotted on the plasticity chart on Figure 2. The natural water content measured on selected samples from this stratum range from about 17 percent to 26 percent, with an average of about 21 percent. In general, the water contents were found to be at or slightly above the measured plastic limits, corresponding to a liquidity index of less than 1.

4.2.4 Lower Clayey Silt

The predominant deposit at the site was encountered beneath the silty clay stratum and consists of brown to reddish grey clayey silt with occasional silty clay to silt seams / layers and containing trace of sand and gravel. Grain size distribution curves of a selected sample of the clayey silt and a silt / clay seam / layer are shown on Figures 3 and 5, respectively.

Standard Penetration Testing (SPT) in the recent boreholes measured 'N' values within this deposit ranging from 3 to 15 blows per 0.3 m at penetration. In the previous boreholes, all located on the west side of the existing Hwy. 406, 'N' values ranging from 2 blows to 33 blows per 0.3 m of penetration were measured within the clayey silt deposit. Typically, the measured 'N' values range from 2 blows to 13 blows per 0.3 m of penetration. The field vane testing carried out in this deposit during the recent investigation gave undrained shear strength values varying from about 40 kPa to 60 kPa indicating a firm to stiff consistency. The results of laboratory unconfined shear strength tests carried out as part of the previous investigation indicate shear strength values of between 42 kPa and 115 kPa throughout the deposit. The deposit is classified as firm to very stiff. The sensitivity of the deposit, as estimated from the field vane tests, ranges from about 1.5 to 4, implying that the clayey stratum in this area is of low to medium sensitivity based on the classification system provided in CFEM (1992).

Atterberg Limits testing conducted on selected clayey silt samples obtained from this stratum indicate liquid limits (w_L) of between about 21 percent and 26 percent and plasticity indices (I_P) of between about 4 percent and 10 percent. Atterberg limits testing was also carried out on two silt / clay seams found within the Shelby tube samples obtained in Borehole P-1A of the current investigation. The results indicate liquid limits (w_L) of about 31 percent and 34 percent and plasticity indices (I_P) of about 13 percent and 17 percent for the silt / clay seams / layers. The results of the Atterberg limits testing carried out on samples of this stratum obtained for the previous investigation show liquid limits (w_L) ranging from about 23 percent to 46 percent and plasticity indices (I_P) ranging from about 7 percent to 23 percent. The higher values measured on the previous samples were obtained from Shelby Tubes (sample type TW shown on the logs) where it is likely that the silty clay seams / layers were targeted for testing. The results of the Atterberg Limits testing classify this stratum as an inorganic clayey silt of low plasticity with the silty clay / clayey silt seams / layers having low to intermediate plasticity. The results of the current Atterberg Limits testing are shown on the plasticity chart on Figures 4 and 6 for the main deposit and the seam / layers, respectively. The natural water content measured on selected samples from this stratum typically range from about 17 percent to 37 percent, with an average of about 25 percent. These water contents vary significantly with respect to relationship with the

liquid limits and plastic limits; likely reflecting the wide range of soil types and the interlayering of the deposit.

The measurements of mass and dimensions conducted to estimate the natural bulk unit weight of two carefully trimmed samples from this stratum that were collected during the current investigation resulted in values of about 20 kN/m^3. The specific gravity measured on these two samples produced an average value of 2.73. Bulk unit weight determinations from the previous investigation gave values ranging from 18.4 kN/m^3 to 22 kN/m^3 with an average value of 20 kN/m^3.

Consolidation tests (oedometer) were performed on two samples from this stratum. The results are summarized below.

Borehole (Sample)	Elevation (Depth) (m)	$ó_{vo}'$ (kPa)	$ó_p'$ (kPa)	OCR	e_o	C_r	C_c	c_v (cm^2/s)
P-1A (1)	176 (5)	100	505	5.1	0.562	0.031	0.151	1.1 x 10^{-1}
P-1A (2)	172.9 (8.1)	156	455	2.9	0.661	0.024	0.144	5.3 x 10^{-2}

where : $ó_{vo}'$ is the effective overburden pressure in kPa
$ó_p'$ is the pre-consolidation pressure in kPa
OCR is the overconsolidation ratio
e_o is the initial void ratio
C_r is the recompression index
C_c is the compression index
c_v is the estimated coefficient of consolidation for anticipated stress range at sample depth in cm^2/s

The detailed results of the consolidation tests are provided in Appendix B. Plots showing the Void Ratio versus Pressure for Samples 1 and 2 are shown on Figures 7 and 8, respectively. Figure 9 is a plot of the preconsolidation stress values for the two oedometer tests in relation to the effective stress profile.

The clayey silt deposit was fully penetrated in Boreholes P-1, P-2, and 80-6A where it was found to be about 6.8 m to 7.4 m thick, corresponding to an Elevation of about 169.9 m to 171.1 m at the base of the deposit.

4.2.5 Silty Clay with Sand and Gravel

Beneath the clayey silt stratum in Boreholes P-2, 80-5A, and 80-6A exists a deposit of reddish grey silty clay with sand and gravel that is 0.6 m to 1.6 m thick at these borehole locations. Standard Penetration Testing (SPT) measured 'N' values of 38 blows to greater than 100 blows per 0.3 m of penetration, indicating a hard consistency. Atterberg limits testing carried out on a

selected sample of the silty clay measured a liquid limit (w_L) of about 20 percent and a plasticity index of about 8 percent (I_P), which indicates that the clay is of low plasticity. The natural water content of this sample was measured at about 10 percent.

4.2.6 Bedrock

Bedrock was encountered at Elevations 169.9 m and 169.2 m in Boreholes P-1 and 80-6A, respectively (about 11.1 and 11.3 m below the ground surface). Bedrock was inferred at 12.7 m depth (Elevation 169.5 m), 12.2 m depth (Elevation 168.2 m), 11.9 m depth (Elevation 168.5 m), and 12 m depth (Elevation 168.6 m) in Boreholes P-2, 80-3A, 80-4A, and 80-5A, respectively, based on auger refusal. Borehole P-1 of the current investigation was advanced 4 m into the bedrock by coring in NQ size. Borehole 80-6A from the previous investigation was advanced about 1.5 m into bedrock. The rock core samples consist of slightly weathered to fresh, grey, medium to coarse-grained, strong to very strong, mainly massive with some thin bedding dolostone. Very few factures exist within the recovered core. Where fractures were encountered, the fracture index is between 1 and 3 fractures per 0.3 m. The Rock Quality Designation (RQD) measured on the core samples range from about 85 percent to 100 percent, which indicates that the rock mass is of good to excellent quality based on the guidelines provided in the Canadian Foundation Engineering Manual (CFEM, 3rd Edition, 1992). In general, the rock mass quality is excellent. Strength testing carried out on four samples of the recovered core gave diametrical point load indices of about 4.8 MPa to 7.3 MPa. The corresponding range in interpreted unconfined compressive strength of the rock mass is about 115 MPa to 175 MPa.

4.2.7 Groundwater Conditions

Water was introduced into Borehole P-1 for coring the bedrock and therefore a water level reading was not obtained upon completion of drilling of this borehole. Borehole P-1A was open and dry upon completion of drilling. Piezometers were sealed into the bedrock and the lower portion of the clayey silt deposit in Borehole P-1 and into the clayey silt deposit in Borehole P-2. The water level measured in the piezometer in Borehole P-1 was at 7.5 m depth (Elevation 173.5 m) about 2 weeks after the completion of drilling and at 2.3 m depth (Elevation 178.7 m) about 3 months after completion of drilling. The water level in the piezometer installed in Borehole P-2 was measured at 5.1 m depth (Elevation 177.1 m) about 2 weeks after its installation. Piezometers were not installed in the previous Boreholes 80-1A and 80-3A to 80-6A. Borehole 80-1A, located about10 m south of Borehole 80-4A, was left open for a period of three days at which time the water level in the borehole was measured. Water was found at about 7 m depth (about Elevation174 m) in this borehole. Water was also measured in the open hole in Borehole 80-5A at about 2.5 m depth (about Elevation 178 m) 18 hours after completion of drilling. It should be noted that Borehole 80-5A was put down immediately to the east of a small surface pond.

Readings from other piezometers installed within the project limits indicate that a perched water condition generally exists within the silty clay with downward drainage through the clayey silt toward the bedrock. The perched water level follows the ground surface within the project limits and is generally within about 2.5 m of the ground surface. The regional groundwater level appears to be controlled by the bedrock and the more previous soil layer that overlies the bedrock. Where the bedrock is at greater depth, the regional groundwater level is also deeper but at the pedestrian subway site, the recent water level readings do not reflect a downward drainage.

It should also be noted that the water levels in the area are subject to seasonal variations.

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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

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 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) 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

(b) Cohesive Soils

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

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

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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*
F factor of safety
V volume
W weight

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 stresses (major, intermediate, minor)
σ_{oct} mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ shear stress
u porewater pressure
E modulus of deformation
G shear modulus of deformation
K bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (con't.)

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)

(c) 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

(d) Consolidation (one-dimensional)

C_c compression index (normally consolidated range)
C_r recompression index (overconsolidated range)
C_S swelling index
C_α 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
σ'_p pre-consolidation pressure
OCR Overconsolidation ratio $=\sigma'_p/\sigma'_{vo}$

(e) Shear Strength

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

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

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
ll - Parallel To	
⊾ - Perpendicular To	

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RECORD OF BOREHOLE No P-1

1 OF 1

METRIC

PROJECT 021-1143
W.P. 275-99-00
DIST 4 HWY 406
DATUM Geodetic

LOCATION N 4771501.6; E 326279.7
BOREHOLE TYPE Solid Stem Augers
DATE October 31, 2002

ORIGINATED BY PKS
COMPILED BY DKB
CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.0	GROUND SURFACE										
0.0	Topsoil										
0.2	Silty Clay, trace sand and gravel, occasional oxidation staining, fissured Very stiff to hard Brown/grey Moist		1	SS	15				○		
			2	SS	21		180		○		
			3	SS	37		179		○		
			4	SS	33				○		0 1 37 62
			5	SS	31		178		○		
176.7							177				
4.3	Clayey Silt, trace sand and gravel with occasional silt to silty clay seams/layers Firm to stiff Grey to reddish grey Wet		6	SS	6		176	× +			
			7	SS	9		175	× +	○		
			8	SS	5		174	× +			
			9	SS	3		173	× +	○		
169.9			10	SS	29		172	× +	○		
11.1	Slightly weathered to fresh, strong to very strong, grey, medium to coarse grained DOLOSTONE, very few fractures, mainly massive, some vuggs, some styolites.						171				
	For bedrock coring details refer to Record of Drillhole P-1.						170		○		
165.9							169				
15.1	END OF HOLE						168				
	Notes: 1. Water level measured in piezometer at 7.5m depth (El.173.5m) on Nov.15, 2002. 2. Water level measured in piezometer at 2.3m depth (El. 178.7m) on Jan.31, 2003.						167				
							166				

$+^3$, $\times^3$. Numbers refer to Sensitivity $\circ^{3\%}$ STRAIN AT FAILURE

PROJECT: 021-1143

RECORD OF DRILLHOLE: P-1

SHEET 2 OF 2

LOCATION: N 4771501.6; E 326279.7

DRILLING DATE: November 1, 2002

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME - 75

DRILLING CONTRACTOR: Geo-Environmental Ltd.

FR/FX-FRACTURE F-FAULT SM-SMOOTH FL.-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 (5 10 15 20)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3})	DIAMETRAL POINT LOAD INDEX (MPa) (2 4 6)	NOTES WATER LEVELS INSTRUMENTATION
12		Slightly weathered to fresh, strong to very strong, grey, medium to coarse grained DOLOSTONE, very few fractures, *mainly massive, some vuggs*, some styolites.		11.10	1								90	MB,R,U R,U			
													60 90	B,R,PL B,R,PL			
													90	B,R,PL			
13					2								90	MB			
													90	MB			
14													90	B,R,PL			
					3								90	B,R,PL			
													90	B,R,PL			
15														MB MB			
		END OF HOLE		15.10													
16																	
17																	
18																	
19																	
20																	
21																	

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PKS
CHECKED: MR

MSS_ROCK 1143-ROCK.GPJ GLDR_CAN.GDT 7/7/03 PS/MMZ

Golder Associates

RECORD OF BOREHOLE No P-1A 1 OF 1 METRIC

PROJECT 021-1143
W.P. 275-99-00
DIST 4 HWY 406
DATUM Geodetic
LOCATION N 4771501.0; E 326279.7
BOREHOLE TYPE Solid Stem Augers
DATE October 31, 2002
ORIGINATED BY PKS
COMPILED BY DKB
CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.0	GROUND SURFACE										
0.0	Topsoil										
0.2	Silty Clay, trace sand and gravel, occasional oxidation staining, fissured Very stiff to hard Brown/grey Moist						180 179 178 177				
176.7											
4.3	Clayey Silt, trace sand and gravel with occasional silt to silty clay seams/layers Firm to stiff Grey to reddish grey Wet		1	TO	PH		176 175 174			20.2	0 1 87 12
172.8			2	TO	PH		173			20.2	0 2 55 43
8.2	END OF HOLE Notes: 1. Stratigraphy based on results of Borehole P-1. 2. Open borehole dry upon completion of drilling.										

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

Golder Associates

RECORD OF BOREHOLE No P-2 1 OF 1 METRIC

PROJECT 021-1143 | W.P. 275-99-00 | DIST 4 | HWY 406 | DATUM Geodetic

LOCATION Sta. 10+120 O/S 12m LT. | BOREHOLE TYPE Solid Stem Augers | DATE January 14, 2003

ORIGINATED BY PKS | COMPILED BY DKB | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.2	GROUND SURFACE						182				
0.9	TOPSOIL		1	SS	7						
	Silty clay, trace sand and gravel, Stiff, Brown, Moist (FILL)		2	SS	4		181				
180.8											
1.4	Silty Clay, trace sand and gravel , occ. oxidation staining, fissured, Stiff to very stiff, Brown/Grey, Moist		3	SS	14		180				
			4	SS	25						
178.5			5	SS	21		179				
3.7	Clayey Silt, trace sand and gravel with occ. silt to silty clay seams/layers, Firm to Stiff, Grey, Wet		6	SS	15		178				
			7	SS	8	▽	177	× +			
	Note: 0.8m thick silt layer present at 3.7m depth.		8	SS	7		176	× +			
			9	SS	7		175				
							174	× +			
			10	SS	3		173	× +			
171.1							172				
11.1	Silty Clay, some sand and gravel, Hard, Grey, Wet		11	SS	4		171				
169.5			12	SS	38		170				
12.7	END OF BOREHOLE Refusal on probable bedrock										

Notes:

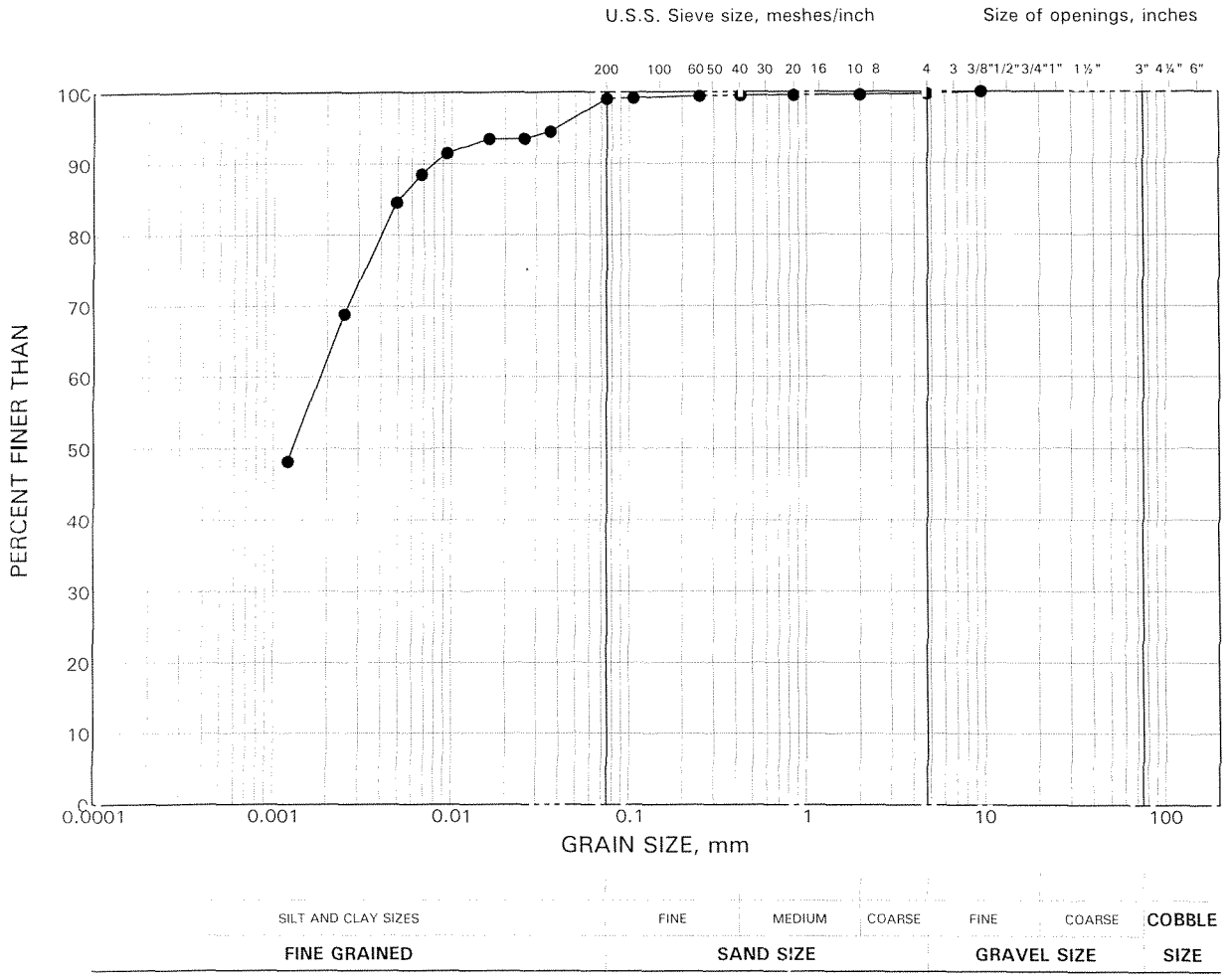
1. Open borehole dry upon completion of drilling.
2. Water level measured in piezometer at 5.1m depth (El. 177.1m) on Jan.31, 2003.

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

MISS_MTO_021-1143.GPJ_ON_MOT.GDT 23/5/03

GRAIN SIZE DISTRIBUTION
Silty Clay, trace sand

FIGURE 1



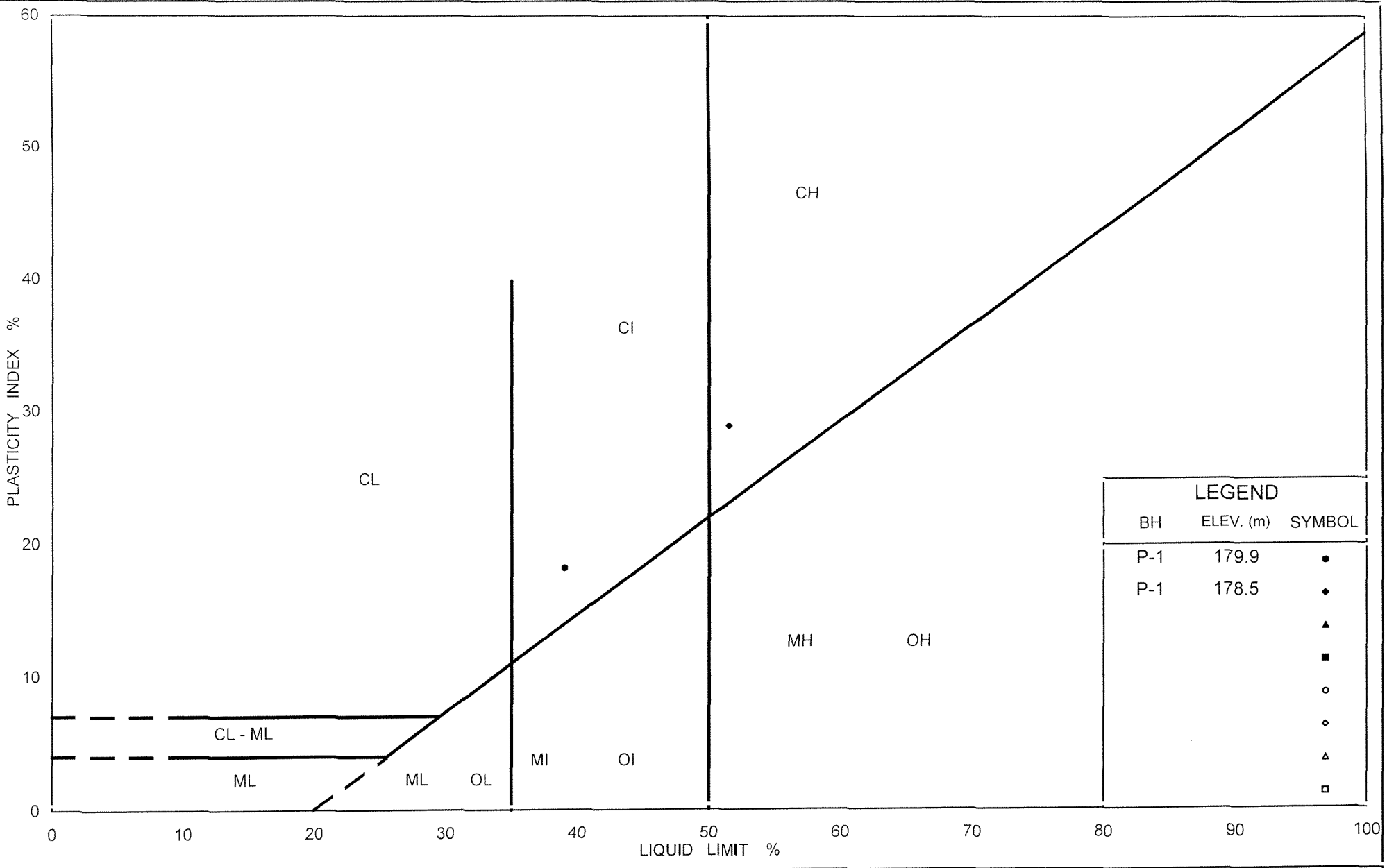
LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	P-1	4	178.1

Project 021-1143-2

Golder Associates

Oct 75 FF-S-21



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Ontario

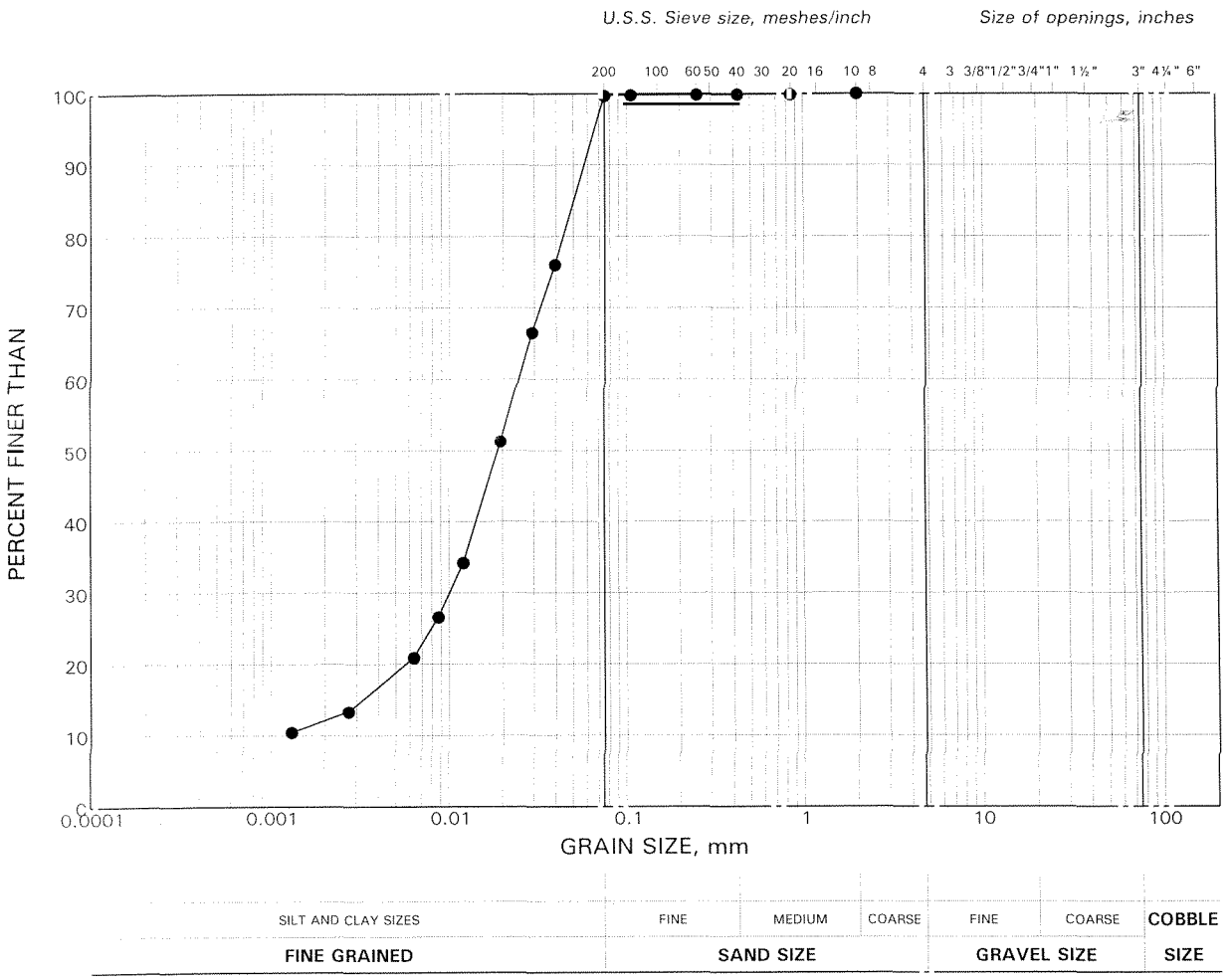
PLASTICITY CHART
Silty Clay

FIG No. 2

Project No. 021-1143-2

GRAIN SIZE DISTRIBUTION
Clayey Silt, trace sand

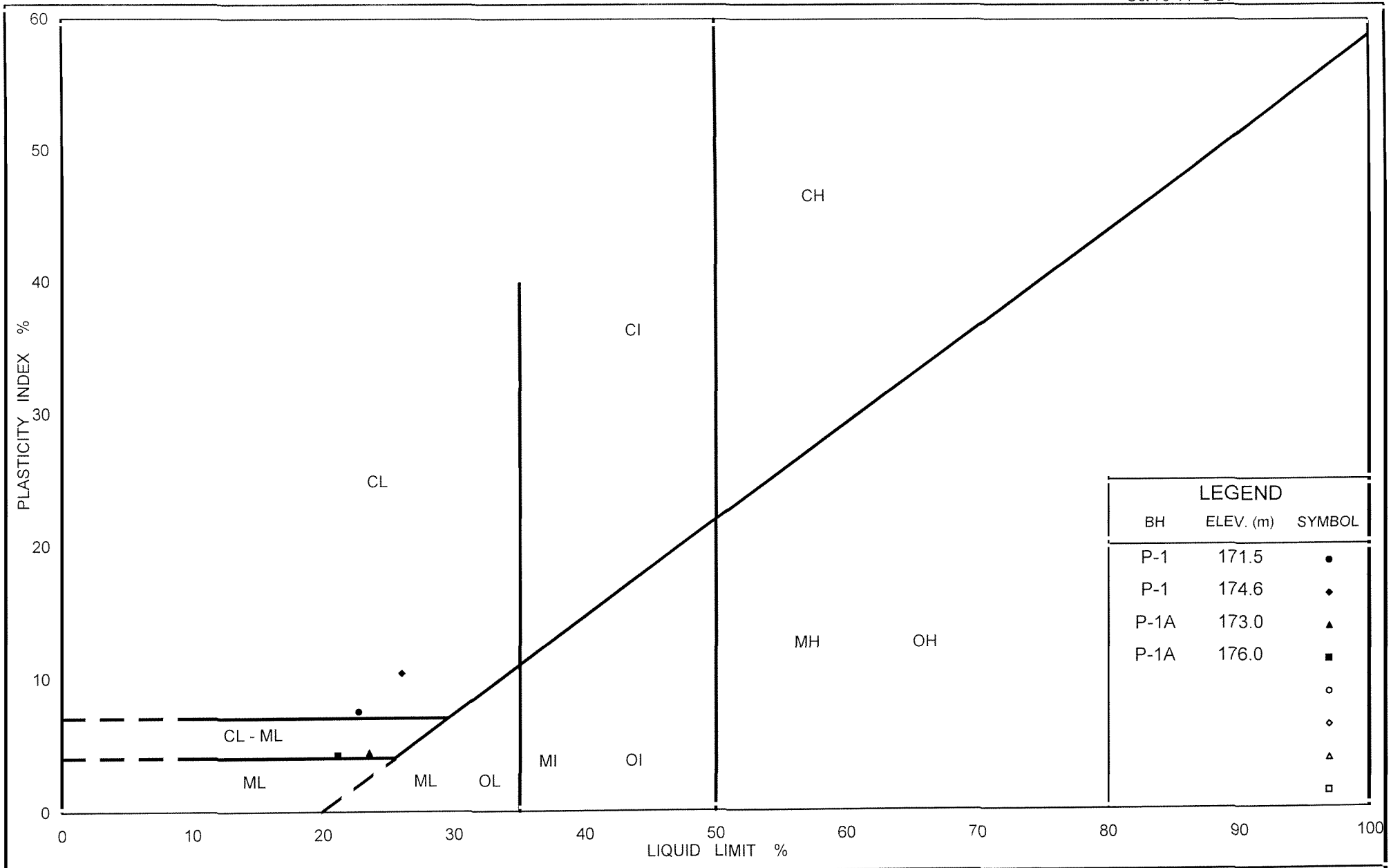
FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	P-1A	1	176.0

Oct 75 FF-S-21



Ministry of Transportation

Ontario

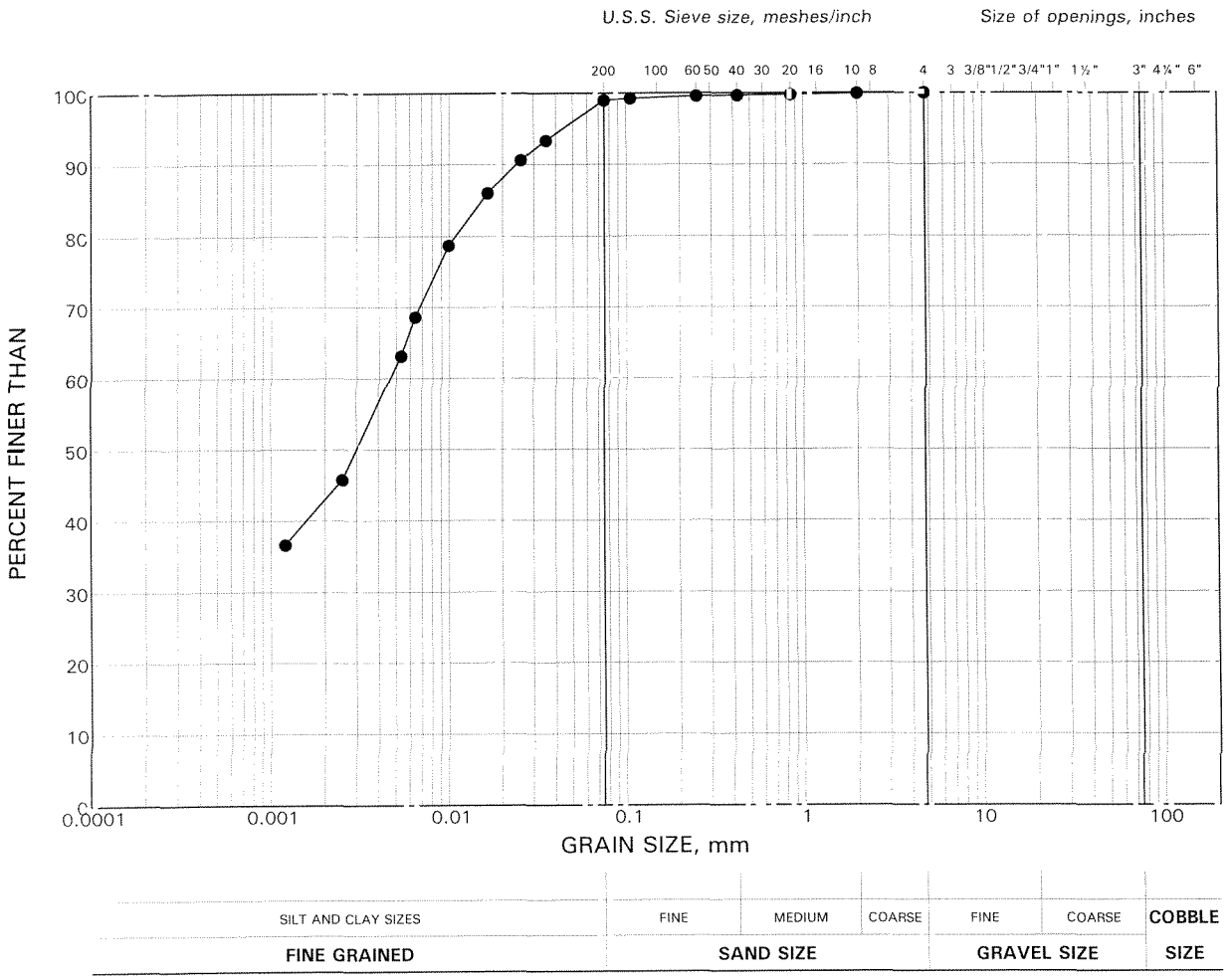
PLASTICITY CHART
Clayey Silt

FIG No. 4

Project No. 021-1143-2

GRAIN SIZE DISTRIBUTION
Clayey Silt, trace sand (seam / layer)

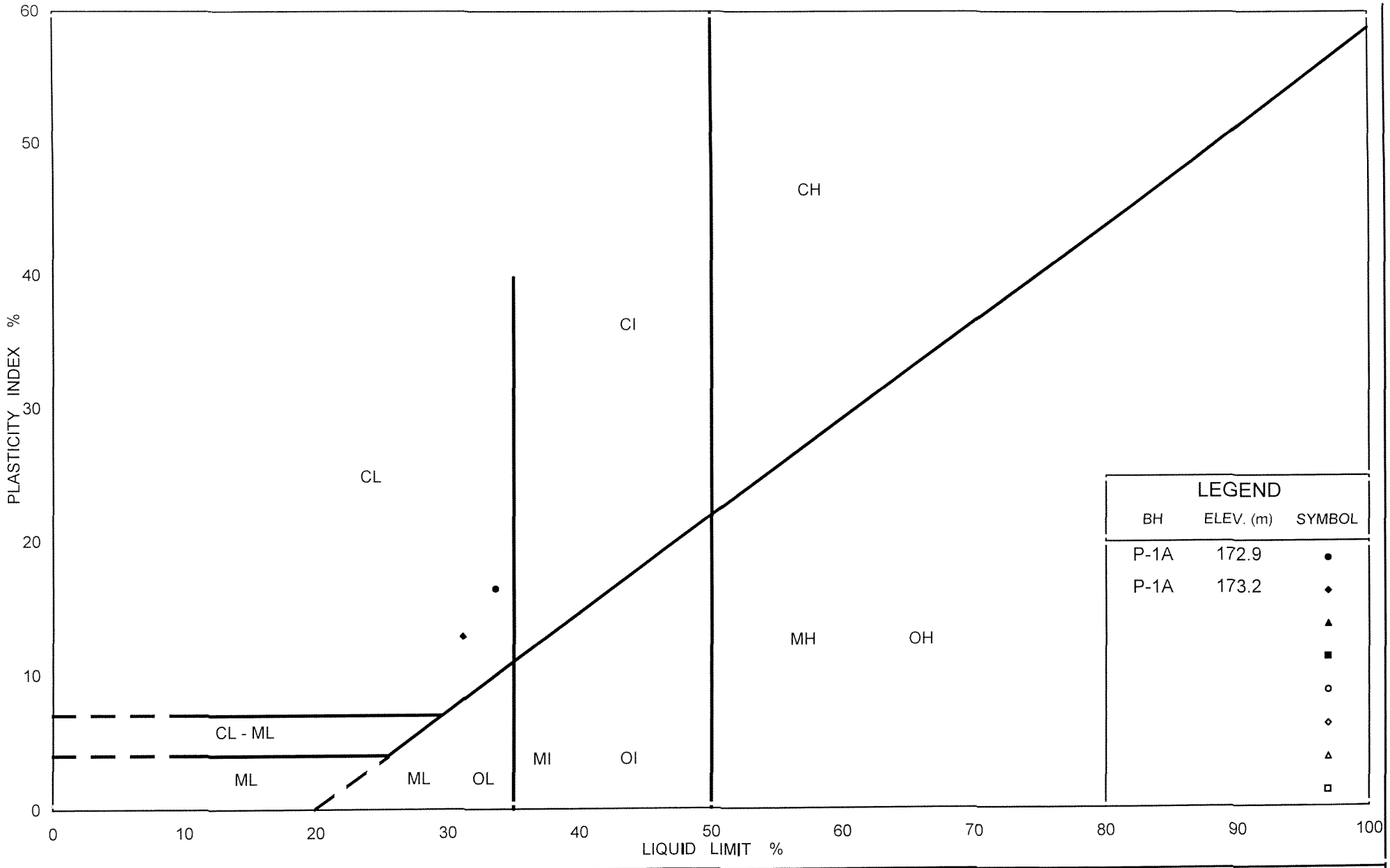
FIGURE 5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	P-1A	2	172.9

Oct 75. FF-S-21



Ministry of Transportation

Ontario

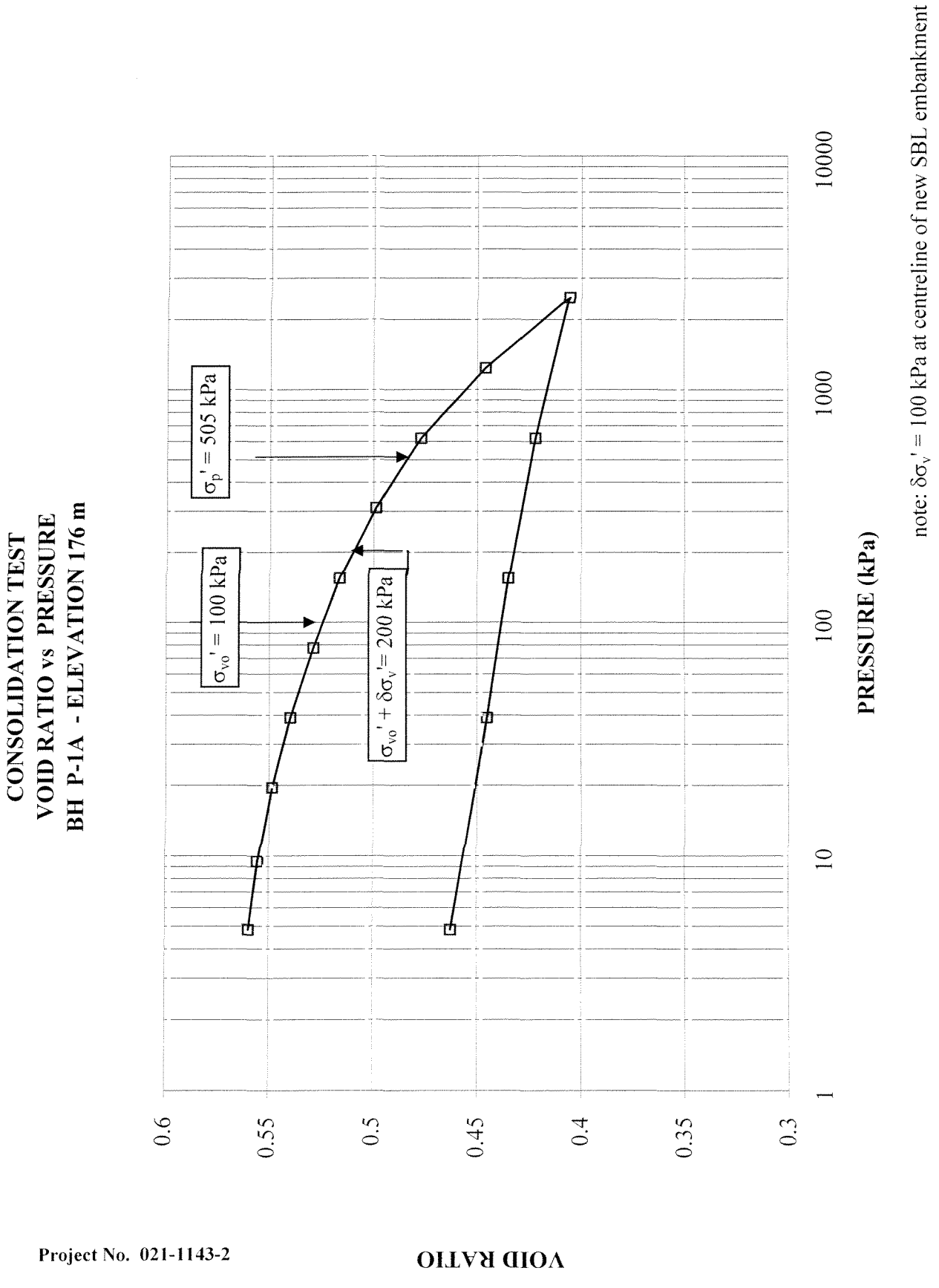
PLASTICITY CHART
Clayey Silt (seam / layer)

FIG No. 6

Project No. 021-1143-2

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

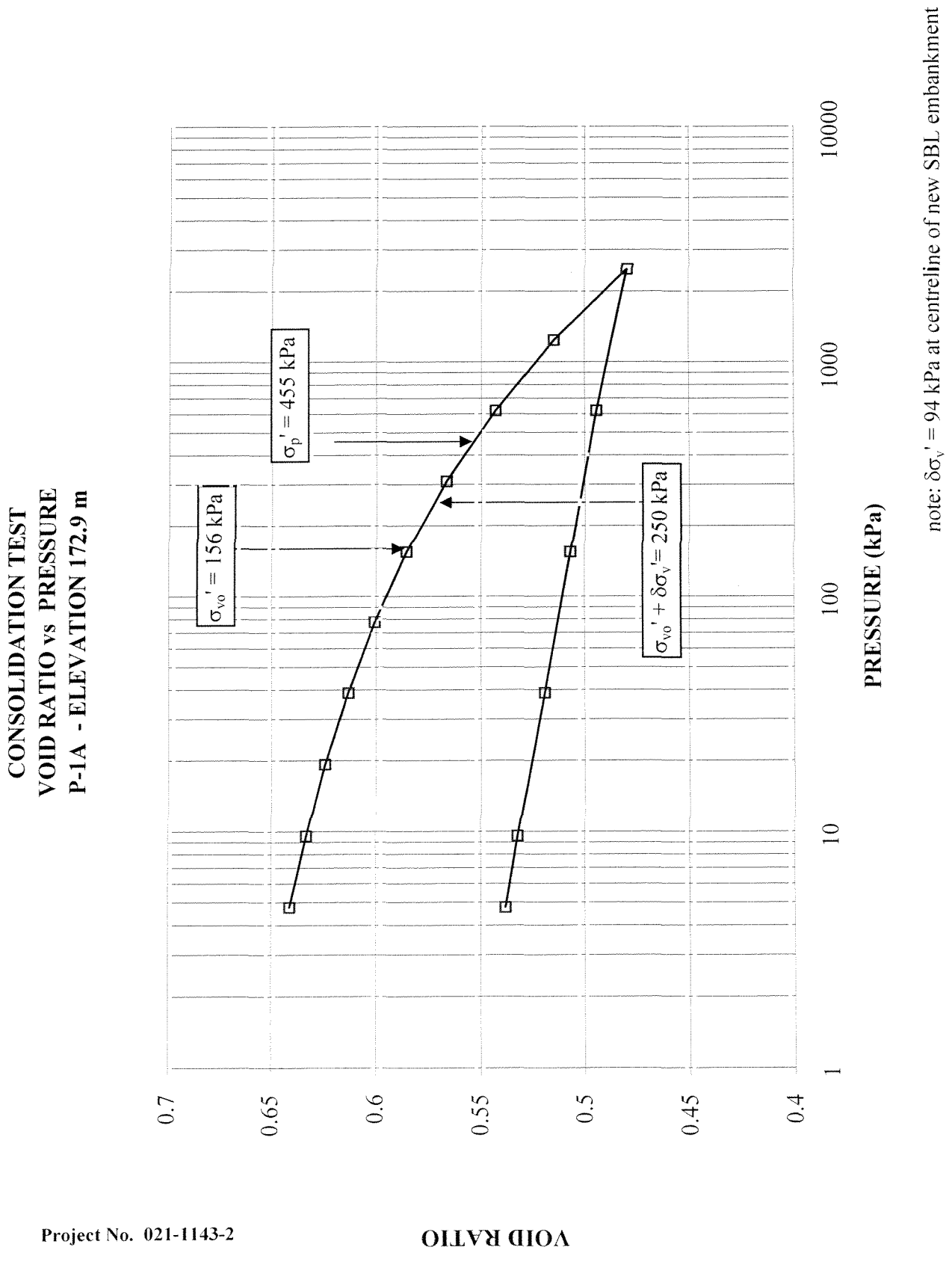
FIGURE 7



Project No. 021-1143-2

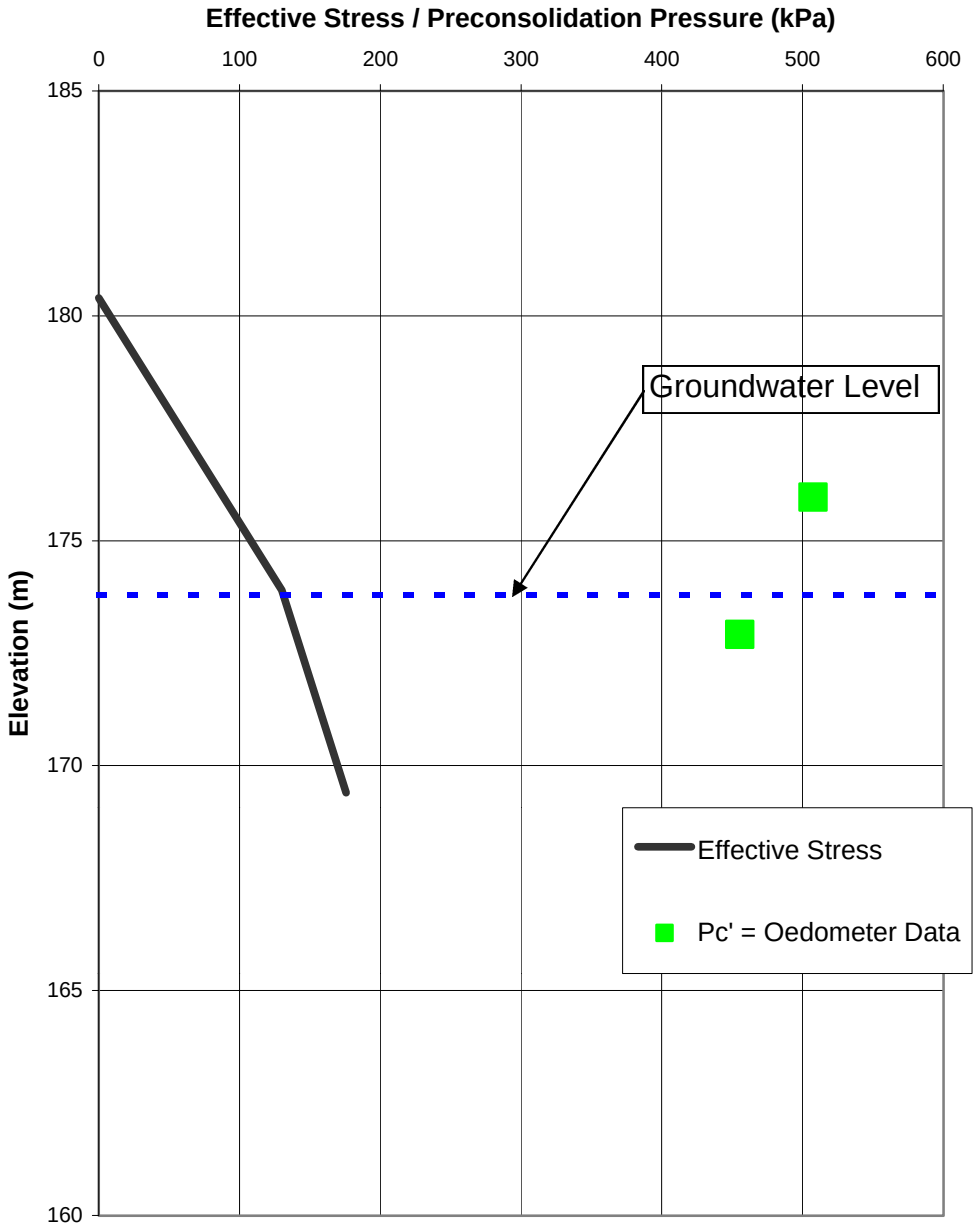
CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE 8



Project No. 021-1143-2

Effective Stress and Preconsolidation Pressure	FIGURE 9



Date: January 2003 Drawn: DKB

Project: 021-1143-2 Checked: ASP

Golder Associates Ltd.

APPENDIX A

RELEVANT RECORD OF BOREHOLE SHEETS
(MTO GEOCRES NO 30M3-176, DATED AUGUST 1980)

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

W P 167-66-01 LOCATION Co-ords. N 4 771 224; E 326 199 ORIGINATED BY SC
DIST 4 HWY 406 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SC
DATUM Geodetic DATE 1980 06 06 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, x LAB VANE; 100 200)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL; WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.8	Ground Level										
0.0	Topsoil						180				
	Silty Clay of Medium Plasticity		1	SS	13					20.6	
	Trace of Sand		2	TW	PH						
	Brown & Grey		3	SS	22		178	120/254 mm			
177.1	Stiff to Hard		4	SS	26						0 1 60 39
3.7			5	SS	18						
	Layers of Inorganic Silt and Silty Clay		6	SS	9		176				
	(Low to Medium Plasticity)		7	SS	6						
	Traces of Sand and Gravel		8	SS	9		174				
			9	TW	PH						
	Firm to Stiff		10	SS	7						
	Grey & Brown		11	TW	PH		172				
			12	SS	2						
			13	TW	PH		170				1 8 83 8
168.4											
12.4	End of Borehole (Refusal to Auger) Probable Bedrock										

+3, x5 : Numbers refer to Sensitivity

15 (20/10) 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 3

W P 167-66-01 LOCATION Co-ords. N 4 771 256; E 326 201 ORIGINATED BY SC
DIST 4 HWY 406 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SC
DATUM Geodetic DATE 1980 06 10 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE; 100, 200)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (15 30 45)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.4	Ground Level										
0.0	Topsoil						180				
	Silty Clay of Medium Plasticity		1	SS	18						
	Trace of Sand		2	TW	PH					20.7	0 2 40 58
	Brown & Grey		3	SS	31		178				
	V. Stiff to Hard		4	SS	23			120/203 mm			0 1 29 70
176.8			5	SS	25						
3.6	Layers of Inorganic Silt and Silty Clay		6	SS	20		176				
	(Low to Medium Plasticity)		7	SS	10						
	Traces of Sand and Gravel		8	TW	PH		174	3		18.38	0 1 29 70
	Firm to V. Stiff		9	SS	16						
			10	TW	PH					20.4	
							172				
			11	SS	2			+2.5			0 3 89 8
							170				
			12	SS	18						
168.2											
12.2	End of Borehole (Refusal to Auger) Probable Bedrock										

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

W P 167-66-01 LOCATION Co-ords. N 4 771 237; E 326 186 ORIGINATED BY SC
DIST 4 HWY 406 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SC
DATUM Geodetic DATE 80 06 10 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.4	Ground Level						180				
0.0	Topsoil										
	Silty Clay of Medium Plasticity Trace of Sand Brown & Grey V. Stiff to Hard		1	SS	29						
			2	SS	34						
			3	SS	31		178				0 1 61 38
176.7			4	SS	23			120/229 mm			
3.7			5	SS	22						
	Layers of Inorganic Silt and Silty Clay (Low to Medium Plasticity) Traces of Sand and Gravel		6	SS	20		176				
			7	SS	9						
			8	TW	PH					20.25	0 0 76 24
			9	SS	33		174				
	Firm to V. Stiff		10	TW	PH					20.4	
			11	SS	2		172	2			
			12	TW	PH		170			22.0	
168.5											
11.9	End of Borehole (Refusal to Auger) Probable Bedrock										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 5

W P 167-66-01 LOCATION Co-ords. N 4 771 278; E 326 191 ORIGINATED BY SC
DIST 4 HWY 406 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SC
DATUM Geodetic DATE 80 06 10 & 11 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 100 200)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL; WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.6	Ground Level						180				
0.0 / 179.6	Topsoil and Organics										
1.0	Silty Clay of Medium Plasticity. Trace of Sand. Brown and Grey Firm to V. Stiff		1	SS	10						
			2	SS	8						
177.7			3	SS	22	▼	178				0 3 36 61
2.9	Layers of Inorganic Silt and Silty Clay (Low to Medium Plasticity) Traces of Sand & Gravel Firm to V. Stiff		4	SS	13						
			5	SS	11						
			6	SS	8		176				
			7	SS	8						
			8	TW	PH					19.8	
			9	SS	9		174				
			10	SS	5						
							172				
			11	TW	PH					20.1	0 2 96 2 / 0 0 74 26
169.8							170				
10.7	Silty Clay with Sand & Gravel Hard		12	SS	90						
168.6											
12.0	End of Borehole (Refusal to Auger) Probable Bedrock										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 (%) STRAIN AT FAILURE / 10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 6

W P 167-66-01 LOCATION Co-ords. N 4 771 307; E 326 202 ORIGINATED BY SC
DIST 4 HWY 406 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SC
DATUM Geodetic DATE 80 06 10 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 100 200)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 15 30 45	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.5	Ground Level						180				
0.0	Topsoil										
	Silty Clay of Medium Plasticity, Trace of Sand, Brown & Grey, Very Stiff		1	SS	17						0 2 64 34
			2	SS	26						
			3	SS	22		178				
			4	SS	26						
176.8											
3.7	Layers of Inorganic Silt and Silty Clay (Low to Medium Plasticity), Traces of Sand and Gravel, Firm to Very Stiff		5	SS	13						
			6	SS	7		176				
			7	TW	PH					18.70	0 2 26 72
			8	SS	12						
			9	SS	5		174				
			10	TW	PH					19.95	
			11	SS	2/500 mm		172				
169.8											
10.7	Silty Clay with Sand and Gravel Hard		12	SS	129		170				27 25 41 7
169.2											
11.3	Dolstone Medium Texture Sound		13	RC	96%						
			14	RC	87%						
167.7			15	RC	96%		168				
12.8	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

15 ⟨20 10⟩ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

APPENDIX B

CONSOLIDATION TEST DATA

OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	021-1143	Sample Number	1
Borehole Number	P1-A	Sample Depth, m	5

TEST CONDITIONS

Test Type	Quick Consolidation	Load Duration, hr	(0.1-0.2)
Oedometer Number	7		
Date Started	02-11-26		
Date Completed	02-11-26		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m^3	20.20
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	16.95
Area, cm^2	31.67	Specific Gravity, assumed	2.70
Volume, cm^3	60.49	Solids Height, cm	1.223
Water Content, %	19.14	Volume of Solids, cm^3	38.73
Wet Mass, g	124.57	Volume of Voids, cm^3	21.76
Dry Mass, g	104.56	Degree of Saturation, %	91.9

TEST COMPUTATIONS

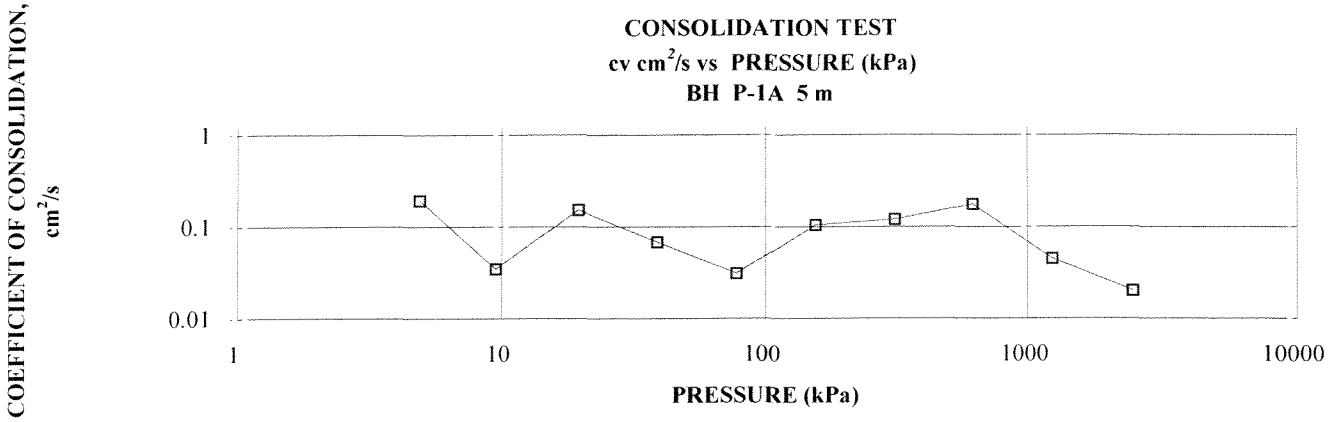
Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.910	0.562	1.910				
4.83	1.907	0.560	1.909	4	1.93E-01	3.03E-04	5.74E-06
9.47	1.902	0.555	1.905	22	3.50E-02	5.87E-04	2.01E-06
19.53	1.894	0.549	1.898	5	1.53E-01	4.32E-04	6.47E-06
38.96	1.883	0.540	1.888	11	6.87E-02	2.94E-04	1.98E-06
77.66	1.869	0.529	1.876	24	3.11E-02	1.83E-04	5.56E-07
155.07	1.854	0.516	1.862	7	1.05E-01	1.06E-04	1.09E-06
310.31	1.833	0.499	1.843	6	1.20E-01	6.98E-05	8.21E-07
618.44	1.806	0.477	1.820	4	1.75E-01	4.54E-05	7.80E-07
1238.68	1.768	0.446	1.787	15	4.52E-02	3.20E-05	1.42E-07
2477.19	1.719	0.406	1.744	32	2.01E-02	2.09E-05	4.13E-08
618.44	1.739	0.422	1.729				
155.07	1.755	0.435	1.747				
38.96	1.767	0.445	1.761				
4.83	1.788	0.463	1.778				

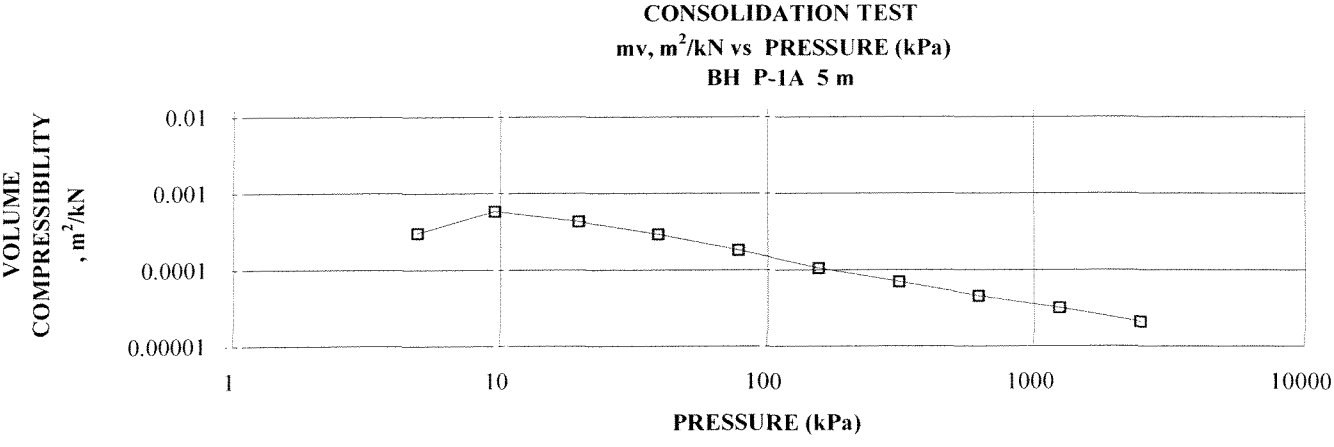
Notes:
void ratio for each increment has been calculated based on dial reading at the end of the increment
k calculated using cv based on t_{90} values.

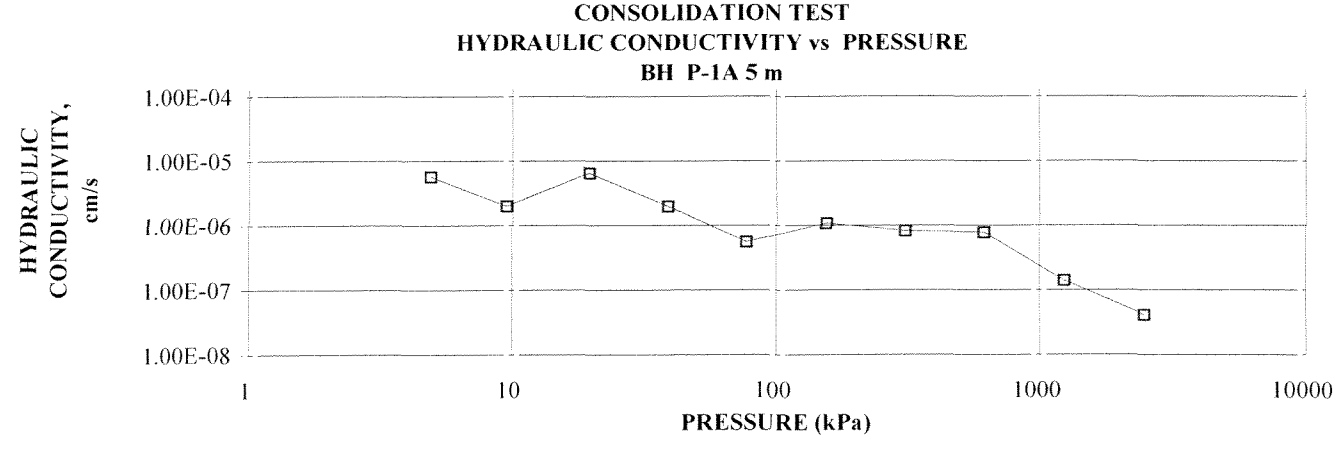
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.79	Unit Weight, kN/m^3	21.56
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m^3	18.10
Area, cm^2	31.67	Specific Gravity, assumed	2.70
Volume, cm^3	56.64	Solids Height, cm	1.223
Water Content, %	19.06	Volume of Solids, cm^3	38.73
Wet Mass, g	124.49	Volume of Voids, cm^3	17.91
Dry Mass, g	104.56		

OEDOMETER CONSOLIDATION SUMMARY



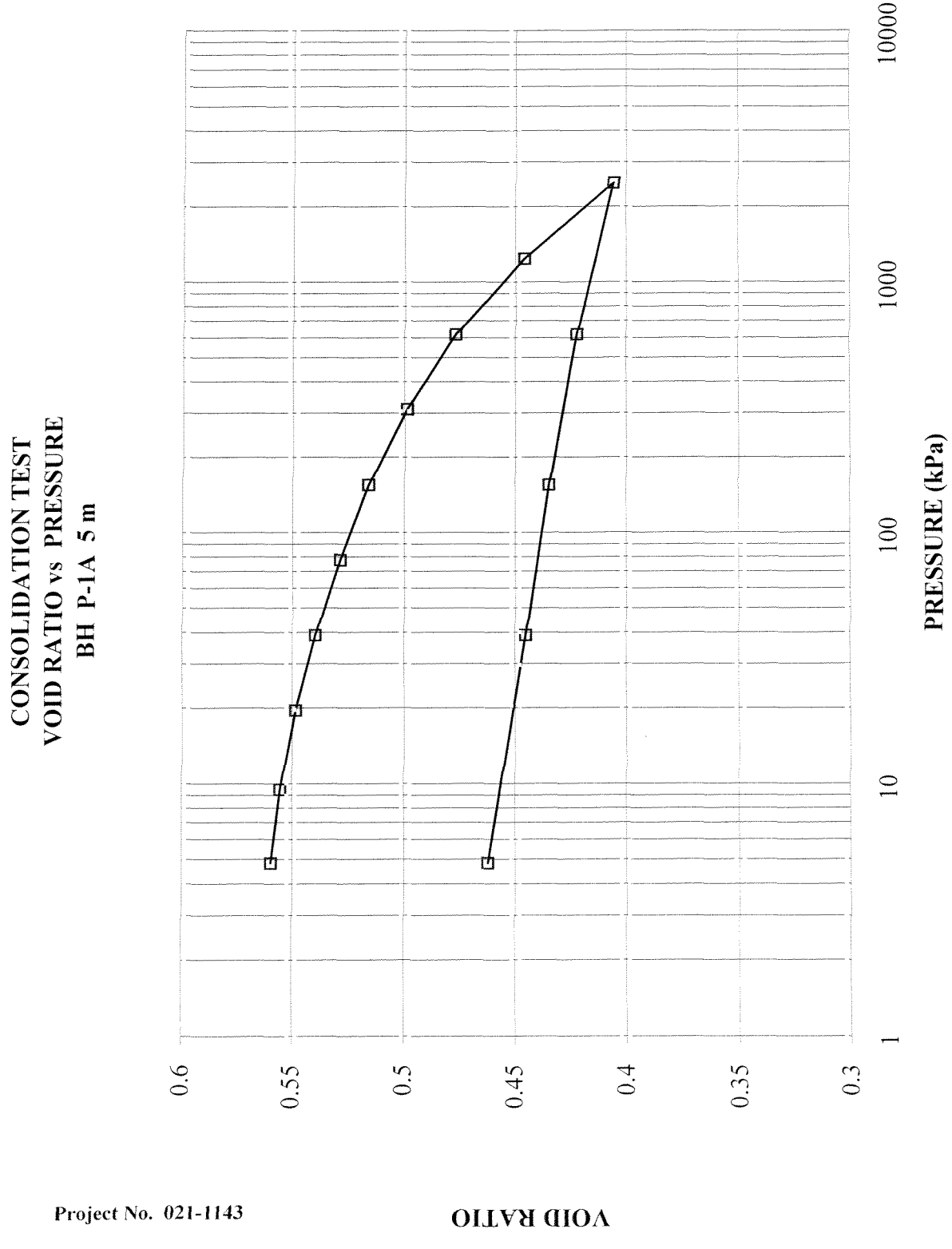




Project No. 021-1143

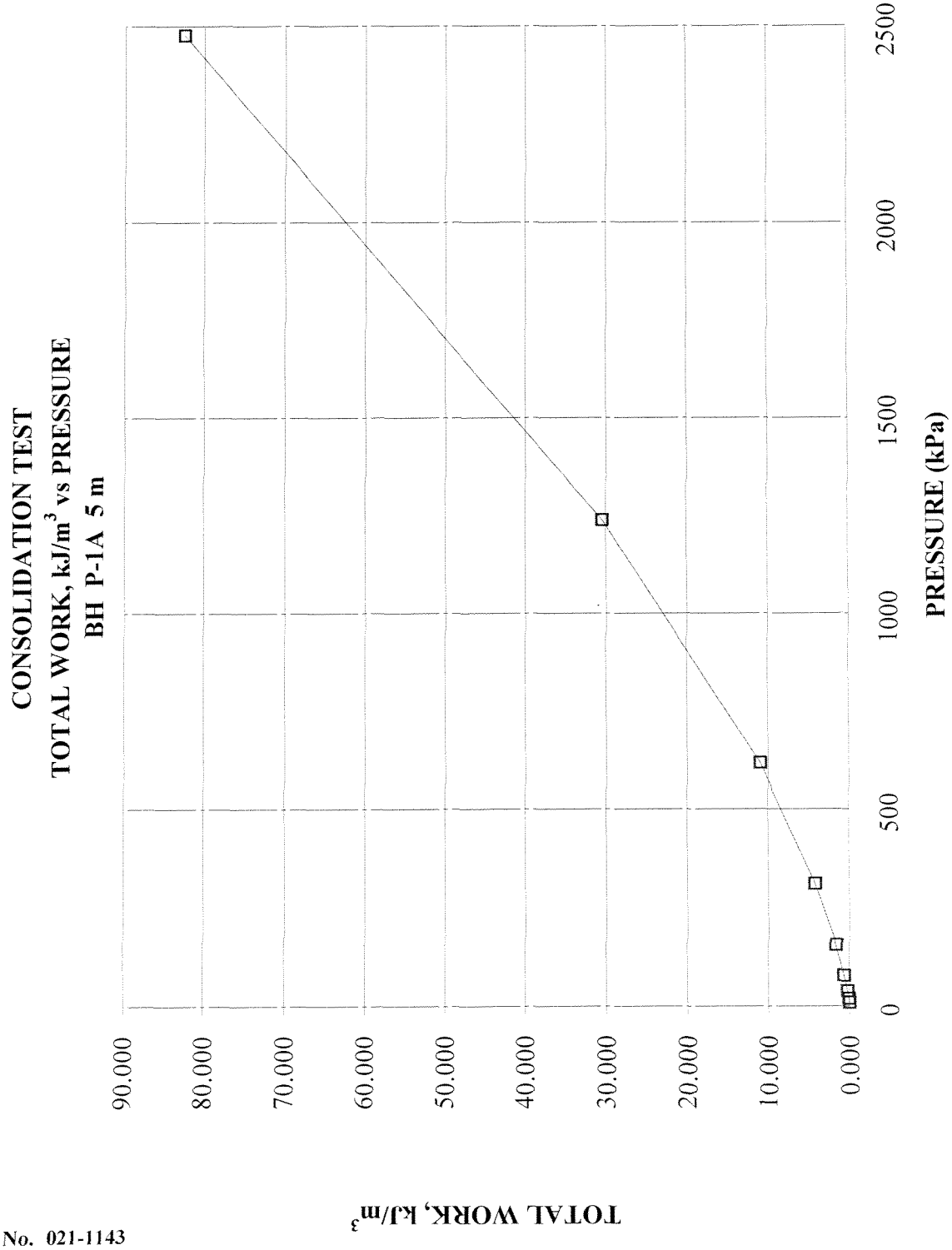
CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE



Project No. 021-1143

FIGURE



Project No. 021-1143

OEDOMETER CONSOLIDATION SUMMARY

SAMPLE IDENTIFICATION

Project Number	021-1143	Sample Number	2
Borehole Number	P-1A	Sample Depth, m	8.1

TEST CONDITIONS

Test Type	Quick	Load Duration, hr	(0.1-0.2)
Oedometer Number	6		
Date Started	02-11-07		
Date Completed	02-11-07		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.91	Unit Weight, kN/m^3	20.15
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	16.12
Area, cm^2	31.61	Specific Gravity, measured	2.73
Volume, cm^3	60.37	Solids Height, cm	1.150
Water Content, %	24.99	Volume of Solids, cm^3	36.35
Wet Mass, g	124.04	Volume of Voids, cm^3	24.02
Dry Mass, g	99.24	Degree of Saturation, %	103.2

TEST COMPUTATIONS

Pressure kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.910	0.661	1.910				
4.76	1.887	0.641	1.899	576	1.33E-03	2.51E-03	3.26E-07
9.56	1.878	0.633	1.883	116	6.48E-03	1.01E-03	6.44E-07
19.29	1.868	0.624	1.873	21	3.54E-02	5.33E-04	1.85E-06
38.75	1.855	0.613	1.862	43	1.71E-02	3.47E-04	5.81E-07
77.53	1.841	0.601	1.848	25	2.90E-02	1.93E-04	5.48E-07
154.98	1.823	0.585	1.832	18	3.95E-02	1.19E-04	4.61E-07
309.76	1.802	0.567	1.812	12	5.80E-02	7.31E-05	4.16E-07
619.50	1.775	0.543	1.788	10	6.78E-02	4.55E-05	3.02E-07
1239.04	1.742	0.515	1.758	10	6.56E-02	2.75E-05	1.76E-07
2477.70	1.702	0.480	1.722	22	2.86E-02	1.72E-05	4.82E-08
619.50	1.719	0.494	1.710				
154.98	1.733	0.507	1.726				
38.75	1.747	0.519	1.740				
9.56	1.762	0.532	1.755				
4.76	1.769	0.538	1.766				

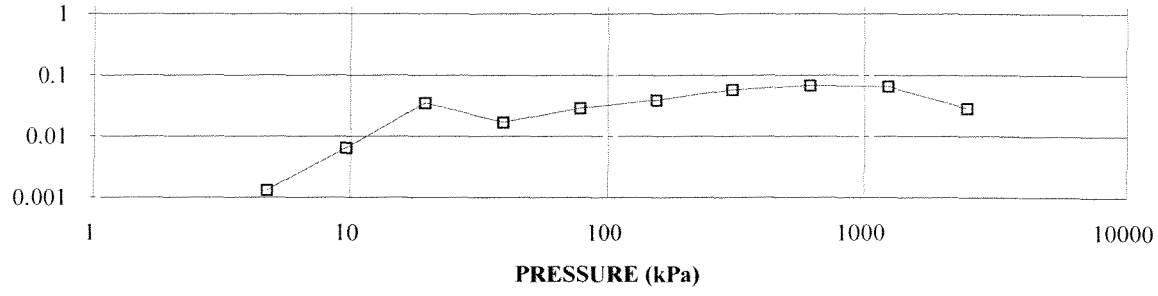
Notes:
k calculated using cv based on t_{90} values.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

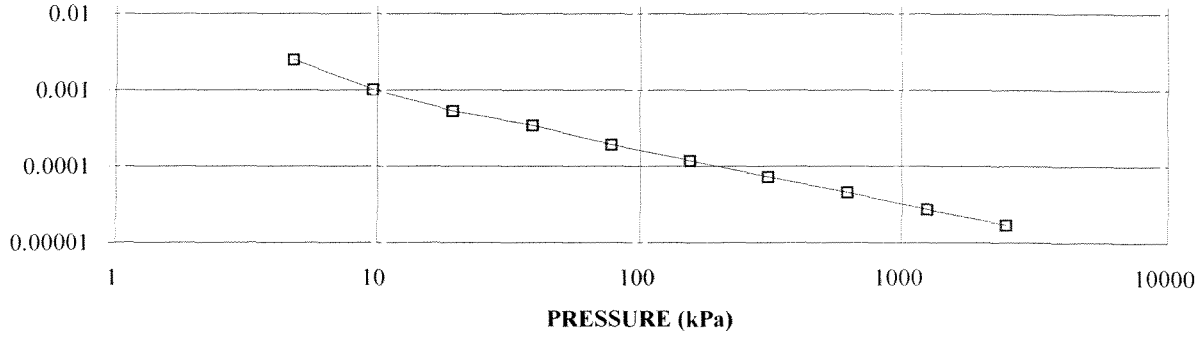
Sample Height, cm	1.77	Unit Weight, kN/m^3	20.94
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	17.40
Area, cm^2	31.61	Specific Gravity, measured	2.73
Volume, cm^3	55.92	Solids Height, cm	1.150
Water Content, %	20.33	Volume of Solids, cm^3	36.35
Wet Mass, g	119.41	Volume of Voids, cm^3	19.57
Dry Mass, g	99.24		

OEDOMETER CONSOLIDATION SUMMARY

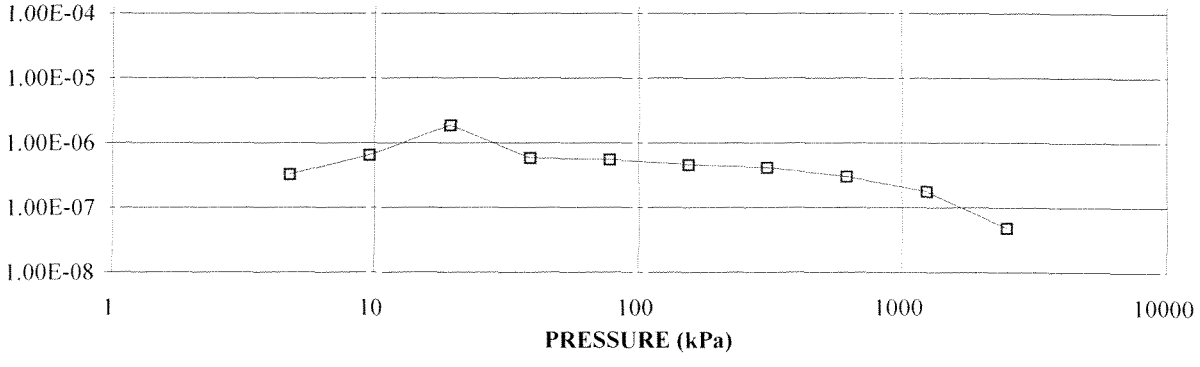
CONSOLIDATION TEST
cv cm^2/s vs PRESSURE (kPa)
P-1A 8.1m



CONSOLIDATION TEST
mv, m^2/kN vs PRESSURE (kPa)
P-1A 8.1m



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs PRESSURE
P-1A 8.1m



Project No. 021-1143