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CONT. No. 94-62

W. O. No. \_\_\_\_\_

STR. SITE No. \_\_\_\_\_

HWY. No. 416

LOCATION \_\_\_\_\_

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

REMARKS: \_\_\_\_\_

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# **FOUNDATION INVESTIGATION REPORT**

**CONTRACT NO. 94-62**



**Ontario**

**Ministry of  
Transportation**

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Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned projects.

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**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^3$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

## FOUNDATION INVESTIGATION REPORT

For

CNR SUBWAY - STRUCTURE NO: 16

W.P. 126-87-01, SITE 3-544

HWY 416, DISTRICT 9, OTTAWA

### 1 Introduction

Acres International Limited (AIL) was retained by the Ministry of Transportation of Ontario (MTO) to undertake a foundation investigation for a proposed CNR bridge structure over Highway 416, District No. 9, Ottawa, WP 126-87-01, Site 3-544. The work was authorized by Agreement 4238-9089-238 dated August 28, 1989.

Drilling and sampling operations were performed by Marathon Drilling Co. Ltd., under the full-time supervision and direction of an Acres geotechnical engineer. Fieldwork commenced on November 2, 1989 and was completed on November 11, 1989. A plan of the site, showing the borehole locations, together with stratigraphic profiles are shown on Drawings No. 1268701-A\* and 1268701-B.\*

All soil samples and bedrock cores were returned to Acres geotechnical laboratory in Niagara Falls for detailed examination, logging and testing.

The results of the field and laboratory investigations are presented in this report, together with an interpretation of the data obtained and recommendations concerning the geotechnical aspects of the design and construction of the proposed bridge and associated works.

\* Dwg Nos 2 & 2A, (Sheet 167-1 and 167-2) of the Contract Drawings.

## 2 Exploratory Work

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The exploratory work consisted of a total of 10 boreholes (BH-101 to BH-110 inclusive) drilled to depths ranging from 11.9 m to 16.3 m in both overburden and bedrock. Initially, the MTO staked the borehole locations and determined their ground surface elevations based on coordinates submitted by Acres. Three of the boreholes (BH-102, BH-107 and BH-109 inclusive) were located in the vicinity of the centerline of the west and east piers of the proposed CNR bridge. BH-101, 105 and 106, inclusive, were located in the vicinity of the west abutment, and BH-103, 109 and 110, inclusive, in the east abutment. BH-104 was located south of the proposed bridge, and was intended to determine the subsurface conditions for the southern part of the project site.

These borehole locations were subsequently modified slightly in the field to allow access and/or clearance from existing structures, etc. The final borehole elevations and their coordinates, as shown on Drawing No. 1268701-A\*, were measured and tied into the initially proposed locations, and are considered to be accurate to within 0.1 m.

Drilling was performed using a CME-55 auger drill rig mounted on an all-terrain tracked vehicle. Hollow stem augers were used to advance the drilling in the overburden, and diamond core drilling with a BX core barrel in the bedrock. A total of 116.4 m of overburden and 20.0 m of bedrock were drilled in the 10 boreholes. A summary for the physical data for each borehole is provided in Table 1.

**Table 1**

### **Summary of Borehole Physical Data**

Borehole Number	Ground Surface Elevation (m)	Coordinates	Overburden/Bedrock Contact		Bottom of Borehole	
			Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
101	86.6	E 358 878.3 N 5021 267.4	11.3	75.3	14.3	72.3
102	86.4	E 358 914.9 N 5021 272.9	12.2	74.2	14.9	71.5
103	86.4	E 358 994.0 N 5021 283.0	13.8	72.6	16.3	70.1
104	86.2	E 358 912.0 N 5021 251.0	12.0	74.2	13.6	72.6
105	86.3	E 358 840.0 N 5021 286.4	10.3	76.0	11.9	74.4
106	85.5	E 358 871.9 N 5021 291.1	10.0	75.5	12.2	73.3
107	85.1	E 358 904.4 N 5021 296.9	10.6	74.5	12.1	73.0
108	85.0	E 358 935.3 N 5021 301.1	11.5	73.5	13.9	71.1
109	84.5	E 358 964.3 N 5021 305.8	11.9	72.6	14.4	70.1
110	85.7	E 358 990.4 N 5021 316.4	12.8	72.9	12.8	72.9

\* Dwg No 2, (Sheet 167-1) of the Contract Drawings.

With the exception of BH-104, 106 and 110, attempts were made to sample the overburden materials at intervals between 1.2 to 1.5 m, using a 51-mm OD split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedure or using a 73-mm OD thin-walled tube sampler (Shelby) as appropriate to the soil type. In these boreholes, field vane shear tests were performed using an Acker field vane tester on the undisturbed cohesive silty clay materials between each consecutive thin-walled tube sample. In BH-104, 106 and 110, almost continuous sampling was performed in the cohesive silty clay materials using a 73-mm OD thin-walled tube piston sampler.

A total of 16 piezometers were installed in the 10 boreholes. At least one piezometer was installed in each borehole. Two piezometers were installed in BH-101, 103, 105, 106, 109 and 110; one at a depth between 3.4 and 7.1 m and another at a depth between 8.5 and 12.3 m. In BH-102, 107 and 108, piezometers were installed in the bedrock.

All soil and rock samples were returned to Acres geotechnical laboratory for more detailed logging and testing. The laboratory testing included natural moisture content determinations, Atterberg limits, grain size analyses including hydrometer tests, unconsolidated-undrained triaxial tests, consolidated-undrained triaxial tests with pore pressure measurements, and unconfined compressive strength tests on rock core specimens.

The results of these tests, together with the details of drilling and sampling, are summarized in the Record of Borehole sheets following the report text.

## 3 Site Conditions

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### 3.1 General Description

The crossing of the CNR tracks and the proposed Highway 416 is located in the vicinity of Bells Corners, in the city of Nepean, south of the existing Highway 417. A key plan of the area is shown on Drawing No. 1268701-A.\*

The site is located between Cedarview Road to the west, a vacant lot belonging to the National Capital Commission (NCC) to the north, and a green belt area to the east and south. Existing CNR railtracks run approximately east-west. The natural topography of the site is generally flat up to the NCC lot, and then gently sloping towards the north near Baseline Road. The existing railtracks are constructed on a single embankment, with a ditch on each side. The existing ground surface is generally grass covered, and a few small bushes exist on the site. A CN service road runs parallel to and to the south of the railtracks. BH-101, 102 and 103 were located at the northern edge of the service road and south of the railtracks. BH-104 is located south of the service road. BH-105 is located east of Cedarview Road, on top of the railway embankment. BH-106, 107, 108 and 109 were all located at approximately the bottom of the north side ditch. The majority of the ditch, except for the eastern part, was dry. It appeared that water runs from the east end of the ditch and turns to the north at a ditch junction located just east of BH-109. BH-110 was located just outside the CNR right-of-way boundary and above the north side ditch.

### 3.2 Soil Conditions

#### 3.2.1 Topsoil and Possible Fill Deposits

Dark brown silty sand with some gravel was encountered in BH-101 to 104, beneath a veneer of grass-covered topsoil. The thickness of this material varies from 0.6 to 1.3 m and it exists in a loose condition. In BH-101, 102 and 103, this material may be a fill material because of its proximity to the edge of the service road located south of the railtrack embankment.

In BH-106 to 110 inclusive, dark gray to dark brown silty clay with some gravel extends to depths between 0.1 and 0.4 m, and is considered as part of the topsoil layer. In BH-105, 1.9 m of similar material was encountered with some black mottling and oxidation staining. The consistency of this silty clay material ranges from soft to stiff.

#### 3.2.2 Silty Clay (Marine Deposit)

A gray silty clay deposit was encountered beneath the surficial silty sand to silty clay with some gravel. The thickness of this deposit varies from west to east, with a minimum thickness being located in the center and western sides of the area under investigation, i.e., around BH-101, 105 and 106. In this area, its thickness ranges from 6.1 to 6.9 m. At the east end of the site, i.e., in the vicinity of BH-103, 109 and 110, the thickness ranges from 10 to 12.8 m. The silty clay deposit contains occasional horizontal to subhorizontal layers or lenses of silty fine sand to silt, the thickness of which vary from 2 to 10 mm. Continuous samples obtained from BH-104, 106 and 107 revealed that these layers and lenses generally exist between el 80 to 83 m. On the eastern side of the site where the deposit is thicker, silty sand and silt layers are also concentrated between el 76.5 and 78.1 m, and below el 75.8 m. In the zones where the thin layers or lenses of silty sand and silt exist, the

\* Dwg No 2, (Sheet 167-1) of the Contract Drawings.

deposit also contains occasional pieces of round fine gravel. Pockets of silty clay or silt were also encountered in these zones.

The average natural moisture content of the marine deposit based on over 70 sample tests is 44%, with a range between 16 and 61%. The natural unit weight ranges from 16.0 to 17.8 kN/m<sup>3</sup>, with an average of 16.9 kN/m<sup>3</sup>. The index properties as determined by Atterberg limits tests indicate Liquid Limit ranges from 49 to 68% and Plastic Limit ranges from 18 to 32%. The average Liquid Limit, Plastic Limit and Plasticity Index are 57, 22 and 35% respectively indicating a material which is highly plastic.

The measured undrained shear strength of this material ranges from 14 to 113 kPa, as determined by field vane tests. A plot of elevation versus undrained shear strength indicates a desiccated crust down to approximately el 82.0 m. The laboratory unconsolidated-undrained triaxial tests provided an undrained shear strength range from 26 to 88 kPa. Figure 1 shows a plot of elevation versus undrained shear strength for this deposit. The sensitivity of the marine deposit, as measured by the field vane, ranges from 2 to 15, with an average of approximately 8, thereby classifying the clay as sensitive to extra sensitive.

Three sets of consolidated-undrained triaxial tests with pore pressure measurements were performed on piston samples taken from BH-104, 106 and 110. The Mohr circles from the tests are plotted in Figure 2, along with a failure envelope. The characteristics of this deposit are rather typical of Champlain clays reported in the literature (e.g., Crawford (1963), Mitchell (1970), Lo (1972)), and are similar to marine clay encountered by Acres at Arnprior, 50 km west of Ottawa (Peggs (1982)). The presence of cementation bonds is reflected in the nonlinear failure envelope shown, especially in the lower stress ranges. Depending on the interpretation used, failure envelopes indicating an effective angle of shearing resistance ranging between 23° and 28° can be drawn together with cohesion intercepts which vary from approximately 28 to 35 kPa.

### **3.2.3 Sand and Silt with Some Gravel and Some Clay (Till)**

A till deposit, consisting of sand and silt with some gravel and some clay and occasional cobbles, was encountered in all boreholes between the marine clay deposit and the bedrock. The thickness of this deposit varies across the site.

The maximum till thickness is located near the center of the area, i.e., around BH-102 and 107, where it varies from 4.5 to 5.2 m. The investigation also reveals that the thickness of the material decreases towards the west and east. In BH-103, 109 and 110, the thickness varies from 0.9 to 1.9 m. At the western side, the thickness is approximately 1.8 m.

The 'N' value of this material, as determined by the SPT, ranges from 1 to 29, with an average of 5, indicating a relative density from very loose to compact, but generally loose.

The natural moisture content of the till ranges from 11 to 33%, with an average of 18%. During the drilling and sampling, the obtained samples were generally wet,

and caving occurred during the retraction of the auger casings. Two samples were tested for their plasticity, and the results indicated that this till material is either nonplastic or has very low plasticity. Results from the grain size analyses exhibit a well-graded material, a typical gradation for till. The clay size content ranges between 7 and 10%. The density of this material, as tested by the SPTs, is relatively low in comparison to typical glacial till deposits. On the basis of its low density, it is expected that this material is a waterlain till, as described in some research papers (McGown et al, 1977, and Dreimanis, 1977).

The existence of this material has also been reported in the Ottawa area by other researchers (Adams, 1960), and the term 'soft till' has been used in their discussion.

The presence of gravel-size particles and possible cobbles made undisturbed samples difficult to obtain. Attempts were made to use thin-walled Shelby tubes to sample this material, but the tip of the tube was always damaged. The paper by Adams (1960) suggested that the unit weight of this material is in the order of  $20.4 \text{ kN/m}^3$ .

### 3.2.4 Summary of Soil Classification Tests

The results of laboratory tests to determine the natural moisture content, the unit weight and the index properties of the soil deposits described in this section are summarized in Table 2. The grain size distribution curves for possible fill materials, marine silty clay and the till are presented in Figures 3, 4 and 5 respectively. Figure 6 contains the plasticity chart, showing Liquid Limits and Plasticity Indexes of the marine silty clay samples.

**Table 2**

#### **Soil Properties**

	Number of Test	Minimum	Maximum	Average
<b>(a) Topsoil and Possible Fill Deposit</b>				
Natural Moisture Content (%)	4	6	30	17
<b>(b) Silty Clay (Marine Deposit)</b>				
Natural Moisture Content (%)	78	16	61	44
Liquid Limit (%)	9	49	68	57
Plastic Limit (%)	9	18	32	22
Unit Weight ( $\text{kN/m}^3$ )	17	16.0	17.8	16.9
<b>(c) Sand and Silt Till</b>				
Natural Moisture Content (%)	14	11	33	17
Liquid Limit (%)	2	14	15	14
Plastic Limit (%)	2	12	15	13

### 3.3 Bedrock Conditions

The bedrock consists of light to medium gray dolomitic limestone with frequent dolomite beddings. The rock is part of the Oxford Formation, deposited during the lower Ordovician period. The dolomite has a fine crystalline texture, but often grades into a medium to coarse sandy clastic dolomite with some sections showing elongated and subrounded intraclasts up to 1.5 cm in length. Occasional shaly partings are present in all boreholes. One 100-mm section of dark gray microcrystalline dolomite was encountered in boreholes BH-101 and BH-102, approximately 2.5 m from top of rock. Up to 1-cm diameter vugs filled with pinkish-white calcite are present in some boreholes.

Bedding in all holes is subhorizontal, and except for the shaly partings, is gradational. Spacing between the shaly partings averages approximately 0.3 to 0.4 m for all holes. In general, the partings are smooth, undulating and intact. Prominently closely spaced partings are present in both BH-101 and BH-102 at approximately 0.5 m from top of rock.

Subvertical jointing was encountered in BH-104 and BH-108. The joints are rough, irregular and show development of calcite crystals and minor mineralization.

In general, the rock is very strong and fresh. Core recoveries ranged from 94 to 100% with an average of 99.5%. RQD values ranged from 40 to 100% with an average of 83%. The average unit weight, based on three core samples, is 27.2 kN/m<sup>3</sup>.

Unconfined compressive strengths obtained from three selected rock core samples ranged from 216.3 and 245.2 MPa, and averaged 230.8 MPa.

### 3.4 Groundwater Conditions

Groundwater level observations from the 16 piezometers, including their detail installations, are summarized in Table 3. The last readings were taken on December 28, 1989, approximately 6 weeks after the completion of the field drilling program.

The water level in the piezometers installed within the marine clay deposit ranges from el 82.0 to 84.8 m, with an average at el 83.6 m. Generally, the lower part of the deposit exhibits a lower piezometric level than the upper part.

The water level in the piezometers installed within the till deposit is generally the same or slightly lower than the level in the marine clay. It ranges from el 81.8 to 84.8 m, with an average at el 83.1 m.

The piezometric level in the bedrock was encountered approximately 3.5 m below the level in the marine clay. The average level based on three piezometric readings is at el 79.9 m.

Within the same elevation zone, the piezometric levels are generally flat. Groundwater observations as indicated by piezometric readings provided above show that there is no potential artesian condition at the area investigated.



Table 3

**Summary of Piezometer Installation  
Details and Observations**

Borehole	Ground Surface Elevation (m)	Elevation of Tip of Piezometer (m)	Elevation of Bentonite Seal		Date of Installation	Water Elevation on Dec 28/89 (m)	Remarks
			Top (m)	Bottom (m)			
101U	86.6	81.7	83.1	81.6	Nov 2/89	84.8	Marine clay
103U	86.4	79.4	80.1	78.7	Nov 4/89	84.2	Marine clay
103L	86.4	74.4	75.1	74.0	Nov 4/89	82.2	Marine clay
105U	86.3	82.3	82.7	81.4	Nov 7/89	83.3	Marine clay
106U	85.5	82.1	82.7	81.6	Nov 8/89	84.4	Marine clay
109U	84.5	80.2	81.0	80.0	Nov 10/89	83.8	Marine clay
109L	84.5	74.8	75.5	74.6	Nov 10/89	82.0	Marine clay
110U	85.7	80.2	80.7	79.8	Nov 11/89	84.2	Marine clay
101L	86.6	76.3	76.8	76.0	Nov 3/89	84.8	Till
104	86.2	75.7	76.1	75.4	Nov 6/89	82.5	Till
105L	86.3	77.0	77.8	76.5	Nov 7/89	83.1	Till
106L	85.5	77.0	77.5	76.6	Nov 7/89	83.4	Till
110L	85.7	73.5	74.0	-	Nov 11/89	81.8	Till
102	86.4	71.9	72.7	-	Nov 3/89	79.3	Bedrock
107	85.1	73.6	74.2	-	Nov 8/89	80.4	Bedrock
108	85.0	71.5	72.3	-	Nov 9/89	80.0	Bedrock

**Legend:** U - upper piezometer  
L - lower piezometer

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Acres International Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.



*D. Dundas*  
D. Dundas, P. Eng.  
Sr. Foundation Engineer

**APPENDIX**

# RECORD OF BOREHOLE No 101

METRIC

W P 126-87-01 LOCATION Coords N 5 021 267.4 ; E 358 878.3 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 2, 3, 1989 CHECKED BY JB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	* VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)			
86.6	Ground Level					28/12/89								
0.0	Gravelly silty sand													
85.7	Possible Fill Brown		1	SS	9		86							21 50 23 6
0.9	Silty Clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		2	SS	6									
	CI-CH (Marine Deposit)		3	TW	PH		85							
			4	TW	PH		84							
			5	TW	PH		83							
	Very stiff, becoming soft to firm with depth		6	TW	PM		82							
			7	TW	PH		81							
79.6	Gray						80							
7.0	Sand and silt, with some gravel and some clay; wet, low plasticity to non-plastic, rapid dilatancy		8	TW	PM		79							
	SM-ML (Till)		9	SS	5		78							
			10	TW	PH		77							
			11	SS	5		76							
75.3	Loose Dark Gray						75							
11.3	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh		12	RC BXL	REC 100%		74							RQD = 86%
72.3	Gray		13	RC BXL	REC 100%		73							RQD = 95%
14.3	End of borehole													
*For RC samples, numbers represent Core Recovery.														

\*For RC samples, numbers represent Core Recovery.

# RECORD OF BOREHOLE No 102

METRIC

W P 126-87-01 LOCATION Coords N 5 021 272.9 ; E 358 914.9 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 3, 1989 CHECKED BY 788

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	* VALUES		20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
86.4	Ground Level												
0.0	Gravelly silty sand		1	SS	7								
85.5	(Possible Fill) Brown		2	SS	9								
0.9	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity CI-CH (Marine Deposit)		3	TW	PH								
			4	TW	PH								
			5	TW	PH								
	Very stiff, becoming firm with depth		6	TW	PH								
79.4	Gray		7	TW	PH								
7.0	Sand and silt with some gravel and some clay, wet, low plasticity to non- plastic, rapid dilatancy SM-ML (Till)		8	SS	22								
	Very loose to compact		9	SS	2								
74.2	Dark Gray		10	SS	100/5	cm							
12.2	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh		11	RC BXL	100%								RQD = 67%
			12	RC BXL	100%							27.3	RQD = 84%
71.5	Gray		13	RC BXL	100%								RQD = 87%
14.9	End of borehole												
	*For RC samples, numbers represent Core Recovery.												

## RECORD OF BOREHOLE No 103

METRIC

W P 126-87-01 LOCATION Coords N 5 021 283.0 ; E 358 994.0 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 3, 4, 1989 CHECKED BY JB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION 1% GR SA			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES *			20 40 60 80 100							W <sub>p</sub>	W	W <sub>L</sub>
								SHEAR STRENGTH kPa							WATER CONTENT (%)		
86.4	Ground Level					28/12/99											
0.0	Gravelly silty sand		1	SS	8		86										
85.1	Possible Fill Brown		2	SS	4		85										
1.3	Silty clay, some black mottling		3	SS	5		84										
84.3	Gray		4	TW	PH		83										
2.1	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		5	TW	PH		82										
	CI-CU (Marine Deposit)		6	TW	PM		81										
			7	TW	PM		80										
			8	TW	PM		79										
			9	TW	PM		78										
			10	TW	PH		77										
			11	TW	PH		76										
73.6	Soft to firm Gray						75										
12.8	Sand and silt with some gravel and some clay		12	SS	11		74										
72.6	SM-ML (Till)						73										
13.8	Compact Dark Gray						72										
	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh		13	RC	REC		71										
70.1	Gray		14	RC	REC												
16.3	End of borehole																

\*For RC samples, numbers represent Core Recovery.

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 104

METRIC

W P 126-87-01 LOCATION Coords N 5 021 251.0 ; E 358 912.0 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 6, 1989 CHECKED BY JJB

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N VALUES*			20	40	60	80					
86.2	Ground Level					28/12/89										
0.0	Silty clay with some gravel															
85.6	Dark Brown															
0.6	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	15		86									
			2	SS	9		85									
			3	SS	4		84									
			4	TP	PH		83									
			5	TP	PH		82									
	CI-CH (Marine Deposit)		6	TP	PM		81									
			7	TP	PH		80									
			8	TP	PH		79									
			9	TP	PM		78									
			10	TP	PH		77									
79.5	Firm to stiff		11	TP	PH		76									
6.7	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy		12	SS	5		75									
			13	SS	3		74									
			14	SS	3		73									
	SM-ML (Till)		15	SS	4											
			16	SS	5											
			17	SS	18											
74.2	Very loose to compact		18	SS	5											
12.0	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		19	RC BXL	REC 98%											
72.6	Gray															
13.6	End of borehole															

\*For RC samples, numbers represent Core Recovery.

## RECORD OF BOREHOLE No 105

METRIC

W P 126-87-01 LOCATION Coords N 5 021 286.4 ; E 358 840.0 ORIGINATED BY EH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY EH  
DATUM Geodetic DATE November 6, 7, 1989 CHECKED BY JOB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			* N' VALUES	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W			W <sub>L</sub>
86.3	Ground Level													
0.0	Silty clay with some gravel, black mottling and oxidation staining		1	SS	5									
			2	SS	10									
84.4	Gray		3	SS	10									
1.9	Silty clay, occasional thin layers of silty fine sand to fine sand moist to wet, medium to high plasticity		4	TW	PH									
			5	TW	PH									
			6	TW	PH									
	CI-CH (Marine Deposit)		7	TW	PH									
			8	TW	PH									
			9	TW	PH									
77.8	Firm to stiff Gray		10	SS	4									
8.5	Sand and silt with some gravel and some clay, wet, nonplastic SM-ML (Till)		11	SS	29									
76.0	Loose to compact Dark Gray													
10.3	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh	12	RC	BXL	REC 100%									
74.4	Gray													
11.9	End of borehole													

\*For RC samples, numbers represent Core Recovery.



## RECORD OF BOREHOLE No 106

METRIC

W P 126-87-01

LOCATION Coords N 5 021 291.1 ; E 358 871.9

ORIGINATED BY RH

DIST 9 HWY 416

BOREHOLE TYPE Hollow stem auger, BX rock core

COMPILED BY RH

DATUM Geodetic

DATE November 7, 8, 1989

CHECKED BY JAB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT Y kg/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES*	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)		
85.5	Ground Level											
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity CI-CH (Marine Deposit)		1	SS	7							
			2	TP	PH							
			3	TP	PH							
			4	TP	PH							
	Stiff becoming firm with depth		5	TP	PH							
			6	TP	PH							
			7	TP	PH							
			8	TP	PH							
			9	TP	PH							
			10	TP	PM							
78.6	Gray		11	TP	PH							
6.9	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic SM-ML (Till)		12	SS	3							
			13	SS	7							
			14	SS	7							
75.5	Very loose to compact Dark Gray		15	SS	29							
10.0	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		16	RC EXL	REC 100%							
73.3	Gray		17	RC EXL	REC 100%							
12.2	End of borehole											

28/12/89

UNCONFINED + FIELD VANE  
QUICK TRIAXIAL x LAB VANE

20 40 60 80 100

20 40 60

17.3  
16.8  
16.6

CU Triaxial Test  
See Fig. 2  
0 8 55 37

RQD = 84%

RQD = 100%

\*For RC samples, numbers represent Core Recovery.

+3, x5: Numbers refer to Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

## RECORD OF BOREHOLE No 107

METRIC

W P 126-87-01 LOCATION Coords N 5 021 296.9 : E 358 904.4 ORIGINATED BY RH  
HST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 8, 1989 CHECKED BY SAF

[illegible]

+3, x5. Numbers refer to Sensitivity

## RECORD OF BOREHOLE No 108

**METRIC**

W P 126-87-01 LOCATION Coords N 5 021 301.1; E 358 935.3 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 8, 9, 1989 CHECKED BY JOB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES*			20 40 60 80 100					W <sub>p</sub>	W	W <sub>L</sub>		
								SHEAR STRENGTH kPa									
85.0	Ground Level					28/12/89											
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	8												
			2	TW	PH												
	CI-CH (Marine Deposit)		3	TW	PH												
	Firm, becoming soft with depth		4	TW	PH												
			5	TW	PH												
77.4	Gray																
7.6	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy SM-ML (Till)		6	TW	PH												
			7	SS	3												
	Very loose to loose Dark Gray		8	SS	9												
73.5	Limestone bedrock with frequent dolomite beddings, very strong, fresh, vertical joints at approx. 13-m depth, occasional shaly partings		9	RC BXL	REC 100%												
71.1	Gray		10	RC BXL	REC 94%												
13.9	End of borehole																

\*For RC samples, numbers represent Core Recovery.

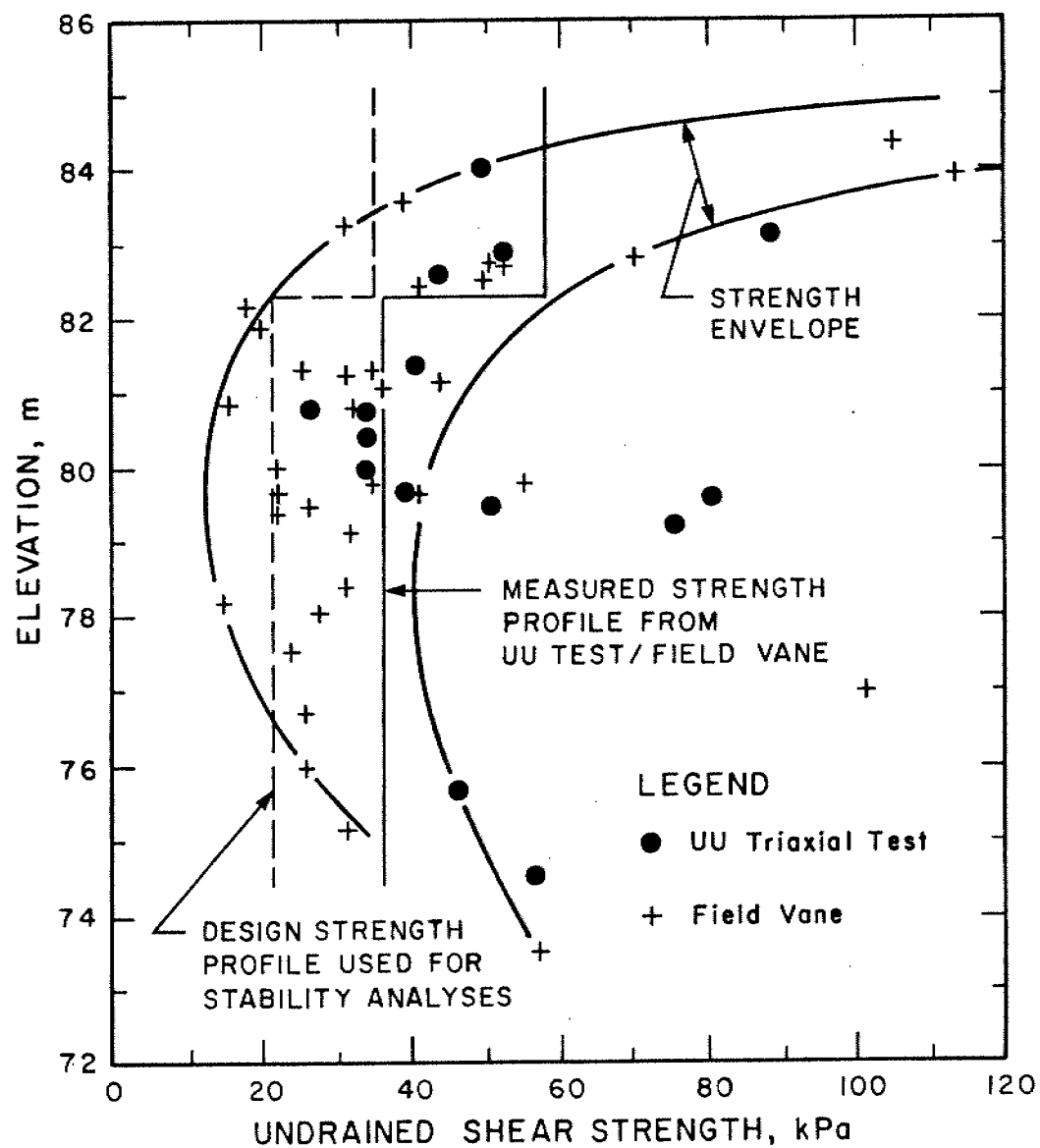
+3, x5: Numbers refer to Sensitivity



RECORD OF BOREHOLE No 109										METRIC				
W P 126-87-01		LOCATION Coords N 5 021 305.8 ; E 358 964.3				ORIGINATED BY RH								
DIST 9 HWY 416		BOREHOLE TYPE Hollow stem auger, BX rock core				COMPILED BY RH								
DATUM Geodetic		DATE November 9, 10, 1989				CHECKED BY TVB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	* VALUES									WATER CONTENT (%) 20 40 60
84.5	Ground Level													
0.0	Silty clay; occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	2		84							0 1 56 43
			2	TW	PH		83							
			3	TW	PH		82							
	CI-CH (Marine Deposit)		4	TW	PH		81							
	Stiff, becoming soft to firm with depth		5	TW	PM		80							
			6	TW	PH		79							
			7	TW	PH		78							
			8	SS	1		77							
74.5			9	TW	PM		76							
10.0	Sand and silt with some gravel and some clay, wet, low plasticity to non-plastic		10	SS	1		75							
72.6	SM-ML (Till)		11	SS	1		74							
11.9	Very loose Dark Gray		12	RC	REC		73							
	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		13	RC	REC		72							
70.1							71							
14.4	End of borehole													

\*For RC samples, numbers represent Core Recovery.

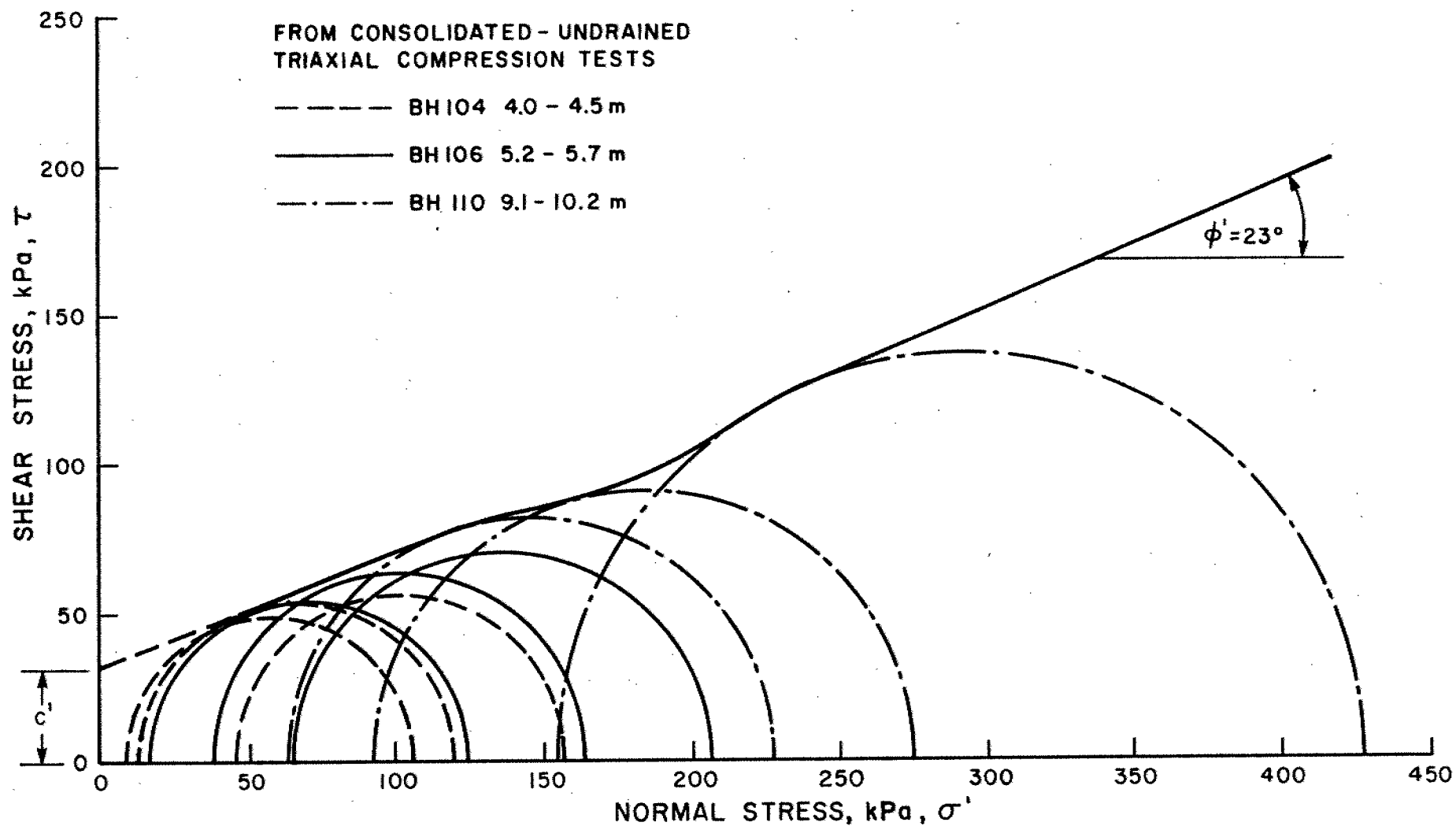
RECORD OF BOREHOLE No 110										METRIC		
W P 126-87-01		LOCATION Coords N 5 021 316.4 ; E 358 990.4				ORIGINATED BY RH						
DIST 9 HWY 416		BOREHOLE TYPE Hollow stem auger, BX rock core				COMPILED BY RH						
DATUM Geodetic		DATE November 10, 11, 1989				CHECKED BY JAE						
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT		UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES*	20 40 60 80 100	Wp W WL	Wp W WL		
85.7	Ground Level											
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	8							
			2	SS	10							
			3	TP	PH							
			4	TP	PH							
			5	TP	PH							
	CI-CH (Marine Deposit)		6	TP	PM							
			7	TP	PH							
	Firm to stiff		8	TP	PM							
			9	TP	PH							
			10	TP	PH							
			11	TP	PM							
			12	TP	PM							
			13	TP	PM							
			14	TP	PH							
			15	TP	PM							
			16	TW	PH							
73.8	Gray		17	TW	PH							
11.9	Sand and silt with some clay, wet, low plasticity to non-plastic		18	SS	2							
72.9	SM-ML (Till)											
12.8	Very loose Dark Gray											
	End of borehole											
	Refusal to auger (probable bedrock)											



# UNDRAINED SHEAR STRENGTH PROFILE OF MARINE CLAY

FIG No 1

W P 126-87-01



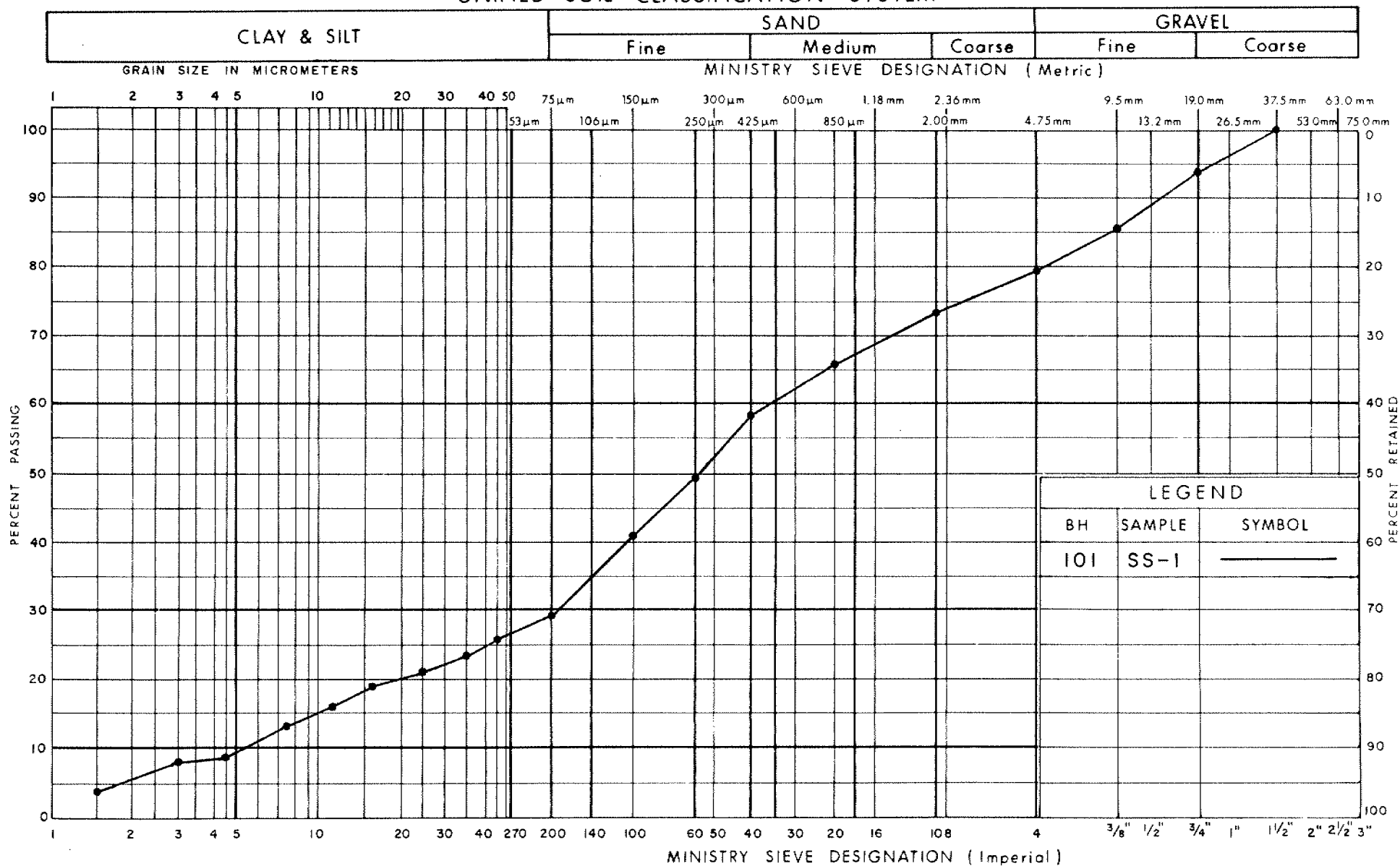
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Transportation

# MOHR CIRCLES AND ENVELOPE-MARINE CLAY

FIG No 2

W P 126-87-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



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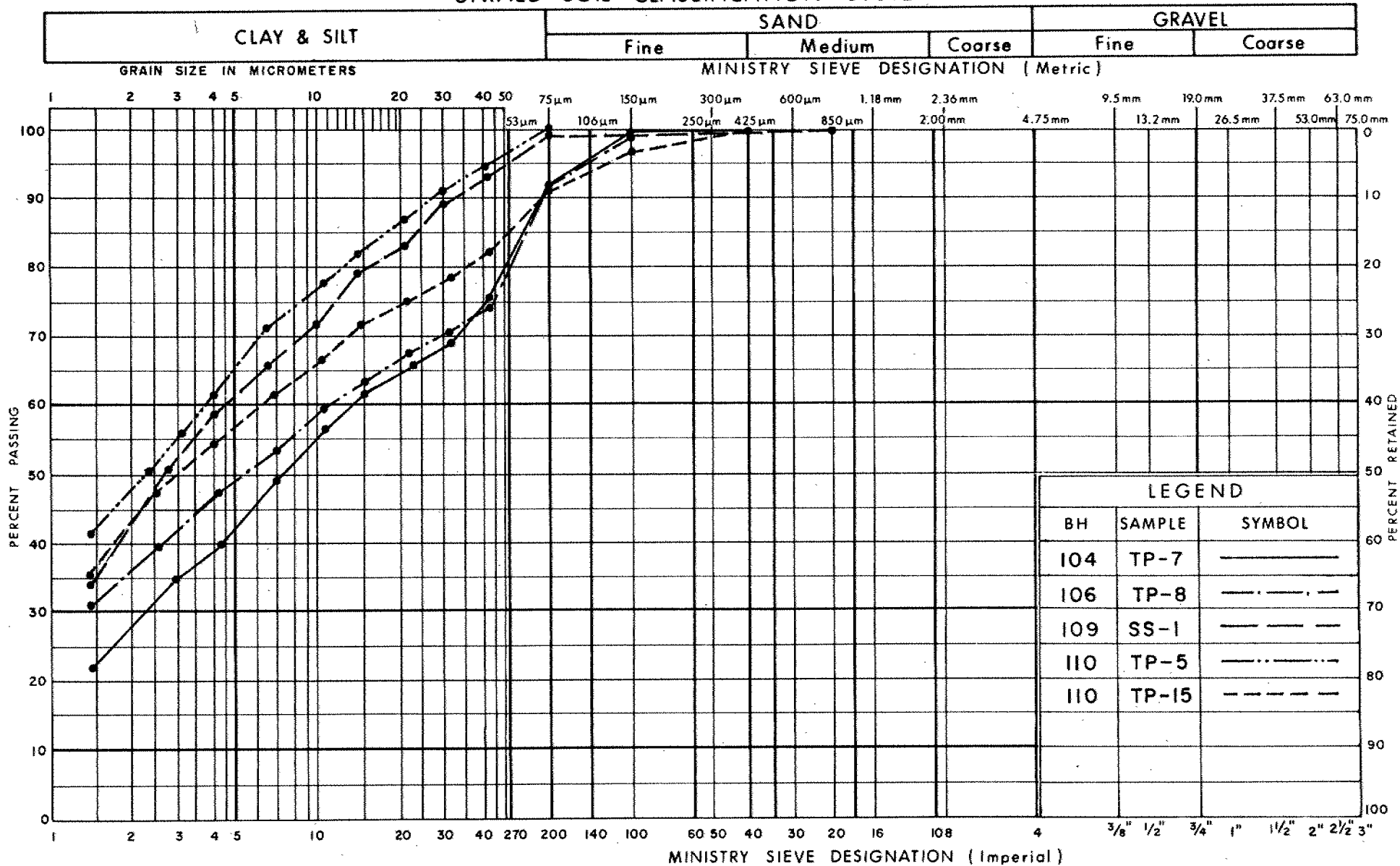
**GRAIN SIZE DISTRIBUTION**  
**GRAVELLY SILTY SAND WITH TRACE OF CLAY**  
**(POSSIBLE FILL)**

FIG No 3

W P 126-87-01



## UNIFIED SOIL CLASSIFICATION SYSTEM



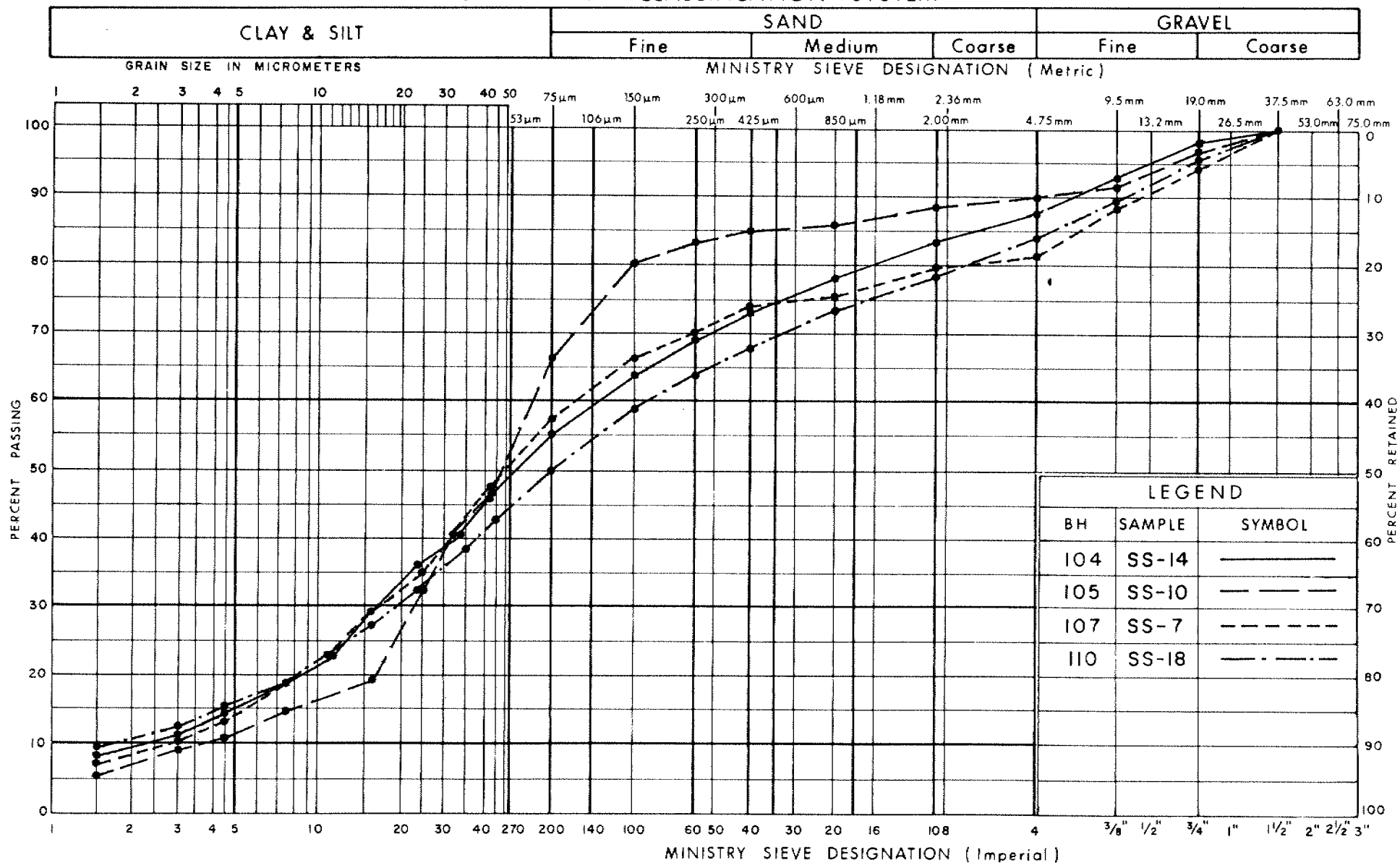
Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION SILTY CLAY (MARINE DEPOSIT)

FIG No 4

W P 126 - 87 - 01

## UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND AND SILT WITH  
SOME GRAVEL AND SOME CLAY (TILL)

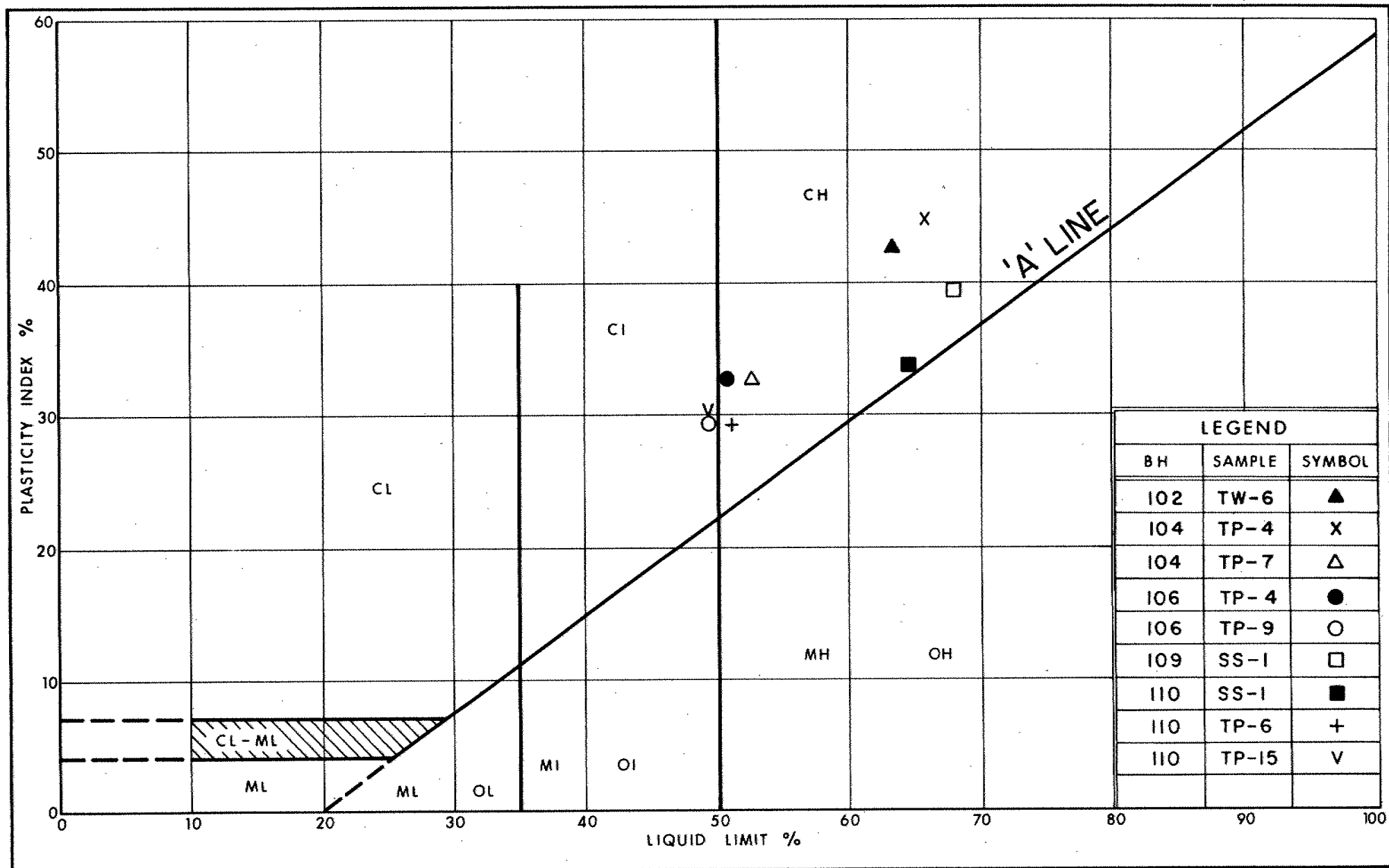
FIG No 5

W P 126-87-01



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Transportation

Ontario

# PLASTICITY CHART SILTY CLAY (MARINE DEPOSIT)

FIG No 6

W P 126-87-01

FOUNDATION INVESTIGATION REPORT  
For  
CNR Detour Embankment at Structure #16  
W.P. 127-87-00A  
Hwy 416, District 9, Ottawa

INTRODUCTION

This report summarizes the results of a geotechnical investigation conducted at the aforementioned site. It is proposed to detour the existing single CNR track along an alignment ranging from approximately 60 m north of its present location.

SITE DESCRIPTION AND GEOLOGY

The site is located along the proposed detour range of alignments approximately 60 metres north of the existing CNR tracks. A ditch consisting of grassland and shrubs separates the site from the existing CNR tracks. A residential subdivision is located south of the CNR tracks and west of Cedarview Road and forest land inhabits the land south of the CNR tracks.

The land generally consists of grassland and random trees. The terrain is predominantly flat but slopes downward immediately north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The native subsoil consists of clay plains interrupted by ridges of rock or sand. Bedrock at the site is of the March/Nepean and Bobcaygeon Formations and consists of sandstone/dolostone and limestone respectively. Fault scarps are also present within the area, an illustration of the numerous normal faults that dominate the region.

The overburden was deposited during and immediately following the Wisconsin glacialiation at which time the area was depressed from the effect of the

glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

#### Field Investigation

The fieldwork for the investigation was carried out on 89.08.03 and consisted of the advancement of two boreholes ranging in depth from 10.4 to 12.2 metres accompanied by two dynamic cone penetration tests advanced to identical range of depths. Hollow stem auger equipment was used to penetrate the overburden. The boreholes were advanced until auger refusal was encountered. Disturbed samples were retrieved at 0.7 m intervals in the surficial silty clay to clayey silt deposit at the site by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586) and relatively undisturbed samples were retrieved at 1.5 m intervals using a Shelby tube sampler in accordance with standard practice (ASTM D1587). In situ vane tests were also conducted in the cohesive surficial deposit, generally at 1.5 m intervals, to determine the undisturbed and remoulded undrained shear strengths of the soil. The test was conducted employing the standard MTO 'N' vane in accordance with ASTM D2573. Samples from the underlying cohesionless deposit were retrieved at 1.5 m intervals using a split spoon sampler.

All samples were identified in the field and then returned to the laboratory for further examination and applicable testing.

Groundwater levels were obtained in the open boreholes at the time of the investigation. The boreholes were backfilled at the completion of the fieldwork.

Survey information related to location and elevation of boreholes was provided by Eastern Region Surveys and Plans.

#### SUBSURFACE CONDITIONS

Subsurface conditions across the site are generally uniform and consist of a native surficial deposit of a cohesive silty clay to clayey silt that extends to

a maximum thickness of 8.7 metres. Underlying this deposit exists a cohesionless deposit consisting of a heterogeneous mixture of silt, sand and gravel that is of glacial origin. It can be inferred from the auger refusal that bedrock or possible boulders (that may comprise the till deposit) underlies the mixture of silt, sand and gravel. A maximum thickness of 3.5 metres of this cohesionless glacial till deposit was penetrated prior to auger refusal.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 1278700A-1.\*

A detailed description of the subsurface conditions encountered is given below.

#### Silty Clay to Clayey Silt

The native surficial deposit at the site consists of a cohesive silty clay to clayey silt that extends to a maximum thickness of 8.7 metres. Occasional sand seams exist interbedded randomly within the deposit. A grain size distribution envelope for this deposit as determined by mechanical analyses is given in Figure 1 and illustrates that the deposit consists generally of equal percentages of clay and silt.

Atterberg Limits were obtained to evaluate the plasticity of the soil and the results are plotted in Figure 2. A summary of the indices is provided in Table 1. Unit weights are also included.

Table 1 - Silty Clay to Clayey Silt

	Range	# of Samples Tested
Natural Moisture Content (w%)	35-55	4
Liquid Limit (w <sub>L</sub> %)	25-39	4
Plastic Limit (w <sub>p</sub> %)	13-18	4
Liquidity Index (I <sub>L</sub> %)	1.5-2.2	4
Unit Weight (kN/m <sup>3</sup> )	16.6-19.8	4

\* Dwg No 2B, (Sheet 167-3) of the Contract Drawings.

The test results reveal that the deposit varies randomly in plasticity ranging from low (clayey silt) to intermediate (silty clay). Liquidity indices for the deposit generally exceed unity illustrating that the natural moisture content is consistently greater than the liquid limit.

Undrained shear strength measurements ( $c_u$ ) were obtained in situ by conducting field vane tests and unconfined compression tests in the laboratory. The results are plotted on the Record of Boreholes in the Appendix and summarized in Table 2 below.

Table 2			
Undrained Shear Strength			
	<u>(<math>c_u</math>) (kPa)</u>	<u>Sensitivity</u>	<u># of Tests</u>
	Range	Range	Range
Field Vane	30->120	2-8	15
Laboratory Test			
- Unconfined Compression	30-35	-	2

A shear strength vs depth profile is provided in Figure 3 in the Appendix. The profile reveals that an upper very stiff crust of approximate thickness of 3 metres overlies the remainder of the deposit that possesses a firm to stiff consistency.

The sensitivity of the soil as defined by the ratio of the undrained strength in the undisturbed state to the undrained strength, at the same water content, in the remoulded state was determined from the field vane tests. The results tabulated in Table 2 indicate values ranging from 2-8 which corresponds to a sensitivity ranging from low to sensitive, but generally the soil can be categorized as sensitive.

The results ( $e - \log p$  curves) of consolidation tests carried out on four samples selected from varying depths and of varying undrained shear strengths are shown in Figure 4 & 4a in the Appendix. The overpreconsolidation pressure ( $P_C - P'_0$ ) which measures the magnitude the soil has been preconsolidated in the past in excess of the existing effective overburden pressure varies from 54 kPa to 181 kPa. The consolidation properties of the stratum derived from laboratory tests are summarized in Table 3 below.

Table 3 - Consolidation Properties

<u>Depth (m)*</u>	<u>Undrained Shear Strength (<math>c_u</math>)</u>	<u>Overconsolidation</u>		<u>Initial Void Ratio (<math>e_0</math>)</u>
		<u>Pressure (<math>P_C - P'_0</math>) (kPa)</u>	<u>Compression Index (<math>c_c</math>)</u>	
0-3	70	181	.91	1.7
3-6	40	54	.89-.99	1.4-1.6
6-9	50	108	1.2	1.5

\*Ground Surface Elevation = 86 metres.

The coefficient of consolidation ( $c_v$ ) was determined using Crawford's procedure. For the loading range equivalent to 1.5 m to 5 m of embankment fill (approximately 30-100 kPa), the coefficient of consolidation ranged from .0037 m<sup>2</sup>/day to .0039 m<sup>2</sup>/day.

Heterogeneous mixture of silt, sand & gravel (Glacial Till)

Underlying the surficial deposit of silty clay to clayey silt, a heterogeneous mixture of silt, sand and gravel (glacial till) exists. A grain size distribution envelope for this deposit is provided in Figure 5 in the Appendix. Penetration through this deposit was restricted in depth by refusal to augering, from which it can be inferred that the deposit is underlain by bedrock or the lower depth of the deposit is composed of boulders. The maximum thickness penetrated in this deposit was 3.5 metres.



Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 1 blow/0.3 m to 9 blows/0.3 m indicating that the deposit is predominantly in a loose state of condition. This uncharacteristic denseness of a till deposit may be attributable to disturbance induced during the sampling procedure.

#### GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements obtained at the time of investigation revealed levels at an elevation ranging from 81.5 to 82.5 m which corresponds to depths ranging from 4.6 m to 2.9 m below the existing ground surface. Groundwater levels, however, are subject to seasonal fluctuations and hence can vary from the values provided in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, J. White and A. Lako, Student Engineers, utilizing equipment owned and operated by Marathon Drilling and Johnston Drilling. The project was carried out by T. Sangiuliano under the general supervision of Dr. B. Iyer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by Dr. B. Iyer and approved by Mr. M.S. Devata, Chief Foundation Engineer.



A handwritten signature in cursive script that reads "D. Dundas".

D. Dundas, P. Eng.  
Senior Foundation Engineer

**APPENDIX**

# RECORD OF BOREHOLE No 16-1

METRIC

W P 127-87-00A LOCATION Co-ords: N 5 021 322.0; E 358 865.0 ORIGINATED BY AL  
 DIST 9 HWY 416 BOREHOLE TYPE HS Auger & Cone Test COMPILED BY TS  
 DATUM Geodetic DATE 89 08 03 CHECKED BY

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			20 40 60 80 100	20 40 60 80 100					
86.1 0.0	Ground Surface													
	Silty Clay		1	SS	12									
	to		2	SS	7									
	Clayey Silt		3	TW	PH									
	Stiff to Hard Firm		4	TW	PH									
	Occ. Sand Seams		5	TW	PM									
78.5 7.6	Het. Mixture of Silt, Sand and Gravel		6	SS	8									
	(Glacial Till)		7	SS	9									
75.7 10.4	End of Borehole													
	Refusal to Auger (Probable Bedrock or Boulder)													

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 16-2

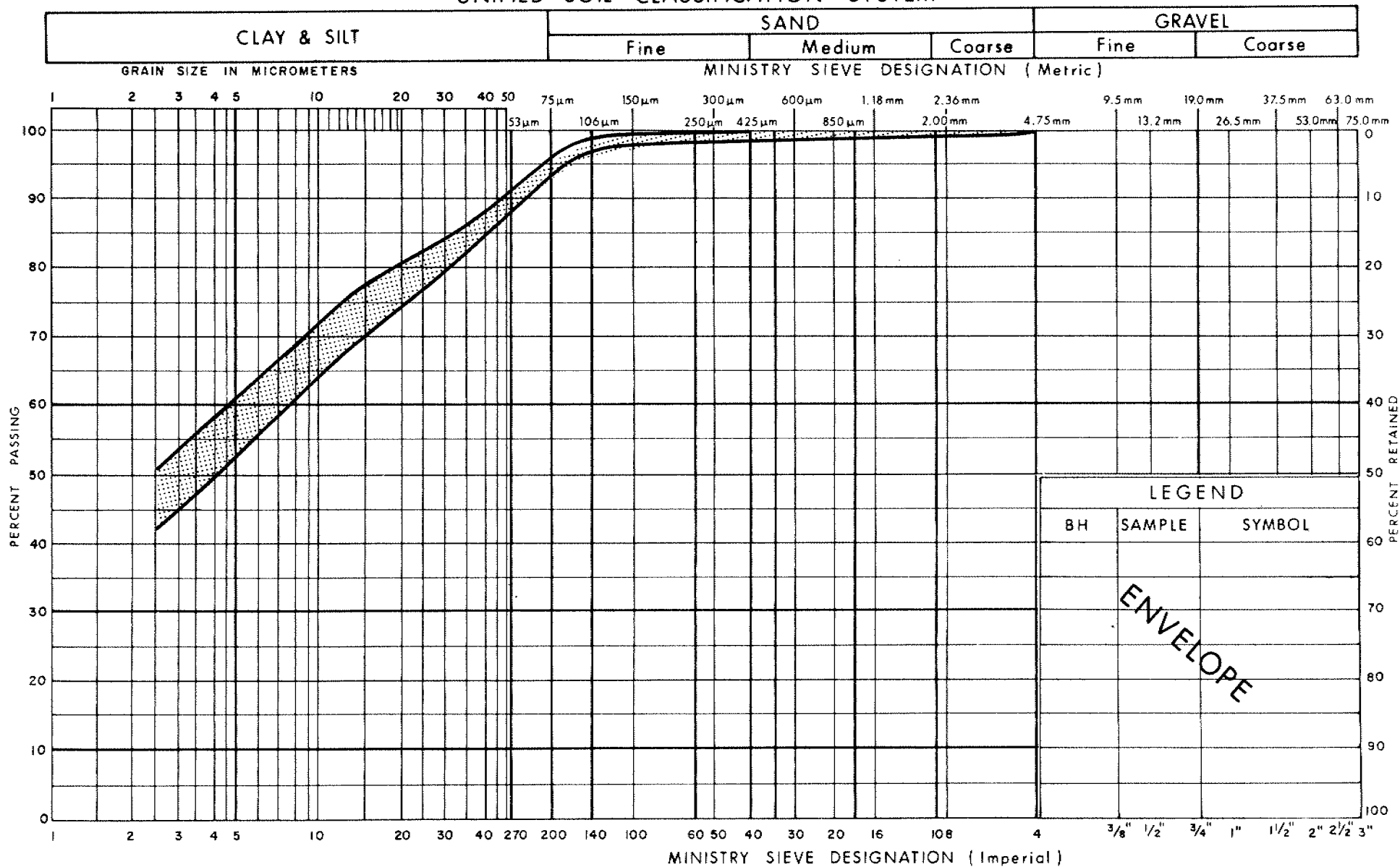
METRIC

W P 127-87-00A LOCATION Co-ords: N 5 021 337.2; E 358 935.0 ORIGINATED BY JW  
 DIST 9 HWY 416 BOREHOLE TYPE HS Auger & Cone Test COMPILED BY JW  
 DATUM Geodetic DATE 89 08 03 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH, kPa		WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	○	○			
85.4	Ground Level						20 40 60 80 100	20 40 60						
0.0	Silty Clay to Clayey Silt Grey, Occ. Sand Seams Stiff Firm		1	SS	12								19.8	0 2 59 39
			2	SS	8								18.1	0 17 58 25
			3	SS	4									
			4	TW	PH									
			5	TW	PH									
			6	TW	PH									
			7	TW	PH									
76.7														
8.7	Het. Mixture of Silt, Sand and Gravel  (Glacial Till)		8	SS	2								28	23 40 9
			9	SS	1									
73.2														
12.2	End of Borehole  Refusal to Auger (Probable Bedrock or Boulder)													

OFFICE REPORT ON SOIL EXPLORATION

## UNIFIED SOIL CLASSIFICATION SYSTEM



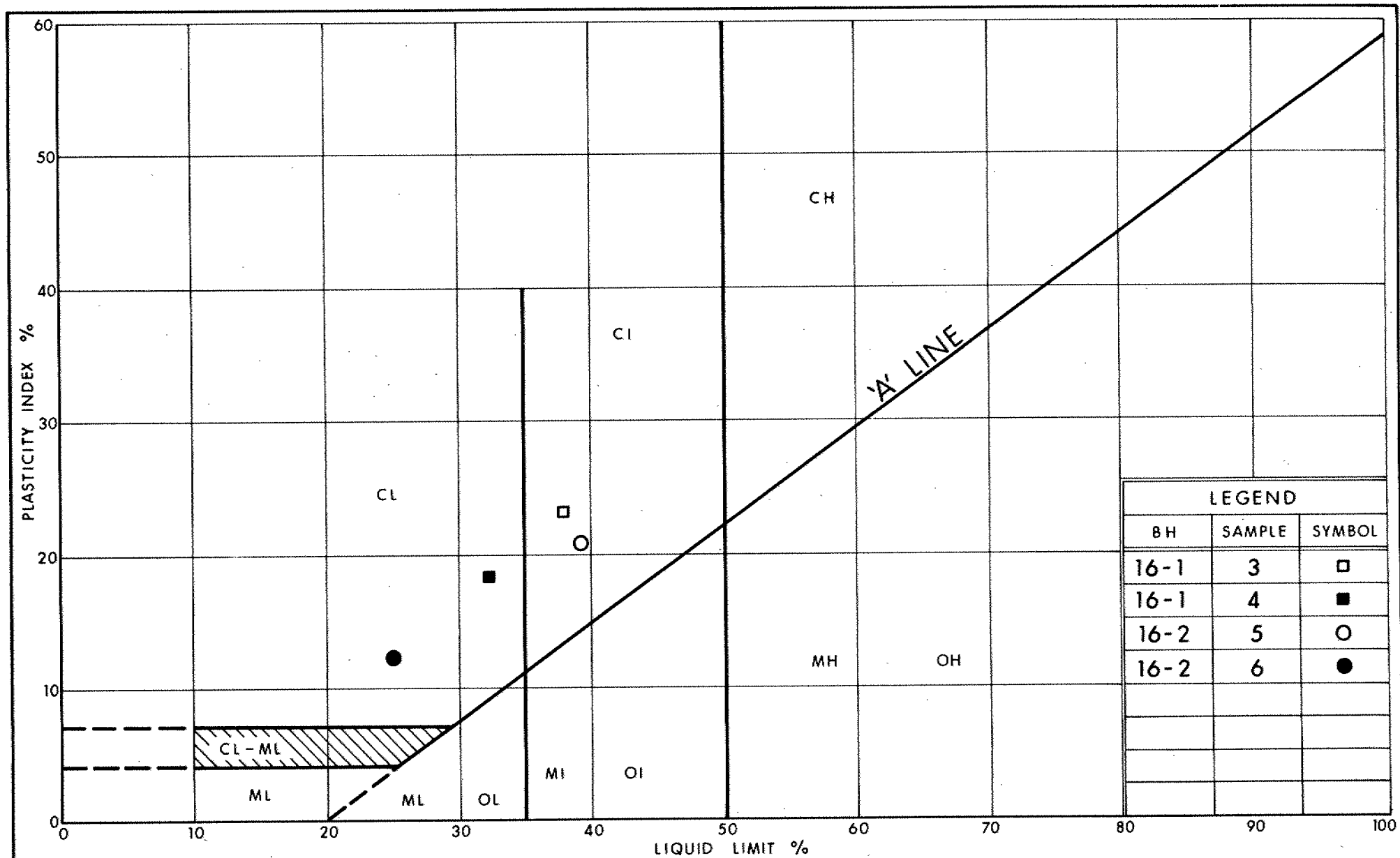
Ontario

Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 127-87-00 (A)



Ontario

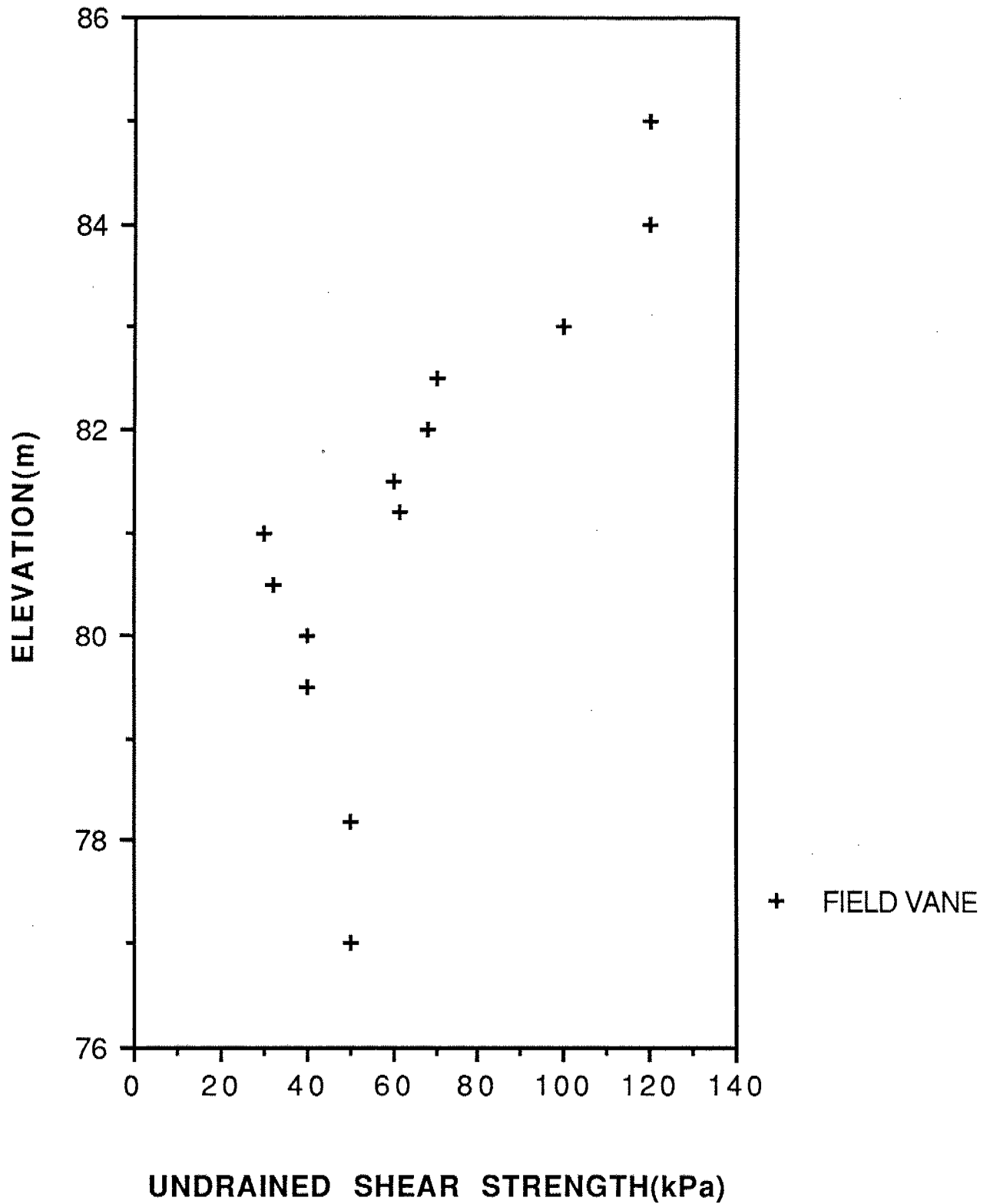
Ministry of  
Transportation

# PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 2

W P 127-87-00(A)

**FIG.3**  
**SHEAR STRENGTH( $C_u$ ) vs. ELEVATION**





## VOID RATIO - PRESSURE CURVES

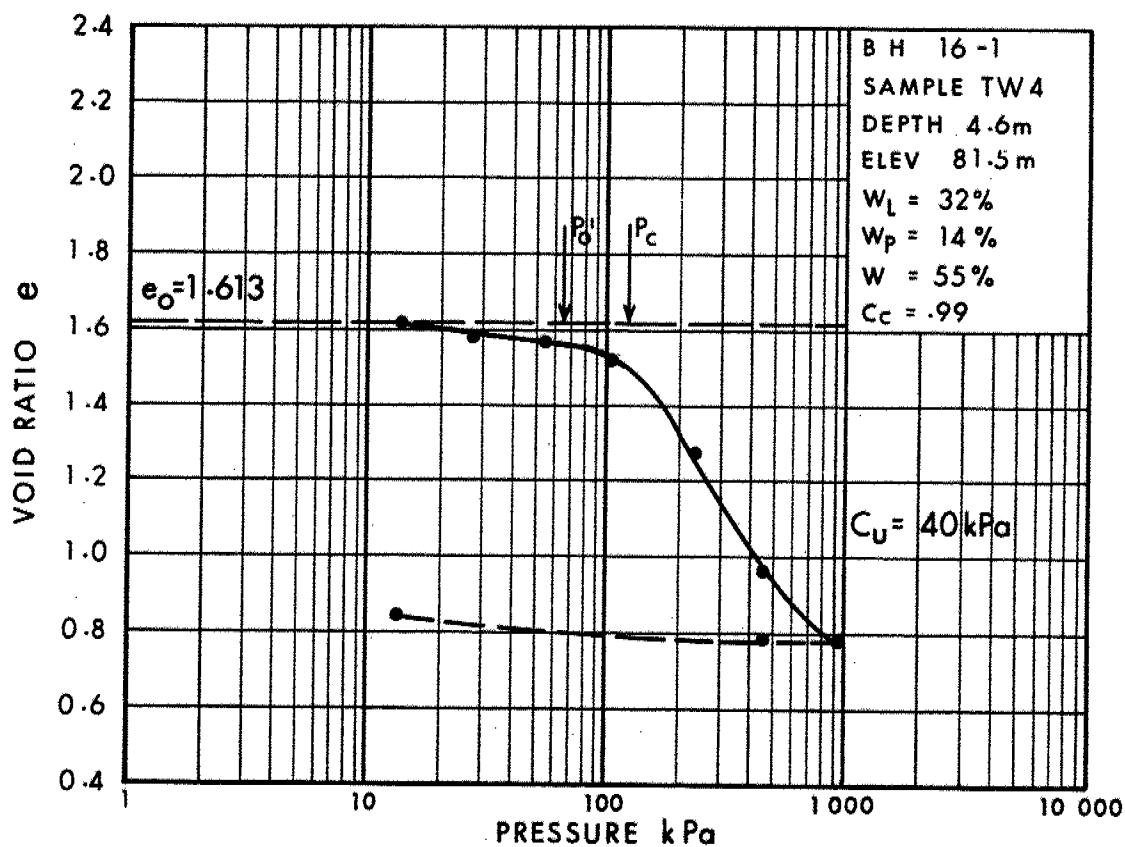
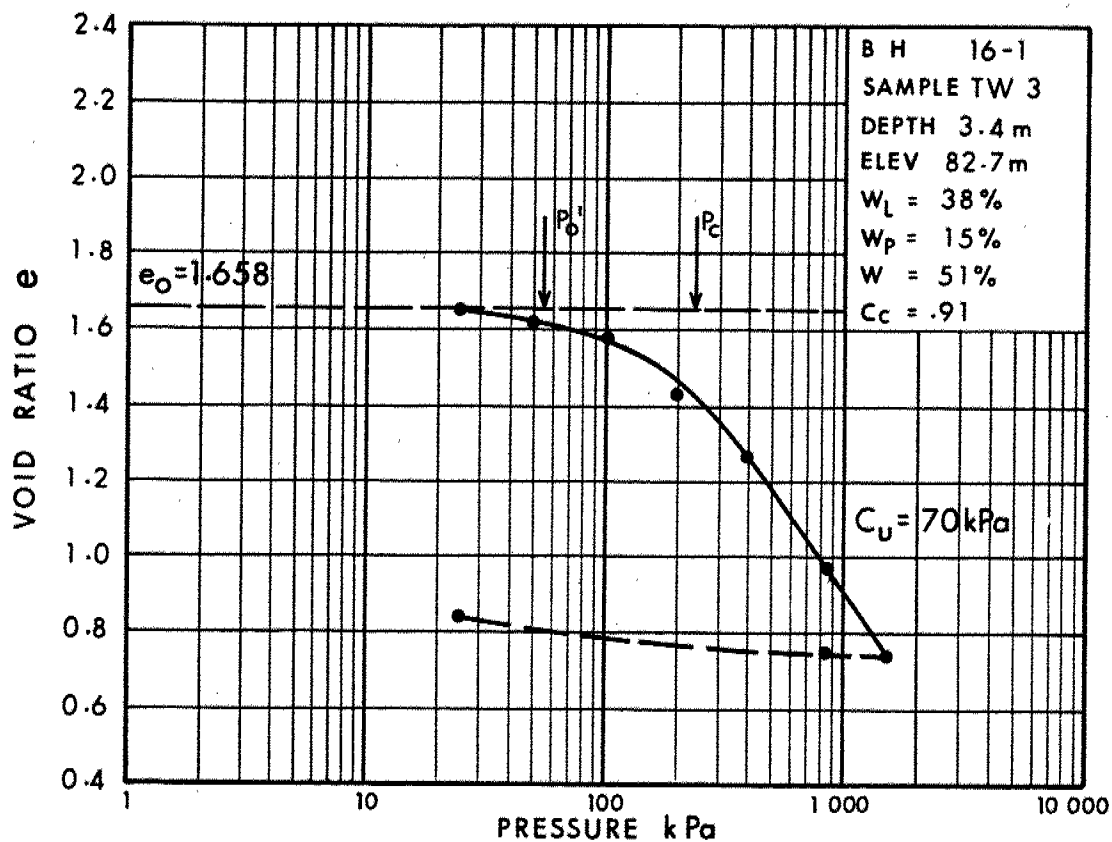


Fig 4

W P 127-87-00 (A)

# VOID RATIO - PRESSURE CURVES

44

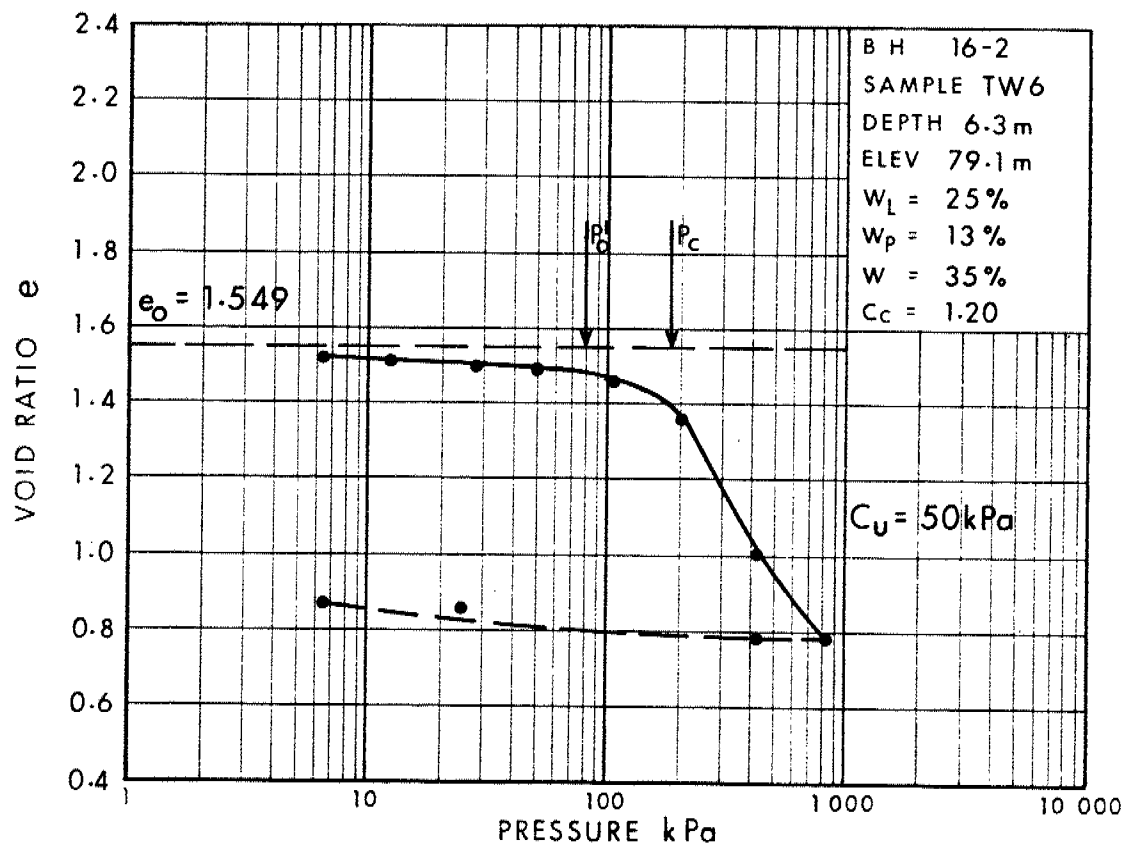
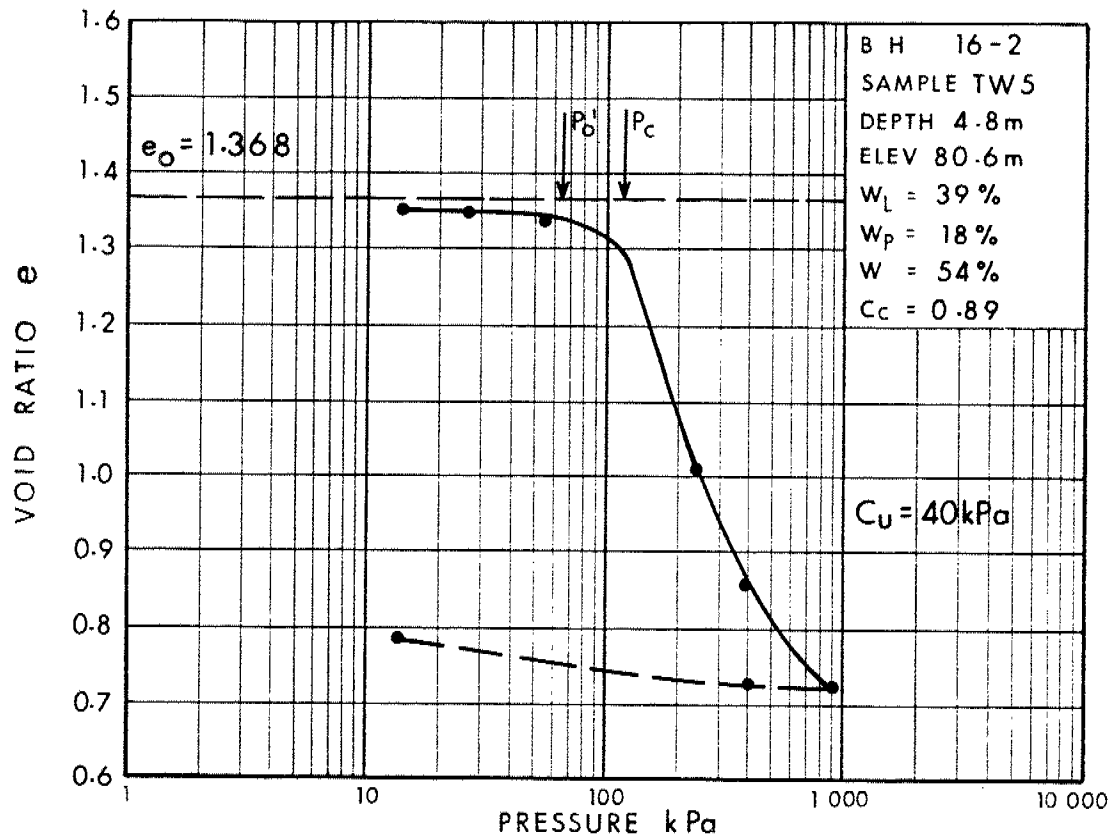
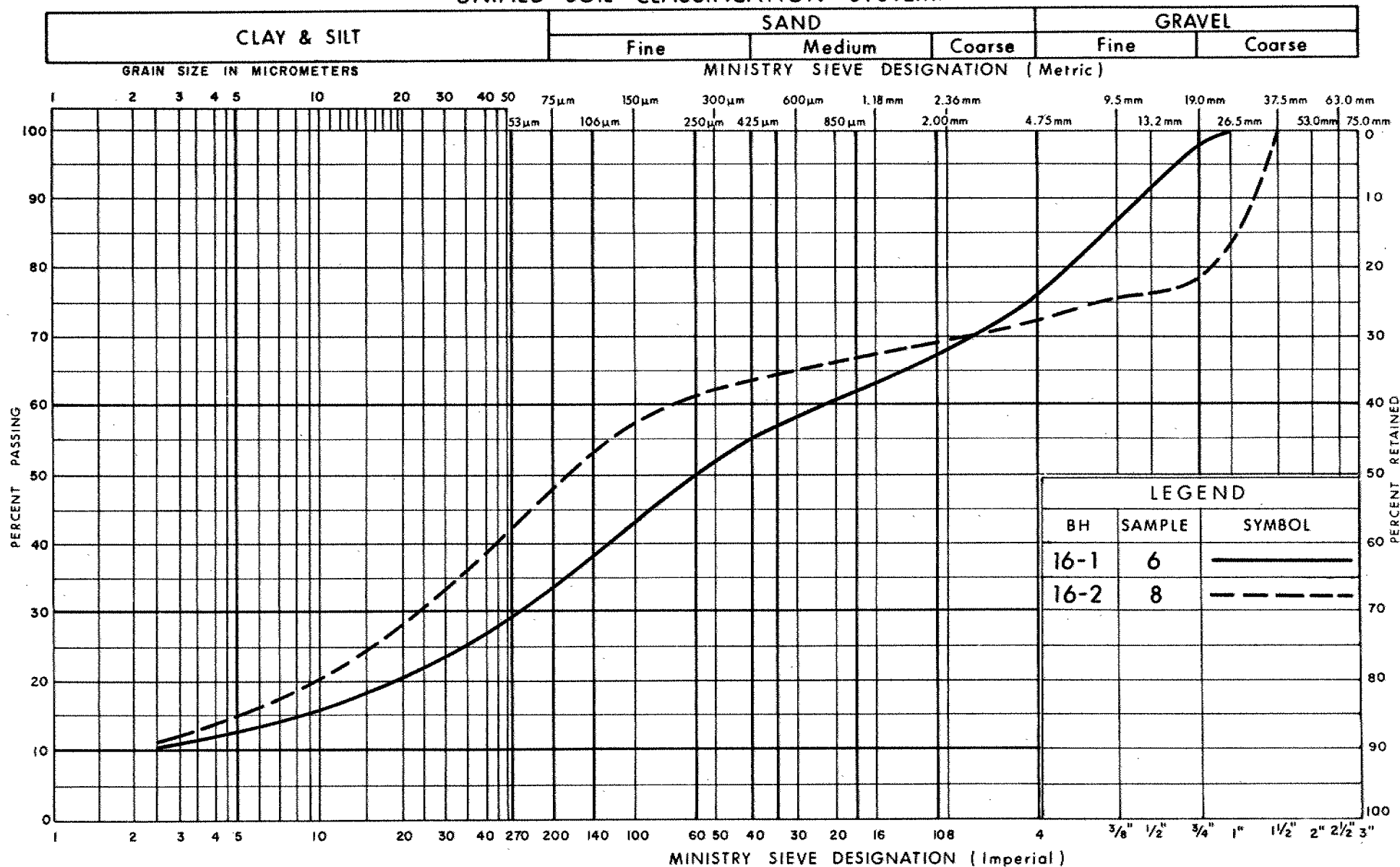


Fig 4A

W P 127-87-00(A)

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
HET MIXTURE OF  
SILT, SAND & GRAVEL (Glacial Till)

FIG No 5

W P 127-87-00 (A)

FOUNDATION INVESTIGATION REPORT  
PROPOSED DIAPHRAGM WALL AND SLOPE CUT  
HIGHWAY 416/CNR SUBWAY  
DISTRICT NO. 9 (OTTAWA)  
NEPEAN, ONTARIO  
W.P. 126-87-01(A)

1.0 INTRODUCTION

The Ministry of Transportation Ontario (MTO) retained Golder Associates (GA) to carry out a geotechnical investigation along the proposed Highway 416 route at a deep cut section adjacent to the Lynwood subdivision in Nepean, Ontario (See Figure 1). Highway 416 is to enter the Ottawa area as a six lane highway along a route just east of Cedarview Road. It is planned to carry Highway 416 under the main CNR tracks which are immediately south of Baseline Road. The vertical alignment results in a cut section between about 5 and 11 metres below the ground surface in this area.

The purpose of this investigation was to determine additional information regarding the soil conditions, the bedrock profile, and the groundwater conditions in the deep cut section area. The factual information from field and laboratory investigations are presented in this report.

## 2.0 SITE DESCRIPTION AND GEOLOGY

The site is located adjacent to the Lynwood Subdivision, with Cedarview Road to the west, and a green belt area to the east and to the south. The existing CNR tracks run approximately in an east-west direction. The ground surface topography between the CN railway line and south end of the Lynwood subdivision is relatively flat. North of the railway tracks, the ground surface falls off relatively quickly towards Baseline Road.

Previous investigations carried out for MTO and by Golder Associates indicated that the subsurface conditions generally consist of deep deposits of sensitive silty clay underlain by glacial till or sand deposits. The overburden thickness is generally about 9 m to 17 m within the study area. Geological maps show that the bedrock consists of limestone or dolomitic limestone of the Oxford Formation.

## 3.0 PREVIOUS INVESTIGATIONS

Previous investigations carried out at the site by GA and others are presented in the following reports:

- Geotechnical and Groundwater Study. Proposed Highway 416. Cedarview Road Corridor Near the Lynwood Subdivision. W.P. 146-74-00-3 District 9 (Ottawa) Nepean, Ontario (GA Report to MTO, Report No. 891-2208). January, 1990.
- Foundation Investigation for Bridge Structure. Proposed Highway 416 and CNR Subway. District No. 9, Ottawa, W.P. 126-87-01, Site 3-544 (Acres Report to MTO). February, 1990.

#### 4.0 PROCEDURE

The field work for this investigation was carried out between June 26 and July 15, 1990.\* The approximate location of the boreholes put down in this investigation, together with the previous boreholes in the cut area, are shown on Drawing 126-87-01(A)-1.\*\* The holes were drilled along three lines along the alignment of the highway, between Station 27+850 and Station 28+200:

- o Ten sampled boreholes and two probe holes along the line for the west wall. Holes were generally located at 20 m spacing intervals.
- o Three sampled boreholes and three probe holes along the centreline of Highway 416. Holes were generally at 40 m spacing intervals.
- o Ten sampled boreholes and two probe holes along the line for the east wall. Holes were generally located at 20 m spacing intervals.

The boreholes and probe holes were advanced to depths ranging from about 9 m to 20 m below ground surface using track mounted CME 55 drill rigs supplied and operated by a local contractor. In all cases, holes were augered to refusal. In addition, rock coring was carried out in eight borings, (at BH's 90-W2, 90-W4, 90-W7, 90-W19, 90-W21, 90-W23, 90-W26 and 90-W29).

\*\*Dwg No 3, (Sheet 185-1) of the Contract Drawings.

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\* BH 90-W9 was drilled as part of a concurrent investigation program for MTO and was put down on May 4, 1990 (Ref. GA Report No. 901-2115).

Bedrock was cored in BXL size for about 3 m in these borings. In sampled boreholes, standard penetration tests were carried out in the overburden and samples were obtained using conventional 50 mm diameter split-spoon sampling equipment. In-situ vane testing was carried out in selected boreholes within the clay stratum. Standpipes were sealed into selected holes to determine the groundwater levels in the various soil strata and in the bedrock.

The field work was carried out under the full-time supervision of members of our engineering staff who located the boreholes, cleared the borehole locations for buried services, directed the drilling and sampling operations, installed the piezometers, logged the borings, and transported the samples to our office.

The as-drilled borehole locations and elevations of the ground surface at the hole locations were provided by MTO. It is understood that these elevations are referenced to Geodetic datum.

The logs of the borings showing the soil and groundwater conditions encountered are given on the Record of Borehole sheets following the text of this report. Relevant borehole logs from previous boreholes are also provided for reference.

## 5.0 SUBSURFACE CONDITIONS

As previously indicated, the subsurface conditions are shown on the Record of Borehole sheets and the approximate locations of the boreholes are shown on Drawing 126-87-01(A)-1.\* The soil profiles along the centreline of the proposed highway, and Section A-A (west of centreline)

\* Dwg No 3, (Sheet 185-1) of the Contract Drawings.

and Section B-B (east of centreline) are shown on Drawing 126-87-01(A)-2 and Drawing 126-87-01(A)-3\*, respectively. The results of laboratory testing are given on Figures 2 to 9, inclusive and on the Record of Borehole sheets.

The following sections of the report presents a discussion on the general subsurface conditions across the site, followed by descriptions of the major soil units, bedrock and groundwater conditions. The boundaries of the soil units described are inferred from observations of auger cuttings and sampling at discrete depth intervals. They represent a transition from one main soil type to another, rather than an exact plane of geological change. Furthermore, conditions can vary between boreholes. Contractors bidding on or undertaking the proposed works should examine the factual results; satisfy themselves as to the adequacy of the information for construction; and, make their own interpretation of the factual data presented as it affects their construction methods, equipment selection, scheduling, and other operations.

### 5.1 General

The subsurface conditions in the general study area generally consist of sensitive silty clay of variable thickness, overlying discontinuous deposits of silty sand and gravel which in turn overlies dolomitic limestone bedrock of the Oxford Formation. In the area close to the CNR tracks, at the north end of the study area, a stratum of glacial till composed of sandy silt some clay and gravel follows the silty clay layer, and this glacial till stratum overlies bedrock directly. The groundwater level measured in standpipes sealed in the overburden and the bedrock indicates a general pattern of underdrainage. Karst

\*Dwg Nos 4 & 5, (Sheet 185-2 & 185-3) of the Contract Drawings.



structures were not encountered at the borehole locations, though localized occurrence for such phenomenon has been reported in the Ottawa area, in particular, at the Queensway Carleton Hospital site. The soil and rock conditions defined in the current investigations are consistent with the results of previous investigations.

During service clearance for drilling in the current 1990 investigations, a gas main, a sanitary sewer and a 1,220 mm diameter watermain were found to be located in the general area of the deep cut section. The approximate locations for these lines are shown on Drawing 126-87-01(A)-1\*, the borehole location plan.

## 5.2 Topsoil and Fill

The railway tracks cross the proposed route of Highway 416 on some 1 to 2 m of ballast fill. Access roads north and south of the tracks are built on minor thicknesses of gravel fill. Away from the railway tracks area, the ground surface is generally covered by some 0.2 m to 0.4 m of topsoil.

## 5.3 Silty Clay

A silty clay stratum was encountered in all of the boreholes put down during the investigation. In general, the thickness of this sensitive silty clay stratum ranged from about 5 m to 15 m. The upper portion of the clay has been weathered to a grey-brown crust. Below the grey-brown crust, the clay is grey in colour. Occasional silty sand and sand seams were encountered in the silty clay stratum.

\* Dwg No 3, (Sheet 185-1) of the Contract Drawings.

The weathered grey brown silty clay layer, some 2 m to 6 m thick, is of stiff to very stiff consistency. In-situ vane shear strength testing carried out in the underlying grey silty clay, gave undrained shear strengths ranging from about 30 kPa near the surface to about 60 kPa at depth indicating a generally firm consistency becoming stiff with depth. The ratio of in-situ vane shear strength to remoulded vane shear strength (sensitivity) varied from 3 to 9.

A summary of the Atterberg limit tests on the silty clay are shown on the plasticity charts on Figures 2 to 4 and also on the Record of Borehole sheets. As shown on Figures 2 to 4, the silty clay has, in general, a medium to high plasticity. The measured water content in the grey-brown weathered silty clay (crust) was about 30 percent near the ground surface increasing to 40 to 50 percent near the base of the weathered layer. As such, the water content was at or below the liquid limits. The measured water content of the unweathered sensitive silty clay was typically about 40 percent to 60 percent, and generally exceeded the measured liquid limits. The results of grain size analyses on representative samples are shown on Figure 6.

#### 5.4 Glacial Till

A deposit of glacial till was encountered below the silty clay deposit in the area of the CNR tracks. The composition of the glacial till was variable, though in general, sandy silt was the predominant material with some gravel and clay size material. While cobbles and boulders were not generally encountered in the augering and sampling operations, the presence of cobbles, and to a lesser extent boulders, must be expected in this Ottawa area glacial till material.

Standard penetration tests carried out within the glacial till gave 'N' values of 2 to 29 blows per 300 mm penetration, indicating the till was very loose to compact in relative density. Some of the lower 'N' values may be due to disturbance of the soil prior to sampling.

Atterberg limit test results on the finer portion of a sample of sandy silt till (BH 90-W2, SA-7) are shown on the plasticity chart on Figure 5 and indicate the relatively non plastic nature of the till. Results for grain size analyses on glacial till samples are shown on Figures 7 and 8 and also on the Record of Borehole sheets. It should be noted that the grain size analyses were carried out on samples obtained by a 50 mm diameter split-spoon sampler and the results may not have shown the presence of coarse gravel, cobble or boulder sized material in-situ.

### 5.5 Sand

Deposits of sand, and sand and gravel, were encountered at the south end of the investigated area, at BH's 90W-9 to 90W-12, at BH 90W-18, and at BH 90W-29 and BH 90W-30.

These deposits were encountered beneath the silty clay layer and generally overlaid bedrock. At the above hole locations, sand came up in the hollow stem auger during drilling, while augering well below the groundwater level.

Results for grain size analyses on typical samples are shown on Figure 9 and on the Record of Borehole sheets. The gradation of the sand deposit has been found in previous investigations to be variable and ranging from fine sand with some silt, to fine to coarse sand with some silt and gravel, to sand and gravel. As noted before, the grain size analyses were carried out on samples obtained by a 50 mm diameter split-spoon sampler and the results may not have shown the presence of coarse gravel, cobble or boulder sized material in-situ.

Standard penetration tests carried out in these deposits indicated a variable loose to compact relative density. Some of the lower 'N' values are due to disturbance of the soil prior to sampling.

#### 5.6 Bedrock

The bedrock surface was determined by boreholes where coring was carried out and inferred in boreholes where auger refusal was encountered. As shown on Drawings 126-87-01(A)-2\* and 126-87-01(A)-3\*, the bedrock was relatively level, ranging from elevation 71 m near the south end of the project area to elevation 76 m near the north end.

The bedrock samples obtained from the cored boreholes consisted of fresh, thinly to thickly bedded grey dolomitic limestone bedrock. Some sandstone layers, shale partings and occasional open horizontal joints were observed in the rock core. The dolomitic limestone core was of good quality, as given by the Rock Quality Designation (RQD) values of between 75 percent and 93 percent and total core recovery approaching 100 percent.

#### 5.7 Groundwater

Standpipes were sealed into the overburden deposits and bedrock to determine the groundwater conditions at the site. Details on the installations of the standpipes and the groundwater levels obtained are given on the Record of Borehole sheets. Groundwater level in some of the open holes was noted following completion of drilling.

\* Dwg Nos 4 & 5, (Sheet 185-2 & 185-3) of the Contract Drawings.

The groundwater level in the standpipes installed during this investigation was measured on July 27, 1990, about two weeks after completion of drilling. Groundwater levels in the south end of the project measured in standpipes sealed into the sand or into the glacial till were within 1 m of ground surface (groundwater elevation of about 86.5). A standpipe sealed into the bedrock in this area had the water level at 2.2 m depth (elevation 85.0). North of the CNR tracks, standpipes sealed in the glacial till indicated water levels at 2.8 m to 4.3 m depth (elevation 83 to 81), while a standpipe sealed into the bedrock indicated a water level at 5.8 m depth (elevation 79.5).

The measured groundwater levels indicated a general pattern of underdrainage to the bedrock.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.



*D. Dundas*

D. Dundas, P. Eng.

Sr. Foundation Engineer

RECORDS OF BOREHOLE SHEETS

August, 1990

901-2256



# RECORD OF BOREHOLE No 90 - W2

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 348; E 358 848 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
 DATUM GEODETIC DATE JUNE 28, 1990 CHECKED BY *RL*

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
85.5	Ground Surface															
0.0	Topsoil															
0.2	Silty clay, occasional silty fine sand seams (weathered crust)  Stiff to very stiff  Brown		1	SS	11								0			
			2	SS	6								0			
			3	SS	3								0			
			4	SS	2								0			
81.5																
4.0	Silty clay, occasional sand seams  Firm Grey		5	SS	WH*								0			
			6	SS	PM								0			
78.5																
7.0	Sandy silt, some gravel and clay, occasional cobble (glacial till)  Loose Grey		7	SS	9								0			
76.3																
9.2	Dolomitic limestone bedrock, fresh, some shale partings, occasional sand- stone layers, trace pyrite  Grey		9	RC BXL	** Rec <sup>m</sup> 100%  RQD 84%											
73.4																
12.1	End of Borehole  *Sank under weight of hammer  ** Rec: Recovery RQD: Rock Quality Designation															

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE





## METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 249; E 358 894 ORIGINATED BY AC  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; EXL Rock Core COMPILED BY RN  
DATUM GEODETIC DATE JUNE 28, 1990 CHECKED BY RN

[illegible]

+3, x5: Numbers refer to Sensitivity

## METRIC

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 90 - W6

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 199; E 358 915 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE JULY 3, 1990 CHECKED BY AN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
86.6	Ground Surface													
0.0	Topsoil													
0.2	Silty clay, some silty fine sand seams (weathered crust)  Grey Brown						86							
84.0														
2.6	Silty clay  Grey						84							
							82							
							80							
79.4														
7.2	Sandy silt, some gravel and cobble (glacial till)  Grey		1	SS	5		78							
							76							
	Becoming more silty with depth													
74.3	Grey													
12.3	End of Borehole Refusal to Auger Probable Bedrock						74							
							72							

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W7

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 181; E 358 923 ORIGINATED BY BB  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
 DATUM GEODETIC DATE July 9, 1990 CHECKED BY RN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE R <sub>10T</sub>					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										WATER CONTENT (%)		
								SHEAR STRENGTH kPa										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
86.9	Ground Surface							20	40	60	80	100	20	40	60					
0.0	Topsoil																			
86.4	Fill - silty sand							Water level in standpipe at elevation 86.2 m on July 27, 1990												
0.5	Silty clay, some fine sand seams (weathered crust)						86													
	Grey Brown		1	SS	5															
84.6																				
2.3	Silty clay, some sand seams						84													
	Firm Grey																			
			2	SS	PM		82													
							80													
78.8			3	SS	PM															
8.1	Silty sand, some fine																			
78.2	to medium gravel Grey																			
8.7	Silty clay, some sand seams						78													
	Grey		4	SS	PM															
75.8							76													
11.1	Sand and silt, some gravel and clay (glacial till)																			
	Very stiff Grey		5	SS	18															
74.1																				
12.8	Dolomitic limestone, some shale partings, some coarse sandstone layers, occasional calcite inclusions, trace pyrite		6	RC BXL	* Rec= 100% RQD= 82%		74										21 32 39 8			
71.9																				
							72													

\* REC: Recovery  
 RQD: Rock Quality Designation

\*3, \*5: Numbers refer to  
 Sensitivity

20  
 15 5 (%) STRAIN AT FAILURE  
 10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W8

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 165; E 358 930 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 10, 11, 1990 CHECKED BY RY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
87.3	Ground Surface													
0.0	Topsoil					*								
0.2	Fill - Silty Sand Brown													
0.5	Silty clay, occasional fine sand seams (weathered crust)													
	Grey Brown													
84.6														
2.7	Silty clay, occasional fine sand seams													
	Grey													
			1	SS	** WH									
78.1														
9.2	Laminated silty sand and clayey silt, some gravel		2	SS	6									
9.6	Silty clay													
77.1	Grey													
10.2	Sandy silt to clayey silt, some gravel, occasional cobble													
			3	SS	3									
	Loose to Dense													
73.8														
13.5	End of Borehole Refusal to Auger Probable Bedrock *Note: Water level not established **Sank under weight of hammer													

+3, x5 : Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W9

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 146; E 358 936 ORIGINATED BY DJS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM Geodetic DATE May 4, 1990 CHECKED BY RA

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		20	40	60	80	100					
87.2	Ground Surface															
0.0	Topsoil															
0.3	Silty clay, occasional sand seams (weathered crust)															
84.5	Grey Brown															
2.7	Silty clay, occasional sand seams and layers															
			1	SS	PM											
			2	SS	PM											
			3	SS	PM											
			4	SS	PM											
			5	SS	PM											
			6	SS	PM											
			7	SS	WH*											
			8	SS	WH*											
77.2																
10.0	Sandy silt and silty sand, some clay and gravel (glacial till)		9	SS	3											
			10	SS	4											
			11	SS	3											
74.7																
12.5	Sand, fine to coarse trace gravel and silt		12	SS	4											
73.6	Compact Grey															
73.2	Sand, fine to coarse, some silt, Compact Grey		13	SS	50/100 mm											
14.0	End of Borehole Refusal to Auger Probable Bedrock *Sank under weight of hammer															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

## RECORD OF BOREHOLE No 90 - WIO

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 126; E 358 947 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 11, 12, 1990 CHECKED BY Lo

[illegible]

+3, x<sup>5</sup>: Numbers refer to Sensitivity



# RECORD OF BOREHOLE No 90 - WII

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 110; E 358 953 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 11, 1990 CHECKED BY AK

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20	40	60	80	100						
87.4	Ground Surface																	
0.0	Topsoil					**												
0.2	Silty clay, some fine silty sand seams (weathered crust)																	
	Stiff Grey						86											
84.7																		
2.7	Silty clay, some fine silty sand seams and bands						84											
	Grey						82											
							80											
79.2			1	SS	WH*													
8.2	Silty clay, layered, some fine sand and sandy silt seams, occasional gravel		2	SS	2													
77.9	Grey		3	SS	3		78											
9.5	Silty fine sand Grey		4	SS	4													
9.8	Silty clay, some fine sand seams Grey																	
77.2																		
10.2	Sand, medium to coarse, some gravel, becoming cobblely with depth		5	SS	20		76											
	Compact Grey						74											
72.9																		
14.5	End of Borehole Refusal to Auger Probable bedrock																	

NOTE: \* Sank under weight of hammer  
 \*\* Water level not established

+3, x5: Numbers refer to  
 Sensitivity

20  
 15  
 10  
 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W12

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 100; E 358 958 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM Geodetic DATE July 12, 1990 CHECKED BY RA

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.6	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, occasional silty sand seams (weathered crust)					*											
	Grey Brown																
84.9							86										
2.7	Silty clay, some silty fine sand layer																
	Grey						84										
							82										
							80										
78.9																	
8.7	Sand, some gravel																
							78										
							76										
							74										
72.7																	
14.9																	

OFFICE REPORT ON SOIL EXPLORATION

End of Borehole  
 Refusal to Auger  
 Probable Bedrock

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
 Sensitivity

20  
 15 5 (%) STRAIN AT FAILURE  
 10



RECORD OF BOREHOLE No 90 - W14

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 334; E 358 888 ORIGINATED BY AC  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE JUNE 28, 1990 CHECKED BY RN

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.0	Ground Surface																
0.0	Fill - mixture of sand silt and gravel																
85.5																	
0.5	Topsoil					*											
85.1																	
0.9	Silty clay, some silty fine sand seams (weathered crust)																
	Grey Brown						84										
82.0																	
4.0	Silty clay, occasional silty fine sand seams						82										
	Grey																
							80										
							78										
77.4																	
8.6	Sandy silt, some gravel and clay (glacial till)																
	Grey						76										
74.9																	
11.1	End of Borehole Refusal to Auger Probable Bedrock																
	*Note: Water level not established						74										
							72										

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5  
0  
5  
10  
15  
20  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W15

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 316; E 358 894 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE JUNE 29, 1990 CHECKED BY RN

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.3	Ground Surface																
0.0 85.8	Fill - mixture of sand and gravel						86										
0.5	Topsoil																
0.8	Silty clay, some silty fine sand seams (weathered crust)  Grey Brown					*											
82.3							84										
4.0	Silty clay, occasional sand seams  Grey						82										
77.9							80										
8.4	Sandy silt, some gravel and clay (glacial till)  Loose Grey						78										
74.7							76										
11.6	Dense						74										
	End of Borehole Refusal to Auger Probable Bedrock  *Note: Water level not established						72										

## METRIC

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			20	40					
86.6	Ground Surface													
86.2	Topsoil													
0.4	Silty clay, some silty fine sand seams (weathered crust)  Grey Brown						86							
83.5							84							
3.1	Silty clay, some sand seams						82							
77.9			1	SS	1		78							
8.7	Sandy silt, some gravel and clay (glacial till)													
	Loose Grey		2	SS	3									
							76							
							74							
73.5														
13.1	End of Borehole Refusal to Auger Probable Bedrock						72							

+3, x<sup>5</sup>; Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



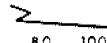






# RECORD OF BOREHOLE No 90 - W20 METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 351; E 358 946 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE JUNE 29, 1990 CHECKED BY A

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			20	40	60	80	100					
85.2	Ground Surface																GR 5A SI CL
0.0	Fill - mixture of sand and gravel, occasional cobble.					*											
84.1																	
1.1	Topsoil						84										
83.7																	
1.5	Silty clay, some silty fine sand seams (weathered crust)  Grey Brown																
80.6							82										
4.6	Silty clay, occasional silty fine sand seams  Grey																
							80										
							78										
							76										
							74										
73.8																	
11.4	Sandy silt, some gravel and clay (glacial till)																
72.7	Grey																
12.5	End of Borehole Refusal to Auger Probable Bedrock  NOTE: * Water level not established						72										

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W21

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 328; E 358 956 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
DATUM Geodetic DATE July 12 and 13, 1990 CHECKED BY RN

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 Y KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.1	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, some silty fine sand layer (weathered crust)		1	SS	11		84										
	Very stiff to stiff  Grey Brown		2	SS	7		Native Backfill										
			3	SS	1											17.5	
82.2	Silty clay, some silty fine sand layer		4	SS	PM		82										
2.9	Firm Grey		5	SS	PM												
			6	SS	PM												
			7	SS	PM												
76.6	Silty clay, some silty fine sand layers, trace gravel		8A	SS	PM												
75.6	Grey		8B	SS	PM												
9.5	Sandy silt to clayey silt, some clay and gravel (glacial till)		9	SS	2												
	Very loose Grey		10	SS	1												
73.1																	
12.0	Dolomitic Limestone Bedrock, fresh, some shale partings, some coarse sandstone seams, occasional calcite inclusions, trace pyrite		11	RC BXL	Rec= 100%  RQD= 93%												
70.4	Grey																
14.7	End of Borehole																

\*Rec = Recovery  
RQD = Rock Quality Designation

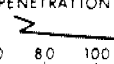

















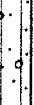
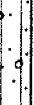
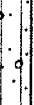

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W22

METRIC

W P 126-R7-01(A) LOCATION Co-ords N 5 021 281; E 358 977 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE JUNE 27, 1990 CHECKED BY *EV*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
								○ UNCONFINED      + FIELD VANE									
								● QUICK TRIAXIAL    x LAB VANE									
					20   40   60   80   100					WATER CONTENT (%) 20   40   60							
86.5	Ground Surface					*	86										
0.0	Fill - mixture of sand and gravel																
85.9																	
0.6	Topsoil																
0.8	Silty clay, some silty fine sand seams (weathered crust)																
	Grey Brown						84										
																	
82.5																	
4.0	Silty clay, occasional silty sand seams						82										
	Grey																
							80										
																	
							78										
																	
							76										
																	
74.4																	
12.1	Sandy silt, some gravel and clay (glacial till)						74										
																	
73.0																	
13.5	End of Borehole Refusal to Auger Probable Bedrock						72										
	* NOTE: water level not established																

+3, x5: Numbers refer to Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 90 - W23

METRIC

W P 126 87 01(A) LOCATION Co-ords N 5 021 263; E 358 983 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
 DATUM GEODETIC DATE JUNE 26, 1990 CHECKED BY RW

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	Wp	W		
70.8	Continued															
15.0	Grey		11	RC BXL	Rec=100% ** RQD=75%											
69.2																
16.6	End of Borehole															
	* Sank under weight of hammer															
	** Rec: Recovery															
	RQD: Rock Quality Designation															

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W24

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 239; E 358993 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE JULY 3, 1990 CHECKED BY AW

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.4	Ground Surface																
0.0 85.9	Topsoil						86										
0.5	Silty clay, some silty fine sand seams (weathered crust).  Grey Brown					*											
83.3 3.1	Silty clay  Grey						84										
							82										
							80										
							78										
	Some silty fine sand layers.  Grey		1	SS	1		76										
							74										
	Trace gravel																
73.3 13.1	Sandy silt, some clay and gravel, and occ. silty sand and gravel layers (glacial till). Very Loose Grey		2	SS	3												
72.3																	
14.1	End of Borehole Refusal to Auger Probable Bedrock						72										

\* NOTE: water level not established

+3, x5: Numbers refer to 20  
Sensitivity 15 ÷ 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W25 METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 222: E 359 001 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 4, 1990 CHECKED BY Ral

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.3	Ground Surface																
0.0	Topsoil						86										
0.2	Silty clay, occasional silty sand seams (weathered crust)																
	Grey Brown																
83.4							84										
2.9	Silty clay, some silty fine sand seams																
	Grey						82										
							80										
							78										
							76										
			1	SS	1												
			2	SS	1		74										
73.1																	
13.2	Sandy silt and clayey silt, some gravel (glacial till)																
72.0	Loose Grey		3	SS	3												
14.3	End of Borehole Refusal to Auger Probable Bedrock						72										

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 90 - W26

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 203; E 359 008 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
DATUM GEODETIC DATE July 4, 1990 CHECKED BY AN

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			20 40 60 80 100	20 40 60 80 100					
86.9	Ground Surface													
0.0	Topsoil													
0.2	Silty clay, trace sand seams (weathered crust)													
			1	SS	16		86							
			2	SS	7									
	Brown		3	SS	4									
83.8	Becoming Grey													
3.1	Silty clay, trace silty sand seams		4	SS	PM									
			5	SS	PM									
	Grey		6	SS	PM									
			7	SS	PM									
78.1														
8.8	Silty clay, becoming more silty with depth		8	SS	PM									
			9	SS	PM									
			10	SS	PM									
72.9	Becoming Sandy													
14.0	Sandy silt, some gravel and trace clay (glacial till)		11	SS	WH*									
71.9	Grey													
15.0														

Continued

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90 - W26

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 203; E 359 008 ORIGINATED BY RB  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger: BXL Rock Core COMPILED BY RN  
DATUM GEODETIC DATE July 4, 1990 CHECKED BY AY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
71.9	Continued															
15.0	Sandy silt, some gravel and trace clay (glacial fill)		12	SS	14											
71.0	Grey															
15.9	Dolomitic Limestone Bedrock, some shale partings, some coarser sandstone layers		13	RC BXL	** Rec=100% RQD=79%											
						70										
						Bentonite										
						Peastone										
68.1	Grey					Standpipe										
18.8	End of Borehole					68										
	* Sank under weight of hammer **Rec = Recovery RQD = Rock Quality Designation					66										

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  $\pm$  5 (%) STRAIN AT FAILURE  
10

## METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 185; E 359 016 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 4, 1990 CHECKED BY RN

[illegible]

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

## METRIC

W P	126-87-01(A)	LOCATION	Co-ords N 5 021 185; E 359 016	ORIGINATED BY	PH
DIST	9 HWY 416	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	RN
DATUM	GEODETIC	DATE	July 4, 1990	CHECKED BY	RN

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 (%) GR SA SI CL							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100									SHEAR STRENGTH kPa			WATER CONTENT (%)			
																	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
Continued																							
71.9							72																
15.2	Sand silt, some gravel and trace clay (glacial till)																						
70.9																							
16.2	End of Borehole Refusal to Auger Probable Bedrock  * Water level not established						70																
							68																

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

## METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 168: E 359 023 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 5, 1990 CHECKED BY Rol

[illegible]

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLOSION

RECORD OF BOREHOLE No 90 - W28

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 168; E 359 023 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 5, 1990 CHECKED BY *RM*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp W WL	20 40 60				
71.9	Continued													
15.2	Clayey silt to sandy silt, some gravel (glacial till)		2	SS	8									
71.0	Loose Grey													
16.1	End of Borehole Refusal to Auger Probable Bedrock													
							70							
							68							

# RECORD OF BOREHOLE No 90 - W29

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 150; E 359 032 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
 DATUM GEODETIC DATE July 15, 1990 CHECKED BY RH

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			20 40 60 80 100							WATER CONTENT (%)	GR SA SI CL			
								SHEAR STRENGTH kPa											
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE										
87.2	Ground Surface																		
0.0	Topsoil																		
0.2	Silty clay, some silty fine sand seams (weathered crust)																		
	Stiff to Very stiff		1	SS	12														
	Grey Brown		2	SS	5														
			3	SS	3														
84.3																			
2.9	Silty clay, some fine sand seams, becoming more silty and sandy with depth.		4	SS	WH*														
			5	SS	1														
	Stiff Grey		6	SS	PH														
			7	SS	PM														
78.4																			
8.8	Silty clay to sandy silt, layered, trace gravel and clay		8	SS	WH*														
77.4	Grey																		
9.8	Silty clay, some silty fine sand layers		9	SS	PM														
			10	SS	PH														
			11	SS	PH														
	Stiff Grey																		
72.9			12	SS	WH*														
14.3	Sand, medium to coarse, some silt, trace gravel																		
72.2	Loose Grey		13	SS	7														

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

## METRIC

W P	126-87-01(A)	LOCATION	Co-ords N 5 021 150; E 359 032	ORIGINATED BY	PH
DIST	9 HWY 416	BOREHOLE TYPE	Hollow Stem Auger; BXL Rock Core	COMPILED BY	RN
DATUM	GEODETIC	DATE	July 15, 1990	CHECKED BY	R/L

[illegible]

+3, x5: Numbers refer to Sensitivity



# RECORD OF BOREHOLE No 90 - W30 METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 128; E 359 039 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 15, 1990 CHECKED BY RL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
87.4	Ground Surface													
0.0	Topsoil													
0.2	Silty clay, some fine sand seams (weathered crust)					*								
85.3	Grey Brown						86							
2.1	Silty clay, some fine sand seams, trace to some fine gravel						84							
	Grey						82							
							80							
							78							
							76							
74.1			1	SS	7		74							
13.3	Sand, fine to coarse, trace silt		2	SS	PM									
	Loose Grey													
72.4														
15.0														

Continued

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity  
 20  
 15  $\phi$  5 (%) STRAIN AT FAILURE  
 10

# RECORD OF BOREHOLE No 90 - W30 METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 128; E 359 039 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 15, 1990 CHECKED BY Ral

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
72.4	Continued																
15.0	Sand, fine to coarse, trace silt		3	SS	PH		72										
70.9	Loose Grey																
16.5	End of Borehole Refusal to Auger Probable Bedrock																
	* Note: Water level not established						70										
							68										

OFFICE REPORT ON SOIL EXPLORATION

**RECORD OF BOREHOLE SHEETS  
FROM PREVIOUS INVESTIGATIONS**

August, 1990

901-2256

RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 168; E 358 762 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.3	Ground Surface																GR SA SI CL
0.0 86.9	Sand and gravel occasional cobble						87										
0.4	Topsoil																
0.8	Silty clay, some silty fine sand seams (weathered crust)		1	SS	7		86										
			2	SS	5												
84.2	Very stiff Grey to stiff Brown						85										
31.1	Silty clay, some silty fine sand seams, trace gravel		3	TW	PH		84										
			4	SS	1												
82.6	Grey						83										
4.7	Sand, fine, some silt, some sandy silt layers		5	SS	9	Native	82										
			6	SS	15												
	Compact Grey		7	SS	16		81										
80.3																	
7.0	Sandy silt, trace to some gravel and clay, some fine sand and clayey silt layers		8	SS	19												
			9	SS	14												
			10	SS	6		79										
			11	SS	19		78										
			12	SS	64		77										
76.2	Loose to very dense Grey		13	SS	52		76										
11.1	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings occasional weathered horizontal joint		14	BXL	RQD=71%	Bentonite Silica Sand	75										
			15	BXL	RQD=55%		74										
			16	BXL	RQD=98%		73										
	Continued																

\*REC: Recovery  
RQD: Rock Quality Designation

# RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74- 00-3 LOCATION Co-ords N 5 021 168; E 358 762 ORIGINATED BY P.H.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger BXL Rock Core COMPILED BY A.C.  
 DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

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			20	40	60	80	100					
	Continued																
	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings, occasional weathered horizontal joint		16	RC BXL	REC- 100% RQD=98%		73										
			17	RC BXL	REC- 100% RQD=98%		72										
71.0							Standpipe										
16.3	End of Borehole																
	*REC: Recovery RQD: Rock Quality Designation																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 101

METRIC

W P 126-87-01 LOCATION Coords N 5 021 267.4 ; E 358 878.3 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 2, 3, 1989 CHECKED BY JB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	* VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)			
86.6	Ground Level					28/12/89								
0.0	Gravelly silty sand		1	SS	9		86						17.8	21 50 23 6
85.7	Possible Fill Brown		2	SS	6									
0.9	Silty Clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity CI-CH (Marine Deposit)		3	TW	PH		85							
			4	TW	PH		84							
			5	TW	PH		83							
			6	TW	PM		82							
			7	TW	PH		81							
79.6	Gray						80							
7.0	Sand and silt, with some gravel and some clay; wet, low plasticity to non-plastic, rapid dilatancy SM-ML (Till)		8	TW	PM		79							
			9	SS	5		78							
			10	TW	PH		77							
			11	SS	5		76							
75.3	Loose Dark Gray						75							
11.3	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh		12	RC BXL	REC 100%		74						RQD = 86%	
72.3	Gray		13	RC BXL	REC 100%		73						RQD = 95%	
14.3	End of borehole													

\*For RC samples, numbers represent Core Recovery.

\*For RC samples,  
numbers represent  
Core Recovery.

## RECORD OF BOREHOLE No 102

METRIC

W P 126-87-01 LOCATION Coords N 5 021 272.9 ; E 358 914.9 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 3, 1989 CHECKED BY JW

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT  Y	REMARKS  GRAIN SIZE DISTRIBUTION 1%
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES *			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)		
86.4	Ground Level					28/12/89								
0.0	Gravelly silty sand													
85.5	(Possible Fill) Brown		1	SS	7		86							
0.9	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		2	SS	9		85							
	CI-CH (Marine Deposit)		3	TW	PH		84				13			
			4	TW	PH		83							
			5	TW	PH		82							
	Very stiff, becoming firm with depth		6	TW	PH		81							
79.4	Gray		7	TW	PH		80							
7.0	Sand and silt with some gravel and some clay, wet, low plasticity to non-plastic, rapid dilatancy		8	SS	22		79							
	SM-ML (Till)		9	SS	2		78							
	Very loose to compact		10	SS	109/5 cm		77							
74.2	Dark Gray		11	RC	100%		76							
12.2	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh		12	RC	100%		75							
71.5	Gray		13	RC	100%		74							
14.9	End of borehole						73							
							72							

+3, x5: Numbers refer to Sensitivity



W P 126-87-01 LOCATION Coords N 5 021 291.1 ; E 358 871.9 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 7, 8, 1989 CHECKED BY JOB

+3, x5; Numbers refer to Sensitivity



## RECORD OF BOREHOLE No 107

METRIC

W P 126-87-01 LOCATION Coords N 5 021 296.9 : E 358 904.4 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 8, 1989 CHECKED BY SAB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			* N VALUES	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)		
85.1	Ground Level												
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	3								
			2	TW	PH								
	CI-CH (Marine Deposit)		3	TW	PH								
			4	TW	PH								
78.9	Firm Gray												
6.2	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy		5	TW	PH								
			6	SS	5								
			7	SS	5								
	SM-ML (Till)		8	SS	100								
10.6	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		9	RC	REC								
73.0				BXL	100%								
12.1	End of borehole												

\*For RC samples, numbers represent Core Recovery.

+3, x5. Numbers refer to Sensitivity

20  
IS  $\phi$  5 1/2" STRUT. AT FAILURE

# RECORD OF BOREHOLE No 109

METRIC

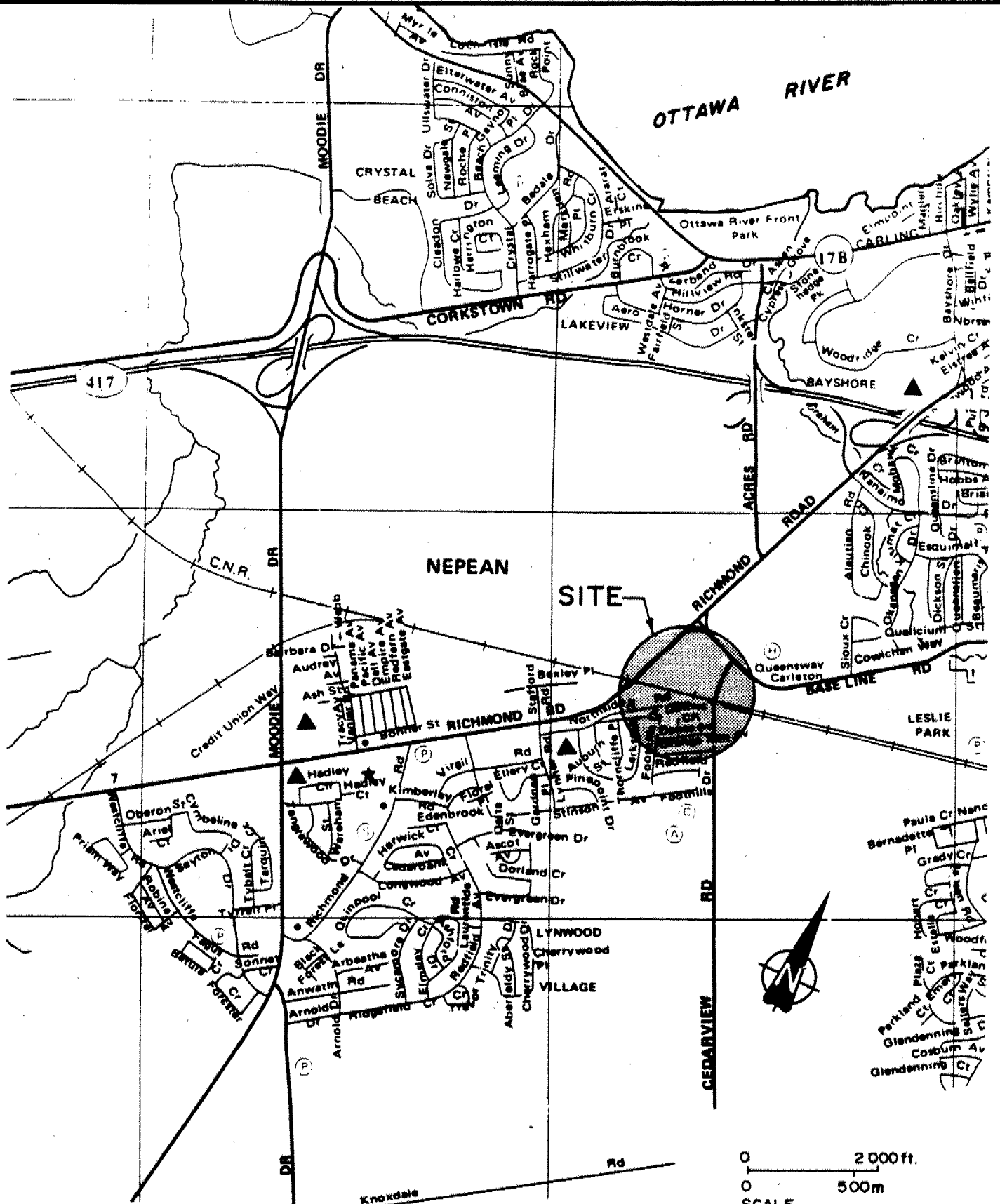
W P 126-87-01 LOCATION Coords N 5 021 305.8 ; E 358 964.3  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core  
 DATUM Geodetic DATE November 9, 10, 1989  
 ORIGINATED BY RH  
 COMPILED BY RH  
 CHECKED BY 78

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT  Y  KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
FIELD DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	* VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>			WATER CONTENT (%)
84.5	Ground Level					28/12/89									
0.0	Silty clay; occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	2		84						17.2 17.2	0 1 56 43	
			2	TW	PH			83							
			3	TW	PH			82							
	CI-CH (Marine Deposit)		4	TW	PH			81							
	Stiff, becoming soft to firm with depth		5	TW	PM			80							
			6	TW	PH			79							
			7	TW	PH			78							
			8	SS	1			77							
			9	TW	PM			76							
74.5	Gray		10	SS	1			75							
10.0	Sand and silt with some gravel and some clay, wet, low plasticity to non-plastic		11	SS	1			74							
72.6	SM-ML (T(11))		12	RC	REC			73							
11.9	Very loose Dark Gray		13	RC	BXL	100%		72							
	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh						71								
70.1	Gray												RQD = 92%		
14.4	End of borehole												RQD = 100%		
	*For RC samples, numbers represent Core Recovery.														

\*For RC samples, numbers represent Core Recovery.

# SITE LOCATION PLAN

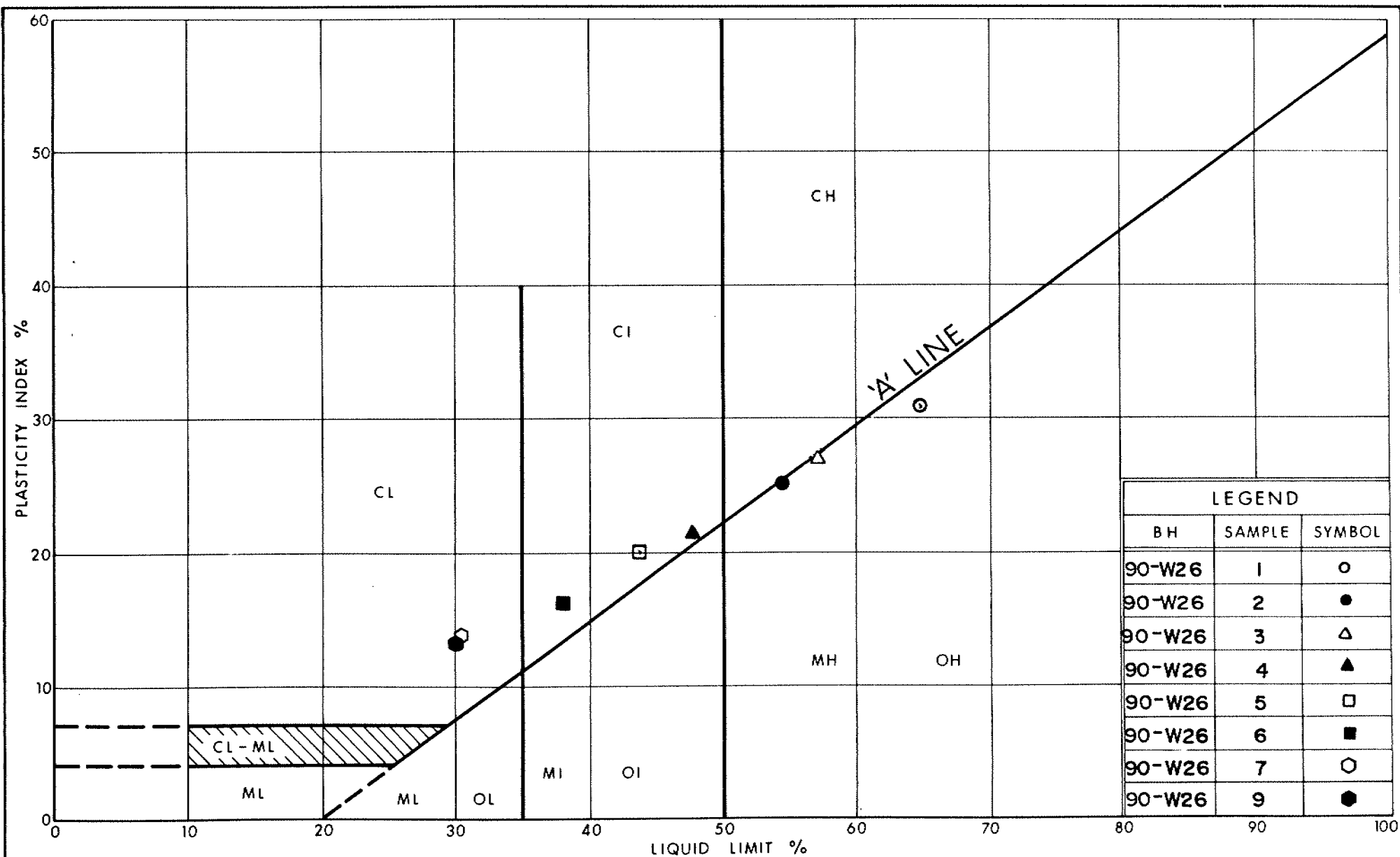
101  
FIGURE I  
WP 126-87-01 A



Date JUNE 12, 1990.  
Project 901-2256

**Golder Associates**

Drawn R.B.C.  
Chkd. *[Signature]*

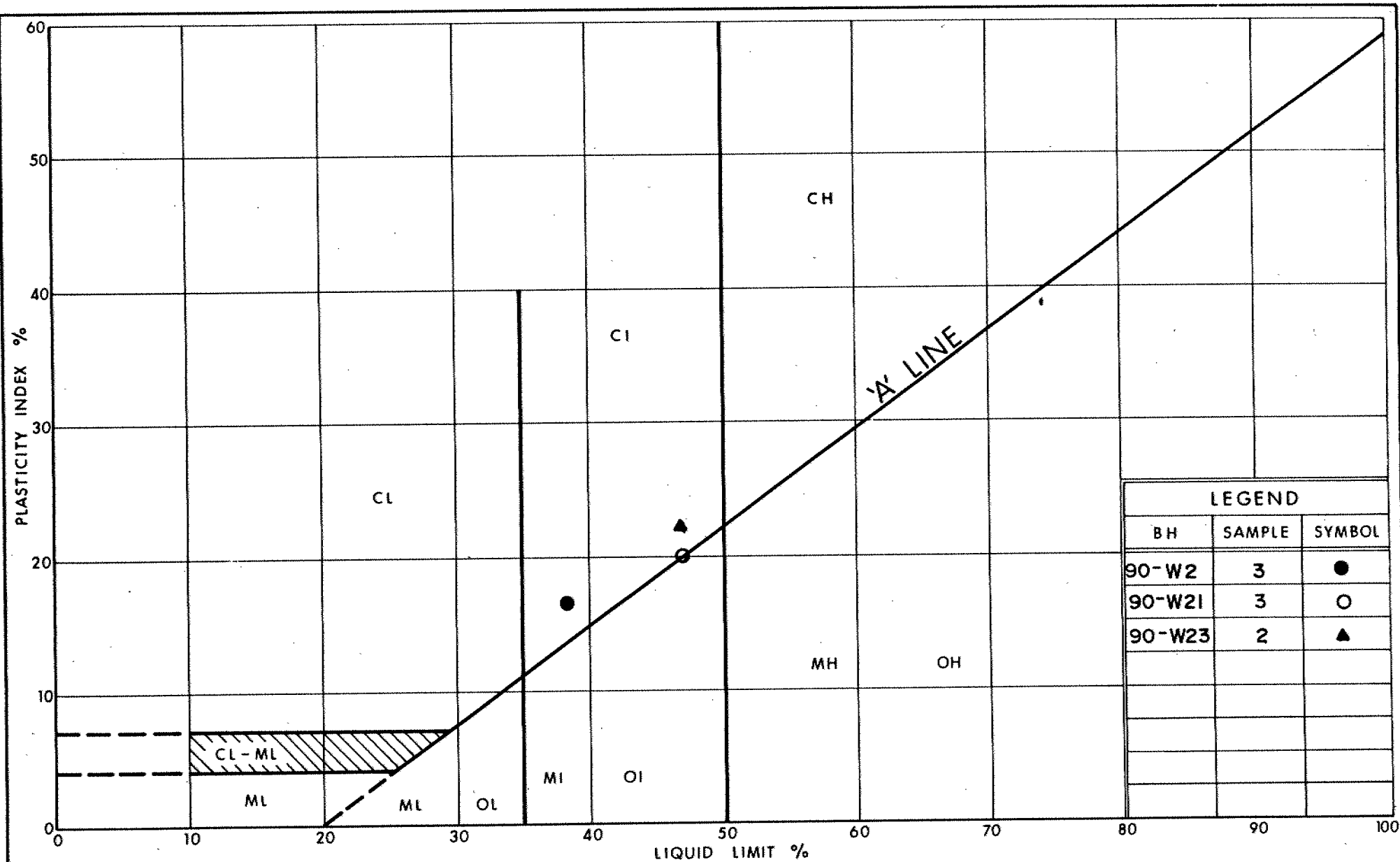


Ministry of  
Transportation

# PLASTICITY CHART SILTY CLAY, some silty sand seams

FIG No 2

W P 126-87-01 A

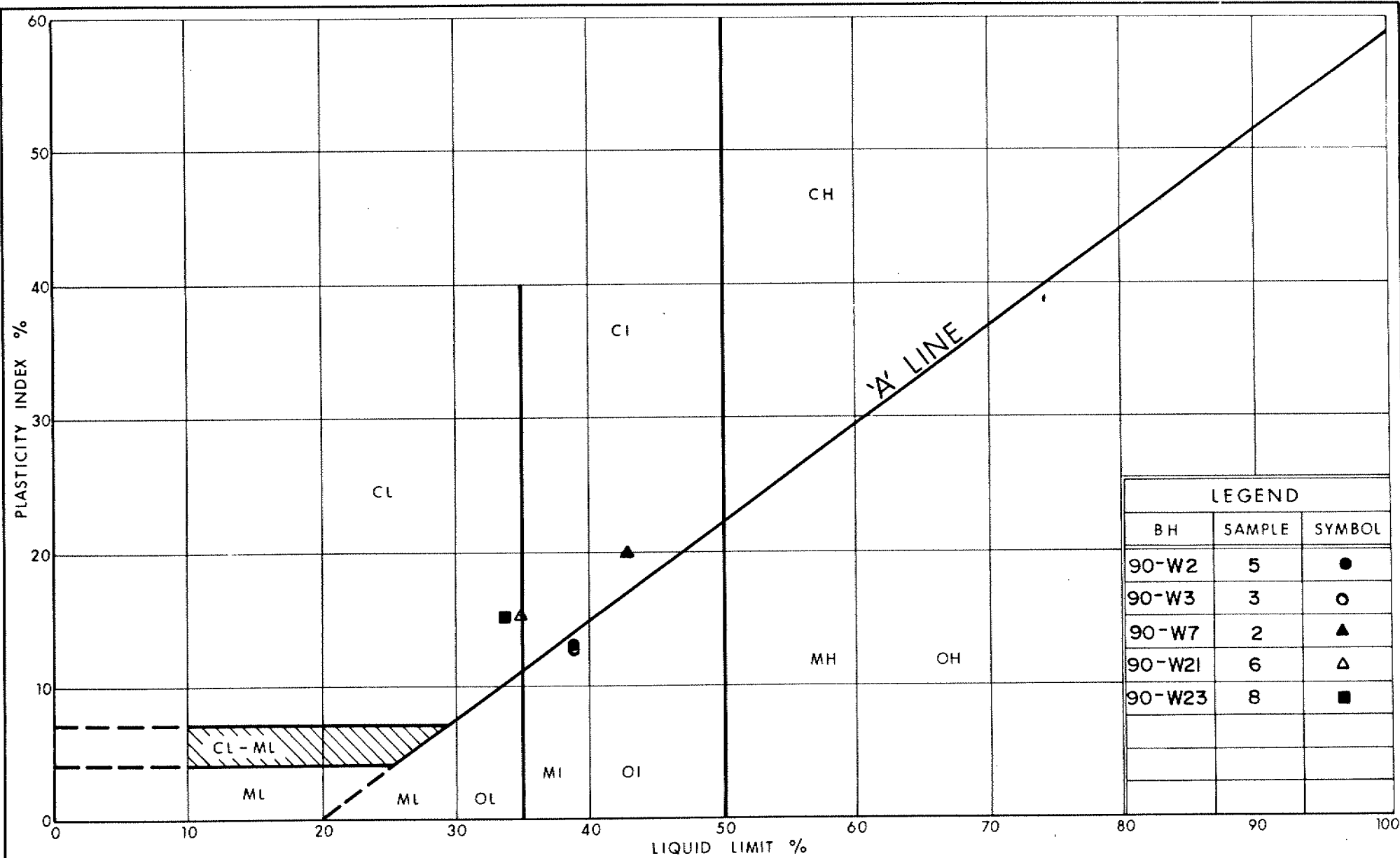


Ministry of  
Transportation

Ontario

**PLASTICITY CHART**  
**SILTY CLAY, some silty sand seams**  
**(Weathered Crust)**

FIG No 3  
 W P 126 - 87 - 01 A



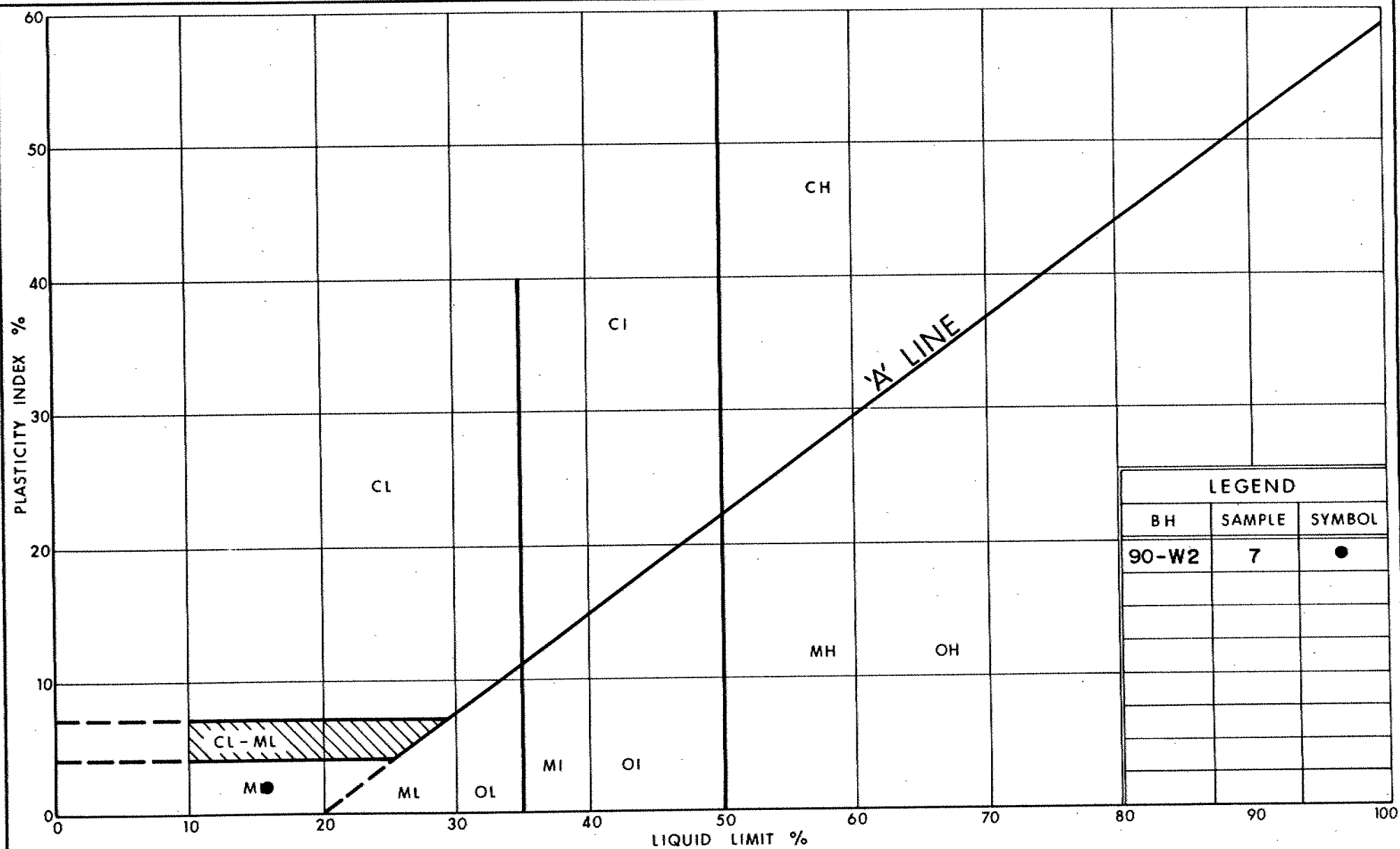
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Ontario

# PLASTICITY CHART SILTY CLAY, some silty sand seams

FIG No 4

W P 126-87-01A



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Transportation

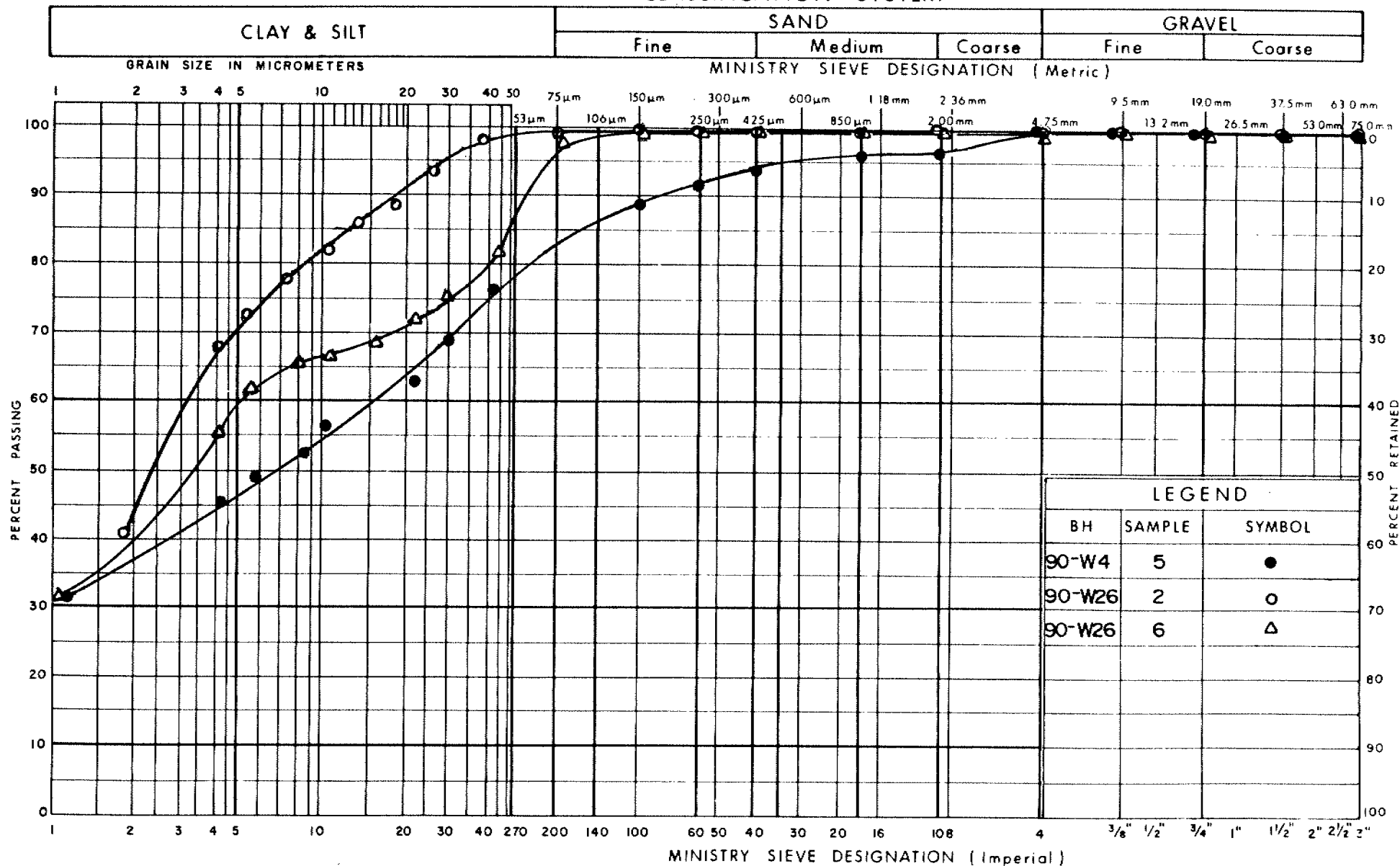
Ontario

**PLASTICITY CHART**  
**SANDY SILT, some gravel and clay ( GLACIAL TILL )**

FIG No 5  
 W P 126-87-01A

105

## UNIFIED SOIL CLASSIFICATION SYSTEM



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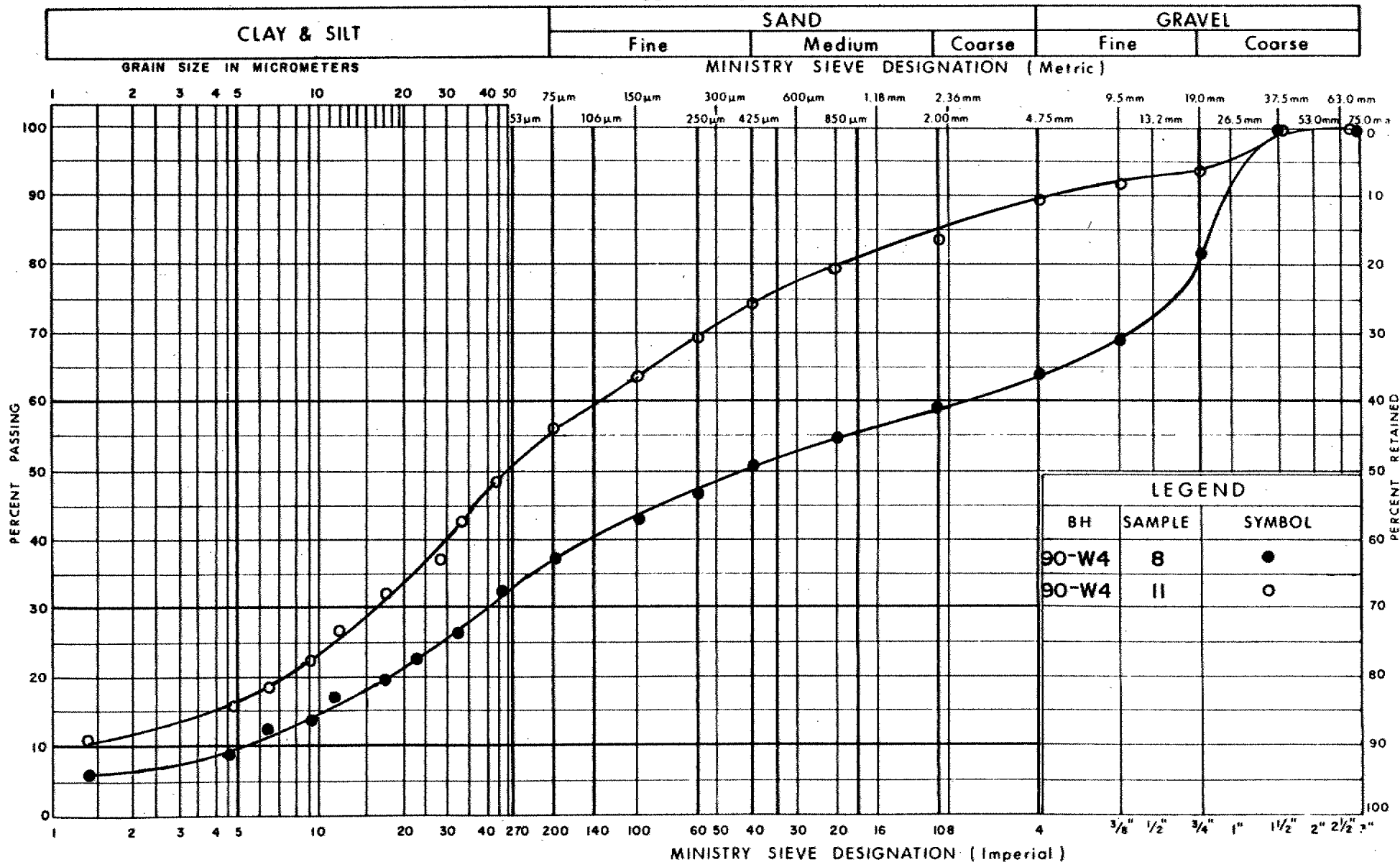
GRAIN SIZE DISTRIBUTION  
SILTY CLAY, some silty sand seams

FIG No 6

W P 126-87-01A



## UNIFIED SOIL CLASSIFICATION SYSTEM

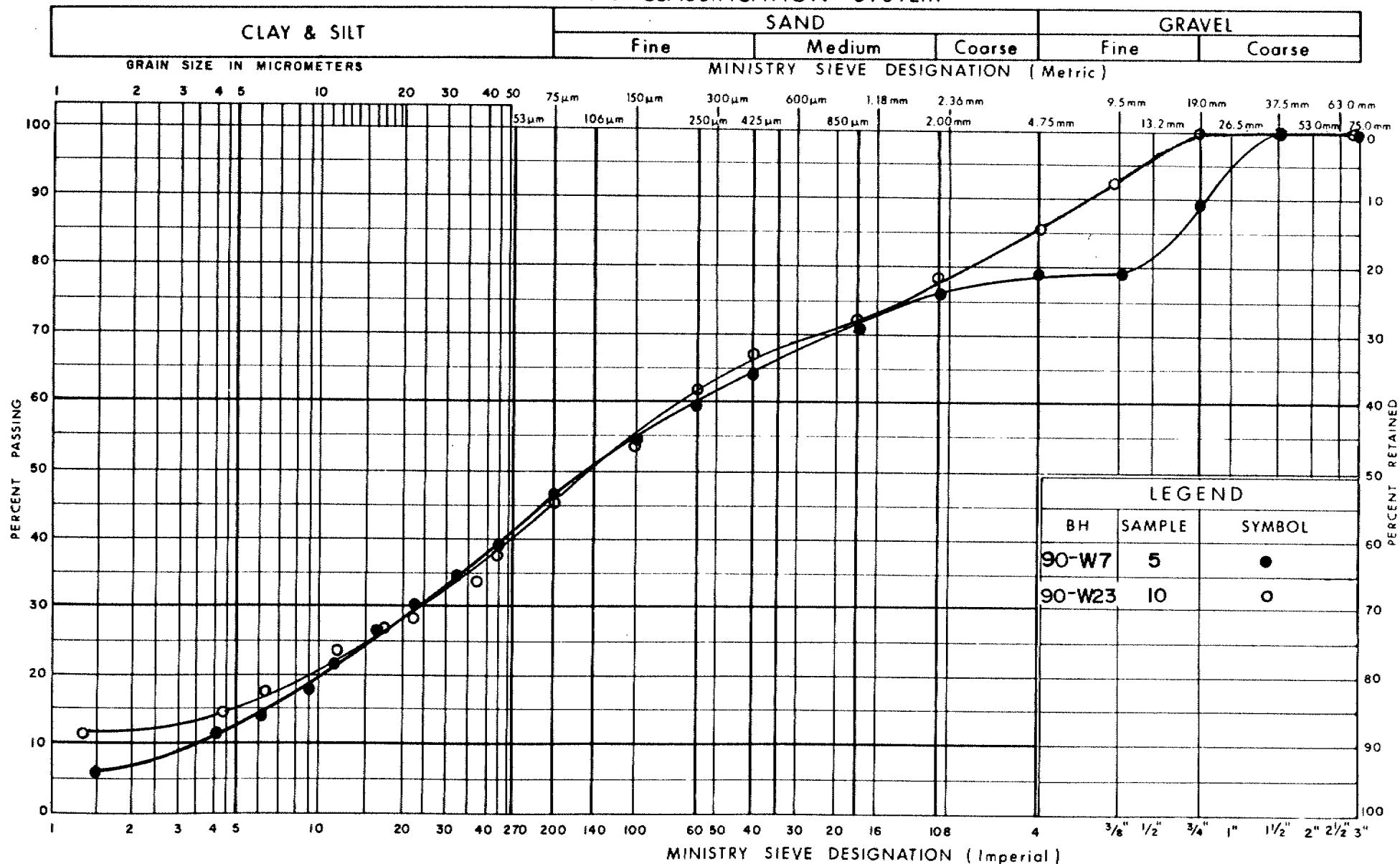


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**GRAIN SIZE DISTRIBUTION**  
SANDY SILT, some gravel and clay  
(GLACIAL TILL)

FIG No 7  
W P 126-87-01A

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

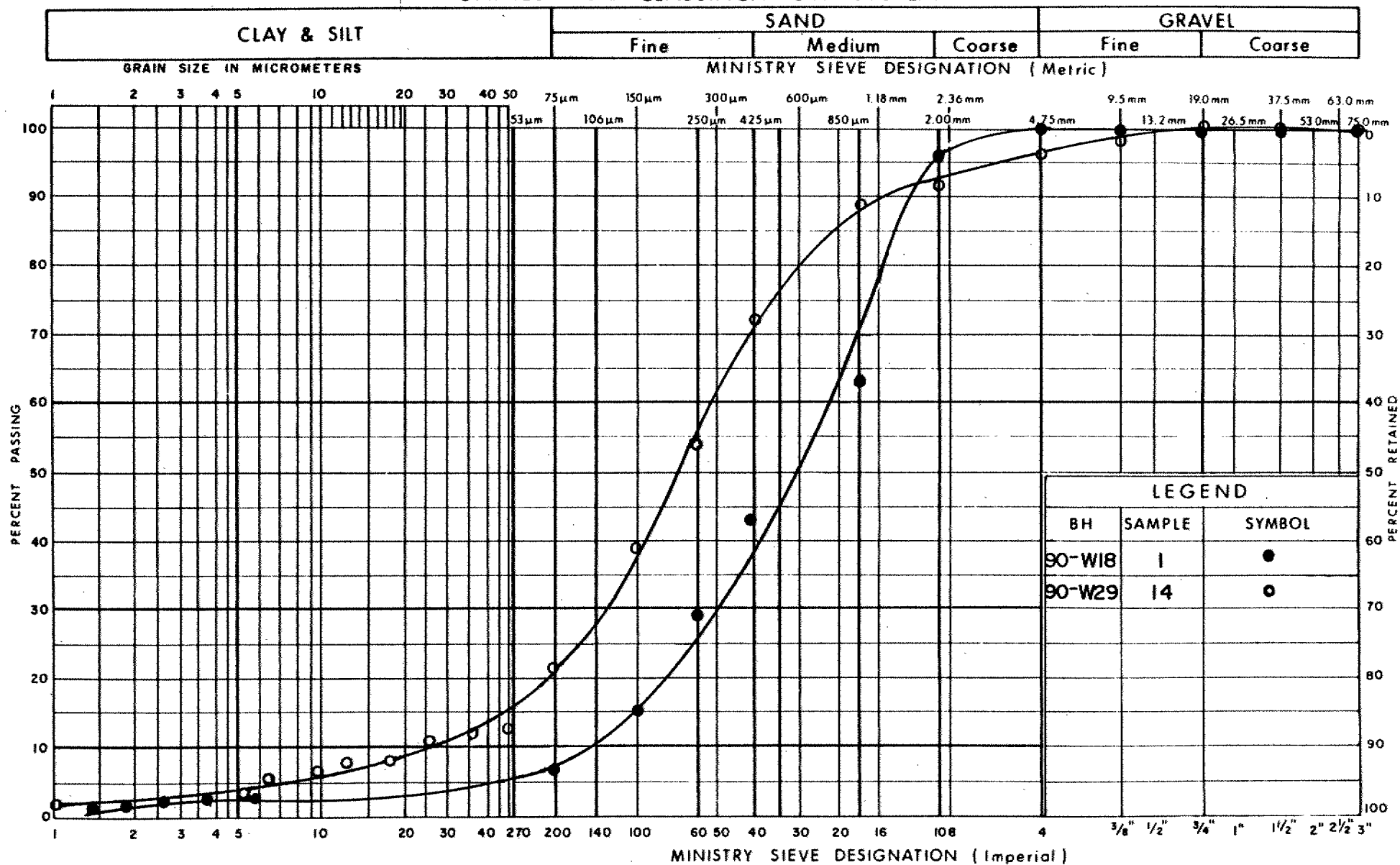
**GRAIN SIZE DISTRIBUTION**  
SAND AND SILT, some gravel and some clay  
(GLACIAL TILL)

FIG No 8

W P 126 - 87 - 01A

801

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

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Transportation

## GRAIN SIZE DISTRIBUTION

SAND, trace gravel and silt

FIG No 9

W P 126-87-01A

601

Additional Foundation Investigation to  
Determine Limits of Diaphragm Walls  
Highway 416 Cut Adjacent to  
Lynwood Village Subdivision  
W.P. 146-74-03B  
Nepean, Ontario

## INTRODUCTION

Four (4) additional boreholes were advanced to establish the limits of the east diaphragm wall. The four boreholes were advanced between 92 10 28-29 using a track mounted drilling unit employing conventional hollow stem augering techniques.

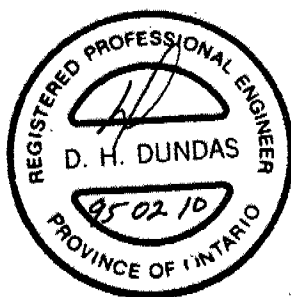
Both split spoon and thin wall samples were retrieved to determine the thickness of the surficial cohesive weak silty clay to clayey silt material and in situ vane tests were conducted to determine the undrained shear strength of the cohesive soil. All boreholes were carried out to practical auger refusal, from which the bedrock surface was inferred. Groundwater levels were measured within the open boreholes.

Section A-A provides a stratigraphical section that also includes Boreholes 9-7 and 9-2 from a previous investigation conducted in the area.

Borehole locations are provided on individual Record of Borehole Sheets.

The results of the recent investigation reveals that the thickness of the surficial silty clay to clayey silt ranges from 9.1 m to 7.6 m. However, beyond borehole 92-W33, the thickness of the cohesive stratum decreases to a thickness of 3 metres (see BH 9-2, Section A-A). The stratum has a surficial crust of very stiff consistency approximately 3 to 3.5 metres in thickness underlain by cohesive material of firm to stiff consistency.

It was evident that the samples of the underlying weaker material contained large natural moisture contents. In situ sensitivity values ranged from 5 to 10 indicating a sensitive to extra sensitive material. The cohesive stratum is underlain by a cohesionless heterogeneous mixture of silt, sand and gravel. This deposit of glacial till origin extends to the bedrock surface and has a thickness of 1.1 m to 2.7 m.



*D. Dundas*  
D. Dundas, P. Eng.  
Senior Foundation Engineer

**APPENDIX**

# RECORD OF BOREHOLE No 92-W31 1 OF 1 METRIC

W.P. 146-74-00-03B LOCATION Co-ords: N 5 021 360.9 E 358 907.6 ORIGINATED BY TS  
 DIST 9 HWY 416 BOREHOLE TYPE HS Auger (Station 28+145, O/S 30 m Right) COMPILED BY TS  
 DATUM Geodetic DATE 92 10 28-29 CHECKED BY MD

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			20	40	60	80	100					
85.2	Ground Surface																
0.0	Silty Clay to Clayey Silt occasional Sand seams  Brown, Very Stiff Grey, Firm to Stiff		1	SS	11		84										
			2	SS	8												
			3	SS	2		82										
			4	SS	2		80										
			5	TW	PM		78										
			6	SS	2		76										
76.7	traces of Sand and Gravel																
8.5	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		7	SS	3												
			8	SS	9												
74.0	Grey, Very Loose to Loose																
11.2	End of Borehole Auger Refusal(Probable Bedrock) * 92 10 30																

RECORD OF BOREHOLE No 92-W32 1 OF 1 METRIC

W.P. 146-74-00-038 LOCATION Co-ords: N 5 021 383.6; E 358 896.9 (Station 28+170, 0/5 30 m Right) ORIGINATED BY TS  
DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS  
DATUM Geodetic DATE 92 10 29 CHECKED BY MD

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			20	40	60	80	100					
85.1	Ground Surface																
0.0	Silty Clay to Clayey Silt occasional Sand Seams		1	SS	12		84										
	Brown, Very Stiff Grey, Stiff		2	SS	4		82										
			3	SS	1		80										
			4	TW	PM		78										
77.2	trace Sand and Gravel		5	SS	3		76										
7.9	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		6	SS	26												
74.8	Grey, Compact																
10.3	End of Borehole Auger Refusal (Probable Bedrock)																
	• 92 10 30																



# RECORD OF BOREHOLE No 92-W33 1 OF 1 METRIC

W.P. 146-74-00-03B LOCATION Co-ords: N 5 021 401.8; E 358 888.4 ORIGINATED BY TS  
 DIST 9 HWY 416 BOREHOLE TYPE HS Auger (Station 28+190, 30 m Right) COMPILED BY TS  
 DATUM Geodetic DATE 92 10 29 CHECKED BY MD

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 7 KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
83.9	Ground Surface																
0.0	Silty Clay to Clayey Silt occasional Sand seams		1	SS	11		83										
	Brown		2	SS	2		81										
	Grey																
	Very Stiff		3	SS	1		79										
	Firm to Stiff		4	SS	1		77										
76.3																	
7.6	Heterogeneous Mixture of Silt, Sand and Gravel		5	SS	23												
75.2	(Glacial Till) Grey, Compact																
8.7	End of Borehole Auger Refusal (Probable Bedrock)																
	+ 92 10 30																

RECORD OF BOREHOLE No 92-W34 1 of 1 METRIC

W.P. 146-74-00-03B LOCATION Co-ords: N 5 021 403.4; E 358 915.2 ORIGINATED BY TS  
DIST 9 HWY 416 BOREHOLE TYPE HS Auger (Station 28+180, O/S 55 m Right) COMPILED BY TS  
DATUM Geodetic DATE 92 10 29 CHECKED BY MD

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
84.3	Ground Surface																
0.0	Silty Clay to Clayey Silt occasional Sand seams		1	SS	14		84										
			2	SS	3		82										
	Brown, Very Stiff		3	SS	1		80										
	Grey, Firm to Stiff		4	TW	PM		78										
			5	SS	1		76										
75.2																	
9.1	Heterogeneous Mixture of Silt, Sand and Gravel		6	SS	12												
74.0	(Glacial Till) Grey, Compact																
10.3	End of Borehole Auger Refusal (Probable Bedrock)																
	* 92 10 30																

RECORD OF BOREHOLE No 9-2

METRIC

W P 127-87-02 LOCATION Co-ords: N 5 021 465.8; E 358 861.4 ORIGINATED BY AL  
DIST 9 HWY 416 BOREHOLE TYPE H S Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY AL  
DATUM Geodetic DATE 89 08 02 CHECKED BY

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			20	40	60	80	100					
80.0	Ground Surface																
0.0	Silty Clay to Clayey Silt Some Sand, Occ. Sand Seams		1	TW	PH		79										
	Brown Grey		2	TW	PH		78									18.8	0 18 45 37
	Stiff																
77.0							77										
3.0	Het. Mixture of Silt, Sand & Gravel		3	TW	PH	Seal											
76.0	(Glacial Till)					Piezometer											
4.0	Bedrock					Seal	76										RQD = 67%
	Sandstone with Interbedded Sandy Dolostone		4	BXL RC	REC 97%	Seal											
	Sound, Unweathered		5	BXL RC	REC 100%	Seal	75										RQD = 80%
						Seal	74										
						Piezometer											
72.8			6	BXL RC	REC 100%	Seal	73										RQD = 100%
7.2	End of Borehole					Seal											

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 9-7

METRIC

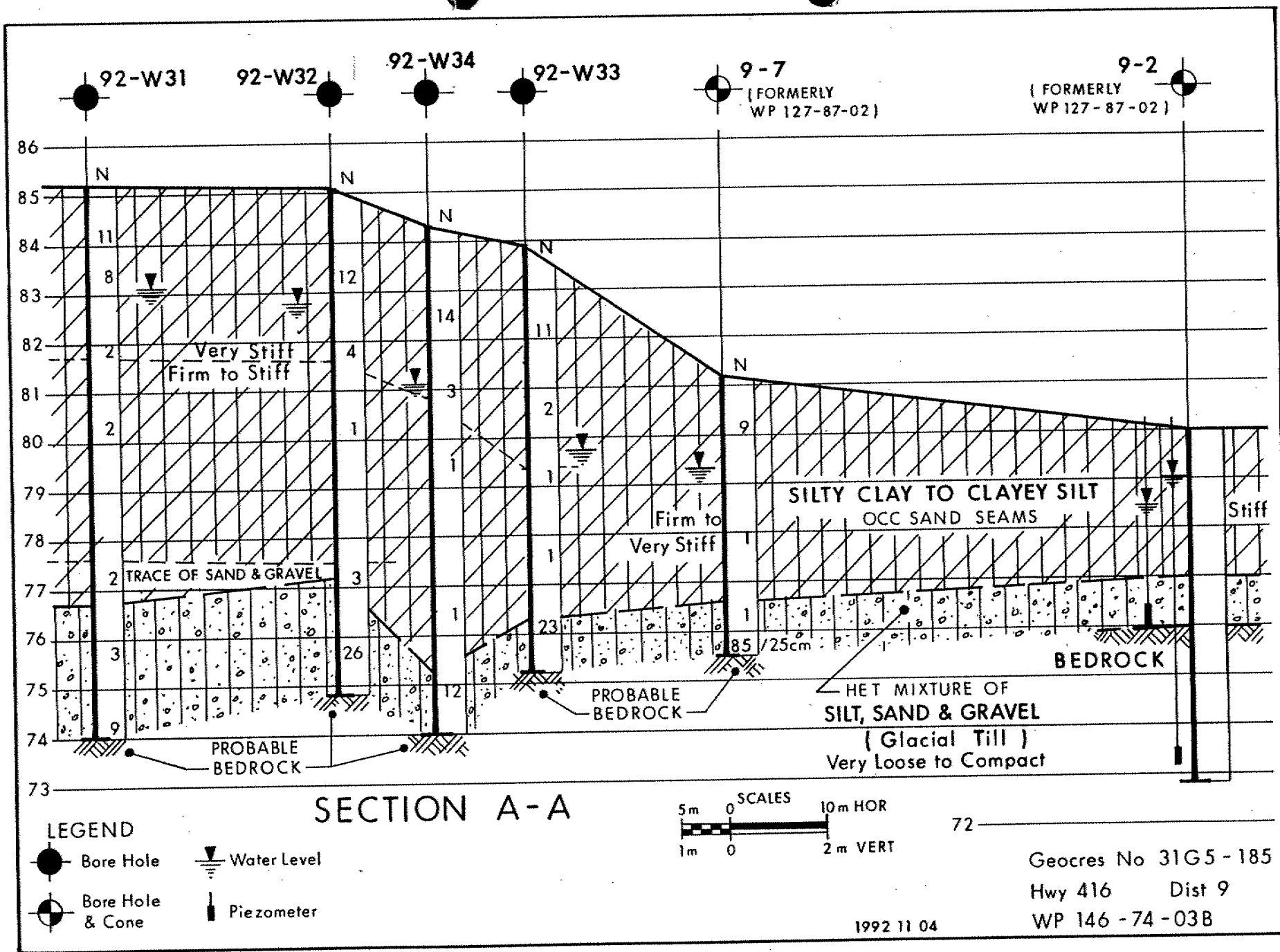
W P 127-87-02 LOCATION Co-ords: N 5 021 423.0; E 358 881.0 ORIGINATED BY TS  
DIST 9 HWY 416 BOREHOLE TYPE H S Auger & Cone Test COMPILED BY TS  
DATUM Geodetic DATE 89 08 03 CHECKED BY

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			20	40	60	80	100					
81.2	Ground Surface																
0.0	Silty Clay to Clayey Silt		1	SS	9		81										
	Brown Grey		2	TW	PH		80										
	Some Sand, Occ. Sand Seams		3	TW	PH		79										
	Firm to V. Stiff		4	SS	1		78										
76.6							77										
4.6	Het. Mixture of Silt, Sand & Gravel		5	SS	1		76										
75.5	(Glacial Till)		6	SS	85	25cm											
5.7	End of Borehole Refusal to Auger (Probable Bedrock)																

OFFICE REPORT ON SOIL EXPLORATION

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



FOUNDATION INVESTIGATION REPORT  
FOR  
CEMENT BENTONITE CUTOFF WALL  
LYNWOOD SUBDIVISION  
W.P. 121-87-00  
HWY 416, DISTRICT 9, OTTAWA

1. INTRODUCTION

The Ministry of Transportation Ontario (MTO) retained Golder Associates Ltd. to carry out a geotechnical investigation along a proposed slurry trench cut off wall for the proposed Highway 416 and re-aligned Cedarview Road cut adjacent to the Lynwood subdivision in Nepean, Ontario (see Key Plan, on Drawing 1218700-A)\*

The purpose of the investigation was to determine the soil conditions, the bedrock profile, and the groundwater conditions in the area of the proposed cut off wall by means of a limited number of detailed boreholes.

2. BACKGROUND AND PREVIOUS INVESTIGATIONS

Highway 416 is to enter the Ottawa area as a four lane, grade separated highway along a route just east of Cedarview Road. Adjacent to the Lynwood subdivision, the Highway 416 alignment requires a deep cut into native soil materials in order that the highway may underpass both the main CNR tracks and Baseline Road. The deep soil cut, which will extend up to 11 metres below ground surface, will intersect water bearing sands and sand and gravel.

Previous subsurface investigations carried out by Golder Associates Ltd. and by others are presented in the following reports:

\* Sheet 211 of the Contract Drawings.

**Ministry of Transportation Ontario (MTO)**

- "Preliminary Investigation for Proposed Highway 416, Century Road to Highway 417", 1984, MTO Report 31G5-138 MTO, "Foundation Investigation Report for Cedarview Road/Highway 416 Underpass", W.P. 121-87-06, District 9, Ottawa, July 1991.
- "Foundation Investigation Report for Cedarview Road/Highway 416 Underpass, W.P. 121-87-06, Site 3-544, District 9, Ottawa", July 1991.

**Golder Associates Ltd. (GAL) (for MTO)**

- "Preliminary Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor Near the Lynwood Subdivision, W.P., 146-74-00-3 District 9 (Ottawa), Nepean, Ontario", March 1989.
- "Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor Near the Lynwood Subdivision, W.P. 146-74-00-3 District 9 (Ottawa), Nepean, Ontario", January 1990.
- Geotechnical Investigation, Proposed Diaphragm Wall and Slope Cut, Highway 416, District 9 (Ottawa), Nepean, Ontario, W.P. 126-87-01(A)", August 1990.
- Engineering Study, Proposed Cut and Railway Underpass, Highway 416, District 9 (Ottawa), Nepean, Ontario, W.P. 121-89-00", August 1990.
- Additional Subsurface Investigation, Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor, Lynwood Subdivision Area, W.P. 416-74-00-3A, District 9 (Ottawa), "May 1991"
- "Pump Test, Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor Lynwood Subdivision Area, W.P. 146-74-00-3 District 9 (Ottawa) Nepean, Ontario, June 1991.

- "Groundwater Impact Assessment of Proposed Highway 416 Construction on Bruce Pit, District 9 (Ottawa), Nepean, Ontario, W.P. 121-87-00", February 1995.
- "Groundwater Level and Precise Settlement Monitoring, Proposed Highway 416, Lynwood Subdivision, W.P. 121-87-00, District 9 (Ottawa)", December 1992 (ongoing).

Acres International (for MTO)

- "Foundation Investigation for Bridge Structure, Proposed Highway 416 and CNR Subway, District Number 9, Ottawa, W.P. 126-87-01, Site 3-544", February 1990.

Golder Associates Ltd. (for City of Nepean)

- "Subsurface Investigation, Proposed Storm Sewers, Lynwood Subdivision, Nepean, Ontario", July 1990.

Golder Associates Ltd. (for the Regional Municipality of Ottawa-Carleton)

- "Geotechnical Investigation, Proposed Bell's Corners Pull-Back Sewer, Phases I and II, Nepean, Ontario", December 1993.

Conestoga Rovers and Associates (CRA) (for MTO)

- "Abandoned Landfill Site Investigation, Bruce Pit, Ottawa, Ontario", January 1989 "Addendum 1, On-Site Waste Material Relocation, Bruce Pit, Nepean, Ontario", April 1991 "Bruce Pit, Abandoned Landfill Site Investigation, Study Design", April 1988.

Where relevant to the proposed cut off wall, copies of the boreholes logs from these previous investigations have been included in Appendix A of this report for reference purposes.

### 3.0 SITE DESCRIPTION AND GEOLOGY

The site of the proposed cut off wall has a variable topography. At the north end, near the south limit of the proposed diaphragm walls, the topography is relatively flat. South of this area to the Bruce Pit, the topography is sloping and rises about 10 metres above the table lands to the north. The Bruce Pit is a



granular upland within a larger, extensive clay plain region with a maximum elevation of approximately 100 metres Geodetic, while the bottom drainage basin, the Bruce Pit pond, is at approximately elevation 87 metres. Surface drainage has been developed from the Bruce Pit into Graham Creek, a tributary of the Ottawa River.

The surficial geology of the site is variable in terms of both lateral and vertical extent. The surficial sands which blanket most of the southern part of the study area abut a cap of mainly marine silty clay to the north, towards the CN railway. Based on previous borehole information, glacial till is expected to underlie the sand and sand and gravel deposits at the south end of the study area near the Cedarview Road bridge; towards the north, the sandy deposits are expected to directly overlie bedrock.

Surficial geology maps indicate that the bedrock underlying the site is composed of dolostone of the Oxford formation. Bedrock core information from the area during previous subsurface evaluations indicates thinly to thickly bedded dolostone, with some sandstone layers and shale partings, as well as some horizontal jointing demonstrating weathering features. Bedrock outcrops of the Oxford formation are indicated on bedrock maps to be present approximately half a kilometre to the northwest and 1 kilometre to the southwest. The Oxford formation is underlain by sandstone and sandy dolostone of the March formation.

#### 4. INVESTIGATION PROCEDURE

The field work for this investigation was carried out between November 16 and 21, 1994. During this time, eight boreholes, numbered 94-1 to 94-8, inclusive, were advanced along the general alignment of the proposed cut off wall. The boreholes were advanced to depths ranging from about 16.4 to 27.3 metres below ground surface using track mounted, hollow stem auger drill rigs supplied and operated by Marathon Drilling Co. Ltd. of Gloucester, Ontario. Standard penetration tests were carried out at regular intervals of depth in the boreholes and samples of the soils encountered were recovered using drive open sampling equipment. The bedrock was cored using NQ size diamond drilling equipment. During the coring, a careful record was kept of the percent core recovery (REC) and Rock Quality Designation (RQD). Pressure packer tests were performed in the rock core holes to assist in evaluating the hydraulic conductivity of the bedrock. Boreholes that were not cored, were advanced until the auger met practical refusal. Standpipes were sealed into some of the boreholes to allow measurement of groundwater levels. The field work was supervised throughout by senior members of our field engineer-

ing staff who directed the drilling operations, logged the boreholes and samples, and observed the in situ testing and standpipe installations.

Samples of the soils recovered from the boreholes were taken to our laboratory for examination by the project engineer and for laboratory classification testing. Selected samples of the soil were tested for moisture content, liquid and plastic limit (Atterberg Limits), and grain size distribution.

Detailed logs of the soil, bedrock and groundwater conditions encountered in the boreholes are given on the Record of Borehole sheets following the text of this report. The locations of the boreholes and previous boreholes advanced by Golder Associates Ltd. and by others are shown on Drawing 1218700-A.\* The results of the laboratory classification testing are given on the Record of Borehole sheets and Figures 1 to 8, inclusive. Simplified soils profiles are given on Drawings 1218700-B\* and 1218700-C.\*

The ground surface elevations at the boreholes were determined by Golder Associates personnel. The elevations were referenced a temporary benchmark CVR-01 established by MTO personnel on the Cedarview Road overpass at Highway 416. The elevation of this point is 97.57 metres, Geodetic datum. The borehole locations were determined by MTO personnel.

## 5. SUBSURFACE CONDITIONS

### 5.1 General

As previously indicated, the soil and groundwater conditions determined from the boreholes are given on the Record of Borehole sheets following the text of this report. The borehole logs indicate the subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of boring, the frequency and recovery of samples, the method of sampling, and the uniformity of subsurface conditions. Subsurface conditions between the boreholes may vary from the conditions encountered in the boreholes. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties.

The groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the borehole logs. These conditions may vary seasonally, or as a consequence of construction activities in the area.

\* Sheets 211, 212 & 213 of the Contract Drawings.

The soil and bedrock descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and Golder Associates does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

## 5.2 Overview of the Subsurface Conditions

Along the west side of the proposed Highway 416 cut, between about Stations 27+500 and 27+900, the subsurface conditions were found to consist of surficial deposits of topsoil and fill, underlain by sensitive deposits of silty clay. The silty clay is underlain within the north part of the site by deposits of loose to compact sand, transitioning to compact to very dense gravelly sand and sand and gravel to the south. The sandy deposits between about Stations 27+700 and 27+900 appear to directly overly bedrock; south of Station 27+700, discontinuous deposits of silty sand and silt and a thin mantle of glacial till exist above bedrock.

Along the east side of the proposed Highway 416, the subsurface is characterized mostly by thick deposits of sand and sand and gravel, transitioning from loose to compact at the north end of the site to compact very dense to the south. North of about Station 27+700, the sand deposits are capped by a deposit of sensitive silty clay, which has a thickness of up to about 13 metres at the north end of the site. For the most part, the boreholes suggest that the bedrock is underlain by discontinuous deposits of silt, layered deposits of silty clay, silt and silty sand, and a mantle of glacial till. However, between about Stations 27+800 and 27+900, the boreholes suggest that the sandy overburden deposits directly overly bedrock.

The following sections provide brief descriptions of the soil strata, bedrock and groundwater conditions encountered in the boreholes advanced during the present investigation. Reference should be made to the Record of Borehole sheets for the subsurface information obtained during the investigation.

## 5.3 Overburden

### 5.3.1 Topsoil and Fill

Surficial deposits of fill were encountered in boreholes 94-1, 94-2 and 94-3. The fill at these locations consists of silty sand, sand and sand and gravel and have a thickness ranging from 0.2 to 1.7 metres.

Surficial deposits of topsoil, having a thickness ranging from 0.2 to 0.7 metres, were encountered in boreholes 94-6, 94-7 and 94-8.

### 5.3.2 Silty Clay

Deposits of sensitive silty clay were encountered beneath the topsoil, fill and surficial sandy deposits at all of the boreholes except borehole 94-4. The thickness of these deposits ranges from about 0.3 metres at borehole 94-2 to about 8.3 metres at borehole 94-8. Where the silty clay is relatively thin, such as at boreholes 94-1, 94-2, 94-3, 94-5 and 94-6, the deposit has been entirely weathered to a grey brown crust. At boreholes 94-7 and 94-8, only the upper 2.3 to 2.5 metres of the deposit is weathered. Standard penetration tests carried out in the weathered silty clay gave N values ranging from 4 to 14 blows per 0.3 metres, which reflect a very stiff to stiff consistency. Atterberg limit tests carried out on samples of the grey brown silty clay showed liquid limit values of 33 and 57 percent and corresponding plastic limit values of 19 and 30 percent. The Atterberg limit results, shown on the Plasticity Chart, Figure 1, are indicative of a clay of low to high plasticity. The moisture content of the weathered silty clay was found to range from 23 to 41 percent.

Below the zone of weathering at boreholes 94-7 and 94-8, the sensitive silty clay is grey and has an apparent firm to stiff consistency. Standard penetration tests carried out in the grey silty clay gave N values ranging from 1 to 2 blows per 0.3 metres. One Atterberg limit test carried out on a sample of the grey silty clay showed liquid and plastic limit values of 36 and 21 percent, which are indicative of a clay of low plasticity. The moisture content of the grey silty clay ranges mostly from 31 to 47 percent, which is near or above the measured liquid limit for this material.

### 5.3.3 Sand, Gravelly Sand

Deposits of sand and gravelly sand were encountered in all of the boreholes advanced during the present investigation. The combined thickness of these deposits in the boreholes ranges from about 3.8 metres in borehole 94-8 to about 11.0 metres in borehole 94-3. Grain size distribution curves for samples of the sand are shown on Figures 2 and 3. Figure 4 presents the grain size distribution curves for samples of sand containing some gravel and gravelly sand, while Figure 5 presents gradation curves for sand with occasional silty clay, silt or sandy silt seams.

It is noted that the samples were obtained using 38 millimetres inside diameter split barrel samplers and, therefore, the grain size distribution curves do not reflect the presence of coarse gravel and cobbles which exist in these deposits.

Standard penetration tests carried out within the sand and gravelly sand deposits showed the following range of N values.

<u>Boreholes</u>	<u>Range of N Values (Blows per 0.3 metres)</u>	<u>Average N Value (Blows per 0.3 metres)</u>
94-1, 94-2 94-7, 94-8	6 to 37	20
94-3, 94-4 94-5, 94-6	6 to 88	44

In general, the N values reflect a loose to compact relative density in the north part of the site and a compact to very dense relative density within the south part of the site

#### 5.3.4 Sand and Gravel

Deposits of sand and gravel were encountered in boreholes 94-2 to 94-6, inclusive; boreholes 94-8 and 94-7 also encountered layers of sand and gravel within relatively thick sand deposits. At some locations, the sand and gravel deposit was found to contain cobbles and boulders. At boreholes 94-7 and 94-8, diamond drilling techniques were required to advance the boreholes through these obstructions. The core recovered from the sand and gravel comprised dolomitic limestone, dolostone, sandstone and granite sticks having a length of up to 0.4 metres. Grain size distribution curves for samples of the sand and gravel are shown on Figure 6. It should be noted that the samples were obtained with 38 millimetre inside diameter split barrel samplers and, therefore, do not reflect the presence of coarse gravel, cobbles, and boulders which exist within this deposit; boulders of variable mineralogy, size and shape should be expected.

The borehole results may not reflect the frequency and size of cobbles and boulders in a deposit since only a very small fraction of the overburden deposit is sampled and hollow stem augers can be deflected during drilling by cobbles and boulders.

Standard penetration tests carried out within the sand and gravel gave N values ranging from 28 to 140 blows per 0.3 metres (average of 71 blows per 0.3 metres) which reflect, for the most part, a dense to very dense relative density.

### 5.3.5 Silt

Deposits of silt were encountered beneath the sand, gravelly sand and sand and gravel deposits at boreholes 94-1, 94-3, 94-4, and 94-7. The thickness of these deposits ranges from about 0.6 metres at borehole 94-3 to about 3.3 metres at borehole 94-1. One grain size distribution test for a sample of sand is shown on Figure 7.

Standard penetration tests carried out within the silt gave N values ranging from 25 to 80 blows per 0.3 metres, which reflect a highly variable, compact to very dense relative density.

### 5.3.6 Layered Silty Clay, Silt and Silty Sand

Layered deposits of silty clay, silt and silty sand having a thickness ranging from 1.1 to 2.5 metres were encountered above the glacial till deposits in boreholes 94-2, 94-4, and 94-5.

Standard penetration testing in these materials gave N values of 12 to 38 blows per 0.3 metres, which reflect a compact to dense relative density.

### 5.3.7 Silty Sand with Clay, Gravel, Cobbles and Boulders

A deposit composed of a heterogeneous mixture of silty sand containing clay, gravel and cobbles (glacial till) was encountered above bedrock in boreholes 94-1 to 94-7, inclusive.

The thickness of this deposit was found to range from 0.1 metres at borehole 94-7 to about 3.8 metres at borehole 94-4 increasing in thickness from north to south at the site.

Grain size distribution curves for samples of the glacial till are provided on Figure 8. It is noted that the samples of the glacial till were obtained with a 38 millimetre inside diameter split barrel sampler and, therefore, do not reflect the presence of coarse gravel, cobble and boulder sizes.

Although boulders were not sampled in the glacial till in the boreholes put down during this investigation, boulders are known to exist within the glacial till and were encountered in previous borehole 17-1 advanced for the proposed Cedarview Road Overpass at Highway 416. Boulders of variable mineralogy (sedimentary limestone dolostone, sandstone, or harder igneous and precambrian rock types), size, shape and frequency are known to exist within the glacial till and should be expected at this site; nested boulders could be encountered.

Standard penetration tests carried out within the glacial till gave N values ranging from 5 to more than 100 blows per 0.3 metres, which reflect a highly variable, loose to very dense relative density.

The moisture content of the glacial till is between 8 and 10 percent.

#### 5.4 Bedrock

Bedrock was cored in four of the boreholes to confirm the location of bedrock, and to determine the type and quality of the bedrock. The remaining boreholes were advanced to practical auger refusal.

Bedrock was encountered in the cored boreholes at depths ranging from 14.2 to 24.2 metres below ground surface (elevation 71.8 to 74.8 metres). Practical auger refusal was obtained in the boreholes at depths of about 16.4 to 23.9 metres below ground surface (elevation 74.1 to 74.2 metres). It is noted that practical auger refusal can also be obtained within dense or bouldery deposits and, therefore, may not be representative of the upper surface of the bedrock.

The bedrock sampled in the boreholes consist of fresh, thinly to thickly bedded, grey dolostone with some shale partings and occasional sandy dolostone layers at depth. Fracturing of the core was evident mostly along near horizontal bedding planes. At borehole 94-4, near vertical, faintly weathered and partially calcite filled joints were also encountered.

A measure of the quality of the dolostone recovered from the boreholes is shown on the Record of Borehole sheets as the percent core recovery (REC) and Rock Quality Designation (RQD). Definitions of these parameters are provided in the bedrock terminology sheet following the text of this report. The core recovery ranged from 92 to 100 percent, the lowest result reflecting the presence of the faintly weathered, near vertical joints in borehole 94-4. The dolostone was found to be of fair to excellent quality, as reflected by RQD values of 46 to 94 percent (average of 73 percent).

Pressure packer tests were carried out in situ to determine the hydraulic conductivity characteristics of the bedrock. The results of this testing is as follows:

<u>Borehole Number</u>	<u>Depth of Testing Below Ground Surface (metres)</u>	<u>Measured Hydraulic Conductivity (centimetres per second)</u>
94-1	17.1 - 19.9	$2 \times 10^{-5}$
94-4	24.9 - 27.3	$4 \times 10^{-4}$
94-7	14.8 - 16.6	$4 \times 10^{-4}$
94-8	15.6 - 18.0	$5 \times 10^{-4}$

### 5.5 Groundwater

The groundwater conditions at the site were determined from water levels obtained in standpipes installed in the completed borings, as shown on the Record of Borehole sheets. These results show that the groundwater level in the sand and sand and gravel deposits ranges from about 3.0 to 11.8 metres below ground surface (elevation 86.0 to 86.3 metres). It is noted that the water levels in the sand and sand and gravel overburden deposit have likely been affected by recent groundwater pumping for the construction of a nearby section of the Bell's Corners Pull Back sewer and, therefore, do not represent stabilized groundwater conditions. The standpipes sealed into the bedrock at boreholes 94-1 and 94-8 showed groundwater levels ranging from about 3.2 to 4.9 metres below ground surface (elevation 83.5 to 85.0 metres). These results indicate a downward hydraulic gradient in the bedrock.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.



*D. Dundas*

D. Dundas, P. Eng.

Sr. Foundation Engineer



**APPENDIX**

RECORD OF BOREHOLE No 94-I

METRIC

W P 121-87-00 LOCATION Co-ords N5 021 034; E 359 087 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY AFC  
DATUM Geodetic DATE November 21, 1994 CHECKED BY AFC

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			20	40	60	80	100				
88.4	Ground Level															
0.0	Fill, Silty Sand															
0.2	Silty clay, occ. sand															
87.1	seam (weathered crust)															
1.3	Silty Sand, trace															
1.6	gravel		1	SS	37											
	Sand, fine to coarse, some gravel and silt															
85.0	Compact to dense															
3.4	Grey Brown		2	SS	15											
	Sand, fine to medium, trace silt, occasional silty sand seam at depth															
			3	SS	10											
			4	SS	12											
	Compact to dense															
	Grey Brown		5	SS	14											
			6	SS	31											
78.0																
10.4	Gravelly sand, trace															
77.4	silt		7	SS	33											
11.0	Silt, some sand, trace clay, occasional sandy silt with gravel layer															
			8	SS	27											
	Compact to dense															
74.1	Grey		9	SS	47											
14.3	Silty sand, some gravel and clay, occasional cobble (Glacial Till)															
			10	SS	18											
71.8	Compact															
16.6	Dolostone, fresh, thinly to thickly bedded, some shale partings, some sandy dolostone layers from 18.8 to 19.9 metres depth		11	RC												
			12	NQ												
			13	RC												
				NQ												
68.5																
19.9	End of Borehole															
	*REC = Recovery RQD = Rock Quality Designation															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 94-2

METRIC

W P 121-87-00 LOCATION Co-ords N5 020 955; E 359 088 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC  
DATUM Geodetic DATE November 19 and 20, 1994 CHECKED BY AFC

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			20	40	60	80	100					
90.5	Ground Level																GR SA SI CL
0.0	Fill, sand with some silty clay pockets, occasional cobble						90										
88.8	Brown																
1.7	Silty clay		1	SS	5												
2.0	(weathered crust) Grey						88										
	Brown																
	Sand, fine to coarse, trace silt and gravel		2	SS	29												
86.9	Compact Grey Brown																
3.6	Sand and gravel, trace																
86.2	silt, occasional cobble						86										
4.3	Sand, fine, trace silt		3	SS	23												0 92 (8)
85.0	Compact Grey brown																
5.5	Sand, fine to medium, trace silt		4	SS	19		84										
	Compact Grey-brown		5	SS	15												0 98 (2)
							82										
			6	SS	15												
80.4																	
10.1	Sand, fine, trace silt						80										
	Loose Grey brown		7	SS	6												0 95 (5)
78.2																	
12.3	Silty clay, silt and silty sand, layered		8	SS	12		78										
77.1	Compact Grey-brown																
13.4	Silty sand, some gravel and clay, occasional cobble and silty sand layer (Glacial Till)		9	SS	5												
							76										
			10	SS	47												
74.1	Loose to Dense Grey																
16.4	End of Borehole Auger Refusal						74										

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No 94-3

METRIC

W P 121-87-00 LOCATION Co-ords N 5020 853; E 359 123 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC  
DATUM Geodetic DATE November 18 and 19, 1994 CHECKED BY AFC

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 94-4

METRIC

W P 121-87-00 LOCATION Co-ord. 5 020 765; E 359 160 ORIGINATED BY SB  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY AFC  
DATUM Geodetic DATE November 19, 1994 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
97.1	Ground Level													GR SA SI CL
0.0	Sand and gravel, trace silt occasional cobble		1	SS	53		97							
			2	SS	63		95							47 46 (7)
	Very Dense Grey Brown		3	SS	140		93							
			4	SS	64		91							
89.8			5	SS	25		89							8 84 (8)
7.3	Sand, fine to coarse, trace silt, trace to some gravel		6	SS	30		87							
	Dense to Grey Very Dense Brown		7	SS	61									
85.4			8	SS	46		85							25 68 (7)
11.7	Gravelly sand, trace silt		9	SS	27		83							
83.7	Dense Grey Brown		10	SS	27		81							0 61 (39)
13.4	Sand, fine and fine to medium, trace silt and travel, occasional silt seam		11	SS	38		79							
81.3	Compact Grey Brown		12	SS	80		77							
15.8	Silty clay, silt, and silty sand, layered, trace gravel		13	SS	53		75							
78.8	Dense Grey		14	SS	53		73							
18.3	Silt, trace sand, gravel, and clay		15	SS	46		71							
76.7	Very Dense Grey		16	RC	REC=100%									
20.4	Silty sand, some gravel and clay, occasional cobble (Glacial Till)		17	NQ	RQD= 46%									
	Dense to Grey		18	RC	REC=100%									
72.9				NQ	RQD= 63%									
24.2	Dolostone, fresh, thinly to medium bedded, some shale partings, occasional faintly weathered near vertical joint, some partially calcite filled			RC	REC= 92%									
69.8				NQ	RQD= 57%									
27.3	End of Borehole						69							
	*REC = Recovery RQD = Rock Quality Designation													

RECORD OF BOREHOLE No 94-5

METRIC

W P 121-87-00 LOCATION Co-ords. N5 020 737; E 359 091 ORIGINATED BY SB  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AEG  
DATUM Geodetic DATE November 15, 1994 CHECKED BY AEG

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
98.1	Ground Level															GR SA SI CL
0.0	Sand, fine and fine to coarse, trace silt, trace to some gravel		1	SS	9		98									
	Loose Grey Brown		2	SS	6		96									
93.4							94									
4.7	Silty clay, some sand seams, scattered trace gravel (weathered crust)		3	SS	6		92									
	Very Stiff Grey Brown		4	SS	6		90									
90.0			5	SS	35		88									
8.1	Sand, some gravel, trace silt		6	SS	52		86									16 78 (6)
	Very Dense Grey Brown		7	SS	88		84									
84.8			8	SS	85		82									20 74 (6)
13.3	Sand and gravel, trace silt		9	SS	104		80									
	Very Dense Grey Brown		10	SS	70		78									40 52 (8)
			11	SS	90		76									
79.3			12	SS	74		74									49 44 (7)
18.8	Silt and silty sand, layered, scattered trace gravel		13	SS	31											
	Dense Grey		14	SS	43											
76.8			15	SS	83											
21.3	Silty sand, some gravel trace clay, occasional cobble (Glacial Till)															
	Dense to Very Dense Grey															16 42 34 8
74.2	End of Borehole															
23.9	Auger Refusal															

RECORD OF BOREHOLE No 94-6

METRIC

W P 121-87-00 LOCATION Co-ords. N5 020 830; E 359 065 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC  
DATUM Geodetic DATE November 17, 1994 CHECKED BY AFC

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			20	40	60	80	100					
93.6	Ground Level																GR SA SI CL
0.0	Topsoil																
92.9																	
0.7	Sand, trace gravel																
1.0	Brown																
	Silty clay, occasional sand seam (weathered crust)		1	SS	14												
	Very Stiff Grey Brown		2	SS	8												
88.9	Sand, fine to medium																
4.7	Brown		3	SS	8												
4.9	Silty clay, some sand																
5.3	Very Stiff Grey Brown																
	Sand, fine to coarse, trace gravel and silt		4	SS	23												
85.8	Compact Grey Brown																
7.8			5	SS	45												
	Gravelly sand, trace silt																
83.5	Dense Grey Brown		6	SS	30												26 69 (5)
10.1	Sand, fine, trace to some silt		7	SS	31												
	Dense to Very Dense Grey Brown		8	SS	79												0.78 (22)
80.0																	
13.6	Gravelly sand and sand and gravel, trace silt, some cobbles		9	SS	60												23 67 (10)
	Very Dense Grey Brown		10	SS	88												
75.9			11	SS	73												40 52 (8)
17.7	Sandy silt, some gravel trace clay, occ. cobble (Glacial Till)		12	SS	>100												12 45 35 8
74.0	Very Dense Grey																
19.6	End of Borehole Auger Refusal																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 94-7

METRIC

W P 121-87-00 LOCATION Co-ords. N5 020 927; E 359 023 ORIGINATED BY SB  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY AFC  
DATUM Geodetic DATE November 17, 1994 CHECKED BY AFC

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			20	40	60	80	100					
89.0	Ground Level																GR SA SI CL
0.0	Topsoil																
0.2	Silty clay, occasional sand seam, scattered trace fine gravel (Weathered Crust) Very Stiff		1	SS	4												
86.5	to Stiff Grey Brown																
2.5	Silty clay, occasional sand seams, trace fine gravel		2	SS	2												
	Stiff Grey		3	SS	2												
82.9																	
6.1	Sand, fine to coarse, trace to some silt, some sand and gravel layers, with boulders		4	SS	18												
			5	SS	25												3 82 (15)
			6	SS	23												
	Compact Grey Brown		7	SS	27												3 91 (6)
			8	SS	>50												
76.1			9	RC	REC=												
12.9	Silt, trace sand		10	SS	25												
75.3	Compact Grey																
13.7	Sand and gravel		11	SS	>70												
14.1	Very Dense Grey																
14.2	Silty Sand Glacial Till Very Dense Grey		12	NQ	RC												REC=100% RQD= 88%
			13	NQ	RC												REC=95% RQD=88%
72.4	Dolostone, fresh, thin to thickly bedded, some shale partings, some sandy dolostone layers																
16.6	between 15.7 and 16.6 metres																
	End of Borehole																
	REC = Recovery RQD = Rock Quality Designation																

OFFICE REPORT ON SOIL EXPLORATION



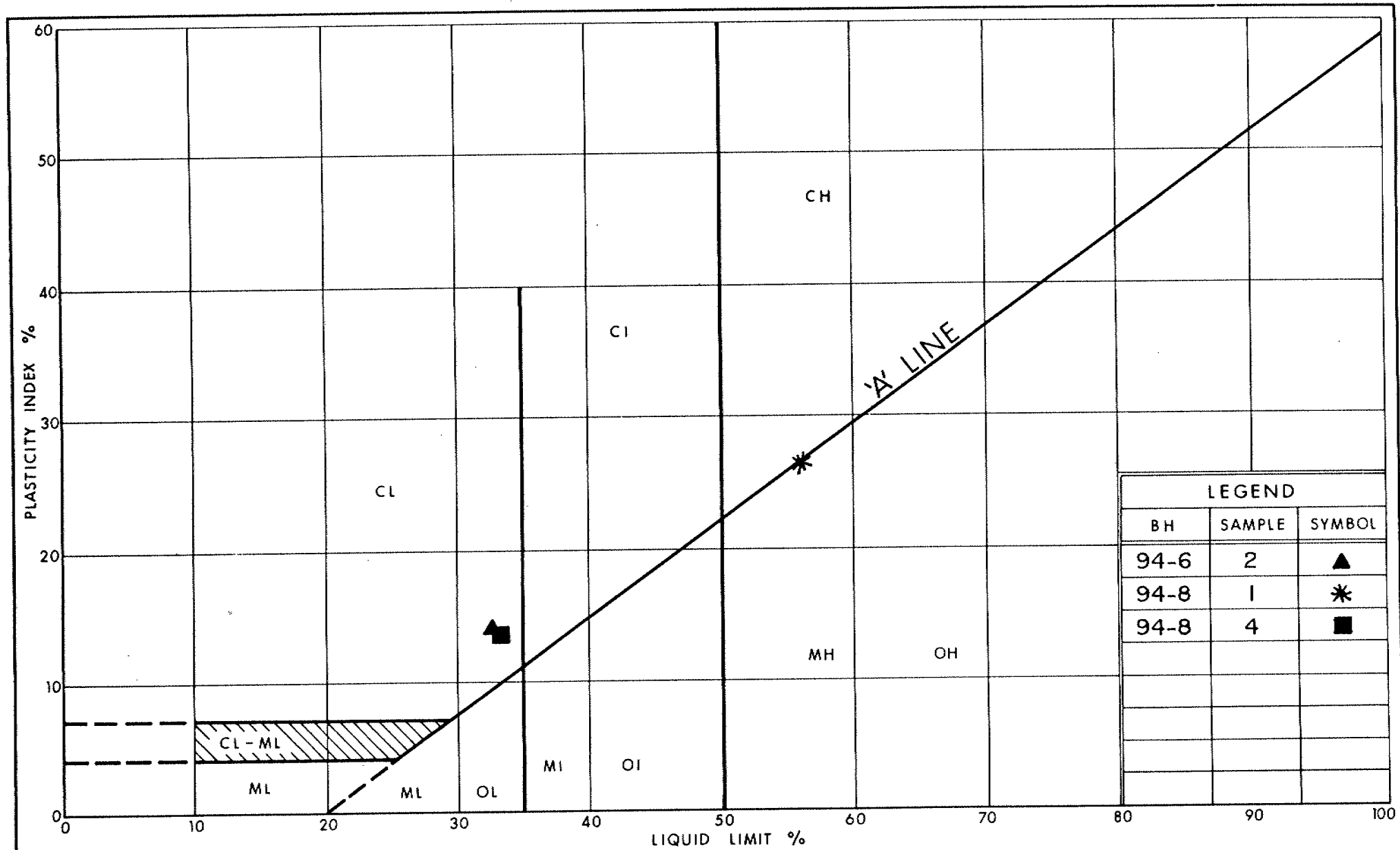
RECORD OF BOREHOLE No 94-8

METRIC

W P 121-87-00 LOCATION Co-ords 5 021 020; E 358 984 ORIGINATED BY DIS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, NO Rock Core COMPILED BY AFC  
DATUM Geodetic DATE November 16, 1994 CHECKED BY AFC

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							SHEAR STRENGTH kPo	WATER CONTENT (%) 20 40 60
								○ UNCONFINED	+ FIELD VANE							
88.2	Ground Level															
0.0	Topsoil						88									
0.2	Silty Clay						Bentonite									
	Very Stiff		1	SS	5											
85.5	To Stiff Grey Brown						86									
2.7			2	SS	1											
	Silty clay with occasional sand seams		3	SS	1		84									
	Firm to Stiff Grey		4	SS	1		Native Backfill									
79.7			5	SS	1		82									
78.5			6	SS	19		80									
	Sand, fine, trace silt, some thin silty clay and sandy silt seams		7	SS	14		78							0 58 (42)		
75.9	Compact Grey		8	SS	28		76							54 37 (9)		
12.3	Sand and gravel, trace silt, with cobbles and boulders		9	RC NQ	*REC= 71%		74									
73.1	Compact to dense Grey Brown to Grey		10	RC NQ	*REC= 35%											
15.1	Dolostone, fresh, thinly to medium bedded, some shale partings, some sandy dolostone layers from 16.5 to 18.0 metres depth		11	RC NQ	*REC= 100%		Bentonite									
			12	RC NQ	*REC= 100% *RQD= 94%		72									
70.2			13	RC NQ	*REC= 100% *RQD= 84%		Sand Fill									
18.0	End of Borehole						Standpipe									
	*REC = Recovery RQD = Rock Quality Designation						70									

OFFICE REPORT ON SOIL EXPLORATION



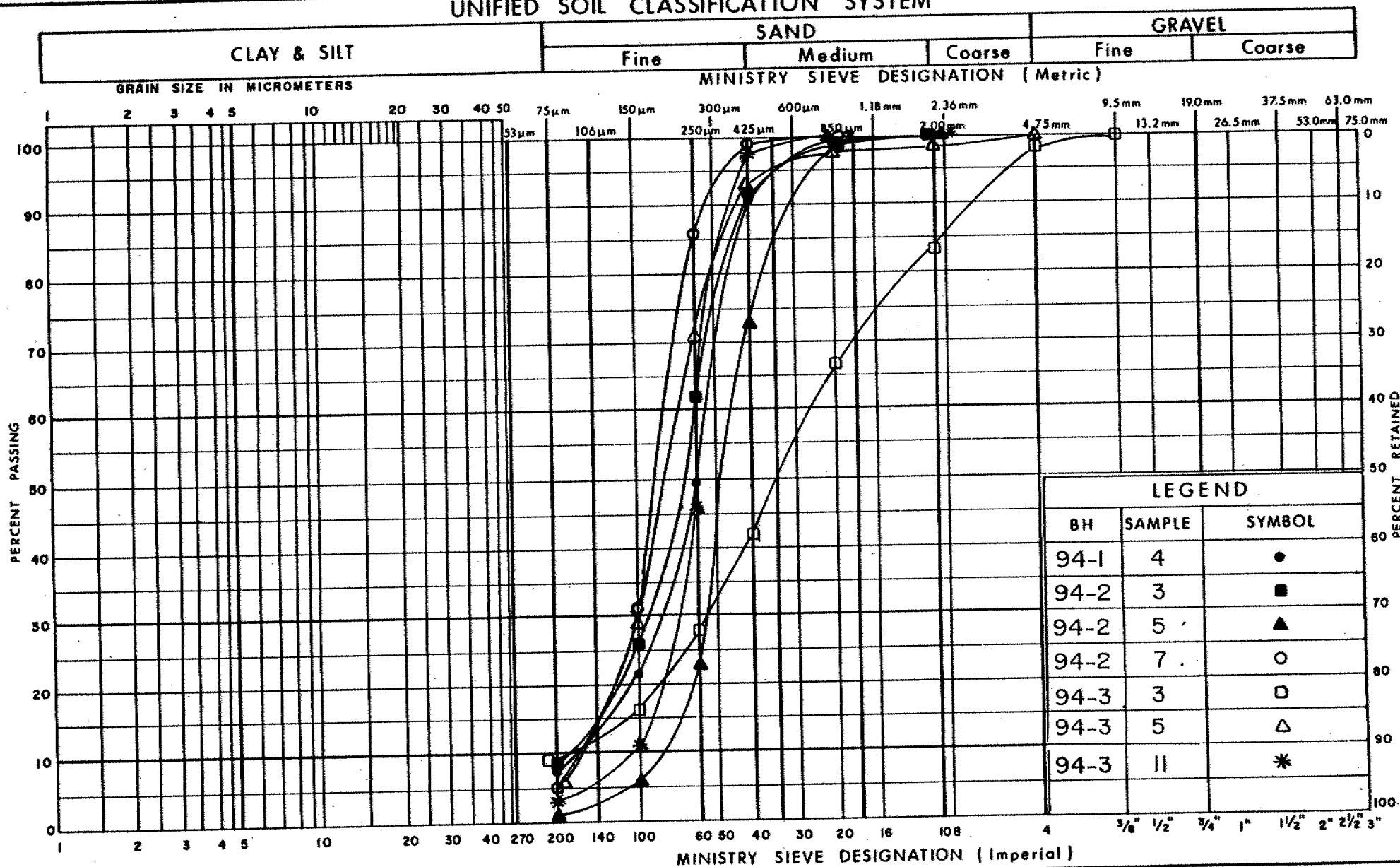
Ministry of  
Transportation  
Ontario

# PLASTICITY CHART SILTY CLAY

FIG No 1

W P 121 - 87 - 06

## UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND, TRACE TO SOME SILT

FIG No 2

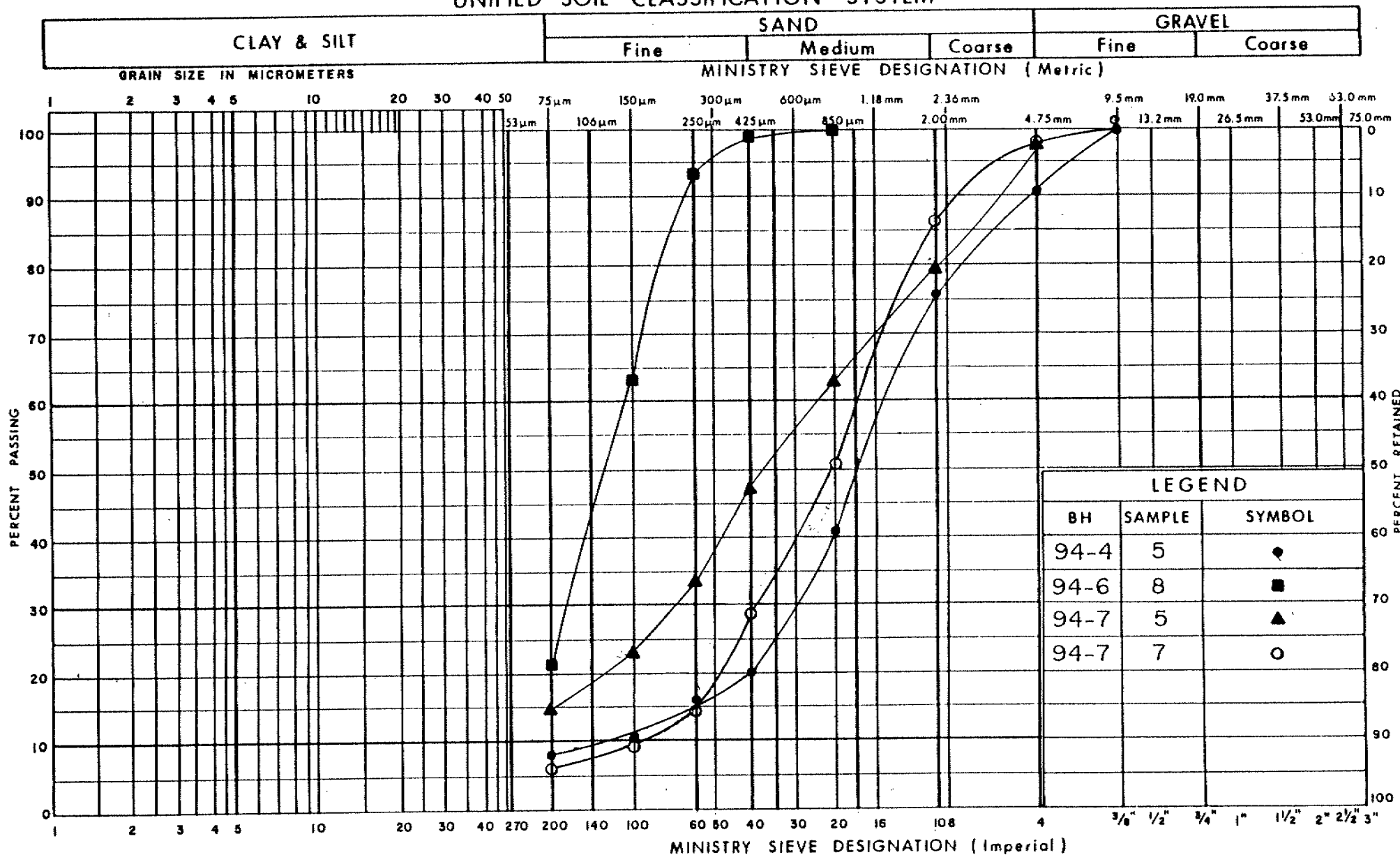
W P 121-87-00



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Transportation

Ontario

## UNIFIED SOIL CLASSIFICATION SYSTEM



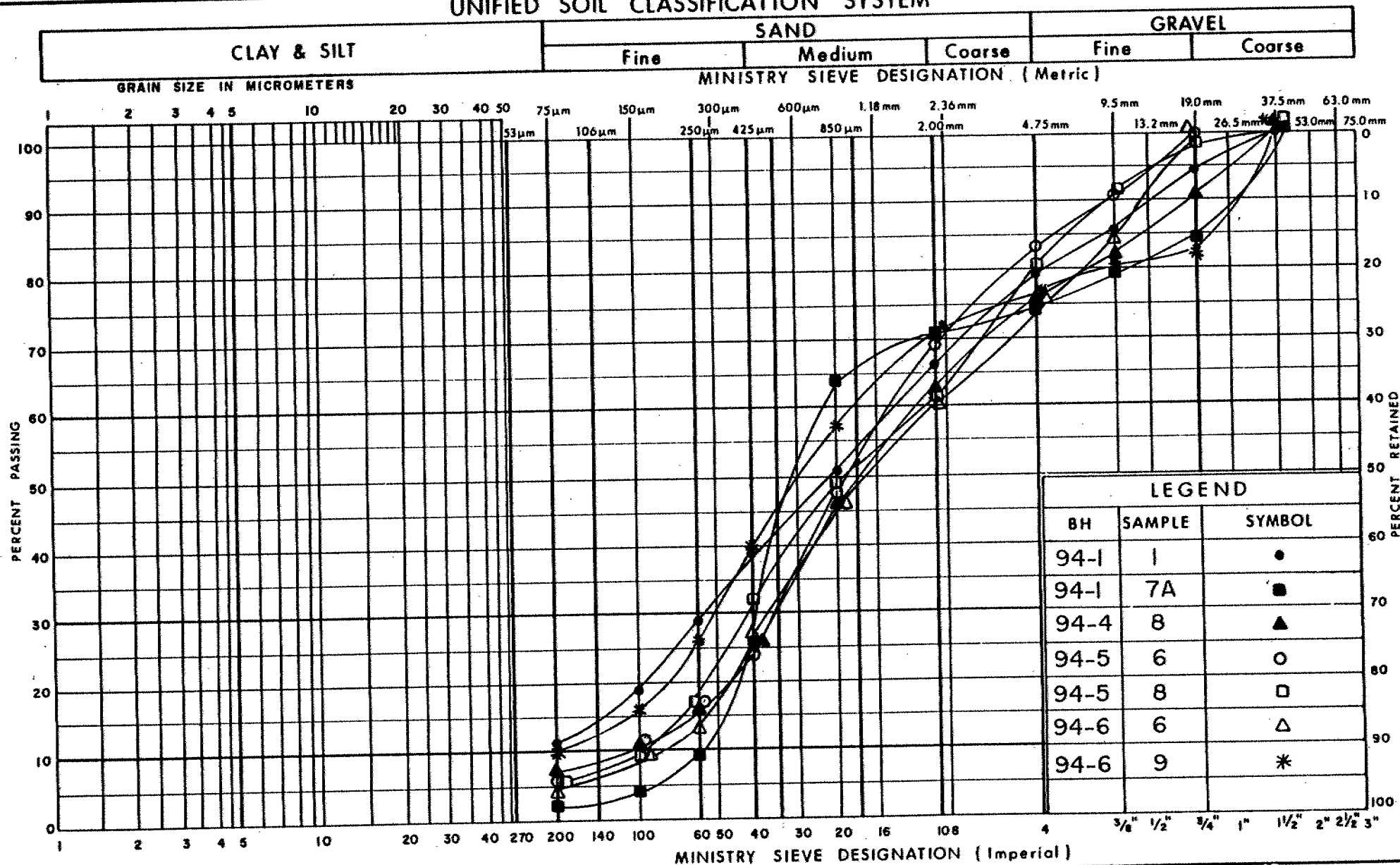
Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
SAND, TRACE TO SOME SILT

FIG No 3

W P 121-87-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND, SOME GRAVEL AND GRAVELLY SAND

FIG No 4

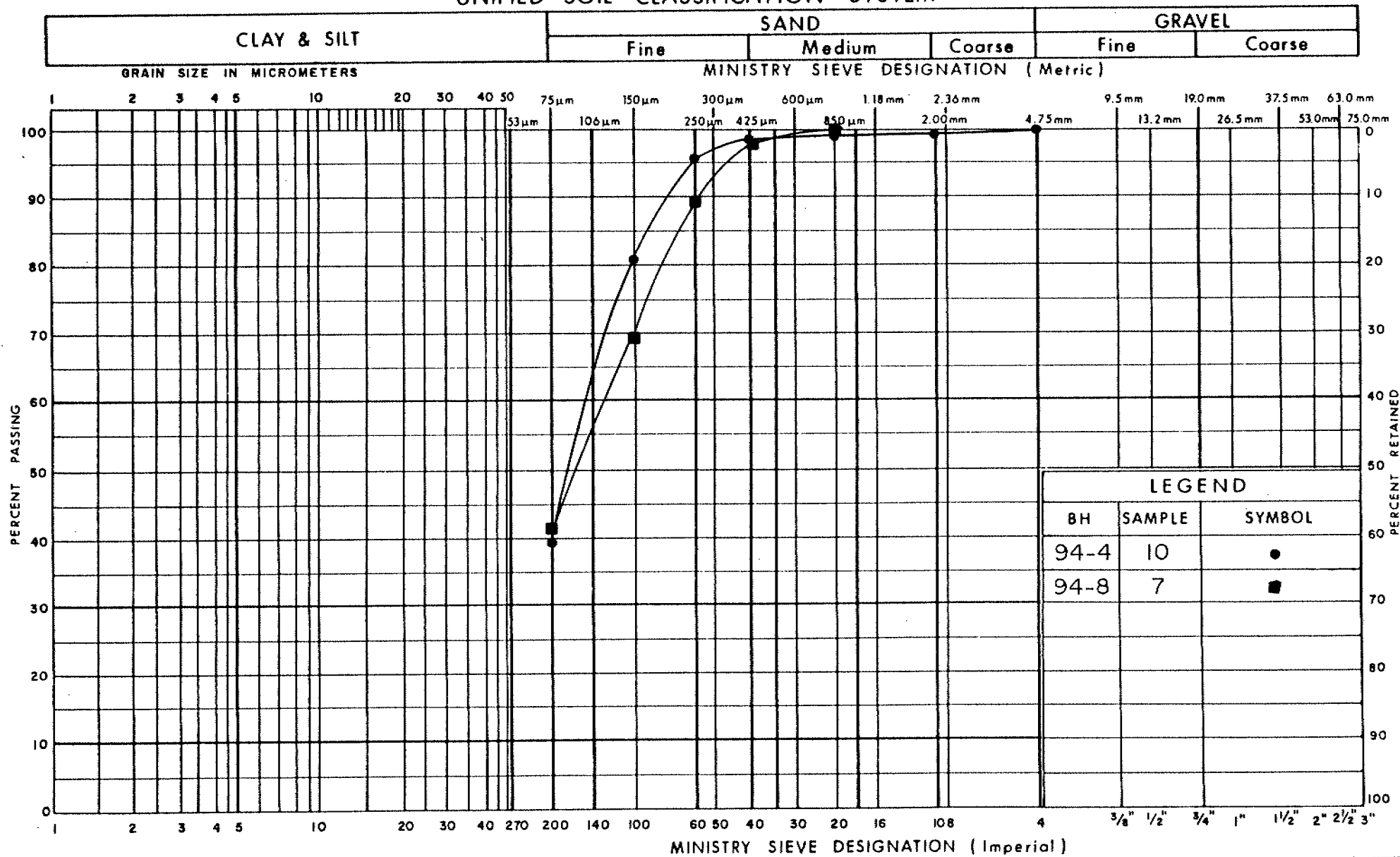
W P 121-87-00



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## UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

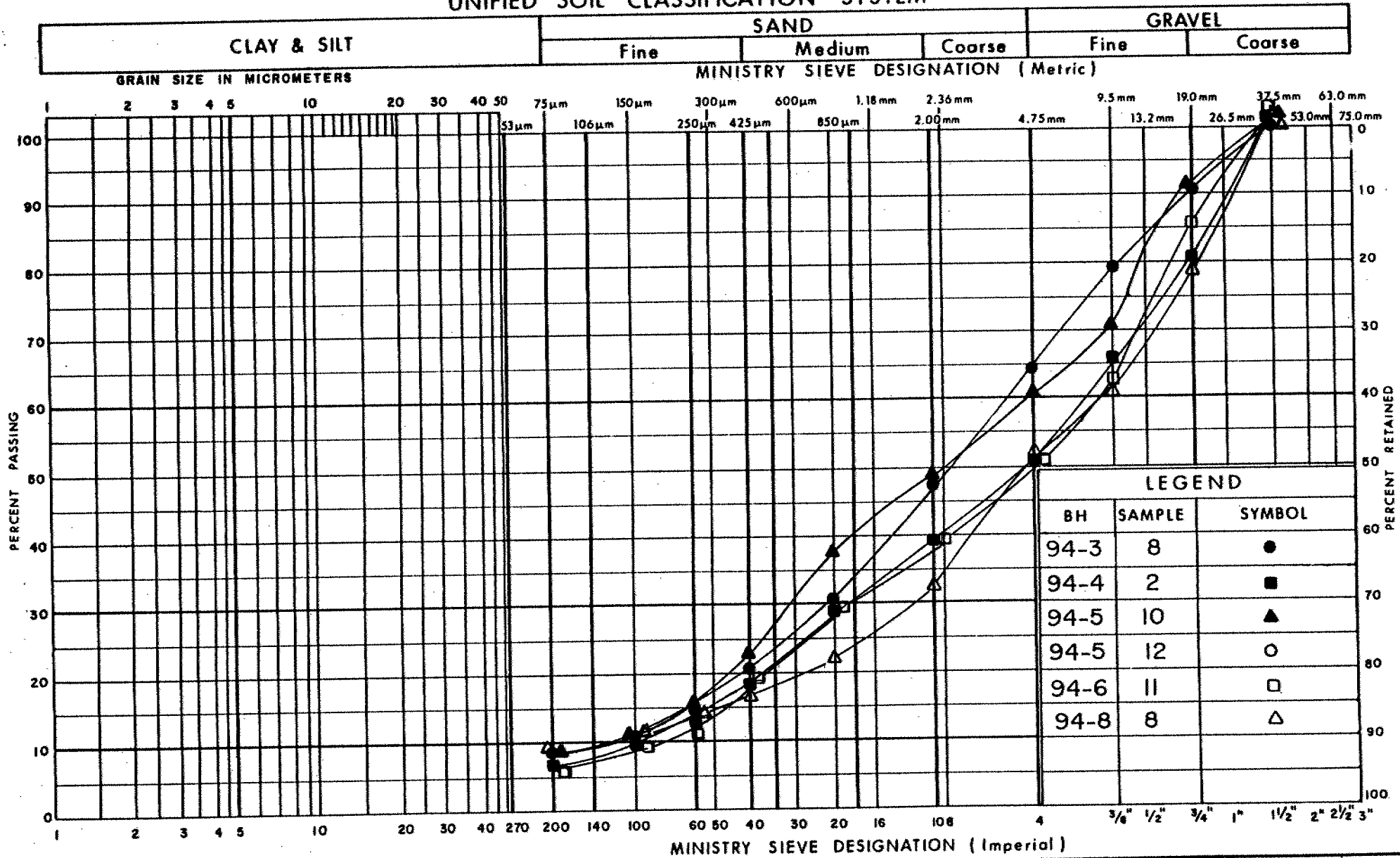
## GRAIN SIZE DISTRIBUTION

SAND, OCCASIONAL SILTY CLAY, SILT, OR  
SANDY SILT SEAMS

FIG No 5

W P 121-87-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



# GRAIN SIZE DISTRIBUTION

## SAND AND GRAVEL

FIG No 6

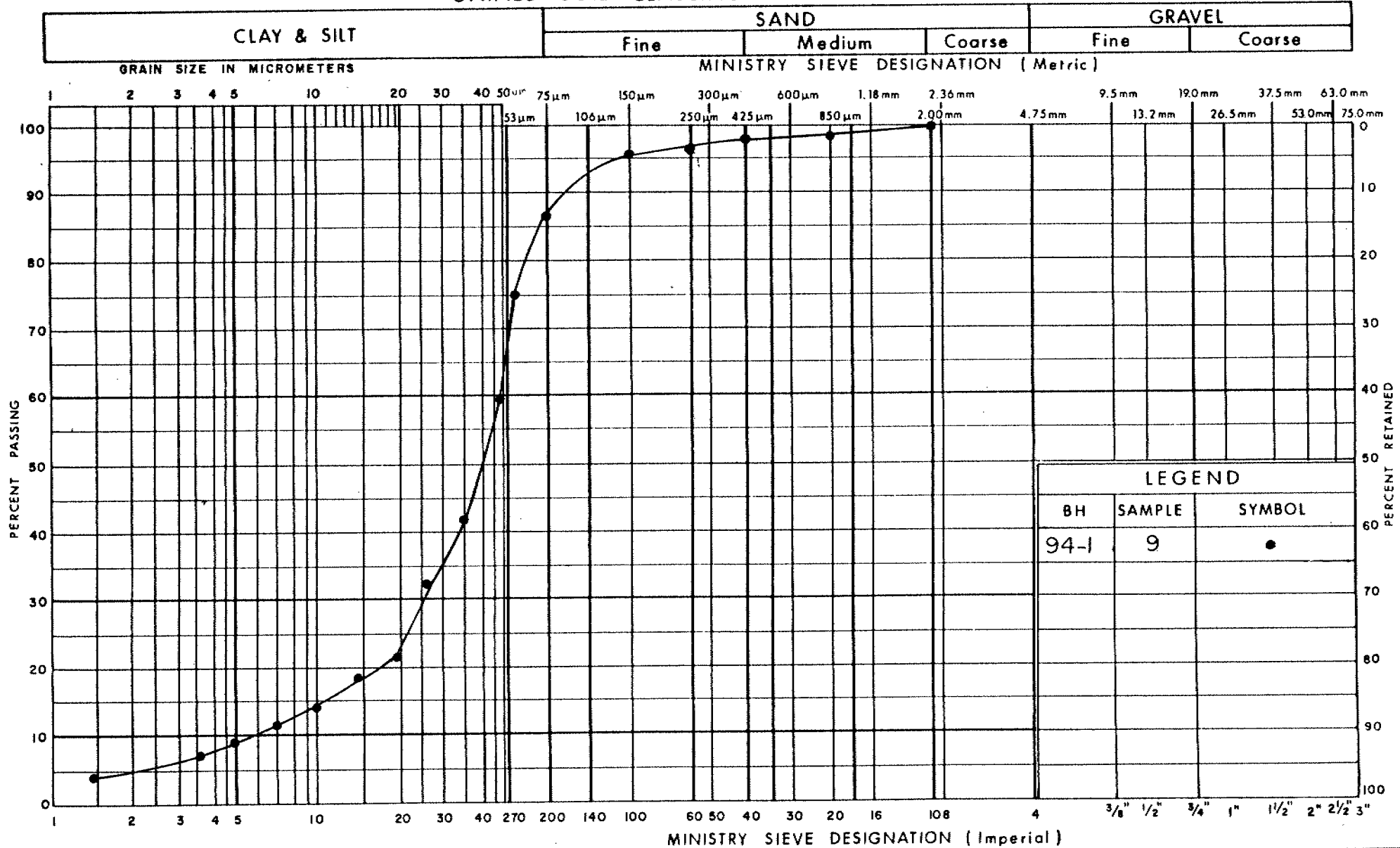
W P 121-87-00



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## UNIFIED SOIL CLASSIFICATION SYSTEM



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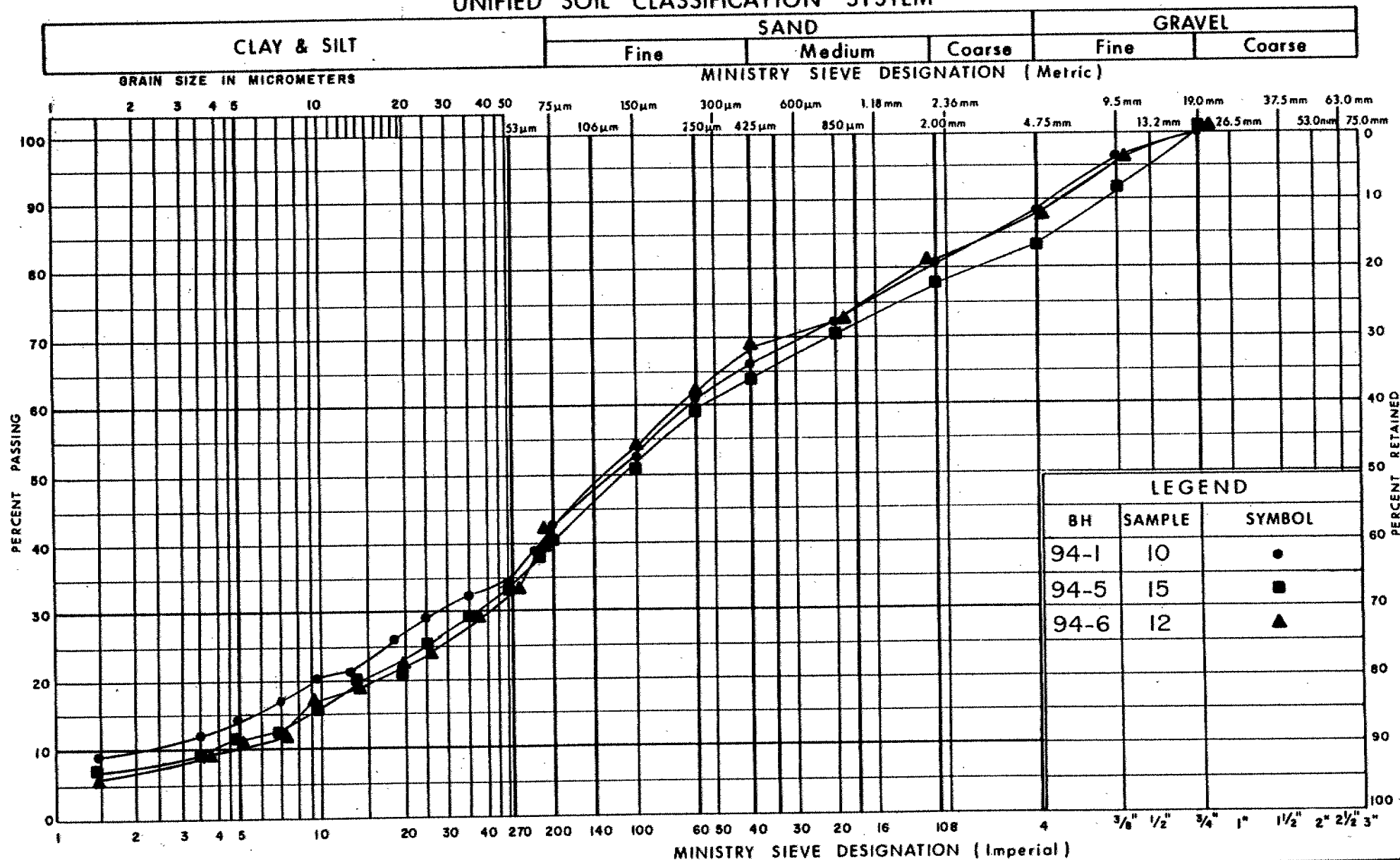
GRAIN SIZE DISTRIBUTION  
SILT, SOME SAND

FIG No 7

W P 121 - 87 - 00



## UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

**GRAIN SIZE DISTRIBUTION**  
SILTY SAND, SOME GRAVEL, TRACE OF SOME CLAY,  
OCCASIONAL COBBLE (GLACIAL TILL)

FIG No 8

W P 121 - 87 - 00

APPENDIX A  
RECORD OF BOREHOLE SHEETS  
PREVIOUS INVESTIGATIONS BY  
GOLDER ASSOCIATES LTD. AND BY OTHERS  
CUT OFF WALL, HIGHWAY 416  
NEPEAN, ONTARIO

# RECORD OF BOREHOLE No 88-7

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 864; E 359 027  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger  
 DATUM Geodetic DATE October 21, 1988  
 ORIGINATED BY PH  
 COMPILED BY AC  
 CHECKED BY AC

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
91.0	Ground Surface																
0.1	Topsoil.																
90.2	Sand, fine to medium trace gravel, some silt. Red Brown																
0.8	Silty clay, some silty sand & sand seams. (Weathered Crust)		1	SS	6												
	Very Stiff Grey Brown		2	SS	6												
			3	SS	4												
			4	SS	1												
87.3	Silty clay, some silty sand & sand seams.																
	Stiff Grey		5	SS	1												
84.7	Sand, layered. Fine to coarse sand, trace silt and silty sand, trace gravel.		6	SS	7												
83.5	Loose to Compact																
7.5	Silty clay, some sand seams.		7	SS	21												
82.8	Grey		8	SS	2												
8.2	End of Borehole																

## METRIC

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	20 40 60					

95.6 Ground Surface

0.0 Fill-sandy silt, some organic matter.

Very Loose Dark Brown & Red Brown

94.1

1.5 Sand, trace silt. Brown

1.7 Clayey silt, some sand seams, trace shells.

1.8 Grey Brown

Silty clay, some silty sand & sand seams.

Stiff Grey

1 SS 3

2 SS 14

3 SS WH\*

4 SS WH

5 SS WH

6 SS WH

7 SS WH

8 SS 1

Bentonite

94

92

Bentonite

Standpipe A

Standpipe A dry on Nov. 10, 1988

Bentonite

90

88

water level in standpipe B at elev. 87.5 m November 10, 1988

Bentonite

86

Standpipe B

+ S=6.2

+ S=4.3

+ S=6.6

+ S=8.2

+ S=7.3

+ S=6.0

+ S=6.8

+ S=5.1

\*Sank under weight  
of hammer

# RECORD OF BOREHOLE No 89-3

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 078; E 358 972 ORIGINATED BY R.B.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 25, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
87.7	Ground Surface															
0.0	Topsoil															
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	7											
	Very Stiff Grey to Stiff Brown		2	SS	5											
24.7			3	SS	1											
3.0	Silty clay, some silty sand and sand seams		4	SS	1											
			5	SS	1											
	Stiff Grey		6	SS	1											
79.8			7	SS	2											
7.9	Clayey silt, trace gravel and sand		8	SS	4											
			9	SS	3											
			10	SS	1											
	Very Stiff Grey to Stiff		11	SS	3											
75.9			12	SS	7											
11.8	Silty sand, fine to medium, trace gravel, some silty clay seams		13	SS	16											
74.8	Compact Grey															
12.9	Sand, fine to coarse, some silt, trace gravel		14	SS	11											
			15	SS	41											
73.0	Compact to Dense Grey															
14.7	End of Borehole Auger Refusal															

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
S (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 89-4

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 995; E 359 010 ORIGINATED BY R.B.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 29, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
88.5	Ground Surface															
0.0	Topsoil															
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	9											
	Very Stiff Grey Brown		2	SS	7											
86.2																
2.3	Silty clay, some sand and silty sand seams		3	SS	2											
			4	SS	WH*											
			5	SS	2											
	Stiff Grey															
82.1																
6.4	Sand, some gravel, trace silt		6	SS	2											
6.6																
	Silty clay, trace sand and silty sand seams															
	Stiff Grey		7	SS	1											
80.1																
8.4	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand layers		8	SS	2											
			9	SS	16											
78.3	Very loose Grey and to Compact Grey Brown															
10.2	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams		10	SS	42											
	Compact to Dense Grey and Grey Brown		11	SS	25											
	Continued															

# RECORD OF BOREHOLE No 89-4 Continued METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 995; E 359 010 ORIGINATED BY R.B.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 29, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa								
						20	40	60	80	100						
	Continued															
	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams.					Well Screen 75										
	Compact to Dense Grey sand: Grey Brown					74										
73.1			12	SS	>100											
15.4	End of Borehole Auger Refusal					73										
	*Sank under weight of hammer															

OFFICE RETURN ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 89-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 917; E 359 045 ORIGINATED BY R.B.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Wash Boring N Casing COMPILED BY A.C.  
 DATUM Geodetic DATE May 30, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
89.7	Ground Surface																
0.0	Topsoil																
0.2																	
	Silty clay and clayey silt, trace sand and silty sand seams		1	SS	11												
			2	SS	6												
87.0	Very Stiff Grey Brown		3	SS	4												
2.7			4	SS	2												
	Silty clay and clayey silt, trace gravel and sand		5	SS	WH*												
			6	TW	WH*												
84.1	Firm to Stiff Grey																
5.6	Sand, fine to coarse, trace gravel, trace to some silt		7	SS	31												
			8	SS	18												
81.6	Compact to Very Dense Grey Brown		9	SS	>100												
81.1	Sand, trace gravel, trace to some silt, some silty fine sand seams, occasional cobble		10	SS	105												
80.6																	
9.1	Very Dense Grey Brown																
	End of Borehole																
	*Sank under weight of hammer																



# RECORD OF BOREHOLE No. 89-13

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 060; E 358 936 ORIGINATED BY DJS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE June 26, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.8	Ground Surface																
0.0 87.4	Topsoil																
0.4	Silty clay (weathered crust)																
5.1	Grey Brown																
2.7	Silty clay		1	SS	WH*												
83.1	Grey																
4.7	Silty Sand		2	SS	13												
82.5	Compact																
5.3	Sandy silt, some gravel, trace clay, occasional cobble		3	SS	10												
80.8	Compact																
7.0	Probably Sand																
80.2	Grey																
7.6	End of Borehole * Sank under weight of hammer.																



## METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	TEST PLOT	NUMBER	TYPE			N' VALUES	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)		
							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE 20 40 60 80 100					

Elevation	Description	Soil Type	Thickness (m)	Notes
88.0	Ground Surface			
0.0	Topsoil			
0.2	Probably silty clay, occasional sand seam			
		1 SS	1	
		2 SS	1	
80.1	Grey Brown to Grey	3 SS	10	
77.9	Silty sand and sand			
78.9	Grey			
9.1	End of Borehole			

Water level in open hole at elev. 86.8 metres on July 4, 1989

20  
15-20 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No. 89-15

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 971; E 358 967 ORIGINATED BY L.Q.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE July 4, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.4	Ground Surface																
0.0	Topsoil																
0.1	Probably silty clay, occasional sand seam with depth						88										
							87										
							86										
							85										
							84										
							83										
82.0	Grey Brown to Grey						82										
6.4	Silty clay, some sand, trace gravel		1	SS	1		81										
							80										
79.6	Grey		2	SS	2		79										
8.8	Silty sand, trace gravel, some clay						78										
78.5	Very loose Grey		3	SS	4												
9.9	Probably sand, some gravel occasional cobble																
77.7	Grey																
10.7	End of Borehole						77										
	* Note: Water level not established																

RECORD OF BOREHOLE No. 89-16

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 911; E 359 095 ORIGINATED BY L.O.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Ganderic DATE July 7, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
93.2	Ground Surface																
0.0	Topsoil						93										
0.2	Sand, trace silt and gravel						92										
90.8	Brown						91										
2.4	Sand and gravel, trace silt, occasional cobble and boulder						90										
89.4	Dense Brown		1	SS	34												
3.8	Sand, fine to medium, trace silt, occasional cobble						89										
			2	SS	23		88										
							87										
			3	SS	22												
	Compact Brown to Grey Brown						86										
85.6	End of Borehole						85										
7.6	* Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No. 89-17

METRIC

W P 146-74-00-3 LOCATION Co -ords N 5 020 864; E 359 112 ORIGINATED BY L.Q.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE July 7, 1989 CHECKED BY A.C.

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		20	40	60	80	100				
95.3	Ground Surface														
0.1 94.8	Silty sand Brown														
0.5 93.3	Probably silty clay, some sand, trace gravel Grey Brown														
2.0 91.6	Probably sand and gravel, trace silt, occasional cobble														
3.7	Sand, fine to medium and fine to coarse, trace gravel and silt														
			1	SS	33										
			2	SS	35										
87.7	Dense Grey Brown														
7.6	Sand and gravel, trace silt, occasional cobble		3	SS	60/150 mm										
85.5	Very Dense to Dense Grey Brown		4	SS	44										
9.8	End of Borehole														
	* Note: Water level not established														

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No. 89-18

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 817; E 359 130

ORIGINATED BY L.Q.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger

COMPILED BY A.C.

DATUM Geodetic DATE July 10, 1989

CHECKED BY A.C.

[illegible]

OFFICE REPUKI UN SOIL EXPLORATION

43, x5. Numbers refer to

20  
15  $\Delta$  5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No. 89-19

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 954: E 359 068 ORIGINATED BY L.Q.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE July 10, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
89.4	Ground Surface															
0.0	Topsoil															
0.2	Silty sand to sandy silt					89										
88.3	Grey Brown															
1.1	Probably silty clay					88										
						87										
						86										
85.6	Grey Brown															
3.8	Sand fine to coarse, trace gravel and silt					85										
84.2	Compact Grey Brown		1	SS	27											
5.2	End of Borehole					84										
	* Note: Water level not established															

# RECORD OF BOREHOLE No. 89-19A

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 954; E 359 069 ORIGINATED BY L.Q.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE July 11, 1989 CHECKED BY A.C.

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			20	40	60	80	100					
89.5	Ground Surface																GR SA SI CL
0.0	See Record of Borehole No. 19						II	Bentonite									
								89									
								Native Backfill									
								Water level at elev. 86.9 metres on July 19, 1989									
								Standpipe									
86.4																	
3.1	End of Borehole							86									



# RECORD OF BOREHOLE No. 89-20

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 000; E 359 047 ORIGINATED BY L.Q.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE July 10, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.7	Ground Surface																
0.0	Topsoil																
88.0	Silty sand, trace gravel																
0.7	Probably silty clay, occasional sand seam																
			1	SS	WH												
			2	SS	PM												
83.4																	
5.3	Sand, fine to medium, trace silt																
			3	SS	6												
82.0	Loose Grey																
6.7	End of Borehole																
	* Sank under weight of hammer.																
	** Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No. 89-21

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 046; E 359 027 ORIGINATED BY A.C.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 11, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.1	Ground Surface																
0.0	Topsoil																
0.2	Probably silty clay, occasional sand seam    Grey Brown to Grey		1	SS	1												
81.1			2	SS	1												
7.0	Probably silty sand																
80.5																	
7.6	End of Borehole																
	* Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No. 89-22

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 152; E 358 971 ORIGINATED BY J.D.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE July 11, 1989 CHECKED BY A.C.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT $\frac{1}{2}$					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80						100
87.3	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, occasional silty sand seam		1	SS	2												
			2	SS	1												
			3	SS	WH*												
			4	SS	PM												
			5	SS	PM												
77.5	Grey Brown to Grey																
9.8	End of Borehole																
	* Sank under weight of hammer.																
	** Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90-26

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 090; E 358 915 ORIGINATED BY D.J.S.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 10, 1990 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
87.7	Ground Surface							20	40	60	80	100					
87.5	Topsoil																
0.2	Silty clay (weathered crust)																
85.3	Grey Brown																
2.4	Silty Clay																
	Grey																
83.3			1	SS	PM												
4.4	Sandy silt, to silty sand, some gravel																
	Loose to		2	SS	4												
	Compact Grey																
82.2																	
5.5	Sand, fine to coarse, trace silt		3	SS	39												
				4	SS	29											
			5	SS	36												
	Compact to Dense Grey		6	SS	25												
78.6			7	SS	24												
9.1	End of Borehole																

# RECORD OF BOREHOLE No 90 - W6

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 199; E 358 915 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE JULY 3, 1990 CHECKED BY R

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
86.6	Ground Surface												
0.0	Topsoil												
0.2	Silty clay, some silty fine sand seams (weathered crust)  Grey Brown												
84.0													
2.6	Silty clay  Grey												
84													
82													
80													
79.4													
7.2	Sandy silt, some gravel and cobble (glacial till)  Grey		1	SS	5								
78													
76	Becoming more silty with depth  Grey												
74.3													
12.3	End of Borehole Refusal to Auger Probable Bedrock												
74													
72													

## METRIC

OFFICE REPORT ON SOIL EXPLORATION

\* DFC - Recovery

+3, x5: Numbers refer to  
15  $\pm$  5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W8

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 165; E 358 930 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 10, 11, 1990 CHECKED BY RN

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.3	Ground Surface																
0.0	Topsoil					*											
0.2	Fill - Silty Sand Brown																
0.5	Silty clay, occasional fine sand seams (weathered crust)																
	Grey Brown																
84.6																	
2.7	Silty clay, occasional fine sand seams																
	Grey																
			1	SS	** WH												
78.1																	
9.2	Laminated silty sand and clayey silt, some gravel		2	SS	6												
9.6	Silty clay																
77.1	Grey																
10.2	Sandy silt to clayey silt, some gravel, occasional cobble		3	SS	3												
	Loose to Dense																
73.8																	
13.5	End of Borehole Refusal to Auger Probable Bedrock *Note: Water level not established **Sank under weight of hammer																

# RECORD OF BOREHOLE No 90 - W9

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 146; E 358 936 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM Geodetic DATE May 4, 1990 CHECKED BY RN

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 (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										SHEAR STRENGTH kPa			WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										20 40 60					
87.2	Ground Surface																						
0.6	Topsoil																						
0.3	Silty clay, occasional sand seams (weathered crust)																						
84.5	Grey Brown																						
2.7	Silty clay, occasional sand seams and layers																						
			1	SS	PM																		
			2	SS	PM																		
			3	SS	PM																		
			4	SS	PM																		
			5	SS	PM																		
			6	SS	PM																		
			7	SS	WH*																		
			8	SS	WH*																		
77.2																							
10.0	Sandy silt and silty sand, some clay and gravel (glacial till)		9	SS	3																		
			10	SS	4																		
			11	SS	3																		
			12	SS	4																		
74.7																							
12.5	Sand, fine to coarse trace gravel and silt																						
73.6	Compact Grey																						
13.6	Sand, fine to coarse, some silt, Compact Grey																						
73.2			13	SS	50/100 mm																		
14.0	End of Borehole Refusal to Auger Probable Bedrock *Sank under weight of hammer																						

+3, x5: Numbers refer to 20 15 x 5 (%) STRAIN AT FAILURE  
Sensitivity



# RECORD OF BOREHOLE No 90 - WIO

METRIC

W P 126-R7-01(A) LOCATION Co-ords N 5 021 126; E 358 947 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 11, 12, 1990 CHECKED BY LA

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			20	40	60	80	100					
87.4	Ground Surface																GR SA SI CL
87.0	Topsoil																
86.2	Silty fine sand Brown																
86.4	Silty clay, some silty sand seams																
	(weathered crust)																
	Grey Brown																
84.7																	
82.7	Silty clay, occasional fine sand seams, trace gravel																
	Grey																
			1	SS	PM												
78.7																	
88.7	Sand, some gravel, trace silt		2	SS	PH												
	Grey																
76.7																	
10.7	Clayey silt, some gravel (glacial till)																
	Some cobbles and boulders with depth																
	Grey																
74.0																	
13.4	End of Borehole Refusal to Auger Probable Bedrock																

# RECORD OF BOREHOLE No 90 - WII

METRIC

W.P. 126-87-01(A) LOCATION Co-ords N 5 021 110; E 358 953 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 11, 1990 CHECKED BY KJ

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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			20	40	60	80	100				
87.4	Ground Surface														
87.4	Topsoil														
86.2	Silty clay, some fine silty sand seams (weathered crust)				**										
84.7	Stiff Grey					86									
82.7	Silty clay, some fine silty sand seams and bands					84									
	Grey					82									
						80									
79.2			1	SS	WH*										
88.2	Silty clay, layered, some fine sand and sandy silt seams, occasional gravel		2	SS	2										
77.9	Grey		3	SS	3										
9.5	Silty fine sand Grey		4	SS	4	78									
9.6	Silty clay, some fine sand seams Grey														
77.2															
10.2	Sand, medium to coarse, some gravel, becoming cobblely with depth		5	SS	20										
	Compact Grey					76									
						74									
72.9															
14.5	End of Borehole Refusal to Auger Probable bedrock														

NOTE: \* Sank under weight of hammer  
\*\* Water level not established

3, 5: Numbers refer to 20  
15-5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W12

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 100; E 358 958 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM Geodetic DATE July 12, 1990 CHECKED BY L

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT $\Sigma$					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80	100					
67.6	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, occasional silty sand seams (weathered crust)					*											
	Grey Brown						86										
84.9																	
2.7	Silty clay, some silty fine sand layer						84										
	Grey																
							82										
							80										
78.9																	
9.7	Sand, some gravel						78										
							76										
							74										
72.7																	
12.4																	

End of Borehole  
 Refusal to Auger

3, x5. Numbers refer to 20  
 15 x 5 1% STRAIN AT FAILURE



## METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W <sub>p</sub>	W		
85.5	Ground Surface						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					GR SA SI CL

[illegible]

+3, x5; Numbers refer to  
Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 90 - W18

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 124; E 358 979 ORIGINATED BY BB  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 5, 1990 CHECKED BY RN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE $\rho_{CT}$					PLASTIC LIMIT $W_p$	NATURAL MOISTURE CONTENT $W$	LIQUID LIMIT $W_L$	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.4	Ground Surface																GR SA SI CL
0.0	Topsoil																
0.2	Silty clay, occasional silty fine sand, (weathered crust)					*											
	Brown						86										
84.0							84										
3.4	Silty clay, occasional silty sand																
	Grey						82										
							80										
							78										
76.2							76										0 93 6 1
11.2	Sand, trace silt		1	SS	PM												
	Grey						74										
72.4																	

End of Borehole  
Refusal to Auger

+3, x5: Numbers refer to 20 15  $\pm$  5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W25

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 222: E 359 001 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETIC DATE July 4, 1990 CHECKED BY RL

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
86.3	Ground Surface																	
0.0	Topsoil						86											
0.2	Silty clay, occasional silty sand seams (weathered crust)																	
	Grey Brown						84											
83.4																		
2.9	Silty clay, some silty fine sand seams						82											
	Grey						80											
							78											
							76											
			1	SS	1													
							74											
			2	SS	1													
73.1																		
13.2	Sandy silt and clayey silt, some gravel (glacial till)																	
72.0	Loose Grey																	
14.3	End of Borehole Refusal to Auger Probable Bedrock						72											

\*3, \*5: Numbers refer to 20  
Sensitivity 15 ± 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W26

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 203; E 359 006 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
 DATUM GEODETIC DATE July 4, 1990 CHECKED BY AN

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
86.9	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, trace sand seams (weathered crust)																
			1	SS	16												
			2	SS	7									0 1 54 45			
	Brown		3	SS	4												
	Becoming Grey																
83.8																	
3.1	Silty clay, trace silty sand seams		4	SS	PM												
			5	SS	PM												
	Grey		6	SS	PM									0 4 56 40			
			7	SS	PM												
78.1																	
0.8	Silty clay, becoming more silty with depth		8	SS	PM												
			9	SS	PM												
			10	SS	PM												
72.9	Becoming Sandy																
14.0	Sandy silt, some gravel, and trace clay (glacial till)		11	SS	WH*												
71.9																	
15.0	Grey																

Continued

+3, x5: Numbers refer to 20  
 15 x 5 (%) STRAIN AT FAILURE



## METRIC

+3, x5; Numbers refer to Sensitivity

W P 126-87-01(A) LOCATION Co-ords N 5 021 185; E 359 016 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM GEODETTIC DATE July 4, 1990 CHECKED BY RN

[illegible]

Continued

+3, x5: Numbers refer to 15-20 (20) STRAIN AT FAILURE

20  
14  $\sigma$  -  $\epsilon$  (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W27

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 185; E 359 016 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY BN  
 DATUM GEODETIC DATE July 4, 1990 CHECKED BY BN

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 (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	SHEAR STRENGTH kPa
	Continued																	
71.9							72											
15.2	Sand silt, some gravel and trace clay (glacial till)																	
70.9																		
16.2	End of Borehole Refusal to Auger Probable Bedrock																	
	* Water level not established						70											
							68											

METRIC

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	SIRAT PLOT NUMBER	TYPE			'N' VALUES	20 40 60 80 100	$W_p$	$W$		
87.1	Ground Surface					SHEAR STRENGTH kPo ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100					GR SA SI CL

[illegible]

Continued

+3, x5: Numbers refer to 20  
15-5 (1%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 90 - W28

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 168; E 359 023 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 5, 1990 CHECKED BY KAV

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
71.9	Continued						72										
15.2	Clayey silt to sandy silt, some gravel (glacial till)		2	SS	8												
71.0	Loose Grey																
16.1	End of Borehole Refusal to Auger Probable Bedrock						70										
							68										



## RECORD OF BOREHOLE No 90 - W29

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 150; E 359 032 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
DATUM GEODETIC DATE July 15, 1990 CHECKED BY RL

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			20	40	60	80	100				
87.2	Ground Surface															
0.0	Topsoil															
0.2	Silty clay, some silty fine sand seams (weathered crust)		1	SS	12											
	Stiff to Very stiff		2	SS	5											
	Grey Brown		3	SS	3											
84.3			4	SS	WH*											
2.9	Silty clay, some fine sand seams, becoming more silty and sandy with depth.		5	SS	1											
	Stiff		6	SS	PH											
	Grey		7	SS	PM											
78.4			8	SS	WH*											
8.8	Silty clay to sandy silt, layered, trace gravel and clay		9	SS	PM											
77.4	Grey		10	SS	PH											
9.8	Silty clay, some silty fine sand layers		11	SS	PH											
	Stiff		12	SS	WH*											
	Grey		13	SS	7											
72.9																
14.3	Sand, medium to coarse, some silt, trace gravel															
72.2	Loose															
	Grey															
15.0																

Continued

+3, x5: Numbers refer to 20  
15 to 1% STRAIN AT FAILURE



## METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to 15  $\phi$  5 (20) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 90 - W30

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 128; E 359 039 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 15, 1990 CHECKED BY RN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>					
87.4	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, some fine sand seams (weathered crust)					*											
	Grey Brown						86										
85.3																	
2.1	Silty clay, some fine sand seams, trace to some fine gravel																
	Grey						84										
							82										
							80										
							78										
							76										
			1	SS	7												
74.1																	
13.3	Sand, fine to coarse, trace silt						74										
	Loose Grey		2	SS	PM												
72.4																	
15.0																	

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x5: Numbers refer to 20  
15-5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 90 - W30

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 128; E 359 039 ORIGINATED BY AC  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 15, 1990 CHECKED BY RN

SOIL PROFILE		STRAT PLOT	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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
72.4	Continued							20	40	60	80	100					
15.0	Sand, fine to coarse, trace silt		3	SS	PH		72										
70.9	Loose Grey																
16.5	End of Borehole Refusal to Auger Probable Bedrock						70										
	* Note: Water level not established						68										

PROJECT: 931-2007

## RECORD OF BOREHOLE 8

SHEET 1 OF 1

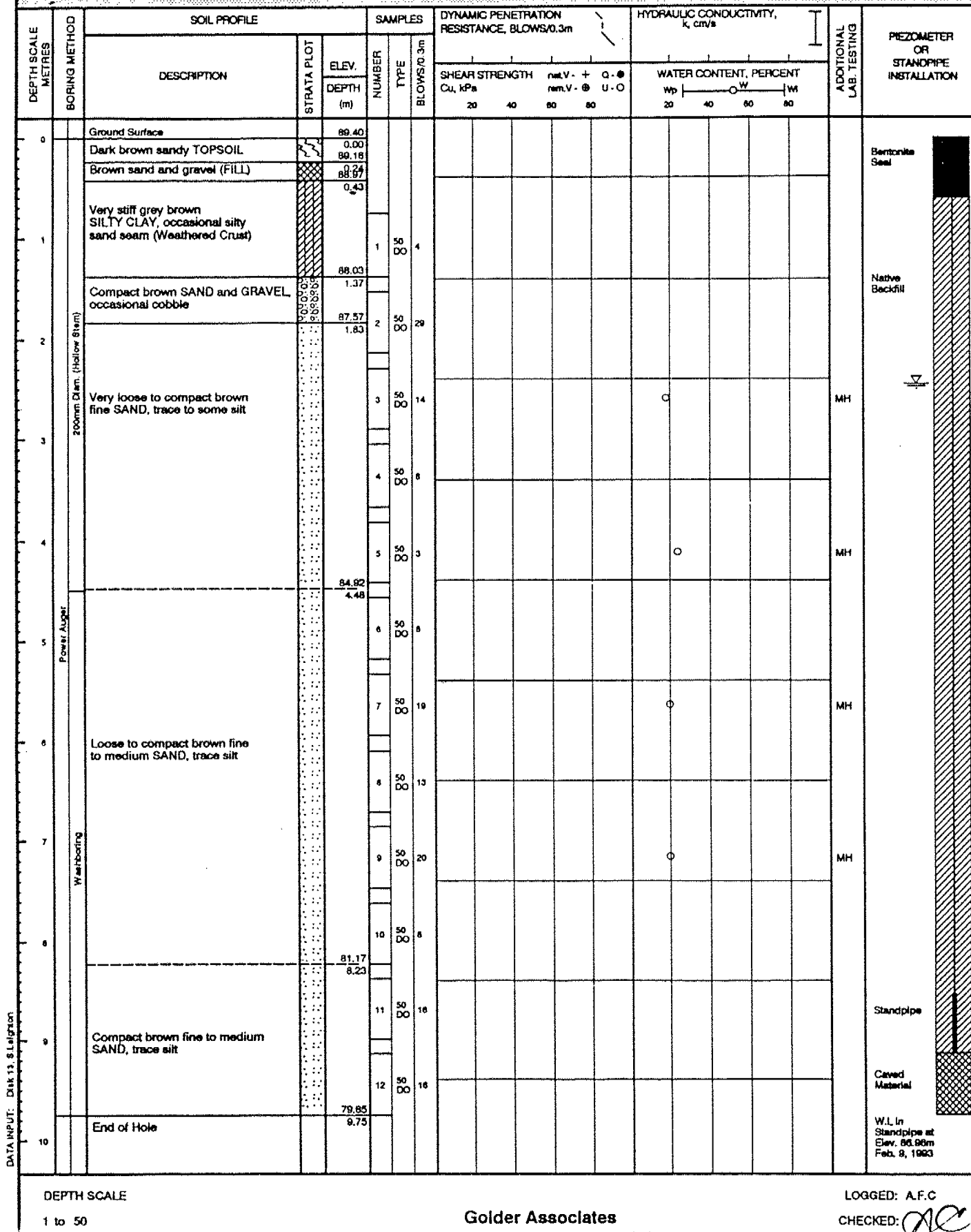
LOCATION: See Plan

BORING DATE: Jan. 27 &amp; 28, 1993

DATUM: Geodetic

SAMPLER HAMMER, 21.2kg; DROP: 760mm

PENETRATION TEST HAMMER, 21.2kg; DROP: 760mm



PROJECT: 931-2007		RECORD OF BOREHOLE 9		SHEET 1 OF 1							
LOCATION: See Plan		BORING DATE: Jan. 27, 1993		DATUM: Geodetic							
SAMPLER HAMMER, 21.2kg; DROP, 760mm		PENETRATION TEST HAMMER, 21.2kg; DROP, 760mm									
DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	rem. V - + rem. V - @ U - O	WATER CONTENT, PERCENT Wp - W - W		
0	200mm Diam. (Hollow Stem)	Ground Surface	88.28								Bentonite Seal
		Dark brown silty TOPSOIL	0.00 87.98 0.30								
1		Firm to very stiff grey brown SILTY CLAY (Weathered Crust)		1	50 DO	9					
2				2	50 DO	3					
3				3	50 DO	WH					
4		Firm grey SILTY CLAY									
5											
6		Possibly grey Silty Sand, trace gravel									
7											
8		Very loose grey fine to medium SAND, trace silt									
9											
10	Compact grey fine SAND, trace to some silt										
11											
12	Loose to compact grey fine to medium SAND, trace silt										
13											
14	Compact to dense grey fine to coarse SAND, trace gravel and silt										
15											
16	End of Hole										
17											

DATA INPUT: Disk 13.8.14g13on

DEPTH SCALE  
1 to 50

Golder Associates

LOGGED: A.F.C.  
CHECKED: AC

W.L. in  
Standpipe at  
Elev. 87.04m  
Feb. 17, 1993

Standpipe  
Caved  
Material

Native  
Backfill



PROJECT: 931-2138

## RECORD OF BOREHOLE 93-1

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Sept. 15, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		STRATA PLOT	SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	ELEV. DEPTH (m)		NUMBER	TYPE	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp	W	WL		
15		CONTINUED FROM PREVIOUS PAGE										
16	200mm Diam. (H.S. - Wash Bore)	Compact brown to grey faintly stratified fine SAND, trace silt	80.02 17.07	8	50 DO	23						Well Screen
17		Compact grey stratified SILTY fine SAND	79.11 17.98	9	50 DO	15						
18				10	50 DO	27						Caved Backfill
19	Power Auger			11	50 DO	25						
20				12	50 DO	21						
21	200mm Diam. (Hollow Stem)	Compact to very dense grey sandy silt, some gravel and clay, occasional silty sand and sandy silt layer, some cobbles and boulders (GLACIAL TILL)		13	50 DO	100						
22												
23												
24		End of Hole	72.89 24.20									Holeplug
25												
26												
27												
28												
29												
30												

W.L. in Screen  
at elev. 87.10m  
(9.99m depth)  
Nov. 15, 1993

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:

PROJECT: 931-2138

## RECORD OF BOREHOLE 93-4

SHEET 1 OF 2

LOCATION: See Plan

BORING DATE: Sept 21, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA ELEV. DEPTH (m)	NUMBER	TYPE	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp	W	Wt		
0		Ground Surface	92.61								
		Dark brown sandy TOPSOIL	92.30 0.30								
1		Yellow brown SILTY SAND, trace to some gravel	91.42 1.19								
2	200mm Diam. (Hollow Stem)			1	50 DO	16					
3											
4				2	50 DO	19					
5		Loose to compact brown stratified fine SAND		3	50 DO	19					
6				4	50 DO	7					
7	Power Auger										
8				5	50 DO	13					
9			84.08 8.53								
10	200mm Diam. (H.S. - Wash Bore)			6	50 DO	14					
11				7	50 DO	9					
12		Loose to compact brown fine to medium SAND, occasional silty sand seam and sandy seam with some silt		8	50 DO	9					
13											
14				9	50 DO	9					
15		CONTINUED ON NEXT PAGE									

DATA INPUT: J. COBISA, DISC 12

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:

PROJECT: 931-2138

## RECORD OF BOREHOLE 93-4

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Sept. 21, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, K, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH		WATER CONTENT, PERCENT					
								Cu, kPa	ru, V. + rem. V. -	Q, - U, -	Wp	W	Wt		
15	Power Auger 200mm Diam. (Hollow Stem) 200mm Diam. (H.S.) - Was	CONTINUED FROM PREVIOUS PAGE													
			77.07	10	50	12									
		Compact brown fine SAND, trace to some silt		15.54											
				78.81											
				18.00											
16															
17															
		Loose to compact grey SILTY fine SAND, trace to some gravel			11	50	22								
18															
19		Compact grey sandy silt, some gravel and clay (GLACIAL TILL)		73.71	12	50	10								
				18.90											
				19.11											
20		End of Hole Auger refusal													
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															

Holeplug

 W.L. in Screen  
 at elev. 98.69m  
 (5.63m depth)  
 Nov. 15, 1993

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:

# RECORD OF BOREHOLE No 9

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 020 929.6; E 358 976.7 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY IR  
 DATUM Geodetic DATE 84 05 15 CHECKED BY EP

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	SIRAT PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80	100				
88.6	Ground Surface															
0.0	Silty Clay some sand  Stiff  Occasional Silt and Sand Seams		1	SS	4											
			2	SS	4											
			3	TW	PH											
			4	SS	4											
			5	SS	3											
82.2	Heterogeneous Mixture Silty Clay with sand trace gravel  Firm to Stiff		6	SS	4											
6.4			7	SS	13											
			8	SS	7											
78.4	Sand some silt		9	GS												
10.2 77.9																
10.7	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 17-1 1 OF 1 METRIC

W.P. 121-87-06 LOCATION Co-ords N5 020 589.5, E 359 118.5 ORIGINATED BY TS  
 DIST 9 HWY 416 BOREHOLE TYPE HS AUGER, BW/AW Casing, Washboring, AQ Rock Core COMPILED BY TS  
 DATUM Geodetic DATE 90 12 17-20 CHECKED BY TS

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 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
97.4	Ground Surface														
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel with traces of ash and wood (Fill Material) Brown, Very Soft to Firm		1	SS	8										5 53 25 17
			2	SS	2										14 51 27 8
			3	SS	2										
			4	SS	4										
			5	SS	11										
92.1			6	SS	9										29 68 (3)
5.3	Compact Dense to Very Dense		7	SS	30										
			8	SS	39										
	Gravelly Sand trace Silt Brown		9	SS	52										36 55 (9)
			10	SS	66										
			11	SS	45										27 62 (11)
			12	SS	48										
			13	SS	40										
			14	SS	34										27 61 (12)
79.1			15	SS	50										27 14 55 4
18.3	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Grey, Very Dense		16	RC	REC 8%										ROD = 0%
			17	SS	172										ROD = 0%
73.3			18	RC	REC										ROD = 75%
24.1	Bedrock, Dolostone Grey, Medium Strong Unweathered		19	RC	REC 100%										
71.7															
25.7	End of Borehole														
	- 90 12 21														

# RECORD OF BOREHOLE No 17-2, 1 OF 1 METRIC

W.P. 121-87-05 LOCATION Co-ords NS 020 587.0, E 359 148.5 ORIGINATED BY TS  
 DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS  
 DATUM Geodetic DATE 91 01 15 CHECKED BY TS

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 7 kn/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
97.3	Ground Surface																
0.0	Sand, trace silt (Fill Material) Brown, Loose		1	SS	8		97										
94.3			2	SS	6		95										
3.0	Sand with traces of Wood, Brick, Concrete and Bottles (Fill Material) Brown, Very Loose to Compact		3	SS	21												
			4	SS	30		93										
			5	SS	13												
			6	SS	4		91										
			7	SS	11												
89.7			8	SS	4												
7.6	Gravelly Sand, trace Silt with random interbedded Silt seams Dense  Brown Grey		9	SS	32		89										
			10	SS	40												
			11	SS	40												
			12	SS	40		87										
			13	SS	37		85										
83.1			14	SS	39												
14.2	End of Borehole  91 01 15																

# RECORD OF BOREHOLE No 17-3

1 OF 1

METRIC

W.P. 121-87-08 LOCATION Co-ords N5 020 707.0, E 359 189.5 ORIGINATED BY FT  
DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS  
DATUM Geodetic DATE 90 12 17-20 CHECKED BY TS

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 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
95.8	Ground Surface																
0.0	Irregular Mixt. of Clayey Silt, Sand and Gravel with traces of Organics (Fill Material)		1	SS	3		95										19 28 43 10
94.8			2	SS	3												1 94 (5)
1.2	Sand with traces of Block Cinder, Bottles and Wood (Fill Material)		3	SS	7		93										
	Brown, Loose to Very Loose		4	SS	8												
91.2			5	SS	7		91										0 90 (10)
4.8	Loose		6	SS	34												
			7	SS	38		89										
			8	SS	40												
	Sand, trace Silt		9	SS	30		87										
	Compact to Dense		10	SS	28												
			11	SS	25												
			12	SS	6 <sup>11</sup>		85										
	Brown		13	SS	19		83										
	Gray		14	SS	37												
			15	SS	47		81										0 90 (10)
			16	SS	35		79										
78.0			17	SS	20		77										
19.8	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till)		18	RC	REC	77%	75										16 38 40 5
73.2	Gray, Compact		19	RC	REC	100%	73										RQD = 27%
22.8	Bedrock, Dolomite																RQD = 90%
71.4	Gray, Medium Strong																
71.4	Unweathered																
24.4	End of Borehole																
	• 90 12 21 -- Disturbed Sample (Unbalanced Hydrostatic Head)																

# RECORD OF BOREHOLE No 17-4 1 OF 1 METRIC

W.P. 121-87-06 LOCATION Co-rds N5 020 688.0 E 359 098.0 ORIGINATED BY FT  
 DIST 9 HWY 415 BOREHOLE TYPE HS Auger COMPILED BY TS  
 DATUM Geodetic DATE 90 12 21 CHECKED BY TS

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 7 KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
98.2	Ground Surface															
0.0	Sand, trace silt Brown, Compact (Fill Material)	X	1	SS	11	DRY										0 94 (6)
96.2			2	SS	12											
2.0	Compact Very Dense		3	SS	100	/15cm										
	Sand		4	SS	100	/10cm										
	some gravel, trace silt		5	SS	100	/10cm										
	Brown		6	SS	100	/15cm										12 82 (6)
88.6			7	SS	100											
9.6	End of Borehole															
	- 90 12 21															

# RECORD OF BOREHOLE No 17-10 1 OF 1

METRIC

W.P. 121-87-06 LOCATION Co-ords N5 020 726.0, E 359 199.6 ORIGINATED BY TS  
 DIST 9 HWY 416 BOREHOLE TYPE Cone Test COMPILED BY TS  
 DATUM Geodetic DATE 88 11 29 CHECKED BY JP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W		
98.4	Ground Surface															
0.0	Probable Sand (Fill Material)															
94.9																
1.5	Probable Sand															
8.3																
8.1	End of Borehole (Cone Test)															
	Formerly BH 5 (WP 125-87-00)															

# STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 2

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OV½-88

PROJECT NO.: 2396

DATE COMPLETED: 25 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	96.903 96.90	CONCRETE PROTECTIVE COLLAR			
	TOPSOIL: sandy, silty loam, compact, brown, slightly moist.	96.83	150mm# CASING CONCRETE			
1.0	SW SAND: trace silt, trace fine gravel, dense, well graded, medium to coarse grained, brown, slightly moist.		200mm# BOREHOLE	1SS	×	34
2.0			CEMENT/BENTONITE GROUT	2SS	×	40
3.0	- little gravel		50 mm # PVC PIPE	3SS	×	38
4.0			BENTONITE SEAL	4SS	×	72
5.0			NATURAL CAVE-IN	5SS	×	28
6.0	- very dense, moist		BENTONITE SEAL	6SS	×	54
7.0			SAND PACK	7SS	×	37
8.0	- dense		WELL SCREEN	8SS	×	53
9.0	- very moist, slight plasticity, some silt	87.66				
10.0						
11.0	- very dense, occasional silt seam, angular gravel, wet					
12.0		84.62				
13.0	SM SAND: some silt, very dense, fine grained, poorly graded, massive, grey, wet.	84.10				
	END OF HOLE @ 12.80 m BGS.					

## SCREEN DETAILS:

Screened Interval:  
84.80 to 86.33 AMSL  
Length - 1.52m

Diameter - 50mm  
Slot # 10  
Material - PVC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



4/05/88

**Golder Associates Ltd.**

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Ottawa, Ontario, Canada K2C 2B5  
Telephone (613) 224-5864  
Fax (613) 224-9928



201

REPORT TO  
MINISTRY OF TRANSPORTATION ONTARIO  
GEOTECHNICAL AND GROUNDWATER STUDY  
PROPOSED HIGHWAY 416  
CEDARVIEW ROAD CORRIDOR  
NEAR THE LYNWOOD SUBDIVISION  
W.P. 146-74-00-3 - DISTRICT 9 (OTTAWA)  
NEPEAN, ONTARIO

January 1990

891-2208

## 1.0 INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation Ontario (MTO) to carry out a geotechnical and groundwater study along the proposed Highway 416 adjacent to the Lynwood subdivision in Nepean, Ontario (see Key Plan, Figure 1). The purpose of this investigation was to determine the soil, bedrock and groundwater conditions in this area and, based on the factual information obtained, to assess the possible effects of the proposed highway cut on the groundwater regime.

As proposed, the Highway 416 alignment will be in cut (depressed section) through the National Capital Commission (N.C.C.) lands opposite the Lynwood subdivision about 60 to 80 metres east of Cedarview Road. Adjacent to the subdivision, the proposed roadway will be in cut section to between about 5 and 11 metres below existing ground surface (including an allowance for 1.5 metre deep drainage swales).

## 2.0 SITE DESCRIPTION AND GEOLOGY

The Lynwood subdivision is located to the west of Cedarview Road. The distance between the first row of houses in the subdivision and the centreline of the proposed highway is between about 105 metres near the CN railway line to the north and 115 metres near Bell High School to the south.

South of the proposed cut roadway section lies the Bruce pit. As a result of past granular material extraction, the average ground surface elevation across the abandoned pit floor is about 10 metres below the level of Cedarview Road. Two shallow ponds exist at the base of the pit due to groundwater flow into the pit. Currently, the site is used for recreation and includes hiking pathways, cross country ski trails and a toboggan hill.



The topography between the CN railway line and the south end of the Lynwood subdivision is relatively flat with a slight increase in grade to the south. From the south end of the subdivision to the north side of the Bruce Pit, the topography is gently sloping and rises about 7 to 8 metres above the lands to the north.

Based on previous work carried out by MTO and by Golder Associates, it is expected that the subsurface conditions in the area of the proposed highway cut and the Lynwood subdivision consist of deep deposits of sensitive silty clay underlain by glacial till or sand deposits. Near the Bruce Pit, the subsurface conditions are expected to consist of deep deposits of sand and sand and gravel. Geological maps suggest that bedrock consists of limestone or dolomitic limestone of the Oxford formation.

### 3.0 PREVIOUS INVESTIGATIONS

Previous preliminary investigations have been carried out at the site by MTO and by Golder Associates.

During May, 1984, MTO carried out a preliminary investigation along the proposed Highway 416 route between Richmond Road to the north and the Bruce Pit to the south. The results of this work are presented in report number 31G5-138, entitled, "Preliminary Investigation for Proposed Highway 416, Century Rd. to Hwy. 417".

Golder Associates carried out a preliminary investigation to determine the effect of the proposed highway cut on the groundwater regime in the Lynwood subdivision area; the results of this work are presented in Golder Associates report number, 881-2294-3 entitled "Preliminary Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor near the Lynwood Subdivision,

W.P. 146-74-03-District 9 (Ottawa), Nepean, Ontario", dated March, 1989. Three boreholes were put down along the proposed cut section during the investigation. One borehole advanced adjacent to Cedarview Road showed that a section of the proposed highway cut opposite the subdivision would likely be carried out within layered silty sand and sand to about 8.5 metres below the existing groundwater level. Since the extent of the deposit was not known, recommendations were given for advancing additional detailed boreholes along the route alignment and in the subdivision.

#### 4.0 PROCEDURE

The field work for this investigation was carried out in two stages between May 24 and July 11, 1989.

During the first stage of the investigation from May 24 to June 9, 1989, four (4) boreholes, numbered 89-1, 89-3, 89-4 and 89-5, were advanced along the west side of the proposed highway alignment and three (3) boreholes numbered 89-7, 89-8 and 89-9 were advanced along the west side of Cedarview Road. The boreholes were advanced to depths ranging from 9.1 to 14.7 metres below ground surface using a track mounted CME 55 drill rig supplied and operated by a local contractor. Standard penetration tests were carried out in all of the boreholes and samples of the soils encountered were recovered using drive open sampling equipment. Except for borehole 89-5 which was advanced with rotary drilling techniques between about 5.6 and 9.1 metres depth, the split spoon samples were obtained from within hollow stem augers. Standpipes and/or well screens were sealed into most of the boreholes to determine the groundwater levels in the various soil strata.

Following an evaluation of the factual information obtained from the first stage program which indicated that the sand deposit likely extended to below the subdivision and, in some areas, directly overlies bedrock, a second stage investigation was carried out to delineate the extent and depth of the sand deposit and to

investigate the feasibility of a cut-off wall to prevent groundwater seepage from below the subdivision. This second stage investigation was carried out between June 27 and July 17, 1989. During this time, two deep boreholes, numbered 89-2 and 89-6, were put down in the subdivision area to confirm the extent of the sand deposit in this area; bedrock was cored using BXL size diamond drilling equipment to determine the type and quality of the bedrock. Thin walled 70 millimetre inside diameter Shelby tube samples of the silty clay were recovered for consolidation testing. Pressure packer testing was carried out in the bedrock to determine the approximate hydraulic conductivity of the bedrock. Multiple standpipes were sealed into the overburden deposits and bedrock to determine the existing vertical hydraulic gradients at these locations.

To adequately determine the extent of the sand deposit in the area of the proposed highway cut, thirteen boreholes (numbered 89-10 to 89-22, inclusive), were advanced at the site to depths ranging from 5.2 to 10.7 metres below existing ground surface. These boreholes were either terminated when sand was encountered beneath deposits of silty clay or were taken to below the proposed depth of the highway cut. Standard penetration testing was carried out at 1.5 metre intervals of depth in the lower part of the boreholes only to confirm the presence of sandy deposits. A standpipe was sealed into borehole 89-19A to determine the groundwater level; in some of the other boreholes, the water level in the open hole was determined following the drilling.

All of the field work was supervised by a member of our engineering staff who located the boreholes, directed the drilling operations, carried out the in situ testing and logged the overburden samples.

Samples of the soils encountered were taken to our laboratory for detailed examination and classification testing. Samples of the soils encountered were tested for moisture content, liquid and plastic limits and grain size distribution. An oedometer

consolidation test was carried out on a relatively undisturbed Shelby tube sample of the silty clay recovered from borehole 89-2.

Detailed logs of the soil and groundwater conditions encountered in the boreholes are given on the Record of Borehole sheets following the text of this report. Logs from previous boreholes put down by Golder Associates, MTO and Conestoga-Rovers and Associates in and adjacent to the Lynwood subdivision are provided for reference purposes. The approximate locations of the boreholes are given on Drawing 1467400-3A\*. The soil profiles are provided on Drawings 1467400-3B\* and 1467400-3C\*. The results of the laboratory testing are given on Figures 2 to 12, inclusive and on the Record of Borehole sheets.

The borehole locations were determined by our staff and are referenced to existing site features. The ground surface elevations at the borehole locations were referenced to the fire hydrant located on Cedarview Road, north of Dante Street. The elevation of the arrowhead on the hydrant was provided by the City of Nepean as 87.73 metres, Geodetic datum.

## 5.0 SUBSURFACE CONDITIONS

As previously indicated, the detailed soil, bedrock and groundwater conditions determined from the boreholes are given on the Record of Borehole sheets following the text of this report. The following presents a brief description of the general subsurface conditions across the site followed by descriptions of the soil, bedrock and groundwater conditions encountered.

### 5.1 General

The subsurface conditions along this section of the proposed highway 416 and within the Lynwood subdivision consist of weathered and grey sensitive silty clay of variable thickness, followed by discontinuous and variable deposits of silty sand, sand or sand and

\* Sheets 214, 215 & 216 of Contract Drawings.

gravel, followed by dolomitic limestone bedrock; in some areas, a mantle of glacial till was encountered above bedrock. In general, the silty clay deposit was found to have a thickness of between about 2 to 10 metres and varies in thickness markedly over relatively short distances. The silty sand, sand and sand and gravel deposits are also highly variable in terms of both thickness and gradation.

The bedrock consists of dolomitic limestone of the Oxford formation. The upper 5 metres of the bedrock was found to be thinly to thickly bedded with occasional weathered joints. Pressure packer testing in vertical boreholes in the bedrock indicates an approximate hydraulic conductivity of between  $1 \times 10^{-3}$  and  $1 \times 10^{-6}$  centimetres per second. The hydraulic conductivity appears to be controlled by the presence of fractured seams and weathered joints.

The measured groundwater level in the overburden was found to range between about elevation 84.7 and 89.0 metres. In contrast, the groundwater level measured in the bedrock within the subdivision is between about elevation 79.8 and 82.6 metres, which is lower than that measured in the overlying soils.

## 5.2 Topsoil, Fill

Roadway fill materials composed of crushed stone, sand and gravel and silty sand were encountered at the locations of boreholes 89-1, 89-2 and 89-6 to 89-9, inclusive. The thickness of these fills was found to range from 0.2 to 1.3 metres.

Surficial deposits of topsoil having a thickness of 0.2 to 0.5 metres were encountered at the remaining borehole locations. Topsoil was also encountered beneath the roadway fills.

### 5.3 Silty Clay, Clayey Silt

Deposits of sensitive silty clay or clayey silt were encountered in most of the boreholes put down during the investigation; only boreholes 89-9 and 89-16 did not encounter silty clay and/or clayey silt.

Where the silty clay deposit is relatively thick, the upper 1.8 to 6.3 metres of the deposit was found to be weathered to a grey brown crust. At boreholes 89-17, 89-18 and 89-19, the deposit was found to have a thickness of between 0.6 and 2.7 metres and appears weathered throughout. The standard penetration resistance N values measured within the weathered grey brown silty clay were found to be 1 to 10 blows per 0.3 metres, which reflect a stiff to very stiff consistency. Atterberg limit testing on the weathered silty clay gave liquid limits of between 44 and 53 percent and plastic limits of between 22 and 28 percent. A summary of the Atterberg limit tests performed on the weathered silty clay is given on the Plasticity Chart, Figure 2; these results show that the upper weathered silty clay has a medium to high plasticity. The water content of the weathered silty clay was found to vary from 30 to 52 percent and generally increases with depth.

Beneath the weathered zone, the silty clay is grey in colour with occasional silty sand and sand seams. In situ vane shear strength testing carried out in the grey silty clay gave undrained shear strengths ranging from 28 to 88 kilopascals, which reflect a firm to stiff consistency. Atterberg limit tests carried out on samples of the grey silty clay gave liquid limits of 38 to 54 percent and plastic limit values of 15 to 23, indicating a medium to high plasticity. A summary of the Atterberg limit test results is given on Figures 3 and 4. The water content of the grey silty clay was shown to be between 27 and 55 percent, which approaches or exceeds the measured liquid limits.

An oedometer consolidation test was carried out on a relatively undisturbed sample of the silty clay recovered from borehole 89-2B; the results of this testing are given on the Void Ratio - Pressure Curve, Figure 12. This sample of the silty clay was shown to have an apparent past preconsolidation pressure of 90 kilopascals which is about 45 kilopascals in excess of the existing overburden pressure. The compression and recompression indices for this sample were found to be 1.8 and 0.01, respectively.

Previous oedometer testing by MTO on a sample of the silty clay recovered from previous MTO borehole 6 showed an apparent past preconsolidation pressure of 112 kilopascals, which is about 55 to 60 kilopascals in excess of the overburden pressure.

Deposits of silty clay and clayey silt were encountered at borehole 89-5, and beneath the grey silty clay at boreholes 89-1 and 89-3. The thickness of this deposit ranges from about 0.7 metres at borehole 89-1 to about 5.4 metres at borehole 89-5. A grain size distribution curve of the clayey silt encountered at borehole 89-3 is given on Figure 5. Atterberg limit tests carried out on a sample of the clayey silt gave a liquid limit of 32 and a plastic limit of 18. The moisture content of the silty clay and clayey silt was found to range from 21 to 38 percent.

#### 5.4 Sandy Silt, Silty Sand

Deposits of sandy silt and silty sand containing variable amounts of gravel and occasional silty clay seams were encountered at depths ranging from 1.3 to 11.8 metres below ground surface at the locations of boreholes 89-1, 89-2, 89-3, 89-9, 89-10, 89-11, 89-13, 89-15, 89-21 and at previous Golder Associates borehole 88-4. The thickness of the deposits at these locations ranges between 0.7 and 4.1 metres. A grain size distribution curve for the silty sand and sandy silt encountered at borehole 89-9 is given on Figure 6; the grain size distribution curves on Figure 7 present results for the silty sand and silty sand and gravel layers in previous

borehole 88-4. Standard penetration tests carried out within these deposits gave N values of between 2 to over 100 blows per 0.3 metres which reflect a highly variable very loose to very dense relative density.

#### 5.5 Sand, Sand and Gravel

All of the boreholes, except boreholes 89-1, 89-10 and 89-22 which were advanced at the north end of the study area, encountered deposits of sand and/or sand and gravel. These deposits were encountered at depths ranging from 0.2 to 12.9 metres below ground surface and have a thickness ranging from about 1.0 metre to more than 9 metres.

The sand deposit was found to be quite variable in terms of gradation, ranging from fine sand containing some silt, to fine to medium and fine to coarse sand with variable amounts of silt and gravel, and to sand and gravel. Grain size distribution curves for representative samples of the sand and sand and gravel materials encountered are given on Figures 8, 9 and 10. It should be noted that the grain size analyses were carried out on 38 millimetre I.D. split barrel samples of the material and may not reflect the presence of coarse gravel, cobble or boulder sizes.

Standard penetration testing carried out within these deposits gave N values ranging from 2 to over 100 blows per 0.3 metres which reflect a highly variable very loose to compact relative density, although in most cases, a compact relative density is indicated.

#### 5.6 Glacial Till

Deposits of glacial till were encountered in boreholes 89-1, 89-7, 89-8 and 89-9 at depths ranging from 6.8 to 12.4 metres below existing ground surface. The thickness of the deposit at the above locations ranges from 0.2 metres at borehole 89-7 to about 5.1 metres at borehole 89-1. The glacial till can be generally



described as a heterogeneous mixture of sandy silt containing some gravel and clay; cobbles and boulders should also be expected in this deposit. A grain size distribution curve for a sample of the glacial till recovered from borehole 89-1 is given on Figure 11. It should be noted that the grain size distribution test was carried out on a 38 millimetre I.D. split barrel sample of the material and therefore would not reflect the presence of cobbles or boulders. Standard penetration tests carried out within the glacial till gave N values of 5 to 14 blows per 0.3 metres, which reflect a loose to compact state of packing.

### 5.7 Bedrock

Two cored boreholes, numbered 89-2 and 89-6, encountered dolomitic limestone bedrock at between about 11.1 and 11.2 metres below ground surface (elevation 76.2 to 77.2 metres). At the locations of boreholes 89-1, 89-3, 89-4 and 89-9, auger refusal was encountered at depths of between about 11.9 and 15.4 metres below ground surface (elevation 73.1 to 76.3). These results show that the bedrock surface elevation decreases from west to east across the study area.

The bedrock retrieved from the cored boreholes consists of fresh, thinly to thickly bedded grey dolomitic limestone bedrock. Some sandstone layers, shale partings and occasional open horizontal joints were observed in the core retrieved.

The dolomitic limestone was found to be of good quality, as evidenced by percent core recoveries of between 99 and 100 percent and Rock Quality Designation (R.Q.D.) values of between 67 and 98 percent.

Pressure packer testing was carried out in the bedrock to determine the approximate hydraulic conductivity of the bedrock. The results of this testing, given on Table 1 following the text of this report, show that the hydraulic conductivity of the bedrock ranges

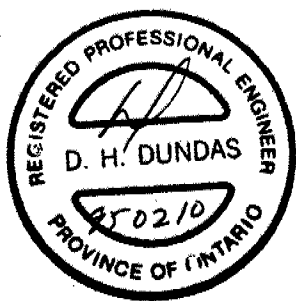
from the "no take condition" (i.e. less than  $1 \times 10^{-6}$  centimetres per second) to about  $1 \times 10^{-3}$  centimetres per second. The hydraulic conductivity of the bedrock appears to be controlled by the presence of open joints or fractures which likely occur at variable depths in the bedrock.

### 5.8 Groundwater

Standpipes and well screens were sealed into the overburden deposits and bedrock to determine the groundwater conditions at the site. Details on the installations of the standpipes and well screens are given on the Record of Borehole sheets together with the groundwater levels obtained. In addition, the groundwater level in some of the open holes was noted following the completion of drilling. The groundwater level measured in standpipes sealed in the sandy deposits ranges between elevation 85.5 metres at borehole 89-2 to 87.5 metres at previous Golder Associates borehole 88-7 (about 0.6 to 3.5 metres below existing ground surface). Standpipes sealed in the silty clay and clayey silt deposits showed groundwater levels ranging from 0.1 to 2.3 metres below ground surface (elevation 84.7 to 89.0 metres). The groundwater level measured in the bedrock ranges from 5.8 to 7.5 metres below ground surface (elevation 79.8 to 82.6 metres).

Multiple standpipe installations in boreholes 89-2 and 89-6 show that the groundwater level measured in the bedrock is between about 3.5 to 5.6 metres lower than in the overburden materials, which reflects a downward hydraulic gradient. Where multiple standpipes were installed in the overburden materials (boreholes 89-2, 89-3, 89-6, 88-4 and 88-7), the difference in groundwater level measured in the silty clay and that measured in the underlying sandy deposit was found to be between 0.1 and 1.5 metres; in most cases, the groundwater level in the silty clay was found to be higher than in the sandy deposit.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.



*D. Dundas*

D. Dundas, P. Eng.

Sr. Foundation Engineer

TABLE 1  
SUMMARY OF PRESSURE PACKER  
TEST RESULTS

<u>Borehole Number</u>	<u>Depth (metres)</u>	<u>Measured Hydraulic Conductivity (cm/s)</u>
89-2	11.4 - 13.0	No Take
	12.8 - 14.3	$2 \times 10^{-5}$
	14.3 - 15.9	No Take
89-6	11.4 - 12.8	$1 \times 10^{-4}$
	12.0 - 13.6	No Take
	13.6 - 15.1	$1 \times 10^{-3}$

# RECORD OF BOREHOLE No 89-1

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 245: E 358 907 ORIGINATED BY R.B.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Steam Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 24, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.5	Ground Surface																
86.1	Topsoil																
0.4	Silty clay, some silty sand seams (weathered crust)		1	SS	10		86										
	Very Stiff Grey Brown		2	SS	10		85										
83.5			3	SS	4		84										
3.0	Silty clay, some sand seams		4	SS	2		83										
	Firm Grey		5	SS	WH		82										
80.6	Clayey silt, some gravel and sand		6	SS	2		81										
79.9	Silty sand and gravel		7	SS	4		80										
6.8	Sandy silt, some gravel and clay (glacial till)		8	SS	7		79										
	Loose Grey		9	SS	6		78										
76.3			10	SS	5		77										
10.2	Sandy silt, some gravel, trace to some clay (Glacial Till)		11	SS	6		76										
	Compact Grey		12	SS	24		75										
74.6			13	SS	>100		74										
11.9	End of Borehole Auger Refusal																
	*Sank under weight of hammer																

RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 168; E 358 762 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	20 40 60		
87.3	Ground Surface													
86.9	Sand and gravel occasional cobble						87							
0.4	Topsoil													
0.8	Silty clay, some silty fine sand seams (weathered crust)		1	SS	7		86							
			2	SS	5									
84.2	Very stiff Grey to stiff Brown						85							
31.1	Silty clay, some silty fine sand seams, trace gravel		3	TW	PH		84							
			4	SS	1									
82.6	Grey						83							
4.7	Sand, fine, some silt, some sandy silt layers		5	SS	9		82							
			6	SS	15									
	Compact Grey		7	SS	16		81							
80.3														
7.0	Sandy silt, trace to some gravel and clay, some fine sand and clayey silt layers		8	SS	19		80							
			9	SS	14									
			10	SS	6		79							
			11	SS	19		78							
			12	SS	64		77							
76.2	Loose to very dense Grey		13	SS	52		76							
11.1	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings occasional weathered horizontal joint		14	BXL	RQD=71%		75							
			15	BXL	RQD=95%									
			16	BXL	RQD=98%		74							
	Continued						73							

\*REC: Recovery  
RQD: Rock Quality Designation

RECORD OF BOREHOLE No. 89-2

METRIC

W P 145-74- 00-3 LOCATION Co-ords N 5 021 168; E 358 762 ORIGINATED BY P.H.  
DIST a HWY 416 BOREHOLE TYPE Hollow Stem Auger BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
	Continued																
	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings, occasional weathered horizontal joint		16	RC BXL	REC-100% RQD=98%		73										
			17	RC BXL	REC-100% RQD=98%		72										
71.0							Standpipe										
16.3	End of Borehole																
	*REC: Recovery RQD: Rock Quality Designation																

## RECORD OF BOREHOLE No. 89-2A

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 168; E 358 761 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 29, 1989 CHECKED BY A.C.

SOIL PROFILE						DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPo	Wp W WL		
87.3	Ground Surface							20 40 60 80 100	20 40 60		
0.0	See Record of Borehole No. 89-2						87				
						Bentonite	86				
						Water level at elev. 85.5 metres on July 19, 1989					
						Native Fill	85				
							84				
						Bentonite					
						Sand	82				
81.2						Standpipe					
6.1	End of Borehole						81				

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity





RECORD OF BOREHOLE No 89-3

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 078; E 358 972 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE May 25, 1989 CHECKED BY A.C.

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			20	40	60	80	100					
87.7	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	7												
	Very Stiff Grey to Stiff Brown		2	SS	5												
84.7			3	SS	1												
3.0	Silty clay, some silty sand and sand seams		4	SS	1												
			5	SS	1												
	Stiff Grey		6	SS	1												
79.8			7	SS	2												
7.9	Clayey silt, trace gravel and sand		8	SS	4												
			9	SS	3												
			10	SS	1												
	Very Stiff Grey to Stiff		11	SS	3												
75.9			12	SS	7												
11.8	Silty sand, fine to medium, trace gravel, some silty clay seams		13	SS	16												
74.8	Compact Grey																
12.9	Sand, fine to coarse, some silt, trace gravel		14	SS	11												
			15	SS	41												
73.0	Compact to Dense Grey																
14.7	End of Borehole Auger Refusal																

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE RECORD ON SOIL EXAMINATION



# RECORD OF BOREHOLE No 89-4 Continued METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 995; E 359 010 ORIGINATED BY R.B.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 29, 1989 CHECKED BY A.C.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W		
	Continued															
73.1	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams.  Compact Grey and to Dense Grey Brown					Well Screen 75										
						74										
						73										
15.4	End of Borehole Auger Refusal  *Sank under weight of hammer															

OFFICE RECORD ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 917; E 359 045 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Wash Boring N Casing COMPILED BY A.C.  
DATUM Geodetic DATE May 30, 1989 CHECKED BY A.C.

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			20	40	60	80	100					
89.7	Ground Surface																GR SA SI CL
0.0	Topsoil																
0.2	Silty clay and clayey silt, trace sand and silty sand seams		1	SS	11												
	Very Stiff Grey Brown		2	SS	6												
87.0			3	SS	4												
2.7	Silty clay and clayey silt, trace gravel and sand		4	SS	2												
			5	SS	WH*												
	Firm to Stiff Grey		6	TW	WH*												
84.1																	
5.6	Sand, fine to coarse, trace gravel, trace to some silt		7	SS	31												
			8	SS	18												
	Compact to Very Dense Grey Brown		9	SS	>100												
81.6																	
87.1	Sand, trace gravel, trace to some silt, some silty fine sand seams, occasional cobble		10	SS	105												
80.6																	
9.1	Very Dense Grey Brown																
	End of Borehole																
	*Sank under weight of hammer																

Water level in open hole at elev. 88.6 metres on June 1, 1989

+ s = 12.8

2 89 (9)

1 93 (6)

8 77 (15)

## RECORD OF BOREHOLE No. 89-6

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 995; E 358 844 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 29 and 30, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo		WATER CONTENT (%)			
								20 40 60 80 100		20 40 60			
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL x LAB VANE					
88.4	Ground Surface												
0.1	Fill												
0.2	Topsoil												
0.4	Silty clay, some silty fine sand seams, (weathered crust)		1	SS	7								
			2	SS	8								
85.0	Very Stiff Grey Brown		3	TW	PH		Bentonite						
3.4	Silty clay, some silty fine sand seams						Standpipe A						
							Bentonite,	+ S = 8.9					
			4	TW	PH		84	+ S = 3.8					
							83 Native Backfill	+ S = 5.6					
								+ S = 4.9					
			5	SS	2		Water level in standpipe C at elev. 82.6 metres on July 19, 1989						
								+ S = 4.5					
							81	+ S = 3.3					
			6	SS	1								
							80	+ S = 4.8					
								+ S = 3.4					
	Stiff Grey		7	SS	2		Bentonite						
78.4							Peststone						
10.0	Sand, fine, some silt, trace gravel, some sandy silt layer		8	SS	23		Standpipe B						
77.4	Compact Grey												
11.0	Sandy silt, some gravel Grey		9	SS	31								
11.2	Dolomitic limestone bedrock, thinly to thickly bedded Grey		RC		REC= 99%		77 Bentonite						
			10	BXL	RQD= 67%								
	Continued						76						

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity



## METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 995; E 338 844 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 29 and 30, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80			100	W <sub>p</sub>	W	W <sub>L</sub>
								SHEAR STRENGTH kPa						WATER CONTENT (%)			
						</											

+3, x5: Numbers refer to Sensitivity



W P 146-74-00-3 LOCATION Co-ords N 5 021 024; E 358 914 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 5, 1989 CHECKED BY A.C.

[illegible]

+3, x5: Numbers refer to Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10



RECORD OF BOREHOLE No 89-8

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 906; E 358 959 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 6, 1989 CHECKED BY A.C.

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			20	40	60	80	100					
89.4	Ground Surface																
0.1	Asphalt						Asphalt										
88.9	Fill - crushed Stone																
0.5	Fill, sand and gravel																
0.7	Topsoil Dark Grey																
0.8	Sand, fine to coarse Brown																
			1	SS	6												
	Silty clay occasional fine to coarse sand seam (weathered crust)		2	SS	3												
	Very Stiff to Stiff Grey Brown		3	SS	1												
85.5																	
3.9																	
	Silty clay, occasional sand seam		4	SS	1												
			5	SS	WH*												
82.1	Firm to Stiff Grey																
7.3	Sandy silt, some gravel and clay (glacial till)		6	SS	7												
			7	SS	9												
			8	SS	6												
			9	SS	5												
			10	SS	5												
77.8	Loose Grey																
11.6	Sand, fine to coarse, some gravel, trace to some silt																
76.6	Compact Grey		11	SS	23												
12.8	Sand, fine to coarse, trace silt		12	SS	29												
76.0	Compact Grey																
13.4	Sand and gravel, occasional cobble																
75.2	Dense Grey		13	SS	100												
14.2	End of Borehole																
	*Sank under weight of hammer																

+3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 89-9

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 132; E 358 873 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 6, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
88.2	Ground Surface																GR SA SI CL
0.1	Asphalt						Asphalt										
	Fill crushed stone																
87.3	Fill sand and gravel occasional cobble																
0.9	Fill - silty sand, trace gravel																
86.9	Very Loose Brown		1	SS	3		Bentonite										
1.3	Silty sand, occasional silty clay seam																
86.4	Loose Brown		2	SS	10		Water level at elev. 86.5 metres on June 8, 1989										
1.8	Sand, fine to medium trace gravel						86										
85.8	Compact Grey																
2.4	Sand and gravel, occasional cobble and boulder, trace silt		3	SS	32												40 49 (11)
85.2	Dense Grey																
3.0							85										
	Sand, fine, trace to some silt		4	SS	14		Cave Material										
83.2	Compact Grey		5	SS	14		84										
5.0																	
	Sand, fine, some silt		6	SS	14		83										0 80 (20)
			7	SS	8												
			8	SS	12		82										
							Well Screen										
80.9	Loose to Compact Grey		9	SS	14		81										
7.3	Silty sand and sandy silt, occasional silty clay seam, scattered trace gravel		10	SS	10		80										2 39 54 5
			11	SS	15												
			12	SS	9		79										
77.6	Loose to Compact Grey		13	SS	15		78										
10.6	Sandy silt, some gravel and clay, occasional cobble (Glacial Till)																
76.3	Compact to Dense Grey		14	SS	14		77										
11.9	End of Borehole Auger Refusal						76										

RECORD OF BOREHOLE No. 89-10

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 206; E 358 886 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Gendetic DATE June 23, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
86.6	Ground Surface																
0.0	Topsoil																
0.2	Probably Silty Clay																
							86										
							85										
							84										
							83										
82.2	Grey Brown to Grey						82										
4.4	Silty clay, trace gravel, occasional silty sand seam		1	SS	1		81										
81.1	Grey						80										
5.5	Sandy silt to silty sand, some gravel and clay		2	SS	14		79										
							78										
77.9	Very Loose Grey						77										
8.7	Silty clay, some sand, trace gravel		4	SS	1		76										
76.4	Grey						75										
10.2	Probably silty sand																
75.9																	
10.7	End of Borehole																
	* Note: Water level not established																



RECORD OF BOREHOLE No. 89-12

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 110; E 358 919 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 26, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.7	Ground Surface																
0.0	Topsoil																
87.2																	
0.5	Silty clay (weathered crust)																
85.2	Grey Brown																
2.5	Silty clay, occasional sand seam																
84.0	Grey		1	SS	WH*												
3.7	Sand, fine to coarse, trace gravel, occasional silty sand seam																
82.5	Dense Grey		2	SS	33												
5.2	End of Borehole																
	*Sank under weight of hammer																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No. 89-13

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 060; E 358 936 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 26, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	W	LIQUID LIMIT W <sub>L</sub>		
87.8	Ground Surface																
0.0	Topsoil																
87.4																	
0.4	Silty clay (weathered crust)																
85.1	Grey Brown																
2.7	Silty clay		1	SS	WH*												
83.1	Grey																
4.7	Silty Sand		2	SS	13												
82.5	Compact Grey																
5.3	Sandy silt, some gravel, trace clay, occasional cobble																
			3	SS	10												
80.8	Compact Grey																
7.0	Probably Sand																
80.2	Grey																
7.6	End of Borehole																
	* Sank under weight of hammer.																

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No. 89-14

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 023; E 358 953 ORIGINATED BY L.Q.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 4, 1989 CHECKED BY A.C.

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No. 89-15

METRIC

W P 146-74-00 -3 LOCATION Co-ords N 5 020 971; E 358 967 ORIGINATED BY L.Q.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 4, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT  Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo					WATER CONTENT (%)				
								20 40 60 80 100					Wp W Wl				
88.4	Ground Surface																
0.0	Topsoil																
0.1							88										
	Probably silty clay, occasional sand seam with depth						87										
							86										
							85										
							84										
							83										
82.0	Grey Brown to Grey		1	SS	1		82										
6.4	Silty clay, some sand, trace gravel						81										
			2	SS	2		80										
79.6	Grey						79										
8.8	Silty sand, trace gravel, some clay		3	SS	4		78										
78.5	Very loose Grey																
9.9	Probably sand, some gravel occasional cobble																
77.7	Grey																
10.7	End of Borehole																
	* Note: Water level not established						77										

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No. 89-16

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 911; E 359 095 ORIGINATED BY L.O.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 7, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>	
93.2	Ground Surface															
0.0	Topsoil						93									
0.2	Sand, trace silt and gravel						92									
90.8	Brown						91									
2.4	Sand and gravel, trace silt, occasional cobble and boulder						90									
89.4	Dense Brown		1	SS	34		89									
3.8	Sand, fine to medium, trace silt, occasional cobble						88									
			2	SS	23		87									
							86									
			3	SS	22											
85.6	Compact Brown to Grey Brown															
7.6	End of Borehole															
	* Note: Water level not established						85									

RECORD OF BOREHOLE No. 89-17

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 864; E 359 112 ORIGINATED BY L.Q.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 7, 1989 CHECKED BY A.C.

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 <sup>o</sup> VALUES			20	40	60	80	100					
95.3	Ground Surface Topsoil																
0.1 94.8	Silty sand Brown						95										
0.5	Probably silty clay, some sand, trace gravel						94										
93.3	Grey Brown						93										
2.0	Probably sand and gravel, trace silt, occasional cobble						92										
91.6							91										
3.7	Sand, fine to medium and fine to coarse, trace gravel and silt		1	SS	33		90										
			2	SS	35		89										
87.7	Dense Grey Brown		3	SS	60/150 mm		88										
7.6	Sand and gravel, trace silt, occasional cobble						87										
85.5	Very Dense Grey to Dense Brown		4	SS	44		86										
9.8	End of Borehole						85										
	* Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No. 89-19

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 954: E 359 068 ORIGINATED BY L.Q.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 10, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20   40   60   80   100	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)					
89.4	Ground Surface																
0.0	Topsoil																
0.2	Silty sand to sandy silt						89										
88.3	Grey Brown																
1.1	Probably silty clay						88										
							87										
							86										
85.6	Grey Brown																
3.8	Sand fine to coarse, trace gravel and silt					*	85										
84.2	Compact      Grey Brown		1	SS	27												
5.2	End of Borehole						84										
	* Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No. 89-20

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 000; E 359 047 ORIGINATED BY L.O.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 10, 1989 CHECKED BY A.C.


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			20	40	60	80	100					
88.7	Ground Surface																GR SA SI CL
0.0	Topsoil																
88.0	Silty sand, trace gravel																
0.7	Probably silty clay, occasional sand seam																
			1	SS	WH*												
			2	SS	PM	**											
83.4	Grey Brown to Grey																
5.3	Sand, fine to medium, trace silt																
			3	SS	6												
82.0	Loose Grey																
6.7	End of Borehole																
	* Sank under weight of hammer.																
	** Note: Water level not established																

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No. 89-21

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 046; E 359 027 ORIGINATED BY A.C.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 11, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LQUID LIMIT	UNIT WEIGHT  Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>									
								SHEAR STRENGTH kPo						WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
88.1	Ground Surface						20 40 60 80 100													
0.0	Topsoil																			
0.2	Probably silty clay, occasional sand seam																			
	Grey Brown to Grey		1	SS	1															
			2	SS	1															
81.1																				
7.0	Probably silty sand																			
80.5																				
7.6	End of Borehole																			
	* Note: Water level not established																			

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No. 89-22

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 152; E 358 971 ORIGINATED BY L.O.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.

DATUM Geodetic DATE July 11, 1989 CHECKED BY A.C.

[illegible]

+3, x<sup>5</sup>: Numbers refer to Sensitivity



**RECORD OF BOREHOLE SHEETS  
FROM PREVIOUS INVESTIGATIONS**

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							W <sub>p</sub> W W <sub>L</sub>		
								SHEAR STRENGTH kPa							WATER CONTENT (%)		
81.0	Ground Surface						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	20	40	60					GR SA SI		

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 88-4

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 150; E 358 904 ORIGINATED BY PR  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
DATUM Geodetic DATE October 20, 1988 CHECKED BY AC

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.3	Ground Surface															
0.0	Topsoil.															
0.2	Silty clay, some silty fine sand seams. (Weathered Crust)															
	Very Stiff Grey Brown	1	SS	8												
85.3		2	SS	4												
2.0	Silty clay, some silty fine sand seams.															
	Firm Grey	3	SS	1												
		4	SS	PM												
83.0																
4.3	Silty sand & gravel, trace clay.															
82.1	Loose Grey	5	SS	5												24 38 (38)
5.2	Sand, layered. Fine to coarse sand, some gravel & silt, fine sand with some silt, medium to coarse sand, trace gravel, silty sand, some gravel.	6	SS	3												12 53 (35)
		7	SS	14/15												
	Loose to Compact Grey Brown and Grey	8	SS	26												3 94 (3)
		9	SS	23												21 60 (19)
78.2																
9.1	End of Borehole															

RECORD OF BOREHOLE No 88-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 082; E 358 806 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
DATUM Geodetic DATE October 17, 1988 CHECKED BY AC

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			20	40	60	80	100					
88.2	Road Surface															
0.1	Asphalt.					88										
87.3	Fill-sand, some gravel, trace to some silt. Brown		1	AS*												
0.9	Silty clay, some silty fine sand seams. (weathered crust) Very Stiff Grey Brown to Stiff		2	SS	10											
			3	SS	6											
85.3			4	SS	2											
2.9	Silty clay, some silty fine sand seams. Firm Grey		5	SS	WP**											
83.7						86										
4.5	Silty sand & gravel.		6	SS	6											
83.0	Loose Grey															
5.2	End of Borehole															
	*AS: Auger Sample **Sank under weight of hammer															

# RECORD OF BOREHOLE No 88-6

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 852; E 358 895 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
 DATUM Geodetic DATE October 17, 1988 CHECKED BY AC

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
89.2	Road Surface															
0.1	Asphalt.															
88.6	Fill-sand & gravel, trace silt, occasional cobble. Brown															
0.6	Silty clay, some silty fine sand seams. (Weathered Crust)		1	SS	5											
	Very Stiff Grey Brown		2	SS	5											
86.4			3	SS	2											
2.8	Silty clay, some silty fine sand seams.															
	Stiff Grey		4	SS	1											
			5	SS	WH*											
84.0																
5.2	End of Borehole															
	*Sank under weight of hammer															

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE RECORD ON SOIL CATALOGUE

RECORD OF BOREHOLE No 88-7

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 864; E 359 027 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
DATUM Geodetic DATE October 21, 1988 CHECKED BY AC

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			20	40	60	80	100					
91.0	Ground Surface															
0.1	Topsoil.															
90.2	Sand, fine to medium trace gravel, some silt: Red Brown															
0.8	Silty clay, some silty sand & sand seams. (Weathered Crust)		1	SS	6											
	Very Stiff Grey Brown		2	SS	6											
			3	SS	4											
			4	SS	1											
87.3																
3.7	Silty clay, some silty sand & sand seams.															
	Stiff Grey															
			5	SS	1											
84.7																
6.3	Sand, layered. Fine to coarse sand, trace silt and silty sand, trace gravel.		6	SS	7											
83.5	Loose to Compact		7	SS	21											
7.5	Silty clay, some sand seams.															
82.8	Grey		8	SS	2											
8.2	End of Borehole															



# RECORD OF BOREHOLE No 5

METRIC

W P 146-74-00-5 LOCATION Co-ords. N 5 020 688.8; E 359 110.3 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
 DATUM Geodetic DATE 84 05 15 CHECKED BY [Signature]

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			20	40						60
98.1	Ground Surface													GR SA SI CL	
0.0	Landfill Silty Sand trace gravel		1	SS	15										
	Sand some silt trace gravel pieces of wire cable, rubber tires		2	SS	5										9 70 16 5
	Loose to Compact		3	SS	14										
			4	SS	7										
92.9															
5.2	Sand with gravel some silt		5	SS	72									42 48 9 1	
			6	SS	38										
	Dense to Very Dense		7	SS	49									22 61 14 3	
			8	SS	100										
85.9															
12.2	End of Borehole														
	* Note: Groundwater Elevation assumed to be at the Elevation of Caving in the Open Borehole.														

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 6

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 021 257.6; E 358 850.6 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY IR  
 DATUM Geodetic DATE 84 05 16 CHECKED BY GP

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 Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100
								SHEAR STRENGTH kPa							WATER CONTENT (%)		
86.7	Ground Surface																
0.0	Silty Clay		1	SS	21												
	some sand trace sand		2	SS	15									O.M.* = 0.83			
	Very Stiff		3	SS	11												
	occasional silt and sand seams		4	SS	2/	45 cm											
			5	TW	PM								17.1				
			6	SS	2/	45 cm											
			7	TW	PM								17.0	c' = 33 kPa φ' = 24° 0 8 56 36 C <sub>c</sub> = 0.71 e <sub>o</sub> = 1.35 P <sub>c</sub> = 112 kPa			
	Firm to Stiff		8	TW	PM								17.4				
			9	SS	2												
			10	TW	PH								17.9	c' = 24 kPa φ' = 32° 0 17 55 28 C <sub>c</sub> = 0.92 e <sub>o</sub> = 1.192 P <sub>c</sub> = 232 kPa			
75.9																	
10.8	End of Borehole Refusal to Auger Probable Bedrock																
	* Note: O.M. indicates percentage of organic matter by weight.																

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 7

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 020 720.8; E 359 177.2 ORIGINATED BY HS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY IR  
DATUM Geodetic DATE 84 05 15 CHECKED BY GP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
96.5	Ground Surface														
0.0	Fill Silty Clay with sand  Firm		1	SS	4		96								
94.2							95								
2.3			2	SS	2		94								
	very loose						93								0 91 8 1
			3	SS	33		92								
	Sand trace silt						91								
			4	SS	38		90								0 94 5 1
	Dense						89								
			5	SS	53		88								
	some silt						87								0 76 22 2
			6	SS	40		86								
	and silt						85								1 45 50 4
			7	SS	38		84								
84.2			8	SS	20/15 cm		83								
12.3	End of Borehole														
82.5															
14.0	End of Cone Test														
	* Note: Water level not established.														

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 8

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 021 271.0; E 358 938.7 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
 DATUM Geodetic DATE 84 05 15 CHECKED BY JP

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
86.4	Ground Surface													
0.0	Silty Clay													
	trace organics		1	SS	12									
	trace sand		2	SS	9									
	Very Stiff													
	Clay		3	SS	6									
	Stiff													
	Firm		4	SS	1/45 cm									
77.6														
8.8	Heterogeneous Mixture of Silty Clay with sand some gravel		5	SS	10									
	Firm to Stiff		6	SS	5									
			7	SS	5									
			8	SS	8									
73.3														
13.1	End of Borehole Refusal to Auger Probable Bedrock													

+3, x5: Numbers refer to 20  
Sensitivity 15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 9

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 020 929.6; E 358 976.7 ORIGINATED BY HS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY IR  
DATUM Geodetic DATE 84 05 15 CHECKED BY

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	20 40 60 80 100					
88.6	Ground Surface												
0.0													
	Silty Clay		1	SS	4								
	some sand		2	SS	4								
	Stiff												
			3	TW	PH								
	Occasional Silt and Sand Seams		4	SS	4								
			5	SS	3								
82.2			6	SS	4								
6.4	Heterogeneous Mixture Silty Clay with sand trace gravel												
	Firm to Stiff		7	SS	13								
			8	SS	7								
78.4													
10.2	Sand some silt												
77.9			9	GS									
10.7	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 10

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 020 521.9; E 359 252.3 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
 DATUM Geodetic DATE 84 05 16 CHECKED BY [Signature]

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
97.6	Ground Surface													
0.0														
	Sand		1	SS	18									
	trace silt													
	Compact		2	SS	16									0 94 5 1
			3	SS	21									
			4	SS	22									
			5	SS	20									0 97 (3)
	dense		6	SS	38									
			7	SS	30									
			8	SS	29									
			9	SS	40									0 96 (4)
			10	SS	39									
	compact		11	SS	17									0 97 (3)
	some silt		12	SS	16									
82.5														
15.1														

Continued

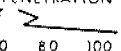

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

Continued

# RECORD OF BOREHOLE No 10 Continued METRIC

W P 146-74-00-3 LOCATION Co.ords. N 5 020 521.9; E 359 252.3 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
 DATUM Geodetic DATE 84 05 16 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 			PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAI PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE				
82.5	Continued														
15.1	Sand  with silt   Compact		13	SS	16									1 65 29 2	
			14	SS	11										

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 11

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 021 086.1; E 358 912.2 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
 DATUM Geodetic DATE 84 05 15 CHECKED BY GP

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			20	40	60	80	100					
87.7	Ground Surface																
0.0	Silty Clay trace sand  Stiff		1	SS	6												
			2	TW	PH												
	some sand trace gravel		3	SS	0	**											
84.7																	
3.0	Sandy Silt some gravel to sand some silt trace gravel		4	TW	PH												
			5	SS	26												
83.1	Compact																
4.6	End of Borehole																
	*Note: Water level immediately after augering.																
	** Sank under own weight																

# RECORD OF BOREHOLE No 12

METRIC

W P 146-74-00-3 LOCATION Co-ords. N 5 020 485.6; E 359 175.3 ORIGINATED BY HS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
 DATUM Geodetic DATE 84 05 18 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
96.7	Ground Surface																
0.0	Silty Clay (fill) trace sand trace of roots Stiff		1	SS	14												
95.0																	
1.7	Sand trace silt		2	SS	10												
			3	SS	17												
	Compact		4	SS	42												
			5	SS	40												
			6	SS	46												
	Dense		7	SS	61												
	Very Dense																
	some silt																
87.1			8	SS	71												
9.6	End of Borehole																
	* Note: Water level not established.																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 1

PROJECT NAME: BRUCE PIT

PROJECT NO.: 2396

CLIENT: MTO

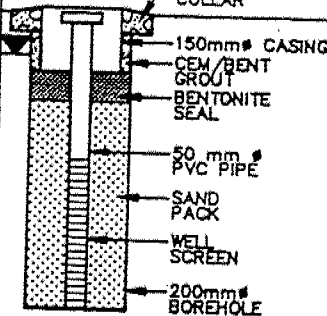
LOCATION: AS PER PLAN

HOLE DESIGNATION: OW1--88

DATE COMPLETED: 27 APR 1988

DRILLING METHOD: 108 mm ID HSA

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	87.311 87.31				
1.0	PT PEAT: amorphous, fibrous in a slightly woody structure, compact, brown, very moist.	87.11				
2.0	SM SAND: little silt, compact, fine to medium grained, poorly graded, massive, brown, moist. - wet - grey	86.87		1SS	X	13
3.0	END OF HOLE • 3.05 m BGS.	84.26	<p>SCREEN DETAILS: Screened Interval: 84.26 to 85.79 AMSL Length -1.52m Diameter -50mm Slot # 10 Material- PVC</p>	2SS	X	16
4.0						
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						
13.0						

## NOTES:

MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



2/05/88

# STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 2

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OV $\frac{1}{2}$ -88

PROJECT NO.: 2396

DATE COMPLETED: 25 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	96.903 96.90 96.83	CONCRETE PROTECTIVE COLLAR			
	TOPSOIL: sandy, silty loam, compact, brown, slightly moist.		150mm# CASING CONCRETE			
1.0	SW SAND: trace silt, trace fine gravel, dense, well graded, medium to coarse grained, brown, slightly moist.		200mm# BOREHOLE	1SS	⊗	34
2.0			CEMENT/BENTONITE GROUT	2SS	⊗	40
3.0	- little gravel		50 mm # PVC PIPE	3SS	⊗	38
4.0			BENTONITE SEAL	4SS	⊗	72
5.0			NATURAL CAVE-IN	5SS	⊗	28
6.0	- very dense, moist		BENTONITE SEAL	6SS	⊗	54
7.0			SAND PACK	7SS	⊗	37
8.0	- dense		WELL SCREEN	8SS	⊗	53
9.0	- very moist, slight plasticity, some silt	87.66				
10.0						
11.0	- very dense, occasional silt seam, angular gravel, wet					
12.0		84.62				
13.0	SM SAND: some silt, very dense, fine grained, poorly graded, massive, grey, wet.	84.10				
	END OF HOLE • 12.80 m BGS.					

## SCREEN DETAILS:

Screens Interval:  
84.80 to 86.33 AMSL  
Length -1.52m

Diameter -50mm  
Slot # 10  
Material-PVC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



4/05/88

# STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 3

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW-88

PROJECT NO.: 2396

DATE COMPLETED: 26 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	98.262 98.26 98.21	CONCRETE PROTECTIVE COLLAR			
1.0	TOPSOIL: sandy loam, brown, moist. SP SAND: trace silt, compact, poorly graded, medium grained, layered, light brown, slightly moist.		150mm# CASING			
2.0			200mm# BOREHOLE	1SS	⊗	7
3.0			CEMENT/ BENTONITE GROUT	2SS	⊗	11
4.0	CL CLAY (Till): little silt, little fine gravel, trace sand, stiff, low plastic, green-grey, silt seams, moist, occasional wet lenses of coarse sand.	94.66	50 mm # PVC PIPE	3SS	⊗	5
5.0				4SS	⊗	11
6.0				5SS	⊗	85
7.0	SW SAND: some silt, some fine gravel, very dense, well graded, fine to coarse grained, layered, slightly moist.	91.61		6SS	⊗	>100
8.0			BENTONITE SEAL	7SS	⊗	57
9.0			SAND PACK	8SS	⊗	58
10.0	- little gravel, massive, wet, grey-brown	87.97	WELL SCREEN			
11.0						
12.0	- siltier, very moist					
13.0	END OF HOLE @ 12.80 m BGS.	85.45	SCREEN DETAILS: Screened Interval: 86.59 to 88.11 AMSL Length -1.52m			

Diameter -50mm  
Slot # 10  
Material-PVC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



4/05/88

# STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 4

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW4-88

PROJECT NO.: 2396

DATE COMPLETED: 27 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE			
				NUMBER	STATE	VALUE	* HNU (ppm)
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	95.707 95.71	CONCRETE PROTECTIVE COLLAR				
1.0	REFUSE: decayed domestic garbage, plastic, wood, black, moist, compact.		150mm# CASING				
2.0			200mm# BOREHOLE				
3.0			CEMENT/BENTONITE GROUT				
4.0			50 mm # PVC PIPE				
5.0							
6.0							
7.0	SP SAND: trace silt, compact, medium grained, uniform, massive, light grey-brown, moist, garbage odour.	89.46	BENTONITE SEAL	1SS	X	32	3
8.0	- occasional thin seam of coarse sand	87.87		2SS	X	32	2
9.0							
10.0	SM SAND: little silt, dense, fine grained, poorly graded, grey-brown, massive, very moist, garbage odour.	86.56	SAND PACK	3SS	X	29	
11.0			WELL SCREEN	4SS	X	27	
12.0	ML SILT: some sand, compact, layered, thin laminations of fine sand, wet, grey, slight garbage odour.	84.67					
13.0	SM SAND: little silt, fine grained, poorly graded, massive, compact, grey, wet, odourless.	83.15 82.91		5SS	X	17	
	END OF HOLE @ 12.80 m BGS. * - HNU READING FROM SAMPLE HEAD SPACE		SCREEN DETAILS: Screened Interval: 84.73 to 87.78 AMSL Length - 3.05m			Diameter - 50mm Slot # 10 Material - PVC	

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



5/05/88

# STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 5

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW5-88

PROJECT NO.: 2396

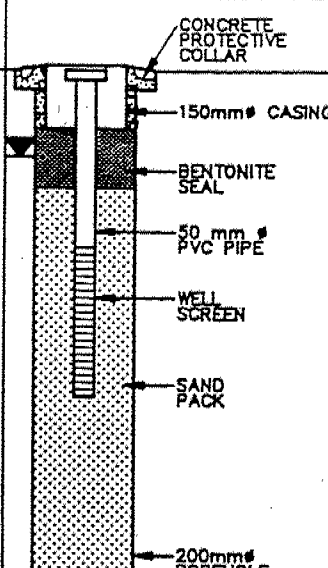
DATE COMPLETED: 26 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	88.534 88.53	 <p>CONCRETE PROTECTIVE COLLAR</p> <p>150mm# CASING</p> <p>BENTONITE SEAL</p> <p>50 mm # PVC PIPE</p> <p>WELL SCREEN</p> <p>SAND PACK</p> <p>200mm# BOREHOLE</p>			
1.0	SP SAND: little silt, compact, uniform, medium grained, massive, brown, moist.	87.63				
2.0	- wet			1SS	⊗	17
3.0	SM SAND: some silt, compact, fine grained, layered with occasional 3 cm seams of coarse sand, wet, grey, thin silt seams.	85.64		2SS	⊗	20
4.0	- siltier, not as dense					
5.0	END OF HOLE @ 5.18 m BGS.	83.35	<p>SCREEN DETAILS: Screened Interval: 85.18 to 86.71 AMSL Length -1.52m Diameter -50mm Slot # 10 Material- PVC</p>	3SS	⊗	15
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						
13.0						

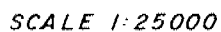
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS ○

WATER FOUND ∇

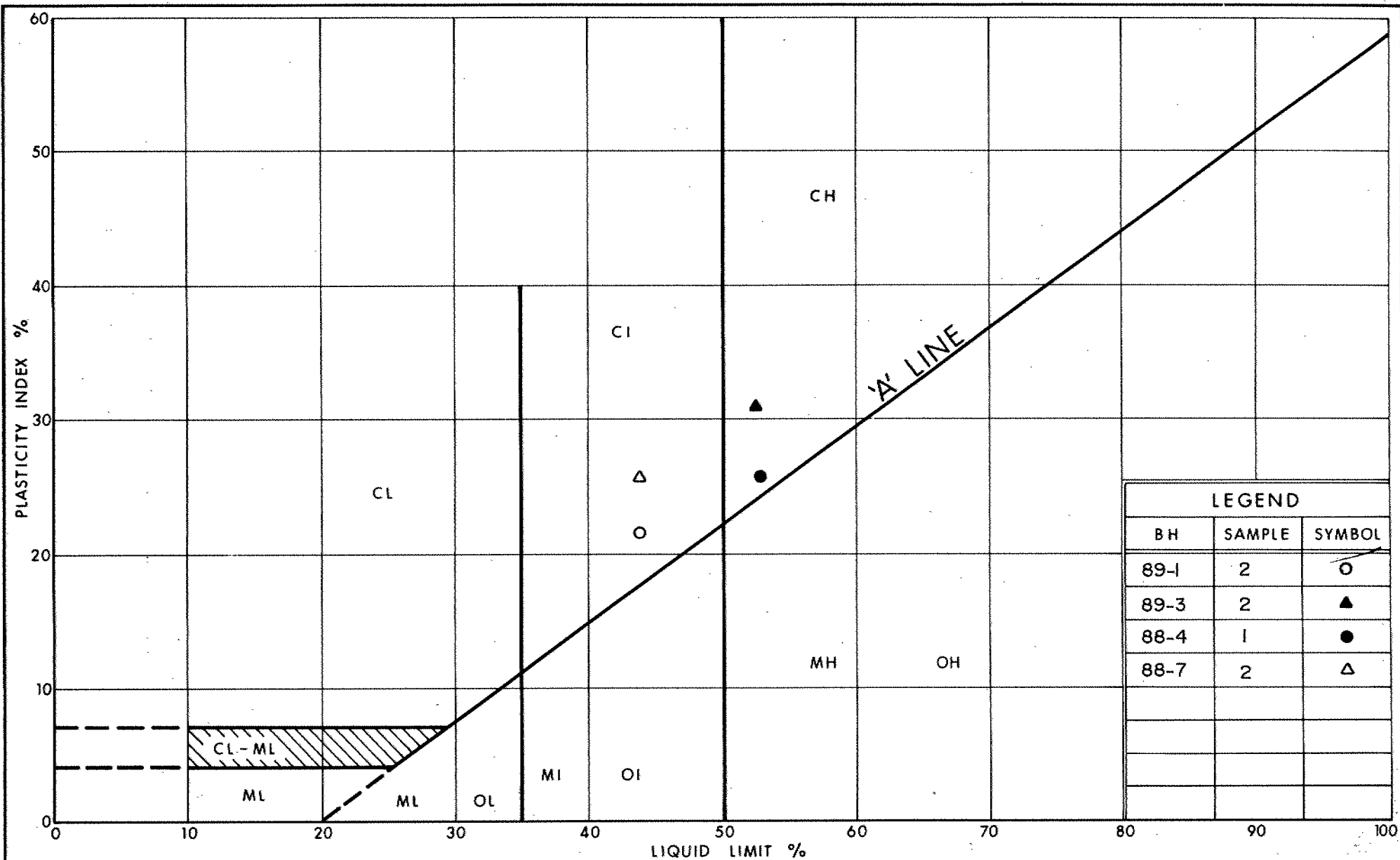
STATIC WATER LEVEL ▼ 2/05/88

WP 146-74-00-3



THIS DRAWING IS TO BE READ IN CONJUNCTION  
WITH ACCOMPANYING REPORT.

Drawn JC  
Chkd. AC



Ministry of  
Transportation

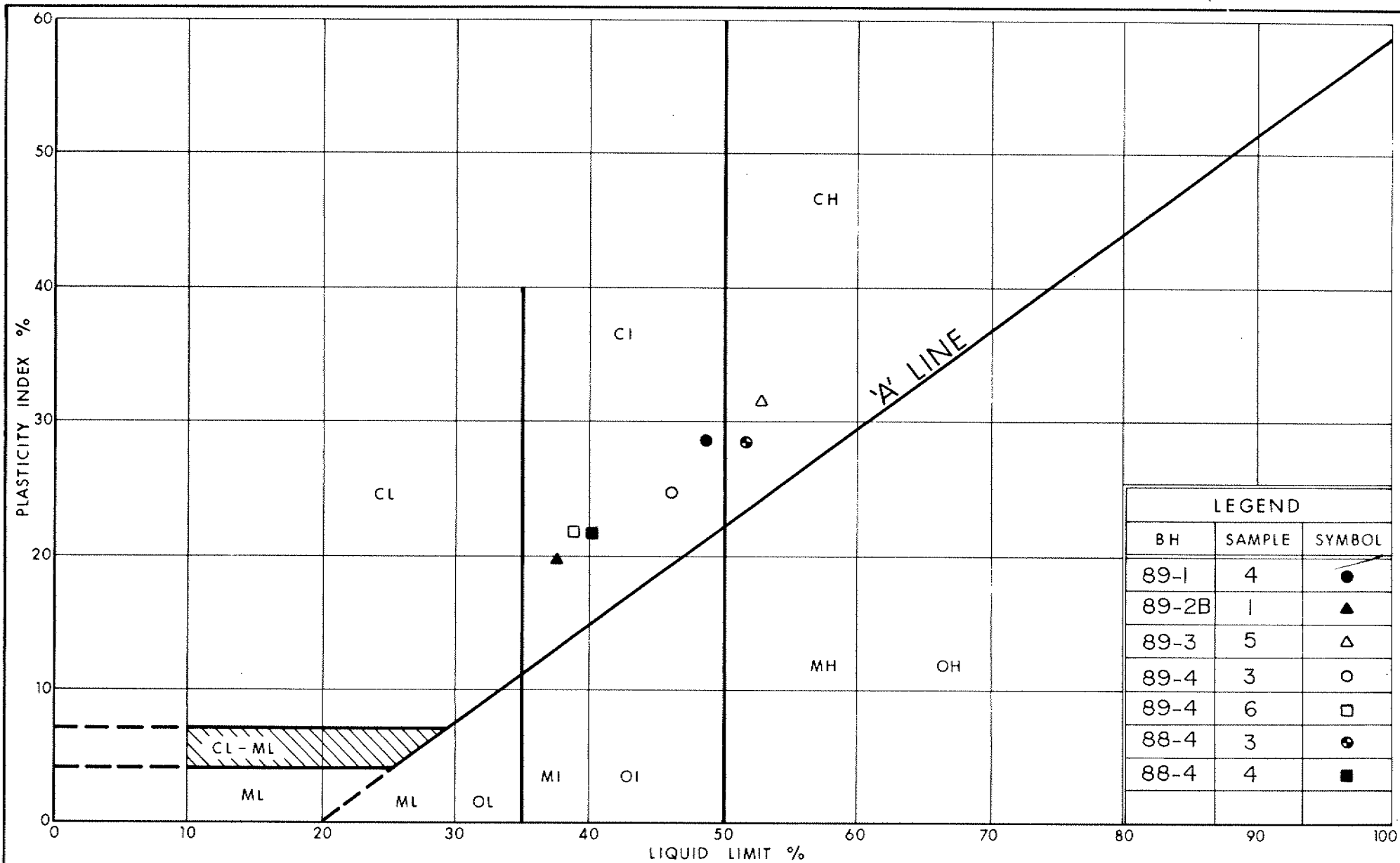
Ontario

**PLASTICITY CHART**  
SILTY CLAY, some silty sand seams  
(Weathered Crust)

FIG No 2

W P 146-74-00-3

265



Ministry of  
Transportation

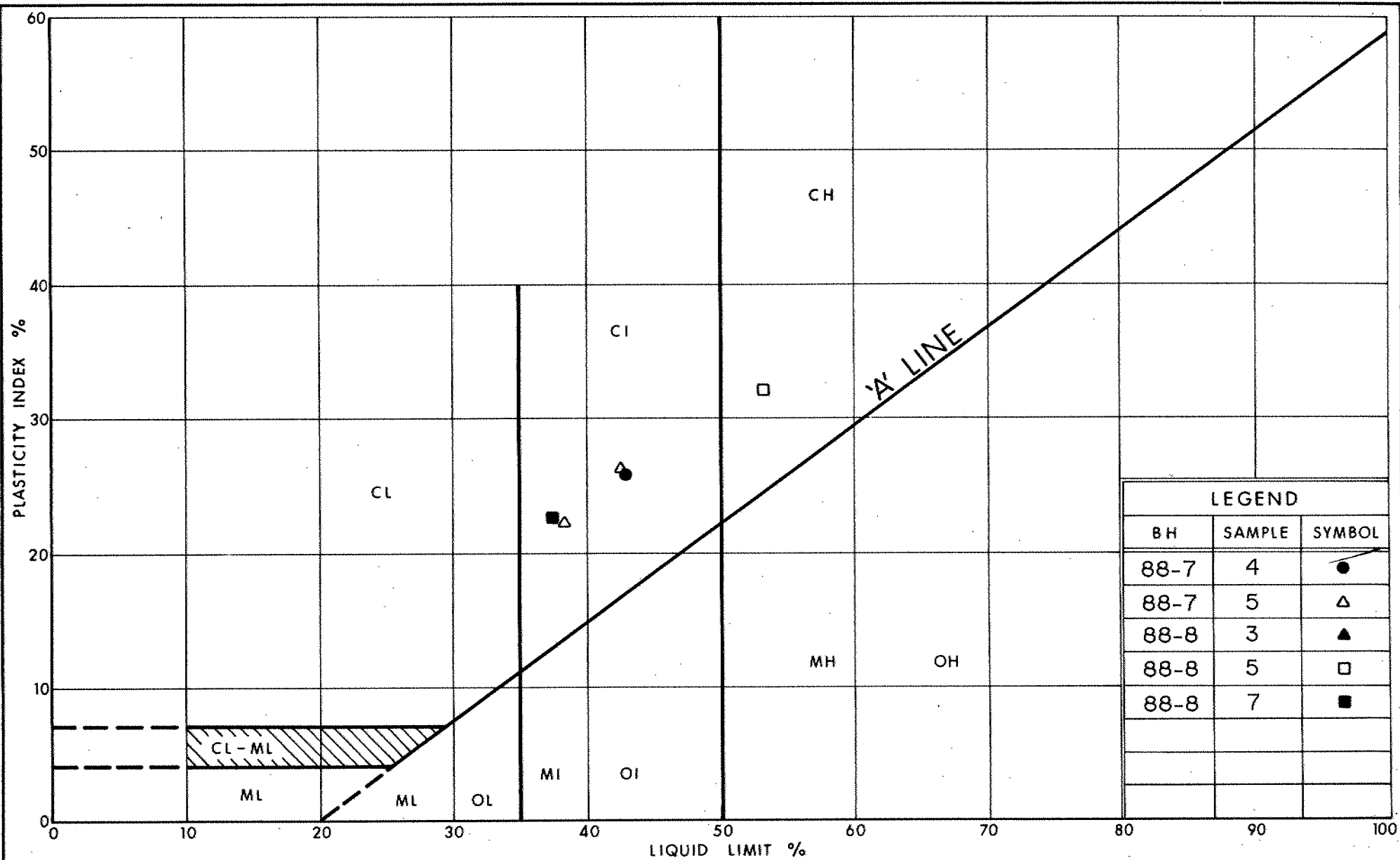
# PLASTICITY CHART

SILTY CLAY, some silty sand and sand seams

FIG No 3

W P 146-74-00-3





Ministry of  
Transportation  
Ontario

## PLASTICITY CHART

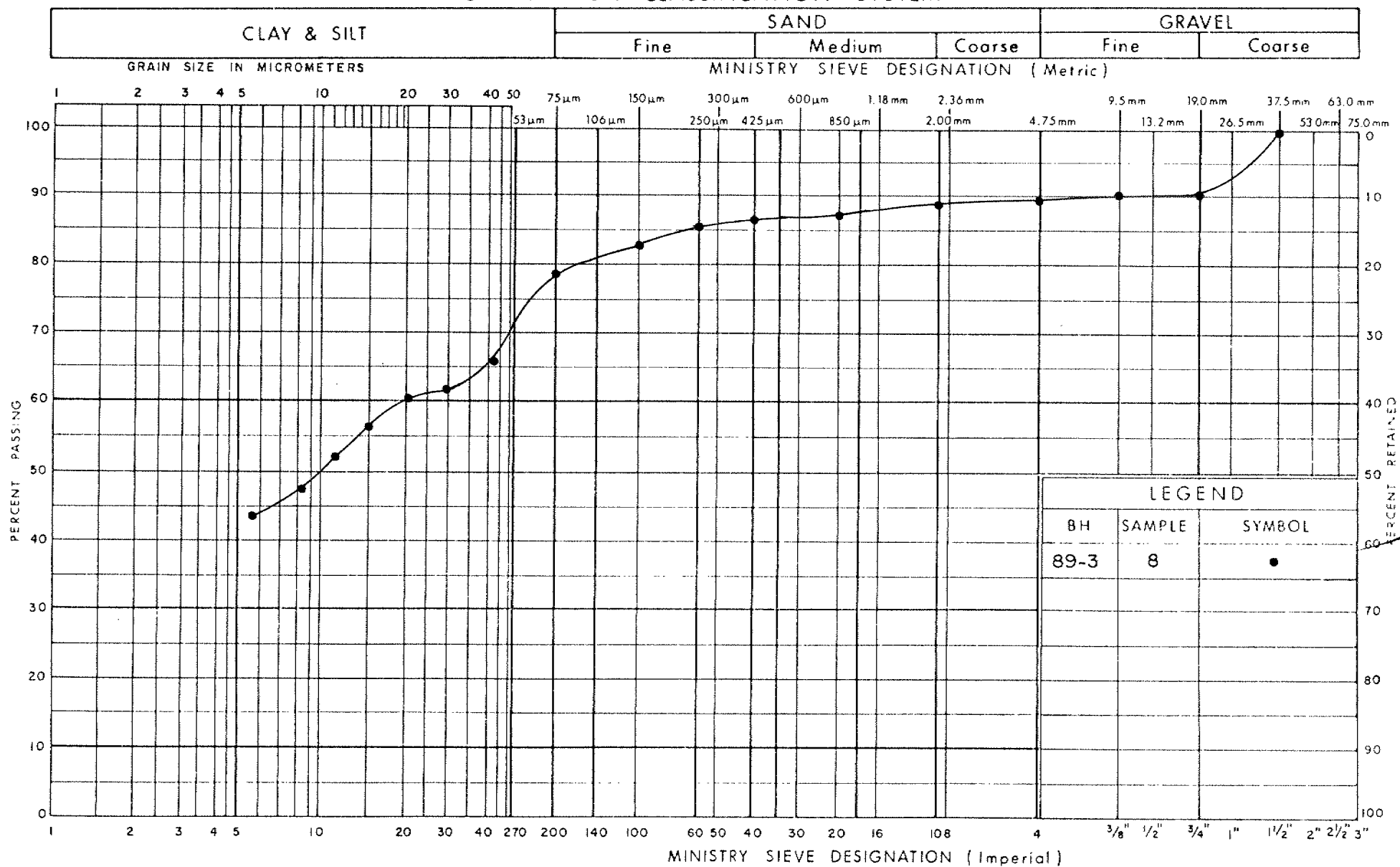
SILTY CLAY, some silty sand and sand seams

FIG No 4

W P 146-74-00-3

267

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

Ontario

## GRAIN SIZE DISTRIBUTION

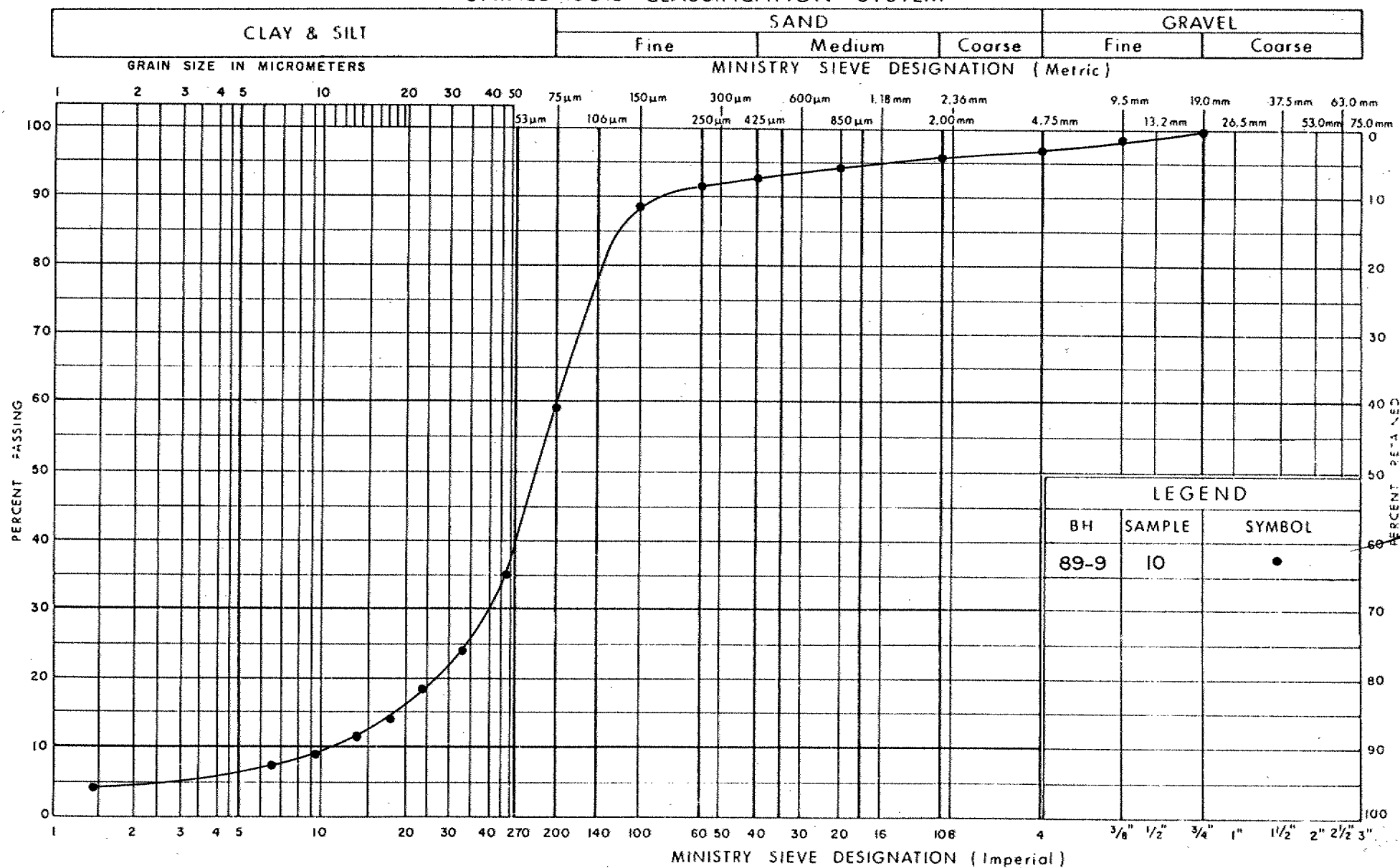
CLAYEY SILT, trace gravel and sand

FIG No 5

W P 146-74-00-3

89Z 268

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

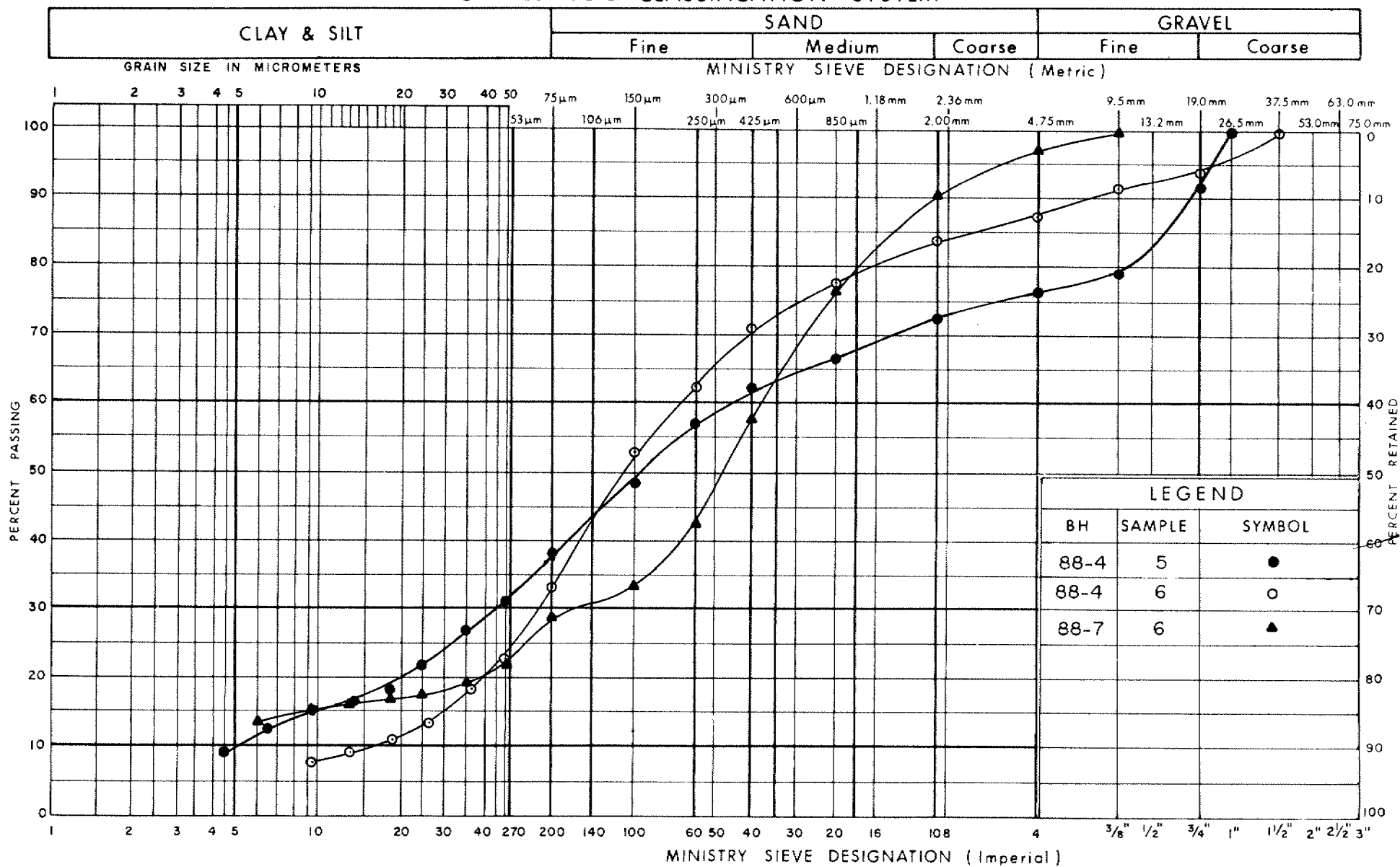
## GRAIN SIZE DISTRIBUTION

SILTY SAND and SANDY SILT

FIG No 6

W P 146-74-00-3

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION

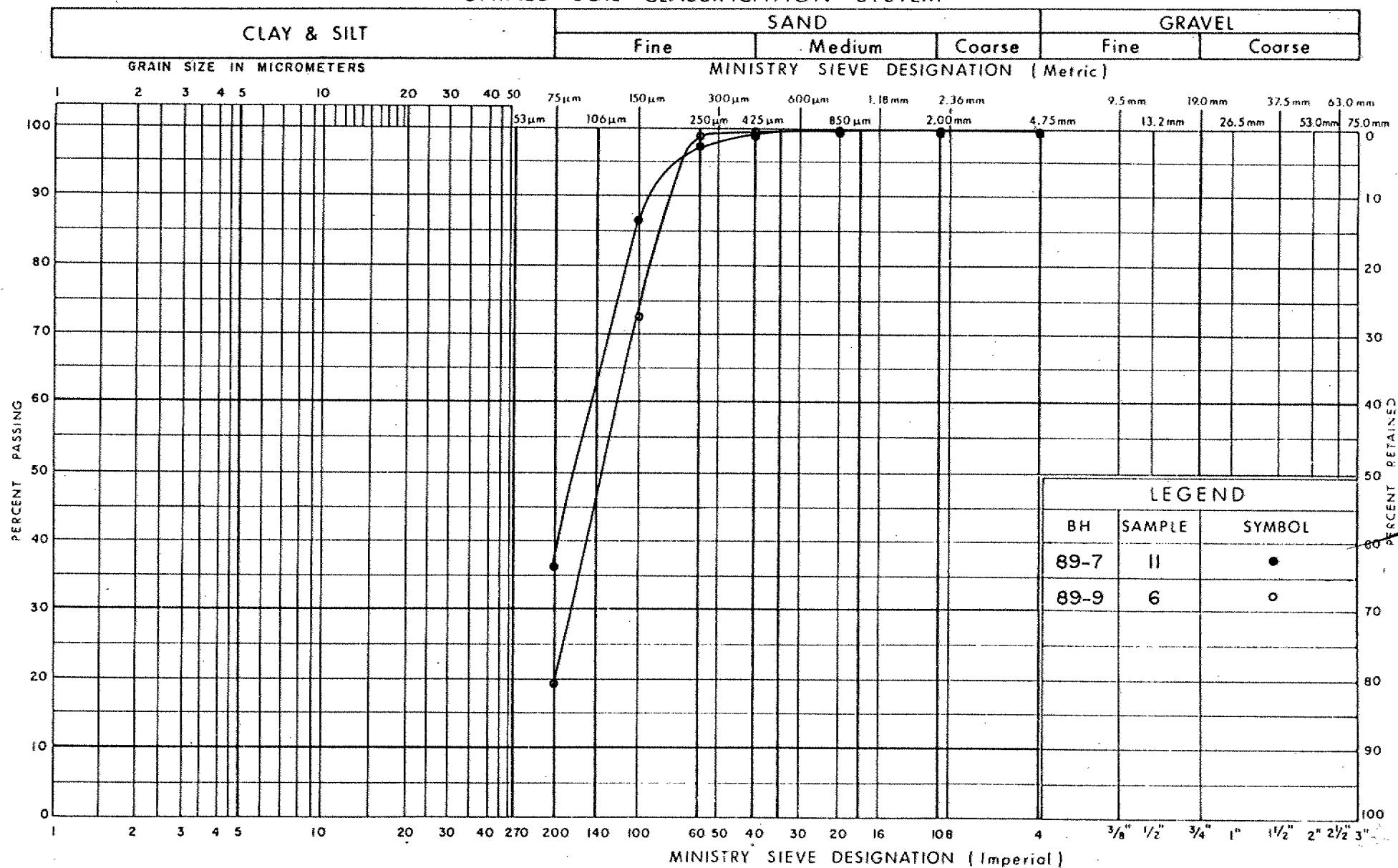
SILTY SAND

FIG No 7

W P 146-74-00-3

270

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

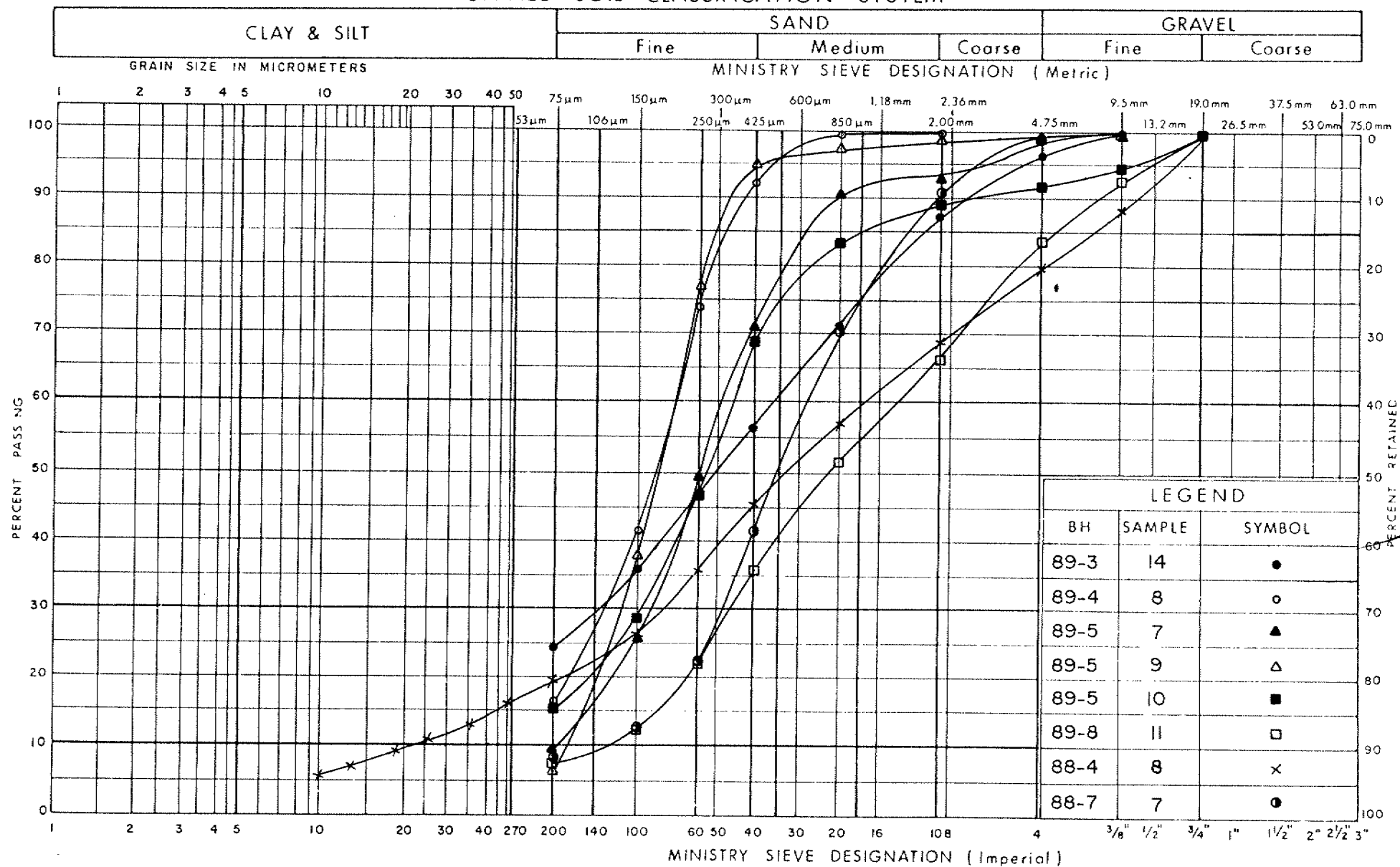
## GRAIN SIZE DISTRIBUTION

Fine SAND, some silt

FIG No 8

W P 146-74-00-3

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

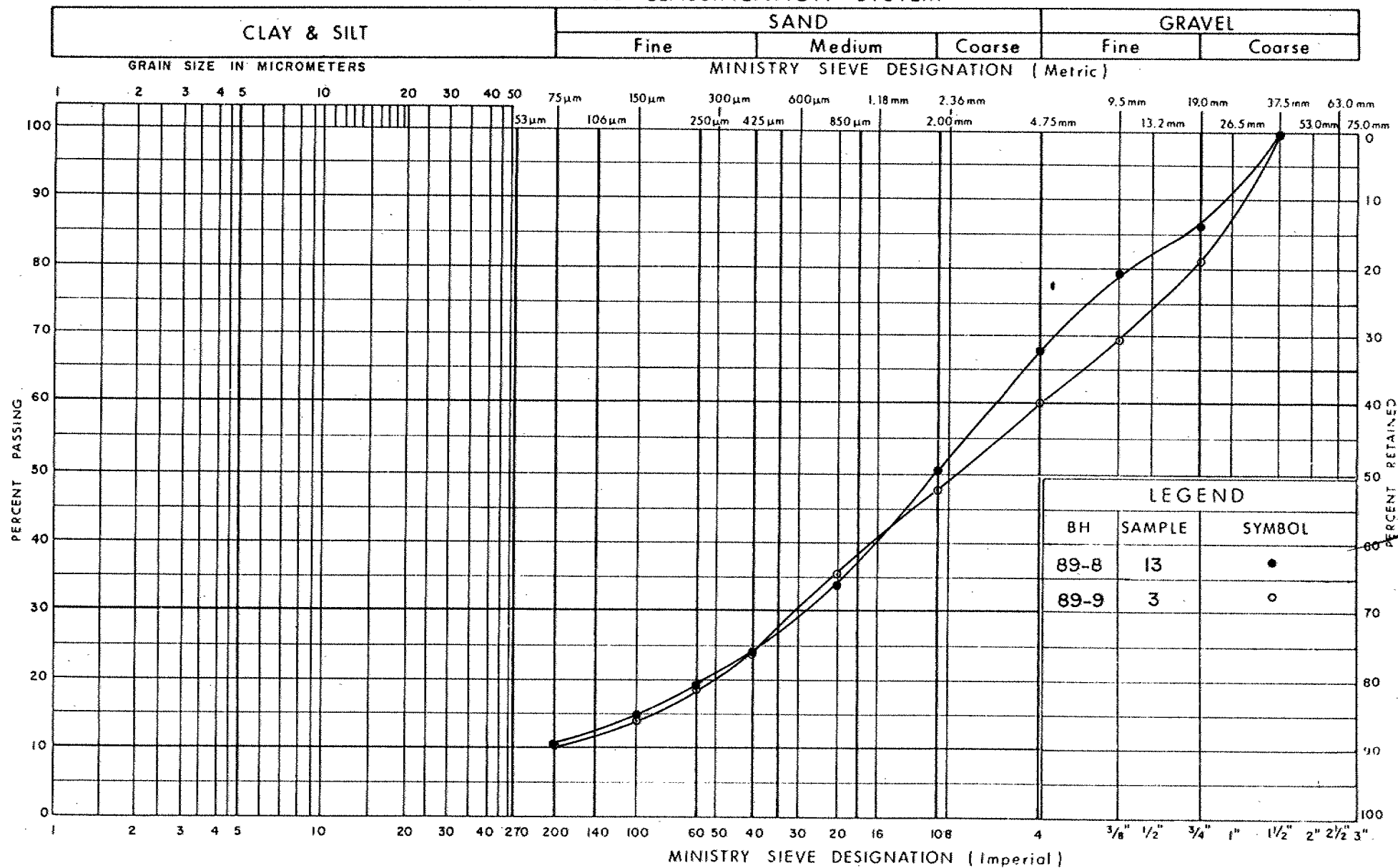
## GRAIN SIZE DISTRIBUTION

SAND, trace to some silt and gravel

FIG No 9

W P 146-74-00-3

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

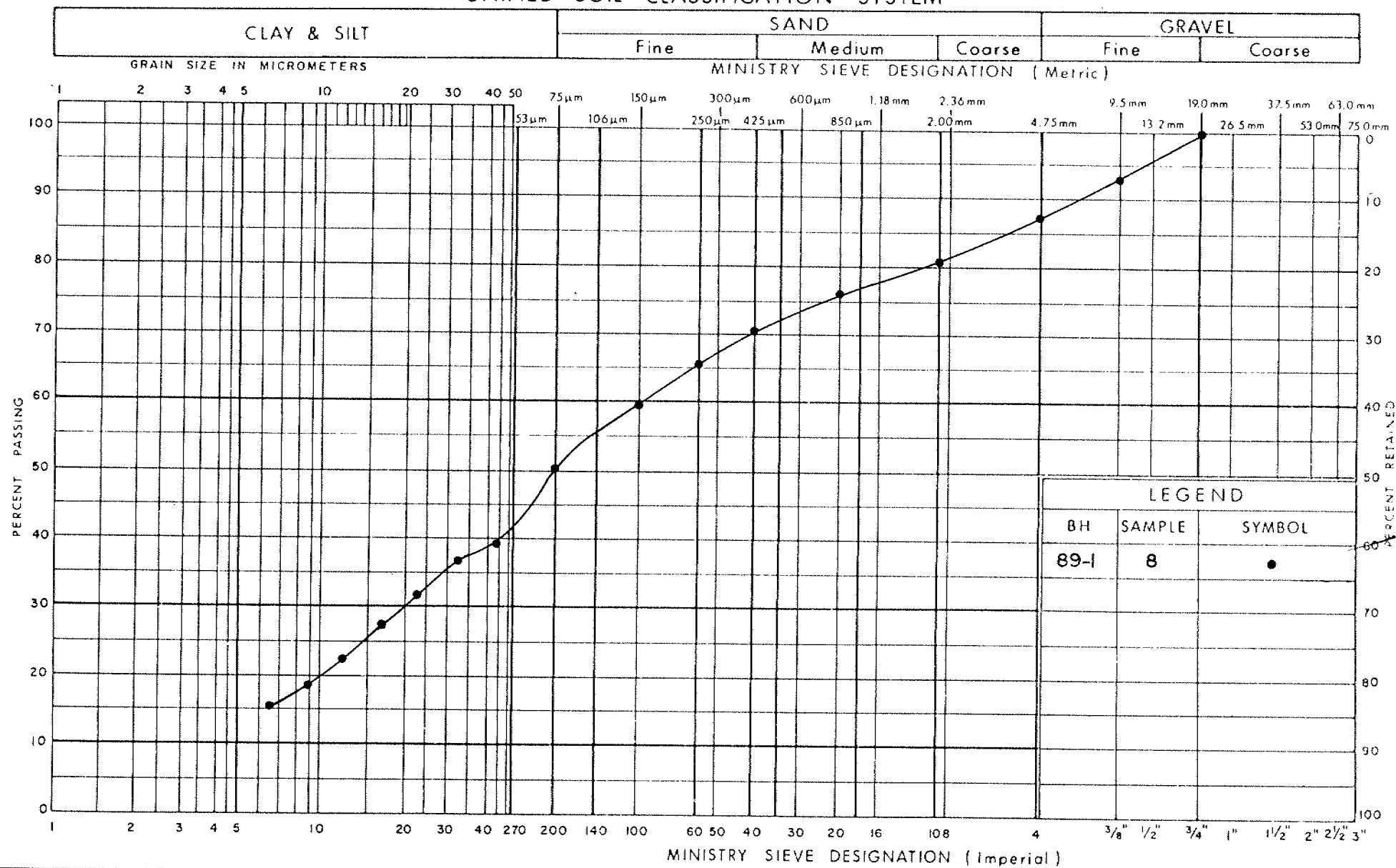
## GRAIN SIZE DISTRIBUTION

SAND and GRAVEL, occasional cobble

FIG No 10

W P 146-74-00-3

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

SANDY SILT, some gravel and clay  
(GLACIAL TILL)

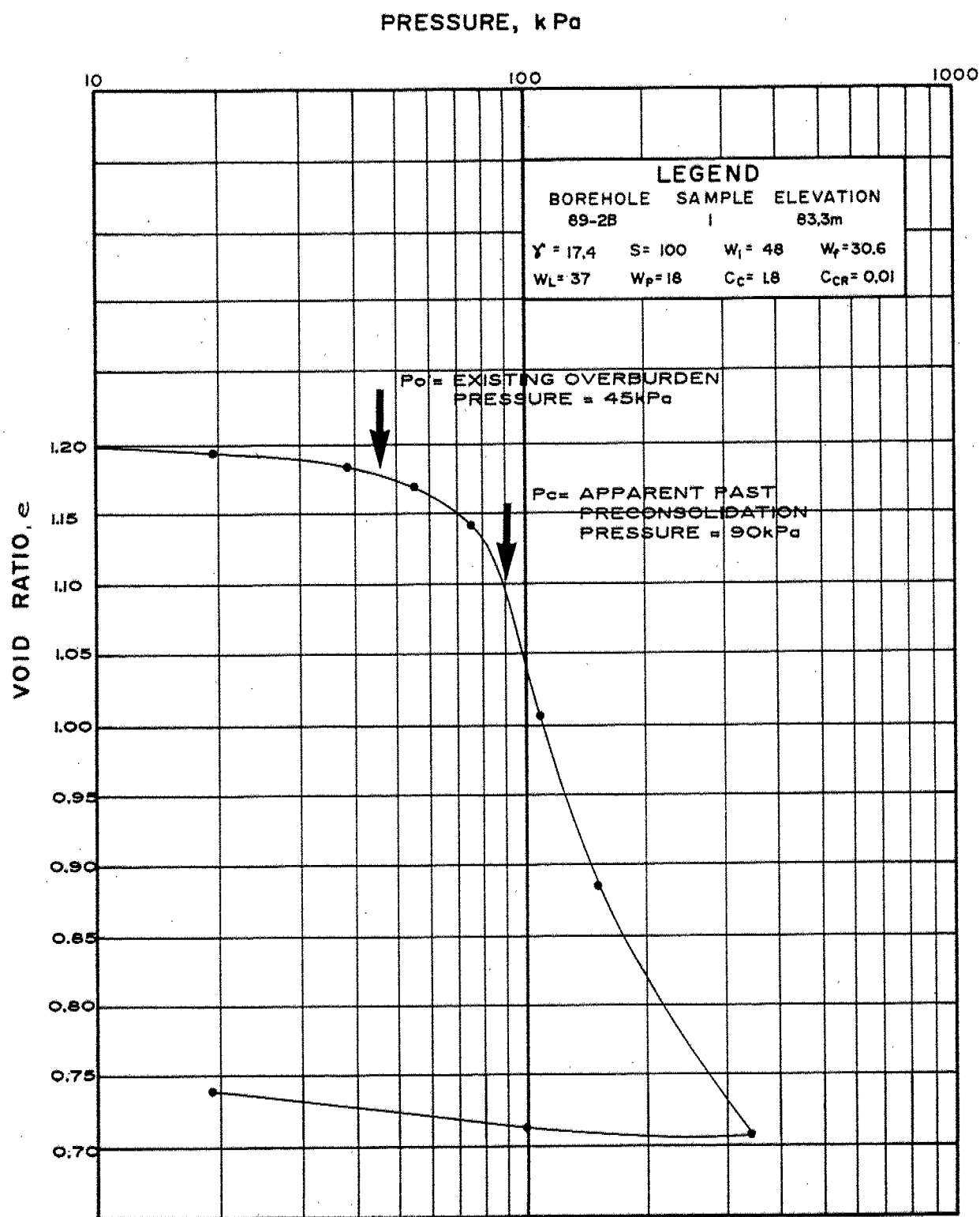
FIG No II

W P 146-74-00-3



# VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 12  
WP 146-74-00-3



Golder Associates

**Golder Associates Ltd.**

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Ottawa, Ontario, Canada K2C 2B8  
Telephone (613) 224-8864  
Fax (613) 224-9928



REPORT TO  
MINISTRY OF TRANSPORTATION ONTARIO  
  
PUMP TEST  
GEOTECHNICAL AND GROUNDWATER STUDY  
PROPOSED HIGHWAY 416  
CEDARVIEW ROAD CORRIDOR  
LYNWOOD SUBDIVISION AREA  
W.P. 146-74-00-3-DISTRICT 9 (OTTAWA)  
NEPEAN, ONTARIO

January 1991

901-2115

## 1. INTRODUCTION

The Ministry of Transportation Ontario (MTO) retained Golder Associates Ltd. to carry out a pump test along the proposed Highway 416 route adjacent to the Lynwood subdivision in Nepean, Ontario.

The purpose of this investigation was to determine the general hydraulic characteristics of a sandy aquifer which underlies the site by means of a pump test and, based on the factual results obtained, to provide guidelines for the design of the temporary and permanent roadway groundwater control systems and to provide an estimate on the expected groundwater inflow rate into the systems.

## 2. SITE DESCRIPTION AND GEOLOGY

Plans are being prepared for the construction of a multi-lane freeway (Highway 416) within the lands located on the east side of Cedarview Road in Nepean, Ontario (see Key Plan, Figure 1). As proposed, the distance between the first row of houses in the subdivision along Cedarview Road and the centreline of the proposed highway is between about 105 and 115 metres in this area. Adjacent to the subdivision, the proposed roadway will be in cut section to between about 5 and 11 metres below existing ground surface (including an allowance for 1.5 to 2.0 metre deep drainage swales).

Between the CN railway line along the north limit of the subdivision and the south end of the subdivision, the topography is relatively flat with a slight increase in grade to the south. South of this area to the Bruce Pit, the topography is gently sloping and rises about 7 to 8 metres above the lands to the north. As a result of past granular materials extraction, the average ground surface elevation across the abandoned Bruce pit floor is about 10 metres below the level of Cedarview Road. Two shallow ponds exist at the base of the pit due to groundwater inflow into the pit.

Currently, the site is used for recreation and includes hiking pathways, cross country ski trails and a toboggan hill.

Surficial geology maps suggest that the north part of the study area is underlain by abandoned river channel deposits composed of silt and silty clay. To the south, the surficial deposits are mostly sand and fluvial glacial deposits composed of sand and gravel. An examination of aerial photographs suggests that the general area may be underlain by numerous subparallel sand valleys and ridges orientated in a northwest-southeast direction, separated by silty clay. The bedrock underlying the area is dolomitic limestone with some thin sandstone beds.

### 3. PREVIOUS INVESTIGATIONS

Previous investigations have been carried out at the site by MTO, Acres International Ltd. and Golder Associates Ltd.

During May, 1984, MTO carried out a preliminary investigation along the proposed Highway 416 route between Richmond Road to the north and the Bruce Pit to the south. The results of this study are presented in MTO report number 31G5-138, W.P. 146-74-00, entitled, "Preliminary Investigation for Proposed Highway 416, Century Road to Hwy. 417".

Golder Associates carried out a preliminary investigation to determine the effects of the proposed highway cut on the groundwater regime in the Lynwood subdivision area; the results of this work are presented in Golder Associates report number, 881-2294-3 entitled "Preliminary Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor near the Lynwood Subdivision, W.P. 146-74-

03-District 9 (Ottawa), Nepean, Ontario", dated March, 1989. Three boreholes were put down along the proposed cut section during the investigation. One borehole advanced adjacent to Cedarview Road showed that a section of the proposed highway cut opposite the subdivision might be carried out within layered silty sand and sand to about 8.5 metres below the existing groundwater level.

Between May 1989 and January 1990, Golder Associates carried out a geotechnical and groundwater study of the area to better define the extent of the sandy deposits and to assess the possible effects of the proposed highway cut on the groundwater regime. The subsurface conditions in the study area were determined by means of twenty two (22) boreholes. The subsurface conditions along this section of Highway 416 and within the adjacent part of the Lynwood subdivision were found to consist of weathered (grey brown) and unweathered (grey) silty clay of variable thickness, followed by variable deposits of silty sand, sand, and sand and gravel, followed by discontinuous deposits of glacial till and then by dolomitic limestone bedrock. The investigation showed that the proposed highway cut would be carried out through silty sand, sand, and sand and gravel below the groundwater level, or through silty clay or clayey silt underlain, in some areas, by sandy deposits. The results of the investigation also indicated that temporary groundwater lowering and a permanent roadway subdrain system may cause changes in the groundwater regime in the subdivision. To better assess the extent and amount of groundwater drawdown and the possible effects of groundwater control on the subdivision, a pumping test was recommended.

Acres International Ltd. has carried out a subsurface investigation for the proposed CN bridge structure located at the north end of the study area. The results of this investigation are presented in a report entitled, "Foundation Investigation for Bridge

January 1991

901-2115

Structure, Proposed Highway 416 and CNR Subway, District No. 9, Ottawa, W.P. 126-87-01, Site 3-544", dated February 1990.

Golder Associates Ltd. has also carried out a subsurface investigation to assess the feasibility of a deep roadway cut in the silty clay deposits at the north end of the study area near the CN rail line.

The results of this study are provided in report number 901-2256, "Geotechnical Investigation, Proposed Diaphragm Wall and Slope Cut, Highway 416, District 9 (Ottawa), Nepean, Ontario W.P. 126-87-01(A)", dated August, 1990, and report number 901-1339, "Engineering Study, Proposed Cut and Railway Underpass, Highway 416, District 9 (Ottawa), Nepean, Ontario, W.P. 121-89-00", dated August, 1990.

#### 4. INVESTIGATION PROCEDURE

The groundwater investigation program documented in this report was carried out between May 4, and 11, 1990 during which time four (4) monitoring wells numbers 90-W9, 90-24, 90-25, and 90-26, were drilled using a track mounted hollow stem auger drill rig supplied and operated by Marathon Drilling Co. Ltd. of Ottawa, Ontario. These boreholes were advanced to depths ranging from 9.1 to 14.0 metres below ground surface. The overburden was sampled in the lower part of the boreholes using a conventional 50 millimetre diameter drive open sampler to determine the thickness and general characteristics of the sandy deposits. The boreholes were completed as monitoring wells in order to allow subsequent measurement of groundwater levels. The monitoring wells in boreholes 90-24, 90-25 and 90-26 consist of 38 millimetre diameter schedule 40 threaded PVC riser pipe fitted with 1.5 metre long section of machine slotted PVC screen. After installation, all monitoring wells were developed by pumping. At borehole 90-W9, the monitoring

well installation consists of a 300 millimetre long PVC plastic standpipe connected to a 13 millimetre diameter riser pipe. The field work was supervised throughout by a member of our engineering staff.

The soil samples recovered from the monitoring well boreholes were returned to our laboratory for examination. Grain size distribution analyses were carried out on samples of sand recovered from borehole 90-24, which is located in close proximity to the test well. These results were used to select an appropriate well screen size and length for the test well. The results of the grain size distribution analyses are provided on Figure 3.

The test well was drilled between June 25 and July 11, 1990 using a cable tool rig supplied and operated by Olympic Drilling of Ottawa. A 406 millimetre diameter hole was drilled and cased to a depth of about 6 metres and a 300 millimetre diameter casing was then advanced to about 10.7 metres, terminating in glacial till below a stratum of sand. Based on the grain size distribution results obtained from borehole 90-24 and the material recovered during the well drilling, a 254 millimetre diameter, 25 slot well screen with a natural sand pack was selected. The screened interval extended from 8.8 to 10.7 metres below ground surface. The annulus between the permanent well casing and overburden deposits was filled with bentonite. A diagram of the test well and inferred subsurface conditions at the test well location are provided on Figure 2.

The test well was initially developed by surging and pumping with compressed air. Additional development was required and was achieved by alternately backwashing the screened section using a sealed packer and pumping with compressed air. A copy of the driller's log for the test well is provided in Appendix B. It should be noted that the recommended pumping rate on the driller's log is the driller's estimate only, based on his observations during well development.

The pumping test was carried out between July 12 and 14, 1990. The pump used was a Honda surface pump discharging into the swale along the east side of Cedarview Road. The pumping test was conducted at a constant discharge rate of  $137 \text{ m}^3/\text{d}$  (21 Igpm) up to elapsed time 1680 minutes, at which time the pump was stopped briefly in order to repair the discharge line. The pump was subsequently restarted at  $118 \text{ m}^3/\text{d}$  (18 Igpm) and the test continued to elapsed time 2580 minutes (43 hours). It was not possible to match the earlier pumping rate.

The water levels in the pumping well and monitoring wells were measured at a decreasing frequency suitable for the interpretation of the aquifer properties. At the end of the pumping test, water level recovery measurements were made at a decreasing frequency in order to measure the rate of recovery. The water levels in the wells were monitored until 95 percent recovery had been attained.

Water levels were measured in the monitoring wells installed as part of this investigation (boreholes 90-W9, 90-24, 90-25, 90-26) and in piezometers or standpipes installed in boreholes 90-W10, 89-2A, 89-2B, 89-6B, 89-7, 89-9 and 88-4, drilled by Golder Associates during previous subsurface investigations. Summaries of the drawdown and recovery data are provided in Appendix A.

Groundwater samples were collected during the pumping test and submitted to Accutest Laboratories Ltd. in Nepean, Ontario for general water quality analyses. Copies of the chemical analyses are included in Appendix C.

Detailed logs of the soil and groundwater conditions encountered in the boreholes are given on the Record of Borehole sheets following the text of this report. Borehole logs from previous boreholes advanced by Golder Associates which are relevant to this particular study have been included for reference purposes. The approximate locations of the boreholes and the test well are given on Drawing 1467400-3A.\*

\* Sheet 217 of the Contract Drawings.



The borehole and test well locations and elevations were surveyed by MTO personnel. The elevations are referenced to Geodetic datum.

## 5. SUBSURFACE CONDITIONS IN MONITORING WELLS

The subsurface conditions in the study area have been described in reports 891-2208 (W.P. 146-74-00-3), and 901-2256 (W.P. 126-87-01(A)) prepared by Golder Associates Ltd., which should be read in conjunction with this report.

The soil and groundwater conditions encountered in the monitoring well boreholes are given on the Record of Borehole sheets following the text of this report.

Boreholes 90-W9, 90-24, 90-25, and 90-26 advanced in the area of the test well for monitoring purposes, encountered deposits of weathered grey brown and grey silty clay to depths of between 4.0 to 10.0 metres below ground surface, followed by variable deposits consisting of sandy silt, silty sand and sand. Fine to coarse sand containing trace amounts of silt was encountered in all of these boreholes; this stratum was found to have a thickness ranging from 1.1 metres at borehole 90-W9 to more than 3.6 metres at borehole 90-26. Grain size distribution curves for samples of the sand encountered in borehole 90-24, located in close proximity to the test well, are given on Figure 3.

Sandy silt till was encountered in boreholes 90-W9 and 90-24.

Standpipes and monitoring wells installed within the fine to coarse sand layer showed water levels ranging 0.8 to 1.3 metres below ground surface (elevation 86.4 metres).

## 6. DISCUSSION AND RECOMMENDATIONS

### 6.1 General

This section of the report provides recommendations based on an interpretation of the pumping test results and previous boreholes advanced at the site by Golder Associates during this and previous subsurface investigations. It is stressed that the information in this portion of the report is provided for the guidance of the design engineers. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects the proposed construction techniques, schedule, and equipment capabilities.

The borehole results from this and previous investigations indicate the approximate subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of boring, the frequency of sampling, and the uniformity of the subsurface conditions. Subsurface conditions between the boreholes may vary significantly from conditions encountered in the boreholes.

### 6.2 Interpretation of Pumping Test Results

#### 6.2.1 General

As indicated, the pump test was conducted at a constant discharge rate of 137 m<sup>3</sup>/d (21 Igpm) up to an elapsed time of 1680 minutes (28 hours). Due to the period of non-pumping and not being able to match the pumping rate on re-start, the data acquired after 1680 minutes elapsed time were not used in the technical analyses.

However, sufficient data were collected to provide good technical analyses of aquifer hydraulic parameters.

The drawdown cone was a broad, flat cone which propagated quickly, typical of high hydraulic conductivity in semi-confined aquifers with low storativity. The aquifer becomes a water table or unconfined aquifer to the south, in the area of the Bruce Pit but the drawdown cone did not appear to extend far enough in this direction during the test to be influenced by the unconfined conditions.

The aquifer pinches out to the north of the pumping well in the area of the CN Railway Line. This condition should act as a barrier boundary condition on the pump test response. However, it is likely that during the test the drawdown cone did not extend far enough in this direction to be significantly influenced by this barrier condition.

#### 6.2.2 Transmissivity

The pumping test data have been analyzed using the Modified Jacob Non-Equilibrium method and the Theis type curve matching method. A summary of the results of the analyses have been tabulated on Table 1 and the analyses are provided in Appendix A.

The range of estimated values for transmissivity are between 41.1 and 122.0 m<sup>2</sup>/d with the geometric mean (weighted average) being 85.8 m<sup>2</sup>/d. There is one anomalously low value (41.1 m<sup>2</sup>/d) which was estimated using the drawdown data from the pumping well. This low value is considered to be not representative of the aquifer as it is biased by the low efficiency of the pumping well. The analysis of the recovery data from the pumping well is more representative of the transmissivity of the aquifer in the vicinity of the pumping well.

The low efficiency of the well is demonstrated by the fact that the observed drawdown (7.03 metres) was much greater than the theoretical drawdown (2.60 metres) estimated from the distance drawdown data plot (Figure 4). The low efficiency of the pumping well is a common problem that occurs when the drilling process causes disturbance of layered aquifer material adjacent to the well bore. While the additional development with the sealed packer improved the well yield, it is likely that the low efficiency of the well was due to the continuing influence of fine sand in the well area. For this reason analyses of the observation well data yield more reliable estimates of aquifer characteristics.

#### 6.2.3 Hydraulic Conductivity

The hydraulic conductivity can be estimated by dividing transmissivity by the aquifer thickness. A summary of the estimates of hydraulic conductivity determined in this manner are presented on Table 1. In general, the values range from  $10^{-1}$  to  $10^{-2}$  centimetres per second. However, there possibly are zones or strata of significantly higher and lower hydraulic conductivity.

Estimates of hydraulic conductivity based on grain size analyses (Hazen Method) indicate values of  $10^{-2}$  to  $10^{-3}$  centimetres per second for the sand aquifer.

#### 6.2.4 Storativity

The storativity of the aquifer was estimated from the drawdown data of observation wells 88-4A and 90-W10 using the Theis type curve matching technique. The estimated storativities are  $4.3 \times 10^{-4}$  and  $9.0 \times 10^{-6}$  for wells 88-4A and 90-W10, respectively. These values are typical of confined to semi-confined aquifer conditions.

### 6.2.5 Radius of Influence

The theoretical drawdown at the well is estimated to be 2.6 m and the observed drawdown at the furthest observation point (Well 89-6B) 160 m away was 0.47 m after 1680 minutes elapse time. The drawdown cone was broad and relatively flat and had not yet stabilized after 2580 minutes (43 hours) elapse time. This observation suggests that dewatering during construction and during permanent groundwater control could result in a significant area of water level drawdown. Table 2 summarizes the observed drawdown at elapse time 1680 minutes and Figure 4 is a distance drawdown plot of this data.

### 6.2.6 Groundwater Chemistry

Two water samples were collected from the test well during the pumping test at 35 and 42 hours elapse time during the test. The analyses are presented in Table 3 and the actual laboratory report is provided in Appendix C.

The samples were tested for basic inorganic parameters, phenols and trace metals and the results were compared to the Ontario Drinking Water Objective (ODWO). The only parameter to exceed ODWO criterion was iron. The iron concentrations of 0.40 and 0.41 milligrams per litre are slightly higher than the criterion of 0.3 milligrams per litre. The criterion for iron is set for aesthetic reasons as opposed to health concerns, therefore, discharge of the water with this elevated concentration for iron will not be of environmental concern.

The concern relating to iron in the dewatering for the road cut would be a reddish brown or orange staining of material that would be in prolonged contact with this water.

It should be noted that these analyses represent the chemical nature of the water at the time of pump testing. The quality of the dewatering water could change with time during temporary dewatering for construction and during permanent dewatering after construction.

The water quality could change with time if the groundwater control system causes groundwater of a different chemical nature to flow towards the cut. We are aware that the proposed highway passes over an area of former landfilling activity, in the vicinity of the Bruce Pit. At this time there are no indications that this former landfill is significantly impacting groundwater quality in the area. It is conceivable that some change in groundwater quality may occur during dewatering due to the former landfill, but we can not predict such a possibility nor the chemical nature of such impact based on the information available to us at this time.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.



*D. Dundas*  
D. Dundas, P. Eng.  
Sr. Foundation Engineer

TABLE 1SUMMARY OF TRANSMISSIVITIES AND ESTIMATED HYDRAULIC CONDUCTIVITIES  
FROM PUMP TEST DATA

<u>WELL</u>	<u>ANALYSIS METHOD</u>	<u>TRANSMISSIVITY</u>	<u>AQUIFER THICKNESS</u>	<u>ESTIMATED HYDRAULIC CONDUCTIVITY</u>	
		<u>m<sup>2</sup>/d</u>	<u>m</u>	<u>m/d</u>	<u>(cm/sec)</u>
Pumping Well	Jacob - Drawdown	41.1	> 2.1	-	-
Pumping Well	Jacob - Recovery	90.6	> 2.1	-	-
88-4A	Jacob - Drawdown	93.5	> 3.9	-	-
88-4A	Theis - Drawdown	91.1	> 3.9	-	-
90-W10	Jacob - Drawdown	92.0	2.0	46.0	$5.3 \times 10^{-2}$
90-W10	Theis - Drawdown	78.1	2.0	39.1	$4.5 \times 10^{-2}$
89-2A	Jacob - Drawdown	122.0	2.3	53.0	$6.1 \times 10^{-2}$
89-2B	Jacob - Drawdown	75.5	2.3	32.8	$3.8 \times 10^{-2}$
89-6B	Jacob - Drawdown	80.2	1.0	80.2	$9.3 \times 10^{-2}$
89-7	Jacob - Drawdown	110.3	1.8	61.3	$7.1 \times 10^{-2}$
89-9	Jacob - Drawdown	67.2	6.0	11.2	$1.3 \times 10^{-2}$
90-W9	Jacob - Drawdown	103.7	1.5	69.1	$8.0 \times 10^{-2}$
90-24	Jacob - Drawdown	79.2	5.3	14.9	$1.7 \times 10^{-2}$
90-25	Jacob - Drawdown	89.7	> 5.1	-	-
90-26	Jacob - Drawdown	93.1	> 4.7	-	-
All Wells	Distance Drawdown	100.7	-	-	-
Geometric Mean		85.8	-	-	-

TABLE 2DISTANCE - DRAWDOWN DATA  
AFTER 1680 MINUTES OF PUMPINGPumping Rate: 137.5 m<sup>3</sup>/d (21 Igpm)

<u>Observation Point</u>	<u>Distance from Pumping Well (metres)</u>	<u>Drawdown (metres)</u>
Pumping Well		7.03
Well 90-24	1.7	1.81
Well 90-25	8.1	0.99
Well 88-4A	17.2	0.94
Well 90-W9	23.1	0.14
Well 90-W10	34.9	1.30
Well 89-9	42.0	0.61
Well 90-26	47.9	0.78
Well 89-7	112.0	0.64
Well 89-2A	145.0	0.24
Well 89-2B	145.0	0.10
Well 89-6B	160.0	0.47

NOTE: These data are presented graphically on Figure 4.



TABLE 3  
GROUNDWATER CHEMICAL ANALYSES

Source: Test Well - Pumping Test

<u>PARAMETER</u>	<u>UNITS</u>	<u>SAMPLE 1</u> <u>(35 hours)</u>	<u>SAMPLE 2</u> <u>(42 hours)</u>	<u>ODWO*</u>
Temperature (Field)	deg. C	8	7	
Conductivity (Field)	µS	700	750	
pH (Field)		7.4	7.7	6.5 to 8.5
Alkalinity	mg/L	228	228	
Total Dissolved Solids	mg/L	478	470	500
Chemical Oxygen Demand	mg/L	<3	6	
Biological Oxygen Demand	mg/L	<1	<1	
Bromide	mg/L	1.1	1.5	
Chloride	mg/L	74	72	250
Fluoride	mg/L	0.08	0.11	2.4
Phosphate	mg/L	0.14	0.20	
Sulphate	mg/L	69	68	500
Nitrate	mg/L	<0.10	<0.10	10
Nitrite	mg/L	<0.10	<0.10	1.0
Ammonia	mg/L	<0.10	<0.10	
Total Nitrogen	mg/L	<0.10	<0.10	
Phenols	mg/L	<0.002	<0.002	0.002
Aluminum	mg/L	<0.03	<0.03	
Barium	mg/L	0.33	0.33	1.0
Beryllium	mg/L	0.06	0.06	
Boron	mg/L	<0.01	<0.01	5.0
Cadmium	mg/L	<0.002	<0.002	0.005
Calcium	mg/L	91	88	
Chromium	mg/L	<0.01	<0.01	0.05
Cobalt	mg/L	<0.02	<0.02	
Copper	mg/L	<0.002	<0.002	1.0
Iron	mg/L	0.40	0.41	0.3
Lead	mg/L	<0.002	<0.002	0.05
Magnesium	mg/L	33	33	
Manganese	mg/L	0.05	0.05	0.05
Molybdenum	mg/L	<0.01	0.01	
Nickel	mg/L	<0.02	<0.02	
Phosphorus	mg/L	<0.1	0.1	
Potassium	mg/L	5	5	
Silicon	mg/L	5.3	5.8	
Silver	mg/L	<0.01	<0.01	0.05
Sodium	mg/L	19	19	
Strontium	mg/L	0.28	0.29	
Sulfur	mg/L	29	29	
Thallium	mg/L	<0.01	<0.01	
Tin	mg/L	0.7	0.8	
Titanium	mg/L	<0.01	<0.01	
Vanadium	mg/L	<0.01	<0.01	
Zinc	mg/L	<0.01	<0.01	5.0

\* ODWO - Ontario Drinking Water Objective

# RECORD OF BOREHOLE No 90-24

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 138; E 358 917 ORIGINATED BY D.J.S.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE May 8 and 9, 1990 CHECKED BY A.C.

OFFICE REPORT ON SOIL EXPLORATION

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			20	40	60	80	100					
87.3	Ground Surface																
0.0	Topsoil																
0.2																	
	Silty clay (weathered crust)																
	Grey brown																
84.6																	
2.7																	
	Silty clay, occasional silty sand seam		1	SS	WH*												
			2	SS	PM												
	Grey		3	SS	PM												
82.0																	
5.3	Sandy silt, some gravel and clay		4	SS	1 for 45cm												
81.5	Very loose Grey				12 for 15cm												
5.8	Sand, fine to coarse trace gravel and silt																
80.9	Compact Grey		5	SS	17												
6.4	Sand, fine, trace to some silt		6	SS	33												
	Compact to dense Grey		7	SS	18												
79.2																	
8.1	Sand, fine to coarse trace gravel and silt		8	SS	15												
			9	SS	33												
	Compact to dense Grey		10	SS	53												
76.5																	
10.8	Silty sand, trace gravel		11	SS	52												
76.2	Dense Grey																
11.1	Sandy silt, some gravel and clay (glacial till)																
75.3	Compact Grey		12	SS	13												
12.0	End of Borehole																
	*Sank under weight of hammer																



## RECORD OF BOREHOLE No 90-26

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 090; E 358 915 ORIGINATED BY D.J.S.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE May 10, 1990 CHECKED BY A.C.

[illegible]

+3, x<sup>5</sup>: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 90 - W9

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 146; E 358 936 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
DATUM Geodetic DATE May 4, 1990 CHECKED BY RN

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%) 20 40 60
								SHEAR STRENGTH kPa							
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× LAB VANE						
87.2	Ground Surface							20 40 60 80 100							
0.0	Topsoil														
0.3	Silty clay, occasional sand seams (weathered crust)														
84.5	Grey Brown														
2.7	Silty clay, occasional sand seams and layers														
			1	SS	PM										
			2	SS	PM										
			3	SS	PM										
			4	SS	PM										
			5	SS	PM										
			6	SS	PM										
			7	SS	WH*										
			8	SS	WH*										
77.2															
10.0	Sandy silt and silty sand, some clay and gravel (glacial till)		9	SS	3										
			10	SS	4										
			11	SS	3										
			12	SS	4										
74.7															
12.5	Sand, fine to coarse trace gravel and silt														
73.6	Compact Grey														
13.6	Sand, fine to coarse, some silt, compact Grey														
73.2			13	SS	50/100 mm										
14.0	End of Borehole Refusal to Auger Probable Bedrock *Sank under weight of hammer														

+3, x5: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE SHEETS  
FROM PREVIOUS INVESTIGATIONS

# RECORD OF BOREHOLE No 90 - W10 METRIC

W P 126-27-01(A) LOCATION Co-ords N 5 021 126; E 358 947 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RN  
 DATUM GEODETIC DATE July 11, 12, 1990 CHECKED BY RL

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.4	Ground Surface																
0.0	Topsoil																
0.2	Silty fine sand Brown																
0.4	Silty clay, some silty sand seams																
	(weathered crust)																
	Grey Brown																
84.7																	
2.7	Silty clay, occasional fine sand seams, trace gravel																
	Grey																
			1	SS	PM												
78.7																	
8.7	Sand, some gravel, trace silt		2	SS	PH												
	Grey																
76.7																	
10.7	Clayey silt, some gravel (glacial till)																
	Some cobbles and boulders with depth																
	Grey																
74.0																	
13.4	End of Borehole Refusal to Auger Probable Bedrock																

RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 162; E 358 772 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

OFFICE REPORT ON SOIL EXPLORATION

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			20 40 60 80 100									
								SHEAR STRENGTH kPa									
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	WATER CONTENT (%)							
								20 40 60 80 100		20 40 60				GR SA SI CL			
87.3	Ground Surface																
0.0	Sand and gravel																
86.9	occasional cobble																
0.4	Topsoil																
0.8	Silty clay, some silty fine sand seams (weathered crust)		1	SS	7												
			2	SS	5												
84.2	Very stiff Grey to stiff Brown								+ s=3.3 + s= 2.2								
34.1	Silty clay, some silty fine sand seams, trace gravel		3	TW	PH												
			4	SS	1												
82.6	Grey																
4.7	Sand, fine, some silt, some sandy silt layers		5	SS	9		Native										
			6	SS	15												
	Compact Grey		7	SS	16												
80.3																	
7.0	Sandy silt, trace to some gravel and clay, some fine sand and clayey silt layers		8	SS	19												
			9	SS	14												
			10	SS	6												
			11	SS	19												
			12	SS	64												
	Loose to very dense Grey																
76.2			13	SS	52												
11.1	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings occasional weathered horizontal joint			RC	REC=100%												
			14	BXL	RQD=71%												
				RC	REC=95%												
			15	BXL	RQD=95%												
				RC	REC=100%												
			16	BXL	RQD=98%												
	Continued																
	*REC: Recovery RQD: Rock Quality Designation																

\*REC: Recovery  
RQD: Rock Quality Designation



# RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74- 00-3 LOCATION Co-ords N 5 021 162; E 358 772 ORIGINATED BY P.H.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger BXL Rock Core COMPILED BY A.C.  
 DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
	Continued															
	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings, occasional weathered horizontal joint		16	RC BXL	REC=100% RQD=98%											
			17	RC BXL	REC=100% RQD=98%											
71.0						Standpipe										
16.3	End of Borehole															
	*REC: Recovery RQD: Rock Quality Designation															

OFFICE REPORT ON SOIL EXPLORATION

## METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 162; E 358 772 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 29, 1989 CHECKED BY A.C.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80			100
87.3	Ground Surface													
0.0	See Record of Borehole No. 89-2					87								
						86								
						85								
						84								
						82								
81.2														
6.1	End of Borehole					81								

OFFICE REPORT ON SOIL EXPLORATION

W P 146-74-00-3 LOCATION Co-ords N 5 021 162; E 358 772 ORIGINATED BY L.Q.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 7, 1989 CHECKED BY A.C.

+3, x<sup>5</sup>: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No. 89-6

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 995; E 358 844  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core  
DATUM Geodetic DATE June 29 and 30, 1989  
ORIGINATED BY P.H.  
COMPILED BY A.C.  
CHECKED BY A.C.

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			20	40	60	80	100					
88.4	Ground Surface																
0.1	Fill																
0.2	Topsoil																
0.4	Silty clay, some silty fine sand seams, (weathered crust)		1	SS	7												
			2	SS	8												
85.0	Very Stiff	Grey Brown	3	TW	PH												
3.4	Silty clay, some silty fine sand seams																
			4	TW	PH												
			5	SS	2												
			6	SS	1												
			7	SS	2												
78.4	Stiff	Grey															
10.0	Sand, fine, some silt, trace gravel, some sandy silt layer		8	SS	23												
77.4	Compact	Grey	9	SS	31												
11.0	Sandy silt, some gravel	Grey															
11.2	Dolomitic limestone bedrock, thinly to thickly bedded	Grey	10	BXL	RQD=67%												
	Continued																



RECORD OF BOREHOLE No 89-7

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 024; E 358 914 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 5, 1989 CHECKED BY A.C.

OFFICE REPORT ON SOIL EXPLORATION

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			20	40	60	80	100				
88.5	Ground Surface															
88.5	Asphalt															
0.2	Fill crushed stone, Grey															
87.8	Fill, sand and gravel															
0.7	Topsoil															
0.9	Silty clay, occasional sand seam, scattered trace gravel (weathered crust)		1	SS	7											
			2	SS	6											
85.8	Very Stiff Grey Brown		3	SS	9											
2.7	Silty clay, occasional sand seam		4	SS	WH											
			5	SS	WH											
	Firm to Stiff Grey		6	SS	WH											
			7	SS	WH											
79.0			8	SS	WH											
9.5	Sandy silt, some clay		9	SS	WH											
9.8	Sand, fine to medium, trace silt															
10.1	Loose Grey		10	SS	14											
77.9	Silty clay Stiff Grey		11	SS	13											
10.6	Sand, fine, some silt		12	SS	>100											
	Compact Grey															
76.1	Sandy silt, some gravel															
12.4	trace clay Grey															
12.6	End of Borehole															
	*Sank under weight of hammer															



# RECORD OF BOREHOLE No 88-4

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 150; E 358 904 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
DATUM Geodetic DATE October 20, 1988 CHECKED BY AC

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	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
87.3	Ground Surface												
0.0	Topsoil.												
0.2	Silty clay, some silty fine sand seams. (Weathered Crust)												
	Very Stiff Grey Brown	1	SS	8									
85.3		2	SS	4									
2.0	Silty clay, some silty fine sand seams.												
	Firm Grey	3	SS	1									
		4	SS	PM									
83.0													
4.3	Silty sand & gravel, trace clay.												
82.1	Loose Grey	5	SS	5									
5.2	Sand, layered. Fine to coarse sand, some gravel & silt, fine sand with some silt, medium to coarse sand, trace gravel, silty sand, some gravel.	6	SS	3									
		7	SS	14/150mm									
	Loose to Compact Grey Brown and Grey	8	SS	26									
		9	SS	23									
78.2													
9.1	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION



## KEY PLAN

FIGURE 1  
WP 146-74-00-3SCALE  
1:18,500

SPECIAL NOTE  
THIS DRAWING IS TO BE READ IN CONJUNCTION  
WITH ACCOMPANYING REPORT

Date SEPT. 17, 1990  
Project 901-2115

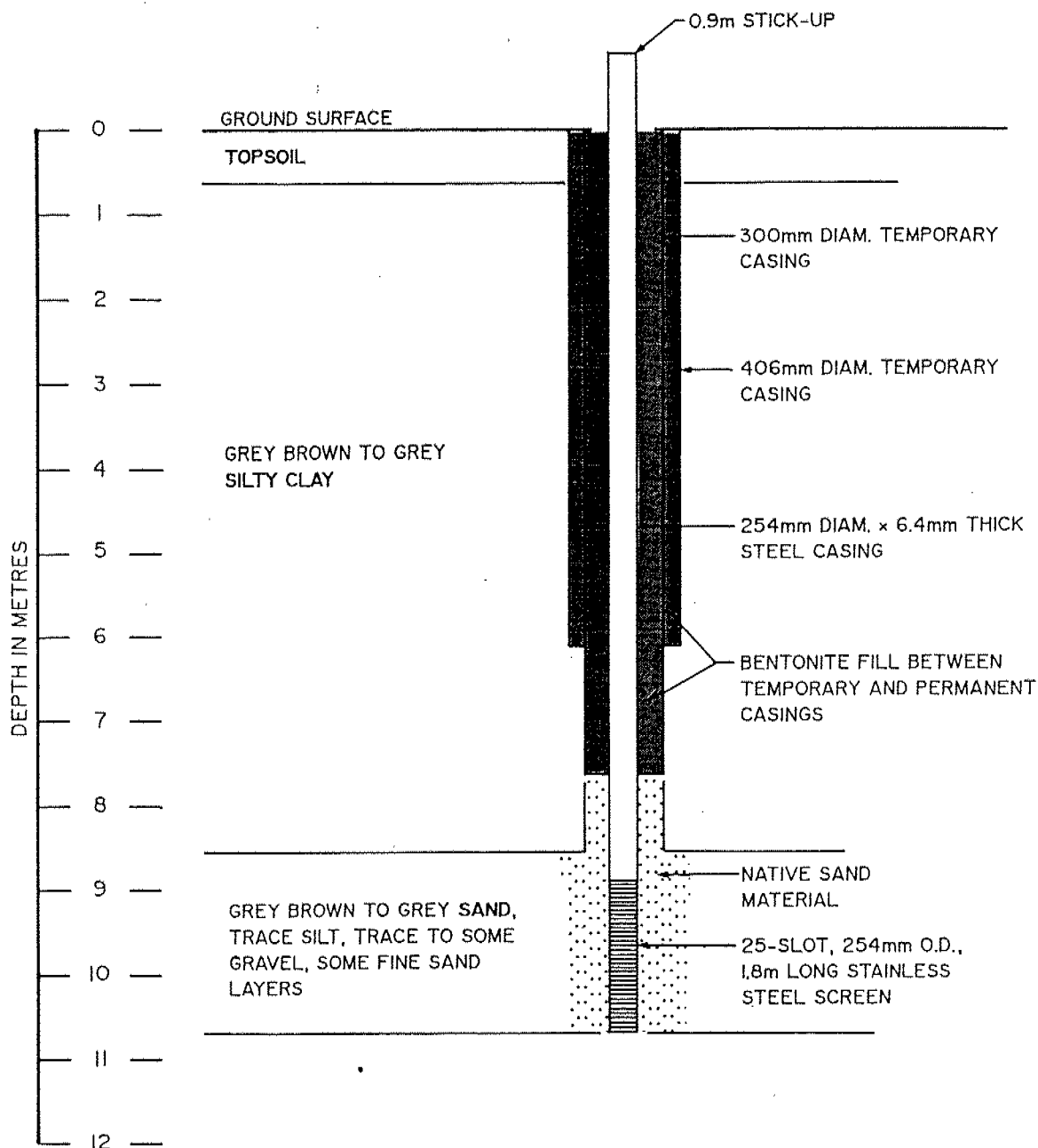
Golder Associates

Drawn JC  
Chkd. \_\_\_\_\_

## SCHEMATIC DRAWING OF TEST WELL

FIGURE 2

WP 146-74-00-3

NOTE

SOIL STRATIGRAPHY INFERRED FROM SAMPLES  
OF SOIL RECOVERED DURING INSTALLATION  
OF THE WELL

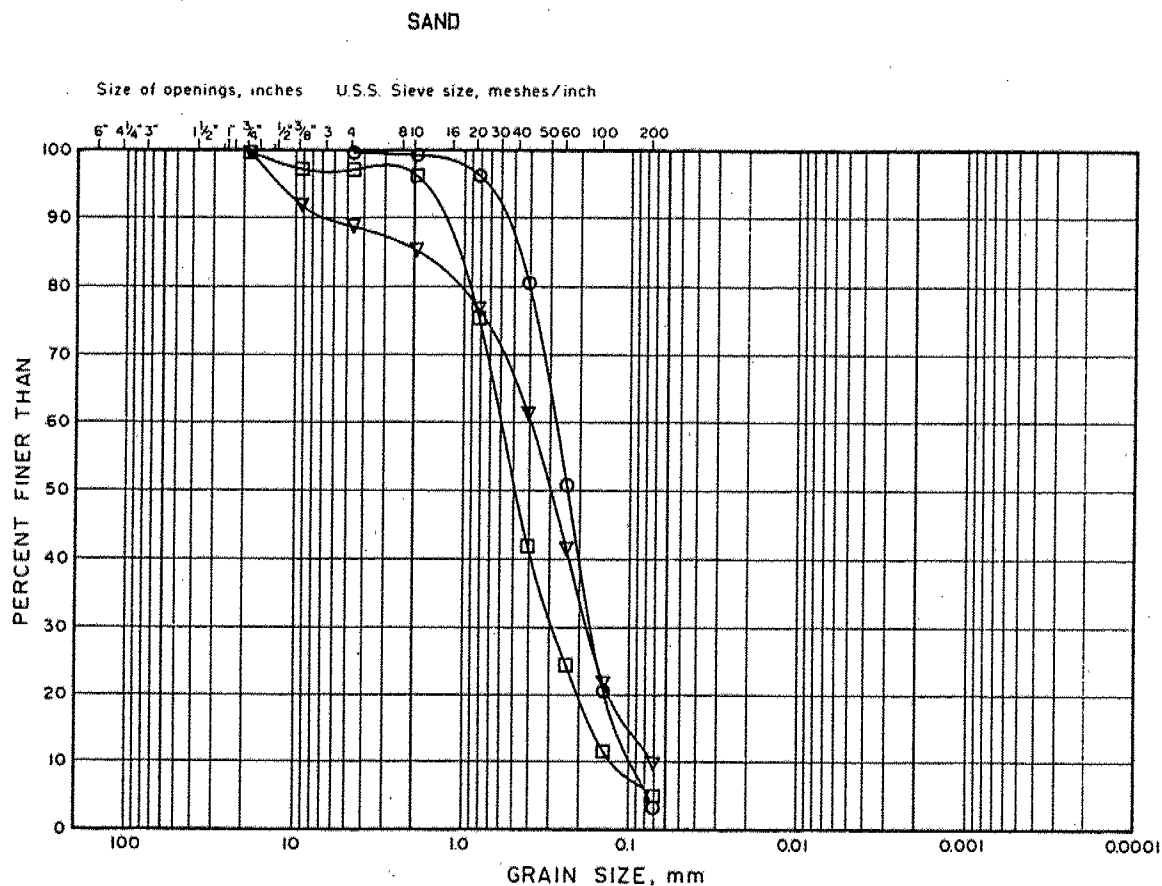
Date SEPT. 17, 1990Project 901-2115**Golder Associates**Drawn JC

Chkd. \_\_\_\_\_

## GRAIN SIZE DISTRIBUTION

FIGURE 3

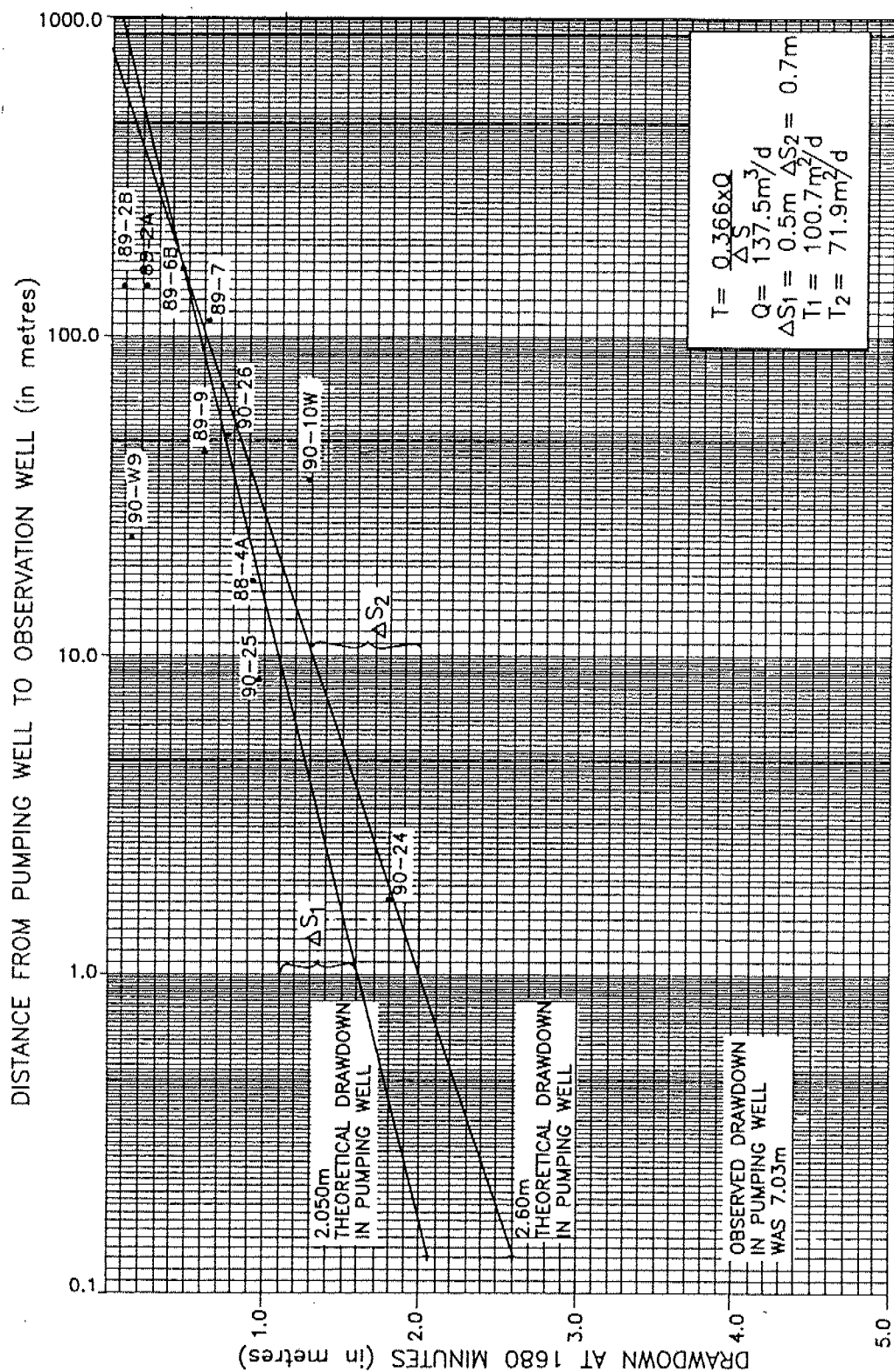
WP 146-74-00-3



## DISTANCE - DRAWDOWN PLOT

FIGURE 4

WP 146-74-00-3



Date SEPT. 17, 1990

Project 901-2115

Golder Associates

Drawn TDR

Chkd

**APPENDIX A**

**SUMMARIES OF DRAWDOWN  
AND RECOVERY DATA**

JOB NUMBER 901-2115  
DATE OF TEST JULY/13/90  
WELL NUMBER PW-1

## PUMPING TEST DATA

READING No.	TIME (min)	DRAWDOWN (m)
1	1.00	2.55
2	2.00	3.23
3	3.00	3.88
4	4.00	4.40
5	5.00	4.74
6	6.00	4.99
7	7.00	5.26
8	8.00	5.40
9	9.00	5.50
10	10.00	5.63
11	12.00	5.68
12	14.00	5.81
13	16.00	5.69
14	18.00	5.77
15	20.00	5.81
16	25.00	5.81
17	30.00	5.81
18	40.00	5.95
19	50.00	6.02
20	60.00	6.06
21	75.00	6.12
22	90.00	6.09
23	105.00	6.09
24	120.00	6.10
25	150.00	6.12
26	180.00	6.02
27	240.00	6.05
28	300.00	6.42
29	360.00	6.49
30	420.00	6.36
31	480.00	6.34
32	600.00	6.91
33	720.00	6.87
34	840.00	6.87
35	1080.00	6.88
36	1200.00	6.90
37	1440.00	6.95
38	1680.00	7.03
39	1760.00	3.15
40	1766.00	4.75
41	1767.00	5.05
42	1768.00	5.15
43	1769.00	5.25
44	1770.00	5.35
45	1772.00	5.43
46	1774.00	5.47
47	1776.00	5.49

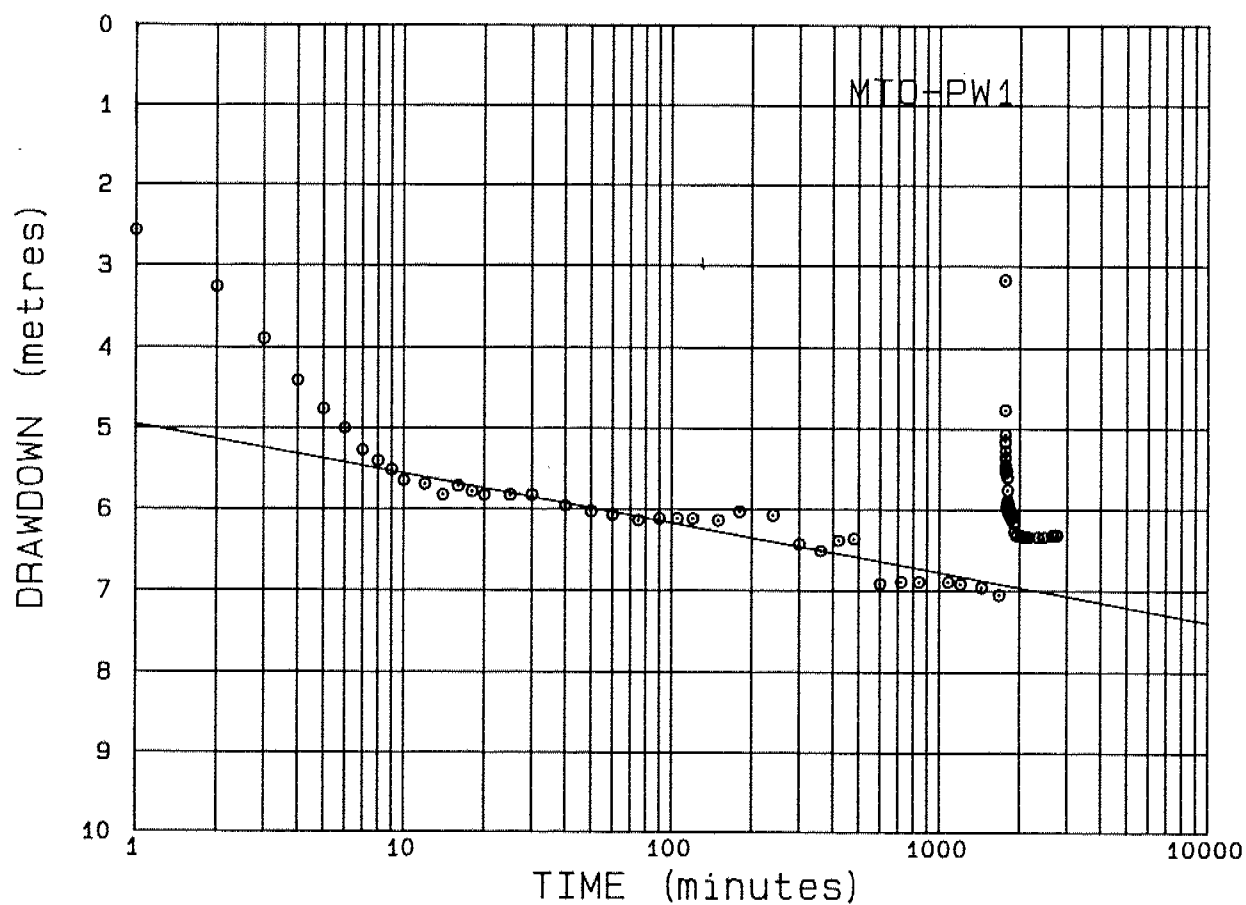
48	1778.00	5.50
49	1782.00	5.50
50	1787.00	5.49
51	1802.00	5.59
52	1804.00	5.75
53	1805.50	5.87
54	1806.50	5.90
55	1807.50	5.93
56	1808.00	5.94
57	1810.00	5.97
58	1812.00	5.97
59	1814.00	5.98
60	1819.00	5.99
61	1829.00	6.00
62	1839.00	6.00
63	1849.00	6.01
64	1859.00	6.03
65	1879.00	6.08
66	1899.00	6.08
67	1909.00	6.15
68	1919.00	6.26
69	1950.00	6.29
70	2040.00	6.31
71	2100.00	6.32
72	2160.00	6.32
73	2340.00	6.32
74	2460.00	6.33
75	2640.00	6.30
76	2740.00	6.30
77	2740.00	6.30

#### SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres)  
TRANSMISSIVITY (metres squared per day) 41.1  
DATA FROM 12.00 TO 1680.00 minutes USED

DRAWDOWN DATA  
TEST WELL

FIGURE AI  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 41.1 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 90I-2115

**Golder Associates**

Drawn JC  
Chkd



JOB NUMBER 901-2115  
 DATE OF TEST JULY/14/90  
 WELL NUMBER PW-1

## RECOVERY TEST DATA

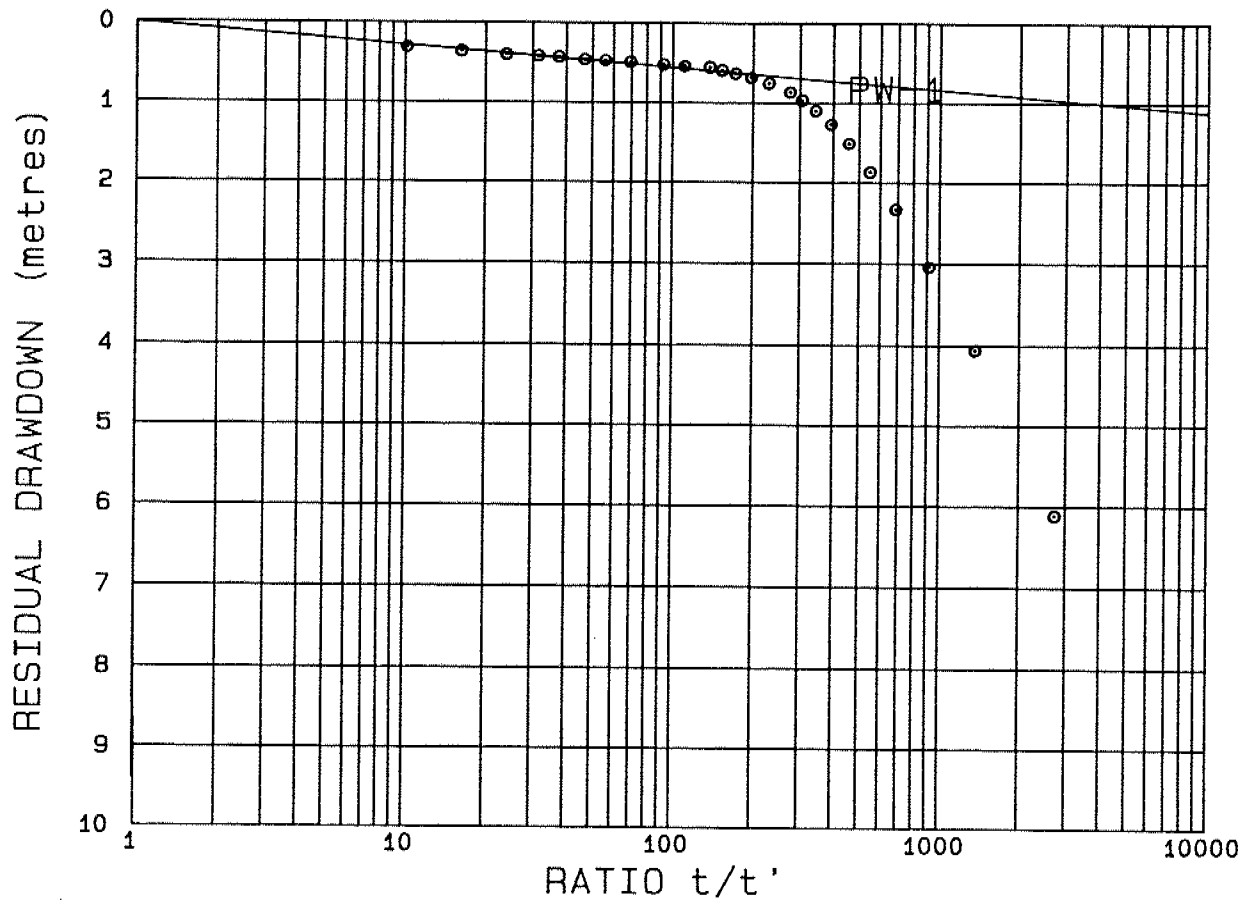
READING No.	TOTAL ELAPSED TIME (min)	TIME SINCE SHUTOFF (min)	RATIO $t/t'$	RESIDUAL DRAWDOWN (m)
1	2741.00	1.00	2741.00	6.10
2	2742.00	2.00	1371.00	4.05
3	2743.00	3.00	914.33	3.03
4	2744.00	4.00	686.00	2.32
5	2745.00	5.00	549.00	1.86
6	2746.00	6.00	457.67	1.50
7	2747.00	7.00	392.43	1.26
8	2748.00	8.00	343.50	1.09
9	2749.00	9.00	305.44	0.96
10	2750.00	10.00	275.00	0.86
11	2752.00	12.00	229.33	0.75
12	2754.00	14.00	196.71	0.68
13	2756.00	16.00	172.25	0.63
14	2758.00	18.00	153.22	0.59
15	2760.00	20.00	138.00	0.55
16	2765.00	25.00	110.60	0.54
17	2770.00	30.00	92.33	0.52
18	2780.00	40.00	69.50	0.49
19	2790.00	50.00	55.80	0.47
20	2800.00	60.00	46.67	0.46
21	2815.00	75.00	37.53	0.43
22	2830.00	90.00	31.44	0.42
23	2860.00	120.00	23.83	0.40
24	2920.00	180.00	16.22	0.36
25	3040.00	300.00	10.13	0.31

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
 DISTANCE TO OBSERVATION WELL (metres)  
 TRANSMISSIVITY (metres squared per day) 90.6  
 DATA FROM 12.00 TO 300.00 minutes USED

# DRAWDOWN DATA TEST WELL

FIGURE A2  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 90.6 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 90I-2115

**Golder Associates**

Drawn JC  
Chkd

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 90-24

## PUMPING TEST DATA

READING No.	TIME (min)	DRAWDOWN (m)
1	1.00	0.43
2	2.00	0.66
3	3.00	0.82
4	4.00	0.93
5	5.00	0.99
6	6.00	1.02
7	7.00	1.08
8	12.00	1.15
9	14.00	1.16
10	15.00	1.14
11	17.00	1.16
12	19.00	1.16
13	21.00	1.19
14	26.00	1.22
15	33.00	1.24
16	36.00	1.25
17	41.00	1.29
18	46.00	1.31
19	50.00	1.33
20	60.00	1.36
21	75.00	1.39
22	90.00	1.39
23	105.00	1.41
24	120.00	1.42
25	150.00	1.45
26	180.00	1.43
27	240.00	1.45
28	300.00	1.55
29	360.00	1.58
30	415.00	1.58
31	475.00	1.57
32	595.00	1.71
33	715.00	1.71
34	835.00	1.72
35	1075.00	1.75
36	1195.00	1.75
37	1435.00	1.79
38	1675.00	1.81
39	1754.00	1.05
40	1755.00	1.14
41	1756.00	1.12
42	1781.00	1.35
43	1782.00	1.39
44	1783.00	1.42
45	1784.00	1.45
46	1785.00	1.47
47	1787.00	1.48
48	1789.00	1.49

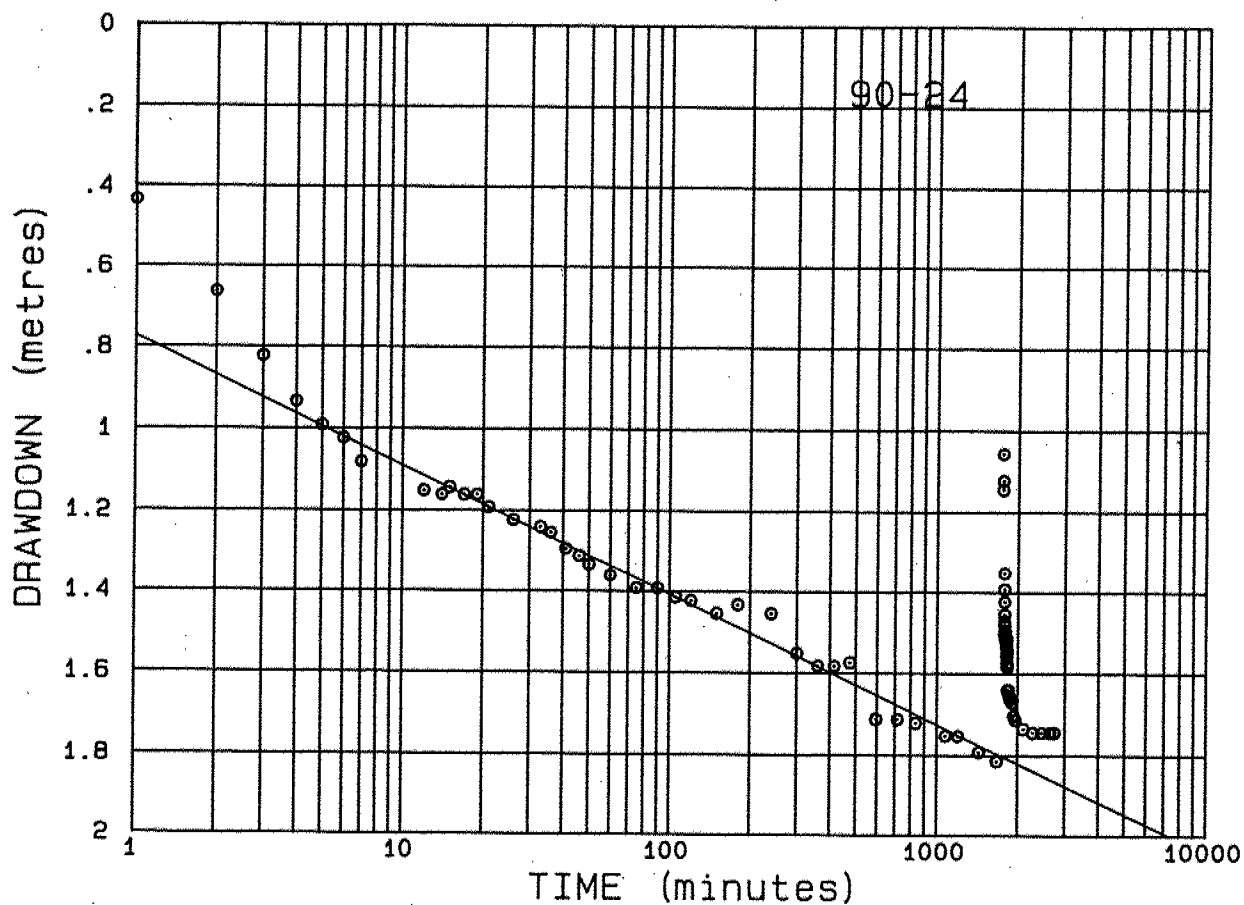
49	1791.00	1.49
50	1793.00	1.50
51	1797.00	1.51
52	1802.00	1.51
53	1817.00	1.51
54	1819.00	1.52
55	1819.50	1.53
56	1820.50	1.54
57	1821.50	1.55
58	1822.50	1.55
59	1823.50	1.56
60	1825.00	1.57
61	1827.00	1.58
62	1829.00	1.58
63	1831.00	1.64
64	1841.00	1.64
65	1851.00	1.64
66	1861.00	1.65
67	1871.00	1.66
68	1891.00	1.66
69	1911.00	1.67
70	1932.00	1.70
71	1962.00	1.71
72	2100.00	1.73
73	2280.00	1.74
74	2460.00	1.74
75	2640.00	1.74
76	2740.00	1.74

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day)	137.5
DISTANCE TO OBSERVATION WELL (metres)	1.7
TRANSMISSIVITY (metres squared per day)	79.2
DATA FROM 12.00 TO 1675.00 minutes USED	

DRAWDOWN DATA  
OBSERVATION WELL 90-24

FIGURE A3  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 79.2 METRES SQUARED PER DAY

Date OCT 18, 1990  
Project 90I-2115

Golder Associates

Drawn JC  
Chkd. \_\_\_\_\_

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 90-25

## PUMPING TEST DATA

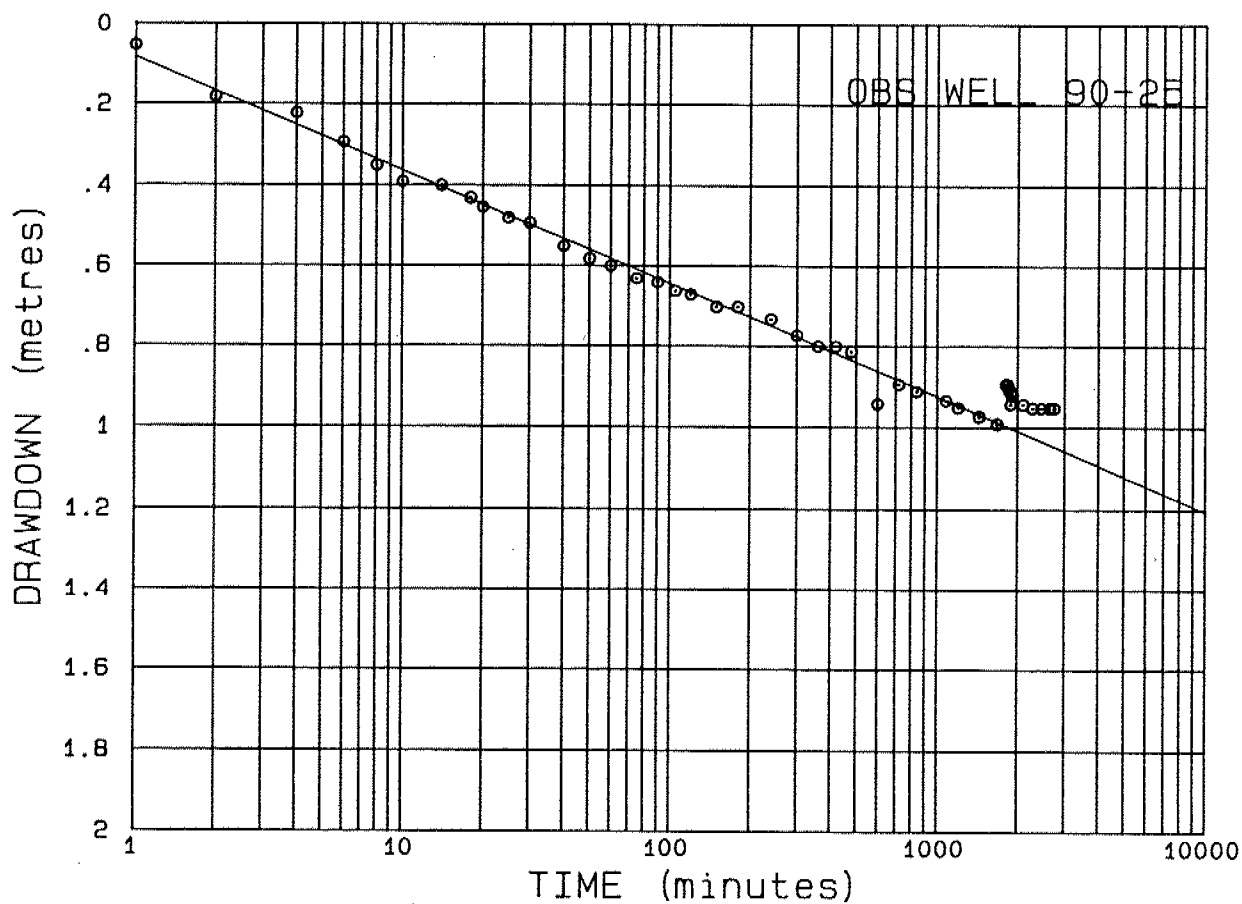
READING No.	TIME (min)	DRAWDOWN (m)
1	1.00	0.05
2	2.00	0.18
3	4.00	0.22
4	6.00	0.29
5	8.00	0.35
6	10.00	0.39
7	14.00	0.40
8	18.00	0.43
9	20.00	0.45
10	25.00	0.48
11	30.00	0.49
12	40.00	0.55
13	50.00	0.58
14	60.00	0.60
15	75.00	0.63
16	90.00	0.64
17	105.00	0.66
18	120.00	0.67
19	150.00	0.70
20	180.00	0.70
21	240.00	0.73
22	300.00	0.77
23	360.00	0.80
24	420.00	0.80
25	480.00	0.81
26	600.00	0.94
27	720.00	0.89
28	840.00	0.91
29	1080.00	0.93
30	1200.00	0.95
31	1440.00	0.97
32	1680.00	0.99
33	1817.00	0.89
34	1834.00	0.89
35	1854.00	0.90
36	1885.00	0.94
37	1895.00	0.91
38	1915.00	0.92
39	2100.00	0.94
40	2280.00	0.95
41	2460.00	0.95
42	2640.00	0.95
43	2740.00	0.95

SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 8.1  
TRANSMISSIVITY (metres squared per day) 89.7  
DATA FROM 1.00 TO 480.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 90-25

FIGURE A4  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 89.7 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 90I-2115

Golder Associates

Drawn JC  
Chkd.



JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 90-26

## PUMPING TEST DATA

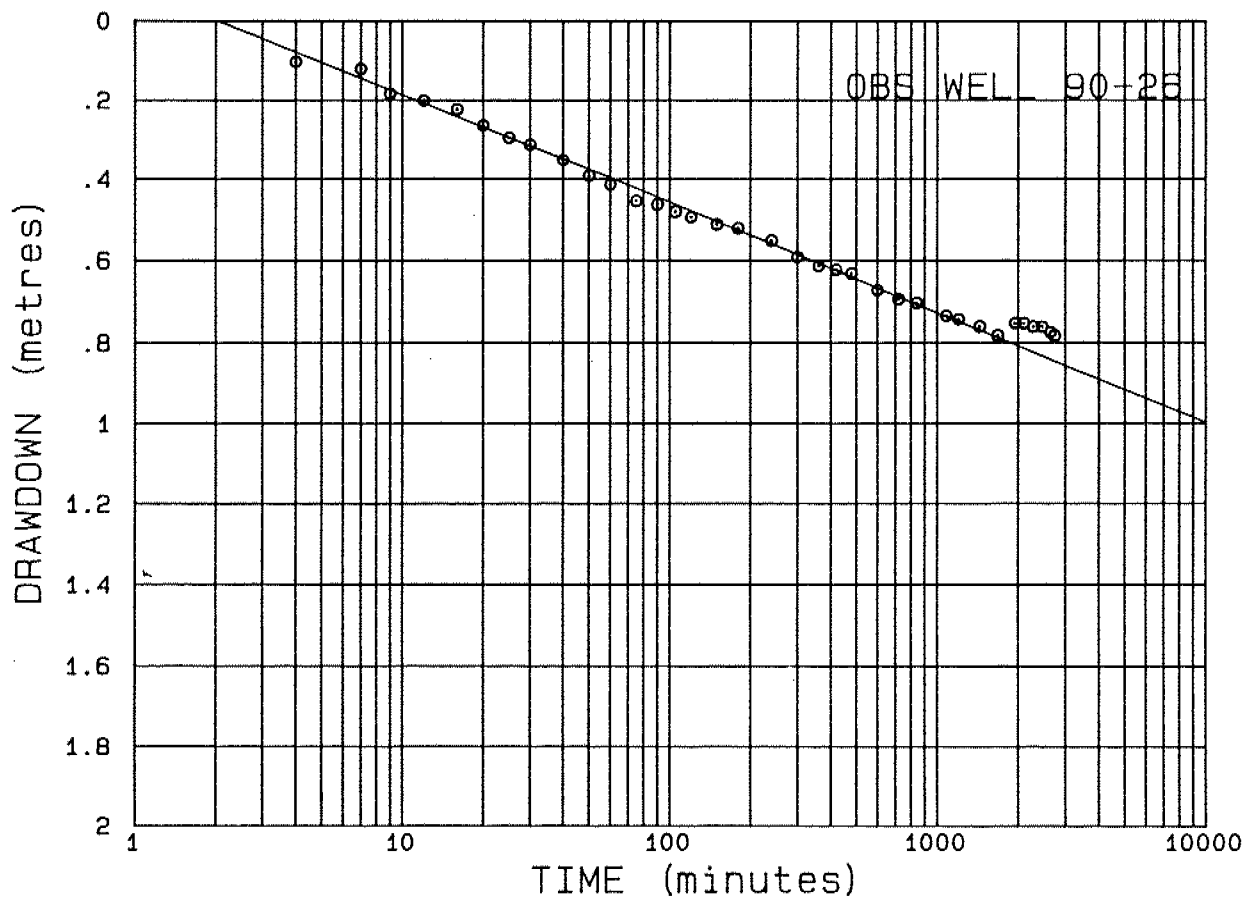
READING No.	TIME (min)	DRAWDOWN (m)
1	1.00	0.04
2	4.00	0.10
3	7.00	0.12
4	9.00	0.18
5	12.00	0.20
6	16.00	0.22
7	20.00	0.26
8	25.00	0.29
9	30.00	0.31
10	40.00	0.35
11	50.00	0.39
12	60.00	0.41
13	75.00	0.45
14	90.00	0.46
15	105.00	0.48
16	120.00	0.49
17	150.00	0.51
18	180.00	0.52
19	240.00	0.55
20	300.00	0.59
21	360.00	0.61
22	420.00	0.62
23	480.00	0.63
24	600.00	0.67
25	720.00	0.69
26	840.00	0.70
27	1080.00	0.73
28	1200.00	0.74
29	1440.00	0.76
30	1680.00	0.78
31	1950.00	0.75
32	2100.00	0.75
33	2280.00	0.76
34	2460.00	0.76
35	2640.00	0.77
36	2740.00	0.78

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 47.9  
TRANSMISSIVITY (metres squared per day) 93.1  
DATA FROM 7.00 TO 1680.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 90-26

FIGURE A5  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 93.1 METRES SQUARED PER DAY

Date OCT 18, 1990  
Project 90I-2115

Golder Associates

Drawn JC  
Chkd \_\_\_\_\_

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 90-W9

## PUMPING TEST DATA

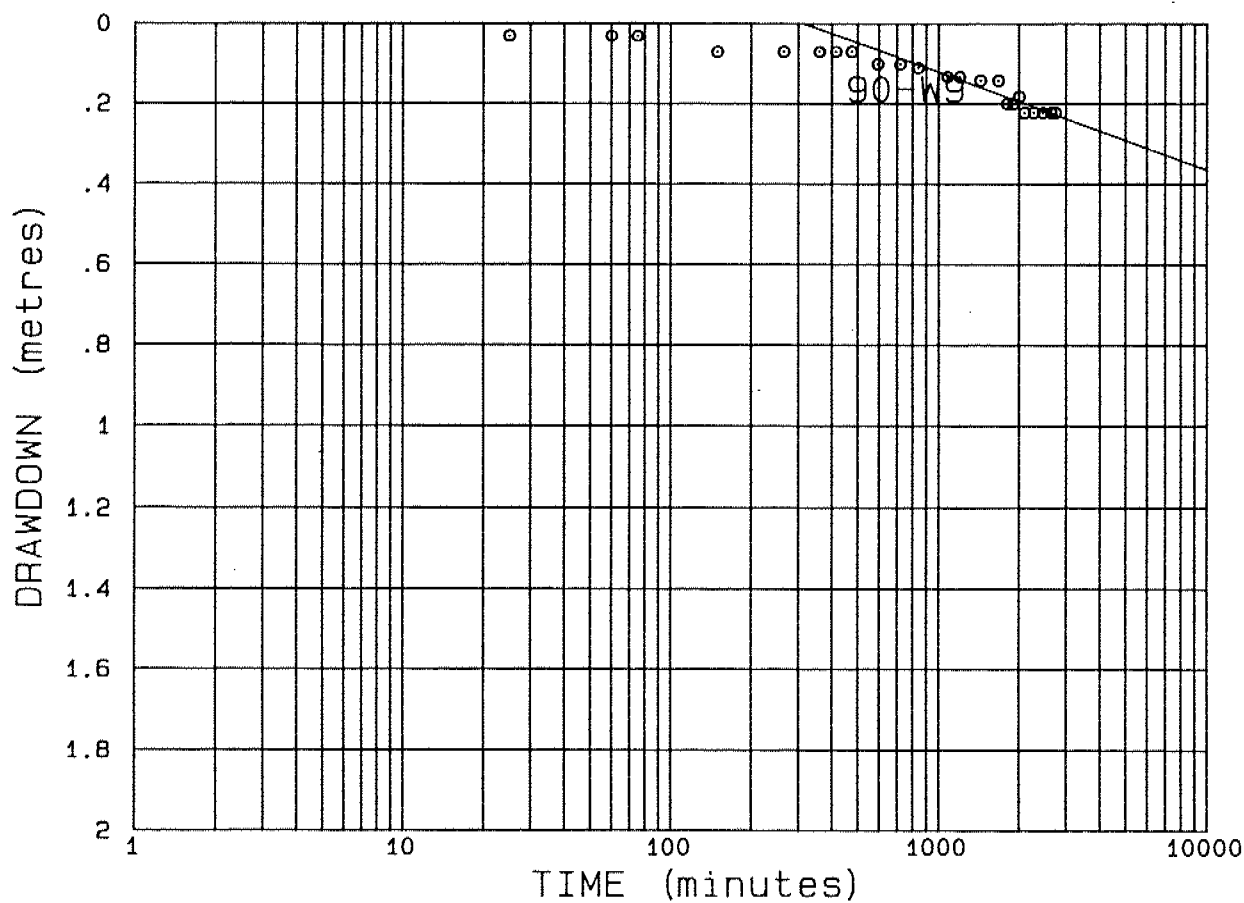
READING No.	TIME (min)	DRAWDOWN (m)
1	25.00	0.03
2	60.00	0.03
3	75.00	0.03
4	150.00	0.07
5	265.00	0.07
6	360.00	0.07
7	415.00	0.07
8	475.00	0.07
9	595.00	0.10
10	720.00	0.10
11	840.00	0.11
12	1080.00	0.13
13	1200.00	0.13
14	1440.00	0.14
15	1680.00	0.14
16	1807.00	0.20
17	1907.00	0.20
18	2007.00	0.18
19	2100.00	0.22
20	2280.00	0.22
21	2460.00	0.22
22	2640.00	0.22
23	2740.00	0.22

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 23.1  
TRANSMISSIVITY (metres squared per day) 103.7  
DATA FROM 720.00 TO 2460.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 90-W9

FIGURE A6  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 103.7 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 90I-2115

**Golder Associates**

Drawn JC  
Chkd. \_\_\_\_\_

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 90-W10

## PUMPING TEST DATA

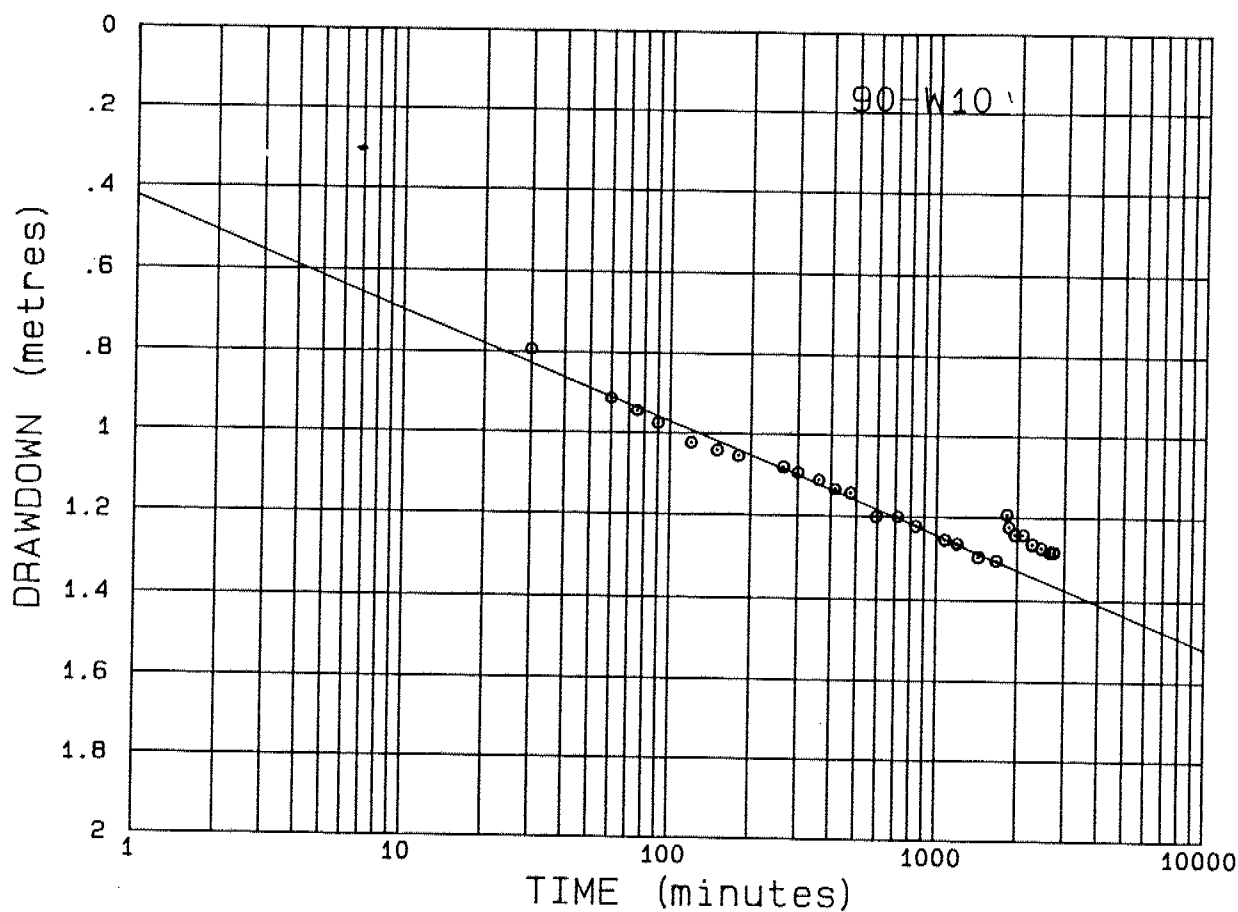
READING No.	TIME (min)	DRAWDOWN (m)
1	30.00	0.79
2	60.00	0.91
3	75.00	0.94
4	90.00	0.97
5	120.00	1.02
6	150.00	1.04
7	180.00	1.05
8	265.00	1.08
9	300.00	1.09
10	360.00	1.11
11	415.00	1.13
12	475.00	1.14
13	595.00	1.20
14	715.00	1.20
15	835.00	1.22
16	1075.00	1.25
17	1195.00	1.26
18	1435.00	1.29
19	1675.00	1.30
20	1825.00	1.19
21	1860.00	1.22
22	1963.00	1.24
23	2100.00	1.24
24	2280.00	1.26
25	2460.00	1.27
26	2640.00	1.28
27	2740.00	1.28

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 34.9  
TRANSMISSIVITY (metres squared per day) 92.0  
DATA FROM 30.00 TO 1675.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 90-W10

FIGURE A7  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 92.0 METRES SQUARED PER DAY

Date OCT. 18, 1990

Project 90I-2115

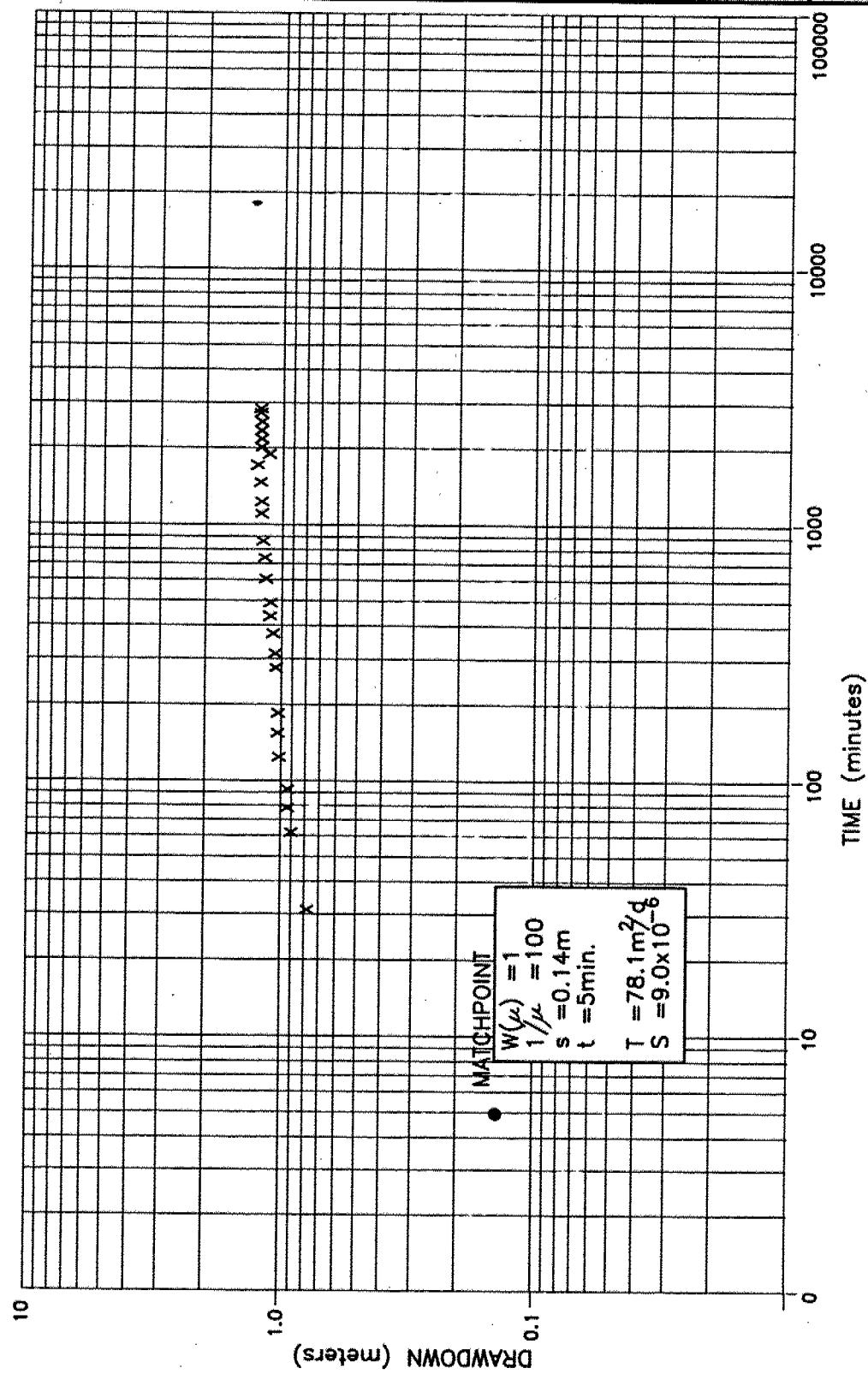
Golder Associates

Drawn JC

Chkd.

# THEIS ANALYSIS OF DRAWDOWN DATA OBSERVATION WELL 90-W.10

FIGURE A8  
WP 146-74-00-3



Date SEPT. 17, 1990

Project 901-2115

**Golder Associates**

Drawn TDR

Chkd

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 88-4A

## PUMPING TEST DATA

READING No.	TIME (min)	DRAWDOWN (m)
1	1.00	0.07
2	2.00	0.11
3	3.00	0.17
4	4.00	0.20
5	5.00	0.24
6	6.00	0.25
7	7.00	0.28
8	12.00	0.31
9	14.00	0.33
10	16.00	0.33
11	18.00	0.35
12	20.00	0.36
13	22.00	0.37
14	24.00	0.39
15	26.00	0.42
16	28.00	0.43
17	30.00	0.45
18	47.00	0.46
19	50.00	0.48
20	60.00	0.50
21	75.00	0.52
22	90.00	0.54
23	105.00	0.55
24	120.00	0.57
25	150.00	0.60
26	180.00	0.61
27	240.00	0.63
28	300.00	0.68
29	360.00	0.71
30	415.00	0.72
31	475.00	0.72
32	595.00	0.79
33	715.00	0.81
34	835.00	0.83
35	1075.00	0.87
36	1195.00	0.89
37	1435.00	0.91
38	1675.00	0.94
39	1818.00	0.86
40	1834.00	0.86
41	1854.00	0.87
42	1874.00	0.87
43	1904.00	0.88
44	2100.00	0.90
45	2280.00	0.92
46	2460.00	0.93
47	2500.00	0.94

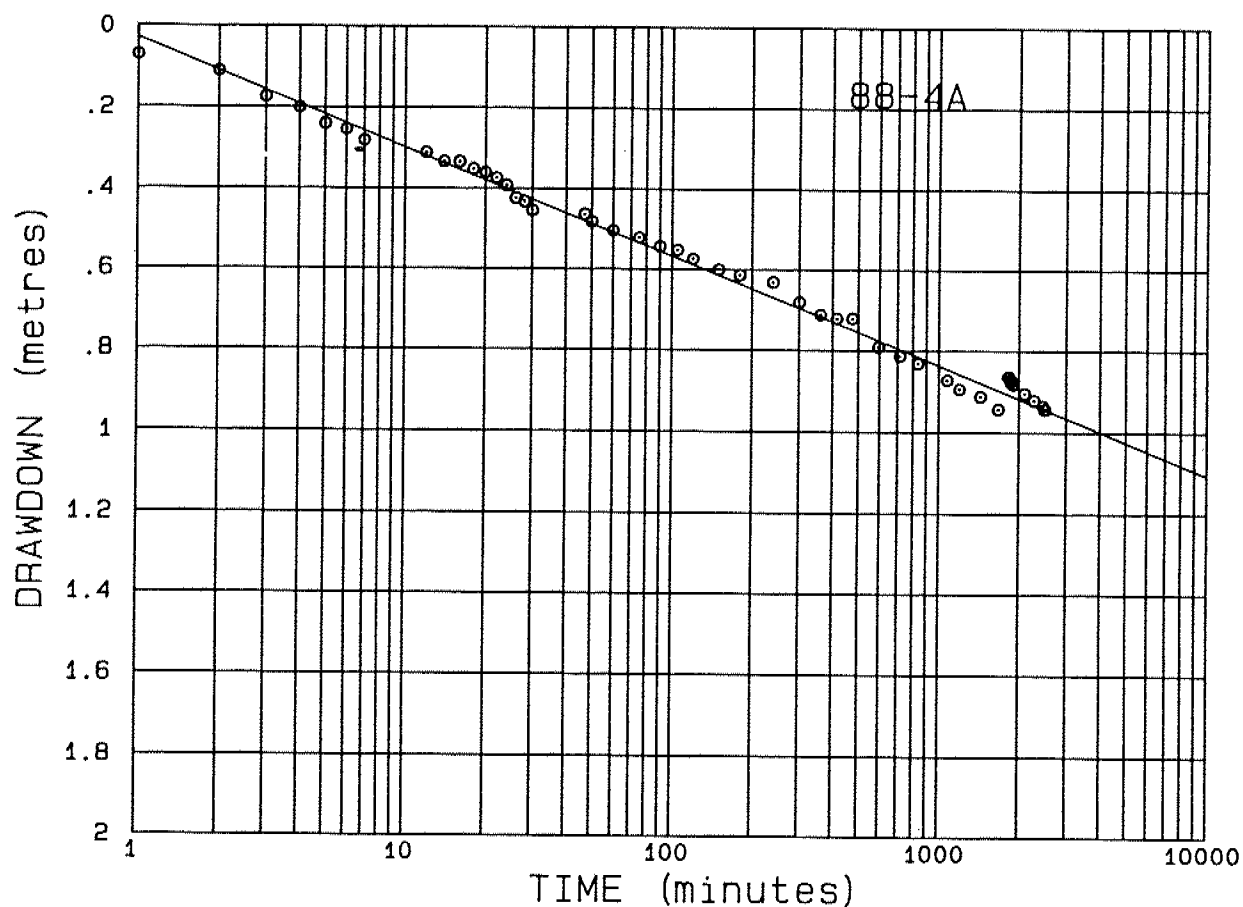


## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day)	137.5
DISTANCE TO OBSERVATION WELL (metres)	17.2
TRANSMISSIVITY (metres squared per day)	93.5
DATA FROM	1.00 TO 1675.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 88-4A

FIGURE A9  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 93.5 METRES SQUARED PER DAY

Date OCT. 18, 1990

Project 90I-2115

**Golder Associates**

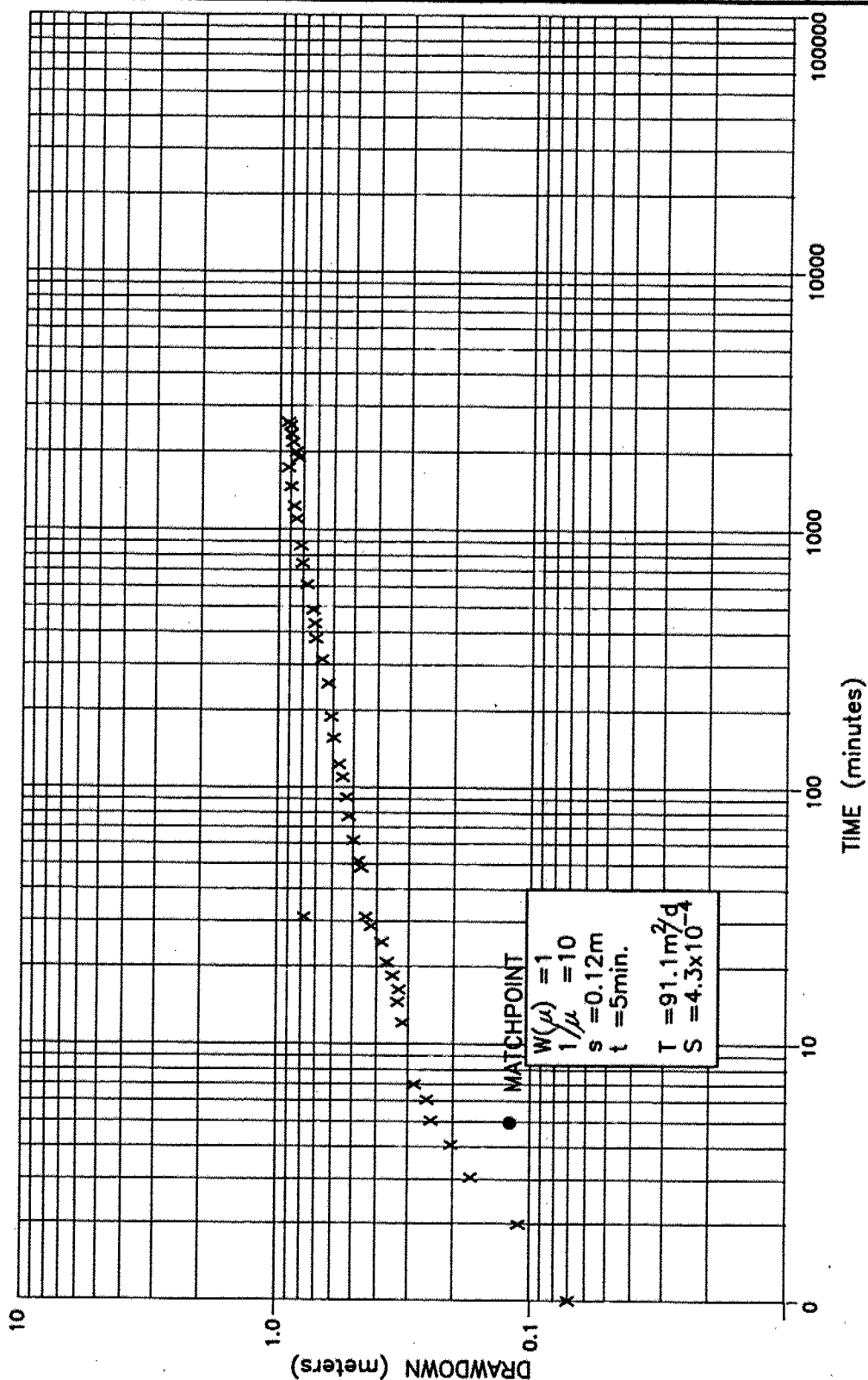
Drawn JC

Chkd. \_\_\_\_\_

# THEIS ANALYSIS OF DRAWDOWN DATA OBSERVATION WELL 88-4A

FIGURE AIO

WP 146-74-00-3



Date SEPT. 17, 1990

Project 901-2115...

Golder Associates

Drawn TDR.....

Chkd .....

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 89-2A

## PUMPING TEST DATA

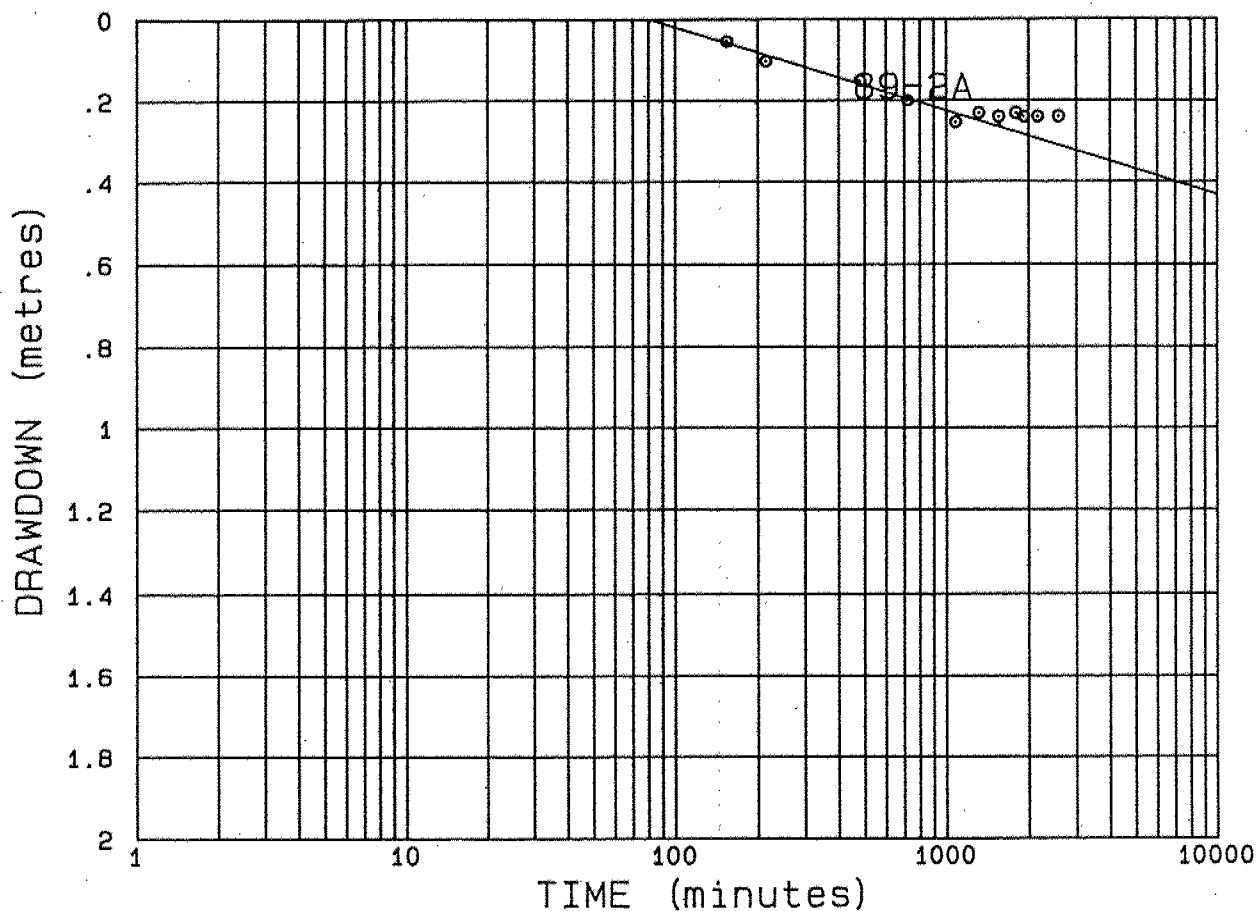
READING No.	TIME (min)	DRAWDOWN (m)
1	94.00	0.04
2	154.00	0.05
3	214.00	0.10
4	480.00	0.15
5	720.00	0.20
6	1080.00	0.25
7	1320.00	0.23
8	1560.00	0.24
9	1800.00	0.23
10	1920.00	0.24
11	2160.00	0.24
12	2580.00	0.24

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 145.0  
TRANSMISSIVITY (metres squared per day) 122.0  
DATA FROM 154.00 TO 720.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 89-2A

FIGURE All  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 122.0 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 901-2115

Golder Associates

Drawn JC  
Chkd.

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 89-2B

## PUMPING TEST DATA

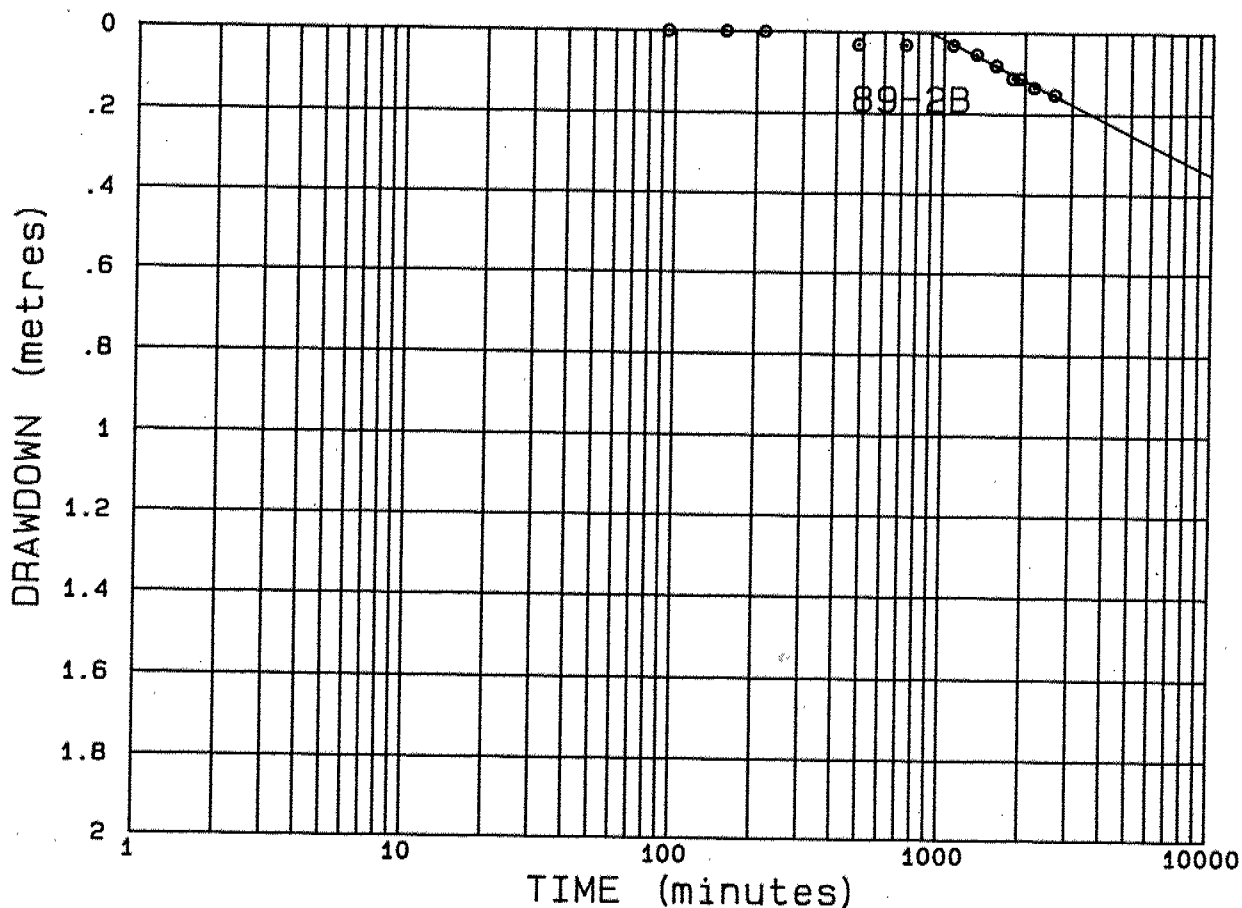
READING No.	TIME (min)	DRAWDOWN (m)
1	94.00	0.00
2	154.00	0.00
3	214.00	0.00
4	480.00	0.03
5	720.00	0.03
6	1080.00	0.03
7	1320.00	0.05
8	1560.00	0.08
9	1800.00	0.11
10	1920.00	0.11
11	2160.00	0.13
12	2580.00	0.15

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 145.0  
TRANSMISSIVITY (metres squared per day) 75.5  
DATA FROM 1080.00 TO 2580.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 89-2B

FIGURE A12  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 75.5 METRES SQUARED PER DAY

Date OCT. 18, 1990

Project 90J-2115

Golder Associates

Drawn JC

Chkd.

JOB NUMBER 901-2115  
DATE OF TEST JULY /12/90  
WELL NUMBER 89-6B

## PUMPING TEST DATA

READING No.	TIME (min)	DRAWDOWN (m)
1	94.00	0.04
2	154.00	0.10
3	214.00	0.23
4	480.00	0.31
5	720.00	0.38
6	1080.00	0.43
7	1320.00	0.43
8	1560.00	0.45
9	1800.00	0.48
10	1920.00	0.47
11	2160.00	0.48
12	2580.00	0.49

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 160.0  
TRANSMISSIVITY (metres squared per day) 80.2  
DATA FROM 94.00 TO 2580.00 minutes USED



JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 89-7

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PUMPING TEST DATA

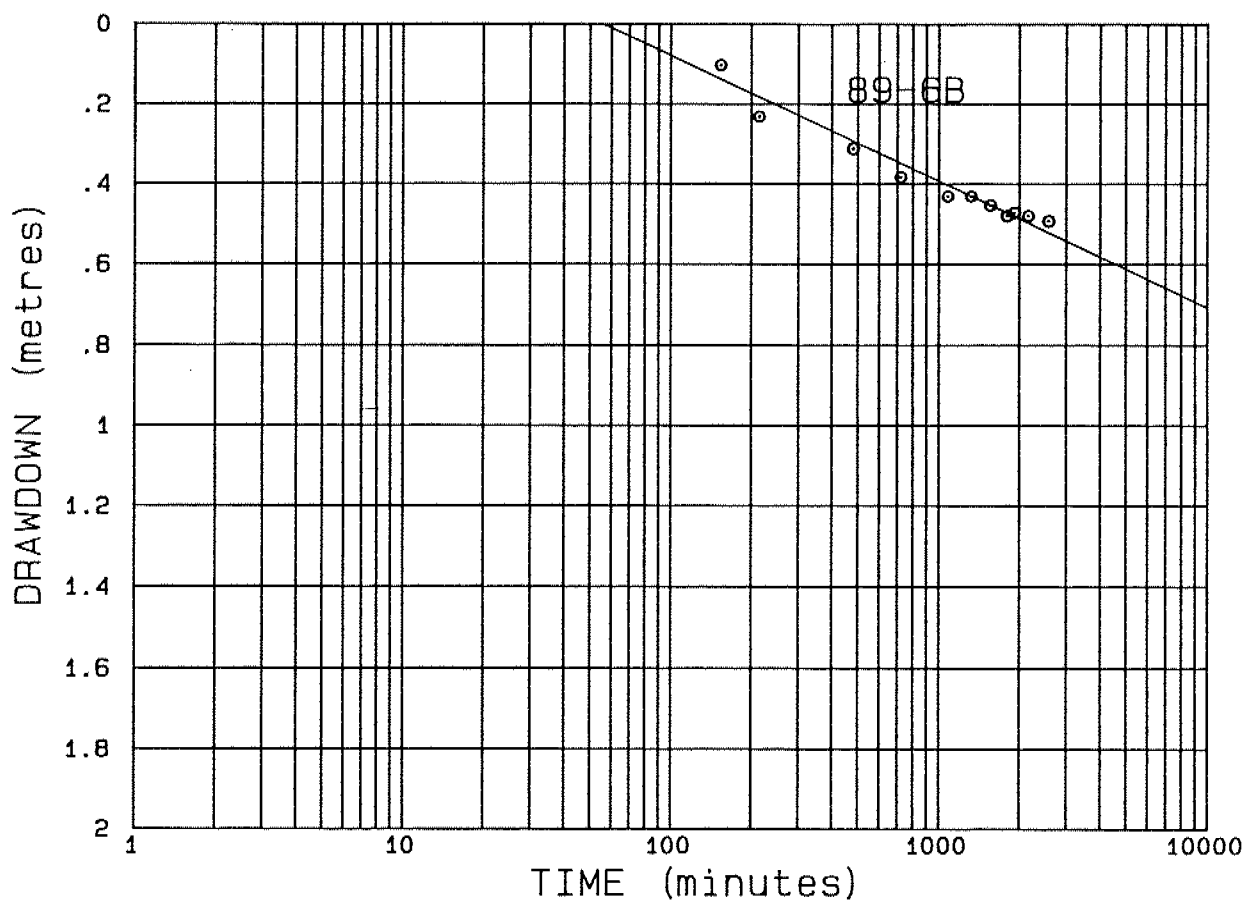
READING No.	TIME (min)	DRAWDOWN (m)
1	30.00	0.19
2	60.00	0.31
3	75.00	0.33
4	90.00	0.35
5	105.00	0.37
6	120.00	0.38
7	150.00	0.39
8	180.00	0.41
9	240.00	0.43
10	300.00	0.46
11	360.00	0.48
12	420.00	0.49
13	480.00	0.50
14	600.00	0.54
15	720.00	0.56
16	840.00	0.57
17	1080.00	0.59
18	1200.00	0.61
19	1440.00	0.62
20	1680.00	0.64
21	1920.00	0.61
22	2100.00	0.62
23	2280.00	0.62
24	2460.00	0.63
25	2640.00	0.63
26	2740.00	0.63

SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 112.0  
TRANSMISSIVITY (metres squared per day) 110.3  
DATA FROM 60.00 TO 1680.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 89-6B

FIGURE A13  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 80.2 METRES SQUARED PER DAY

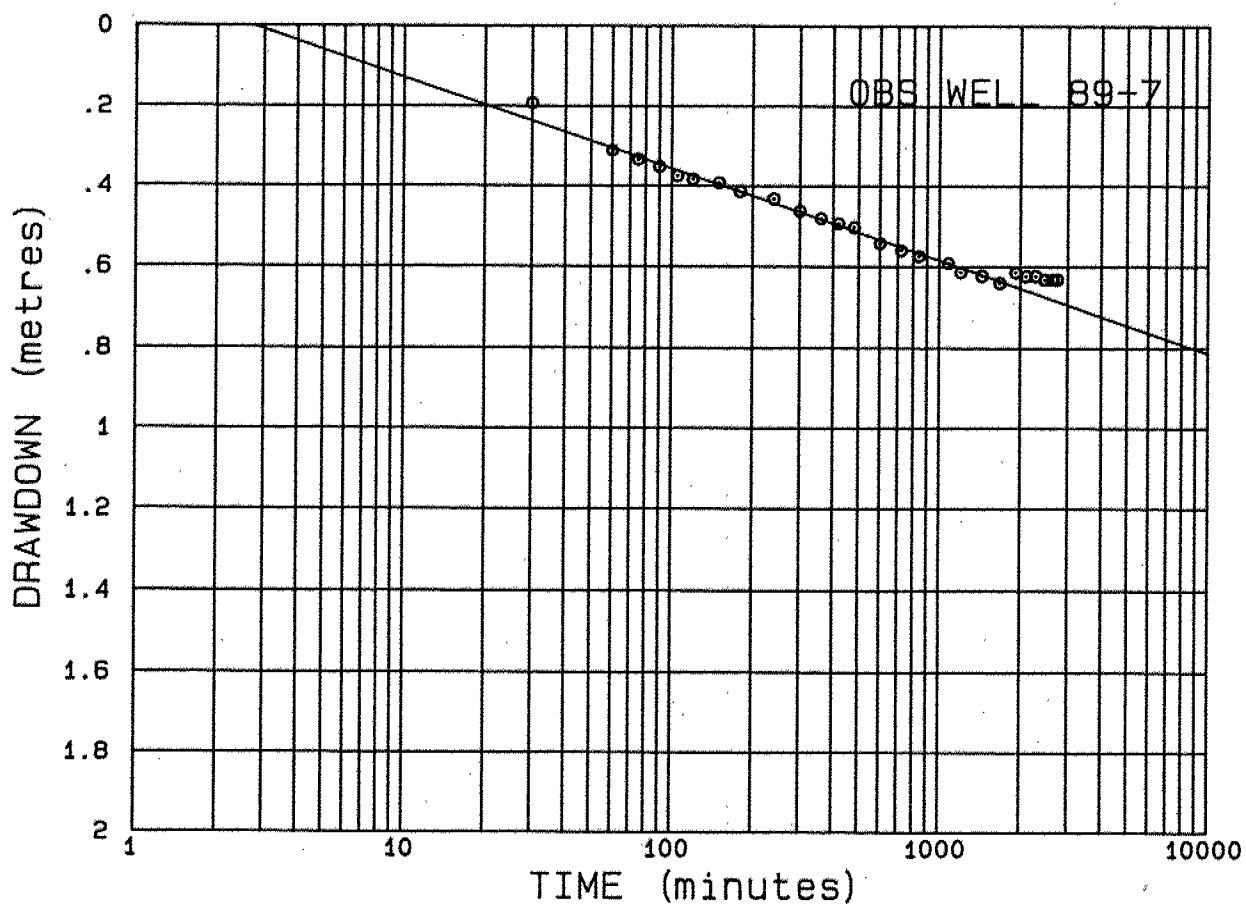
Date OCT 18, 1990  
Project 90I-2115

**Golder Associates**

Drawn JC  
Chkd. \_\_\_\_\_

DRAWDOWN DATA  
OBSERVATION WELL 89-7

FIGURE A14  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 110.3 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 90I-2115

**Golder Associates**

Drawn JC  
Chkd. \_\_\_\_\_

JOB NUMBER 901-2115  
DATE OF TEST JULY/12/90  
WELL NUMBER 89-9

## PUMPING TEST DATA

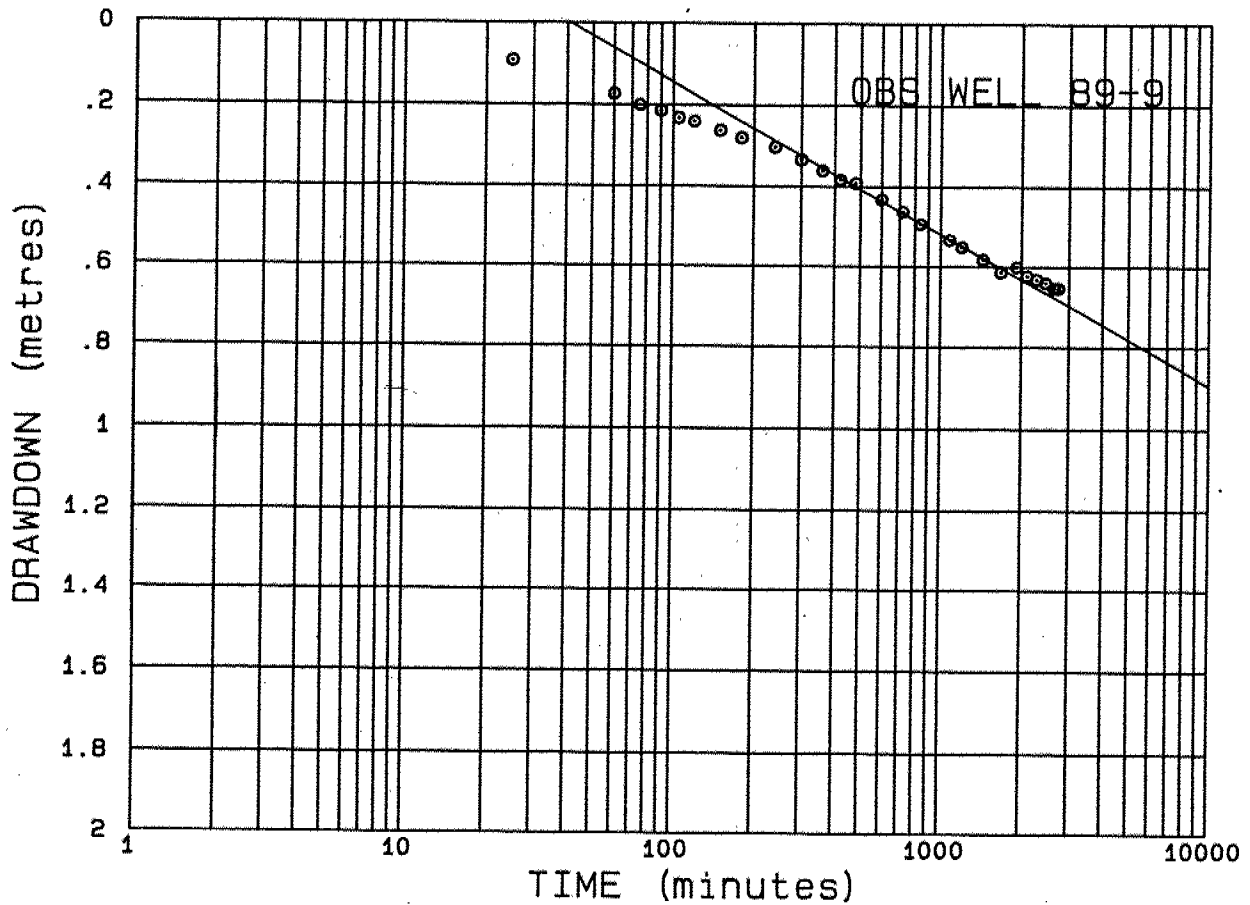
READING No.	TIME (min)	DRAWDOWN (m)
1	25.00	0.09
2	60.00	0.17
3	75.00	0.20
4	90.00	0.21
5	105.00	0.23
6	120.00	0.24
7	150.00	0.26
8	180.00	0.28
9	240.00	0.30
10	300.00	0.33
11	360.00	0.36
12	420.00	0.38
13	480.00	0.39
14	600.00	0.43
15	720.00	0.46
16	840.00	0.49
17	1080.00	0.53
18	1200.00	0.55
19	1440.00	0.58
20	1680.00	0.61
21	1920.00	0.60
22	2100.00	0.62
23	2280.00	0.63
24	2460.00	0.64
25	2640.00	0.65
26	2740.00	0.65

## SUMMARY OF RESULTS

PUMPING RATE (cubic metres per day) 137.5  
DISTANCE TO OBSERVATION WELL (metres) 42.0  
TRANSMISSIVITY (metres squared per day) 67.2  
DATA FROM 300.00 TO 1680.00 minutes USED

DRAWDOWN DATA  
OBSERVATION WELL 89-9

FIGURE A15  
WP 146-74-00-3



Q= 137.5 CUBIC METRES PER DAY  
T= 67.2 METRES SQUARED PER DAY

Date OCT. 18, 1990  
Project 901-2115

**Golder Associates**

Drawn JC  
Chkd. \_\_\_\_\_

APPENDIX B  
WATER WELL RECORD



The Ontario Water Resources Act

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# WATER WELL RECORD

1 PRINT ONLY IN SPACES PROVIDED  
2 CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT				TOWNSHIP		R.D. OR CITY		LOCALITY		LOCALITY	
OTTAWA - CARLETON				NEPEAN		BELL		CORNERS			
OWNER (SURNAME FIRST)				ADDRESS		DATE COMPLETED					
Ministry Transportation Ont.				Cedarview Rd. & Baseline Rd.		DAY - 12 - MO - 07 - YR - 80					

[illegible][illegible]

CASING & OPEN HOLE RECORD			
INSTR DIA W INCHES	METER &	WELL IN. X METERS L. W.	DEPTH FEET L. M.
16"	<input type="checkbox"/> STEEL <input checked="" type="checkbox"/> GALVANIZED <input type="checkbox"/> CONCRETE <input checked="" type="checkbox"/> OPEN HOLE <input checked="" type="checkbox"/> PLASTIC		0' 35'
10"	<input checked="" type="checkbox"/> STEEL <input checked="" type="checkbox"/> GALVANIZED <input type="checkbox"/> CONCRETE <input type="checkbox"/> OPEN HOLE <input type="checkbox"/> PLASTIC	-250	+3' -29'
10"	<input checked="" type="checkbox"/> STEEL <input checked="" type="checkbox"/> GALVANIZED <input type="checkbox"/> CONCRETE <input type="checkbox"/> OPEN HOLE <input type="checkbox"/> PLASTIC		20' 35'

SCREEN	SIZES OF OPENING (SLOT NO.)	DIAMETER	LENGTH
	25	10" 1/4	6' 1"
	MATERIAL AND TYPE	SHEET NO. OF OF SCREEN	
	STAINLESS STEEL	29' 1"	

PLUGGING & SEALING RECORD			
DATE	TIME	MAKING AND TYPE	REMARKS
01	25	15 Bags of Holeplug	

PUMPING TEST	PUMPING TEST METHOD		PUMPING RATE		PRESSURE IN THE PUMPING				
	<input checked="" type="checkbox"/> PUMP <input type="checkbox"/> RAISIN		25		GPM		1		
	STATIC LEVEL		WATER LEVEL END OF PUMPING		WATER LEVELS DURING		PUMPING		
							PELOUSRY		
			15 MINUTES		30 MINUTES		45 MINUTES		
			60 MINUTES						
1.80 FEET		26 FEET		7 FEET		10 FEET		15 FEET	
26 FEET									
IF FLOWING GIVE RATE		PUMP INHALE SET AT		WATER AT END OF TEST					
BELOW NORMAL PUMP TYPE		GPM		26		FEET		X	
		RECOMMENDED		PUMPING		UNWINDING		PUMP	
		SETTING		FEET		DATA		GPM	
<input checked="" type="checkbox"/> SHALLOW <input type="checkbox"/> DEEP		27		25					

FINAL STATUS OF WELL	<input type="checkbox"/> WATER SUPPLY <input type="checkbox"/> OBSERVATION WELL <input checked="" type="checkbox"/> TEST HOLE <input checked="" type="checkbox"/> RECHARGE WELL	<input type="checkbox"/> ABANDONED INSUFFICIENT SUPPLY <input type="checkbox"/> ABANDONED POOR QUALITY <input type="checkbox"/> UNFINISHED <input type="checkbox"/> DEWATERING
WATER USE	<input type="checkbox"/> DOMESTIC <input type="checkbox"/> STOCK <input type="checkbox"/> IRRIGATION <input type="checkbox"/> INDUSTRIAL <input type="checkbox"/> OTHER	<input type="checkbox"/> COMMERCIAL <input type="checkbox"/> MUNICIPAL <input type="checkbox"/> PUBLIC SUPPLY <input type="checkbox"/> COOLING OR A/P CONDITIONING <input type="checkbox"/> NOT USED
METHOD OF CONSTRUCTION	<input checked="" type="checkbox"/> CABLE TOOL <input checked="" type="checkbox"/> ROTARY (CONVENTIONAL) <input type="checkbox"/> ROTARY (REVERSE) <input type="checkbox"/> ROTARY (AIR) <input type="checkbox"/> AIR PERCUSSION	<input type="checkbox"/> BORING <input type="checkbox"/> DIAMOND <input type="checkbox"/> JETTING <input type="checkbox"/> DRIVING <input type="checkbox"/> DIGGING <input type="checkbox"/> OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE

INDICATE NORTH BY ARROW

TRAIN TRACK

Cedarview Rd

1000'

120'

48212

DRAWN BY: [illegible]

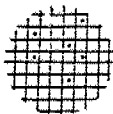
CONTRACTOR	NAME OF WELL CONTRACTOR	WELL CONTRACTOR'S LICENCE NUMBER
	OLYMPIC DRILLING CO. LIMITED.	4006
	ADDRESS	
	P.O. #. 9180 OTTAWA, ONT. K1G - 3T9	
	JODIE BENWICK	TO 460
	SIGNATURE OF TECHNICIAN/CONTRACTOR	SUBMISSION DATE
	<i>Jodie Benwick</i>	DAY 12 MO 07 YEAR 99

OFFICE USE ONLY			

APPENDIX C

CHEMICAL ANALYSIS OF  
GROUNDWATER SAMPLES



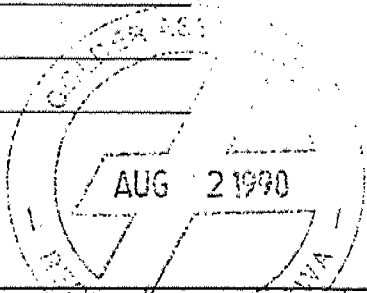
**ACCUTEST**

LABORATORIES LTD.

146 Colonnade Rd., Suite 202, Nepean, Ontario K2E 7Y3 (613) 727-5692

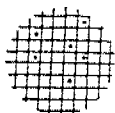
LAB REPORT NO.: A0-1 37

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**REPORT OF ANALYSES**Client: Golder AssociatesDate: July 30, 1990Attn: Mr. Rob FinlayProject: 901-2115

Parameter	Units	Sample	Sample	Sample	Sample	Sample
		35 hrs	42 hrs			
Fe	mg/L					
Mn	mg/L					
Hardness	mg/L CaCO <sub>3</sub>					
Alkalinity	mg/L CaCO <sub>3</sub>	228	228			
pH						
Conductivity	umhos					
F	mg/L	0.08	0.11			
Na	mg/L					
N-NO <sub>3</sub>	mg/L	<0.10	<0.10			
N-NO <sub>2</sub>	mg/L	<0.10	<0.10			
N-NH <sub>3</sub>	mg/L	<0.10	<0.10			
S	mg/L	69	68			
CL	mg/L	74	72			
Phenols	mg/L	<0.002	<0.002			
Turbidity	NTU					
Colour	Pt/Co Units					
Ca	mg/L					
Mg	mg/L					
Tannin & Lignin	mg/L					
Total Nitrogen	mg/L	<0.10	<0.10			
K	mg/L	5	5			
BOD	mg/L	<1	<1			
COD	mg/L	<3	6			
TDS	mg/L	478	470			
Br	mg/L	1.1	1.5			
PO <sub>4</sub>	mg/L	0.14	0.20			

ANALYST: \_\_\_\_\_

**ACCUTEST**

LABORATORIES LTD.

146 Colonnade Rd., Suite 202, Nepean, Ontario K2E 7Y3 (613) 727-5692

348

LAB REPORT NO.: 90-1187

## REPORT OF ANALYSES

Client: Golder AssociatesDate July 30, 1990Project: 901-2115

Parameter	Units	Sample	Sample	Sample	Sample	Sample
		35 hrs	42 hrs			
Ca	mg/L	91	88			
Mg	mg/L	33	33			
Na	mg/L	19	19			
Al	mg/L	<0.03	<0.03			
Ba	mg/L	0.33	0.33			
Be	mg/L	0.06	0.06			
B	mg/L	<0.01	<0.01			
Cd	mg/L	<0.002	<0.002			
Cr	mg/L	<0.01	<0.01			
Co	mg/L	<0.02	<0.02			
Cu	mg/L	<0.002	<0.002			
Fe	mg/L	0.40	0.41			
Pb	mg/L	<0.002	<0.002			
Mn	mg/L	0.05	0.05			
Mo	mg/L	<0.01	0.01			
Ni	mg/L	<0.02	<0.02			
P	mg/L	<0.1	0.1			
Si	mg/L	5.3	5.8			
Ag	mg/L	<0.01	<0.01			
Sr	mg/L	0.28	0.29			
S	mg/L	29	29			
Tl	mg/L	<0.01	<0.01			
Ti	mg/L	<0.01	<0.01			
V	mg/L	<0.01	<0.01			
Zn	mg/L	<0.01	<0.01			
Sn	mg/L	0.7	0.8			

ANALYST:

**Golder Associates Ltd.**

1796 Courtwood Crescent  
Ottawa, Ontario, Canada K2C 2B5  
Telephone (613) 224-5864  
Fax (613) 224-9928



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**REPORT TO**  
**MINISTRY OF TRANSPORTATION ONTARIO**

**ADDITIONAL SUBSURFACE INVESTIGATION  
GEOTECHNICAL AND GROUNDWATER STUDY  
PROPOSED HIGHWAY 416  
CEDARVIEW ROAD CORRIDOR  
LYNWOOD SUBDIVISION AREA  
W.P. 146-74-00-3A DISTRICT 9 (OTTAWA)  
NEPEAN, ONTARIO**

**May 1991**

**901-2410**

## 1. INTRODUCTION

The Ministry of Transportation Ontario (MTO) retained Golder Associates Ltd. to carry out a pump test along the proposed Highway 416 route adjacent to the Lynwood subdivision in Nepean, Ontario (see Key Plan, Figure 1). Based on the information obtained, the possible effects of the proposed Highway 416 construction on the groundwater regime in the subdivision were to be determined.

The results of the pump test are provided in a previous report number 901-2115 prepared by Golder Associates Ltd., entitled "Pump Test, Geotechnical and Groundwater Study, Proposed Highway 416, Cedarview Road Corridor, Lynwood Subdivision Area, W.P. 146-74-00-3 District 9 (Ottawa), Nepean, Ontario" dated October 1990.

The borings in the near portion of the subdivision, in the previous investigation, suggested that the aquifer is overlain by two silty clay deposits. One silty clay deposit has a firm to stiff consistency and should be relatively unaffected by the groundwater drawdown. A second silty clay deposit which may have been infilled after deposition of the first deposit appears to be softer and near normally consolidated. The delineation of the lateral extent and thickness of this second silty clay deposit is important in order to identify potential problem areas within the subdivision.

This report provides additional subsurface information obtained within the Lynwood Subdivision.

It is planned to carry Highway 416 under the CN rail line located south of Baseline Road. The vertical alignment results in a cut section between about 5 and 11 metres below ground surface (including an allowance for 1.5 to 2.0 metre deep drainage swales).

## 2. SITE DESCRIPTION AND GEOLOGY

Between the CN railway line which is just north of the subdivision and the south end of the subdivision, the topography is relatively flat. South of this area to Bruce Pit, the topography is gently sloping and rises about 7 to 8 metres above the table lands to the north. As a result of past granular materials extraction, the average ground surface elevation across the abandoned pit floor is about 10 metres below the level of Cedarview Road. Two shallow ponds exist at the base of the pit due to groundwater inflow into the pit. Currently, the Bruce Pit area is used for recreation and includes hiking pathways, cross country ski trails and a toboggan hill.

The subdivision area near proposed Highway 416 has a relatively flat topography. The houses in the subject area are about 30 years old and consist of single storey, wood frame structures with concrete basements. Site servicing presently consists of municipal water supply and sanitary sewers, although construction of a separate storm sewer service is being planned.

Mature trees exist on some of the residential properties.

## 3. SUMMARY OF PUMP TEST RESULTS

As indicated previously, the results of a pump test carried out at the site are provided in Golder Associates Ltd. report 901-2115 (WP 146-74-00-3). The pump test was carried out on a 254 millimetre diameter well, with a natural sand pack, for an

elapsed time of 43 hours. The water levels in the pumping well and in ten (10) monitoring wells were measured during the pumping test to evaluate the hydraulic properties of the sandy aquifer.

#### 4. INVESTIGATION PROCEDURE

To better define the subsurface conditions in the subdivision, thirteen (13) additional boreholes, numbered 90-27 to 90-39 inclusive, were advanced between Cedarview Road and Larkspur Drive. The boreholes were advanced between May 11, 1990 and October 22, 1990 to depths ranging from 5.6 to 11.1 metres below ground surface. Boreholes 90-27 to 90-30 inclusive, were advanced using a track mounted hollow stem auger drill rig, whereas boreholes 90-31 to 90-39 inclusive, were put down using a truck mounted rig. Standard penetration testing was carried out in all of the

May 1991

901-2410

boreholes and samples of the soils encountered were recovered using drive open sampling equipment. In addition, relatively undisturbed, 73 millimetre diameter, Shelby tube samples of grey silty clay were recovered for consolidation testing. In situ vane testing was carried out to determine the shear strength characteristics of the silty clay deposits. Standpipes were sealed into some of the boreholes to determine the groundwater levels in the subdivision. All of the field work was supervised by a member of our engineering staff who located the boreholes, directed the drilling operations, carried out the in situ testing and logged the overburden samples.

Samples of the soils encountered were taken to our laboratory for examination and classification testing, including moisture content, liquid and plastic limit, and grain size distribution. Two oedometer consolidation tests were carried out on relatively undisturbed Shelby tube samples of silty clay recovered from boreholes 90-29 and 90-30 to supplement the previous consolidation data from borehole 89-2B.

Detailed logs of the soil and groundwater conditions encountered in the boreholes are given on the Record of Borehole sheets following the text of this report. Logs for relevant boreholes advanced in the subdivision during previous investigations by Golder Associates Ltd. are also provided for reference purposes. The approximate locations of the boreholes put down during the present investigation and during previous subsurface investigations in the Lynwood subdivision are given on Drawing 14674003A\* The results of the laboratory testing are provided on Figures 2 to 4, and on the Record of Borehole sheets.

The borehole locations were determined by our staff and are referenced to existing site features. The ground surface elevations at the borehole locations were referenced to the top of casing at borehole 88-4. This elevation was previously established by MTO personnel as 87.93 metres, Geodetic datum.

\* Sheet 218 of the Contract Drawings.

## 5. SUBSURFACE CONDITIONS IN LYWOOD SUBDIVISION

As previously indicated, the detailed soil and groundwater conditions determined from the boreholes are given on the Record of Borehole sheets following the text of this report. The following presents general descriptions of the various soil strata encountered in the boreholes.

### Topsoil, Fill

Fill material composed of silty sand and gravel, and sand and gravel were encountered in the boreholes advanced on the roadways. The thickness of these fills ranged from 0.2 to 0.6 metres at the test hole locations. Silty clay and clayey silt fill was encountered beneath silty sand and gravel fill at borehole 90-33 and within 1.5 metres of ground surface at borehole 90-39.

Deposits of topsoil having a thickness of 0.1 to 0.2 metres were encountered beneath the roadway fills.

### Sensitive Silty Clay

Deposits of sensitive silty clay were encountered in all of the boreholes put down during this investigation. The silty clay deposits were encountered at depths ranging from 0.3 to 1.5 metres below ground surface. Where fully penetrated, the deposits were found to have a thickness ranging from 3.3 to 8.4 metres and extend to depths of 3.7 to 9.1 metres (elevation 78.5 to 84.6 metres).



The upper 1.6 to 4.3 metres of the silty clay deposit were found to be weathered to a grey brown crust. Standard penetration resistance N values measured in the weathered crust range from 1 to 9 blows per 0.3 metres, which reflect a stiff to very stiff consistency in the Ottawa area clays.

Beneath the upper weathered zone, grey silty clay having a thickness of 0.2 to more than 4.7 metres was encountered. In situ vane testing gave shear strengths ranging from a low of about 33 kilopascals (borehole 90-32) to about 68 kilopascals. A composite plot of vane shear strength for all of the boreholes is given on Figure 5. As indicated, most of the vane shear strengths are between about 45 and 60 kilopascals. Atterberg limit tests carried out on samples of the grey silty clay gave liquid limits of 50 to 59 and plastic limit values of 21 to 23. The water content of the grey silty clay was shown to be between 40 and 55 percent.

Two oedometer consolidation tests were carried out on relatively undisturbed samples of silty clay recovered from boreholes 90-29 and 90-30. The results of this testing are given on Figures 2 and 3. These samples were shown to have an apparent past preconsolidation pressure of between about 220 and 240 kilopascals, corresponding to about 160 and 170 kilopascals in excess of the existing overburden pressure. The in-situ vane shear strength measured in the adjacent boreholes was 80 and 60 kilopascals, respectively. For shear strengths of 45 to 60 kilopascals, the past preconsolidation pressure is estimated to be of the order of 170 to 240 kilopascals.

Previous oedometer consolidation testing by Golder Associates Ltd. on a sample of silty clay recovered from borehole 89-2B showed an apparent past preconsolidation pressure of 90 kilopascals, or 45 kilopascals in excess of the existing overburden pressure at that location. This past preconsolidation pressure corresponds to a shear strength of 30 kilopascals or less. Shear strength values in this range were only

encountered in a thin layer at depth in borehole 90-32 (33 kilopascals) and in previous borehole 88-5 (28 and 32 kilopascals).

### Silty Sand, Sand

Some of the boreholes advanced in the subdivision encountered deposits of silty sand or sand beneath the silty clay deposit. Specifically, sandy deposits were encountered in boreholes 90-31, 90-39 and possibly at borehole 90-30. Previous boreholes 89-2, 89-6, 89-7, 89-8, and 89-9 advanced by Golder Associates Ltd. in the subdivision also encountered deposits composed of silty sand, sand, and sand and gravel. The sandy deposits appear to exist in the east part of the subdivision and along Northside Road, although variations in subsurface conditions could exist between the boreholes.

In the subdivision area, the thickness of the sandy deposits was found to range from 0.2 metres at borehole 90-39 to about 9.3 metres at previous borehole 89-9.

### Glacial Till

Glacial till was encountered beneath the grey silty clay at boreholes 90-28, 90-31, 90-32, 90-33, 90-34, 90-35, 90-37, 90-38, and 90-39. Previous boreholes 89-7, 89-8, and 89-9 also encountered glacial till deposits beneath the silty clay, sand, or silty sand.

The glacial till is slightly cohesive and is a heterogeneous mixture of all grain sizes, but may be generally described as a sandy silt or silty sand with gravel and clay; cobbles and boulders may also be expected in the deposit. Grain size distribution curves for samples of the glacial till encountered are given on Figure 4. It should be noted that the grain size analyses were carried out on 38 millimetre I.D. split barrel samples of the material and do not reflect the presence of cobble or boulder sizes.

May 1991

901-2410

Standard penetration testing carried out within the glacial till during the present investigation gave N values ranging from 2 to 36 blows per 0.3 metres, which reflect a very loose to dense relative density.

#### Groundwater Levels

The groundwater levels were measured in standpipes sealed in the completed borings. Details on the installations of the standpipes are given on the Record of Borehole sheets together with the groundwater levels obtained.

The groundwater levels measured in standpipes sealed into the silty clay deposits range from about 1.9 to 3.0 metres below ground surface (elevation 84.2 to 87.5 metres) at boreholes 90-27, 90-31, 90-33, 90-34, and 90-36. In the glacial till at borehole 90-38, the groundwater level was found to be somewhat lower, being at 4.6 metres below ground surface (elevation 82.9 metres).

In general, the groundwater levels measured in the silty clay decrease from south to north in the subdivision area.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.



*D. Dundas*  
D. Dundas, P. Eng.  
Sr. Foundation Engineer

## RECORD OF BOREHOLE No 90-27

METRIC

W P 146-74-00-A LOCATION Co-ords N 5 021 033; E 358 892 ORIGINATED BY D.J.S.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE May 11, 1990 CHECKED BY A.C.

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 (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)	
								SHEAR STRENGTH kPa							○ UNCONFINED + FIELD VANE		● QUICK TRIAXIAL x LAB VANE		
88.1	Ground Surface																		
	Asphalt																		
0.1	Fill, sand and gravel																		
87.6	Brown																		
0.5	Silty clay (weathered crust)																		
	Very stiff Grey to stiff Brown		1	SS	2														
85.5																			
2.6	Silty clay, some silty sand seams		2	TP	PH														
	Firm to Stiff Grey		3	TP	PH														
82.3																			
5.8	End of Borehole																		

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 90-28

METRIC

W P 146-74-00 - A LOCATION Co-ords N 5 021 099; E 358 811 ORIGINATED BY D.J.S.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE May 11, 1990 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	20 40 60			
88.3	Ground Surface													
0.0	Fill sand and gravel													
88.0	Brown													
0.3	Topsoil													
0.4	Silty clay, some silty sand seams (weathered crest)					*								
			1	SS	5									
	Very Stiff to stiff	Grey Brown												
85.4														
2.9	Silty clay		2	TP	PH									
84.6	Grey													
3.7	Sandy silt, some gravel and clay (glacial till)		3	TP	PH									
			4	SS	3									
	Very loose to compact	Grey												
82.2			5	SS	13									
6.1	End of Borehole													
	* Water level not established													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 90-29

METRIC

W P 146-74-00 -A LOCATION Co-ords N 5 020 994; E 358 844 ORIGINATED BY D.J.S.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 24, 1990 CHECKED BY A.C.

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
88.4	Ground Surface													
0.0	Fill													
0.2	Topsoil													
0.4	Silty clay, some silty fine sand seams (weathered crust)					*	88							
	Very Stiff	Grey brown					87							
85.0							86							
3.4	Silty clay, some silty sand seams						85							
	Stiff	Grey	1	TP	PH		84							
			2	TP	PH		83							
			3	TP	PH		82					17.0	e <sub>0</sub> =1.27 P <sub>c</sub> =240kPa	
			4	TP	PH		81							
80.3			5	TP	PH									
8.1	End of Borehole						80							
	* Water level not established													

## METRIC

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2695 2696 2697 2698 2699 2700 2701 2702 2703 2704 2705 2706 2707 2708 2709 2710 2711 2712 2713 2714 2715 2716 2717 2718 2719 2720 2721 2722 2723 2724 2725 2726 2727 2728 2729 2730 2731 2732 2733 2734 2735 2736 2737 2738 2739 2740 2741 2742 2743 2744 2745 2746 2747 2748 2749 2750 2751 2752 2753 2754 2755 2756 2757 2758 2759 2760 2761 2762 2763 2764 2765 2766 2767 2768 2769 2770 2771 2772 2773 2774 2775 2776 2777 2778 2779 2780 2781 2782 2783 2784 2785 2786 2787 2788 2789 2790 2791 2792 2793 2794 2795 2796 2797 2798 2799 2800 2801 2802 2803 2804 2805 2806 2807 2808 2809 2810 2811 2812 2813 2814 2815 2816 2817 2818

+3, x5: Numbers refer to Sensitivity



RECORD OF BOREHOLE No 90-31

METRIC

W.P. 146-74-00-A LOCATION Co-ords N 5 021 124; E 358 590 ORIGINATED BY DM  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC  
DATUM Geodetic DATE October 17, 1990 CHECKED BY AFC

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
87.2	Ground Surface																			
0.0	Asphalt						87													
86.7	Fill, silty sand, some gravel						Bentonite													
0.5	Silty clay, some silty sand seams (weathered crust)						Native Fill													
			1	SS	5															
			2	SS	2															
	Very Stiff Grey Brown		3	SS	WH*															
83.1																				
4.1	Silty sand and gravel						83													
82.3	Very loose Grey																			
4.9	Silty clay		4	SS	2		Bentonite													
							Sand Fill Standpipe													
81.4	Stiff Grey																			
5.8	Silty sand, some gravel and clay (glacial till)																			
80.5	Very loose Grey		5	SS	3		81													
6.7	End of Borehole						Bentonite													
	*Sank under weight of hammer																			
							79													

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	NATURAL MOISTURE CONTENT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			PLASTIC LIMIT $w_p$	LIMIT $w_l$		
89.7	Ground Surface						20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		20 40 60 GR SA SI CL		

[illegible]

# WFFILE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

## METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 90-34

METRIC

W P 146-74-00-A LOCATION Co-ords N 5 020 939; E 358 652 ORIGINATED BY DM  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC  
DATUM Geodetic DATE October 18, 1990 CHECKED BY AFC

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.0	Ground Surface																
0.0	Asphalt																
0.1	Fill, sand and gravel																
0.3																	
	Silty clay, occasional silty sand seam (weathered crust)		1	SS	5												
	Very stiff Grey brown		2	SS	2												
83.4																	
4.6	Silty clay, occasional silty sand seam		3	SS	PM												
	Firm to stiff Grey		4	SS	PM												
81.4																	
6.6	Sandy silt, some gravel and clay (glacial till)		5	SS	WH*												
80.4	Very loose Grey																
7.6	Silty sand, some gravel and clay (glacial till)		6	SS	10												
79.8	Compact Grey																
8.2	End of Borehole																
	*Sank under weight of hammer																

OFFICE REPORT ON SOIL EXPLORATION

## METRIC

+3, x5: Numbers refer to Sensitivity

## METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 90-37

METRIC

W P 146-74-00-A LOCATION Co-ords N 5 020 953; E 358 747 ORIGINATED BY DM  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC  
 DATUM Geodetic DATE October 19, 1990 CHECKED BY AFC

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			20	40	60	80	100					
88.0	Ground Surface																
87.7	Asphalt																
87.7 0.3	Fill, sand and gravel																
	Silty clay, some silty sand seams (weathered crust)		1	SS	9	*	87										
	Very stiff Grey brown		2	SS	3		85										
83.4 4.6	Silty clay, some silty sand seams		3	SS	PM		83										
	Firm to stiff Grey		4	SS	PM		81										
79.9 8.1	Sandy silt, trace gravel, some clay		5	SS	2		79										
78.2 9.8	Dense Grey		6	SS	38												6 27 56 11
	End of Borehole																
	* Water level not established						77										

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

## METRIC

# PROFILE REFLECT UN SOIL EXPLORATION

[illegible]

+3, x5: Numbers refer to Sensitivity



# RECORD OF BOREHOLE No 90-39

METRIC

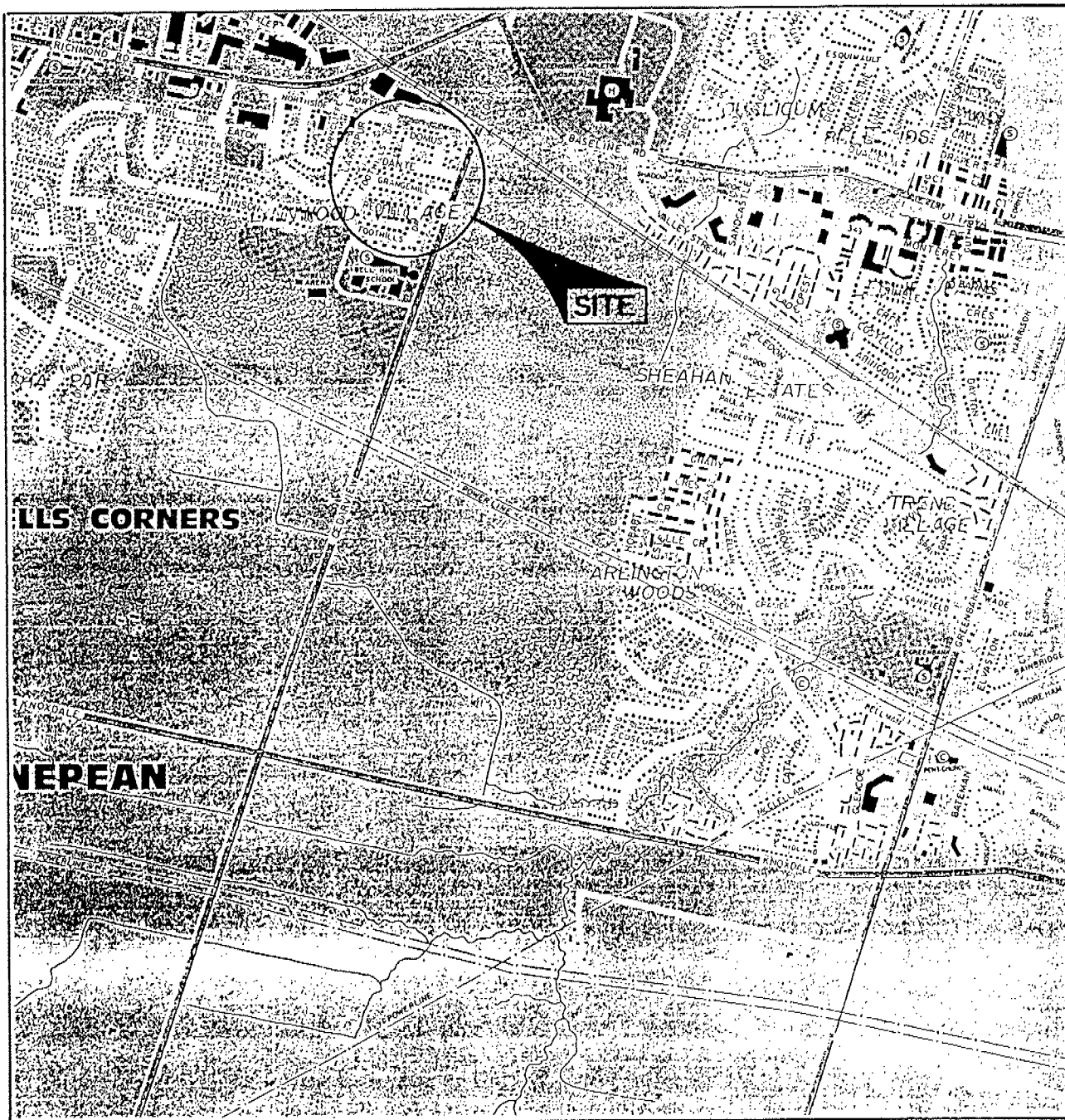
W P 146-74-00-A LOCATION Co-ords N 5 021 209; E 358 690 ORIGINATED BY DM  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY APC  
 DATUM Geodetic DATE October 22, 1990 CHECKED BY APC

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
							20 40 60 80 100					20 40 60					
86.4	Ground Surface																
0.0	Fill, clayey silt some organic material					*	86										
84.9																	
1.5	Silty clay, occasional silty sand seam (weathered crust)		1	SS	6		84										
83.3	Very stiff                      Grey brown																
3.1	Silty clay, some silty sand seams		2	SS	PM												
81.4	Firm                              Grey						82										
5.0	Silty sand		3	SS	PM												
5.2	Grey																
	Sandy silt, some gravel and clay		4	SS	6												
			5	SS	4		80										
	Loose to dense                              Grey		6	SS	36												
78.2	End of Borehole						78										
8.2	* Water level not established																

## KEY PLAN

FIGURE 1

WP 146-74-00-A



SCALE  
1:18,500



SPECIAL NOTE  
THIS DRAWING IS TO BE READ IN CONJUNCTION  
WITH ACCOMPANYING REPORT

Date DEC. 5, 1990

Project 901-2410

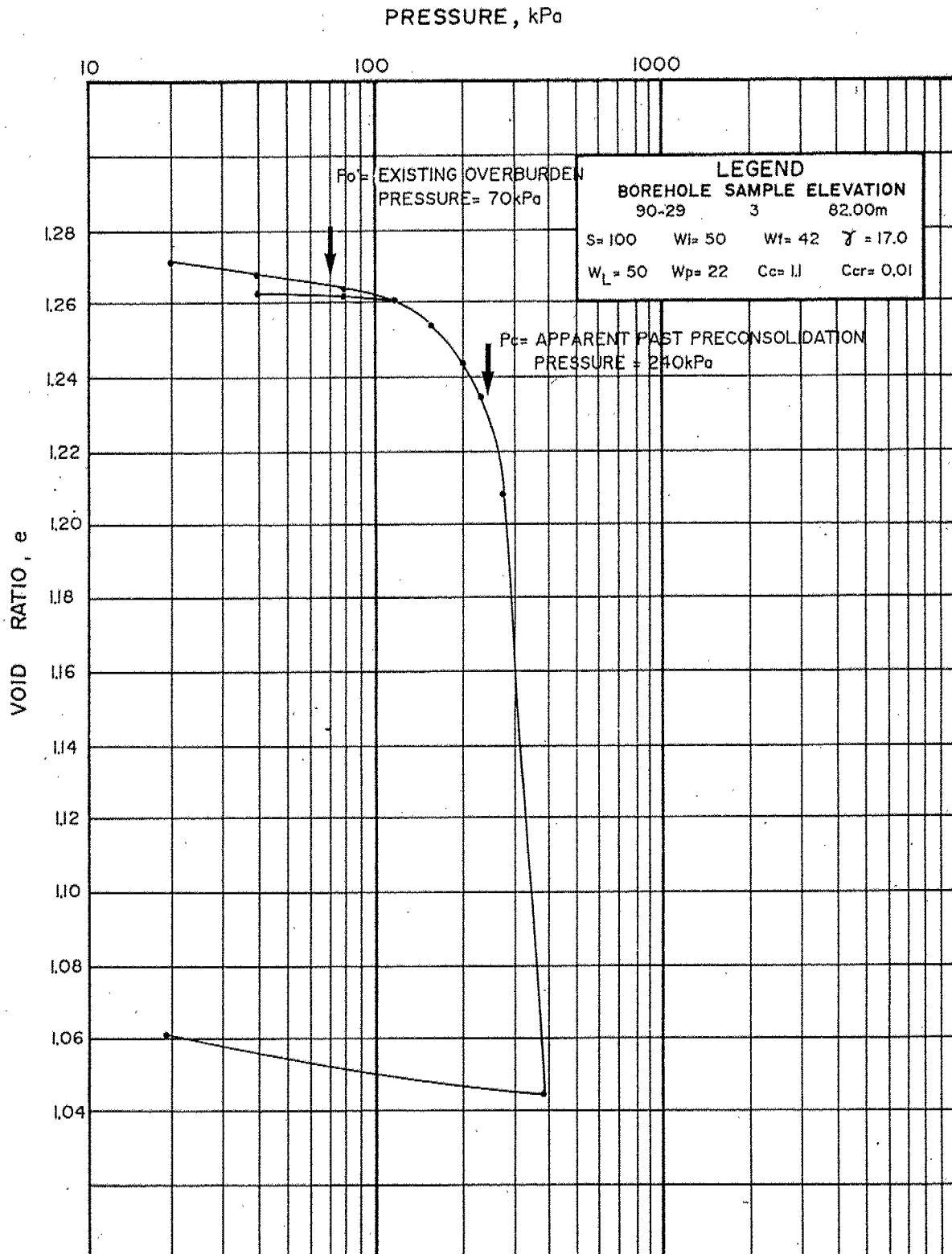
Golder Associates

Drawn JC

Chkd AC

# VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

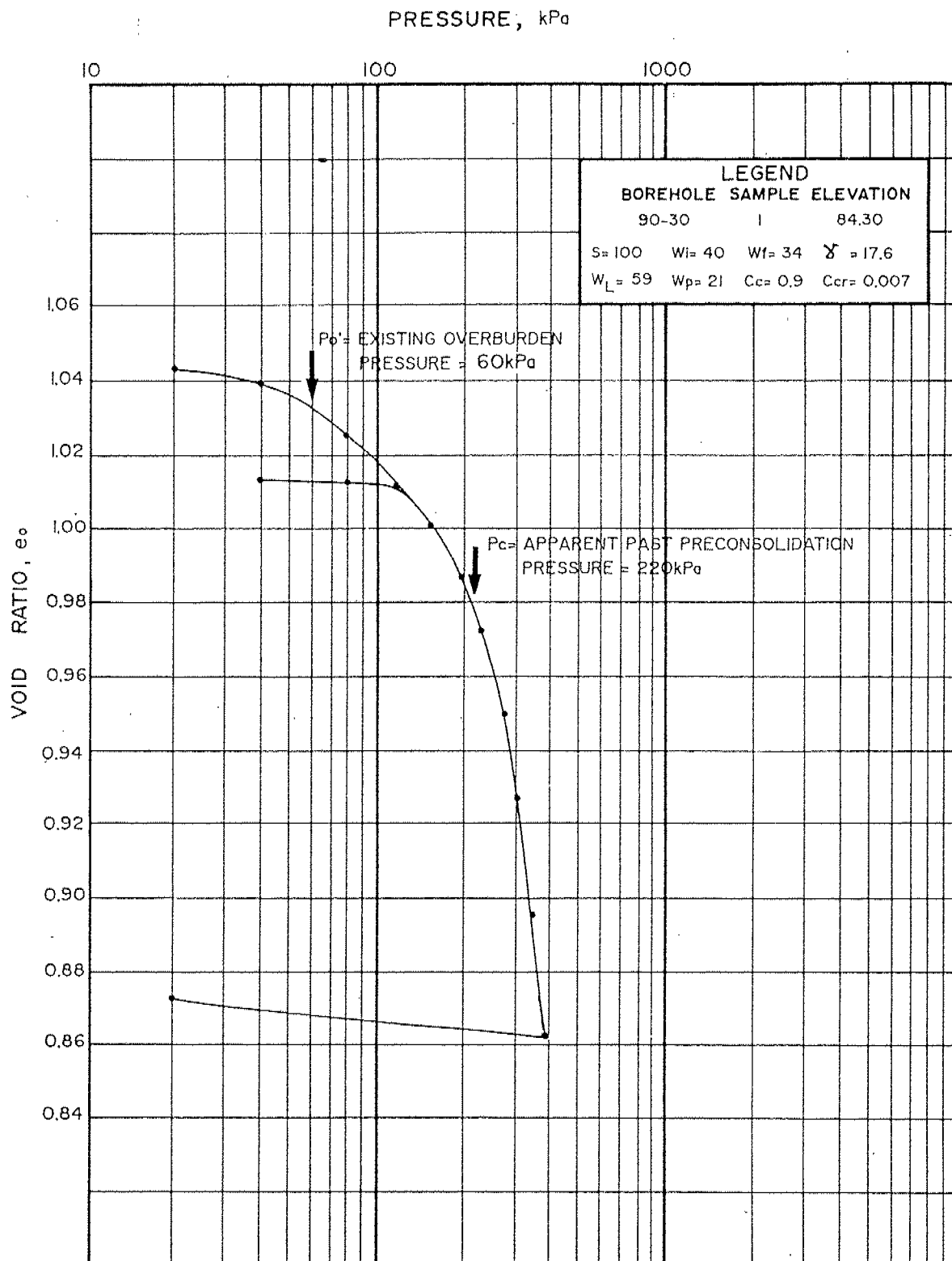
FIGURE 2  
WP 146-74-00-A



Golder Associates

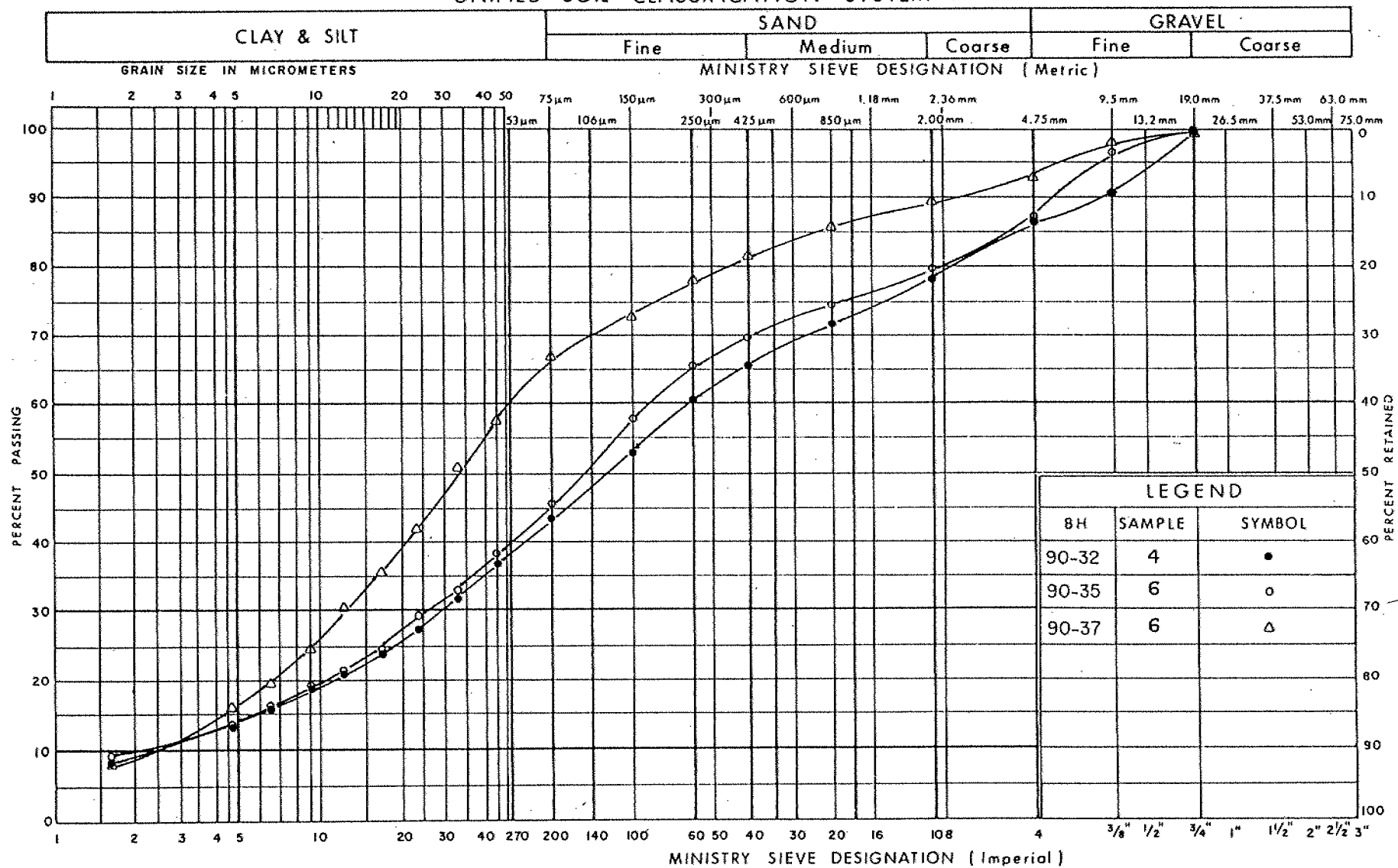
# VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 3  
WP 146-74-00-A



Golder Associates

## UNIFIED SOIL CLASSIFICATION SYSTEM



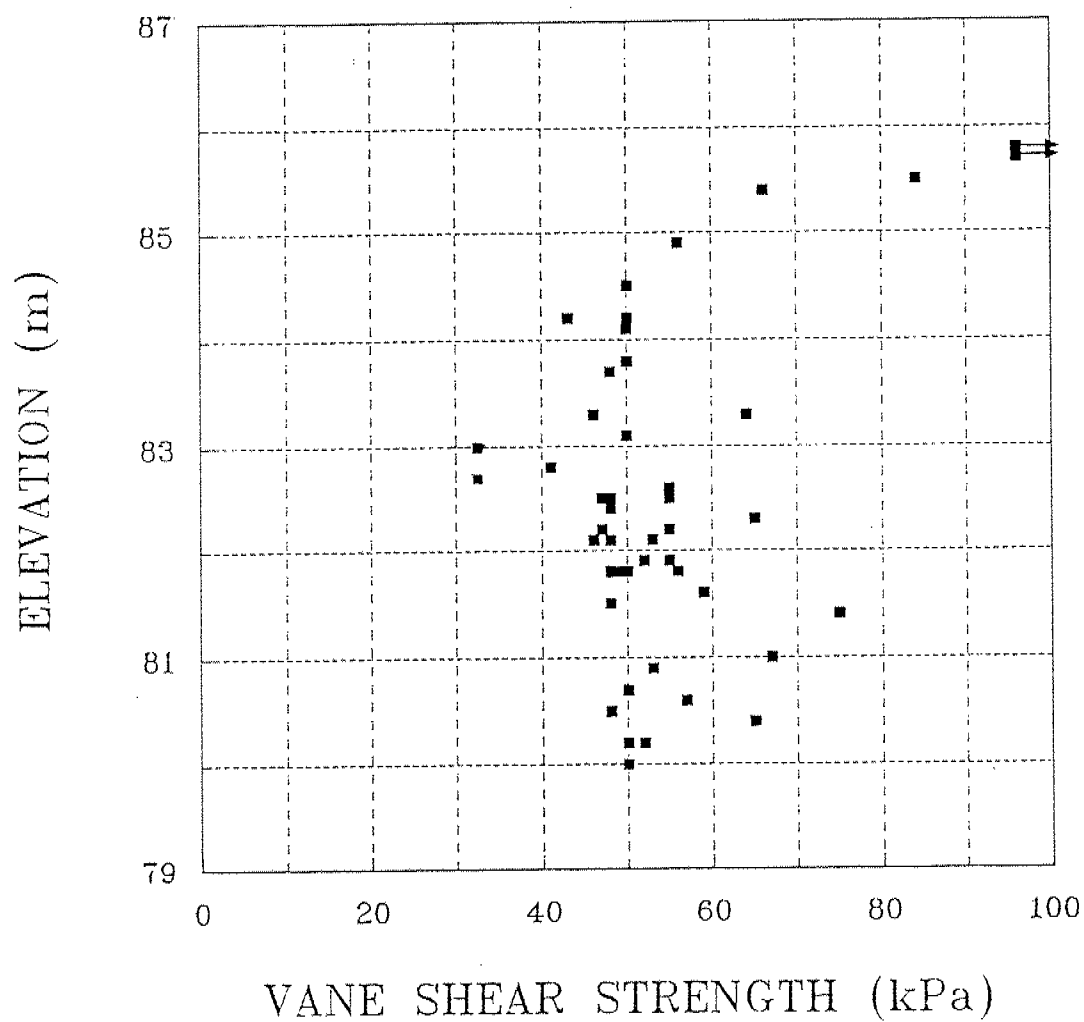
Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

SILTY SAND, some gravel and clay  
(GLACIAL TILL)

FIG No 4

W P 146-74-00-3A

VANE SHEAR STRENGTH versus  
ELEVATIONFIGURE 5  
WP 146-74-00-3ADate DEC. 4, 1990  
Project 90I-2410

Golder Associates

Drawn JC  
Chkd. MC

**RECORD OF BOREHOLE SHEETS  
PREVIOUS INVESTIGATIONS BY  
GOLDER ASSOCIATES LTD.**

# RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 162; E 358 772 ORIGINATED BY P.H.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
 DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

OFFICE REPORT ON SOIL EXPLORATION

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
87.3	Ground Surface													
0.0	Sand and gravel													
86.9	occasional cobble													
0.4	Topsoil													
0.8	Silty clay, some silty fine sand seams (weathered crust)		1	SS	7									
			2	SS	5									
84.2	Very stiff Grey to stiff Brown													
3.1	Silty clay, some silty fine sand seams, trace gravel		3	TW	PH									
			4	SS	1									
82.6	Grey													
4.7	Sand, fine, some silt, some sandy silt layers		5	SS	9									
			6	SS	15									
	Compact Grey		7	SS	16									
80.3														
7.0	Sandy silt, trace to some gravel and clay, some fine sand and clayey silt layers		8	SS	19									
			9	SS	14									
			10	SS	6									
			11	SS	19									
			12	SS	64									
	Loose to very dense Grey		13	SS	52									
76.2														
11.1	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings occasional weathered horizontal joint		14	BXL	RQD=71%									
			15	BXL	RQD=95%									
			16	BXL	RQD=98%									
	Grey													
	Continued													

\*REC: Recovery  
 RQD: Rock Quality Designation



RECORD OF BOREHOLE No. 89-2

METRIC

W P 146-74- 00-3 LOCATION Co-ords N 5 021 162; E 358 772 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 27 and 28, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
	Continued																
71.0	Dolomitic limestone bedrock, fresh, thin to thickly bedded, some sandstone layers and shale partings, occasional weathered horizontal joint		16	RC BXL	REC-100% RQD-98%		73										
			17	RC BXL	REC-100% RQD-98%		72										
16.3	End of Borehole						Standpipe -71										
	*REC: Recovery RQD: Rock Quality Designation																



## METRIC

SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
87.3	Ground Surface										

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

## RECORD OF BOREHOLE No. 89-6

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 995; E 358 844 ORIGINATED BY P.H.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY A.C.  
DATUM Geodetic DATE June 29 and 30, 1989 CHECKED BY A.C.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

15  $\phi$  5 (%) STRAIN AT FAILURE





# RECORD OF BOREHOLE No 89-8

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 906; E 358 959

ORIGINATED BY DJS

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger

COMPILED BY A.C.

DATUM Geodetic DATE June 6, 1989

CHECKED BY A.C.

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE		WATER CONTENT (%)							
								● QUICK TRIAXIAL × LAB VANE		20 40 60							
89.4	Ground Surface																
0.1	Asphalt						Asphalt										
88.9	Fill - Crushed Stone																
0.5	Fill, sand and gravel																
0.7	Topsoil Dark Grey																
0.8	Sand, fine to coarse Brown																
			1	SS	6												
	Silty clay occasional fine to coarse sand seam (weathered crust)		2	SS	3												
							Water level at elev. -87.3 metres on June 8, 1989										
	Very Stiff to Stiff Grey Brown		3	SS	1												
85.5																	
3.9																	
	Silty clay, occasional sand seam		4	SS	1												
			5	SS	WH*												
82.1	Firm to Stiff Grey																
7.3	Sandy silt, some gravel and clay (glacial till)		6	SS	7												
			7	SS	9												
			8	SS	6												
			9	SS	5												
			10	SS	5												
77.8	Loose Grey																
11.6	Sand, fine to coarse, some gravel, trace to some silt																
76.6	Compact Grey		11	SS	23												
12.8	Sand, fine to coarse, trace silt																
76.0	Compact Grey		12	SS	29												
13.4	Sand and gravel, occasional cobble																
75.2	Dense Grey		13	SS	44 for 300 mm 100 for 25 mm												
14.2	End of Borehole																
	*Sank under weight of hammer																

+3, x5: Numbers refer to 20  
Sensitivity 15 S (%) STRAIN AT FAILURE  
10

## RECORD OF BOREHOLE No 89-9

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 132; E 358 873 ORIGINATED BY DJS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE June 6, 1989 CHECKED BY A.C.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+<sup>3</sup>, x<sup>5</sup> : Numbers refer to Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 88-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 082; E 358 806 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
 DATUM Geodetic DATE October 17, 1988 CHECKED BY AC

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			20	40	60	80	100					
88.2	Road Surface															GR SA SI CL
0.1	Asphalt.															
87.3	Fill-sand, some gravel, trace to some silt. Brown		1	AS*												
0.9	Silty clay, some silty fine sand seams. (weathered crust) Very Stiff Grey Brown to Stiff		2	SS	10											
			3	SS	6											
85.3			4	SS	2											
2.9	Silty clay, some silty fine sand seams. Firm Grey		5	SS	WH*											
83.7																
4.5	Silty sand & gravel.		6	SS	6											
83.0	Loose Grey															
5.2	End of Borehole															
	*AS: Auger Sample **Sank under weight of hammer															

# RECORD OF BOREHOLE No 88-6

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 020 852; E 358 895 ORIGINATED BY PH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC  
 DATUM Geodetic DATE October 17, 1988 CHECKED BY AC

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
89.2	Road Surface																
0.1	Asphalt.																
88.6	Fill-sand & gravel, trace silt, occasional cobble. Brown																
0.6	Silty clay, some silty fine sand seams. (Weathered Crust)		1	SS	5		88										
	Very Stiff Grey Brown		2	SS	5												
			3	SS	2												
86.4	Silty clay, some silty fine sand seams.																
2.8	Stiff Grey		4	SS	1		86										
			5	SS	WH*												
84.0																	
5.2	End of Borehole																
	*Sank under weight of hammer																

## Pull Back Sewer Depressurization Data

Contract 94-22

Hay. 416, District 9, Ottawa

Local groundwater data collected as a result of the pull-back sewer depressurization system to facilitate the installation of sewer provided high capacity aquifer assessment data.

The Bell's Corners pull-back sewer is a 900 millimetres diameter concrete pipe with an invert elevation near 80 metres ASL or some 7 metres below the general groundwater level. In the area of excavation, local materials graded from silty clay to coarse sands and gravels from north to south. The contractor for the pull-back sewer lowered water levels in the sand and gravels to below invert levels so that all excavation and pipe laying could be conducted in essentially dry conditions.

The depressurization system developed by the contractor used 2 stages of wellpoints connected to headers and vacuum pumps. At the outset of depressurization in early August 1994, the system included a single line of wellpoints at ground surface and one vacuum pump while at the end of construction, the system included two rows of wellpoints along each side of the excavation connected to three vacuum pumps. The final few weeks of pumping had few changes to mechanical system with relatively steady flowrates measured at approximated 2600 cubic metres per day (400 Imperial gallons per minute) by GAL staff.

The drawdown data associated with this latter period of depressurization indicated water level declines of approximately 7 metres within the excavation, 2.5 metres below the Lynwood subdivision and 0.7 metres adjacent to north-east corner of the East Pond at GAL borehole 93.2.

NOTE: The preceding report is an excerpt from a report prepared by Golder Associates Ltd. for this project.



*D. Dundas*  
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**REPORT ON**

**MINISTRY OF  
TRANSPORTATION ONTARIO  
GROUNDWATER IMPACT ASSESSMENT  
OF PROPOSED  
HIGHWAY 416 CONSTRUCTION  
BRUCE PIT  
NEPEAN, ONTARIO**

**Submitted to:**

**Ministry of Transportation Ontario  
355 Counter Street  
Postal Bag 4000  
Kingston, Ontario  
K7L 5A3**

**February 1995**

**931-2138**

## INTRODUCTION

This report describes the subsurface information retrieved during a foundation investigation conducted in conjunction with a groundwater impact assessment study of the proposed Hwy. 416 construction on the Bruce Pit pond.

The site location is as shown on the Key Plan attached (see Figure 1)

## SUBSURFACE CONDITIONS

The groundwater borehole and monitoring well construction program documented in this report was carried out between September 15 and 21, 1993 during which time four (4) monitoring wells, 93-1, 93-2, 93-3 and 93-4, were drilled using a track mounted hollow stem auger drill rig supplied and operated by Marathon Drilling Co. Ltd. of Ottawa, Ontario. These boreholes were advanced to depths ranging from 17.4 to 24.2 metres below ground surface. The overburden was sampled using a conventional 50 millimetre diameter drive open sampler to determine the thickness and general characteristics of the mainly sandy deposits. The boreholes were completed as monitoring wells in order to allow subsequent measurement and monitoring of groundwater levels and sampling of groundwater for quality assessment. The monitoring wells in all boreholes consist of 50 millimetre diameter schedule 40 threaded PVC riser pipe fitted with a 3.0 metre long section of machine slotted PVC screen. After installation, all monitoring wells were developed by bailing. The field work was supervised throughout by a member of our engineering staff. The borehole logs and monitoring well construction is presented in Appendix A. The borehole elevations were tied to a local Geodetic datum by MTO field survey staff.

The locations of these boreholes and other boreholes advanced on previous projects are illustrated on Figure 2\* of the contract drawings.

A subsurface profile between the proposed Hay. 416 and the Bruce Pit east pond is illustrated on Figure 3\* of the contract drawings.

The soil samples recovered from the monitoring well boreholes were returned to our laboratory for examination. Grain size distribution analyses were carried out on selection samples of sand recovered from borehole 93-3 and 93-4. The results of the grain size distribution analyses are present on Figure 4.

Figure 5 illustrates continuous groundwater level monitoring data at B 93.2. Appendix B includes Hvorslev Rising Head Test Data and curves produced at Boreholes 93-1, 93-2, 93-3 and 93-4.

\* Sheets 220 & 221 of the Contract Drawings.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

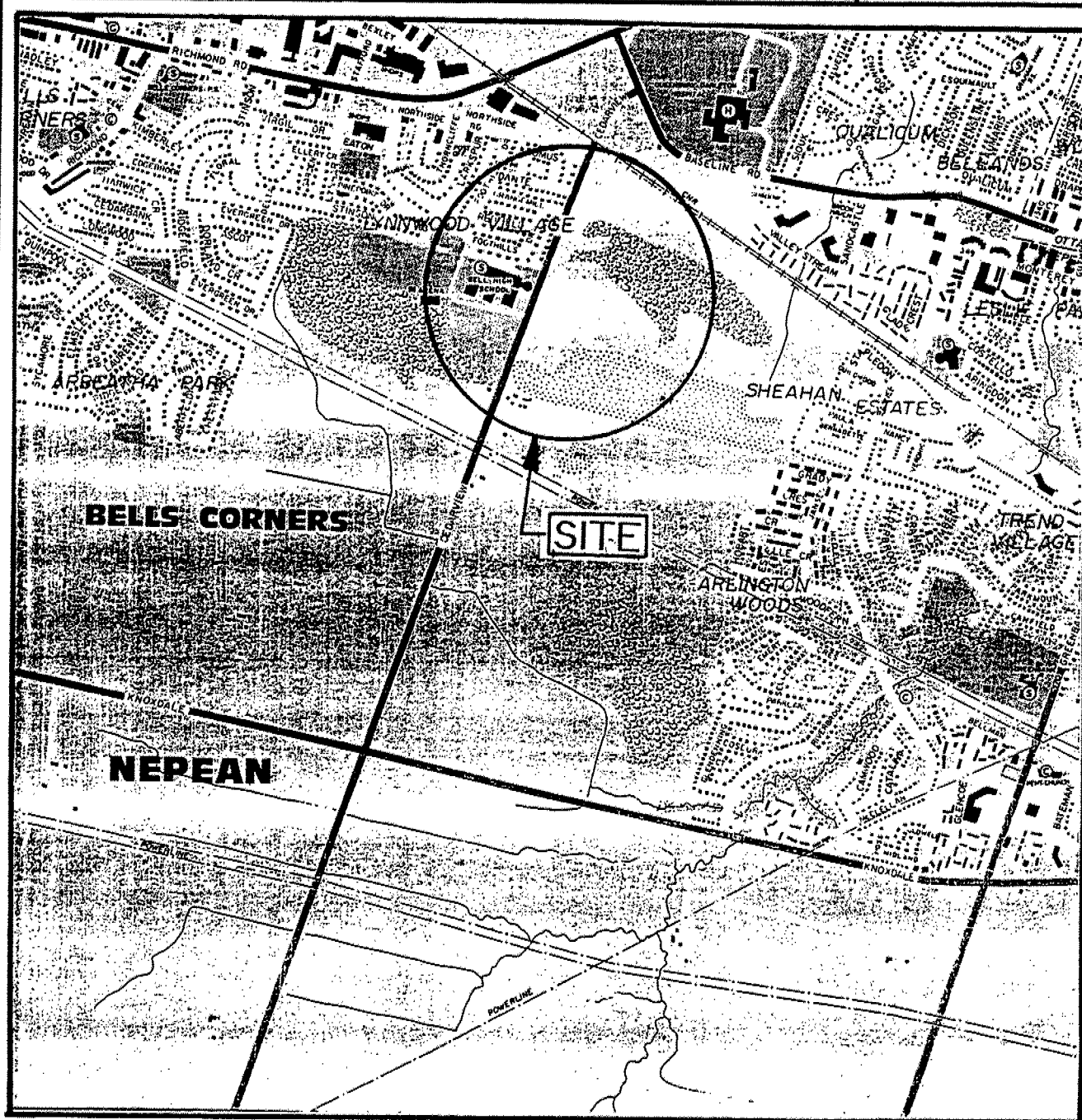


*D. Dundas*  
D. Dundas, P. Eng.  
Sr. Foundation Engineer



## KEY PLAN

FIGURE 1



SCALE 1 : 18,500



**SPECIAL NOTE**  
THIS DRAWING IS TO BE READ IN CONJUNCTION  
WITH ACCOMPANYING REPORT

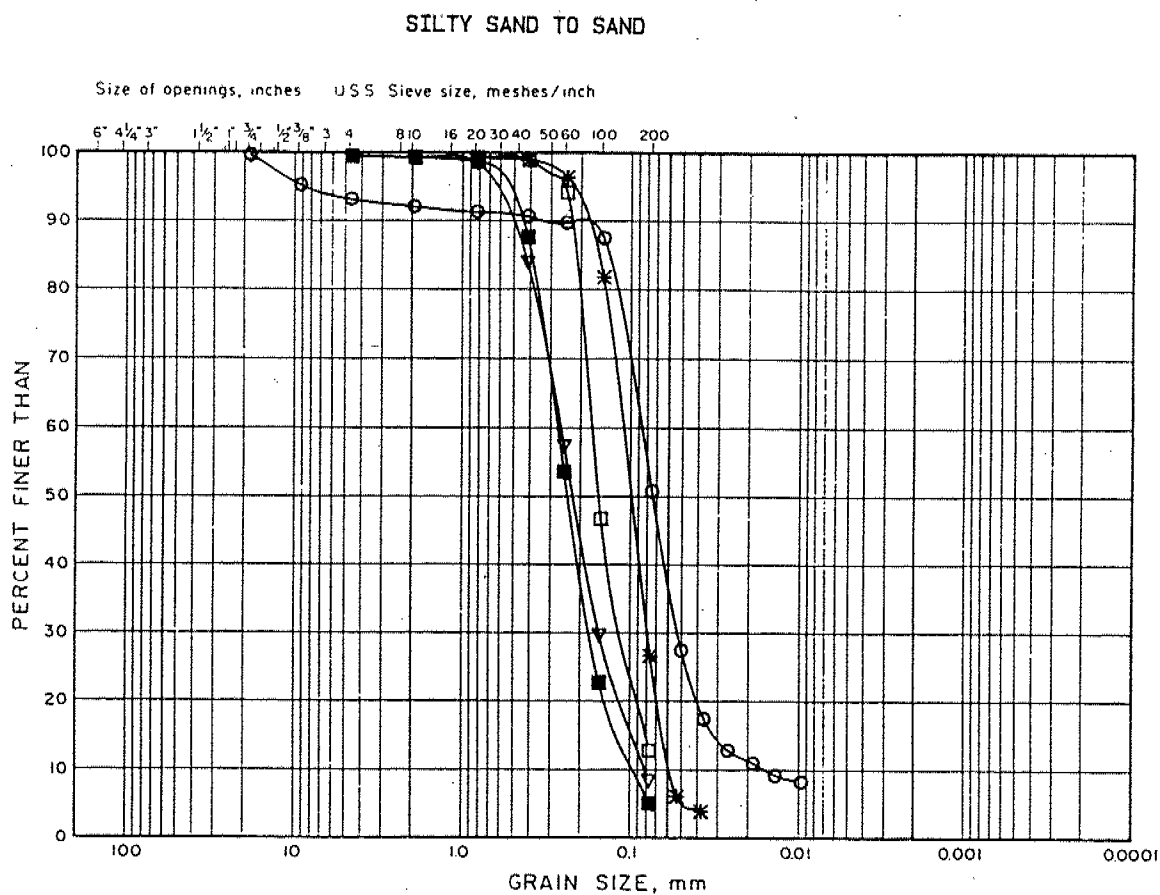
Date APR. 7, 1994  
Project 931-2138

Golder Associates

Drawn SL  
Chkd. \_\_\_\_\_

## GRAIN SIZE DISTRIBUTION

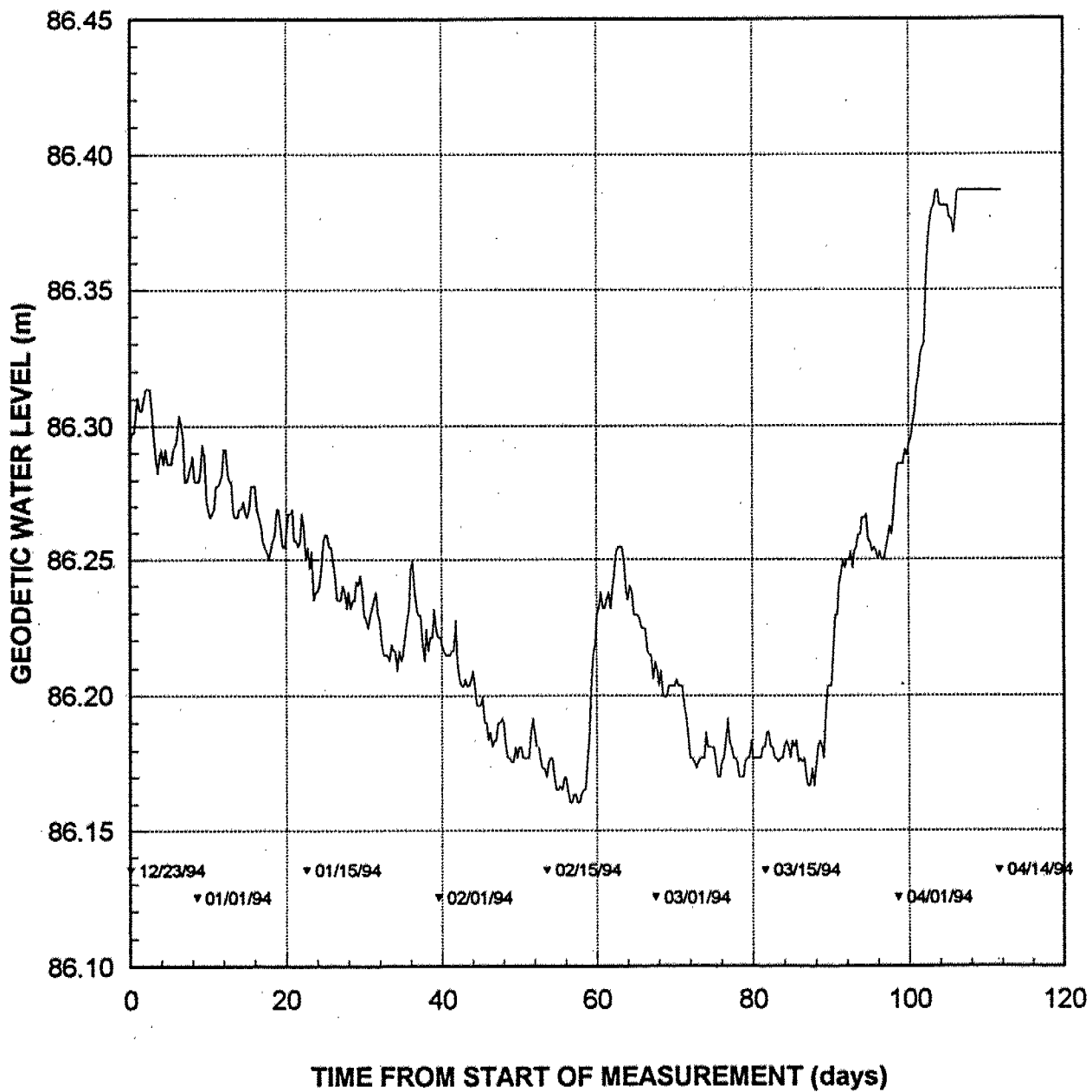
FIGURE 4



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH (m)
O	93-3	7	10.97
□	93-3	9	14.02
▽	93-4	7	10.97
■	POND BOTTOM PIT	3	0 - 0.15
*	POND BOTTOM PIT	4	0 - 0.15

**CONTINUOUS GROUNDWATER LEVEL  
MONITORING DATA (BH 93-2, BRUCE PIT)****FIGURE 5**Date JUNE 7, 1994Project 931 - 2138**Golder Associates**Drawn M.M.H.Chkd

February 1995

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931-2136

## APPENDIX A

### BOREHOLE LOGS AND MONITORING WELL CONSTRUCTION

PROJECT: 931-2138

## RECORD OF BOREHOLE 93-1

SHEET 1 OF 2

LOCATION: See Plan

BORING DATE: Sept. 15, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP: 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP: 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa 20 40 60 80	WATER CONTENT, PERCENT Wp — W — Wt 20 40 60 80					
0	Power Auger 200mm Diam. (Hollow Stem) 200mm Diam. (H.S. - Wash Bore)	Ground Surface	97.09										
		Dark brown sandy TOPSOIL	0.06								Cement Seal		
1		Brown fine to coarse SAND and GRAVEL, occasional cobble									Native Backfill		
2			94.85										
			2.44										
3				1	50 DO	27							
4		Compact brown fine to coarse SAND											
5													
6			91.90										
			5.49										
7		Dense brown fine to coarse SAND, trace gravel		2	50 DO	43					Holeplug		
8													
				3	50 DO	44							
9			88.25										
			8.84										
10		Compact brown faintly stratified fine SAND, trace silt		4	50 DO	25							
11													
				5	50 DO	26							
12			85.51										
			11.58										
13		Compact brown to grey faintly stratified fine SAND, trace silt		6	50 DO	21					Native Backfill		
14													
				7	50 DO	19							
15		CONTINUED ON NEXT PAGE									Well Screen		

DATA INPUT: J. COBISA, DISC 12

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:

PROJECT: 931-2138

## RECORD OF BOREHOLE 93-1

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Sept. 15, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT	
								Cu, kPa	nat. V - + rem. V - @			Q - ● U - ○	Wp
15	200mm Diam. (H.S. - Wash Bore)  Power Auger  200mm Diam. (Hollow Stem)	CONTINUED FROM PREVIOUS PAGE											
16		Compact brown to grey faintly stratified fine SAND, trace silt		8	50 DO	23							
17				9	50 DO	15							
18		Compact grey stratified SILTY fine SAND		79.11 17.07	10	50 DO	27						
19				11	50 DO	25							
20				12	50 DO	21							
21		Compact to very dense grey sandy silt, some gravel and clay, occasional silty sand and sandy silt layer, some cobbles and boulders (GLACIAL TILL)		13	50 DO	> 100							
22													
23													
24				72.89 24.20									
25		End of Hole											
26													
27													
28													
29													
30													

Well Screen

Caved Backfill

Holeplug

W.L. in Screen at elev. 87.10m (9.99m depth) Nov. 15, 1993

DEPTH SCALE

LOGGED: KAM

1 to 75

Golder Associates

CHECKED:



PROJECT: 931-2138

## RECORD OF BOREHOLE 93-2

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Sept. 17, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, K, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION			
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT, PERCENT						
				DEPTH (m)					Cu, kPa	nat.V - + rem.V - ⊕	Q - ● U - ○	Wp	W			Wt		
								20	40	60	80	20	40	60	80			
15	Power Auger 200mm Diam. (H.S. - Wash Bore)	CONTINUED FROM PREVIOUS PAGE																
16		Compact brown stratified fine SAND			10	50 DO	29											
17																		
17					72.16 17.22	11	50 DO	12										
18		Loose to compact grey fine SAND, trace to some silt																
19						12	50 DO	8										
20																		
21						13	50 DO	12										
22				End of Hole Auger Refusal		67.50 21.88												
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		

W.L. in Screen  
at elev. 88.77m  
(2.61m depth)  
Nov. 15, 1983

Native  
Backfill

Holeplug

Caved  
BackfillW.L. in Screen  
at elev. 68.77m  
(2.61m depth)  
Nov. 15, 1993

DATA INPUT: J. COBISA, DISC 12

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:



PROJECT: 931-2138

## RECORD OF BOREHOLE 93-3

SHEET 1 OF 2

LOCATION: See Plan

BORING DATE: Sept 20, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP: 760mm

PENETRATION TEST HAMMER, 83.5kg; DROP: 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp			
				DEPTH (m)								
0	200mm Diam. (Hollow Stem)	Ground Surface		89.01								
		Dark brown sandy TOPSOIL		0.15								
		Brown SILTY fine SAND										
1	200mm Diam. (Hollow Stem)			87.94								
				1.07								
2	200mm Diam. (Hollow Stem)	Stiff grey brown SILTY CLAY, occasional silty sand seam and layer (Weathered Crust)				1	50					
3	200mm Diam. (Hollow Stem)					2	50					
4	200mm Diam. (Hollow Stem)	Loose brown faintly stratified fine SAND, occasional fine to coarse sand seams										
5	200mm (41.5" - Wash Bore)					3	50					
6	200mm (41.5" - Wash Bore)											
7	200mm (41.5" - Wash Bore)											
8	200mm (41.5" - Wash Bore)	Loose to compact brown to grey faintly stratified fine SAND				5	50					
9	200mm (41.5" - Wash Bore)											
10	200mm (41.5" - Wash Bore)					6	50					
11	200mm (41.5" - Wash Bore)											
12	200mm (41.5" - Wash Bore)	Compact grey SILTY fine SAND, trace gravel				7	50					
13	200mm (41.5" - Wash Bore)											
14	200mm (41.5" - Wash Bore)	Compact grey faintly stratified fine SAND, occasional silty fine sand seam				8	50					
15	200mm (41.5" - Wash Bore)											
						9	50					

DATA INPUT: J. COBISA, DISC 12

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:

PROJECT: 931-2138

## RECORD OF BOREHOLE 93-3

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Sept. 20, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa nat. V - + Q - ● rem. V - @ U - ○	WATER CONTENT, PERCENT Wp — W — Wl				
15	Power Auger (1/2" Stem, 3" Dia. (1/4" S. - Wash Box))	CONTINUED FROM PREVIOUS PAGE										
16		Compact grey faintly stratified fine SAND, occasional silty fine sand seam	73.16 15.65	10	50 DO	20						
17		Compact grey sandy silt, some gravel and clay (GLACIAL TILL)	71.84 17.37	11	50 DO	27						
18		End of Hole Auger Refusal										
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

Holeplug

Caved Backfill

W.L. in Screen  
at elev. 86.86m  
(2.15m depth)  
Nov. 15, 1993

DATA INPUT: J. COBISA, DISC 12

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:



PROJECT: 931-2138

## RECORD OF BOREHOLE 93-4

SHEET 2 OF 2

LOCATION: See Plan

BORING DATE: Sept. 21, 1993

DATUM: Geodetic

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	WATER CONTENT, PERCENT Wp	W		
				DEPTH (m)								
15	Power Auger 200mm Diam. (Hollow Stem) 200mm Diam. (H.B. Wash)	CONTINUED FROM PREVIOUS PAGE										
				77.07	10	50	12					
				15.54		00						
16		Compact brown fine SAND, trace to some silt		78.81								
				18.00								
17		Loose to compact grey SILTY fine SAND, trace to some gravel			11	50	22					
						00						
18												
					12	50	10					
				73.71		00						
19	Compact grey sandy silt, some gravel and clay (GLACIAL TILL)		18.90									
			19.11									
20	End of Hole Auger refusal											
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

Holeplug

W.L. in Screen  
at elev. 86.69m  
(5.83m depth)  
Nov. 15, 1993

DEPTH SCALE

1 to 75

Golder Associates

LOGGED: KAM

CHECKED:

February 1995

931-2138

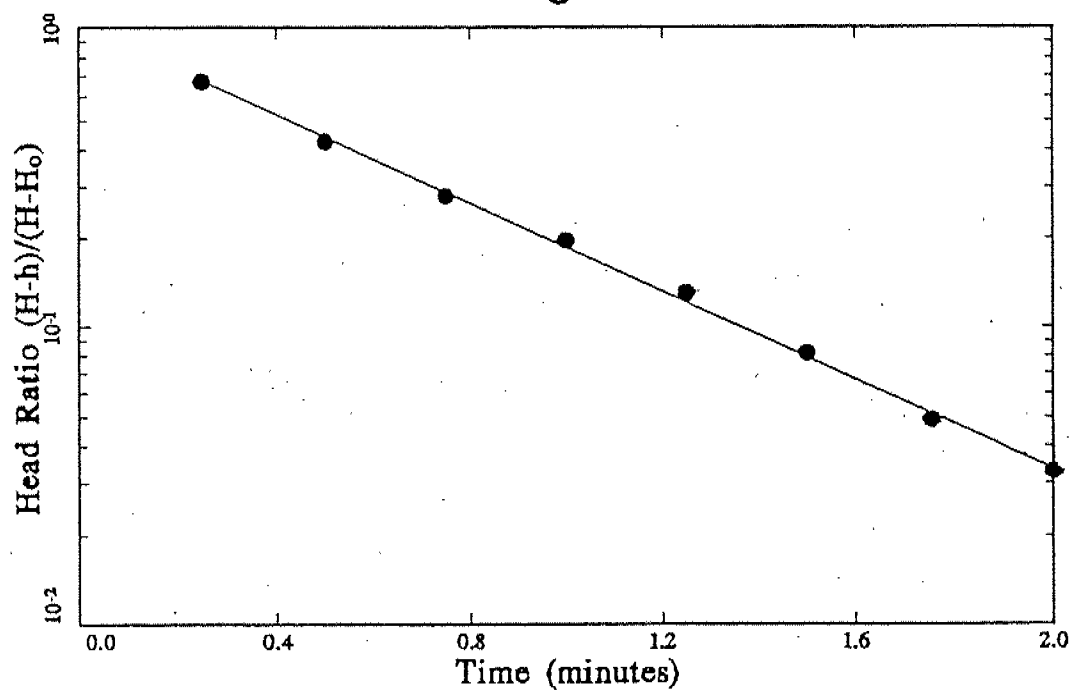
407

## **APPENDIX B**

### **HVORSLEV RISING HEAD TEST DATA AND CURVES**

Dec. 9, 1993 4:16:46 PM

## Monitoring Well 93-1

Hydraulic Conductivity,  $K = 9.7E-04$  cm/secBasic Time Lag,  $T_0 = 0.6$  minutes

Project Number : 934-2138

Date Tested : October 19, 1993

Type of Test : Rising Head

Reference : Hvorslev (1951)

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File: 2138BH1.RPT  
 Saved: 12-09-93 at 04:19:24 pm

Page 1

Title: Monitoring Well 93-1

Project Number: 931-2138  
 Date Tested: October 19, 1993  
 Type of Test: Rising Head  
 Analysis Method: Hvorslev (1951)

# Water Level vs. Time Records

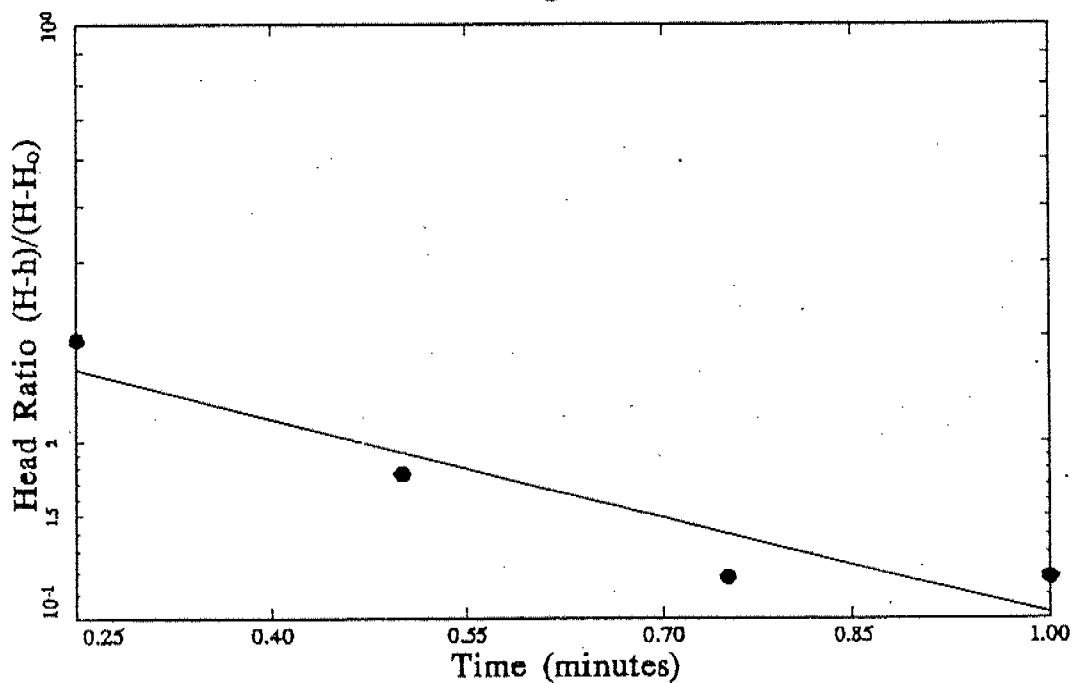
Reading Number	Time (min)	Water Level (m)
1	0.250	10.600
2	0.500	10.450
3	0.750	10.360
4	1.000	10.310
5	1.250	10.270
6	1.500	10.240
7	1.750	10.220
8	2.000	10.210

Radius of Borehole = 10.00 cm  
 Radius of Well = 2.50 cm  
 Length of Well Screen = 305.00 cm  
 Static Water Level = 10.19 m  
 Initial Water Level = 10.80 m

Hydraulic conductivity,  $K = 9.7E-04$  cm/sec  
 Basic time lag,  $T_0 = 0.6$  minutes

Dec. 9, 1993 4:20:24 PM

## Monitoring Well 93-2



Hydraulic Conductivity,  $K > 1 \times 10^{-2}$  cm/sec.  
Basic Time Lag,  $T_0$

Project Number : 934-2138

Date Tested : October 19, 1993

Type of Test : Rising Head

Reference : Hronkav (1951)

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File: 2138BH2.RPT  
 Saved: 12-09-93 at 04:22:04 pm

Page 1

Title: Monitoring Well 93-2

Project Number: 931-2138  
 Date Tested: October 19, 1993  
 Type of Test: Rising Head  
 Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

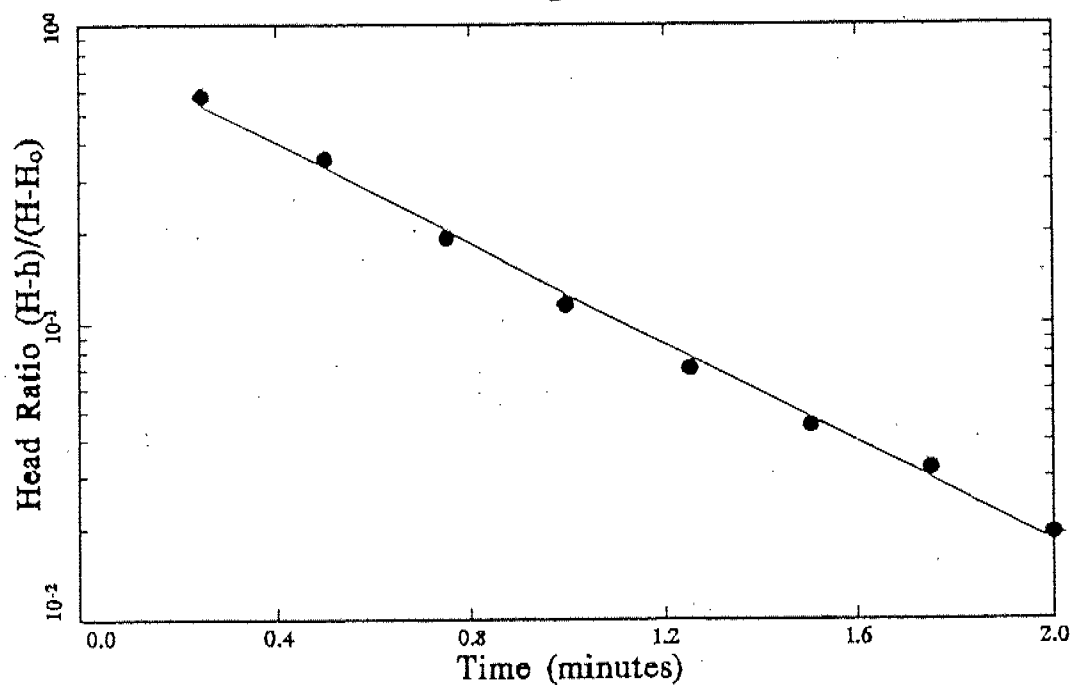
Reading Number	Time (min)	Water Level (m)
1	0.250	2.780
2	0.500	2.760
3	0.750	2.750
4	1.000	2.750

Radius of Borehole = 10.00 cm  
 Radius of Well = 2.50 cm  
 Length of Well Screen = 305.00 cm  
 Static Water Level = 2.73 m  
 Initial Water Level = 2.90 m

Hydraulic conductivity,  $K = > 1 \times 10^{-2}$  cm/sec.  
 Basic time lag,  $T_0 =$  UNDEFINED

Dec. 9, 1993 4:22:30 PM

## Monitoring Well 93-3



Hydraulic Conductivity,  $K = 1.3E-03$  cm/sec  
Basic Time Lag,  $T_0 = 0.44$  minutes

Project Number : 934-1138

Date Tested : October 19, 1993

Type of Test : Rising Head

Reference : Hvorslev (1951)

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File: 2138BH3.RPT  
 Saved: 12-09-93 at 04:24:01 pm

Page 1

Title: Monitoring Well 93-3

Project Number: 931-2138  
 Date Tested: October 19, 1993  
 Type of Test: Rising Head  
 Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

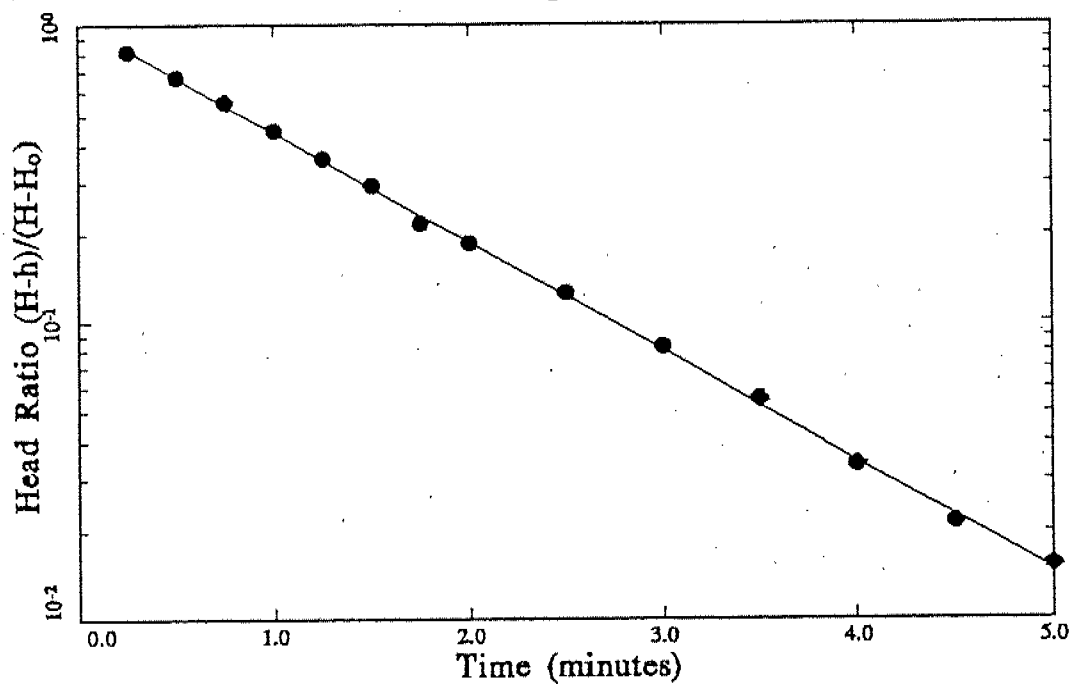
Reading Number	Time (min)	Water Level (m)
1	0.250	3.250
2	0.500	2.900
3	0.750	2.650
4	1.000	2.530
5	1.250	2.460
6	1.500	2.420
7	1.750	2.400
8	2.000	2.380

Radius of Borehole = 10.00 cm  
 Radius of Well = 2.50 cm  
 Length of Well Screen = 305.00 cm  
 Static Water Level = 2.35 m  
 Initial Water Level = 3.90 m

Hydraulic conductivity,  $K = 1.3E-03$  cm/sec  
 Basic time lag,  $T_0 = 0.44$  minutes

Dec. 9, 1993 4:24:25 PM

## Monitoring Well 93-4



Hydraulic Conductivity,  $K = 4.8E-04$  cm/sec  
Basic Time Lag,  $T_0 = 1.2$  minutes

Project Number : 934-2138

Date Tested : October 19, 1993

Type of Test : Rising Head

Reference : Hvorslev (1951)

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File: 2138BH4.RPT  
 Saved: 12-09-93 at 04:25:24 pm

Page 1

Title: Monitoring Well 93-4

Project Number: 931-2138  
 Date Tested: October 19, 1993  
 Type of Test: Rising Head  
 Analysis Method: Hvorslev (1951)

Water Level vs. Time Records

Reading Number	Time (min)	Water Level (m)
1	0.250	8.500
2	0.500	8.030
3	0.750	7.650
4	1.000	7.300
5	1.250	7.020
6	1.500	6.800
7	1.750	6.550
8	2.000	6.450
9	2.500	6.250
10	3.000	6.110
11	3.500	6.020
12	4.000	5.950
13	4.500	5.910
14	5.000	5.890

Radius of Borehole = 10.00 cm  
 Radius of Well = 2.50 cm  
 Length of Well Screen = 305.00 cm  
 Static Water Level = 5.84 m  
 Initial Water Level = 9.10 m

Hydraulic conductivity,  $K = 4.8E-04$  cm/sec  
 Basic time lag,  $T_o = 1.2$  minutes

Foundation Investigation Report  
For  
High Mast Lights #C-4 to #C-11  
WP 121-87-00, Site N/A  
Hwy 416, District 9, Ottawa

The subsurface information relating to specific High Mast Lights #C-4 to #C-11 is indicated on the appended Table 1 and detailed on the appended borehole sheets. The subsurface information at high mast light locations may be inferred from the closest borehole.

MISCELLANEOUS

The information was compiled by D. Kwok, Project Foundation Engineer based on data extracted from previous relevant subsurface investigations.

The report was reviewed by B. Iyer, Sr. Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



*D. Dundas*  
D. Dundas, P.Eng.  
Senior Foundation Engineer

**APPENDIX**

W.P. 121-87-00

Table 1

## REFERENCE BOREHOLE NUMBERS

HML Pole #	Ref. BH No.	Project No.	Orig. Grade	Final Grade
C-4	10	146-74-00	96.70	94.3
	12	146-74-00	96.70	
	CRA-5	146-74-00-2	88.53	
C-5	17-6	121-87-06	91.2	93.45
	10	146-74-00	97.6	
	CRA-5	146-74-00-2	88.53	
C-6	17-1	121-87-06	97.4	92.05
	5	146-74-00	98.1	
	CRA-4	146-74-00-2	95.71	
C-7	89-5	146-74-00-3	89.7	87.60
	89-17	146-74-00-3	95.3	
	89-18	146-74-00-3	97.1	
C-8	89-4	146-74-00-3	88.5	85.55
	89-5	146-74-00-3	89.7	
	9	146-74-00	88.6	
C-9	89-3	146-74-00-3	87.7	81.95
	89-21	146-74-00-3	88.1	
	90-W30	126-87-01(A)	87.4	
C-10	89-10	146-74-00-3	86.6	86.7
	89-11	146-74-00-3	87.0	
	90-W6	126-87-01(A)	86.6	
	90-W7	126-87-01(A)	86.9	
C-11	16-2	127-87-00(A)	85.4	78.60
	90-W20	126-87-01(A)	85.2	
	90-W21	126-87-01(A)	85.1	
	90-W15	126-87-01(A)	86.3	
	108	126-87-01	85.0	



FORMER

RECORD OF BOREHOLE No 10

METRIC

W P 146-74-00 LOCATION Co-ords. N 5 020 521.9; E 359 252.3 ORIGINATED BY RS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
DATUM Geodetic DATE 84 05 16 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	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	W VALUES								
97.6	Ground Surface												
0.0													
	Sand		1	SS	18								
	trace silt												
	Compact		2	SS	16								0 94 5 1
			3	SS	21								
			4	SS	22								
			5	SS	20								0 97 (3)
	----- dense		6	SS	38								
			7	SS	30								
			8	SS	29								
			9	SS	40								0 96 (4)
			10	SS	39								
	----- compact		11	SS	17								0 97 (3)
			12	SS	16								
	----- some silt												
82.3													
15.1													

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

Continued

FORMER			RECORD OF BOREHOLE No 10 Continued										METRIC			
W P 146-74-00			LOCATION Co.ords. N 5 020 521.9; E 359 252.3										ORIGINATED BY HS			
DIST 9 HWY 416			BOREHOLE TYPE Hollow Stem Auger										COMPILED BY IR			
DATUM Geodetic			DATE 84 05 16										CHECKED BY			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W		
82.5 15.1	Continued		13	SS	16											1 68 29 2
	Sand with silt		14	SS	11											
	Compact															
76.0 21.6	End of Borehole Refusal to Auger Probable Bedrock															
	* Note: Groundwater Elevation assumed to be at the Elevation of Caving in of the Open Borehole.															

OFFICE REPORT ON SOIL EXPLORATION

FORMER			RECORD OF BOREHOLE No 12				METRIC									
W P 146-74-00			LOCATION Co-ords. N 5 020 485.6; E 359 175.3				ORIGINATED BY RS									
DIST 9 HWY 416			BOREHOLE TYPE Hollow Stem Auger				COMPILED BY IR									
DATUM Geodetic			DATE 84 05 18				CHECKED BY									
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
96.7	Ground Surface															
0.0	Silty Clay (fill) trace sand trace of roots Stiff		1	SS	14											
95.0																
1.7	Sand trace silt		2	SS	10											
			3	SS	17											
	Compact		4	SS	42											
			5	SS	40											
			6	SS	46											
	Dense		7	SS	61											
	Very Dense															
	some silt															
87.1			8	SS	71											
9.6	End of Borehole															
	* Note: Water level not established.															

OFFICE REPORT ON SOIL EXPLORATION

FORMER

STRATIGRAPHIC AND INSTRUMENTATION LOG  
(OVERBURDEN)

422

PROJECT NAME: BRUCE PIT

CRA - 5

PROJECT NO.: 2396

HOLE DESIGNATION: OW5-88

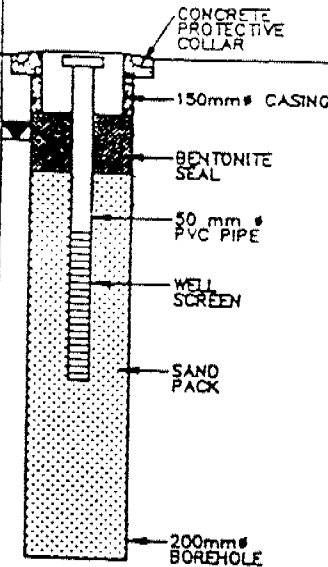
CLIENT: MTO

DATE COMPLETED: 26 APR 1988

LOCATION: AS PER PLAN

DRILLING METHOD: 108 mm ID HSA

CPA SUPERVISOR: S. CROSSMAN

DEPTH - BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	88.534 88.53				
- 1.0	SP SAND: little silt, compact, uniform, medium grained, massive, brown, moist.	87.63				
- 2.0	- wet			1SS	×	17
- 3.0	SM SAND: some silt, compact, fine grained, layered with occasional 3 cm seams of coarse sand, wet, grey, thin silt seams.	85.64		2SS	×	20
- 4.0	- siltier, not as dense			3SS	×	15
- 5.0	END OF HOLE • 5.18 m BGS.	83.35	SCREEN DETAILS: Screened Interval: 85.18 to 86.71 AMSL Length -1.52m Diameter -50mm Slot # 10 Material- PVC			
- 6.0						
- 7.0						
- 8.0						
- 9.0						
- 10.0						
- 11.0						
- 12.0						
- 13.0						

## NOTES:

MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS ○

WATER FOUND ▽

STATIC WATER LEVEL ▽

2/05/88

FORMER		RECORD OF BOREHOLE No 17-6		1 OF 1		METRIC					
W.P. 121-87-00		LOCATION Co-ords N5 020 653.4, E 359 216.4		ORIGINATED BY TS							
DIST 9 HWY 416		BOREHOLE TYPE Cone Test, Hollow Stem Auger		COMPILED BY TS							
DATUM Geodetic		DATE 88 11 28		CHECKED BY JP							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER								
91.2	Ground Surface										
0.0	Sand Brown, Compact										
89.7	(Fill Material)		1	SS	10						
1.5	Sand with Occ. Silt seams		5	SS	40						
			3	SS	32						
			4	SS	38						
	Brown, Dense to Very Dense		5	SS	68						
84.6			6	SS	21						
6.8	End of Borehole										
	Formerly BH 1 (WP 125-87-00)										
	88 11 28										

FORMER

RECORD OF BOREHOLE No 10

METRIC

W P 146-74-00 LOCATION Co-ords. N 5 020 521.9; E 359 252.3  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger ORIGINATED BY HS  
DATUM Geodetic DATE 84 05 16 COMPILED BY IR  
CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N VALUES			20	40					
97.6	Ground Surface													
0.0														
	Sand		1	SS	18									
	trace silt													
	Compact		2	SS	16									0 94 5 1
			3	SS	21									
			4	SS	22									
			5	SS	20									0 97 (3)
	dense		6	SS	38									
			7	SS	30									
			8	SS	29									
			9	SS	40									0 96 (4)
			10	SS	39									
	compact		11	SS	17									0 97 (3)
	some silt		12	SS	16									
82.5														
15.1														

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

Continued



## FORMER

## RECORD OF BOREHOLE No 10 Continued METRIC

W P 146-74-00 LOCATION Co.ords. N 5 020 521.9; E 359 252.3 ORIGINATED BY RS  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY IR  
DATUM Geodetic DATE 84 05 16 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	W VALUES			20 40 60 80 100	Wp	W	W <sub>L</sub>	WATER CONTENT (%)					
82.5 15.1	<del>Continued</del>  Sand with silt  Compact		13	SS	16		82									1 68 29 2	
			14	SS	11		81										
							80										
							79										
							78										
							77										
76.0 21.6	End of Borehole Refusal to Auger Probable Bedrock  * Note: Groundwater Elevation assumed to be at the Elevation of Caving in of the Open Borehole.																

\*3, x5: Numbers refer to  
Sensitivity20  
15 5 (%) STRAIN AT FAILURE  
10

## FORMER

STRATIGRAPHIC AND INSTRUMENTATION LOG  
(OVERBURDEN)

CRA - 5

PROJECT NAME: BRUCE PIT

PROJECT NO.: 2396

CLIENT: MTO

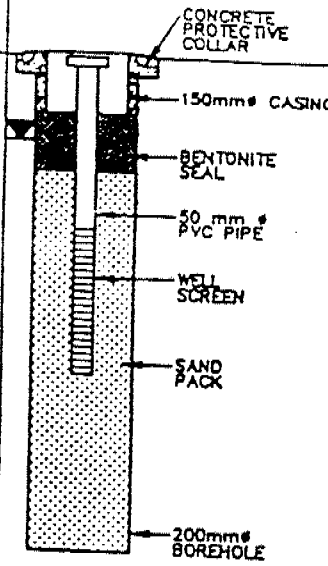
LOCATION: AS PER PLAN

HOLE DESIGNATION: OW5-88

DATE COMPLETED: 26 APR 1988

DRILLING METHOD: 108 mm ID HSA

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	88.534 88.53	 <p>CONCRETE PROTECTIVE COLLAR</p> <p>150mm Ø CASING</p> <p>BENTONITE SEAL</p> <p>50 mm Ø PVC PIPE</p> <p>WELL SCREEN</p> <p>SAND PACK</p> <p>200mm Ø BOREHOLE</p>			
- 1.0	SP SAND: little silt, compact, uniform, medium grained, massive, brown, moist.					
- 2.0	- wet	87.63				
- 3.0	SM SAND: some silt, compact, fine grained, layered with occasional 3 cm seams of coarse sand, wet, grey, thin silt seams.	85.64		1SS	X	17
- 4.0				2SS	X	20
- 5.0	- siltier, not as dense			3SS	X	15
	END OF HOLE • 5.18 m BGS.	83.35				
- 6.0						
- 7.0						
- 8.0						
- 9.0						
- 10.0						
- 11.0						
- 12.0						
- 13.0						

SCREEN DETAILS:  
 Screened Interval:  
 85.18 to 86.71 AMSL  
 Length - 1.52m  
 Diameter - 50mm  
 Slot # 10  
 Material - PVC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



2/05/88



FORMER

RECORD OF BOREHOLE No 17-1

1 OF 1

METRIC

W.P. 121-87-00 LOCATION Co-ords NS 020 689.5, E 359 118.5 ORIGINATED BY TS  
DIST 9 HWY 416 BOREHOLE TYPE HS AUGER, BW/AW Casing, Washboring, AQ Rock Core COMPILED BY TS  
DATUM Geodetic DATE 90 12 17-20 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
97.4	Ground Surface													
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel with traces of ash and wood (Fill Material) Brown, Very Soft to Firm		1	SS	6		97							5 53 25 17
			2	SS	2									14 51 27 8
			3	SS	2		95							
			4	SS	4									
92.1			5	SS	11		93							
5.3	Compact Dense to Very Dense		6	SS	9		91							29 68 (3)
	Gravelly Sand trace Silt Brown		7	SS	30									
			8	SS	39		89							36 55 (8)
			9	SS	52									
			10	SS	66		87							27 82 (11)
			11	SS	45									
			12	SS	48		85							
			13	SS	40		83							
			14	SS	34		81							27 61 (12)
79.1							79							
18.3	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Gray, Very Dense		15	SS	50		77							27 14 55 4
			16	RC	REC 6%		75							RCO = 0%
73.3			17	SS	172									RCO = 0%
24.1	Bedrock, Dolostone Gray, Medium Strong Unweathered		18	RC	REC 100%		73							RCO = 75%
25.7	End of Borehole													
	* 90 12 21													

FORMER

RECORD OF BOREHOLE No 5

METRIC

W P 146-74-00

LOCATION Co-ords. N 5 020 688.8; E 359 110.3

ORIGINATED BY HS

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY TR

DATUM Geodetic

DATE 84 05 15

CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
98.1 0.0	Ground Surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
	Landfill Silty Sand trace gravel		1	SS	15									
	Sand some silt trace gravel pieces of wire cable, rubber tires		2	SS	5									9 70 16 5
	Loose to Compact		3	SS	14									
			4	SS	7									
92.9 5.2	Sand with gravel some silt		5	SS	72									42 48 9 1
			6	SS	38									
	Dense to Vary Dense		7	SS	49									22 61 14 3
			8	SS	100									
85.9 12.2	End of Borehole													
	* Note: Groundwater Elevation assumed to be at the Elevation of Caving in the Open Borehole.													

OFFICE REPORT ON SOIL EXPLORATION

## FORMER

STRATIGRAPHIC AND INSTRUMENTATION LOG  
(OVERBURDEN)

CRA - 4

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW4-88

PROJECT NO.: 2396

DATE COMPLETED: 27 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE			
				NUMBER	STATE	VALUE	HNU (ppm)
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	95.707 95.71	CONCRETE PROTECTIVE COLLAR				
1.0	REFUSE: decayed domestic garbage, plastic, wood, black, moist, compact.		150mm Ø CASING				
2.0			200mm Ø BOREHOLE				
3.0			CEMENT/ BENTONITE GROUT				
4.0			50 mm Ø PVC PIPE				
5.0							
6.0							
7.0	SP SAND: trace silt, compact, medium grained, uniform, massive, light grey-brown, moist, garbage odour.	89.46	BENTONITE SEAL	1SS	×	32	3
8.0	- occasional thin seam of coarse sand	87.87		2SS	×	32	2
9.0							
10.0	SM SAND: little silt, dense, fine grained, poorly graded, grey-brown, massive, very moist, garbage odour.	86.56	SAND PACK	3SS	×	29	
11.0			WELL SCREEN				
12.0	ML SILT: some sand, compact, layered, thin laminations of fine sand, wet, grey, slight garbage odour.	84.67		4SS	×	27	
13.0	SM SAND: little silt, fine grained, poorly graded, massive, compact, grey, wet, odourless.	83.15 82.91		5SS	×	17	
	END OF HOLE @ 12.80 m BGS. * - HNU READING FROM SAMPLE HEAD SPACE		SCREEN DETAILS: Screened Interval: 84.73 to 87.78 AMSL Length - 3.05m			Diameter - 50mm Slot # 10 Material - PVC	

## NOTES:

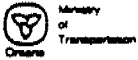
MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS ○

WATER FOUND ∇

STATIC WATER LEVEL ▼

5/05/88



POLE NO C7

430

W.P. 121-87-00

## FORMER

## RECORD OF BOREHOLE No 89-5

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5020 917; E 359 045 ORIGINATED BY P.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Wash Boring N Casing COMPLETED BY A.C.  
DATUM Geodetic DATE May 30, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT (%)			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
89.7	Ground Surface																
0.0	Topsoil																
0.2	Silty clay and clayey silt, trace sand and silty sand seams		1	SS	11												
	Very Stiff Grey Brown		2	SS	6												
87.0			3	SS	4												
2.7	Silty clay and clayey silt, trace gravel and sand		4	SS	2												
			5	SS	WH*												
	Firm to Stiff Grey		6	TW	WR*												
84.1																	
5.6	Sand, fine to coarse, trace gravel, trace to some silt		7	SS	31												
			8	SS	18												
81.6	Compact to Very Dense Grey Brown		9	SS	>100												
81.1	Sand, trace gravel, trace to some silt, some silty fine sand seams, occasional cobble		10	SS	105												
80.6																	
9.1	Very Dense Grey Brown																
	End of Borehole																
	*Sank under weight of hammer																

3, x 5: Numbers refer to 20  
Sensitivity 15 5 (%) STRAIN AT FAILURE  
10

UPPER RIGHT ON SOIL EXPLANATION

**FORMER**

W P 146-74-00-3 LOCATION Co -ords N 5 020 864: E 359 112 ORIGINATED BY L.C.  
DIST. 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 7, 1989 CHECKED BY A.C.

[illegible]

\* 3, x 5 Numbers refer to Sensitivity

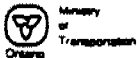
FORMER

W P 146-74-00-3 LOCATION Co-ords N 5 020 817: E 359 130 ORIGINATED BY L.T.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.G.  
DATUM Geodetic DATE July 10, 1989 CHECKED BY A.G.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

FORMER			RECORD OF BOREHOLE No 89-4				METRIC					
W.P. 146-74-00-3			LOCATION Co-ords N 5020 995; E 359 010				ORIGINATED BY R.B.					
DIST 9 HWY 416			BOREHOLE TYPE Hollow Stem Auger				COMPILED BY A.C.					
DATUM Canadian			DATE May 29, 1989				CHECKED BY A.C.					
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
88.5	Ground Surface											
0.0	Topsoil											
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	9							
86.2	Very Stiff Grey Brown		2	SS	7							
2.3	Silty clay, some sand and silty sand seams		3	SS	2							
			4	SS	WH*							
			5	SS	2							
	Stiff Grey											
82.1	Sand, some gravel, trace silt		6	SS	2							
	Silty clay, trace sand and silty sand seams											
	Stiff Grey		7	SS	1							
80.1												
8.4	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand layers		8	SS	2							
			9	SS	16							
78.3	Very loose Grey and to Compact Grey Brown											
10.2	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams		10	SS	42							
	Compact to Dense Grey and Grey Brown		11	SS	25							
Continued												



POLE NO C8

434

W.P. 121-87-00

FORMER

RECORD OF BOREHOLE No 89-4 Continued METRIC

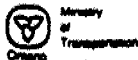
W P 146-74-00-3 LOCATION Co-ords N 5 020 995: E 359 010 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE May 29, 1989 CHECKED BY A.C.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			Wp	W	W <sub>L</sub>	Wp	W	W <sub>L</sub>				
	Continued															
	Sand, fine to medium and fine to coarse, some silt, trace gravel, some silty sand seams.				Well Screen 75											
	Compact Grey sand to Dense Grey Brown				74											
73.1			12	SS	>100											
15.4	End of Borehole Auger Refusal															
	*Sank under weight of hammer															

+3, x<sup>5</sup>: Numbers refer to Sensitivity  
20  
15  $\diamond$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION





POLE NO C8

435  
W.P. 121-87-90

FORMER			RECORD OF BOREHOLE No 89-5				METRIC					
W P 146-74-00-3		LOCATION Co-ords N 5020 917; E 359 045		ORIGINATED BY R.B.								
DIST 9 HWY 416		BOREHOLE TYPE Hollow Stem Auger, Wash Boring N Casing		COMPILED BY A.C.								
DATUM Geodetic		DATE May 30, 1989		CHECKED BY A.C.								
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
89.7	Ground Surface											
0.0	Topsoil											
0.2												
	Silty clay and clayey silt, trace sand and silty sand seams		1	SS	11							
	Very Stiff Grey Brown		2	SS	6							
87.0			3	SS	4							
2.7			4	SS	2							
	Silty clay and clayey silt, trace gravel and sand		5	SS	WH*							
	Firm to Stiff Grey		6	TW	WH*							
84.1												
5.6			7	SS	31							
	Sand, fine to coarse, trace gravel, trace to some silt		8	SS	18							
	Compact to Very Dense Grey Brown		9	SS	>100							
81.6			10	SS	105							
80.6												
9.1												
	Very Dense Grey Brown											
	End of Borehole											
	*Sank under weight of hammer											

Water level in open hole at elev. 86.6 metres on June 1, 1989

+ S = 12.8

2 89 (9)

1 93 (6)

8 77 (15)

## METRIC

ORIGINATED BY HS  
COMPILED BY IR  
CHECKED BY \_\_\_\_\_

+3, x5: Numbers refer to Sensitivity



POLE NO C9

W.P. 121-87-00

437

FORMER

RECORD OF BOREHOLE No 90 - W30

METRIC

W P 126-87-01(A)

LOCATION Co-ords N 5 021 128; E 359 039

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY AC

DATUM GEODETIC

DATE July 15, 1990

COMPILED BY RN

CHECKED BY RJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	20 40 60		
87.4	Ground Surface													
0.0	Topsoil													
0.2	Silty clay, some fine sand seams (weathered crust)					*								
85.3	Grey Brown						86							
2.1	Silty clay, some fine sand seams, trace to some fine gravel						84							
	Grey						82							
							80							
							78							
							76							
74.1			1	SS	7		74							
13.3	Sand, fine to coarse, trace silt													
	Loose Grey		2	SS	PM									
72.4														
15.0														

Continued

+3, x5: Numbers refer to Sensitivity

20  
15  $\pm$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLOSION

FORMER

RECORD OF BOREHOLE No 90 - W30

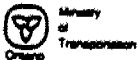
METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 128; E 359 039  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger  
DATUM GEODETIC DATE July 15, 1990  
ORIGINATED BY AC  
COMPILED BY RN  
CHECKED BY RN

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
72.4	Continued													
15.0	Sand, fine to coarse, trace silt		3	SS	PH		72							
70.9	Loose Grey													
16.5	End of Borehole Refusal to Auger Probable Bedrock													
	* Note: Water level not established						70							
							68							

\* 3, \* 5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (% STRAIN AT FAILURE)



POLE NO C9

W.P. 121-87-00

439

## FORMER

## RECORD OF BOREHOLE No 89-3

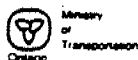
METRIC

W.P. 146-74-00-3 LOCATION Co-ords N 5 021 078; E 358 972 ORIGINATED BY R.B.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPLETED BY A.C.  
DATUM Geodetic DATE May 25, 1989 CHECKED BY A.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT Moisture CONTENT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Moisture CONTENT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
87.7	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, some silty sand seams (weathered crust)		1	SS	7												
	Very Stiff Grey to Stiff Brown		2	SS	5												
34.7			3	SS	1												
3.0	Silty clay, some silty sand and sand seams		4	SS	1												
	Stiff Grey		5	SS	1												
			6	SS	1												
79.8			7	SS	2												
7.9	Clayey silt, trace gravel and sand		8	SS	4												
			9	SS	3												
			10	SS	1												
	Very Stiff Grey to Stiff		11	SS	3												
75.9			12	SS	7												
11.8	Silty sand, fine to medium, trace gravel, some silty clay seams		13	SS	16												
74.8	Compact Grey		14	SS	11												
12.9	Sand, fine to coarse, some silt, trace gravel		15	SS	41												
73.0	Compact to Dense Grey																
14.7	End of Borehole Auger Refusal																

+3, x5: Numbers refer to Sensitivity  
20  
15  
10

5 (%) STRAIN AT FAILURE



FORMER

## RECORD OF BOREHOLE No. 89-21

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 046; E 359 027 ORIGINATED BY A.C.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
DATUM Geodetic DATE July 11, 1989 CHECKED BY A.C.

[illegible]

**FORMER**

RECORD OF BOREHOLE No 90 - W6

METRIC

W/ b 126-87-01(A)

LOCATION Co-ords N 5 021 199; E 358 915

ORIGINATED BY PH

DIST 9 HWY 416

BOREHOLE TYPE      Hollow Stem Auger

COMPILED BY RY

DATUM \_\_\_\_\_ GEODETIC \_\_\_\_\_

DATE        JULY 3, 1990

CHECKED BY AW

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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100					
86.6	Ground Surface												
0.0	Topsoil												
0.2	Silty clay, some silty fine sand seams (weathered crust)						86						
	Grey Brown							Water level in open hole at elevation 85.6 m on July 3, 1990					
84.0													
2.6	Silty clay						84						
	Grey												
							82						
							80						
79.4													
7.2	Sandy silt, some gravel and cobble (glacial till)		1	SS	5								
	Grey						78						
	Becoming more silty with depth						76						
74.3	Grey												
12.3	End of Borehole Refusal to Auger Probable Bedrock						74						
							72						

+3, +5: Numbers refer to Sensitivity

13  $\diamond$  5 (%) STRAIN AT FAILURE



POLE NO C10

442  
W.P. 121-87-00

## FORMER

## RECORD OF BOREHOLE No 90 - W7

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 181; E 358 923 ORIGINATED BY BB  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
DATUM GEODETIC DATE July 9, 1990 CHECKED BY RN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE R <sub>10T</sub>				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					W <sub>p</sub>	W			W <sub>L</sub>
								SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE		WATER CONTENT (%)							
								● QUICK TRIAXIAL × LAB VANE		20 40 60							
86.9	Ground Surface																
0.0	Topsoil																
0.1	Fill - silty sand																
0.5	Silty clay, some fine sand seams (weathered crust)																
	Grey Brown		1	SS	5												
84.6																	
2.5	Silty clay, some sand seams																
	Firm Grey		2	SS	PM												

\* REC: Recovery  
RQD: Rock Quality Designation

\*3, \*5: Numbers refer to  
Sensitivity

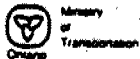
20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



POLE NO C10

W.P. 121-87-00



## FORMER

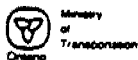
## RECORD OF BOREHOLE No. 89-10

METRIC

W.P. 146-74-00-3 LOCATION Co-ords N 5 021 206; E 358 886 ORIGINATED BY P.H.  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE June 21, 1989 CHECKED BY A.C.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40					
86.6	Ground Surface													
0.0	Topsoil													
0.2	Probably Silty Clay													
82.2	Grey Brown to Grey													
4.4	Silty clay, trace gravel, occasional silty sand seam		1	SS	1									
81.1	Grey													
5.5	Sandy silt to silty sand, some gravel and clay		2	SS	14									
77.9	Very Loose Grey													
8.7	Silty clay, some sand, trace gravel		4	SS	1									
76.4	Grey													
10.2	Probably silty sand													
75.9														
10.7	End of Borehole													
	* Note: Water level not established													

POLE NO C10

4 4  
W.P. 121-87-00

## FORMER

RECORD OF BOREHOLE No. 89-11

METRIC

W P 146-74-00-3 LOCATION Co-ords N 5 021 176: E 358 896 ORIGINATED BY DJS  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.C.  
 DATUM Geodetic DATE June 23, 1989 CHECKED BY A.C.

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	VALUES			20	40	60	80	100					
87.0	Ground Surface																
0.0 86.6	Topsoil																
0.4	Probably silty clay (weathered crust)																
83.3	Grey brown																
3.7	Silty Clay																
79.8	Grey		1	SS	WH												
7.2	Sandy silt, some gravel and clay																
78.5	Very Loose Grey		2	SS	PH												
8.5	Sand, fine to medium																
77.1	Compact Grey		3	SS	2												
9.9	Sand, medium to coarse																
76.3	Grey		4	SS	11												
10.7	End of Borehole																
	*Sank under weight of hammer																

\*3, \*5 Numbers refer to Sensitivity

20' 15' 5' (%) STRAIN AT FAILURE

OFFICE REPORT USE SOIL EXPLORATION

# FORMER

RECORD OF BOREHOLE No 108

METRIC

W P 126-87-01

LOCATION Coords N 5 021 301.1; E 358 433.3

ORIGINATED BY RH

DIST 9 HWY 416

BOREHOLE TYPE Hollow stem auger, BX rock core

COMPILED BY RH

DATUM Geodetic

DATE November 8, 9, 1989

CHECKED BY JSB

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

FORMER

RECORD OF BOREHOLE No 90 - W15

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 316; E 358 894  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger ORIGINATED BY AC  
DATUM GEODETIC DATE JUNE 29, 1990 COMPILED BY RN  
CHECKED BY RN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
86.3	Ground Surface													
0.0	Fill - mixture of sand and gravel						86							
85.8														
0.5	Topsoil													
0.8	Silty clay, some silty fine sand seams (weathered crust) Grey Brown					*								
82.3							84							
4.0	Silty clay, occasional sand seams Grey						82							
77.9							80							
8.4	Sandy silt, some gravel and clay (glacial till) Loose Grey						78							
74.7							76							
11.6	Dense						74							
	End of Borehole Refusal to Auger Probable Bedrock						72							
	*Note: Water level not established													



POLE NO C11

447

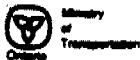
W.P. 121-87-00

FORMER			RECORD OF BOREHOLE No 90 - W20				METRIC							
W P 126-87-01(A)		LOCATION Co-ords N 5 021 351; E 358 946		ORIGINATED BY AC										
DIST 9 HWY 416		BOREHOLE TYPE Hollow Stem Auger		COMPILED BY RN										
DATUM GEODETIC		DATE JUNE 29, 1990		CHECKED BY A/										
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	20 40 60 80 100					
85.2	Ground Surface													
0.0	Fill - mixture of sand and gravel, occasional cobble.					*								
84.1														
83.7	Topsoil													
1.5	Silty clay, some silty fine sand seams (weathered crust) Grey Brown													
80.6														
4.6	Silty clay, occasional silty fine sand seams Grey													
73.8														
11.4	Sandy silt, some gravel and clay (glacial till)													
72.7	Grey													
12.5	End of Borehole Refusal to Auger Probable Bedrock  NOTE: * Water level not established													

\* 3, x 5: Numbers refer to Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



## FORMER

## RECORD OF BOREHOLE No 90 - W21

METRIC

W P 126-87-01(A) LOCATION Co-ords N 5 021 328; E 358 956 ORIGINATED BY PH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core COMPILED BY RN  
DATUM Geodetic DATE July 12 and 13, 1990 CHECKED BY RN

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.1	Ground Surface																
0.0	Topsoil																
0.2	Silty clay, some silty fine sand layer (weathered crust)																
	Very stiff to stiff		1	SS	11		84							0			
	Grey Brown		2	SS	7		Native Backfill										
82.2			3	SS	1											17.5	
2.9	Silty clay, some silty fine sand layer		4	SS	PM		82							0			
	Firm																
	Grey		5	SS	PM												
			6	SS	PM											16.8	
			7	SS	PM												
76.6																	
8.5	Silty clay, some silty fine sand layers, trace gravel																
75.6	Grey		8A														
9.5	Sandy silt to clayey silt, some clay and gravel (glacial till)		8B	SS	PM												
	Very loose		9	SS	2												
	Grey		10	SS	1												
73.1																	
12.0	Dolomitic Limestone Bedrock, fresh, some shale partings, some coarse sandstone seams, occasional calcite inclusions, trace pyrite		11	RC BXL	Rec=100% RQD=93%												
70.4	Grey																
14.7	End of Borehole																

\*Rec = Recovery  
RQD = Rock Quality Designation

+3, +5: Numbers refer to 20  
15 to 5 (%) STRAIN AT FAILURE  
10



POLE NO C11

449  
W.P. 12-87-00

FORMER

RECORD OF BOREHOLE No 16-2

METRIC

W P 127-87-00A

LOCATION Co-ords: N 5 021 337.2; E 358 935.0

DIST 9 HWY 416

BOREHOLE TYPE HS Auger &amp; Cone Test

ORIGINATED BY JW

DATUM Geodetic

DATE 89 08 03

COMPILED BY JW

CHECKED BY

## SOIL PROFILE

## SAMPLES

GROUND WATER  
CONDITIONS

ELEVATION SCALE

DYNAMIC CONE PENETRATION  
RESISTANCE PLOT

20 40 60 80 100

SHEAR STRENGTH  $kPa$ 

O UNCONFINED + FIELD VANE

• QUICK TRIAXIAL x LAB VANE

20 40 60 80 100

PLASTIC LIMIT  
NATURAL MOISTURE  
CONTENT

Wp W WL

WATER CONTENT (%)

20 40 60

UNIT  
WEIGHT  
YREMARKS  
&  
GRAIN SIZE  
DISTRIBUTION  
(%)

GR SA SI CL

ELEV  
DEPTH

DESCRIPTION

Ground Level

Silty Clay  
to  
Clayey Silt  
Gray, Occ. Sand Seams  
Stiff  
Firm

1 SS 12

2 SS 8

3 SS 4

4 TW PH

5 TW PH

6 TW PH

7 TW PH

76.7

8.7

Het. Mixture of  
Silt, Sand and  
Gravel

8 SS 2

9 SS 1

73.2

12.2

End of Borehole  
Refusal to Auger  
(Probable Bedrock  
or Boulder)

84

82

80

78

76

74

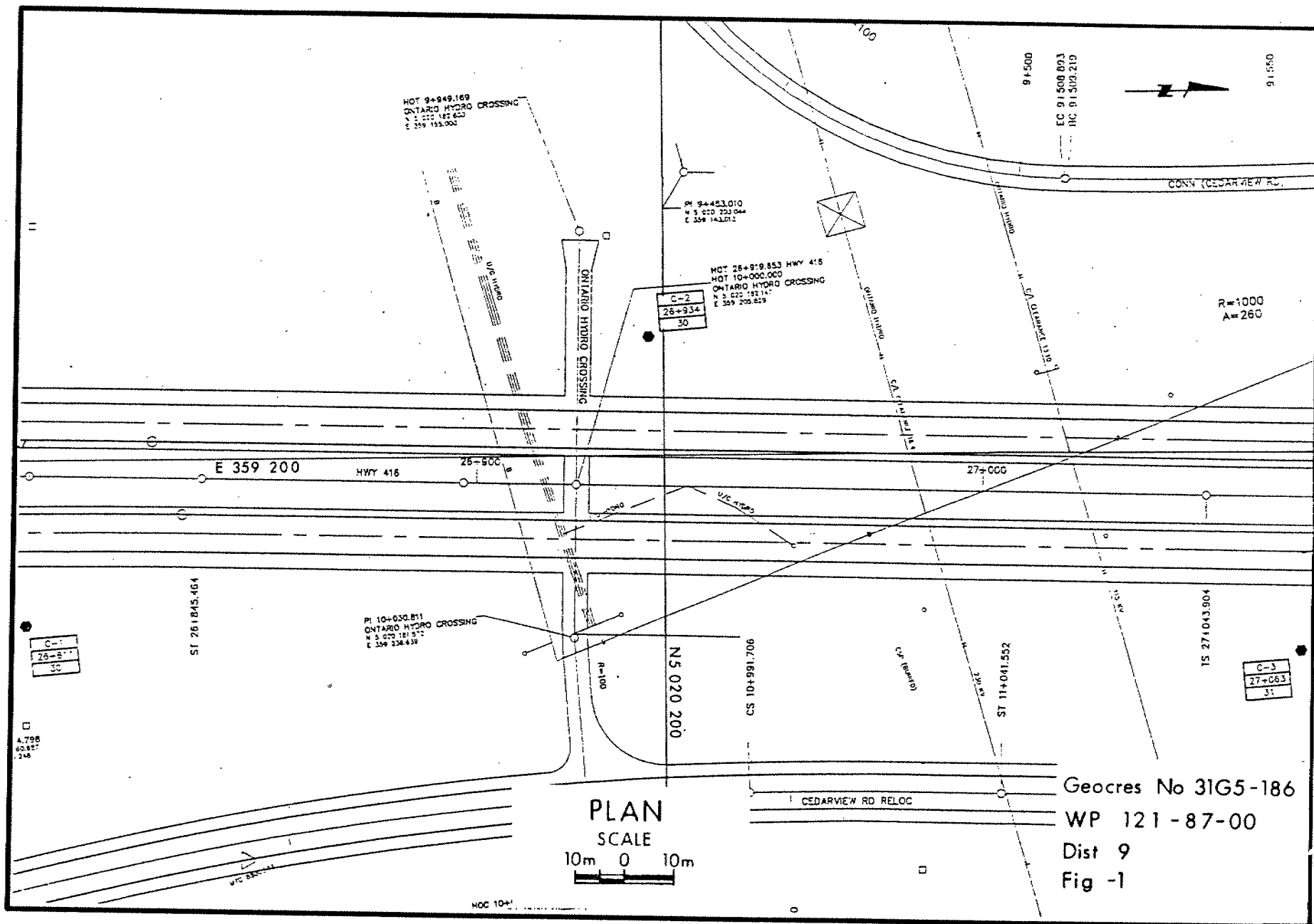
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18.1 0 17 58 25

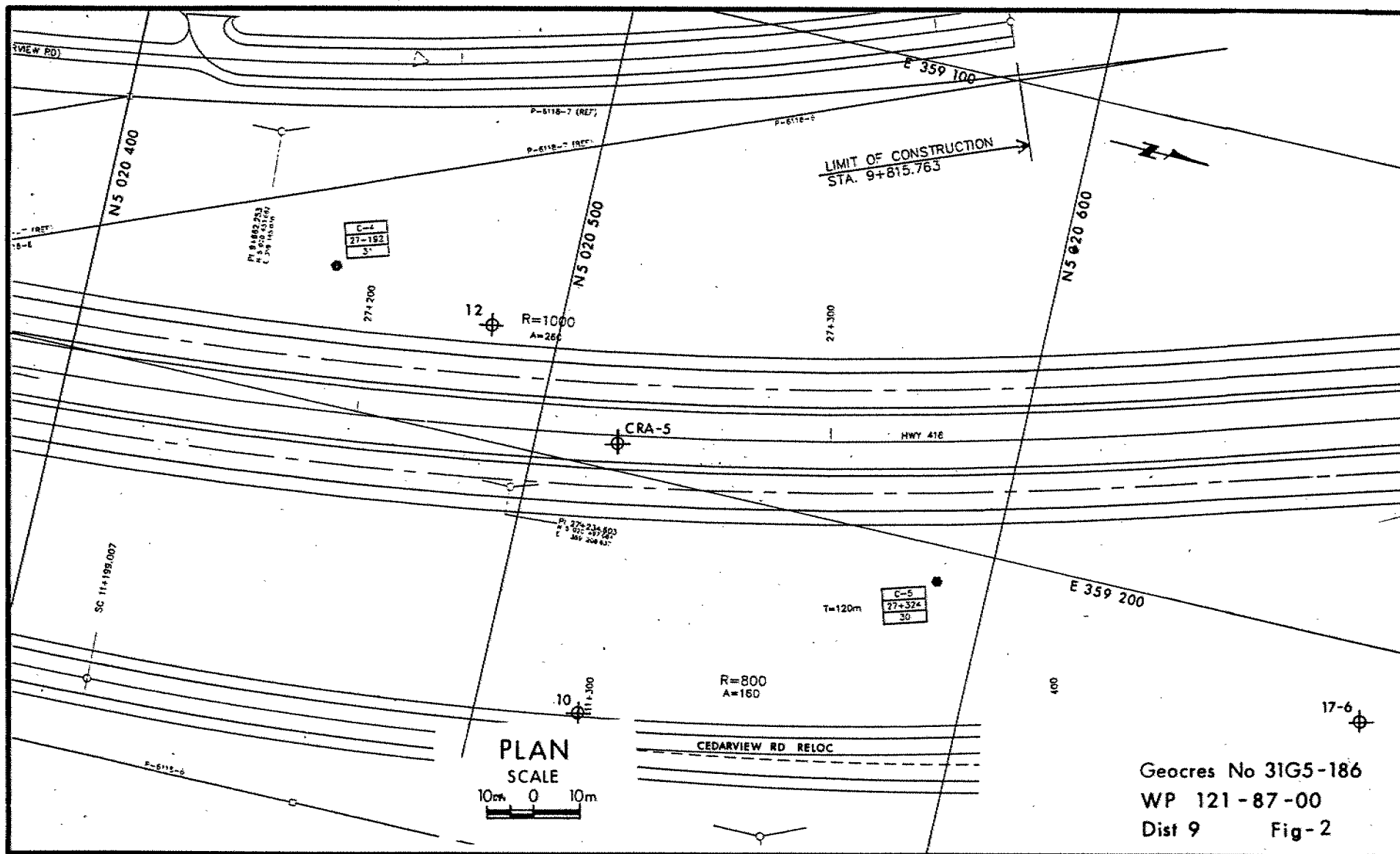
28 23 40 9

OFFICE REPORT ON SOIL EXPLORATION

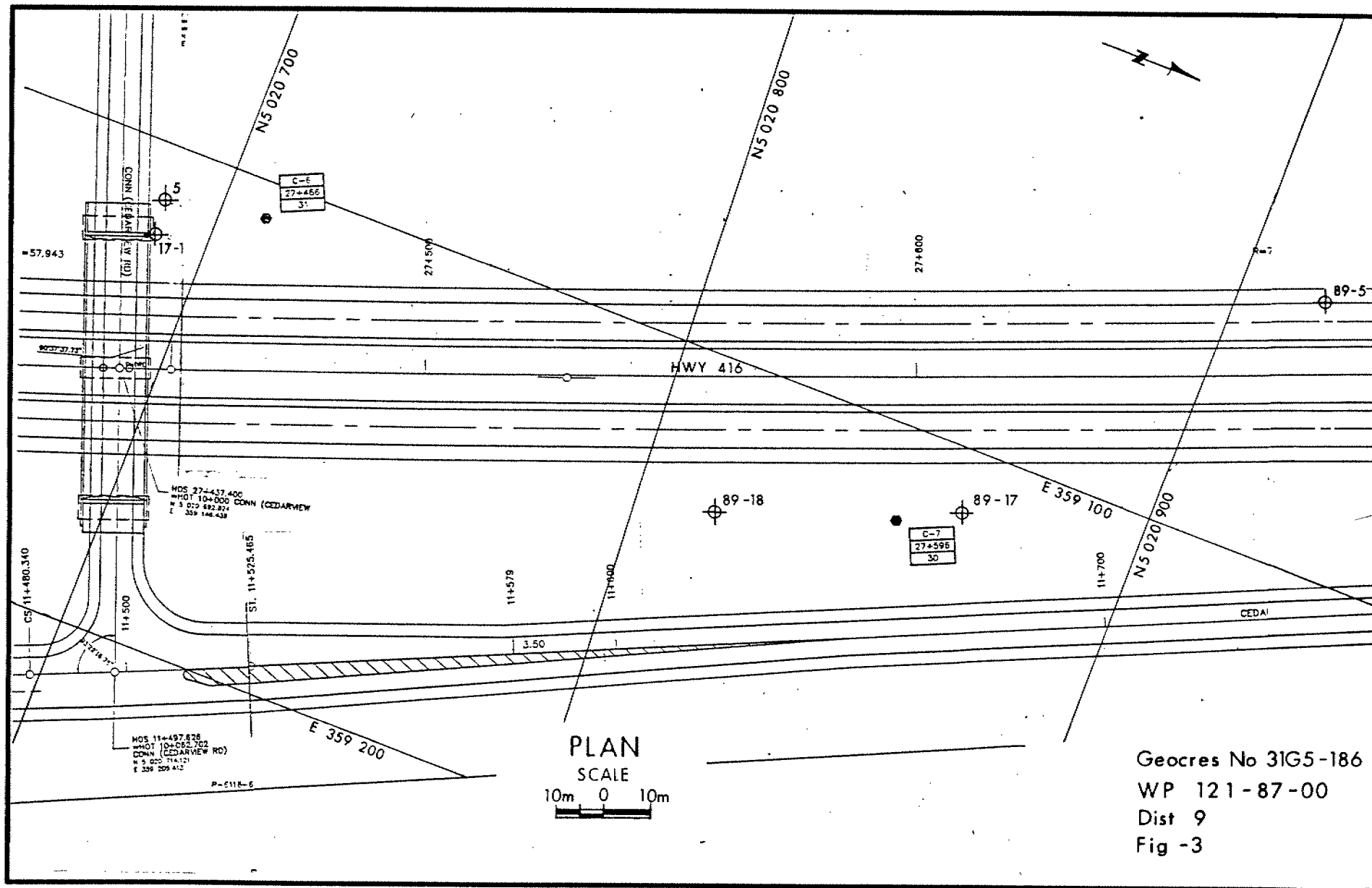
3, x 5: Numbers refer to  
Sensitivity.20  
15  $\div$  5 (%) STRAIN AT FAILURE  
10

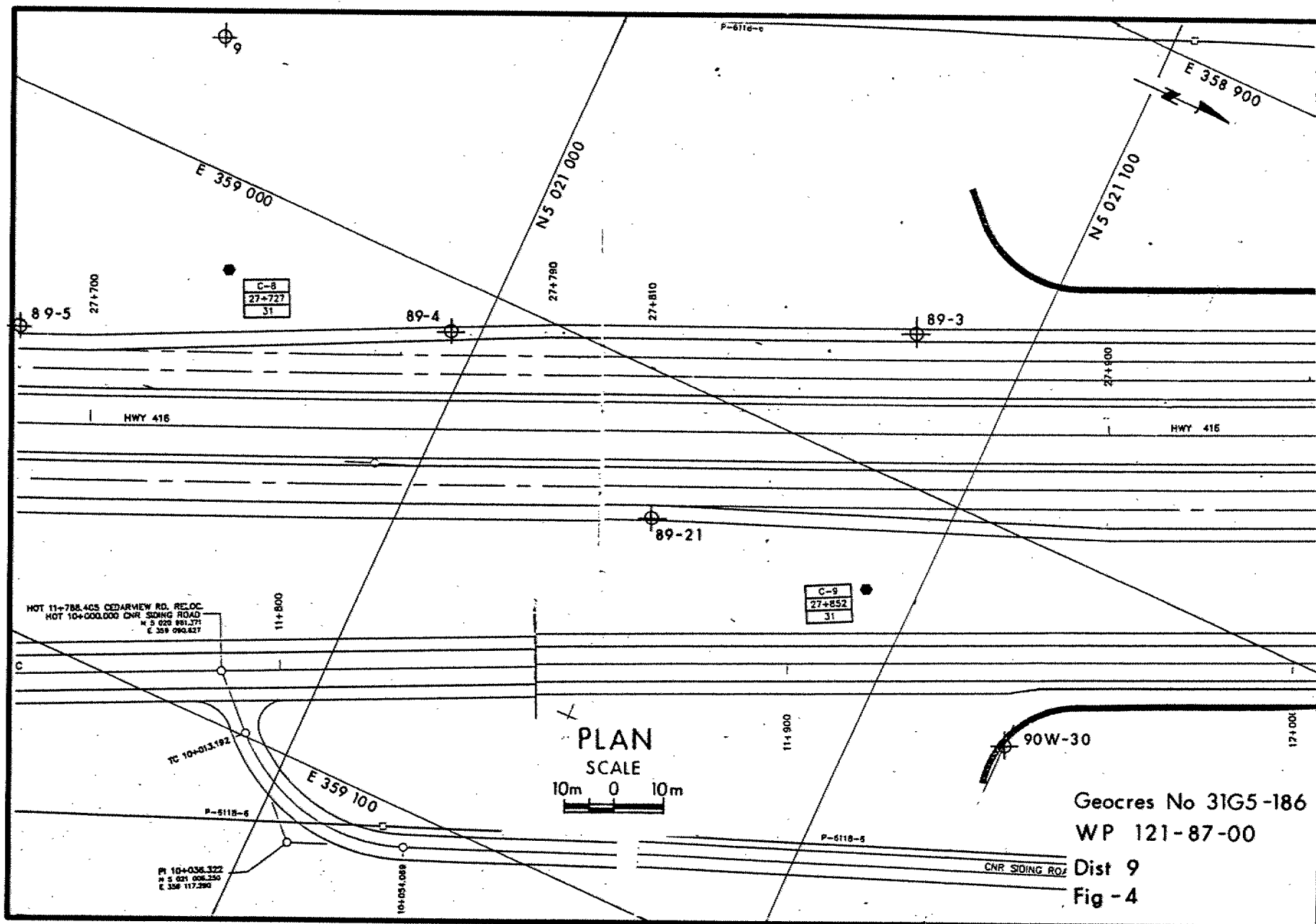


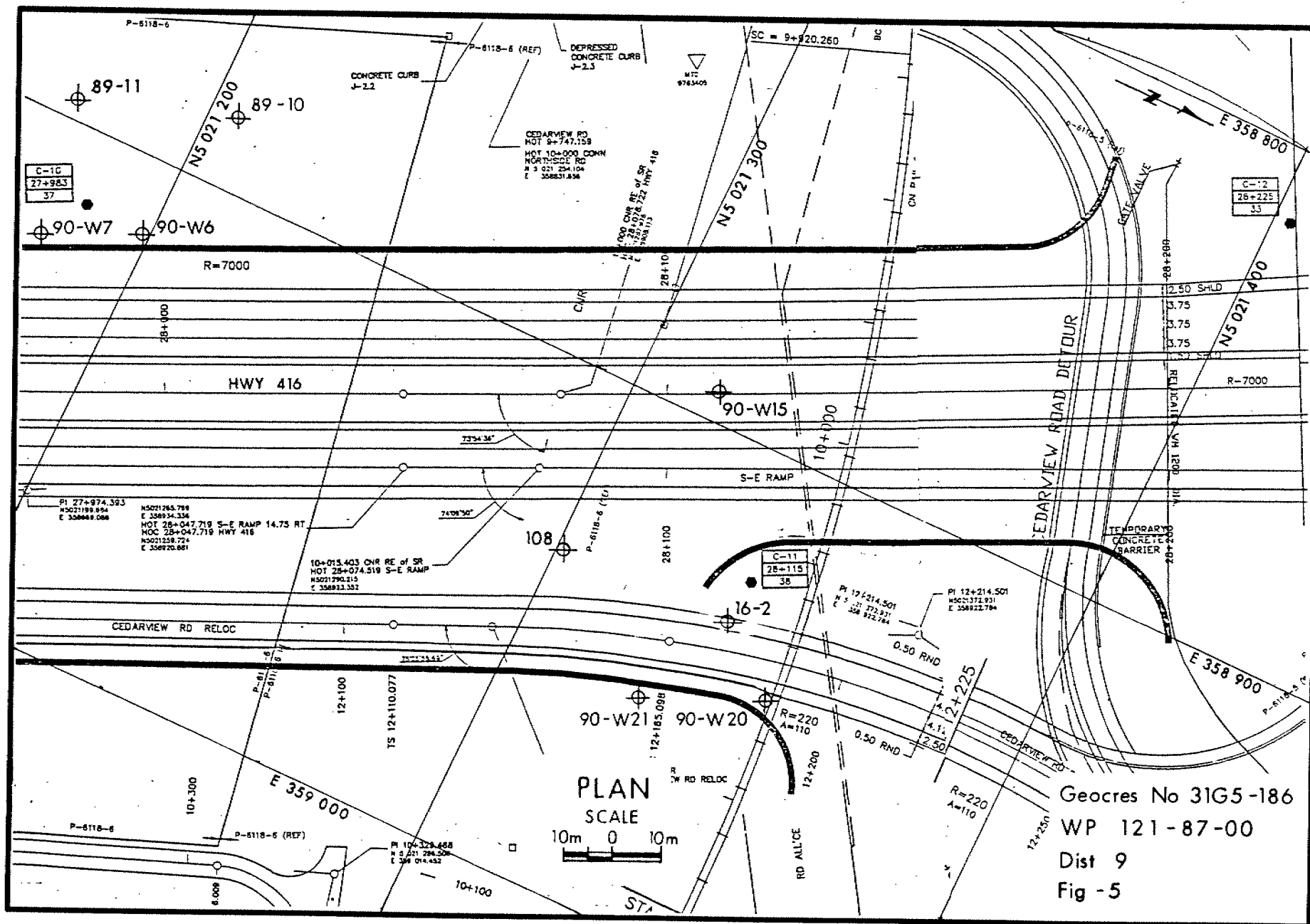




Geocres No 31G5-186  
 WP 121-87-00  
 Dist 9 Fig-2





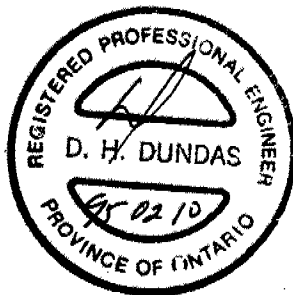


ADDENDUM  
to  
Foundation Investigation Report  
For  
High Mast Lights  
Knoxdale Road to Baseline Road  
WP 121-87-00, Site N/A  
Hwy 416, District 9, Ottawa

For  
High Mast Lights #C1 to #C3

The attached Subgrade Check Field Sheet summarizes subsurface information at the borehole locations. The borehole locations are indicated on the attached Figures 1 to 3 inclusive in relation to reference points. This information was provided by the Eastern Region Geotechnical Section.

Subsurface conditions at High Mast Light locations may be inferred from the summary of the closest borehole.



*D. Dundas*  
D. Dundas, P.Eng.  
Sr. Foundation Engineer

PAGE NO. ①  
TWP. CITY OF NEPEAN

DATE MAY 18/93  
W P NO. 127-27-00

Borehole  
H.M.L C-2

P.A.

0-400 Br Sa Tps

400-1.75 Br Si Sa wet @ 1.75 93-LV-27 dense

1.75-2.50 Gny Si Cl moist & stiff 93-LV-24 MB 2.00 75 KPa

2.50-4.00 Gny Si Cl moist & Firm 93-LV-25 MB 3.00 50 KPa

4.00-5.80 Gny Si Cl soft & Wet 93-LV-26 MB 4.50 20 KPa

5.80-7.50 Gny Si Cl soft & Sat 93-LV-28 MB 7.00 12 KPa

7.50-9.00 Gny Si Cl soft & Sat 93-LV-29 MB 8.30 10 KPa

9.00-10.50 Gny CL Si tns v ASa & Gr 93-LV-30 MB 9.50 dense

10.50-11.00 Gny Si Sa with Cl & Gr dense

Borehole

H.M.L C-1 (30m WEST APPROX Q 4146)

P.A.

0-300 Br Cl Tps

(water rising in hole to 1.30m)

300-2.00 Gny Si Cl dry & stiff 93-LV-31 MB 1.00 100 KPa

2.00-4.00 Gny Si Cl soft & wet 93-LV-32 MB 2.50 12 KPa

4.00-7.50 Gny Cl Si tns of Sa & Gr (dense) 93-LV-34 MB 5.00

7.50 NFP BR. 93-LV-35 MB 7.50

Borehole

H.M.L C-3 (20m NORTH OF (STAKED LOCATION))

P.A.

0-200 Br Sa Tps

(SEEPAGE @ 1.20)

200-900 Br Si Sa dense 93-LV-36

900-4.00 Gny Si Cl moist & Firm 93-LV-37 MB 1.50 93-LV-38 MB 3.50

4.00-5.00 Gny Si Cl soft & wet 20 KPa

5.00-6.00 Gny Si Cl soft & Sat 10 KPa

6.00-8.20 Gny Sa Si with Cl dense 93-LV-39 MB 7.00

8.20-11.00 Gny Si Sa dense 93-LV-40

(N.B. VANE ATTEMPTED AT 3<sup>rd</sup> LOCATIONS  
UNABLE TO PUSH)

WY NO. LOCATION CEDARVIEW RD.

E.B.  
ENGINEER

Figure 1

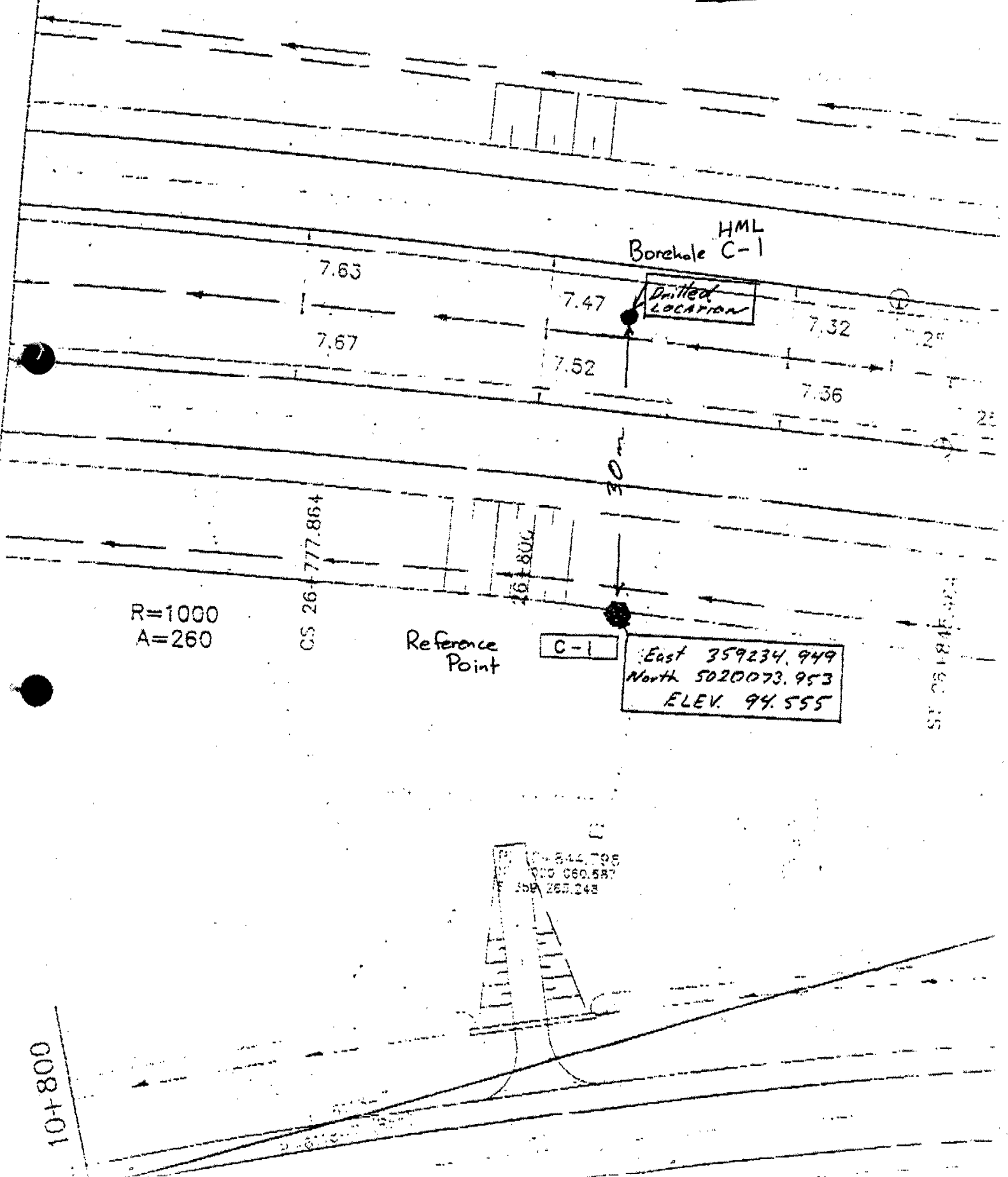


Figure 2

1. 94 453.10  
2. 5 781 203.04  
3. 339 10.013

Reference Point  
East 359175.948  
North 5020196.300  
ELEV 95.844  
C-2

Drilled Location (Borehole HML C-2)

271901

CS 10+991.706

ST 11+041.552



Figure 3

TS 27+03.904

Reference  
Point

C-3

20m

Drilled  
Location

(Borehole HML C-3)

East 359237.999  
North 5020324.006  
ELEV. 90.270

MATCH LINE STA.

4.50

7.25 1.0 RN

7.25 1.0 RN

3.75 1.50 SHL

3.75

3.00 SHLD

1.0 RND

MATCH LINE STA. 11+150

0.50 RN

2.50 SH

3.50

3.50

2.50 SHL

0.50 RN

11+100

SCALE



Series I



ACRES

**Ministry of Transportation  
Province of Ontario**

**Foundation Investigation for Bridge Structure  
Proposed Highway 416 and CNR Subway  
District No. 9, Ottawa  
WP 126-87-01, Site 3-544**

*GEOCREP # 3165-173*

**February 1990**

**Acres International Limited  
Niagara Falls, Ontario**

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2	Soil Properties
3	Summary of Piezometer Installation Details and Observations
4	Design Parameters for Total Stress Analyses

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1268701-B	Borehole Locations and Soil Strata - Sheet B

# 1 Introduction

Acres International Limited (AIL) was retained by the Ministry of Transportation of Ontario (MTO) to undertake a foundation investigation for a proposed CNR bridge structure over Highway 416, District No. 9, Ottawa, WP 126-87-01, Site 3-544. The work was authorized by Agreement 4238-9089-238 dated August 28, 1989.

The location, site plan and section of the proposed bridge are shown on MTO Plan E-52-416-

Drilling and sampling operations were performed by Marathon Drilling Co. Ltd., under the full-time supervision and direction of an Acres geotechnical engineer. Fieldwork commenced on November 2, 1989 and was completed on November 11, 1989. A plan of the site, showing the borehole locations, together with stratigraphic profiles are shown on Drawings No. 1268701-A and 1268701-B.

All soil samples and bedrock cores were returned to Acres geotechnical laboratory in Niagara Falls for detailed examination, logging and testing.

The results of the field and laboratory investigations are presented in this report, together with an interpretation of the data obtained and recommendations concerning the geotechnical aspects of the design and construction of the proposed bridge and associated works.



## 2 Exploratory Work

The exploratory work consisted of a total of 10 boreholes (BH-101 to BH-110 inclusive) drilled to depths ranging from 11.9 m to 16.3 m in both overburden and bedrock. Initially, the MTO staked the borehole locations and determined their ground surface elevations based on coordinates submitted by Acres. Three of the boreholes (BH-102, BH-107 and BH-109 inclusive) were located in the vicinity of the centerline of the west and east piers of the proposed CNR bridge. BH-101, 105 and 106, inclusive, were located in the vicinity of the west abutment, and BH-103, 109 and 110, inclusive, in the east abutment. BH-104 was located south of the proposed bridge, and was intended to determine the subsurface conditions for the southern part of the project site.

These borehole locations were subsequently modified slightly in the field to allow access and/or clearance from existing structures, etc. The final borehole elevations and their coordinates, as shown on Drawing No. 1268701-A, were measured and tied into the initially proposed locations, and are considered to be accurate to within 0.1 m.

Drilling was performed using a CME-55 auger drill rig mounted on an all-terrain tracked vehicle. Hollow stem augers were used to advance the drilling in the overburden, and diamond core drilling with a BX core barrel in the bedrock. A total of 116.4 m of overburden and 20.0 m of bedrock were drilled in the 10 boreholes. A summary for the physical data for each borehole is provided in Table 1.

**Table 1**

### Summary of Borehole Physical Data

Borehole Number	Ground Surface Elevation (m)	Coordinates	Overburden/Bedrock Contact		Bottom of Borehole	
			Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
101	86.6	E 358 878.3 N 5021 267.4	11.3	75.3	14.3	72.3
102	86.4	E 358 914.9 N 5021 272.9	12.2	74.2	14.9	71.5
103	86.4	E 358 994.0 N 5021 283.0	13.8	72.6	16.3	70.1
104	86.2	E 358 912.0 N 5021 251.0	12.0	74.2	13.6	72.6
105	86.3	E 358 840.0 N 5021 286.4	10.3	76.0	11.9	74.4
106	85.5	E 358 871.9 N 5021 291.1	10.0	75.5	12.2	73.3
107	85.1	E 358 904.4 N 5021 296.9	10.6	74.5	12.1	73.0
108	85.0	E 358 935.3 N 5021 301.1	11.5	73.5	13.9	71.1
109	84.5	E 358 964.3 N 5021 305.8	11.9	72.6	14.4	70.1
110	85.7	E 358 990.4 N 5021 316.4	12.8	72.9	12.8	72.9

With the exception of BH-104, 106 and 110, attempts were made to sample the overburden materials at intervals between 1.2 to 1.5 m, using a 51-mm OD split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedure or using a 73-mm OD thin-walled tube sampler (Shelby) as appropriate to the soil type. In these boreholes, field vane shear tests were performed using an Acker field vane tester on the undisturbed cohesive silty clay materials between each consecutive thin-walled tube sample. In BH-104, 106 and 110, almost continuous sampling was performed in the cohesive silty clay materials using a 73-mm OD thin-walled tube piston sampler.

A total of 16 piezometers were installed in the 10 boreholes. At least one piezometer was installed in each borehole. Two piezometers were installed in BH-101, 103, 105, 106, 109 and 110; one at a depth between 3.4 and 7.1 m and another at a depth between 8.5 and 12.3 m. In BH-102, 107 and 108, piezometers were installed in the bedrock.

All soil and rock samples were returned to Acres geotechnical laboratory for more detailed logging and testing. The laboratory testing included natural moisture content determinations, Atterberg limits, grain size analyses including hydrometer tests, unconsolidated-undrained triaxial tests, consolidated-undrained triaxial tests with pore pressure measurements, and unconfined compressive strength tests on rock core specimens.

The results of these tests, together with the details of drilling and sampling, are summarized in the Record of Borehole sheets following the report text.

## **3 Site Conditions**

### **3.1 General Description**

The crossing of the CNR tracks and the proposed Highway 416 is located in the vicinity of Bells Corners, in the city of Nepean, south of the existing Highway 417. A key plan of the area is shown on Drawing No. 1268701-A.

The site is located between Cedarview Road to the west, a vacant lot belonging to the National Capital Commission (NCC) to the north, and a green belt area to the east and south. Existing CNR railtracks run approximately east-west. The natural topography of the site is generally flat up to the NCC lot, and then gently sloping towards the north near Baseline Road. The existing railtracks are constructed on a single embankment, with a ditch on each side. The existing ground surface is generally grass covered, and a few small bushes exist on the site. A CN service road runs parallel to and to the south of the railtracks. BH-101, 102 and 103 were located at the northern edge of the service road and south of the railtracks. BH-104 is located south of the service road. BH-105 is located east of Cedarview Road, on top of the railway embankment. BH-106, 107, 108 and 109 were all located at approximately the bottom of the north side ditch. The majority of the ditch, except for the eastern part, was dry. It appeared that water runs from the east end of the ditch and turns to the north at a ditch junction located just east of BH-109. BH-110 was located just outside the CNR right-of-way boundary and above the north side ditch.

### **3.2 Soil Conditions**

#### **3.2.1 Topsoil and Possible Fill Deposits**

Dark brown silty sand with some gravel was encountered in BH-101 to 104, beneath a veneer of grass-covered topsoil. The thickness of this material varies from 0.6 to 1.3 m and it exists in a loose condition. In BH-101, 102 and 103, this material may be a fill material because of its proximity to the edge of the service road located south of the railtrack embankment.

In BH-106 to 110 inclusive, dark gray to dark brown silty clay with some gravel extends to depths between 0.1 and 0.4 m, and is considered as part of the topsoil layer. In BH-105, 1.9 m of similar material was encountered with some black mottling and oxidation staining. The consistency of this silty clay material ranges from soft to stiff.

#### **3.2.2 Silty Clay (Marine Deposit)**

A gray silty clay deposit was encountered beneath the surficial silty sand to silty clay with some gravel. The thickness of this deposit varies from west to east, with a minimum thickness being located in the center and western sides of the area under investigation, i.e., around BH-101, 105 and 106. In this area, its thickness ranges from 6.1 to 6.9 m. At the east end of the site, i.e., in the vicinity of BH-103, 109 and 110, the thickness ranges from 10 to 12.8 m. The silty clay deposit contains occasional horizontal to subhorizontal layers or lenses of silty fine sand to silt, the thickness of which vary from 2 to 10 mm. Continuous samples obtained from BH-104, 106 and 107 revealed that these layers and lenses generally exist between el 80 to 83 m. On the eastern side of the site where the deposit is thicker, silty sand and silt layers are also concentrated between el 76.5 and 78.1 m, and below el 75.8 m. In the zones where the thin layers or lenses of silty sand and silt exist, the

deposit also contains occasional pieces of round fine gravel. Pockets of silty clay or silt were also encountered in these zones.

The average natural moisture content of the marine deposit based on over 70 sample tests is 44%, with a range between 16 and 61%. The natural unit weight ranges from 16.0 to 17.8 kN/m<sup>3</sup>, with an average of 16.9 kN/m<sup>3</sup>. The index properties as determined by Atterberg limits tests indicate Liquid Limit ranges from 49 to 68% and Plastic Limit ranges from 18 to 32%. The average Liquid Limit, Plastic Limit and Plasticity Index are 57, 22 and 35% respectively indicating a material which is highly plastic.

The measured undrained shear strength of this material ranges from 14 to 113 kPa, as determined by field vane tests. A plot of elevation versus undrained shear strength indicates a desiccated crust down to approximately el 82.0 m. The laboratory unconsolidated-undrained triaxial tests provided an undrained shear strength range from 26 to 88 kPa. Figure 1 shows a plot of elevation versus undrained shear strength for this deposit. The sensitivity of the marine deposit, as measured by the field vane, ranges from 2 to 15, with an average of approximately 8, thereby classifying the clay as sensitive to extra sensitive.

Three sets of consolidated-undrained triaxial tests with pore pressure measurements were performed on piston samples taken from BH-104, 106 and 110. The Mohr circles from the tests are plotted in Figure 2, along with a failure envelope. The characteristics of this deposit are rather typical of Champlain clays reported in the literature (e.g., Crawford (1963), Mitchell (1970), Lo (1972)), and are similar to marine clay encountered by Acres at Arnprior, 50 km west of Ottawa (Peggs (1982)). The presence of cementation bonds is reflected in the nonlinear failure envelope shown, especially in the lower stress ranges. Depending on the interpretation used, failure envelopes indicating an effective angle of shearing resistance ranging between 23° and 28° can be drawn together with cohesion intercepts which vary from approximately 28 to 35 kPa.

### **3.2.3 Sand and Silt with Some Gravel and Some Clay (Till)**

A till deposit, consisting of sand and silt with some gravel and some clay and occasional cobbles, was encountered in all boreholes between the marine clay deposit and the bedrock. The thickness of this deposit varies across the site.

The maximum till thickness is located near the center of the area, i.e., around BH-102 and 107, where it varies from 4.5 to 5.2 m. The investigation also reveals that the thickness of the material decreases towards the west and east. In BH-103, 109 and 110, the thickness varies from 0.9 to 1.9 m. At the western side, the thickness is approximately 1.8 m.

The 'N' value of this material, as determined by the SPT, ranges from 1 to 29, with an average of 5, indicating a relative density from very loose to compact, but generally loose.

The natural moisture content of the till ranges from 11 to 33%, with an average of 18%. During the drilling and sampling, the obtained samples were generally wet,

and caving occurred during the retraction of the auger casings. Two samples were tested for their plasticity, and the results indicated that this till material is either nonplastic or has very low plasticity. Results from the grain size analyses exhibit a well-graded material, a typical gradation for till. The clay size content ranges between 7 and 10%. The density of this material, as tested by the SPTs, is relatively low in comparison to typical glacial till deposits. On the basis of its low density, it is expected that this material is a waterlain till, as described in some research papers (McGown et al, 1977, and Dreimanis, 1977).

The existence of this material has also been reported in the Ottawa area by other researchers (Adams, 1960), and the term 'soft till' has been used in their discussion.

The presence of gravel-size particles and possible cobbles made undisturbed samples difficult to obtain. Attempts were made to use thin-walled Shelby tubes to sample this material, but the tip of the tube was always damaged. The paper by Adams (1960) suggested that the unit weight of this material is in the order of  $20.4 \text{ kN/m}^3$ .

### 3.2.4 Summary of Soil Classification Tests

The results of laboratory tests to determine the natural moisture content, the unit weight and the index properties of the soil deposits described in this section are summarized in Table 2. The grain size distribution curves for possible fill materials, marine silty clay and the till are presented in Figures 3, 4 and 5 respectively. Figure 6 contains the plasticity chart, showing Liquid Limits and Plasticity Indexes of the marine silty clay samples.

**Table 2**

#### **Soil Properties**

	<b>Number of Test</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>
<b>(a) Topsoil and Possible Fill Deposit</b>				
Natural Moisture Content (%)	4	6	30	17
<b>(b) Silty Clay (Marine Deposit)</b>				
Natural Moisture Content (%)	78	16	61	44
Liquid Limit (%)	9	49	68	57
Plastic Limit (%)	9	18	32	22
Unit Weight ( $\text{kN/m}^3$ )	17	16.0	17.8	16.9
<b>(c) Sand and Silt Till</b>				
Natural Moisture Content (%)	14	11	33	17
Liquid Limit (%)	2	14	15	14
Plastic Limit (%)	2	12	15	13

### 3.3 Bedrock Conditions

The bedrock consists of light to medium gray dolomitic limestone with frequent dolomite beddings. The rock is part of the Oxford Formation, deposited during the lower Ordovician period. The dolomite has a fine crystalline texture, but often grades into a medium to coarse sandy clastic dolomite with some sections showing elongated and subrounded intraclasts up to 1.5 cm in length. Occasional shaly partings are present in all boreholes. One 100-mm section of dark gray microcrystalline dolomite was encountered in boreholes BH-101 and BH-102, approximately 2.5 m from top of rock. Up to 1-cm diameter vugs filled with pinkish-white calcite are present in some boreholes.

Bedding in all holes is subhorizontal, and except for the shaly partings, is gradational. Spacing between the shaly partings averages approximately 0.3 to 0.4 m for all holes. In general, the partings are smooth, undulating and intact. Prominently closely spaced partings are present in both BH-101 and BH-102 at approximately 0.5 m from top of rock.

Subvertical jointing was encountered in BH-104 and BH-108. The joints are rough, irregular and show development of calcite crystals and minor mineralization.

In general, the rock is very strong and fresh. Core recoveries ranged from 94 to 100% with an average of 99.5%. RQD values ranged from 40 to 100% with an average of 83%. The average unit weight, based on three core samples, is 27.2 kN/m<sup>3</sup>.

Unconfined compressive strengths obtained from three selected rock core samples ranged from 216.3 and 245.2 MPa, and averaged 230.8 MPa.

### 3.4 Groundwater Conditions

Groundwater level observations from the 16 piezometers, including their detail installations, are summarized in Table 3. The last readings were taken on December 28, 1989, approximately 6 weeks after the completion of the field drilling program.

The water level in the piezometers installed within the marine clay deposit ranges from el 82.0 to 84.8 m, with an average at el 83.6 m. Generally, the lower part of the deposit exhibits a lower piezometric level than the upper part.

The water level in the piezometers installed within the till deposit is generally the same or slightly lower than the level in the marine clay. It ranges from el 81.8 to 84.8 m, with an average at el 83.1 m.

The piezometric level in the bedrock was encountered approximately 3.5 m below the level in the marine clay. The average level based on three piezometric readings is at el 79.9 m.

Within the same elevation zone, the piezometric levels are generally flat. Groundwater observations as indicated by piezometric readings provided above show that there is no potential artesian condition at the area investigated.

Table 3

**Summary of Piezometer Installation  
Details and Observations**

Borehole	Ground Surface Elevation (m)	Elevation of Tip of Piezometer (m)	Elevation of Bentonite Seal		Date of Installation	Water Elevation on Dec 28/89 (m)	Remarks
			Top (m)	Bottom (m)			
101U	86.6	81.7	83.1	81.6	Nov 2/89	84.8	Marine clay
103U	86.4	79.4	80.1	78.7	Nov 4/89	84.2	Marine clay
103L	86.4	74.4	75.1	74.0	Nov 4/89	82.2	Marine clay
105U	86.3	82.3	82.7	81.4	Nov 7/89	83.3	Marine clay
106U	85.5	82.1	82.7	81.6	Nov 8/89	84.4	Marine clay
109U	84.5	80.2	81.0	80.0	Nov 10/89	83.8	Marine clay
109L	84.5	74.8	75.5	74.6	Nov 10/89	82.0	Marine clay
110U	85.7	80.2	80.7	79.8	Nov 11/89	84.2	Marine clay
101L	86.6	76.3	76.8	76.0	Nov 3/89	84.8	Till
104	86.2	75.7	76.1	75.4	Nov 6/89	82.5	Till
105L	86.3	77.0	77.8	76.5	Nov 7/89	83.1	Till
106L	85.5	77.0	77.5	76.6	Nov 7/89	83.4	Till
110L	85.7	73.5	74.0	-	Nov 11/89	81.8	Till
102	86.4	71.9	72.7	-	Nov 3/89	79.3	Bedrock
107	85.1	73.6	74.2	-	Nov 8/89	80.4	Bedrock
108	85.0	71.5	72.3	-	Nov 9/89	80.0	Bedrock

**Legend:** U - upper piezometer  
L - lower piezometer

## **4 Geotechnical Design and Construction Considerations**

### **4.1 General**

In summary, the subsurface conditions in the vicinity of the proposed Highway 416 and CNR subway consist of a surficial deposit of sensitive marine clay with a thickness varying from 6 to 13 m. This deposit is generally composed of a desiccated crust about 3 m thick, of firm to stiff consistency, underlain by softer materials below approximately el 82.0 m. The marine clay is underlain by a loose, sand and silt till with a thickness varying from approximately 1 to 5 m. This till was deposited on the limestone-dolomite bedrock which gently slopes down from west to east. The bedrock is fresh, very strong, has frequent subhorizontal bedding planes and is generally of good to excellent quality. Groundwater level measurements, as obtained from piezometers installed in the marine clay and till, were within the marine clay deposit. The piezometric level in the bedrock is substantially lower, indicating a downward flow of groundwater.

It is understood that the work proposed at the subject site involves

- relocating the existing CNR tracks around the north side of the site at such a distance from the proposed bridge to permit the bridge to be constructed
- constructing the new railway bridge
- carrying out the excavation required to pass the proposed Highway 416 and the relocated Cedarview Road under the railway bridge. This excavation will extend from grade at some distance north of the bridge, reach its maximum depth under the bridge and return to grade to the south of the bridge. Excavation of the approach cuts is generally beyond the scope of this investigation.

The major geotechnical design and construction considerations for the above works relate to the excavation or penetration of the sensitive to extra sensitive marine clay. Cuts in these deposits to the depth required for this project are not common. With regard to the bridge foundations, all structure loads must be carried down to the bedrock. Whether this is done by constructing the foundations in open excavations to bedrock or by extending them down by driven piles or caisson-type piles, the properties of the clay will have a significant influence on the design and construction procedures to be selected.

The structure layout will also be controlled to a major extent by the configuration of stable slopes in the marine clay. These slopes will also dictate the distance that the railway detour must be located away from the bridge centerline.

Because of the relatively weak and sensitive nature of the marine clay, it will be necessary to adopt certain precautions in carrying out the excavation work.

The various geotechnical aspects to be considered in the design of these works are discussed in the following sections together with design recommendations.



## 4.2 CNR Bridge Structure

It is assumed that the CNR bridge structure consists of a 3-span bridge with two intermediate pier locations and west and east abutments, as indicated on Drawing No. 1268701-A.

### 4.2.1 Bridge Piers

BH-102 and 107, which are located close to the west pier, encountered bedrock at el 74.2 and 74.5 m, respectively. BH-108, which is located north of the east pier, encountered bedrock at el 73.5 m. The bedrock elevations at the actual pier locations should be relatively close to these elevations.

It is assumed that excavation in the area for construction of the roadway will extend down to approximately el 76 m, which is within the loose till deposit. Since the deposit is not suitable for the support of such a structure, it is recommended that the bridge piers be founded on the bedrock. For the design of the footings on bedrock, a factored bearing capacity of 3000 kPa at 'Ultimate Limit State' is recommended. The bearing capacity at 'Serviceability Limit State' will not govern since the bedrock is assumed to be an unyielding foundation base.

### 4.2.2 Bridge Abutments

The west abutment will be located in the vicinity of BH-101 and 106, where the elevation of the bedrock is at 75.3 and 75.5 m respectively. The east abutment will be in the vicinity of BH-103 and 109, where the bedrock surface was measured at el 72.6 and 72.7 m respectively.

As recommended for the bridge piers, the abutment loads should be carried down to the bedrock. If this achieved by constructing the abutment concrete directly on the bedrock surface, a factored bearing capacity of 3000 kPa is recommended at the 'Ultimate Limit State'. The bearing capacity at the 'Serviceability Limit State' will not govern since the bedrock is assumed to be an unyielding foundation base.

Alternatively, consideration could be given to founding the abutment concrete at a higher level and transferring the loads down to bedrock using driven piles or caisson-type piles. However, the installation of such foundation elements raises some problems regarding the disturbance of the marine clay due to their installation methods. Of the various driven pile options available, 'H' piles probably cause the least disturbance. The clay disturbance results in a significant loss of strength which could, in turn, affect the stability and configuration of the excavation slopes. This may require special measures to be taken in the abutment areas to ensure the stability of slopes. The loss of strength may mean that the piles should be designed as long columns rather than short, as is normally the situation.

There are various options which could be studied in more detail if piling appears to be an attractive solution to the abutment foundations. One would be the driving of the piles from the existing ground level and waiting for the remolded soil around the piles to regain much of its strength loss before undertaking the excavation in the vicinity of the abutments. Other areas of the excavation could proceed in the meantime. When the excavation gets down to the concrete abutment founding level in the abutment areas, the piles would be cut off, a granular mat placed and the

abutment built as part of this investigation, the rate of strength regain has not been studied. This aspect should probably be reviewed as part of the design.

A similar clay remolding problem would exist with the installation of caisson-type piles. With this option, it is recommended that they be built by leaving the steel casings in the ground to avoid the potential problem of soil intrusion into the concrete column on casing withdrawal.

Typically, 310 x 110 'H' piles can support loads of 1600 kN at 'Ultimate Limit State' and 1150 kN at the 'Serviceability Limit State'. To prevent damage of the pile tips on contacting bedrock, it is recommended that the tips be reinforced. If batter piles are to be used, a type of pile shoe similar to the 'APF Hardbite', which can chisel into the bedrock, is recommended to avoid skidding along the bedrock surface. Such shoes should be used on piles driven on any batter flatter than 6V:1H.

Caisson-type piles could be designed as end-bearing columns using a factored bearing pressure of 3000 kPa at 'Ultimate Limit State'.

Concrete abutments founded directly on the bedrock surface could be constructed within sheeted and braced excavations and caissons. The walls of these caissons could consist of steel sheet piles or steel 'H' piles and timber lagging. Such structures should be designed to resist soil pressures as shown in Figure 8. Because of the disturbance and remolding of the sensitive marine clay during pile driving, the strength assumed in determining the soil pressure on the caisson has been assumed to be the remolded value using a minimum average undrained shear strength of 21.5 kPa and an average sensitivity of approximately 8. Further details regarding the undrained shear strength are presented in Section 4.3.2.

To avoid a base heave of the soil within the caisson, all sheeting should extend to bedrock.

Further details regarding the design of such caissons can be provided at a time when the construction concepts are better defined.

#### **4.2.3 Sliding Stability**

Both the west and east abutments will experience some horizontal loadings. Where the abutments are constructed directly on the bedrock surface, it is recommended that a sliding friction angle of 30° be assumed for the contact between the bedrock and concrete, and also along bedding planes within the bedrock. Even though shale partings are present, they are intact and undulate significantly. This angle represents the ultimate sliding resistance and must, therefore, be factored to provide an adequate margin of safety. If the value given above cannot adequately provide the sliding resistance, installation of corrosion protected rock bolts may be required to increase the sliding stability between bedrock and the concrete. It is also important that the exposed bedrock surface be clean from water, clay debris or clay layers from the excavation work prior to concreting of the abutment footings.

## 4.3 Stability of Cut Slopes

### 4.3.1 General

As noted in Section 4.1, the stability of the cut slopes in the sensitive marine clay is the major geotechnical design and construction problem on this site. Some of the significant factors involved in the resolution of this matter are soil strength, effect of soil disturbance, excavation techniques, groundwater conditions, depth of cut and special loading conditions, such as the detoured railway tracks and earthquakes. These factors are discussed below.

The critical stability section is along the eastern side of the site, i.e., in the east abutment area where the marine clay deposit is thickest, approximately 13 m. Most of the numerical stability analyses were performed on the configuration of conditions in this area.

The stability analyses were carried out using the PCSTABL5 computer program based on the Modified Bishop Method.

Two types of analyses have been undertaken; 'total stress' to assess the short-term temporary construction conditions and 'effective stress' to represent the long-term stability. These analyses are described below.

### 4.3.2 Total Stress Analyses

Total stress analyses were undertaken to assess the steepest slope that would have adequate stability for temporary short-term conditions. The marine clay strength used in these analyses was the undrained shear strength obtained from both field vane shear testing and laboratory unconsolidated undrained triaxial compression tests. A correction factor, which depends on the plasticity index of the clay, was used to adjust the field vane strengths for comparison with the values determined by the laboratory triaxial tests (Chandler, 1988).

Table 4 provides a summary of the calculations of the design undrained strength parameters for the marine clay, together with the other parameters used in the analyses. For the clay, a factor of 0.6 was introduced to allow for anisotropy, strain rate, progressive failure effects as well as possible softening of the clay during the excavation process (Benson et al, 1975).

Using the above parameters, various slope arrangements were analyzed to obtain an overall factor of safety of 1.3. The configuration which yielded this value was a uniform slope of 3.5H:1V without any berms or granular fill zones. It was assumed that the groundwater level follows the exposed surface as the excavation proceeds.

Table 4

## Design Parameters for Total Stress Analyses

## Marine Clay

Elevation Range (m)	Undrained Shear Strength (kPa)			Minimum Value of (2) and (3)	Strength for Analyses (Correction Factor 0.6)	Unit Weight (kN/m <sup>3</sup> )
	(1) Uncorrected Average Field Vane Results	(2) Corrected (Chandler, 1988) Avg PI=35	(3) Average U-U Triaxial Test Results			
Above 82.0	61	76	58	58	33.5	16.8
79.5 - 82.0	30	38	36	36	21.5	16.8
Below 79.5	29	36	64	36	21.5	16.8
<b>Till</b>						
c' = 0	$\phi' = 28^\circ$					20.4

## 4.3.3 Effective Stress Analyses

The long-term stability of the cut slopes was assessed on the basis of two sets of effective stress parameters for the marine clay in combination with various other loading assumptions described below.

It is the general belief in the soil mechanics community that the effective cohesion,  $c'$ , component of a lacustrine clay strength reduces with time and approaches zero in the long term. Marine clays, however, are somewhat different in that a small amount of cohesion or tensile strength remains as a result of the particle bonding.

The results of the consolidated undrained tests performed as part of this investigation are presented in terms of Mohr circles and envelope in Figure 2. The tests performed at stress levels comparable to those which will exist in the cut at the subject site define a nonlinear failure envelope. However, at higher stress levels, the more traditional failure envelope becomes apparent. The change in envelope has been explained as being the limit of the strength due to bonding and the point where the friction component becomes effective.

A similar type of envelope was obtained by Acres as a result of fairly extensive testing on a similar clay near Arnprior, Ontario, about 50 km from the site.

The effective angle of shearing resistance defined by the tests on the Ottawa site is approximately  $23^\circ$  with an effective cohesion intercept of approximately 30 kPa.

On the basis of these test results, it has been assumed that the lower bound long-term strength of the marine clay on the subject site would be defined by an effective angle of shearing resistance of  $23^\circ$  and an effective cohesion of zero. Considering

the conservative nature of this strength assumption, a lower-than-normal factor of safety against slope failure appears to be warranted with a value of 1.3 being the one used in considering various slope configurations.

A somewhat less conservative set of strength assumptions was also considered for unusual or dynamic loading conditions. The parameters selected were  $\phi' = 23^\circ$  and  $c' = 5$  kPa. The final configuration developed, together with the stratigraphy and parameters used, are shown in Figure 7. They represent the conditions which apply to the eastern half of the site where the marine clay is thickest. The excavation is defined by three segments cut at a slope of 3H:1V. The segments are separated by two 3-m wide berms at el 81 m and 83.5 m respectively. A granular fill zone, placed over the lower slope, has a surface slope of 3.5H:1V and a top width of 2 m at el 81 m. This zone acts as a weighting berm, prevents seepage from exiting the lower portion of the slope and provides protection against frost penetration into the marine clay in this critical zone of the slope.

It was assumed that the piezometric groundwater levels at the start of excavation would be the same as the average level indicated in Table 3 for each of the three strata. It will be necessary to install an effective drainage system in the slope as excavation proceeds and monitor the lowering in piezometers to ensure that the design assumptions are being met. This is discussed in more detail in a subsequent section of the report. The lowered phreatic surface shown in Figure 7 is the one assumed for long-term stability. The overall slope defined by this configuration is approximately 4H:1V which is very similar to the average slope of 3.5H:1V defined by the 'total stress' analyses.

Other factors taken into account in analyzing the slopes were the loading due to the detoured railroad and those resulting from earthquakes.

Since it is uncertain as to the duration that the railroad detour will be in operation, its effect was considered in the effective stress stability analyses. A loading equivalent to Cooper E85 on a single line track, the centerline of which is located a minimum of 13 m from the crest of the cut slope, was included. It was assumed that the railtracks will be built on a 2-m high granular embankment, 7 m wide at the base, and the impact loading will be equivalent to 55% of the railway live load resulting in a load intensity at the ground surface of 75 kPa.

The results of the stability analyses are shown in Figure 7 and tabulated below for the two sets of assumed strength parameters.

$\phi'$	$c'$	Factor of Safety
23°	0 kPa	1.28
23°	5 kPa	1.58

These factors of safety are considered reasonable.

The effect of earthquake loading was also considered using a seismic coefficient equal to 0.1g in a pseudostatic analysis. Because of the unusual and dynamic nature of such loading, strength parameters of  $\phi' = 23^\circ$  and  $c' = 5$  kPa were used giving a factor of safety of 1.06.

This factor of safety is relatively low, but is considered to be adequate taking into account the relatively conservative nature of the strength parameters and the inherent conservatism of the pseudostatic analysis coupled with the shallow soil deposit.

On the basis of these analyses, it is recommended that the excavation outline shown in Figure 7 be used for the slopes along the eastern side of the excavation and around the north side to the centerline of the cut. Beyond this point, towards the west and along the west side, the upper berm could be deleted because of the less severe soil conditions.

The excavation slope around the south side of the site is discussed further in Section 4.3.4.

#### **4.3.4 Construction**

Because of the generally weak and sensitive nature of the marine clay, special attention must be paid to the excavation techniques used and the necessity to minimize disturbance of the clay particularly near the finished slopes.

The maximum depth of the cut in the marine clay is about 10 m which consists of about 3 m of desiccated crust overlying the weaker unweathered portion of the deposit.

Consideration should be given to undertaking the excavation work in two lifts. The upper one would involve the crust in which conventional equipment, such as dozers and scrapers, might be appropriate. While the depth of material to be excavated below the crust is within the capacity of the larger backhoes, the slope in front on the machine would be too steep to be stable. For this reason, it will probably be necessary to use a dragline for the lower lift.

If the first lift is taken too deep, it may become necessary to operate the equipment involved in the second lift from a granular mat placed over at least a part of the area to provide a suitable working surface.

It will be important to ensure that the cut slopes in the second lift are maintained relatively flat to prevent the triggering of a slide within the cut or near the finished slopes.

Final trimming of the slopes can probably be done with a small dozer. This work is preferably carried out after several weeks of dry weather during which the near surface clay has dried out and increased in strength. Rainfall or freezing and thawing will tend to reduce the strengths. It will be necessary to place some erosion protection on the cut slopes to prevent damage due to precipitation and runoff and establish a surface drainage system since the clay erodes rapidly if left exposed.

The excavation slope to the south of the bridge can be cut much flatter than required for stability since this material must be removed as part of the overall road construction. The contractor may wish to use this area to construct his access road down into the bridge foundation site.

#### **4.3.5 Location of the CNR Detour**

The CNR tracks must be detoured around the bridge construction site on a new embankment. The offset distance between the two lines must be sufficient to allow (a) adequate working space around the bridge foundations, (b) the construction of a stable slope, and (c) sufficient setback from the crest of the excavation to ensure slope stability. Based on the analyses undertaken, the distance from the toe of the excavation slope to the centerline of the relocated railway embankment should be a minimum of 52 m. If a working space of 15 m from the toe of the excavation slope to the centerline of the new bridge is considered adequate, the total offset of the detour centerline should be a minimum of 67 m.

It will be very important that once this distance is established that the toe of the slope is not cut away or the slope oversteepened.

## **4.4 Other Construction Considerations**

### **4.4.1 Control of Groundwater Conditions**

The existing piezometric data indicate that it will be necessary to lower the groundwater levels in the bedrock and the till to avoid boiling and 'blowing up' of the thin overburden layer which will be left over the bedrock as the excavation approaches final grade. Depressurization of the bedrock may also be required to lower the phreatic surface in the overburden slopes to improve their stability. A pumping test conducted prior to construction, using the existing piezometers set in the 10 boreholes drilled for this investigation, would provide useful information required for the design of the depressurizing system. The construction of an effective drainage system at the toe of each berm, together with the depressurization system and a detailed monitoring system, will be important aspects in the success of the excavation at the site.

The design of the depressurizing system is considered to be beyond the scope of this investigation.

The drainage system in each berm and at the toe of the slope is essential for the long-term stability of the slope. Typical details of such a system are shown in Figure 9.

To prevent freezing of the drains, they must be placed a minimum of 1.8 m below the berms. In excavating these drain trenches, it is essential that they be opened in short sections and backfilled with compacted materials before moving on to the next section. Failure to do this in short sections may result in a slope failure.

It is important that water flowing across the area be diverted away from the cut to avoid any flow over the crest and down the slope. This can be done by creating small mounds back from the slope crest to divert the water away from the cut. This is preferable to cutting swales or drainage ditches which may pond water near the crest of the slope and have an adverse effect on the slope stability.

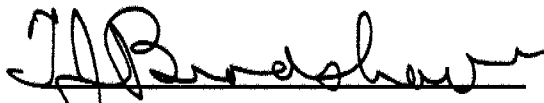
#### 4.4.2 Performance Monitoring

Cuts of the depth proposed for this project are not common anywhere in Canada. It is important therefore that the design assumptions be monitored to confirm satisfactory performance. Physical stability of the cuts may be verified with

- slope indicators
- shear strips
- surface pins.

The groundwater history and performance of the drainage system should also be monitored by piezometers and wiers to check drainage pipe flows. Typically, failures of marine clay slopes occur in the spring under conditions of high groundwater.



  
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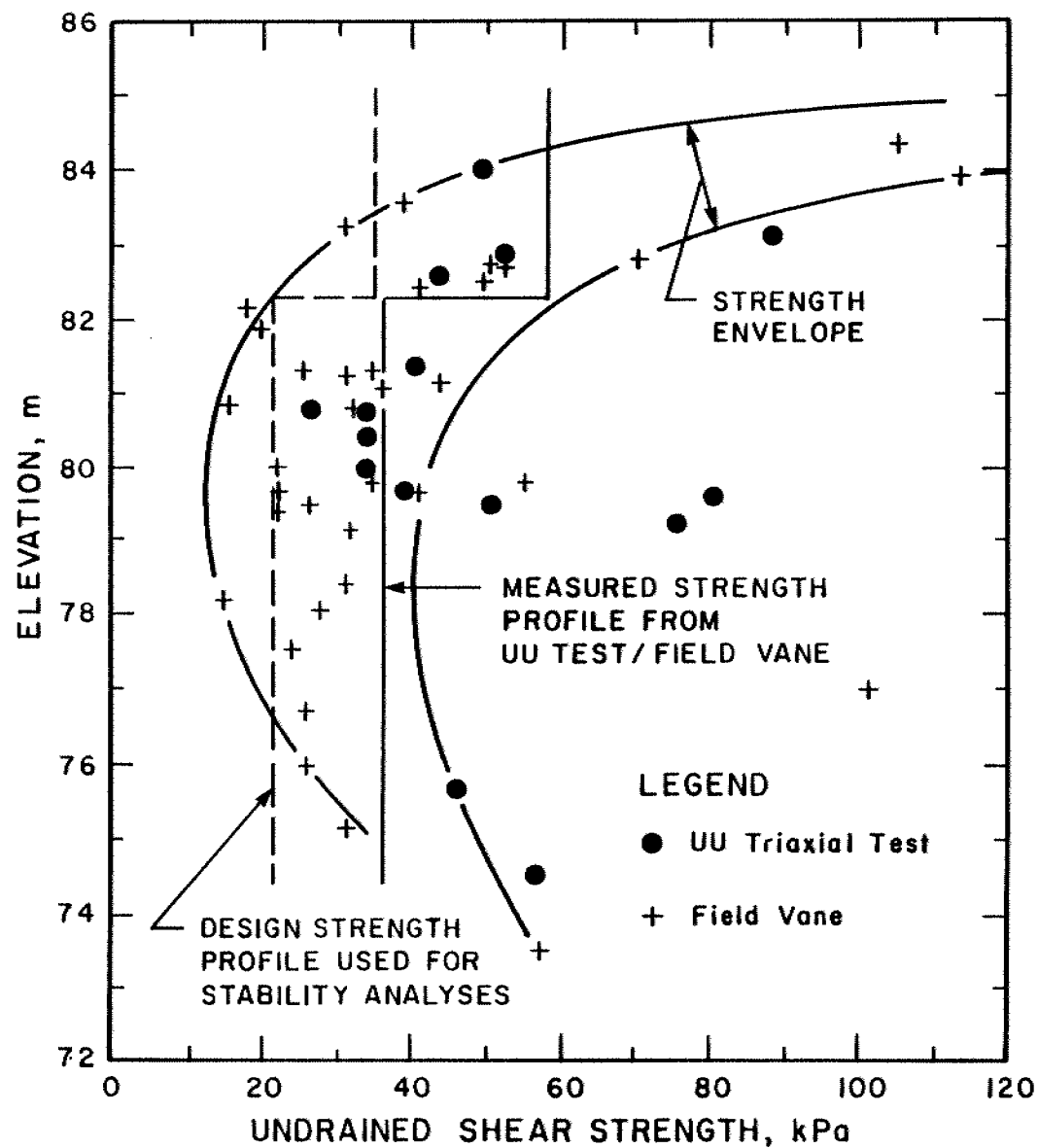


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## Figures

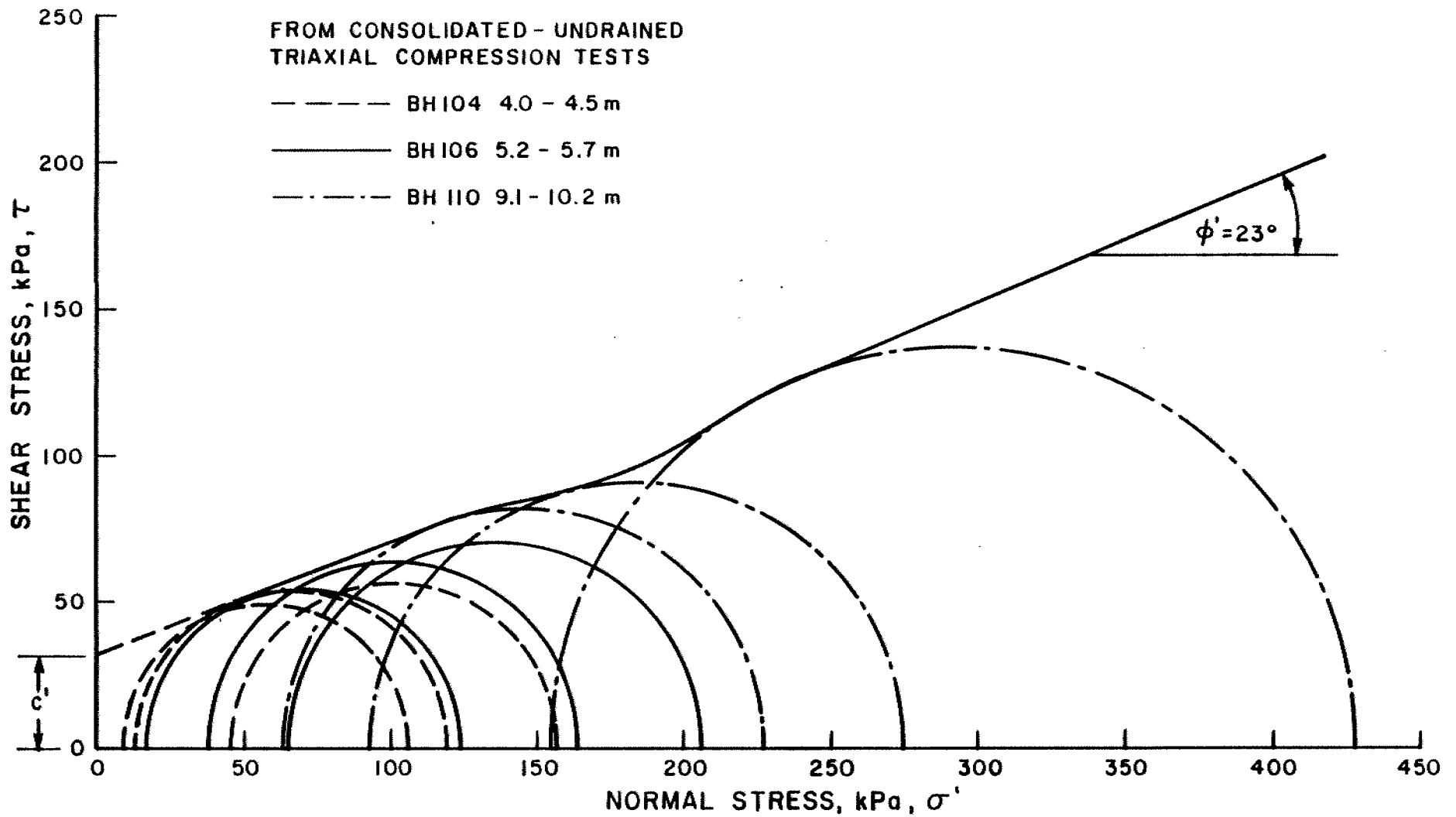


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# UNDRAINED SHEAR STRENGTH PROFILE OF MARINE CLAY

FIG No 1

W P 126-87-01



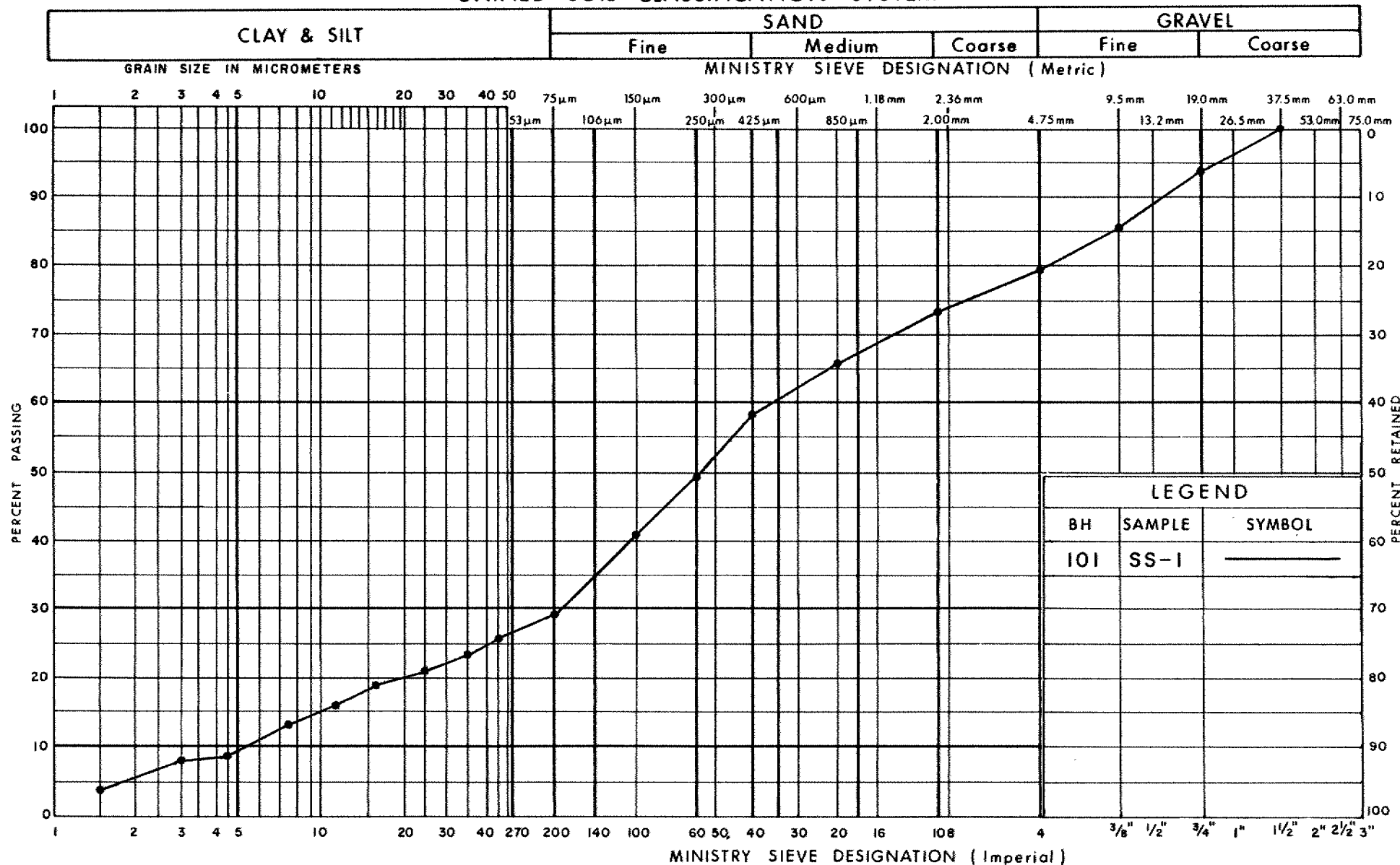
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# MOHR CIRCLES AND ENVELOPE-MARINE CLAY

FIG No 2

W P 126-87-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



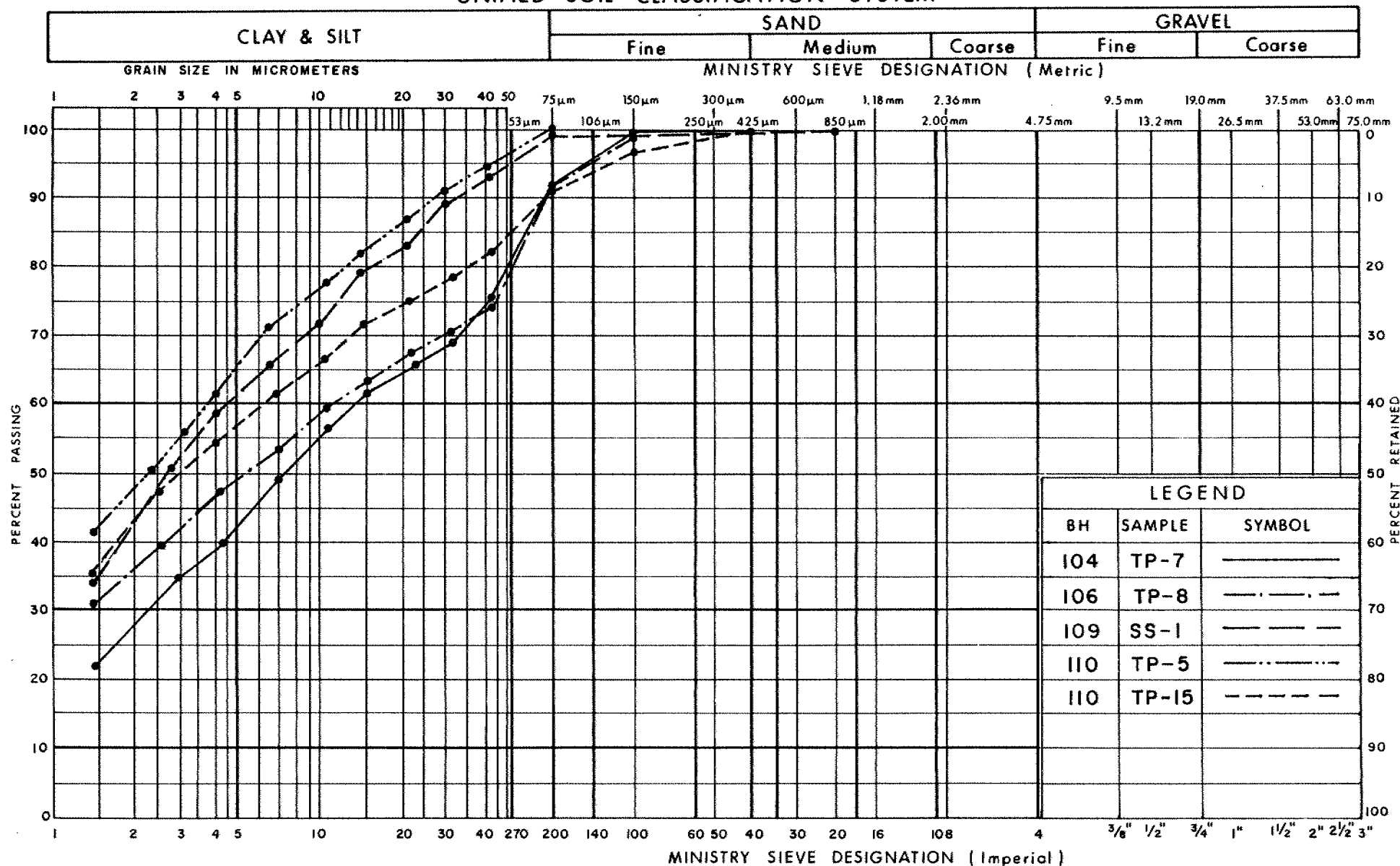
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**GRAIN SIZE DISTRIBUTION**  
**GRAVELLY SILTY SAND WITH TRACE OF CLAY**  
**(POSSIBLE FILL)**

FIG No 3

W P 126-87-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



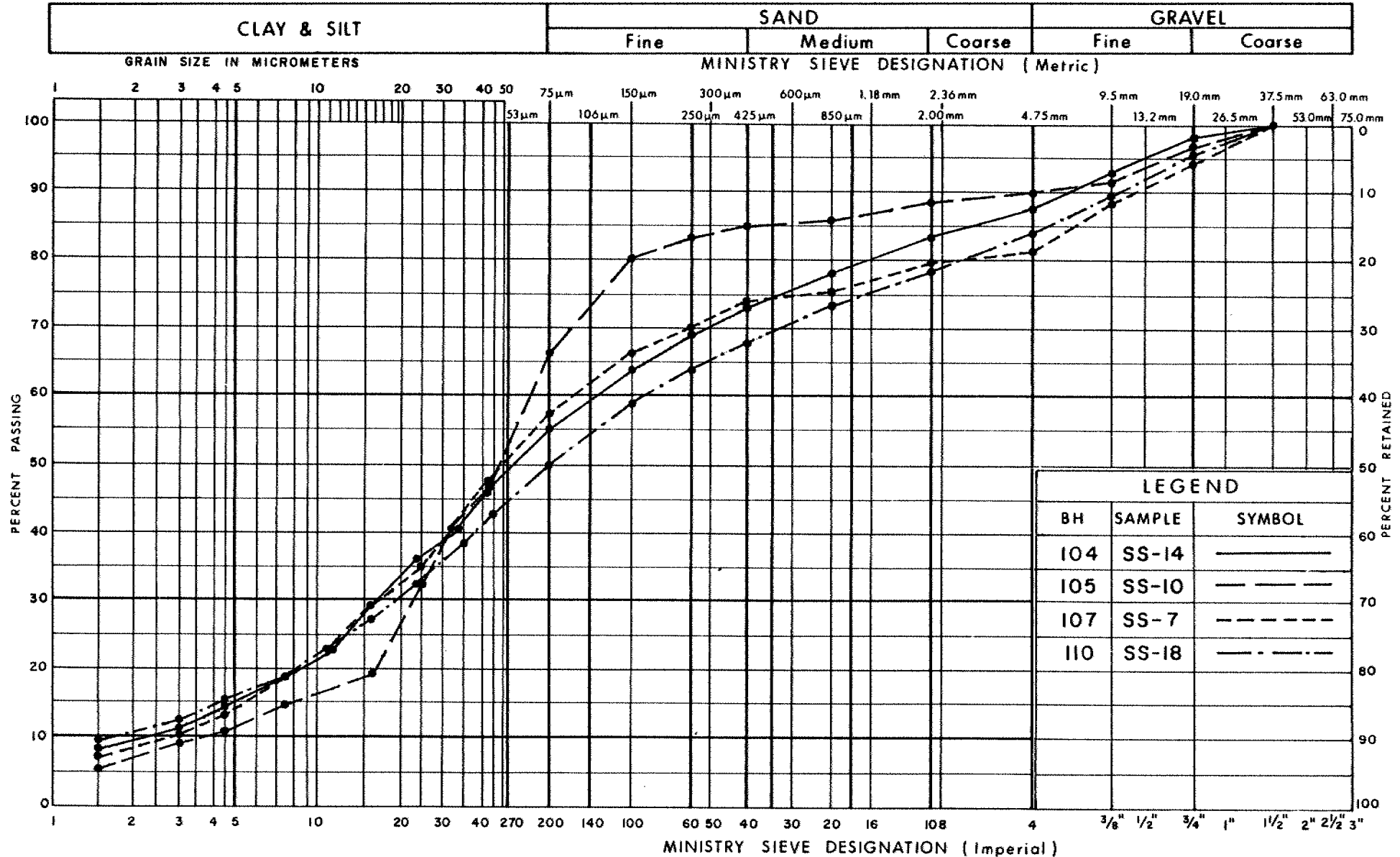
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# GRAIN SIZE DISTRIBUTION SILTY CLAY (MARINE DEPOSIT)

FIG No 4

W P 126-87-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



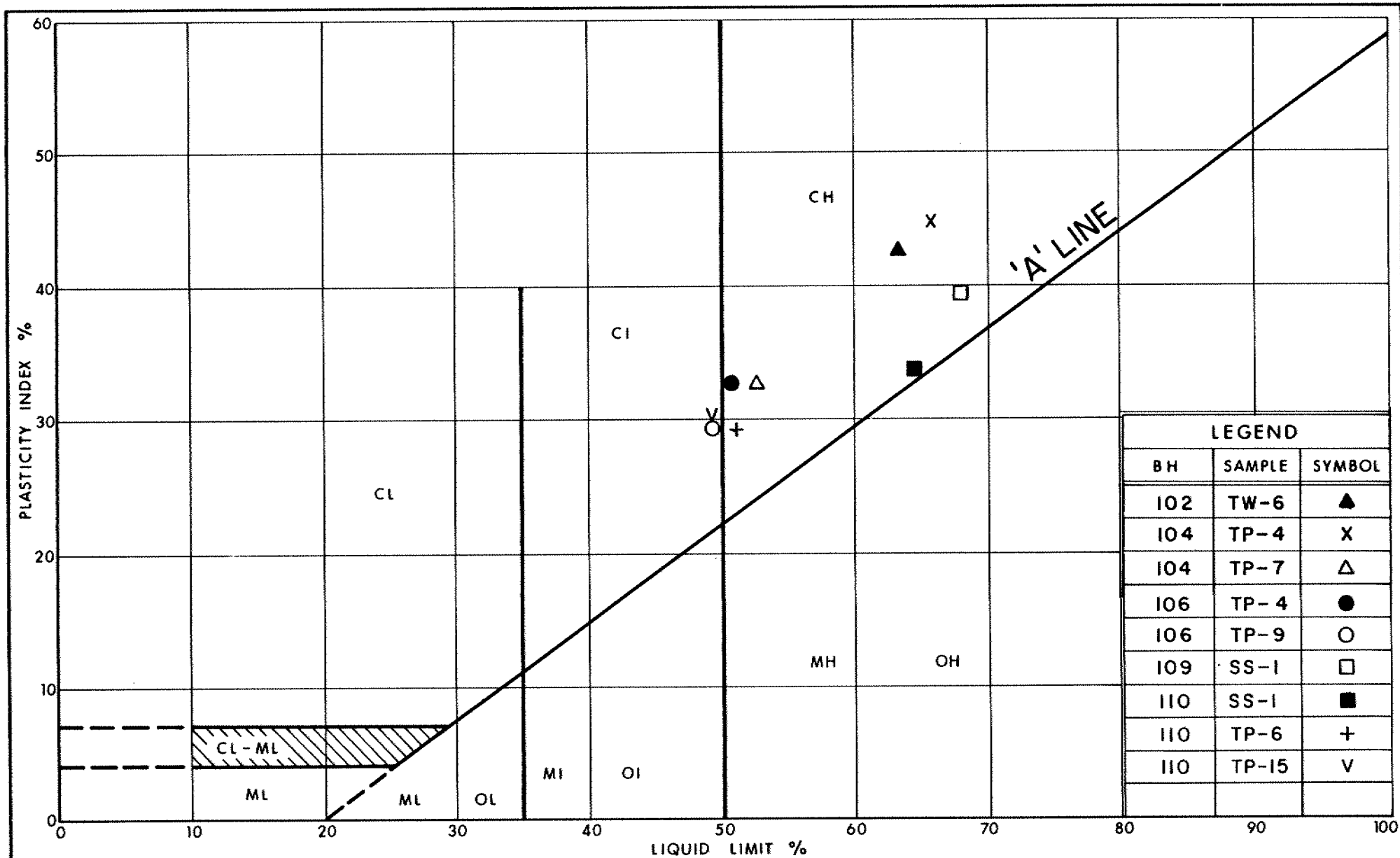
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**GRAIN SIZE DISTRIBUTION  
SAND AND SILT WITH  
SOME GRAVEL AND SOME CLAY (TILL)**

FIG No 5

W P 126-87-01





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Ontario

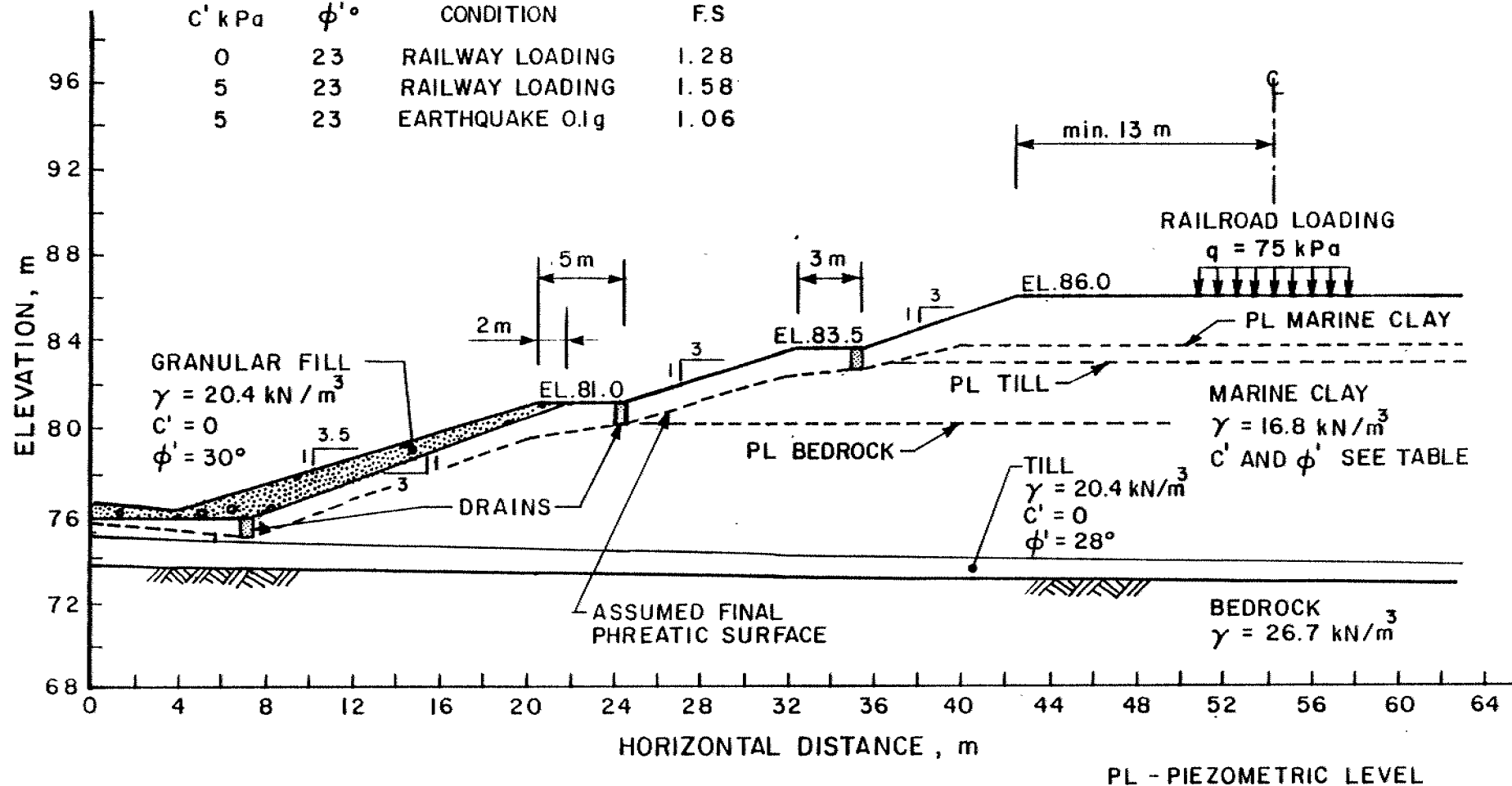
# PLASTICITY CHART SILTY CLAY (MARINE DEPOSIT)

FIG No 6

W P 126-87-01

# STABILITY ANALYSES - MODIFIED BISHOP METHOD

MARINE CLAY $C'$ kPa	$\phi'$ °	CONDITION	MINIMUM F.S.
0	23	RAILWAY LOADING	1.28
5	23	RAILWAY LOADING	1.58
5	23	EARTHQUAKE 0.1g	1.06

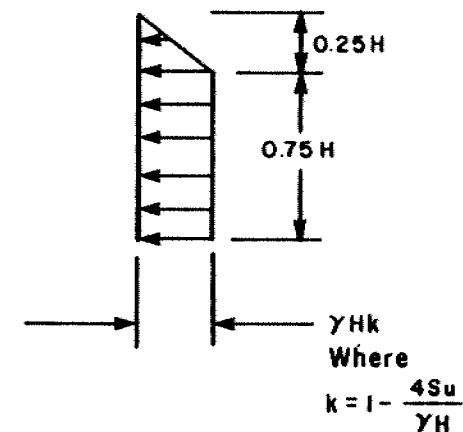
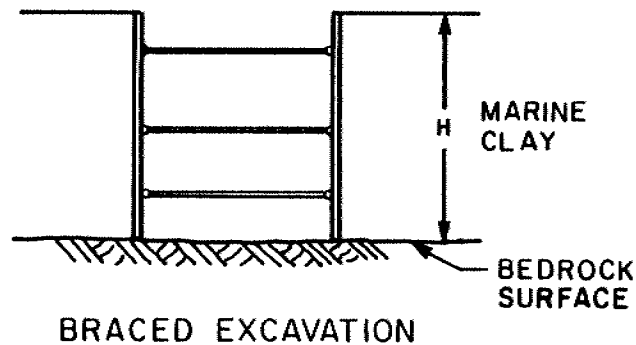


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## SLOPE STABILITY ANALYSES EFFECTIVE STRESS ANALYSES EAST SIDE CONDITIONS

FIG No 7

W P 126-87-01



EARTH PRESSURE DIAGRAM  
 (SEE NOTES 1 AND 2)

NOTES

1- Soil Parameters for Marine Clay

$S_u = 2.5 \text{ kPa}$  (Based on Remolded Strength)

$\gamma = 16.8 \text{ kN/m}^3$

$H$  = Height of Excavation

2- Design Must Also Include Surcharge Loading from Nearby Slopes and Equipment Loads Near the Excavation Area, etc.

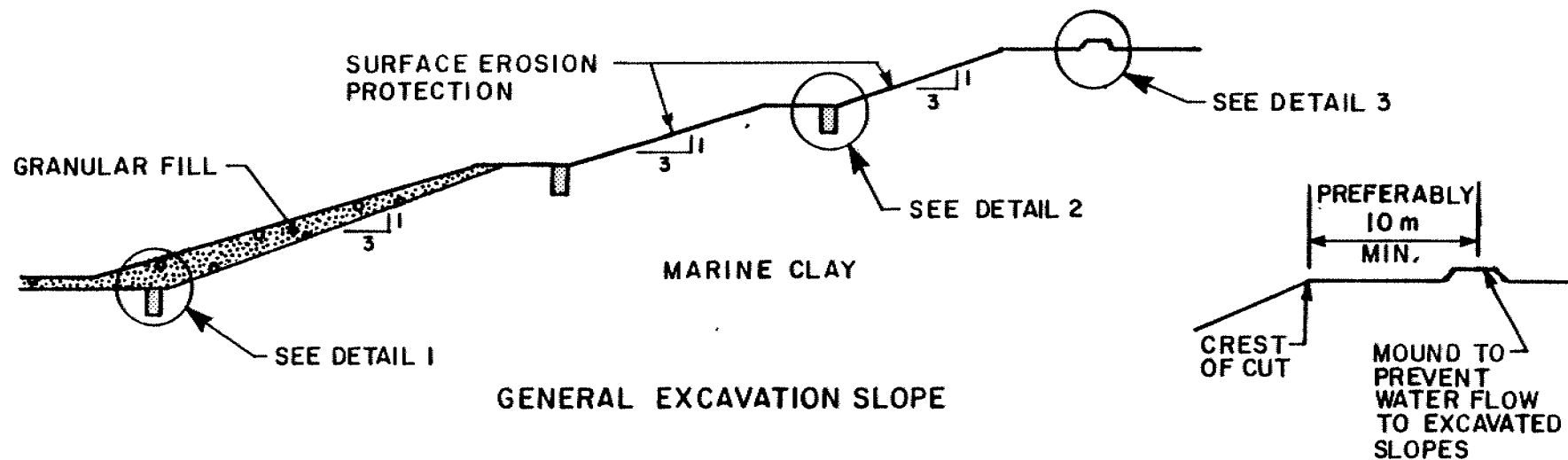


Ministry of  
Transportation

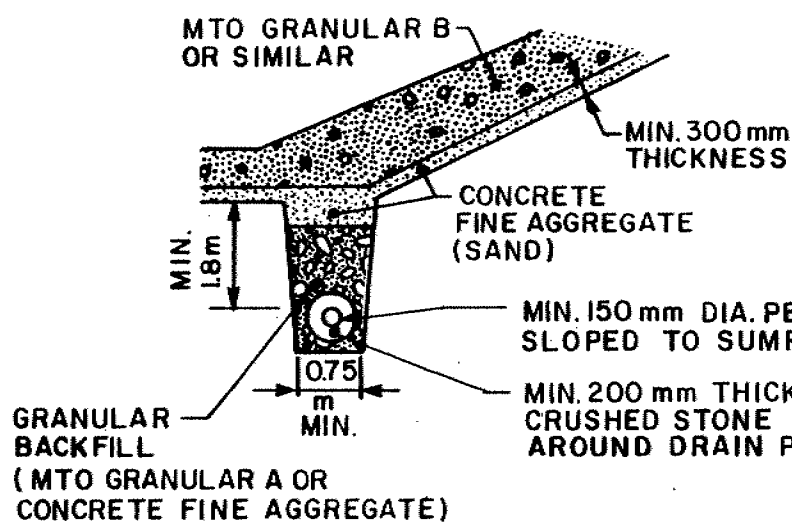
LATERAL EARTH PRESSURE DIAGRAM  
 FOR BRACED EXCAVATION

FIG No 8

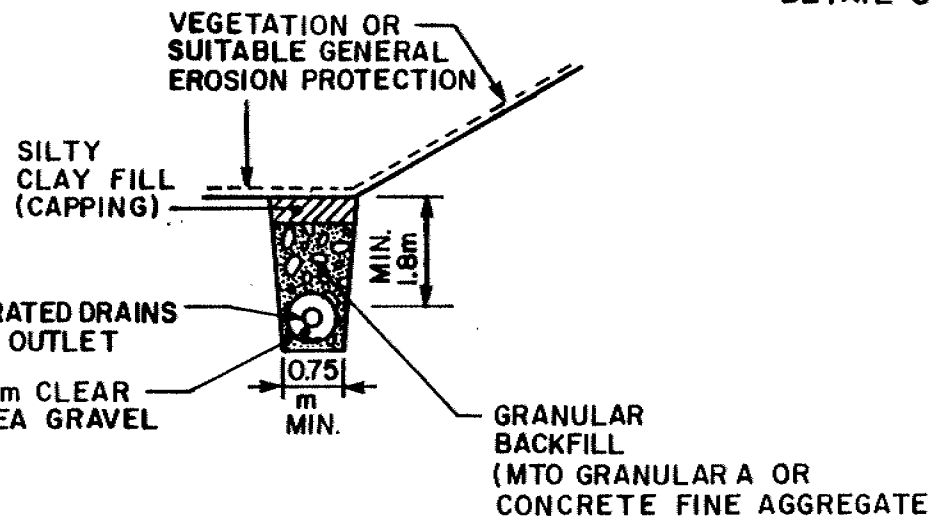
W P 126-87-01



DETAIL 3



DETAIL 1



DETAIL 2

NOT TO SCALE



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Transportation

## RECOMMENDED DRAINAGE SYSTEM

FIG No 9

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**Explanation of Terms  
Used in Report**

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 3	3 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{VO}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_r$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$e$	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$n$	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$w$	1, %	WATER CONTENT	$D$	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$v$	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$i$	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	$j$	kN/m <sup>2</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

### Rock Weathering

Fresh	- No discoloration or loss of strength.
Slightly Weathered	- Some discoloration on discontinuities, no loss of strength.
Moderately Weathered	- Rock is discolored, discontinuities may be open, alteration starting to penetrate, rock is weaker than the fresh rock.
Highly Weathered	- Rock is discolored, discontinuities may be open, alteration penetrates deeply, loss of strength.
Completely Weathered	- Rock is discolored, completely altered but original fabric is preserved. A few core stones may be present. Properties still partly dependent on parent rock.
Residual Soil	- Rock is completely changed to a soil in which original fabric is absent. There is a large change in volume.

### Rock Strength

	<u>Unconfined Compressive Strength</u>	
	<u>MPa</u>	<u>lb/in.</u>
Extremely strong	>200	>29000
Very strong	100 - 200	14500 - 29000
Strong	50 - 100	7750 - 14500
Moderately strong	12.5 - 50	1800 - 7750
Moderately weak	5 - 12.5	725 - 1800
Weak	1.25 - 5	180 - 725
Very weak	<1.25	<180

Fragmented Core - Fractured core where the average fracture spacing is less than 25 mm and the core pieces are less than full core diameter.

Very Closely Broken Core - Fracture core where the average fracture spacing is less than or equal to 50 mm and the core pieces are full core diameter.

Rock Soundness - The term 'sound rock' has been applied where RQD values are consistently greater than 75%.

## **Record of Boreholes**



# RECORD OF BOREHOLE No 101

METRIC

W P 126-87-01 LOCATION Coords N 5 021 267.4 ; E 358 878.3 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 2, 3, 1989 CHECKED BY JLB

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	* VALUES			20 40 60 80 100	20 40 60 80 100					
86.6	Ground Level					28/12/89								
0.0	Gravelly silty sand													
85.7	Possible Fill Brown		1	SS	9		86							21 50 23 6
0.9	Silty Clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity CI-CH (Marine Deposit)		2	SS	6		85							
			3	TW	PH		84							
			4	TW	PH		83							
			5	TW	PH		82							
			6	TW	PH		81							
			7	TW	PH		80							
79.6	Gray		8	TW	PH		79							
7.0	Sand and silt, with some gravel and some clay; wet, low plasticity to non-plastic, rapid dilatancy SM-ML (Till)		9	SS	5		78							
			10	TW	PH		77							
			11	SS	5		76							
75.3	Loose Dark Gray						75							
11.3	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh		12	RC EXL	REC 100%		74							RQD = 86%
72.3	Gray		13	RC EXL	REC 100%		73							RQD = 95%
14.3	End of borehole													

OFFICE REPORT ON SOIL EXPLORATION

\*For RC samples, numbers represent Core Recovery.

\*3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



## METRIC

W P 126-87-01 LOCATION Coords N 5 021 272.9 ; E 358 914.9 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 3, 1989 CHECKED BY JOB

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

\*3, x5: Numbers refer to Sensitivity

15  $\phi$  5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 103

METRIC

W P 126-87-01 LOCATION Coords N 5 021 283.0 ; E 358 994.0  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core  
DATUM Geodetic DATE November 3, 4, 1989  
ORIGINATED BY RH  
COMPILED BY RH  
CHECKED BY *[Signature]*

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W <sub>n</sub>	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES *			20 40 60 80 100	20 40 60 80 100					
86.4	Ground Level				8/12/89	86							
0.0	Gravelly silty sand	1	SS	8		86							
85.1	Possible fill Brown	2	SS	4		85							
1.3	Silty clay, some black mottling	3	SS	5		85							
84.3	Gray	4	TW	PH		84							
2.1	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity	5	TW	PH		83							
	CI-CH (Marine Deposit)	6	TW	PM		82							
		7	TW	PM		81							
		8	TW	PM		80							
		9	TW	PM		79							
		10	TW	PH		78							
		11	TW	PH		77							
73.6	Soft to firm Gray					76							
12.8	Sand and silt with some gravel and some clay	12	SS	11		75							
72.6	SM-ML (Till)					74							
13.8	Compact Dark Gray					73							
	Limestone bedrock with frequent dolomite beddings, occasional calcite-filled vugs and shaly partings, very strong, fresh	13	RC	REC		72							RQD = 98%
70.1	Gray	14	RC	REC		71							RQD = 100%
16.3	End of borehole												

\*For RC samples,  
numbers represent  
Core Recovery.

# RECORD OF BOREHOLE No 104

METRIC

W P 126-87-01 LOCATION Coords N 5 021 251.0 ; E 358 912.0 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 6, 1989 CHECKED BY JMB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIMIT			UNIT WEIGHT Y KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			20 40 60 80 100	SHEAR STRENGTH kPa			Wp	W	WL	
86.2	Ground Level						86		O UNCONFINED + FIELD VANE			WATER CONTENT (%)			
85.6	Silty clay with some gravel Dark Brown		1	SS	15		85		● QUICK TRIAXIAL x LAB VANE			20 40 60			
0.6	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		2	SS	9		84								
			3	SS	4		83								
			4	TP	PH		82								
			5	TP	PH		81								
	CI-CH (Marine Deposit)		6	TP	PM		80								
			7	TP	PH		79								
			8	TP	PH		78								
			9	TP	PM		77								
			10	TP	PH		76								
79.5	Firm to stiff Gray		11	TP	PH		75								
6.7	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy		12	SS	5		74								
			13	SS	3		73								
			14	SS	3										
	SM-ML (Till)		15	SS	4										
			16	SS	5										
			17	SS	18										
74.2	Very loose to compact Dark Gray		18	SS	5										
12.0	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		19	RC	REC										
72.6				BXL	98%										
13.6	End of borehole														

OFFICE REPORT ON SOIL EXPLORATION

\*For RC samples, numbers represent Core Recovery.

# RECORD OF BOREHOLE No 105

METRIC

W P 126-87-01 LOCATION Coords N 5 021 286.4 ; E 358 840.0 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 6, 7, 1989 CHECKED BY JAB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N VALUES			20 40 60 80 100	20 40 60 80 100	Wp	N		
36.3	Ground Level					28/12/89							
0.0	Silty clay with some gravel, black mottling and oxidation staining		1	SS	5		86						
			2	SS	10		85						
84.4	Gray		3	SS	10		84						
1.9	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		4	TW	PH		83						
			5	TW	PH		82						
			6	TW	PH		81						
	CI-CH (Marine Deposit)		7	TW	PH		80						
			8	TW	PH		79						
77.8	Firm to stiff Gray		9	TW	PH		78					16.5	
8.5	Sand and silt with some gravel and some clay, wet, nonplastic SM-ML (Till)		10	SS	4		77						10 23 60 7
76.0	Loose to compact Dark Gray		11	SS	29		76						
10.3	Limestone bedrock with frequent dolomite bed- dings, occasional shaly partings, very strong fresh		12	RC BXL	REC 100%		75						RQD = 97%
74.4													
11.9	End of borehole												

OFFICE REPORT ON SOIL EXPLORATION

\*For RC samples,  
numbers represent  
Core Recovery.

# RECORD OF BOREHOLE No 106

METRIC

W P 126-87-01 LOCATION Coords N 5 021 291.1 ; E 358 871.9 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 7, 8, 1989 CHECKED BY JAB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W <sub>p</sub>	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES*			20 40 60 80 100	20 40 60 80 100					
85.5	Ground Level					08/12/89								
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity CI-CH (Marine Deposit)		1	SS	7		85						17.3	CU Triaxial Test See Fig. 2 0 8 55 37
			2	TP	PH		84							
			3	TP	PH		83							
			4	TP	PH		82							
			5	TP	PH		81							
			6	TP	PH		80							
			7	TP	PH		79							
			8	TP	PH		78							
			9	TP	PH		77							
			10	TP	PM		76							
78.6	Gray		11	TP	PH		75						16.8 16.6	RQD = 84%
6.9	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic SM-ML (Till)		12	SS	3		74							
			13	SS	7									
			14	SS	7									
	Very loose to compact Dark Gray		15	SS	29									
75.5			16	RC BXL	REC 100%									
10.0	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		17	RC BXL	REC 100%									
73.3	Gray													
12.2	End of borehole													

OFFICE REPORT ON SOIL EXPLORATION

\*For RC samples, numbers represent Core Recovery.

# RECORD OF BOREHOLE No 107

METRIC

W P 126-87-01 LOCATION Coords N 5 021 296.9 : E 358 904.4 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 8, 1989 CHECKED BY JGP

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT		UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE			20 40 60 80 100	Wp	Wp	Wp		
85.1	Ground Level			28/12/89							GR SA SI CL
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity	1	SS 3		85					16.5	
		2	TW PH		84						
					83						
	CI-CH (Marine Deposit)	3	TW PH		82						
		4	TW PH		81						
					80						
					79						
					78						
78.9	Firm Gray	5	TW PH		77					18 24 49 9	
6.2	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy	6	SS 5		76						
	SM-ML (Till)	7	SS 5		75						
74.5	Loose Dark Gray	8	SS 100		74						
10.6	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh	9	RC REC BXL 100%							27.0	RQD = 96%
73.0											
12.1	End of borehole										

OFFICE REPORT ON SOIL EXPLORATION

\*For RC samples, numbers represent Core Recovery.

## RECORD OF BOREHOLE No 108

METRIC

W P 126-87-01 LOCATION Coords N 5 021 301.1; E 358 935.3 ORIGINATED BY RH  
DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
DATUM Geodetic DATE November 8, 9, 1989 CHECKED BY 2003

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		UNIT WEIGHT Y KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES*			20	40	60	80	100	W <sub>p</sub>			W	W <sub>L</sub>
								SHEAR STRENGTH kPo					WATER CONTENT (%)				
							○ UNCONFINED + FIELD VANE										
							● QUICK TRIAXIAL × LAB VANE										
							20 40 60 80 100					20 40 60					
85.0	Ground Level					28/12/89											
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	8		84										
			2	TW	PH		83		10								
	CI-CH (Marine Deposit)		3	TW	PH		82										
							81		12								
	Firm, becoming soft with depth		4	TW	PH		80		12								
			5	TW	PH		79										
77.4	Gray						78		15								
7.6	Sand and silt with some gravel and some clay, wet, low plasticity to nonplastic, rapid dilatancy SM-MI (Till)		6	TW	PH		77										
			7	SS	3		76										
							75										
	Very loose to loose Dark Gray		8	SS	9		74										
11.5	Limestone bedrock with frequent dolomite beddings, very strong, fresh, vertical joints at approx. 13-m depth, occasional shaly partings		9	RC BXL	REC 100%		73										
71.1	Gray		10	RC BXL	REC 94%		72										
13.9	End of borehole																
*For RC samples, numbers represent Core Recovery.																	



## METRIC

N P 126-87-01

LOCATION Coords N 5 021 305.8 ; E 358 964.3

ORIGINATED BY RH

DIST 9 HWY 416

BOREHOLE TYPE Hollow stem auger, BX rock core

COMPILED BY        RH

DATUM            Geodetic

DATE November 9, 10, 1989

CHECKED BY TAB

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER TYPE 'N' VALUES							
84.5	Ground Level			38/12/59						
0.0	Silty clay; occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1 SS 2		84					
			2 TW PH		83					
			3 TW PH		82					
	CI-CH (Marine Deposit)		4 TW PH		81					
	Stiff, becoming soft to firm with depth		5 TW PM		80					
			6 TW PH		79					
			7 TW PH		78					
			8 SS 1		77					
74.5	Gray		9 TW PM		76					
10.0	Sand and silt with some gravel and some clay, wet, low plasticity to non-plastic		10 SS 1		75					
72.6	SM-ML (Till)		11 SS 1		74					
11.9	Very loose Dark Gray		12 RC REC BXL 100%		73					
	Limestone bedrock with frequent dolomite beddings, occasional shaly partings, very strong, fresh		13 RC REC BXL 100%		72					
70.1	Gray				71					
14.4	End of borehole									

\*For RC samples, numbers represent Core Recovery.

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 110

METRIC

W P 126-87-01 LOCATION Coords N 5 021 316.4 ; E 358 990.4 ORIGINATED BY RH  
 DIST 9 HWY 416 BOREHOLE TYPE Hollow stem auger, BX rock core COMPILED BY RH  
 DATUM Geodetic DATE November 10, 11, 1989 CHECKED BY JAB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT  γ  KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES*			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>			
85.7	Ground Level					28/12/89								
0.0	Silty clay, occasional thin layers of silty fine sand to fine sand, moist to wet, medium to high plasticity		1	SS	8		85							
			2	SS	10		84							
			3	TP	PH		84							
			4	TP	PH		83							
			5	TP	PH		83							
	CI-CH (Marine Deposit)		6	TP	PM		82							
			7	TP	PH		82							
	Firm to stiff		8	TP	PM		81							
			9	TP	PH		80							
			10	TP	PH		80							
			11	TP	PM		79							
			12	TP	PM		78							
			13	TP	PM		77							
			14	TP	PH		76							
			15	TP	PM		75							
			16	TW	PH		75							
73.8	Gray			17	TW	PH		74						
11.9	Sand and silt with some clay, wet, low plasticity to non-plastic			18	SS	2		73						
72.9														
12.8	SM-ML (Till) Very loose Dark Gray End of borehole Refusal to auger (probable bedrock)													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

**Drawings**

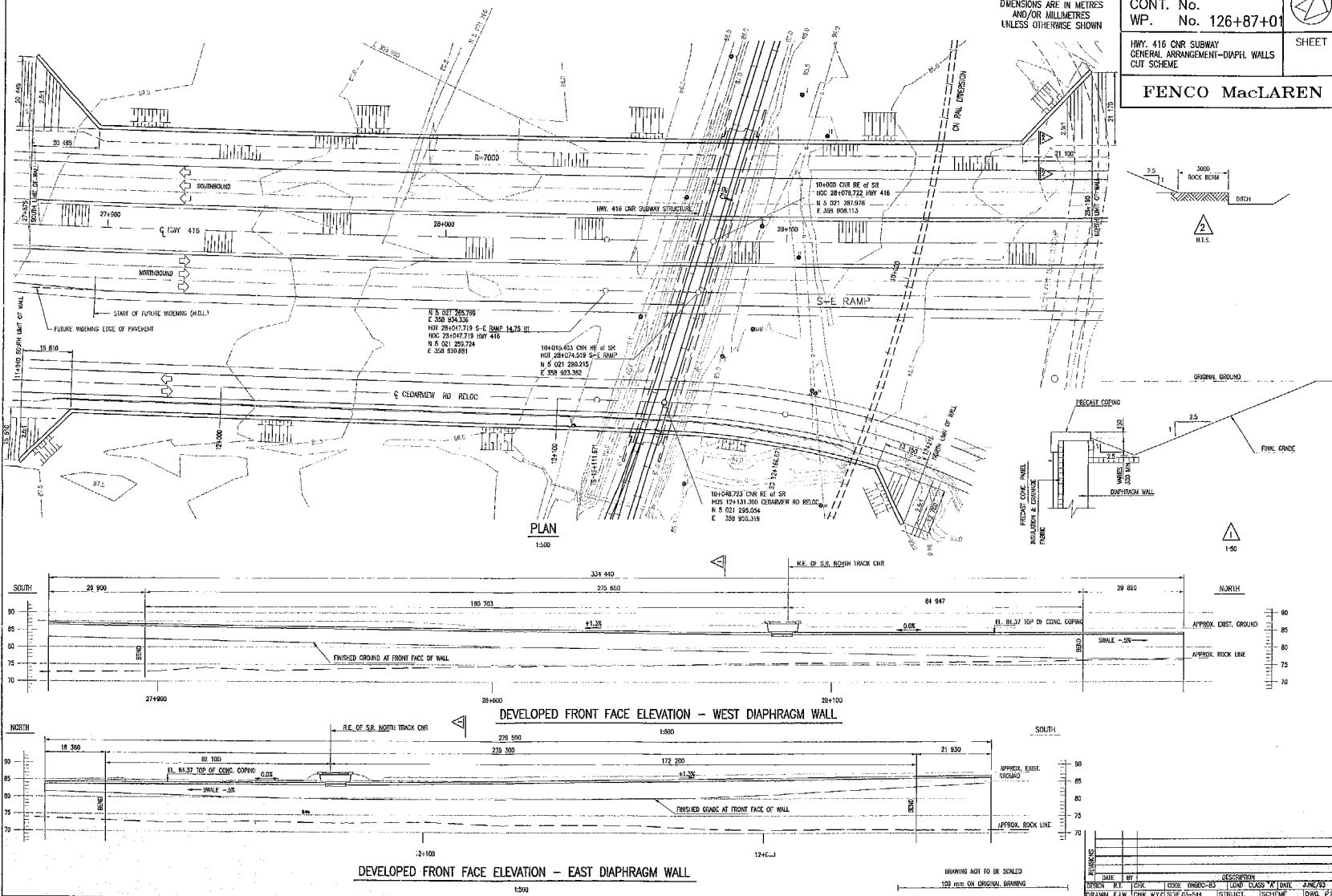
DIST No. 9  
CONT. No.  
WP. No. 126+87+01



SHEET

HWY. 416 CNR SUBWAY  
GENERAL ARRANGEMENT-DIAPHR. WALLS  
CUT SCHEME

FENCO MacLAREN



METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

DIST. No. 9  
CONT. No.  
WP. No. 126-87-01



HWY. 416 CNR SUEWAY  
APPROX. 1.45 KM SOUTH OF HWY. 417  
GENERAL ARRANGEMENT

SHEET

FENCO MacLAREN

### GENERAL NOTES

#### CLASS OF CONCRETE

FOOTINGS, ABUTMENTS AND PIERS 30 MPa  
DECK 35 MPa

#### CLEAR COVER TO REINFORCING STEEL

FOOTINGS 100 ± 25  
ABUTMENTS AND MINOR PILES 60 ± 20  
FRONT FACE 70 ± 20  
BACK FACE 80 ± 20  
PIERS 70 ± 20  
DECK TOP 60 ± 10  
BOTTOM AND SIDES 70 ± 20  
REINFORCING (UNLESS OTHERWISE NOTED)

#### REINFORCING STEEL

REINFORCING STEEL SHALL BE CONC. 400 UNLESS OTHERWISE SPECIFIED.  
BAR WELDS WITH THE SUFFICIENT TENSILE COATED BARS.

#### CONSTRUCTION NOTES

THE CONTRACTOR SHALL ESTABLISH THE BEARING POINT ELEVATIONS BY  
OBTAINING THE ACTUAL BEARING POINT ELEVATIONS FROM THE TOP OF REINFORCING  
ELEVATIONS. IF THE ACTUAL BEARING POINT ELEVATIONS ARE DIFFERENT FROM  
THOSE GIVEN WITH THE BEARING POINT DATA, THE CONTRACTOR SHALL  
ADJUST THE REINFORCING TO SUIT.  
FOR PRESTRESSING NOTES SEE DWG.

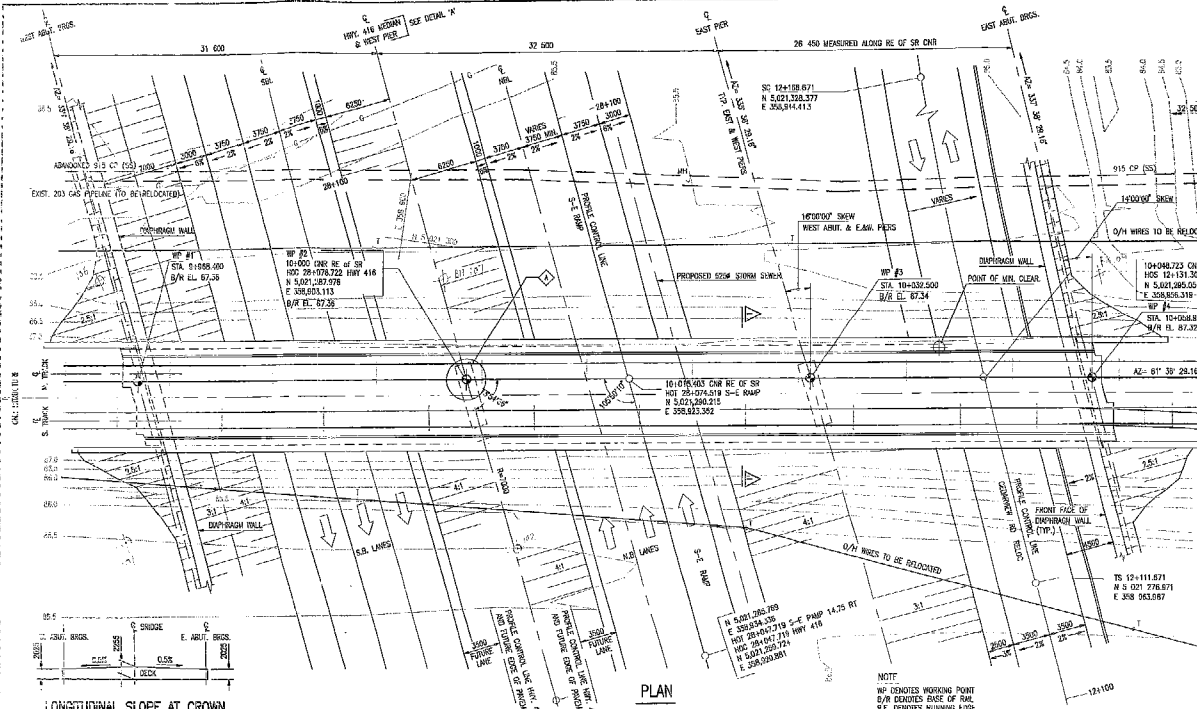
#### DESIGN LOADS

LIVE LOAD - COOPER'S E-80 PLUS DIESEL IMPACT.  
DECK BALANCE 100 kN - 700 mm

#### SPECIFICATIONS

A.R.E.A. MANUAL FOR BRIDGE ENGINEERING (2007) FOR BRIDGE  
IMPACT CSA 1.25-1978 CODE FOR CONCRETE BRIDGE ENGIN.  
CONCRETE - CSA STANDARD A23-1, A23-2  
REINFORCING - CSA STANDARD C30.12, 1977

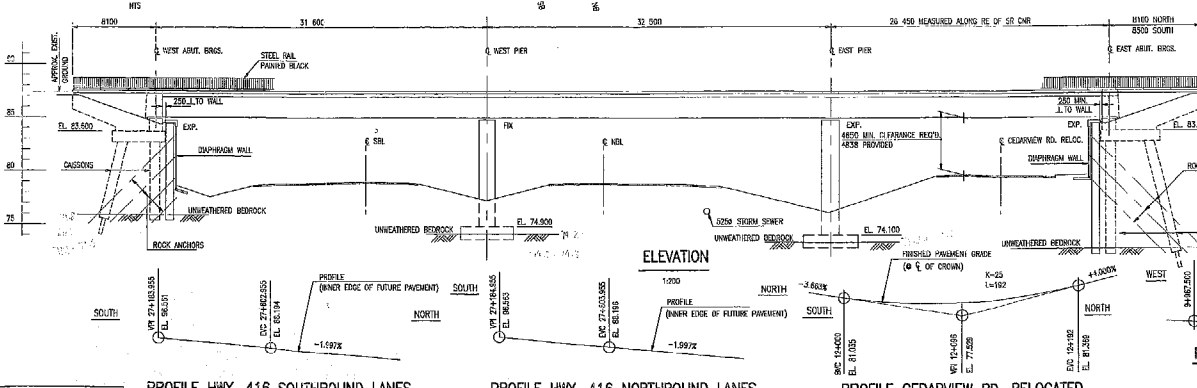
#### NEAREST STATION



LONGITUDINAL SLOPE AT CROWN

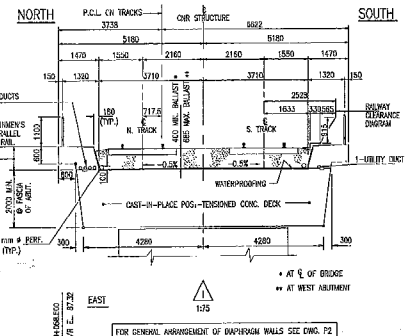
PLAN

1:200



ELEVATION

1:200



PROFILE CNR B/R

N.T.S.

BM ELEV. 87.438

PROFILE HWY. 416 SOUTHBOUND LANES

PROFILE HWY. 416 NORTHBOUND LANES

PROFILE CEDARVIEW RD. RELOCATED

N.T.S.

1:200

TOP OF SE BOLT ON C/S SIGNAL  
87.06 AT 20+100.00 (CNR 416)

N.T.S.

N.T.S.

N.T.S.

1:200

1:25

FOR GENERAL ARRANGEMENT OF DIAPHRAGM WALLS SEE DWG. P2

1:25

1:25

1:25

1:25

1:25

1:25

1:25

1:25

1:25

1:25

1:25

1:25

1:25

MINISTRY OF TRANSPORTATION, CHARGES: PRC-227-88-12

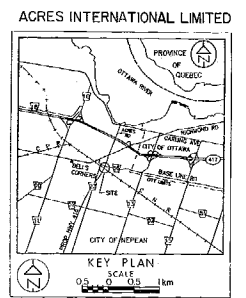
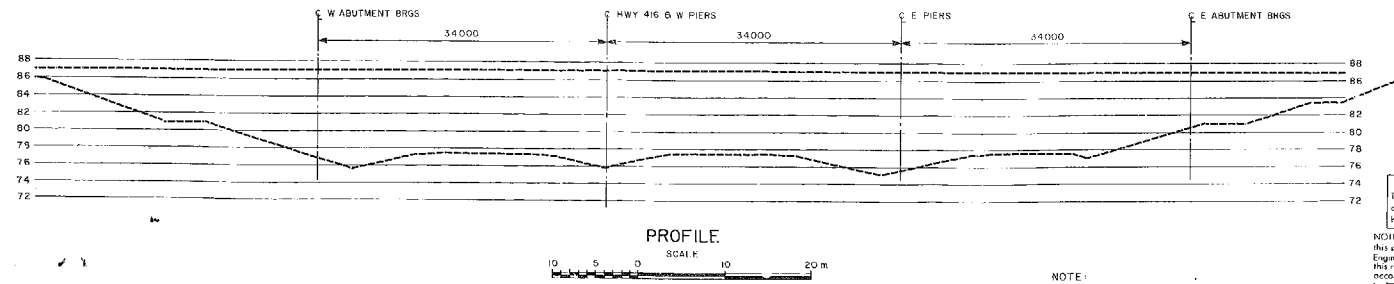
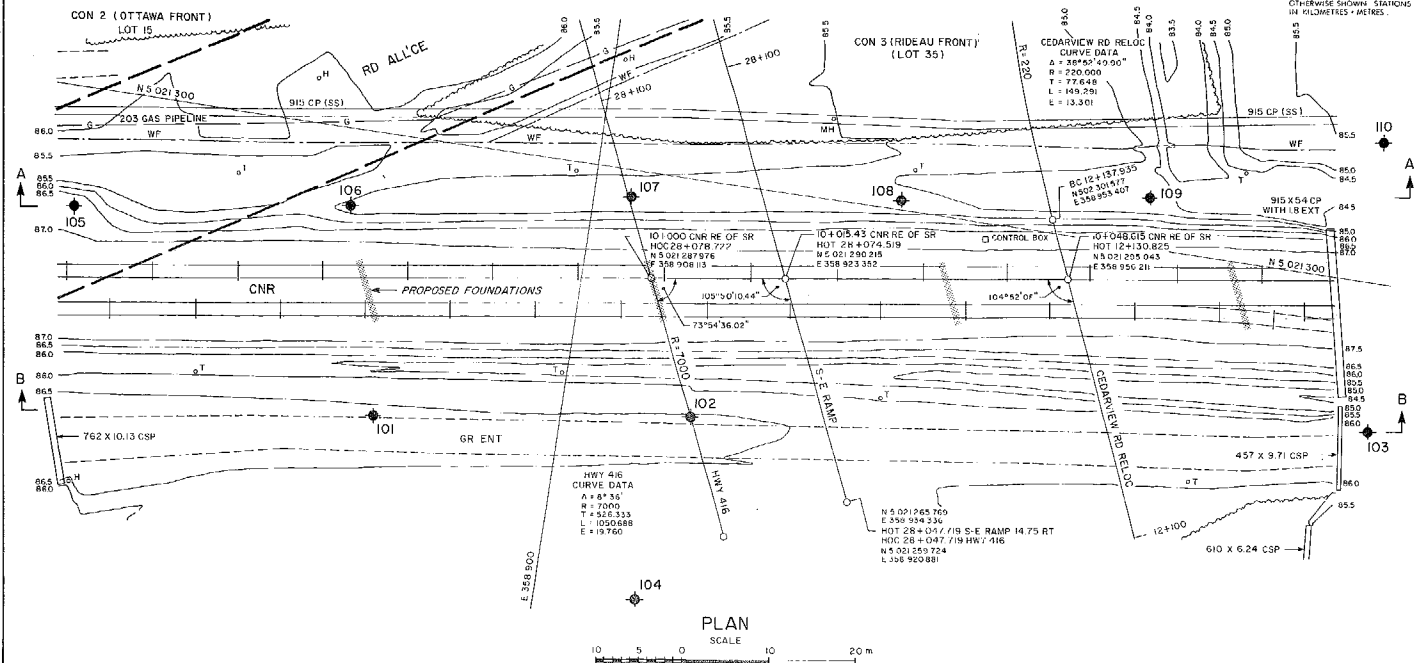
**METRIC**  
DIMENSIONS ARE IN METRES  
AND FOR MATHEMATICS UNLESS  
OTHERWISE SHOWN, STATIONS  
IN KILOMETRES - METRES

CONT No  
WP No 126-87-01

PROPOSED HWY 416 AND CNR  
SUBWAY  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET  
A



**LEGEND**

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N: Blows/0.3m (Std Pen test, 475 l/blow)
- CONE: Blows/0.3m (60T Cone, 475 l/blow)
- WT: at time of investigation
- WL: in Piezometer (1989 12 28)
- Piezometer

No	ELEVATION	COORDINATES NORTH	COORDINATES EAST
101	86.6	5 021 267.4	358 878.3
102	86.4	5 021 272.0	358 914.9
103	86.4	5 021 283.0	358 904.0
104	88.2	5 021 291.0	358 912.0
105	86.3	5 021 288.4	358 840.0
106	85.5	5 021 291.1	358 871.9
107	85.1	5 021 298.9	358 904.4
108	85.0	5 021 301.1	358 935.3
109	84.5	5 021 305.8	358 961.3
110	85.7	5 021 316.4	358 990.4

**=NOTE=**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTES: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102.2 of Form 100.

NOTE:  
For Sections Refer to Dwg No 1268701-B

No	DATE	BY	DESCRIPTION
1			

Geocodes No. 3125-173

DATE	BY	DATE	BY
1990		1990	

Drawn by: 416  
Checked by: 416  
Date: JAN 1990  
Site: 3-544  
DWG: 1268701-A

7-10-15

MINUTE OF TRANSMISSION, CHANDLER, 1915, 1917, 1918

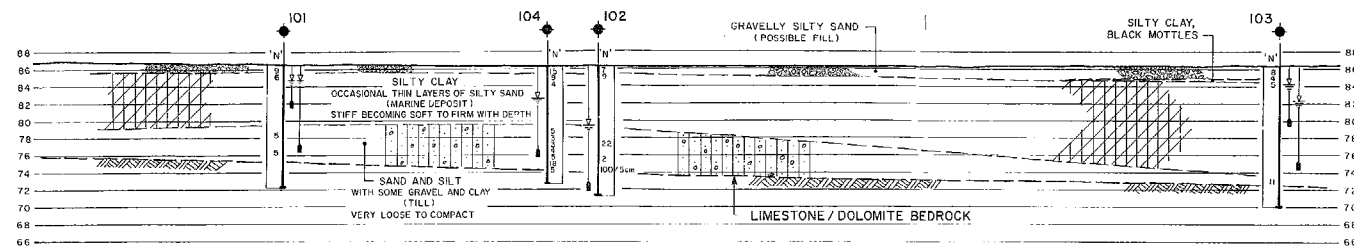
**METRIC**

DIMENSIONS ARE IN METERS  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN CIRCUMFERS - METRES

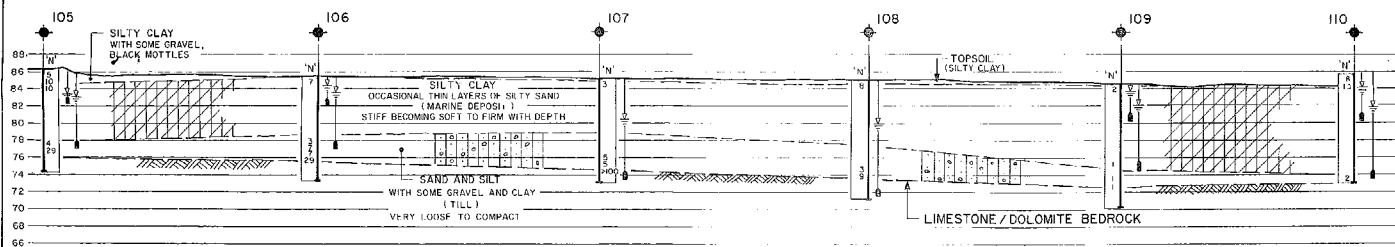
CONT No  
WP No 126-87-01

PROPOSED HWY 416 AND CNR  
SUBWAY  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET  
B



SECTION A-A



SECTION B-B

SCALE  
10 5 0 10 20 m

**LEGEND**

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation
- W.L. in Piezometer (1989 12 28)
- Piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
101	86.6	5021 267.4	358 878.3
102	86.4	5021 272.9	358 914.9
103	86.4	5021 283.0	358 994.0
104	86.2	5021 251.0	358 912.0
105	86.3	5021 286.4	358 840.0
106	85.5	5021 291.1	358 871.9
107	85.1	5021 296.9	358 904.4
108	85.0	5021 301.1	358 935.3
109	84.5	5021 305.8	358 964.3
110	85.7	5021 316.4	358 990.4

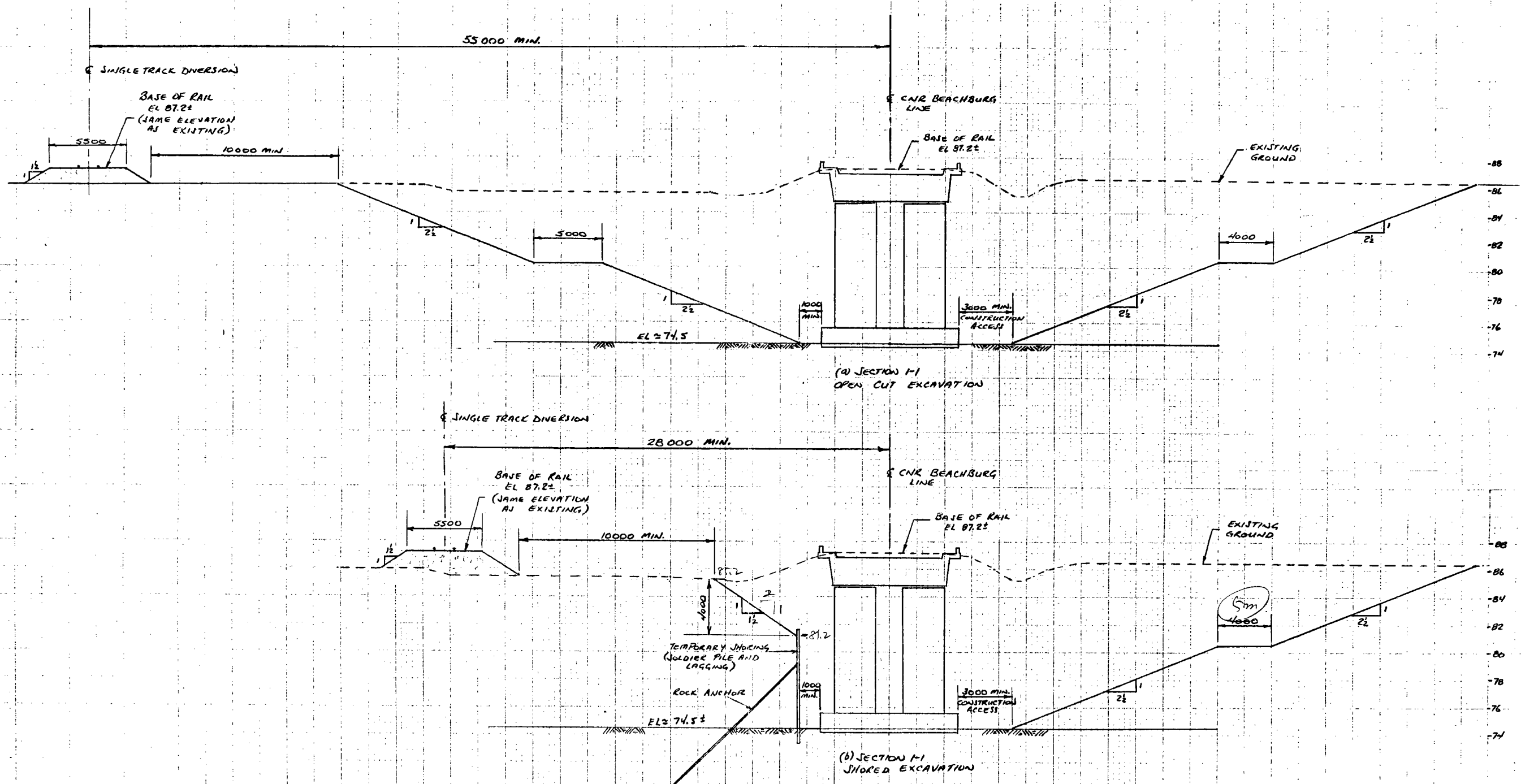
**NOTE**

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office. Information contained in this report and related documents is specifically included in accordance with the conditions of Section 102-2 of Form 100.

NOTE:  
For Plan and Profile  
Refer to Dwg No 1268701-A

DATE	BY	DESCRIPTION
1990	173	Geocres No 3165-173
HWY No 416		DIST 3
SUBMIT	CHECKED	DATE JAN 1990 SITE 3-344
DRAWN	CHECKED	DATE 1990 DWT 1268701-B



**Fenco**

HIGHWAY 416

CNR SUBWAY

M.T.O. W.P. 126-87-01

SITE 3-544

STRUCTURE No. 16

ALTERNATIVE METHODS OF CONSTRUCTION

PREPARED BY: BM

DATE: 29 MAR. 89 SKETCH SK-53085-S3