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DIST. 6 REGION

W.P. No. 369-87-01/02

CONT. No. 93-100

W. O. No.

STR. SITE No. 24-653A/B

HWY. No. 407

LOCATION Hwy 407 & West Humber  
River

No of PAGES - —

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

# **FOUNDATION INVESTIGATION REPORT**

**CONTRACT NO. 93-100**



**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 project.

## EXPLANATION OF TERMS USED IN REPORT

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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

$m_v$	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
$S_t$	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>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

## FOUNDATION INVESTIGATION REPORT

For

Hwy. 407 and The West Humber River

W.P. 369-87-01/02, Site 24-653A/B

Hwy. 407, District 6, Toronto

### INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. Two three span structures have been proposed to carry the east and west bound lanes of Hwy. 407 over the West Humber River. This report contains factual information obtained from this investigation.

### SITE DESCRIPTION

The site is located just north of Steeles Ave. west at the West Humber River within the southern portion of Claireville Conservation Park owned by MTRCA. The area consists of a valley enclosing the river to the east and west.

The topography of the area consists of rolling grass lands with an abandoned apple orchard to the west, a marsh which encroaches on to the West Humber River, and a 9 m high embankment which leads to an unused farmers field to the east. A gravel road, Park Road runs parallel to the river on the west embankment, travelling west away from the site further north. While the east embankment is of a natural formation, the west appears to have had some earthwork to facilitate drainage of the valley into the West Humber River. Runoff from the west flows into a steel corrugated culvert which runs underneath Park Road. Immediately to the south there already exists a three span bridge structure crossing the West Humber River along Steeles Avenue. The natural ground level to the west varies from 167.0 m to 167.6 m, to the east varies from 170.6 m to 173.2 m and the ground elevation of the West Humber River is approximately 163 m with water depths ranging from 45 cm to 2 m at the time of the investigation. Water levels are expected to reach a minimum during winter months. Water levels are controlled by a dam located downstream operated by the MTRCA which remains open during the winter months.

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Physiographically, the site is located in the geological domain known as the "Peel Plain". The "Peel Plain" is the product of the advance and retreat of the wisconsinan ice sheet which covered the area during the pleistocene epoch. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. At some locations, the till is overlain by thin deposits of varved clay. Till sheets of varying composition comprise the "Peel Plain". Generally, the surficial till sheets exhibit a cohesive behaviour whilst the lower till sheets are cohesionless. As characteristics of till material, these deposits contain a wide range of grain size ranging from boulders to clay.

The till sheets are usually separated from one another by interbeds of stratified silt or sand of variable thickness. Bedrock in the area has been found at depths ranging from 25 to 30 m below ground surface and consists of interbedded shale and limestone of the Dundas-Meaford formation, ordovician period.

#### INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and laboratory testing. The procedures employed are discussed below.

##### Field Investigation

The fieldwork for the investigation was carried out between 90 10 25 to 90 11 20 and consisted of a total of 16 boreholes, with 5 on the east embankment, 5 on the west embankment and 6 located within the swamp in the West Humber River. Thirteen boreholes were drilled initially with 3 holes completed two weeks later, commencing upon the drop of water levels as a result of opening the claireville dam located downstream. All boreholes were advanced to depths ranging from 9.6-14.2 metres. Boreholes were placed at abutment pier, and advanced structure locations.

The boreholes were advanced using conventional solid stem augering techniques. A track mounted continuous flight auger drill rig was employed for the operation.

In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 6 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586).

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

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled upon completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by Giffels Engineering Consultants under contract with Central Region Surveys and Plans.

#### Laboratory Analysis

The following laboratory tests were carried on select soil samples:

- 1) Atterberg Size Distributions
- 2) Grain Size Distributions
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on figures and borehole logs included in the Appendix.

#### SUBSURFACE CONDITIONS

##### General

The subsoil stratigraphy on the east embankment consists of a layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) which extended down to the terminated depths of the boreholes (9.6 m-11.1 m). Occasional seams of sandy silt were encountered at lower depths. Further west, at the flood plain of the West Humber River this layer was founded to extend

only 2.5 m to 5.5 m and was underlain by a non-cohesive heterogeneous mixture of sandy silt, clay and gravel (Glacial Till). At depths of approximately 7 m the material contained a greater percentage of gravel. To the west embankment the surficial deposit consisted of 6 m thick of the heterogeneous mixture of sandy silt, gravel and clay as above. Below this material the stratigraphy was similar to those described above with a 1 m-6 m layer of heterogeneous mixture of clayey silt, sand and gravel and the final layer extending to terminated depths, of non-cohesive heterogeneous mixture of sandy silt, clay and gravel. At the west embankment a pocket of heterogeneous mixture of clayey silt, sand and gravel was encountered extending 3.5 m down. A very small pocket of silt was also encountered embedded in the above material. Overall the area has a high percentage of silt and sand with varying proportions of clay and gravel.

The plan and location of boring and the stratigraphical profile are shown on Drawing No. 369870102-A.\* In the Attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets and in the Appendix of this report. A brief description of the different soil types is given below.

#### Silty Sand, trace of Organics

This deposit was only found at the surface of one Borehole (BH 2) in the west embankment. The layer extended 1.2 m deep.

Laboratory results of Grain Size Distribution indicated it comprised primarily of 25% gravel, 51% sand, 18% silt and 5% clay. The material had a compact state of density. In this stratum the Standard Penetration Resistance 'N' value was 12 blows/0.3 m indicating a compact state of density.

#### Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Underlying the above layer at one Borehole (BH 2) and found surficially in another (BH 1) at the west embankment, west abutment location is a layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) extending down with a thickness of 3.6 metres.

\* DWG'S NO 2 & 2A OF THE CONTRACT DWG'S



Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 1 in the Appendix, in an envelope form. The results summarize Grain Size Distribution Tests carried out on this material throughout the site. This deposit was also encountered, to be discussed later, at greater depths. The results indicate the material contains a large percentage of clay and silt with some sand and gravel. The deposit is comprised primarily of 0-26% Gravel, 11-56% sand, 24-69% silt and 5-38% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6.5-34.5	35
Liquid Limit ( $w_L$ )	20-37	35
Plastic Limit ( $w_p$ )	12-21	35
Plastic Index ( $I_p$ )	8-16	35

From the plasticity chart (Figure 2), the layer can be classified as a clayey silt of medium plasticity, the results summarize results carried out on this material throughout the site. This layer was encountered, to be discussed later, at greater depths.

In this stratum the Standard Penetration Resistance 'N' values ranged from 19 blows/0.3 to 65 blows/0.23 metres indicating the material had a very stiff to hard consistency.

#### Heterogeneous Mixture of Sandy Silt, Clay and Gravel (Glacial Till)

Underlying the two layers above in two boreholes (BH's 1 and 2) in the west embankment, west abutment locations and found surficially throughout the rest of the west embankment is a heterogeneous mixture of sandy silt, clay and gravel (Glacial Till). This layer extended down 5.5 m to 11.1 m.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 3 in the Appendix, in an envelope form. The results summarize Grain Size Distribution Tests carried out on this material throughout the site. This deposit was also encountered, to be discussed later, at greater depths. From the above figure it is evident that the layer contains a high proportion of fine sands and silt. The deposit is comprised primarily of 0-38% Gravel, 37-86% Sand, 10-66% Silt and 2-14% Silt.

The results from the Atterberg Limit Test performed on the fine fraction of this deposit is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	7-16	21
Liquid Limit ( $w_L$ )	13-14	21
Plastic Limit ( $w_p$ )	10-13	21
Plastic Index ( $I_p$ )	1-3	21

From the plasticity chart (Figure 4), the layer can be classified as a sandy silt. The above summarizes results carried out on this material throughout the site. This layer was encountered, to be discussed later, at greater depths.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 6 blows/0.3 m to >120 blows/0.2 m. Based on these 'N' values, the material can be described as having a loose to very dense state of relative density.

#### Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Throughout the west embankment underlying the above deposits is another 1.5 m-5.12 m layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial till). This layer continues towards the east lying surficially with a thickness of 2.5-5.7 metres within the West Humber River (Flood Plain) and extending to the east embankment down to the termination length of the boreholes (11.1 metres). A higher proportion of silt was encountered at the surface within the West Humber River (Flood Plain).

Results of Grain Size Distribution Tests carried out on select samples as previously discussed are shown on Figure 1 in the Appendix, in an envelope form. Percentage of comprised materials are similar to those already stated.

Atterberg Limit Tests are similar to those previously stated, as seen on Figure 2. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of  $17.7 \text{ kg/m}^3$  to  $23.6 \text{ kg/m}^3$ .

In this stratum the Standard Penetration Resistance 'N' values ranged from 2 blows/0.3 m to >100 blows/0.3 m indicating the material ranged from very soft to hard. The very soft to firm zones were only encountered within the West Humber River (Flood Plain), thus excluding this area the layer generally had a very stiff to hard consistency.

#### Heterogeneous Mixture of Sandy Silt, Clay and Gravel (Glacial Till)

Underlying the heterogeneous mixture of clayey silt at the west embankment and within the West Humber River (Flood Plain) is a heterogeneous mixture of sandy silt, clay and gravel (Glacial Till). This layer was encountered at depths of 10.1-10.9 m at the west embankment and at depths of 2.5-5.6 metres within the West Humber River, extending down to the terminated depths of the boreholes. At approximately a depth of 8 m a greater percentage of gravel was found at the West Humber River (Flood Plain).

Results of Grain Size Distribution Tests carried out on select samples as previously discussed are shown on Figure 3 in the Appendix, in an envelope form. Percentage of comprises materials are similar to those previously stated.

Atterberg Limit Tests are similar to those previously stated, as seen on Figure 4. Unit weight measurements carried out on samples from this stratum yielded a dry unit weight of  $21.8 \text{ kg/m}^3$ .

In this stratum the Standard Penetration Resistance 'N' values ranged from 24 blows/0.3 m to >120 blows/0.2 m, indicating a dense to very dense state of relative density.

### GROUNDWATER CONDITIONS

Observations of the groundwater level were carried out by measuring the water level in the open boreholes.

Groundwater levels determined at the time of the investigation varied throughout the site, with the east/west abutments having elevations approximately of 168 m and 165 m respectively. As you get nearer to the West Humber River the water levels get drawn down to the current water level of the river. The water level of the West Humber River varied from 164.2 m to 163.5 m, with the depth varying from 2 m to 45 cm. Water levels decrease during the winter months.

The depth of water in the river is a function of the weather and time of season but is primarily controlled by the dam located downstream. This dam remains open during the winter months thus lowering water levels.

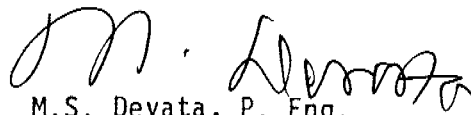
### MISCELLANEOUS

The field work for this investigation was carried out under the supervision of M. Michalek, Jr. Foundation Engineer, utilizing equipment owned and operated by Archer Drilling and Master Soil Investigation.

The project was carried out under the general supervision of Dr. B. Iyer, Sr. Foundation Engineer. The report was written by M. Michalek, reviewed by Dr. B. Iyer and approved by Mr. M. Devata, Chief Foundation Engineer.



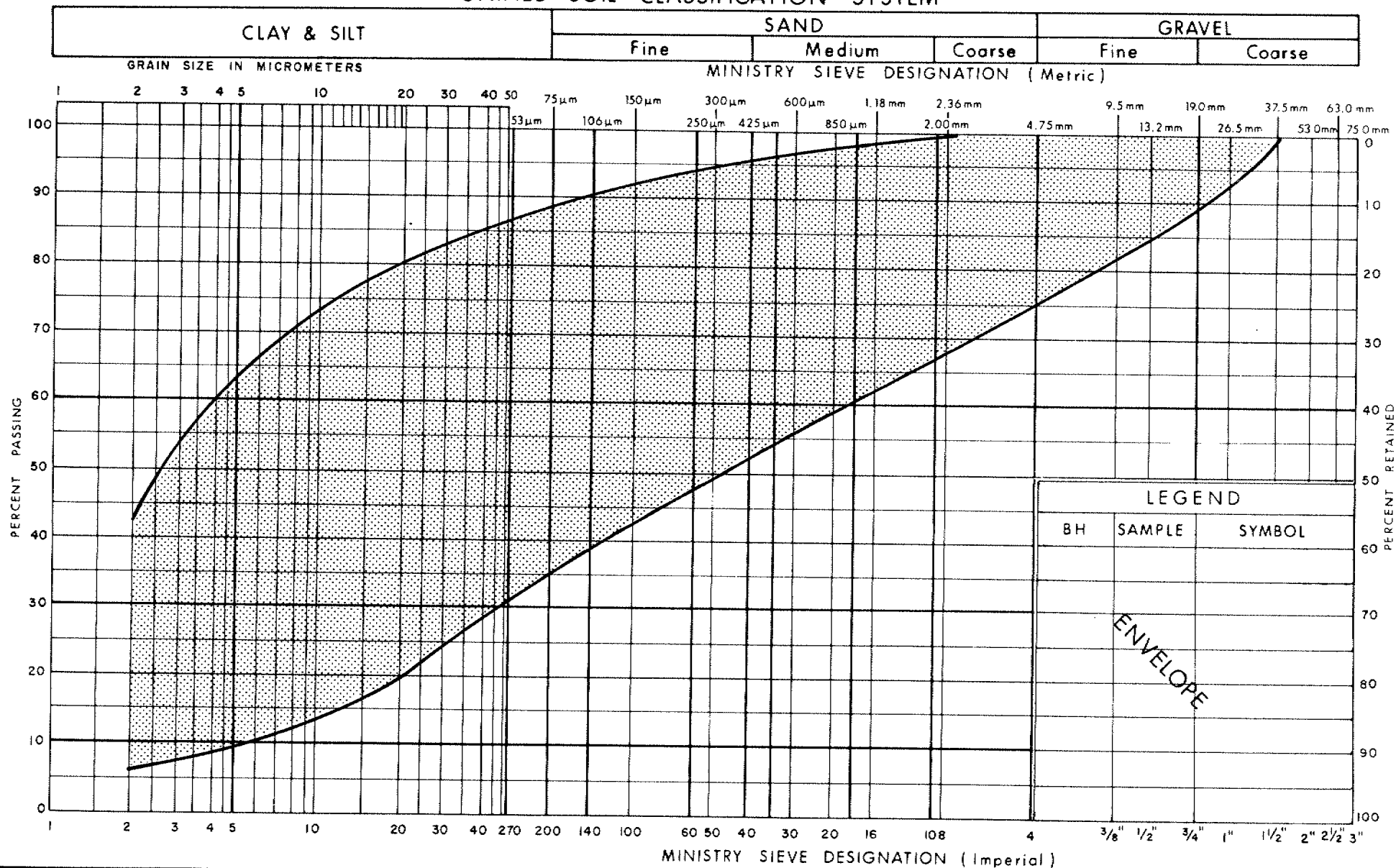
B. Iyer, P. Eng.  
Senior Foundation Engineer



M.S. Devata, P. Eng.  
Chief Foundation Engineer

## APPENDIX

## UNIFIED SOIL CLASSIFICATION SYSTEM

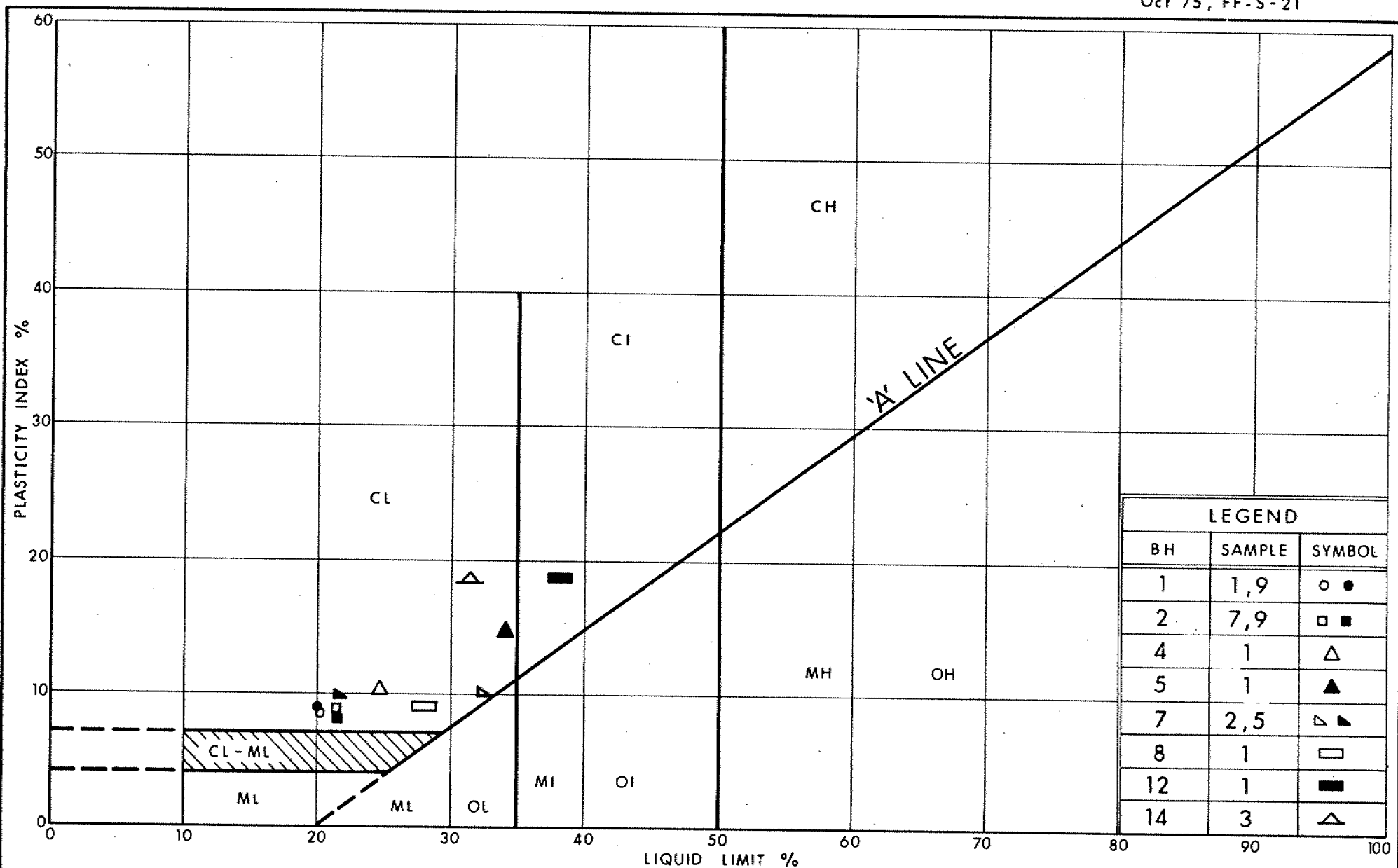


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**GRAIN SIZE DISTRIBUTION**  
**HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL**  
 (GLACIAL TILL)

FIG No 1

W P 369-87-01/02



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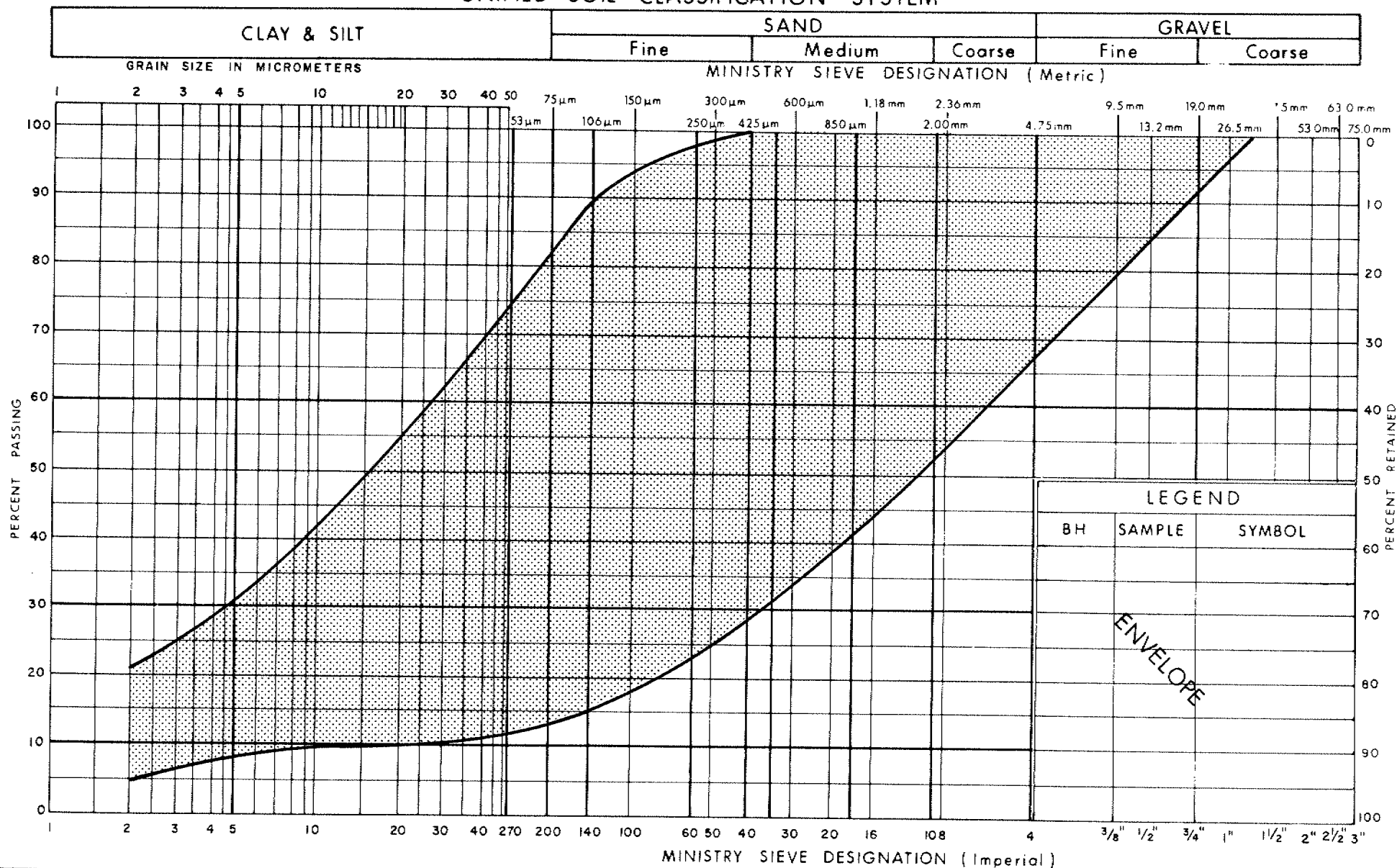
Ontario

PLASTICITY CHART  
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL  
(GLACIAL TILL)

FIG No 2

W P 369-87-01/02

## UNIFIED SOIL CLASSIFICATION SYSTEM



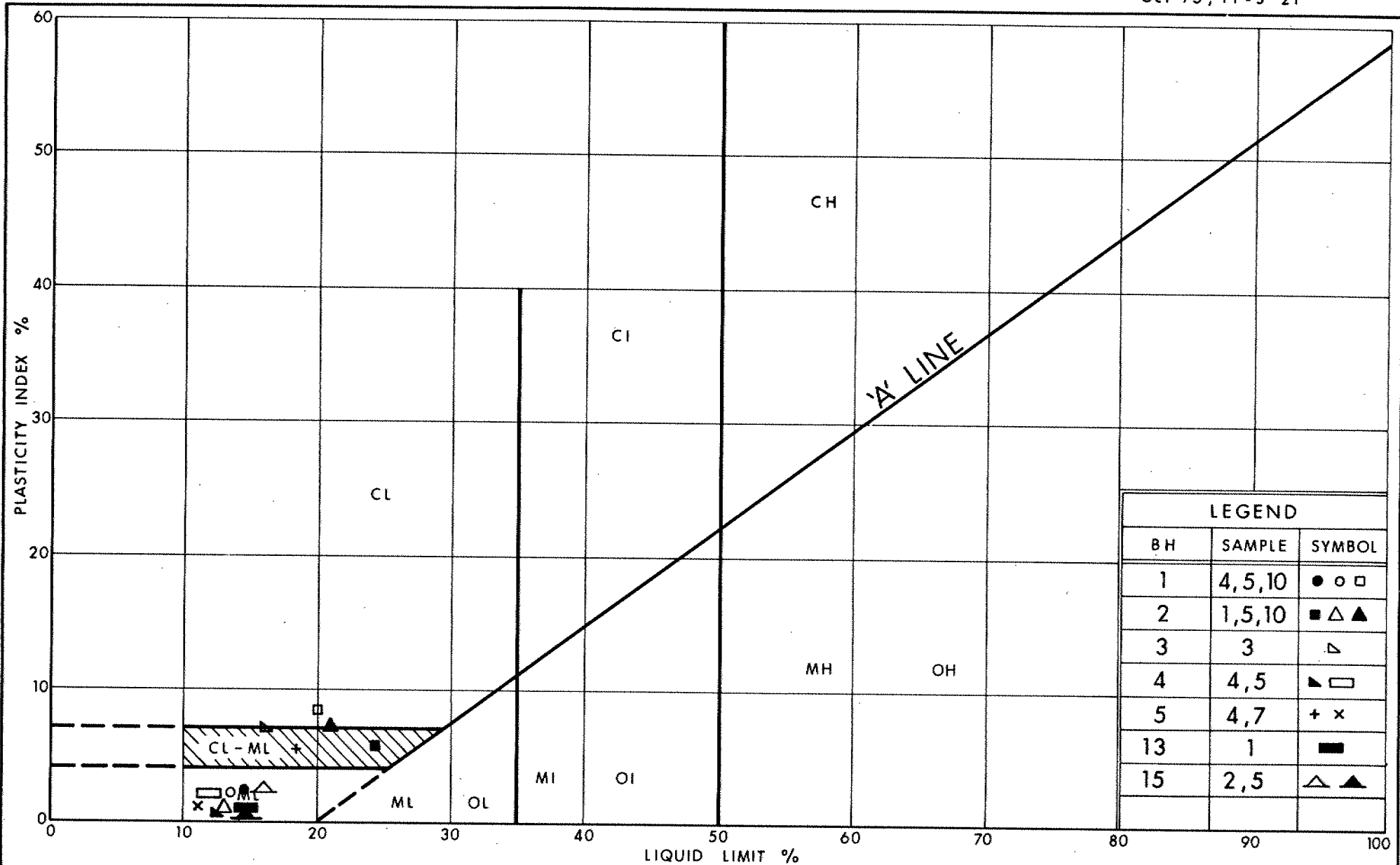
Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**HETEROGENEOUS MIXTURE OF SILT & SAND, CLAY & GRAVEL**  
 (GLACIAL TILL)

FIG No 3

W P 369-87-01/02





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PLASTICITY CHART  
HETEROGENEOUS MIXTURE OF SILT & SAND, CLAY & GRAVEL  
(GLACIAL TILL)

FIG No 4

W P 369-87-01/02

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 369-87-01/02

LOCATION Coords: N 4 845 088.0, E 293 210.5

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOLID STEM AUGER

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.J.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			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	W <sub>L</sub>		
167.0	Ground Surface															
0.0																
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		1	SS	62	/23cm										12 36 36 16
			2	SS	50	/5cm										
			3	SS	44											
			4	SS	24											
163.4																
3.6			5	SS	24											10 49 36 5
	Heterogeneous mixture of Sand, Silt and Gravel, trace Clay (Glacial Till) Compact to Very Dense		6	SS	20											31 53 14 2
			7	SS	120	/23cm										
			8	SS	120	/15cm										
158.4																
8.6			9	SS	60	/10cm										8 34 42 16
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard															
156.9																
10.1																
	Heterogeneous mixture of Sand, Silt and Gravel, trace Clay (Glacial Till) Very Dense		10	SS	120	/10cm										21.9 10 42 36 12
155.9																
11.1	End of Borehole															

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 106.5, E 293 189.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.J.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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	W <sub>p</sub>	W	W <sub>L</sub>		
167.2	Ground Surface																
0.0	Silty Sand trace Organics Compact		1	SS	12		166										26 51 18 5
165.6																	
1.6	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		2	SS	19		165										
164.3			3	SS	51												
2.9			4	SS	56		164										
	Heterogeneous mixture of Silt, Sand and Gravel, Trace Clay (Glacial Till) Very Dense		5	SS	62		163										8 44 36 12
			6	SS	94		162										
161.7																	
5.5			7	SS	102		161										4 56 30 10
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard						160										
			8	SS	60	/5cm	159										
			9	SS	120	/15cm	158										10 46 29 15
							157										
156.3																	
10.9			10	SS	120	/10cm	156										36 36 22 6
	Heterogeneous mixture of Silt, Sand and Gravel, trace Clay (Glacial Till) Very Dense						155										
154.6			11	SS	105	/23cm											
12.6	End of Borehole																

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 126.0, E 293 166.0 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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	20	40	60	80	100	W <sub>p</sub>	W		
167.1	Ground Surface															
0.0																
	Heterogeneous mixture of Silt, Sand and Gravel, trace Clay (Glacial Till) Compact to Very Dense		1	SS	14											23 57 13 7
			2	SS	22											
			3	SS	94											7 43 36 14
			4	SS	81											
162.7			5	SS	108											
4.4			6	SS	103										23.7	7 37 36 20
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	120	/10cm										
			8	SS	130	/28cm										
			9	SS	130	/15cm										
157.5																
9.6	End of Borehole															

# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 369-87-01/02

LOCATION Coords: N 4 845 122.5, E 293 241.0

ORIGINATED BY M.M.

DIST 5 HWY 407

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.I.

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>	WATER CONTENT (%)	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						
164.2	Wet Marsh- 400 mm Water Level																	
0.0																		
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)																	
	Firm to Hard																	
	Sandy Silt		1	SS	4													0 17 63 20
	Firm																	
	Very Stiff																	
			2	SS	16													
	Hard		3	SS	55													
158.7																		
5.5																		
	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till)		4	SS	60													24 45 26 5
	Very Dense																	
			5	SS	73	/15cm												3 71 16 10
			6	SS	120	/15cm												
	Becoming Gravelly		7	SS	80	/15cm												
151.6			8	SS	115	/20cm												
12.6	End of Borehole																	

# RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 369-87-01/02

LOCATION Coords: N 4 845 142.0, E 293 218.5

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.I.

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					
164.1	Wet Marsh- 400 mm Water Level																
0.0																	
	Sandy Silt		1	SS	2		164										0 29 56 15
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		2	SS	4		163										
161.6	Soft						162										0 70 25 5
2.5			3	SS	3												
	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till) Compact to Very Dense		4	SS	24		161										8 20 64 8
			5	SS	46		160										
			6	SS	60		159										
							158										6 47 36 11
			7	SS	56		157										
			8	SS	110	/10cm	156										27 61 6 6
							155										
	Becoming Gravelly		9	SS	110	/18cm	154										
							153										
			10	SS	110	/18cm	152										
151.5																	
			11	SS	120	/25cm											
12.6	End of Borehole																

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 369-87-01/02

LOCATION N 4 845 162.0, E 283 196.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOLID STEM AUGER

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.L.

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					
164.2	SWAMP, 300 mm WATER LEVEL																
0.0							164										
	Sandy Silt						163										
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	5		162										0 31 59 10
	Firm to Very Stiff		2	SS	4		161										9 34 44 13
160.5	Brown Gray		3	SS	34		160										3 68 25 3
3.7			4	SS	31		159										
	Heterogeneous mixture of Silt and Sand Clay and Gravel (Glacial Till) Compact to Very Dense		5	SS	19		158										
			6	SS	101		157										
			7	SS	109	/20cm	156										
			8	SS	101	/15cm	155										38 53 6 3
	Becoming Gravelly		9	SS	106	/15cm	154										
153.1																	
11.1	End of Borehole																

# RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 158.0, E 293 274.5 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/01/09 CHECKED BY B.L.

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					
164.1	Wet Marsh, 100 mm Water Level																
0.0																	
	Brown		1	SS	3		163									17.8	0 26 62 12
	Grey		2	SS	2		162										
	Soft		3	SS	3		161										
	Very Stiff		4	SS	18		160									21.4	8 38 33 21
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		5	SS	4		159										
			6	SS	68		158										
158.5							157										
5.6							156										
	Heterogeneous mixture of Silt and Sand Clay and Gravel (Glacial Till) Very Dense		7	SS	107	/23cm	155										1.5 56 36 6.5
			8	SS	148		154										
	Becoming Gravelly		9	SS	129	/20cm	153										11 75 9 5
			10	SS	125	/20cm	152										
			11	SS	118	/23cm	151										1 76 16 7
149.9			12	SS	130	/15cm	150										
14.2	End of Borehole																



# RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 180.0, E 293 250.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

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					
164.0	Wet Marsh																
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	3		163									19.6	0 39 48 13
	Soft		2	SS	5		162										
	Very Stiff		3	SS	14		161										25 30 29 16
	Brown		4	SS	30		160										
	Grey		5	SS	33		159										25 30 29 16
159.6			6	SS	79		158										
4.4	Heterogeneous mixture of Silt and Sand Clay and Gravel (Glacial Till) Very Dense		7	SS	112	/23cm	157										14 65 13 8
			8	SS	100	/15cm	156										
			9	SS	112	/23cm	155										
	Becoming Gravelly		10	SS	116	/25cm	154										
152.9							153										32 60 6 2
11.1	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 200.0, E 293 227.5 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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					
163.8	Ground Surface																
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	2		163										0 44 44 12
	Soft		2	SS	2		162										
	Stiff		3	SS	15		161										4 62 28 6
	Brown		4	SS	62		160										
	Gray		5	SS	130		159										
	Hard		6	SS	80		158										13 44 29 14
156.3							157										
5.6	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till) Very Dense		7	SS	121	/20cm	156										1 86 9 4
			8	SS	90	/8cm	155										
	Becoming Gravelly		10	SS	100	/13cm	154										
152.7			11	SS	131		153										
11.1	End of Borehole																

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 196.0, E 293 307.0 ORIGINATED BY M.M.  
DIST 5 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

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					
172.0	Ground Surface																
0.0																	
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	27		171										
			2	SS	63		170										
			3	SS	53		169										
			4	SS	52		168										
			5	SS	49		167										
			6	SS	28		166										
			7	SS	73		165										
			8	SS	70		164										
			9	SS	107		163										
			10	SS	80		162										
160.9							161										
11.1	End of Borehole																

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 216.0, E 293 280.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					WATER CONTENT (%)	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			
171.1	Ground Surface													
0.0														
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	17									7 25 43 25
			2	SS	38									
			3	SS	33									
			4	SS	49									
			5	SS	75	/5cm							23.0	7 23 39 31
			6	SS	100	/15cm								7 39 44 10
			7	SS	88									
			8	SS	100	/15cm								19 35 31 15
			9	SS	100	/15cm								
161.5														
9.6	End of Borehole													

# RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 236.0, E 293 258.0 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY D.T.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ 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					
170.6	Ground Surface															
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard  Brown ----- Grey		1	SS	26	/28cm									20.6	3 17 42 38
			2	SS	49											
			3	SS	63											8 35 40 17
			4	SS	78											
			5	SS	123	/25cm									24.0	13 26 42 19
			6	SS	123											4 38 48 10
			7	SS	105	/23cm										
			8	SS	126											
161.0	End of Borehole															

# RECORD OF BOREHOLE No 13

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 078.0, E 293 186.0 ORIGINATED BY M.M.  
 DIST 5 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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					
167.4	Ground surface																
0.0	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till) Compact to Very Dense Brown Grey		1	SS	19		167										2 53 35 10
			2	SS	34		166										
			3	SS	68		165										
			4	SS	54		164										
			5	SS	88		163										
			6	SS	83		162										
161.9							161										0 54 44 2
5.5	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	100	/15cm	160										
			8	SS	100	/10cm	159										
157.8			9	SS	150	/15cm	158										6 32 49 13
9.6	End of Borehole																

# RECORD OF BOREHOLE No 14

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 220.5, E 293 313.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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					
173.1	Ground surface																
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	38		172										0 18 40 42
			2	SS	30		171										3 11 41 45
			3	SS	68		170										
			4	SS	42		169										
			5	SS	30		168										
			6	SS	27		167										
			7	SS	122		166										3 37 45 15
			8	SS	102		165										
			9	SS	70	/15cm	164										3 14 69 14
163.5																	
9.6	End of Borehole  • Water level not encountered																

# RECORD OF BOREHOLE No 15

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 100.0, E 293 159.5 ORIGINATED BY M.W.  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.W.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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					
167.5	Ground surface															
0.0	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till) Loose Very Dense Brown Grey		1	SS	6											
			2	SS	44											6 46 41 7
			3	SS	59											
			4	SS	59											
			5	SS	31											1 38 54 7
			6	SS	55											
162.0																
5.5	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	90	/15cm										26 28 33 13
			8	SS	126	/25cm										
157.9			9	SS	120	/15cm										4 24 64 8
9.6	End of Borehole															



ORIGINATED BY M.M.

COMPILED BY M.M.

1. CHECKED BY B.I.

+3, x5. Numbers refer to Sensitivity

# FOUNDATION INVESTIGATION REPORT

For

Hwy. 407 and Hwy. 50 Underpass

W.P.369-87-09/10, Site No. 37-1334

Hwy. 407, District 6, Toronto

## INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. It is proposed to construct a two span structure which will carry Hwy. 50 over the proposed Hwy. 407. This report contains factual information obtained from this investigation.

## SITE DESCRIPTION

The site is located just north of Steeles Avenue west, along the existing four lane Hwy. 50 in the City of Brampton/Town of Vaughan, Regional Municipality of Peel. The site is characterized by a 5 m to 7 m high embankment fill with Hwy. 50 at an elevation of 181 metres and having approach slopes of +2.40% and -1.50%.

The topography of the area consists of rolling grassland with abandoned farmland to the west and east. To the east a large barn and farmhouse which is enclosed by a wire fence exists. Runoff from both fields is carried by a steel corrugated culvert which runs underneath Hwy. 50. The natural ground is at an elevation of 174.2 metres.

Physiographically, the site is located in the geological domain known as the "Peel Plain". The Peel Plain is the product of the advance and retreat of the wisconsinan ice sheet which covered the area during the pleistocene epoch. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. At some locations, the till is overlain by thin deposits of varved clay.

Till sheets of varying composition comprise the "Peel Plain". Generally, the surficial till sheets exhibit a cohesive behaviour whilst the lower till sheets are cohesionless. As characteristics of till material, these deposits contain a wide range of grain size ranging from boulders to clay.

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The till sheets are usually separated from one another by interbeds of stratified silt or sand of variable thickness. Bedrock in the area has been found at depths ranging from 25 to 30 m below ground surface and consists of interbedded shale and limestone of the Dundas-Meaford Formation, Ordovician period.

### INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and laboratory testing. The procedures employed are discussed below.

### FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 90 09 17 to 90 09 27 and consisted of six sampled boreholes which were advanced to a maximum depth of 20.3 m below the ground surface. Three boreholes were located on the west shoulder and three boreholes on the east shoulder. Boreholes were placed to correspond to abutment and pier locations for the Hwy. 50 underpass.

The elevations of the boreholes advanced at the site at the embankment crest varied from 178.9 m to 180.6 m. One borehole located at the toe of the embankment was at an elevation of 174.2 metres.

In general, subsoil samples were retrieved at 0.7 m intervals for the top 6 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Relatively undisturbed samples were also randomly retrieved using a shelby tube sampler in accordance with Standard Practice (ASTM D1587). In situ vane tests were also conducted between the aforementioned sampling intervals to determine the undisturbed and remolded undrained shear strengths of the cohesive deposits. The vane shear test was conducted employing the standard MTO 'N' value in accordance with ASTM D2573.

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

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled upon completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by Giffels Engineering Consultants under contract with Central Region Surveys and Plans.

### LABORATORY ANALYSIS

The following laboratory tests were carried out on select soil samples.

- 1) Atterberg Limit Tests
- 2) Grain Size Distribution
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on Figures and Borehole Logs included in the Appendix.

### SUBSURFACE CONDITIONS

#### General

The subsoil stratigraphy consisted of various layers of cohesive and non-cohesive materials overlain by the existing fill embankment which extends approximately 5-7 metres deep. The fill can be classified as containing random mixtures of clay, silt, sand and gravel. A trace of organics was encountered at the surface of the native soils. The native soils underlying the above fill material consisted of a 0-4.5 m layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till), 0.7 m to 4.6 m of a sandy silt to silt, another underlying layer of a 3 to 11.7 m Glacial Till but consisting of a non-cohesive heterogeneous mixture of sandy silt, clay and gravel and a layer of silt, some clay, trace sand. While the fill material remained basically uniform throughout the site the natural stratigraphy towards the north contained less of the cohesive till and the silt layers until neither was encountered at the most

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northern boreholes. These boreholes had predominantly more of the non-cohesive Glacial Till. Occasional boulders and cobbles were encountered at lower depths.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 3678702-A\* in the attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets also included in the Appendix of this report. A brief description of the different soil types is given below.

Random Mixture of Clay, Silt, Sand and Gravel (Fill)

The surficial material at the site consists of approximately 4-7.0 m of a random mixture of clay, silt, sand and gravel (Fill) in all boreholes within the fill embankment, primarily down to an elevation of 174.5 m.

Grain Size Distribution Test results are shown on Figure 1 in the Appendix, in an envelope form. The above figure confirms the presence of a varying mixture of clay, silt, sand and gravel. The deposit is comprised of 4-54% gravel, 20-37% sand, 16-67% silt and 6-27% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this report is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6-14.5	9
Liquid Limit ( $w_L$ )	17-42	8
Plastic Limit ( $w_p$ )	12-26	8
Plastic Index ( $I_p$ )	5-16	8

From the Plasticity Chart (Figure 2), the layer can be classified as being non-plastic. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of  $17.7 \text{ kN/m}^3$  to  $21.6 \text{ kN/m}^3$ .

In this stratum the 'N' values ranged from 8 blows/0.3 m to 44 blows/0.3 m indicating the material ranged from stiff to hard.

\* DWG NO 2 OF THE CONTRACT DWG'S

35

Results of Grain Size Distribution tests carried out on select samples are shown on Figure 5 in the Appendix, in an envelope form. From the above figure the layer can be classified as containing a great proportion of silt and some sand. The deposit is comprised primarily of 0-5% gravel, 3-39% sand, 49-87% silt, and 9-14% clay.

The results from the Atterberg Limit Test performed on the fine fraction of this material is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	7-22.5	3
Liquid Limit ( $w_L$ )	16-22	3
Plastic Limit ( $w_p$ )	13-16	3
Plastic Index ( $I_p$ )	3-6	3

From the plasticity chart (Figure 4), the layer can be classified as inorganic silts with fine sands with no plasticity. Unit weight was found to be 20 kN/m<sup>3</sup>.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 20 blows/0.3 m to 105 blows/0.3 m. Based on these 'N' values, the material can be described as having a compact to very dense relative density.

#### Heterogeneous Mixture of Sandy Silt, Clay and Gravel

Underlying all the above materials is a layer of non-cohesive heterogeneous mixture of sandy silt, clay and gravel. This layer remains 3-11.7 m thick throughout the south abutment and pier locations but expands significantly down to the limits of our investigation at the north abutment locations. Interbedded at the north boreholes are seams of silt and gravel.

Results of Grain Size Distribution Tests carried out on select samples from this layer are shown in Figure 7 in the Appendix, in an envelope form. From the above Figure it is evident that the layer can be classified as a well-graded mixture of sand, gravel and silt. This deposit contained 1-15% Gravel, 18-52% sand, 36-52% silt, and 5-28% clay.

The results from the Atterberg Limit Tests performed on cohesive material are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	7-16	10
Liquid Limit ( $w_L$ )	21-32	10
Plastic Limit ( $w_p$ )	12-19	10
Plastic Index ( $I_p$ )	9-21	10

The plasticity chart is plotted in Figure 8. Unit weight measurements from this strata yielded dry unit weights of 15.7 to 23.5 kN/m<sup>3</sup>.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 40 blows/0.3 m to 140 blows/0.3 m indicating a dense to very dense state of relative density.

#### Silt, Some Clay, Trace Sand

The final layer extends from a depth of 11.7 m to 16.2 m down to the subsoil investigation limits of 15.7 m to 20.3 m and is a non-cohesive silt, some clay, trace sand which was encountered only at south abutment and pier locations.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 9 in the Appendix, in an envelope form. From the above Figure it is evident that the layer contains a large percentage of silt. The material consisted of 0-67% Gravel, 1-8% Sand, 78-84% silt and 10-15% Clay.

The results from the Atterberg Limit Tests are summarized below:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	14-19	4
Liquid Limit ( $w_L$ )	17-23	4
Plastic Limit ( $w_p$ )	14-16	4
Plastic Index ( $I_p$ )	3-7	4

2001

The plasticity chart is plotted in Figure 10. Unit weights were found to be 20.8 to 23.3 kN/m<sup>3</sup>.

Standard Penetrations Tests carried out in this deposit revealed 'N' values of High values >100 blows/0.3 m, indicating a very dense state of relative density.

#### GROUNDWATER CONDITIONS

Observations of the groundwater level were carried out by measuring the water levels in the open boreholes. Groundwater levels determined at the time of the investigation were approximately at an elevation ranging from 170 m (11 m depth) to 167.5 m (12 m depth) in all borehole, excluding BH 1 which had a watertable level of 158.7 m (14.7 m). Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

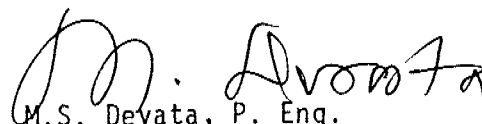
#### MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Michalek, Jr. Foundation Engineer, utilizing equipment owned and operated by Archer Drilling and Master Soil Investigation.

The project was carried out under the general supervision of Dr. B. Iyer, Sr. Foundation Engineer. The report was written by M. Michalek, reviewed by Dr. B. Iyer and approved by Mr. M.S. Devata, Chief Foundation Engineer.



B. Iyer, P. Eng.  
Senior Foundation Engineer

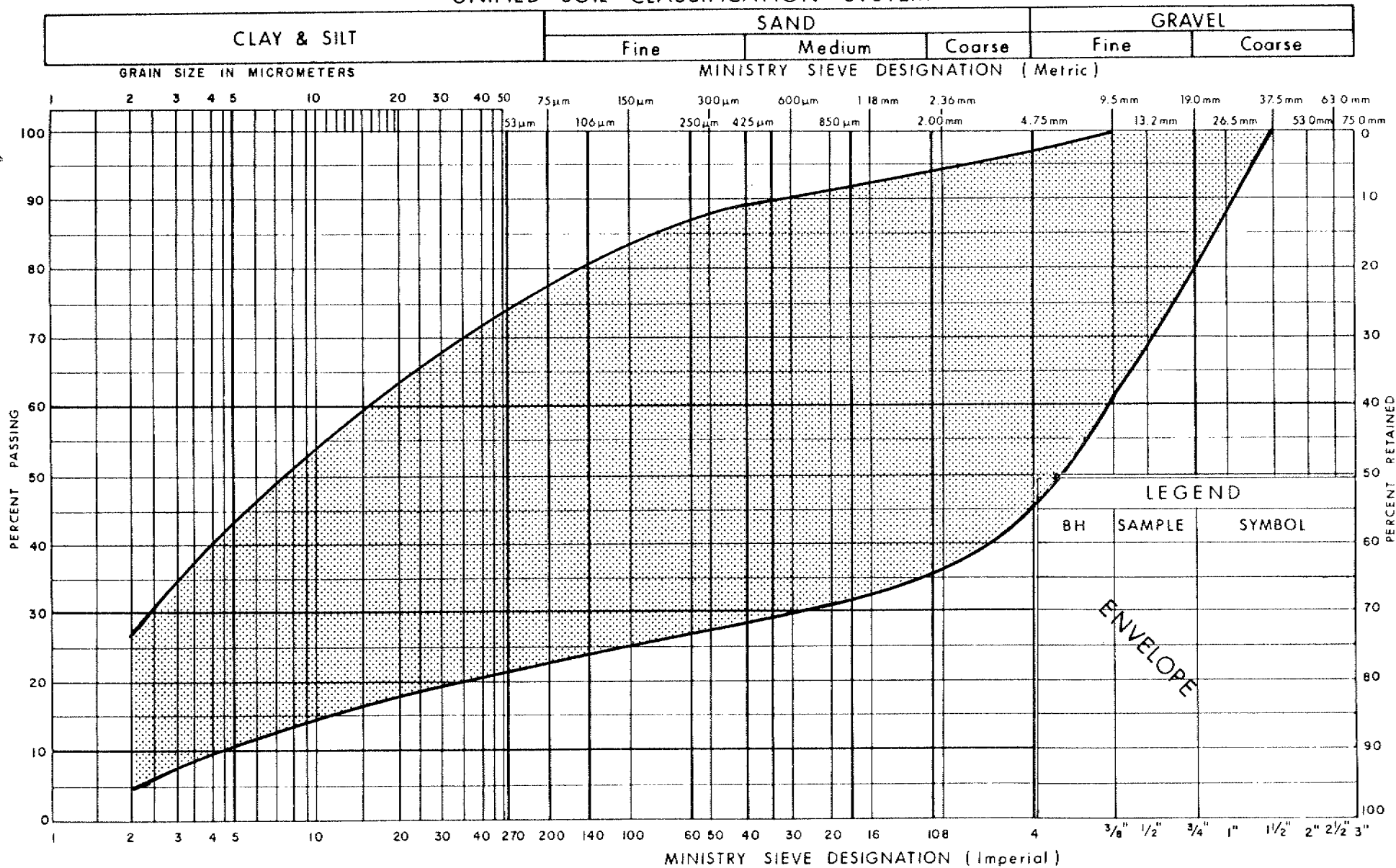


M.S. Devata, P. Eng.  
Chief Foundation Engineer



# APPENDIX

## UNIFIED SOIL CLASSIFICATION SYSTEM

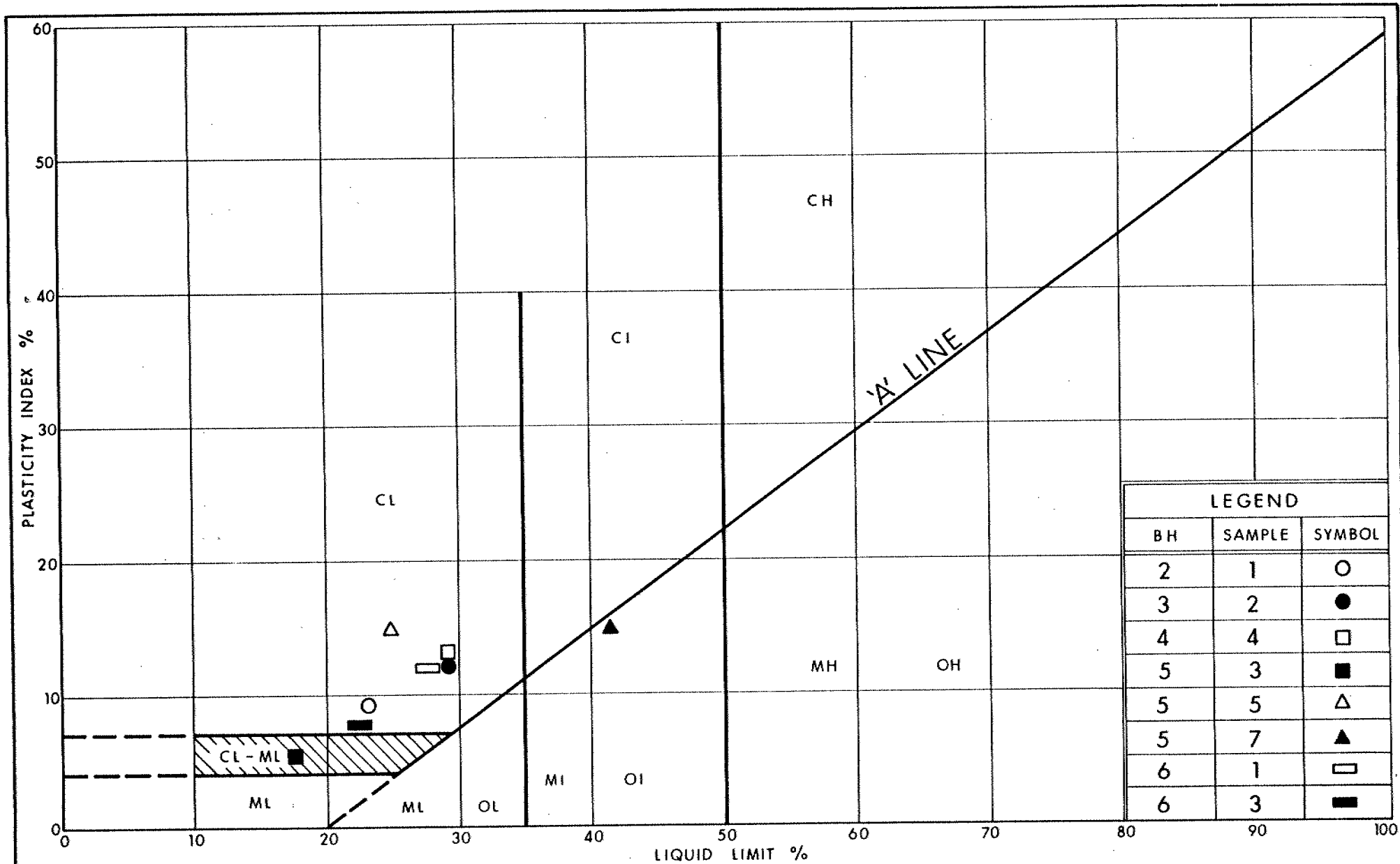


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GRAIN SIZE DISTRIBUTION  
RANDOM MIXTURE OF CLAY, SILT, SAND & GRAVEL  
(FILL)

FIG No 1

W P 369-87-09/10



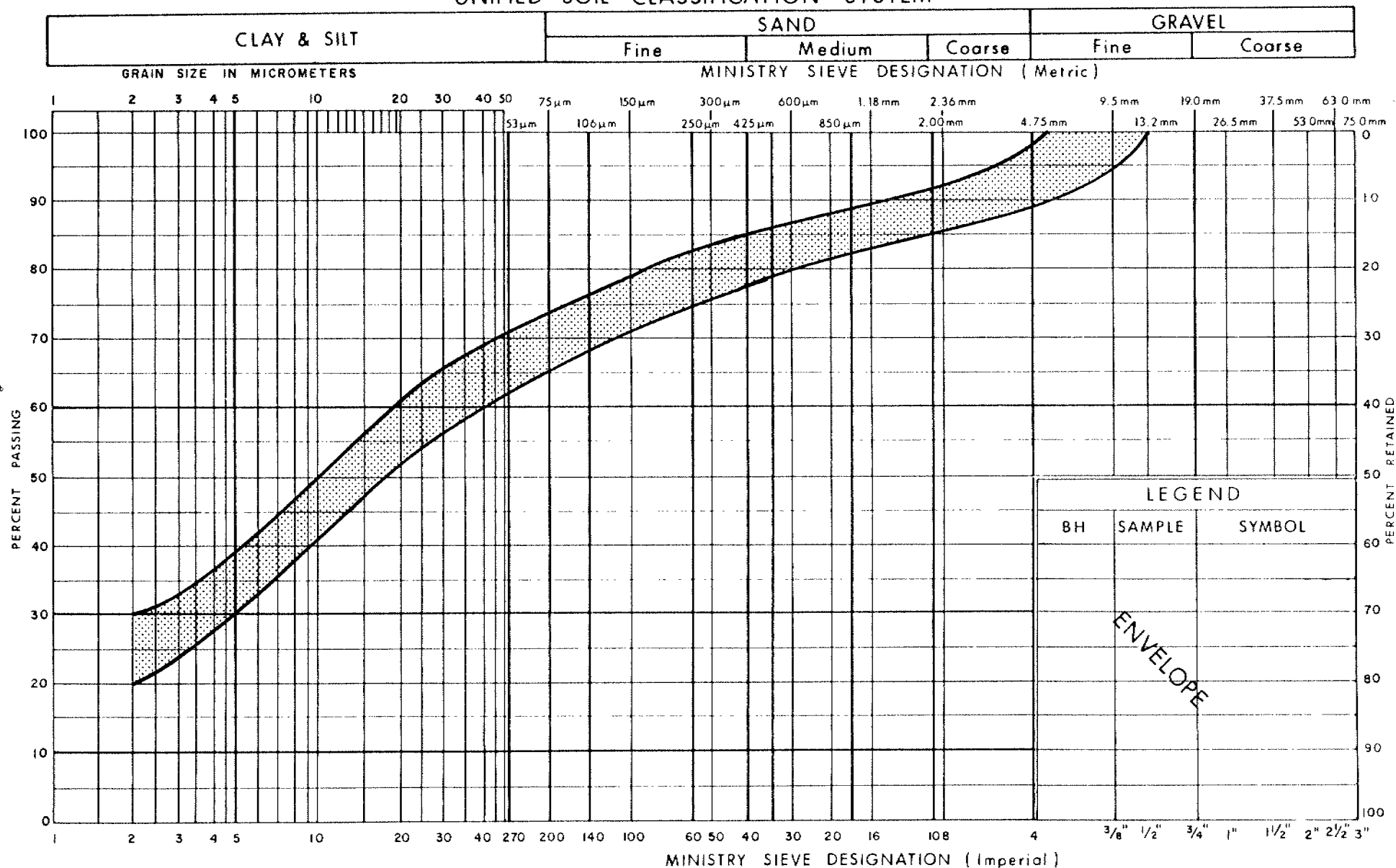
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Ontario

# PLASTICITY CHART RANDOM MIXTURE OF CLAY, SILT, SAND & GRAVEL (FILL)

FIG No 2

W P 369-87-09/10

## UNIFIED SOIL CLASSIFICATION SYSTEM

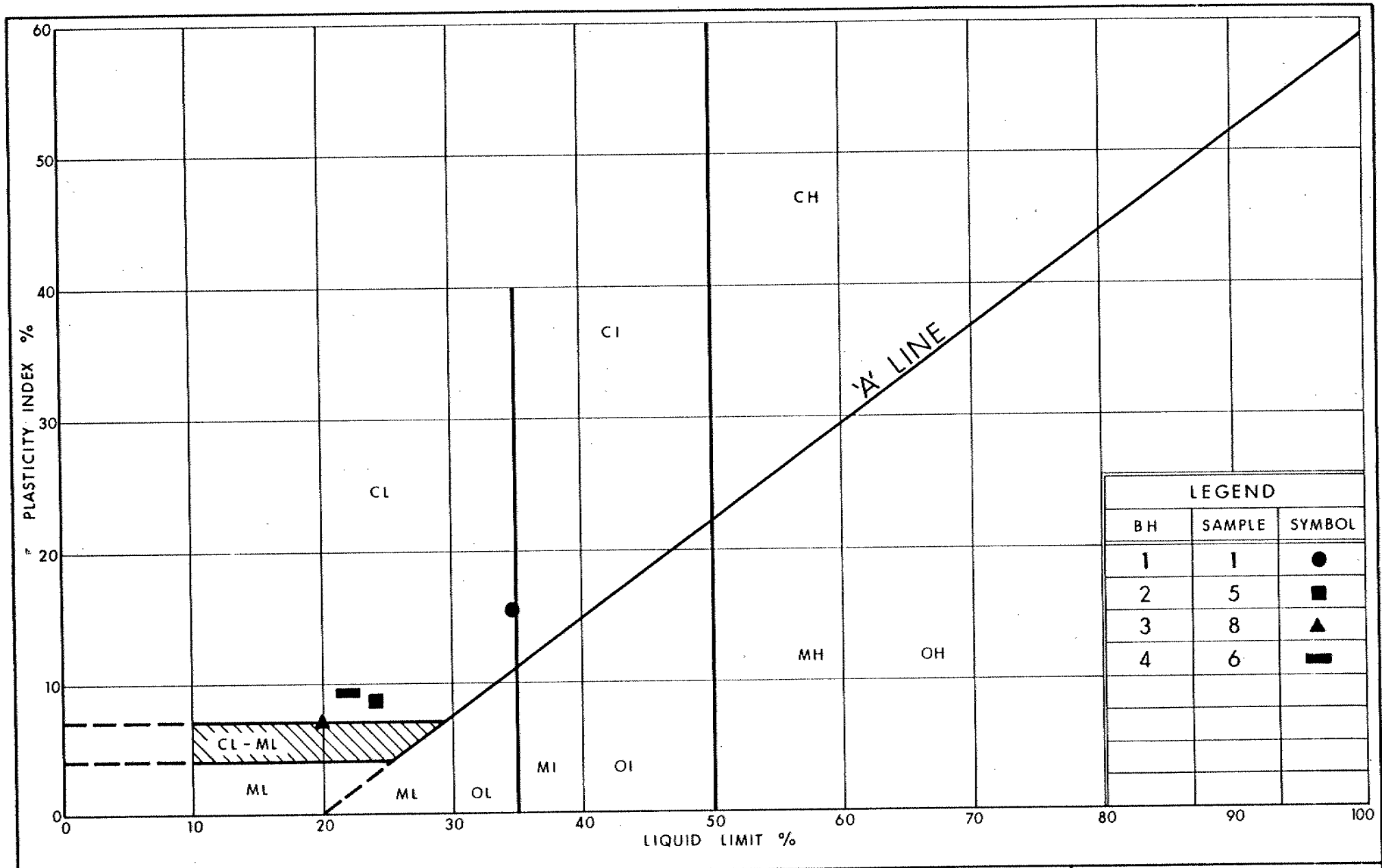


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Transportation

**GRAIN SIZE DISTRIBUTION**  
**HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL**  
**(GLACIAL TILL)**

FIG No 3

W P 369-87-09/10



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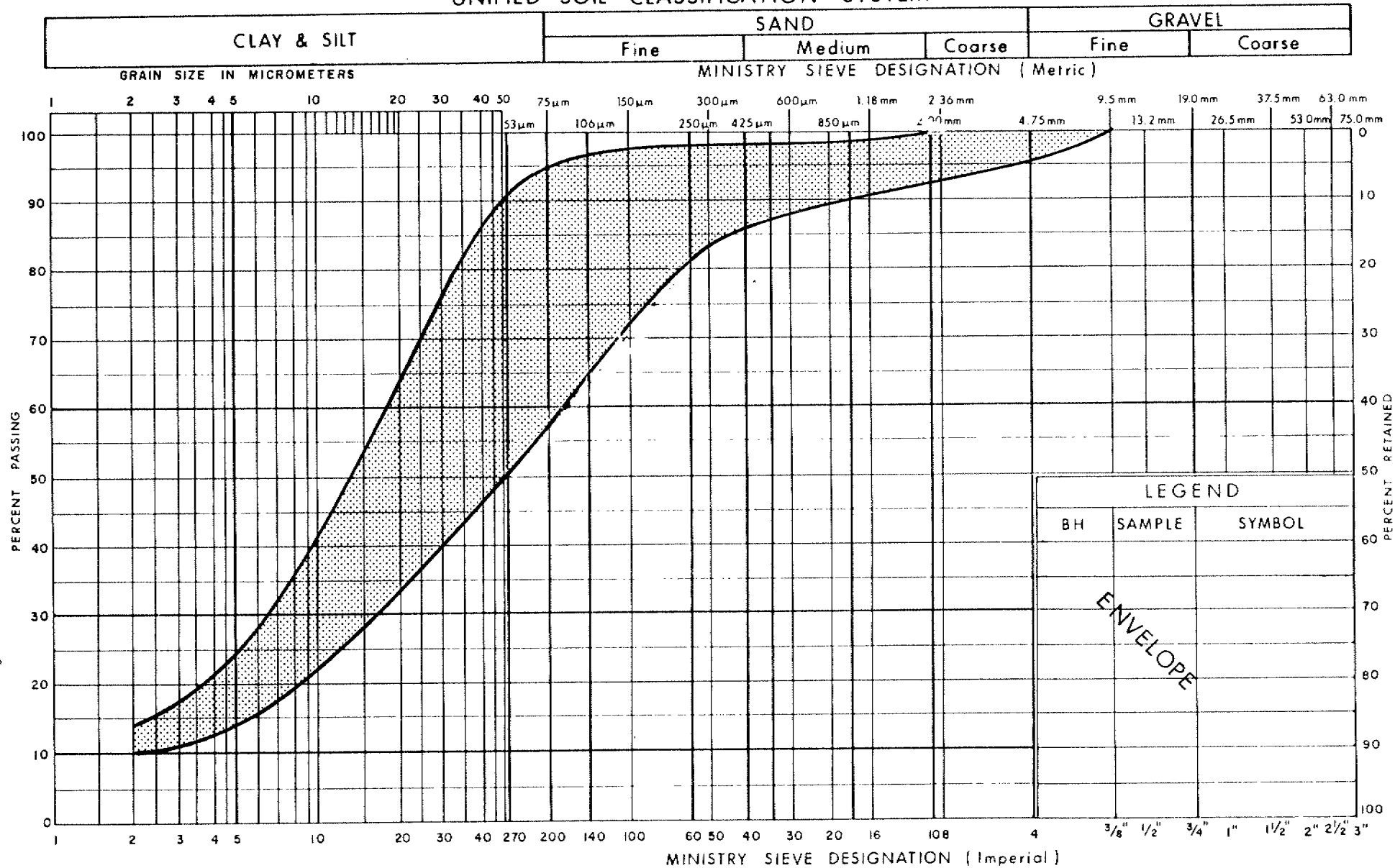
Ontario

# PLASTICITY CHART HETEROGENEOUS MIXTURE OF CLAYEY, SILT, SAND & GRAVEL

FIG No 4

W P 369-87-09/10

## UNIFIED SOIL CLASSIFICATION SYSTEM

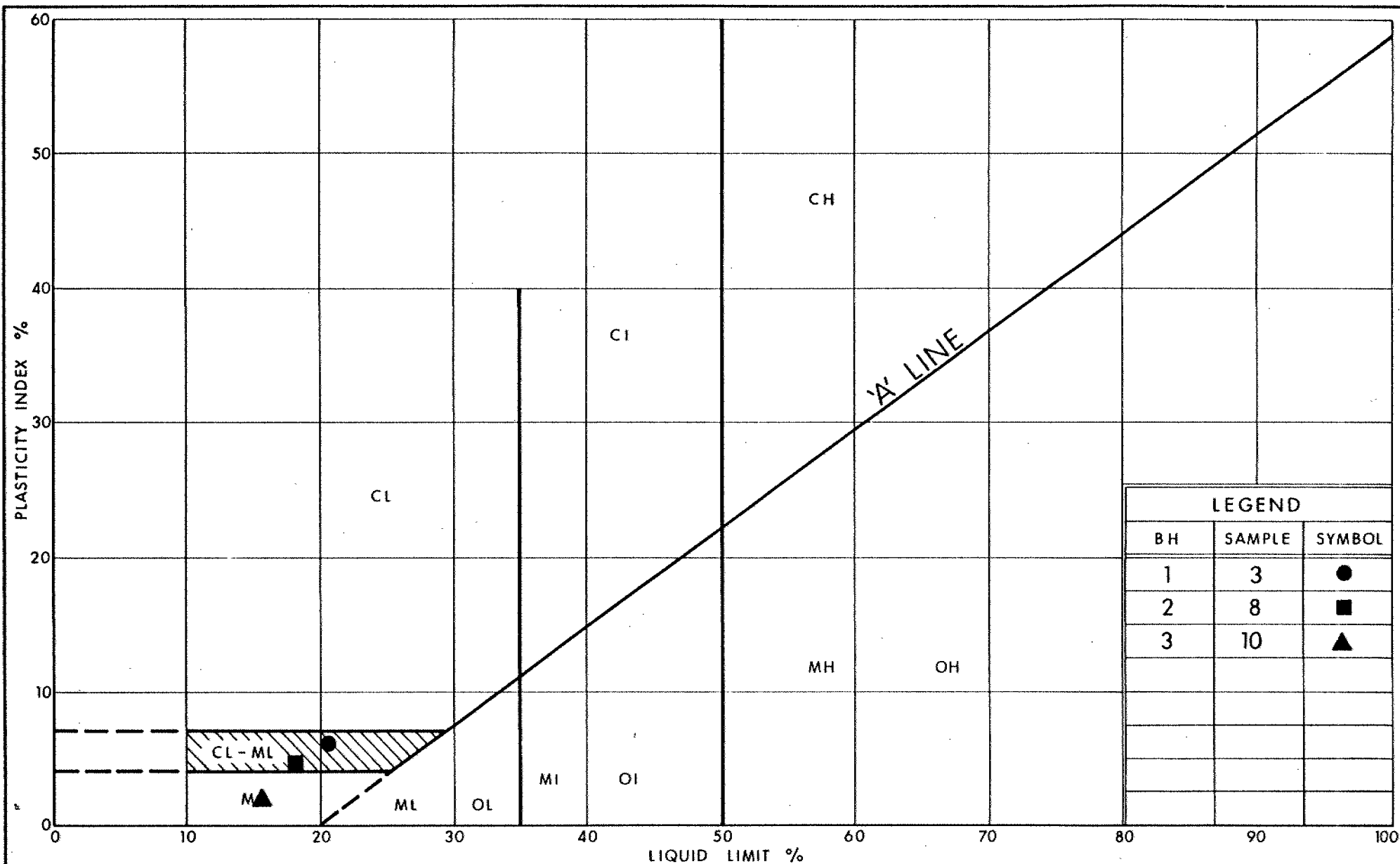


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## GRAIN SIZE DISTRIBUTION SANDY SILT TO SILT

FIG No 5

W P 369-87-09/10



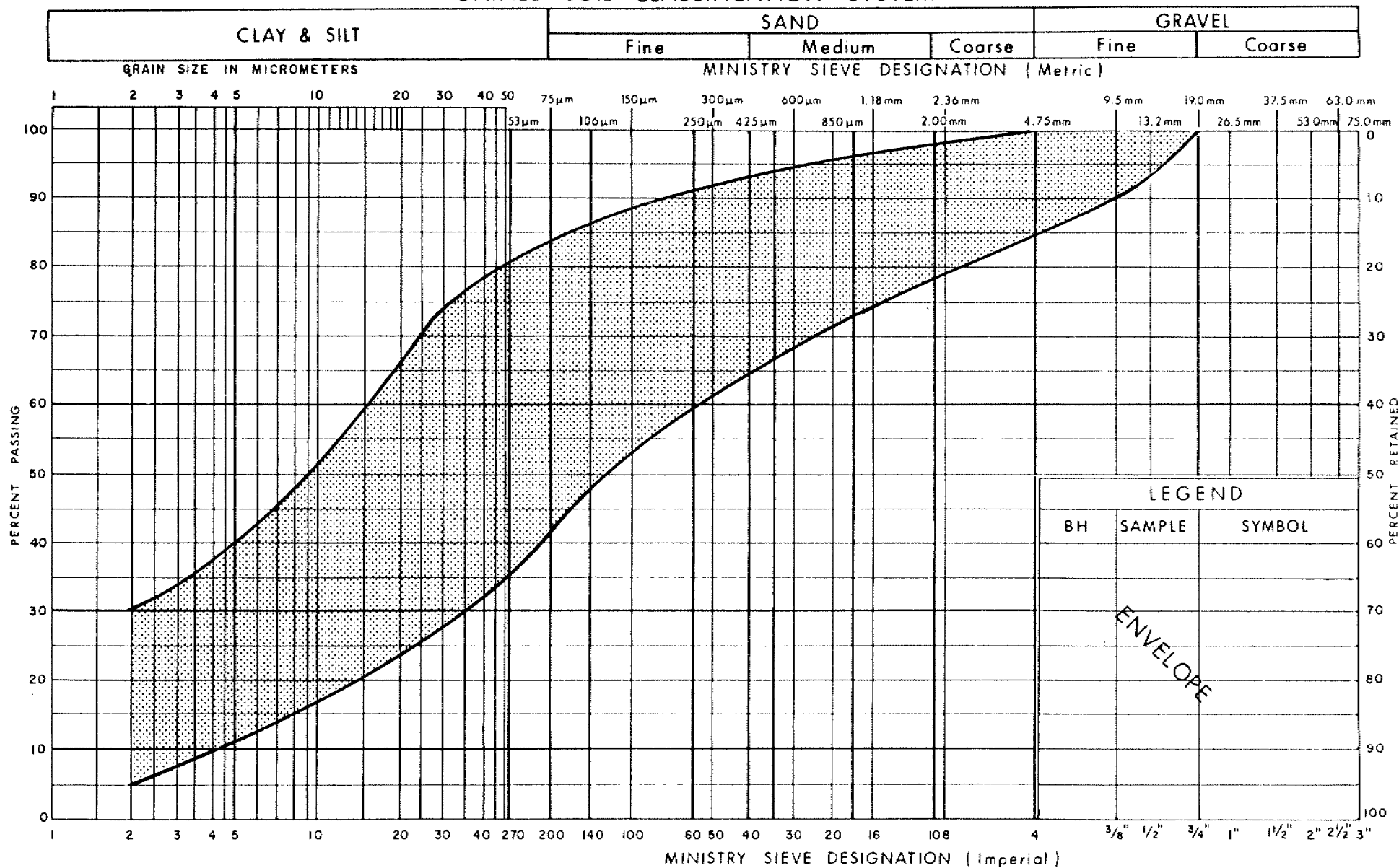
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Ontario

# PLASTICITY CHART SANDY SILT TO SILT

FIG No 6

W P 369-87-09/10

## UNIFIED SOIL CLASSIFICATION SYSTEM



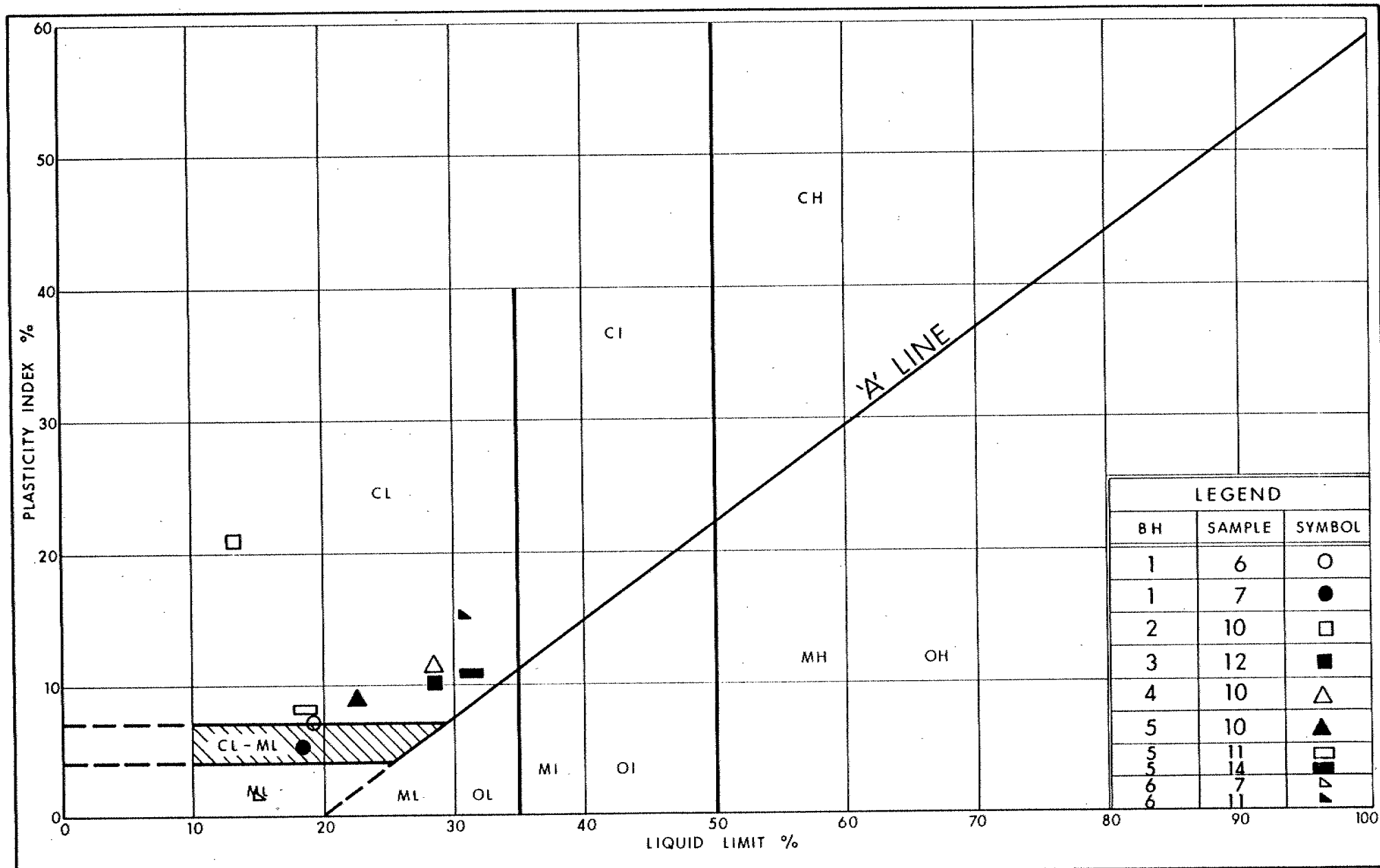
Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**HETEROGENEOUS MIXTURE OF SANDY SILT, CLAY & GRAVEL**  
 (GLACIAL TILL)

FIG No 7

W P 369-87-09/10





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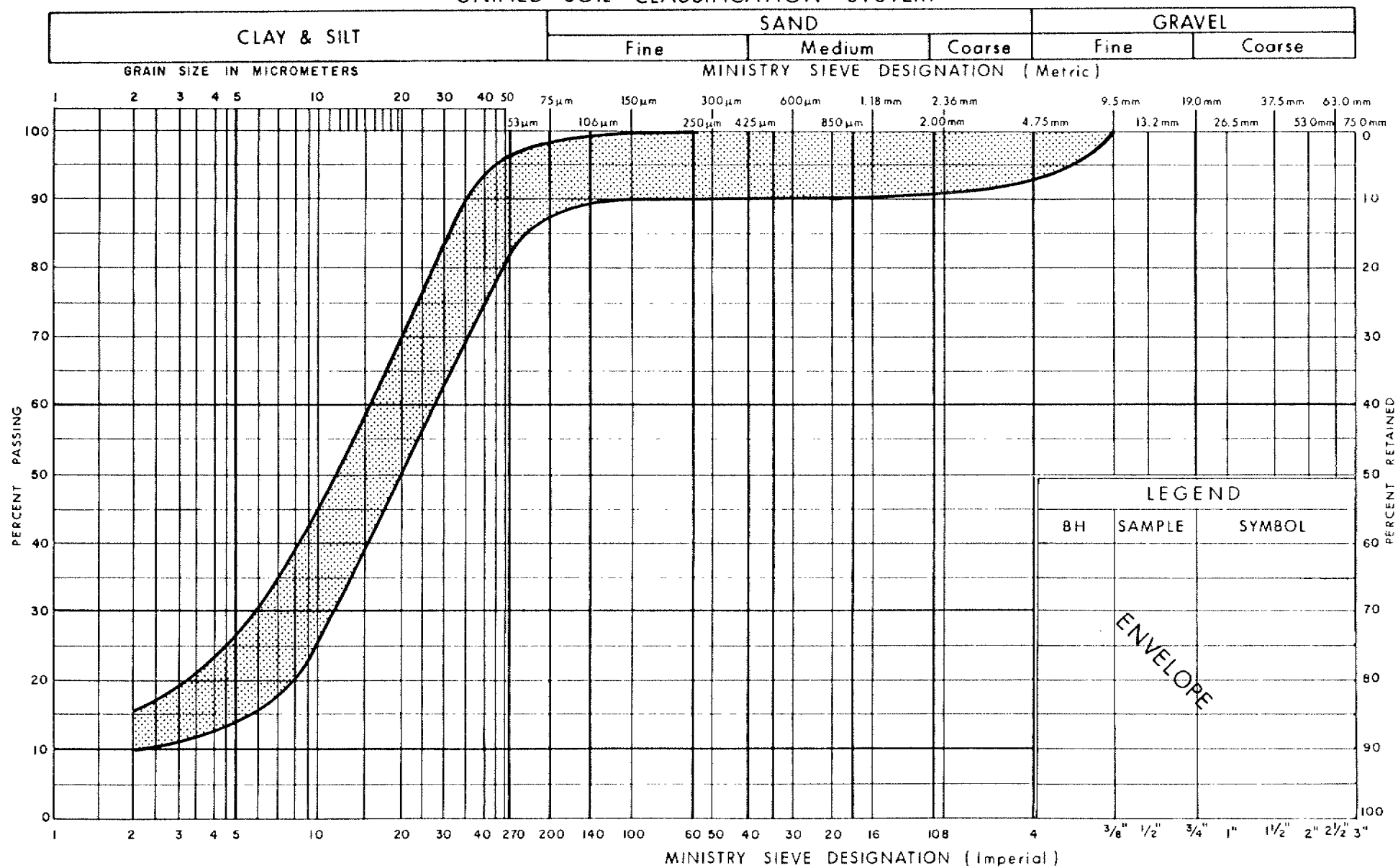
Ontario

PLASTICITY CHART  
HETEROGENEOUS MIXTURE OF SANDY SILT, CLAY & GRAVEL  
(GLACIAL TILL)

FIG No 8

W P 369-87-09/10

## UNIFIED SOIL CLASSIFICATION SYSTEM

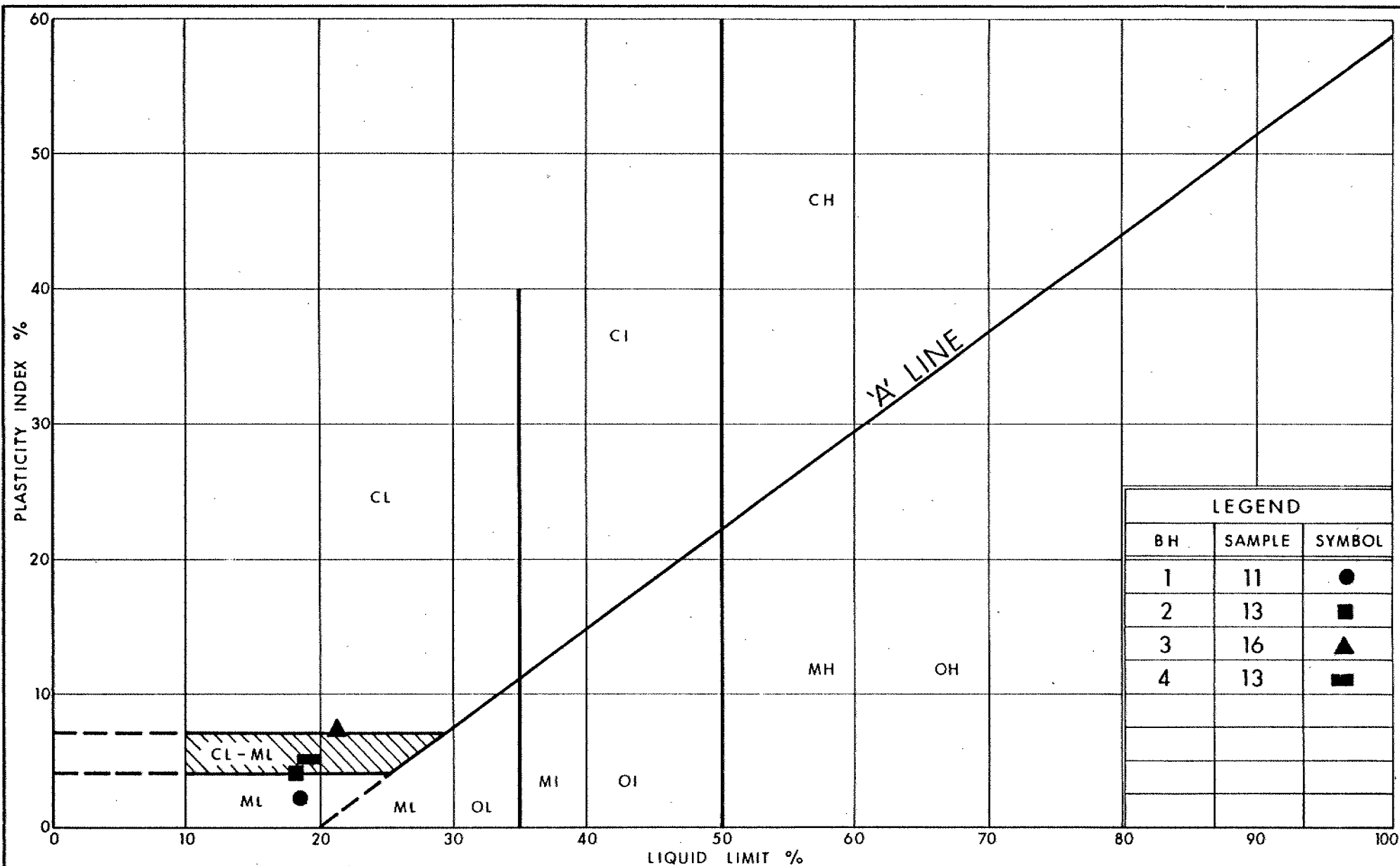


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GRAIN SIZE DISTRIBUTION  
SILT, SOME CLAY, TRACE SAND

FIG No 9

W P 369-87-09/10



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# PLASTICITY CHART SILT, SOME CLAY, TRACE SAND

FIG No 10

W P 369-87-09/10

# RECORD OF BOREHOLE No 1

1 OF 2

METRIC 50

W.P. 369-87-09/10

LOCATION Coords: N 4 845 382.0, E 293 491.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOLID STEM AUGER

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.L.

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	20 40 60 80 100					
175.4	Ground Surface														
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	19		175								5 28 39 28
173.2			2	SS	48		174								
2.1	Sandy Silt to Silt Compact to Dense		3	SS	44		173							20.1	0 3 87 10
	Brown ----- Grey		4	SS	24		172								
170.9			5	SS	39		171								
4.4	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Dense to Very Dense		6	SS	43		170							22.4	5 35 40 20
			7	SS	125		169							22.5	13 35 37 15
			8	SS	76		168								
			9	SS	82		167								
			10	SS	60	/5cm	166								
163.7							165								
11.7	Silt, same Clay, trace Sand Very Dense		11	SS	125	/13cm	164							20.9	1 8 79 12
160.1							163								
15.2							162								
							161								

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued

# RECORD OF BOREHOLE No 1

2 OF 2

METRIC 51

W.P. 369-87-09/10

LOCATION Coords: N 4 845 382.0, E 283 491.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOLID STEM AUGER

COMPILED BY M.M.

DATUM GEODETTIC

DATE 90/10/01

CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W <sub>p</sub>	W	W <sub>L</sub>		
15.2 159.7	Continued		12	SS	120	/15cm	160										
15.7	End of Borehole																

# RECORD OF BOREHOLE No 2

1 OF 2

METRIC 52

W.P. 369-87-09\10

LOCATION Coords: N 4 845 418.0, E 293.516.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOLID STEM AUGER

COMPILED BY M.M.

DATUM GEODETTIC

DATE 90/10/01

CHECKED BY B.I.

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					
178.9	Ground Surface																
0.0	Random mixture of Clay, Silt, Sand and Gravel (Fill) Firm to Very Stiff		1	SS	17		178									21.2	24 32 29 15
			2	SS	8		177										
			3	SS	16		176										
	trace Organics		4	SS	12		175										
174.9							174									21.9	9 24 46 21
4.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff		5	SS	23		173										
			6	SS	25		172										
171.8	Brown						171										
7.1	Grey		7	SS	20		170										
	Sandy Silt to Silt Compact to Very Dense		8	SS	105	/20cm	169										5 30 51 14
			9	SS	31		168										
167.2							167										
11.7	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Dense to Very Dense		10	SS	40		166										8 48 36 8
			11	SS	60		165										
163.7							164										

15.2

Continued

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

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued

# RECORD OF BOREHOLE No 2

2 OF 2

METRIC 53

W.P. 369-87-09\10 LOCATION Coords: N 4 845 418.0, E 293.516.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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					
15.2	Continued		12	SS	100	/10cm										
162.7																
16.2			13	SS	100	/10cm										
			14	SS	100	/15cm										
158.6			15	SS	120	/15cm										
20.3	End of Borehole															

# RECORD OF BOREHOLE No 3

1 OF 2

METRIC 54

W.P. 369-87-09/10 LOCATION Coords: N 4 845 446.0, E 293 472.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		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	20 40 60 80 100	W <sub>p</sub>	W		
180.6	Ground Surface												
0.0	Random mixture of Clay, Silt, Sand, and Gravel (Fill) Stiff to Very Stiff		1	SS	17		180						
			2	SS	18		179			○	—	21.4	28 27 26 19
			3	SS	14		178						
			4	SS	28		177						
			5	SS	24		176						
	trace of Organics		6	SS	12		175						
175.0							174						
5.6	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		7	SS	33		173			○	—	21.3	3 26 52 19
			8	SS	21		172						
			9	SS	125		171						
170.5							170						
10.1	Sandy Silt Very Dense		10	SS	114		169						
168.9							168						
11.7	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Compact to Very Dense		11	SS	17		167						
			12	SS	88		166			○	—	22.4	8 23 44 25
165.4													

15.2

Continued

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

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued



# RECORD OF BOREHOLE No 3

2 OF 2

METRIC 55

W.P. 367-89-09/10

LOCATION Coords: N 4 845 446.0, E 293 472.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE SOUD STEM AUGER

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W <sub>p</sub>	W			W <sub>L</sub>	
15.2	Continued		13	SS	160	/10cm												
164.4																		
16.2																		
			14	SS	113													
			15	SS	120													
160.3	Silt, some Clay trace Sand trace Gravel Very Dense		6	SS	120	/15cm												
20.3			End of Borehole															

# RECORD OF BOREHOLE No. 4

1 OF 2

METRIC 56

W.P. 369-87-09/10 LOCATION Co-ords: N 4 845 463.5, E 293 487.5 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM Geodetic DATE 90 10 01 CHECKED BY B.L.

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	20 40 60 80 100	20 40 60 80 100					
179.8	Ground Surface														
0.0	Random mixture of Clay, Silt Sand and Gravel (Fill)														
	Stiff to Hard		1	SS	33										
			2	SS	14										
			3	SS	31										
			4	SS	44										
173.9			5	SS	52										
5.9	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		6	SS	55										
			7	SS	49										
			8	SS	41										
169.7			9	SS	14										
10.1	Silt, some Sand Compact		10	SS	103										
168.1			11	SS	101										
11.7	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till) Very Dense														
165.1															
14.7															
164.6															
15.2															

Continued

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

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued

# RECORD OF BOREHOLE No 4

2 OF 2

METRIC 57

W.P. 359-87-09/10 LOCATION Co-ords: N 4 845 463.5, E 293 487.5 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
 DATUM Geodetic DATE 90 10 01 CHECKED BY B.L.

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					
164.6	Continued															
15.2	Silt, some Clay Very Dense		12	SS	100	/15cm										
162.6			13	SS	60	/10cm										0 1 84 15
17.2	End of Borehole															

# RECORD OF BOREHOLE No 5

1 OF 2

METRIC 58

W.P. 369-87-09/10

LOCATION Coords: N 4 845 495.0, E 293 445.0

ORIGINATED BY M.M.

DIST 5 HWY 407

BOREHOLE TYPE HOLLOW STEM AUGER, SPLIT SPOON

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/03

CHECKED BY B.I.

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>	WATER CONTENT (%) w	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						
181.1	Ground Surface																	
0.0	Random mixture of Clay, Silt Sand and Gravel (Fill)  Stiff to Hard		1	SS	22	Dry	180										21.6	7 37 44 12
			2	SS	17		179											
			3	SS	16		178											
			4	SS	21		177											54 21 19 6
			5	SS	11		176											
			6	SS	42		175											
			7	SS	14		174										17.8	6 21 48 25
174.0							173											
7.1	Silt, trace Sand  Dense		8	SS	33		172											
172.5							171											
8.6			9	SS	132	/28cm	170										21.0	2 18 52 28
							169											
			10	SS	129	/28cm	168											
							167											
			11	SS	120	/15cm	166										20.3	8 35 40 17
			12	SS	59													
165.8																		
15.2																		

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

Continued

## METRIC 59

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC 60

W.P. 367-89-09/10 LOCATION Coords: N 4 845 510.0, E 293 463.5 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE HOLLOW STEM AUGER, SPLIT SPOON COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/03 CHECKED BY B.I.

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					
180.3	Ground Surface																
0.0	Random mixture of Clay, Silt Sand and Gravel  (Fill)  Stiff to Very Stiff																
			1	SS	15											21.5	8 27 38 27
			2	SS	60	/10cm											
			3	SS	17												
			4	SS	38												
173.5	Silt, trace Sand Dense		5	SS	43												
172.8			6	SS	119												
7.5	Heterogeneous mixture of Sandy Silt, Clay and Gravel (Glacial Till)  Very Dense		7	SS	110												
			8	SS	111												
			9	SS	103	/23cm											
			10	SS	108	/15cm											
			11	SS	105	/28cm											
166.1	Clayey Silt															20.9	7 27 36 30
14.2	End of Borehole																

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

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Transportation

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## **FOUNDATION DESIGN SECTION**

**foundation  
investigation and  
design report**

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 369-87-01/02

DIST 6

HWY 407

STR SITE 24-653A/B

Hwy. 407 and the West Humber River

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# FOUNDATION INVESTIGATION REPORT

For

Hwy. 407 and The West Humber River

W.P. 369-87-01/02, Site 24-653A/B

Hwy. 407, District 6, Toronto

## INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. Two three span structures have been proposed to carry the east and west bound lanes of Hwy. 407 over the West Humber River. This report contains factual information obtained from this investigation pertaining to structural foundations and related earthworks.

## SITE DESCRIPTION

The site is located just north of Steeles Ave. west at the West Humber River within the southern portion of Claireville Conservation Park owned by MTRCA. The area consists of a valley enclosing the river to the east and west.

The topography of the area consists of rolling grass lands with an abandoned apple orchard to the west, a marsh which encroaches on to the West Humber River, and a 9 m high embankment which leads to an unused farmers field to the east. A gravel road, Park Road runs parallel to the river on the west embankment, travelling west away from the site further north. While the east embankment is of a natural formation, the west appears to have had some earthwork to facilitate drainage of the valley into the West Humber River. Runoff from the west flows into a steel corrugated culvert which runs underneath Park Road. Immediately to the south there already exists a three span bridge structure crossing the West Humber River along Steeles Avenue. The natural ground level to the west varies from 167.0 m to 167.6 m, to the east varies from 170.6 m to 173.2 m and the ground elevation of the West Humber River is approximately 163 m with water depths ranging from 45 cm to 2 m at the time of the investigation. Water levels are expected to reach a minimum during winter months. Water levels are controlled by a dam located downstream operated by the MTRCA which remains open during the winter months.

Physiographically, the site is located in the geological domain known as the "Peel Plain". The "Peel Plain" is the product of the advance and retreat of the wisconsinan ice sheet which covered the area during the pleistocene epoch. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. At some locations, the till is overlain by thin deposits of varved clay. Till sheets of varying composition comprise the "Peel Plain". Generally, the surficial till sheets exhibit a cohesive behaviour whilst the lower till sheets are cohesionless. As characteristics of till material, these deposits contain a wide range of grain size ranging from boulders to clay.

The till sheets are usually separated from one another by interbeds of stratified silt or sand of variable thickness. Bedrock in the area has been found at depths ranging from 25 to 30 m below ground surface and consists of interbedded shale and limestone of the Dundas-Meaford formation, ordovician period.

#### INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and laboratory testing. The procedures employed are discussed below.

##### Field Investigation

The fieldwork for the investigation was carried out between 90 10 25 to 90 11 20 and consisted of a total of 16 boreholes, with 5 on the east embankment, 5 on the west embankment and 6 located within the swamp in the West Humber River. Thirteen boreholes were drilled initially with 3 holes completed two weeks later, commencing upon the drop of water levels as a result of opening the clareville dam located downstream. All boreholes were advanced to depths ranging from 9.6-14.2 metres. Boreholes were placed at abutment pier, and advanced structure locations.

The boreholes were advanced using conventional solid stem augering techniques. A track mounted continuous flight auger drill rig was employed for the operation.

In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 6 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586).

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

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled upon completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by Giffels Engineering Consultants under contract with Central Region Surveys and Plans.

#### Laboratory Analysis

The following laboratory tests were carried on select soil samples:

- 1) Atterberg Size Distributions
- 2) Grain Size Distributions
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on figures and borehole logs included in the Appendix.

#### SUBSURFACE CONDITIONS

##### General

The subsoil stratigraphy on the east embankment consists of a layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) which extended down to the terminated depths of the boreholes (9.6 m-11.1 m). Occasional seams of sandy silt were encountered at lower depths. Further west, at the flood plain of the West Humber River this layer was founded to extend

only 2.5 m to 5.5 m and was underlain by a non-cohesive heterogeneous mixture of sandy silt, clay and gravel (Glacial Till). At depths of approximately 7 m the material contained a greater percentage of gravel. To the west embankment the surficial deposit consisted of 6 m thick of the heterogeneous mixture of sandy silt, gravel and clay as above. Below this material the stratigraphy was similar to those described above with a 1 m-6 m layer of heterogeneous mixture of clayey silt, sand and gravel and the final layer extending to terminated depths, of non-cohesive heterogeneous mixture of sandy silt, clay and gravel. At the west embankment a pocket of heterogeneous mixture of clayey silt, sand and gravel was encountered extending 3.5 m down. A very small pocket of silt was also encountered embedded in the above material. Overall the area has a high percentage of silt and sand with varying proportions of clay and gravel.

The plan and location of boring and the stratigraphical profile are shown on Drawing No. 369870102-A. In the Attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets and in the Appendix of this report. A brief description of the different soil types is given below.

#### Silty Sand, trace of Organics

This deposit was only found at the surface of one Borehole (BH 2) in the west embankment. The layer extended 1.2 m deep.

Laboratory results of Grain Size Distribution indicated it comprised primarily of 25% gravel, 51% sand, 18% silt and 5% clay. The material had a compact state of density. In this stratum the Standard Penetration Resistance 'N' value was 12 blows/0.3 m indicating a compact state of density.

#### Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Underlying the above layer at one Borehole (BH 2) and found surficially in another (BH 1) at the west embankment, west abutment location is a layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) extending down with a thickness of 3.6 metres.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 1 in the Appendix, in an envelope form. The results summarize Grain Size Distribution Tests carried out on this material throughout the site. This deposit was also encountered, to be discussed later, at greater depths. The results indicate the material contains a large percentage of clay and silt with some sand and gravel. The deposit is comprised primarily of 0-26% Gravel, 11-56% sand, 24-69% silt and 5-38% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6.5-34.5	35
Liquid Limit ( $w_L$ )	20-37	35
Plastic Limit ( $w_p$ )	12-21	35
Plastic Index ( $I_p$ )	8-16	35

From the plasticity chart (Figure 2), the layer can be classified as a clayey silt of medium plasticity, the results summarize results carried out on this material throughout the site. This layer was encountered, to be discussed later, at greater depths.

In this stratum the Standard Penetration Resistance 'N' values ranged from 19 blows/0.3 to 65 blows/0.23 metres indicating the material had a very stiff to hard consistency.

#### Heterogeneous Mixture of Sandy Silt, Clay and Gravel (Glacial Till)

Underlying the two layers above in two boreholes (BH's 1 and 2) in the west embankment, west abutment locations and found surficially throughout the rest of the west embankment is a heterogeneous mixture of sandy silt, clay and gravel (Glacial Till). This layer extended down 5.5 m to 11.1 m.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 3 in the Appendix, in an envelope form. The results summarize Grain Size Distribution Tests carried out on this material throughout the site. This deposit was also encountered, to be discussed later, at greater depths. From the above figure it is evident that the layer contains a high proportion of fine sands and silt. The deposit is comprised primarily of 0-38% Gravel, 37-86% Sand, 10-66% Silt and 2-14% Silt.

The results from the Atterberg Limit Test performed on the fine fraction of this report is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	7-16	21
Liquid Limit ( $w_L$ )	13-14	21
Plastic Limit ( $w_p$ )	10-13	21
Plastic Index ( $I_p$ )	1-3	21

From the plasticity chart (Figure 4), the layer can be classified as a sandy silt. The above summarizes results carried out on this material throughout the site. This layer was encountered, to be discussed later, at greater depths.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 6 blows/0.3 m to >120 blows/0.2 m. Based on these 'N' values, the material can be described as having a loose to very dense state of relative density.

#### Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Throughout the west embankment underlying the above deposits is another 1.5 m-5.12 m layer of cohesive heterogeneous mixture of clayey silt, sand and gravel (Glacial till). This layer continues towards the east lying surficially with a thickness of 2.5-5.7 metres within the West Humber River (Flood Plain) and extending to the east embankment down to the termination length of the boreholes (11.1 metres). A higher proportion of silt was encountered at the surface within the West Humber River (Flood Plain).

Results of Grain Size Distribution Tests carried out on select samples as previously discussed are shown on Figure 1 in the Appendix, in an envelope form. Percentage of comprised materials are similar to those already stated.

Atterberg Limit Tests are similar to those previously stated, as seen on Figure 2. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of  $17.7 \text{ kg/m}^3$  to  $23.6 \text{ kg/m}^3$ .

In this stratum the Standard Penetration Resistance 'N' values ranged from 2 blows/0.3 m to >100 blows/0.3 m indicating the material ranged from very soft to hard. The very soft to firm zones were only encountered within the West Humber River (Flood Plain), thus excluding this area the layer generally had a very stiff to hard consistency.

#### Heterogeneous Mixture of Sandy Silt, Clay and Gravel (Glacial Till)

Underlying the heterogeneous mixture of clayey silt at the west embankment and within the West Humber River (Flood Plain) is a heterogeneous mixture of sandy silt, clay and gravel (Glacial Till). This layer was encountered at depths of 10.1-10.9 m at the west embankment and at depths of 2.5-5.6 metres within the West Humber River, extending down to the terminated depths of the boreholes. At approximately a depth of 8 m a greater percentage of gravel was found at the West Humber River (Flood Plain).

Results of Grain Size Distribution Tests carried out on select samples as previously discussed are shown on Figure 3 in the Appendix, in an envelope form. Percentage of comprises materials are similar to those previously stated.

Atterberg Limit Tests are similar to those previously stated, as seen on Figure 4. Unit weight measurements carried out on samples from this stratum yielded a dry unit weight of  $21.8 \text{ kg/m}^3$ .

In this stratum the Standard Penetration Resistance 'N' values ranged from 24 blows/0.3 m to >120 blows/0.2 m, indicating a dense to very dense state of relative density.

### GROUNDWATER CONDITIONS

Observations of the groundwater level were carried out by measuring the water level in the open boreholes.

Groundwater levels determined at the time of the investigation varied throughout the site, with the east/west abutments having elevations approximately of 168 m and 165 m respectively. As you get nearer to the West Humber River the water levels get drawn down to the current water level of the river. The water level of the West Humber River varied from 164.2 m to 163.5 m, with the depth varying from 2 m to 45 cm. Water levels decrease during the winter months.

The depth of water in the river is a function of the weather and time of season but is primarily controlled by the dam located downstream. This dam remains open during the winter months thus lowering water levels.



## DISCUSSION AND RECOMMENDATIONS

It is proposed to construct two three span structures each with 26-27 m widths and having end spans of 45 m and a central span of 50 metres, which will carry the east and west bound lanes of Hwy. 407 over the West Humber River in the City of Brampton/Town of Vaughan, Regional Municipality of Peel. Approach fills in the order of magnitude of 8 m for the west and 1 m are needed for the east. The proposed structure calls for the top of pavement for Hwy. 407 EBL and WBL to be at an elevation of approximately 174 m with a Grade of -0.800%. A plan illustrating the proposed structure is shown on Drawing No. 369870102-A in the Appendix of this report.

Piers are located within the marsh encroaching on the West Humber River and Abutments are located immediately east and west of the river.

Current plans specify two 5 lane structures with an option to expand an extra lane on each structure in the future.

The bridge crossing the West Humber River at Steeles Avenue which is approximately 60 m from the proposed structure was constructed in 1963 and is founded on spread footings on the upper fill and is performing satisfactorily. Specific founding elevations are understood to be 160 m for abutments and 158 m for the piers.

The natural ground surface throughout the site was quite variable with the west abutment, east abutment and pier locations having an elevation of 167 m, 173 and 163.7 m respectively.

To facilitate the design and construction of the proposed structure foundations and related earthworks for the approach ramps over the West Humber River, the following foundation and Geotechnical recommendations are provided in the scope of this report.

- 1) Structure Foundations
- 2) Slope Stability
- 3) Lateral Earth Pressure
- 4) Construction Consideration

# 1) Structural Foundations

While three structural options are discussed below, it should be noted that this office recommends the use of shallow spread footings founded on the native soil or perched within the fill for the abutments and either caissons or piles for the pier foundations. Shallow spread footings would avoid problems of dewatering. For the pier locations piles may be more advantageous to use because dewatering for caisson construction may be a problem.

## A. Abutments - Shallow Spread Footing

Shallow spread footings are recommended for the east and west abutments. At the east abutment, the footings would be located on native soil and at the west abutment the footings would be perched within the compact granular fill.

For the west abutment spread footings founded on a Granular 'A' core with an assumed footing width of 3 m (see Figure 5) and constructed as per MTO Standards, the following design parameters are recommended:

Table 1 - Spread Footing Within Fill

	<u>Factored Capacity At U.L.S. (kPa)</u>	<u>Allowable Capacity At S.L.S. Type II (kPa)</u>	<u>West Abutment Elev. (m)</u>
Spread Footings	900	350	173 +/-

For the east abutment founded on or within the native soil also with an assumed footing width of 3 m, the following design parameters are recommended:

Table 2 - Spread Footings on Native

	<u>Factored Capacity At U.L.S. (kPa)</u>	<u>Allowable Capacity At S.L.S. Type II (kPa)</u>	<u>East West Abutment Elev. (m)</u>
Spread Footings	600	400	171 +/-

Bearing capacity reduction to account for inclination of loads acting on shallow foundations shall be carried out in accordance with Section 6-7.3.3.5 of the O.H.B.D.C.

B. Abutments, Piers - Deep Piles

Piers and abutments can be founded on piles.

For purposes of the O.H.B.D.C., the design axial capacity for vertical piles are summarized in Table 3 below:

Table 3 - Axial Capacities - Driven Steel H-Piles

<u>Pile type</u>	<u>Factored Capacity at U.L.S. (kN)</u>	<u>Allowable Capacity at S.L.S. Type II (kN)</u>	<u>Est. Pile Tip Elev. (m)</u>			
			<u>Piers</u>		<u>Abutments</u>	
			<u>East</u>	<u>West</u>	<u>East</u>	<u>West</u>
HP310x110	1600	1150	±156	±155-146	±164	±159-161
HP310x79	1150	890	±156	±155-156	±164	±159-161

The installations of the piles shall be controlled and monitored employing the Hiley dynamic driving formula, driven in accordance with MTO Standards. Assuming an ultimate capacity as tabulated in Table 4 below.

Table 4 - Ultimate Capacity Employing  
Hiley Dynamic Formula

<u>Pile Type</u>	<u>Ultimate Capacity (kN)</u>
HP310x110	3450
HP310x79	2670

Pile spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. Adjacent piles should be checked for heaving during pile installation. Lateral loads shall be supported by batter piles. All piles should be provided with the Standard MTO Pile tip reinforcement (Standard Drawing DD3301).

Excavation for piers should be scheduled during winter months when the river water elevation is low. Some special measures may be required for the construction of pile caps. The construction area may be surrounded by a suitable cofferdam using steel sheet piles and construction carried out from within the enclosure.

C. Abutments, Piers - Drilled Concrete Caissons

Alternatively, structure foundations can be founded on end bearing reinforced concrete caissons installed in drilled shafts. The design axial capacities and founding elevations for 0.76 m diameter concrete caissons are summarized in Table 4 below.

Table 4 - Axial Capacities - Caissons

	Factored Capacity at U.L.S.	Bearing Capacity at S.L.S. Type II	Estimated Pile Tip Elevation
<u>Structure</u>	<u>(kN)</u>	<u>(kN)</u>	<u>(m)</u>
W. Abut.	2250	1500	±159-161
E. Abut.	2250	1500	±164
W. Piers	2250	1500	±155-156
E. Piers	2250	1500	±156

Capacity for other caisson diameters can be obtained in proportion to the respected end bearing areas.

Resistance to lateral load shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

Presence of cohesionless tills at the proposed tip elevations together with relatively high water levels would necessitate special construction measures during the installation of caissons, subject to review by this office.

Silty sand layers submerged beneath the prevailing ground water table can be anticipated at the pier locations (particularly the west piers which could cause cave-ins during construction of caisson. Mud drilling techniques or caisson installation within a steel liner can be used to facilitate penetration through these layers.

2) Slope Stability

No stability problems are anticipated for the proposed 8 m approach fill embankment to the west or the 1 m fill approach to the east constructed with 2H:1V side slopes.

However, if embankment fills exceed 8 m contact this office for further comments.

In addition, an effective erosion control protection scheme, such as sodding, should be provided to protect the exposed slopes. Settlements in the order of magnitude of 80 mm are anticipated at the west abutment due to elastic recompression of the native subsoil and settlements within the fills under its own weight. It is predicted that the majority of settlements will be realized during or immediately following the construction of the embankment.

### 3) Lateral Earth Pressures on Structure

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up. Design parameters of the soil are given below.

Table 4 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction ( $\phi$ )	35°	30°
Unit Weight (kN/m <sup>3</sup> )	22.8	21.2
*Coefficient of Active Earth Pressure (Ka)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure at Rest (Ko)		
- S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

\*Horizontal surface backfill only. Appropriate consideration must be given to sloping surface backfill.

The earth pressure coefficient at rest is to be used in design if the abutment walls are rigid and unyielding. The tabulated earth pressure coefficients are applicable to horizontal surfaces only. The values must be modified to represent sloping surfaces. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

The backfill should be constructed in 300 mm lifts on alternating sides of rigid frame structure so that the maximum differential in backfill heights at no time exceeds 300 mm O.P.S.D. 803 series illustrates the applicable backfill standards and specifications.

#### 4) Construction Considerations

All pile caps and footings shall be protected against frost providing a minimum 1.2 m of earth cover.

No dewatering problems are anticipated for the construction of shallow footings for the east/west abutments. However at the pier locations, depending on the climate and whether the clareville dam is open or closed pile cap construction may intercept the water table, therefore a dewatering scheme would have to be considered. Particular attention should be given to the west piers due to a high percentage of sandy silty encountered (1 m depth) near the surface within the heterogeneous mixture of clayey silt, sand and gravel and due to the nearby het. mixture of sandy silt encountered at a 2.5 m depth. These deposits may cause softening at the base of the pile caps.

A dewatering scheme consisting of an oversized excavation with perimeter ditches within a gravity system will be required. A sump pump discharge system to drain accumulated water will also be required.

Within the limits of the approach fills, if soft soil is encountered, this should be excavated and replaced by compact granular fill.

Even though boulders were not encountered in the boreholes carried out at this site, based on geological evidence cobbles and boulders should be excavated in glacial till deposits.

Special consideration should be given to the design of the west abutment due to the presence of Park Road located (relatively close) just east of the proposed structure. A closed abutment, retaining wall, moving the structure further west or possibly relocating Park Road east are some of the options, which may become necessary to implement.

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of M. Michalek, Jr. Foundation Engineer, utilizing equipment owned and operated by Archer Drilling and Master Soil Investigation.

The project was carried out under the general supervision of Dr. B. Iyer, Sr. Foundation Engineer. The report was written by M. Michalek, reviewed by Dr. B. Iyer and approved by Mr. M.Devata, Chief Foundation Engineer.

*M. Michalek*

M. Michalek  
Jr. Foundation Engineer



*M. Devata*

M. Devata, P.Eng.  
Chief Foundation Engineer

## APPENDIX



## 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 - 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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	T.W. ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	T.W. ADVANCED MANUALLY
TW	THINWALL OPEN	FS	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

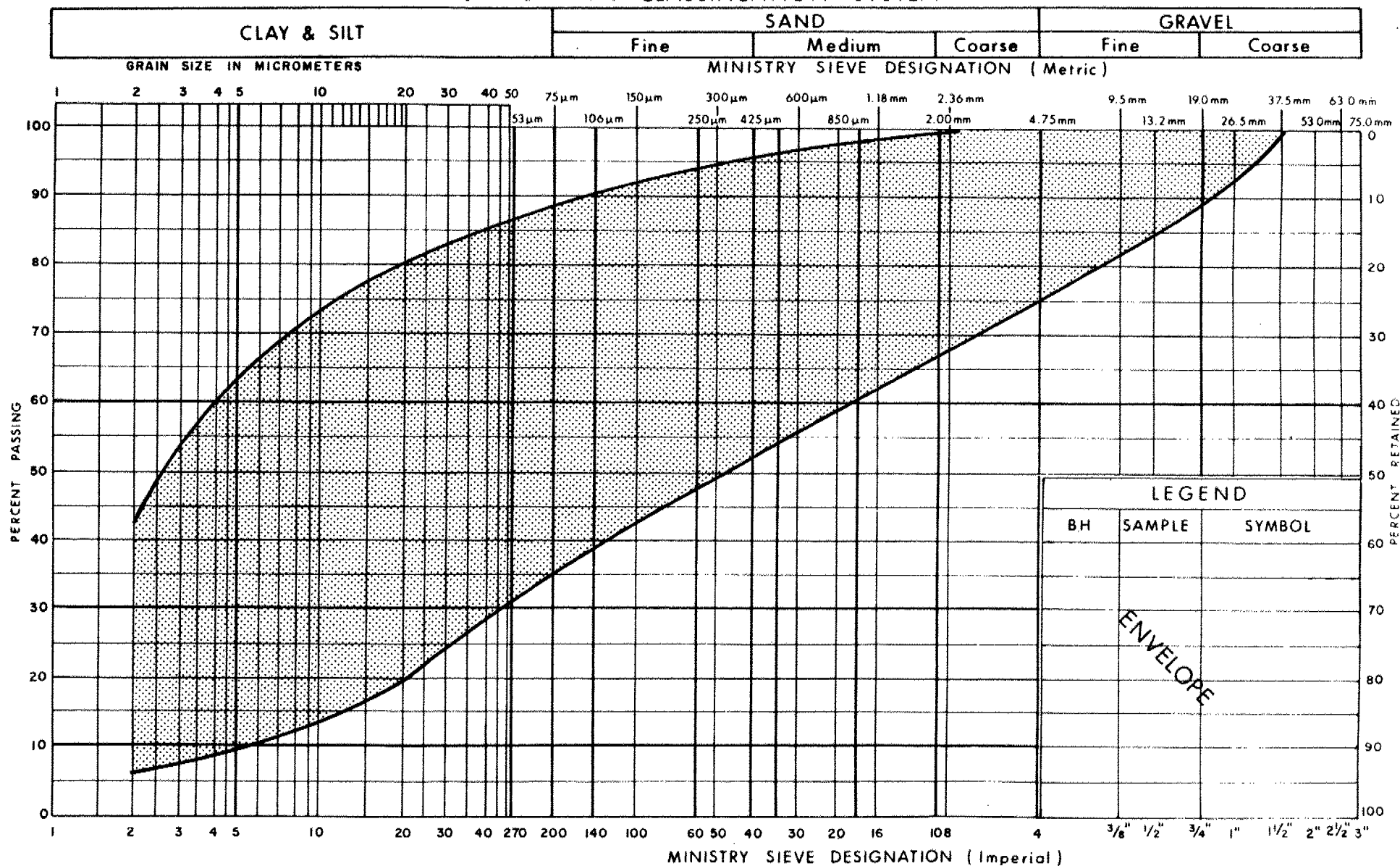
### MECHANICAL PROPERTIES OF SOIL

$m_v$	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
$S_t$	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>3</sup>	SEEPAGE FORCE
$\gamma'$	kn/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

## UNIFIED SOIL CLASSIFICATION SYSTEM

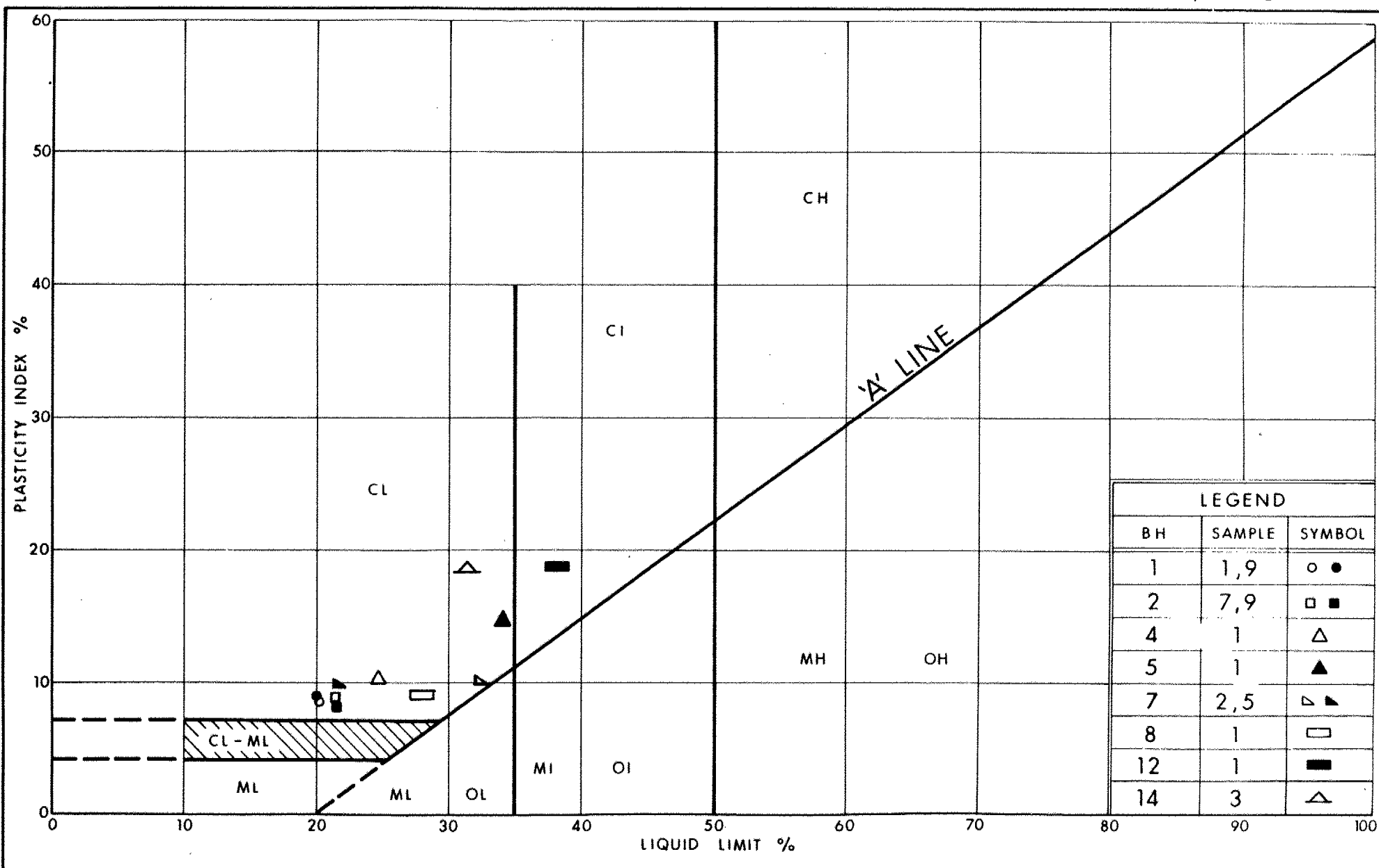


Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL**  
 (GLACIAL TILL)

FIG No 1

W P 369-87-01/02



Ministry of  
Transportation

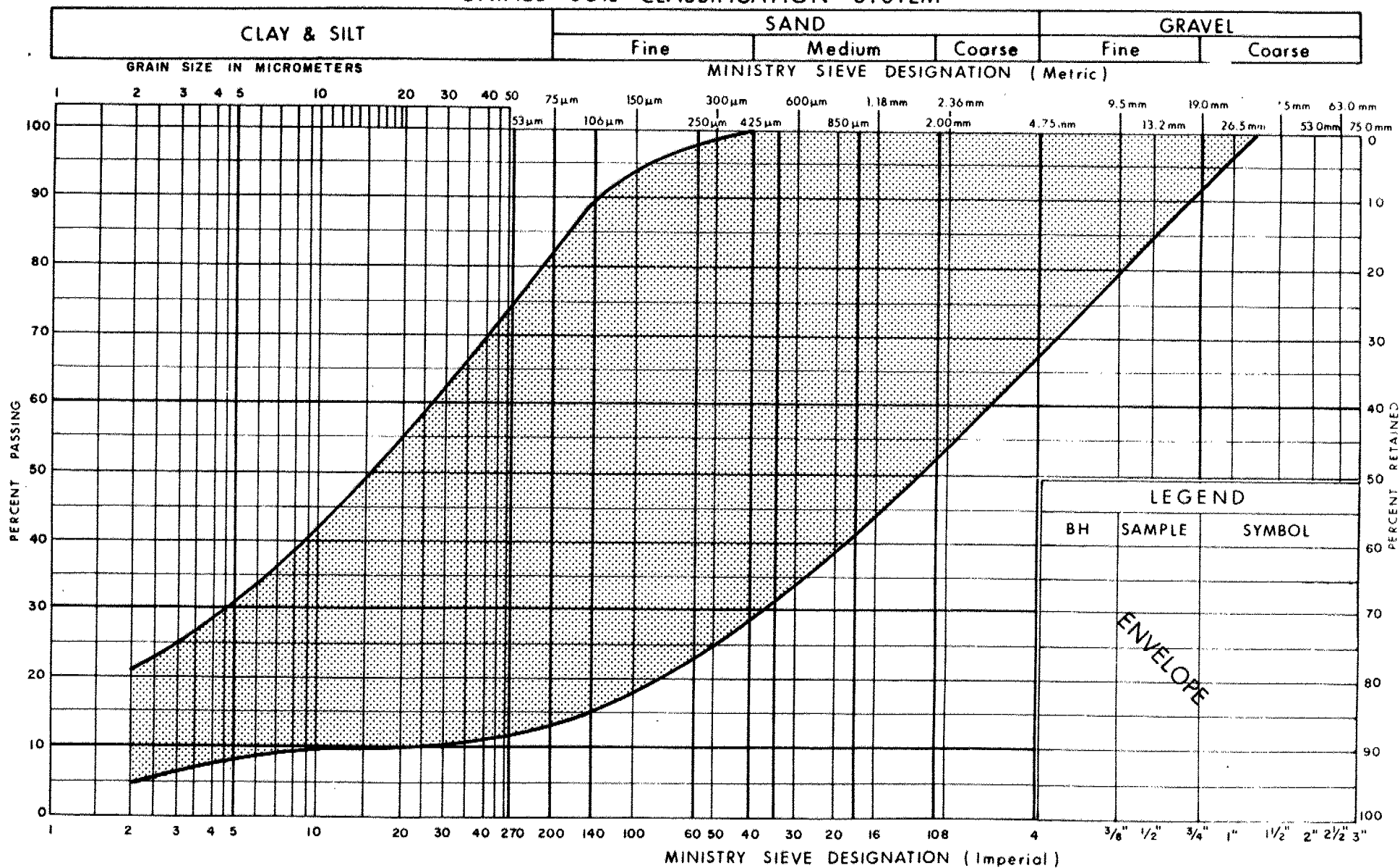
Ontario

PLASTICITY CHART  
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL  
(GLACIAL TILL)

FIG No 2

W P 369-87-01/02

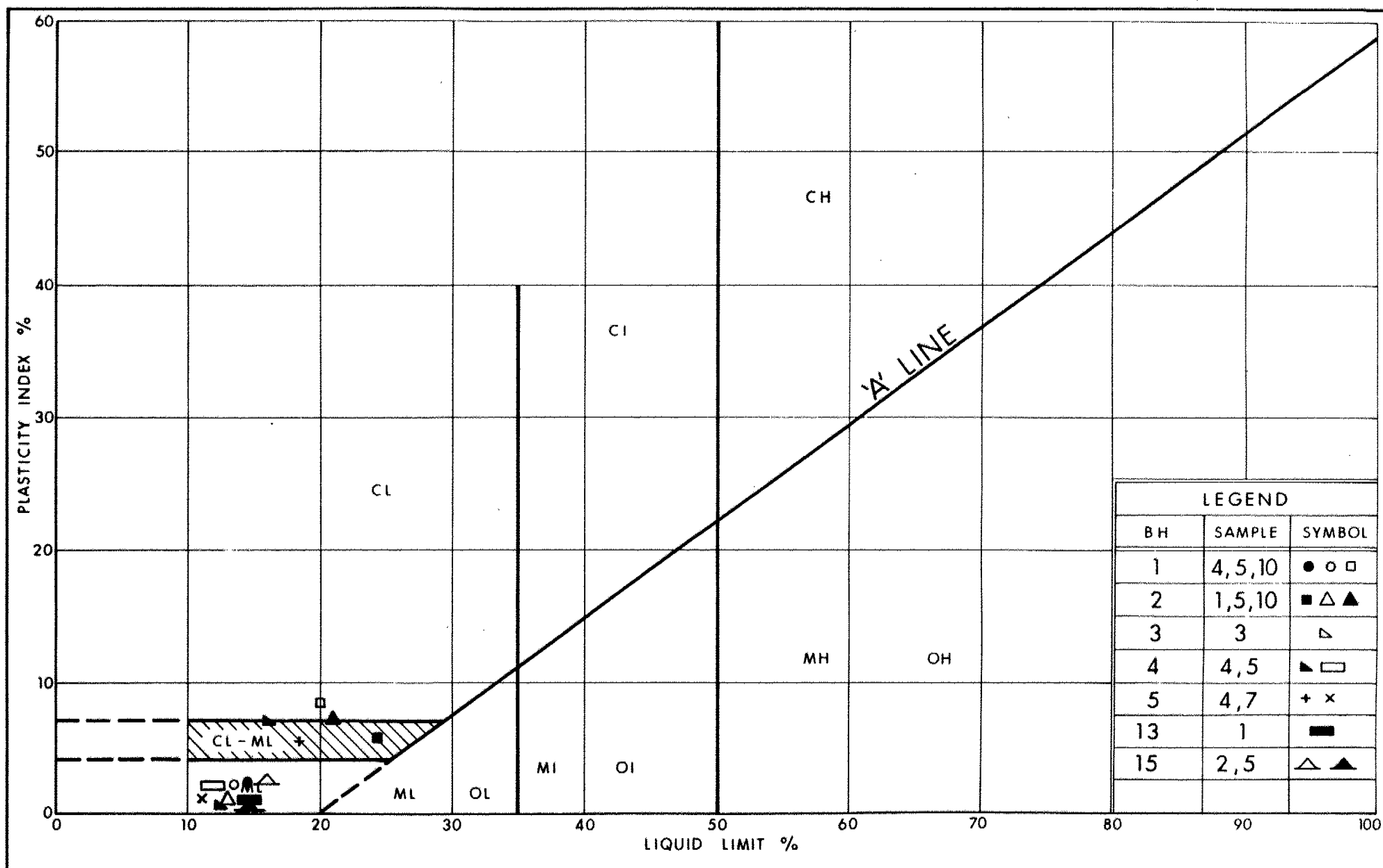
## UNIFIED SOIL CLASSIFICATION SYSTEM


 Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**HETEROGENEOUS MIXTURE OF SILT & SAND, CLAY & GRAVEL**  
 (GLACIAL TILL)

FIG No 3

W P 369-87-01/02



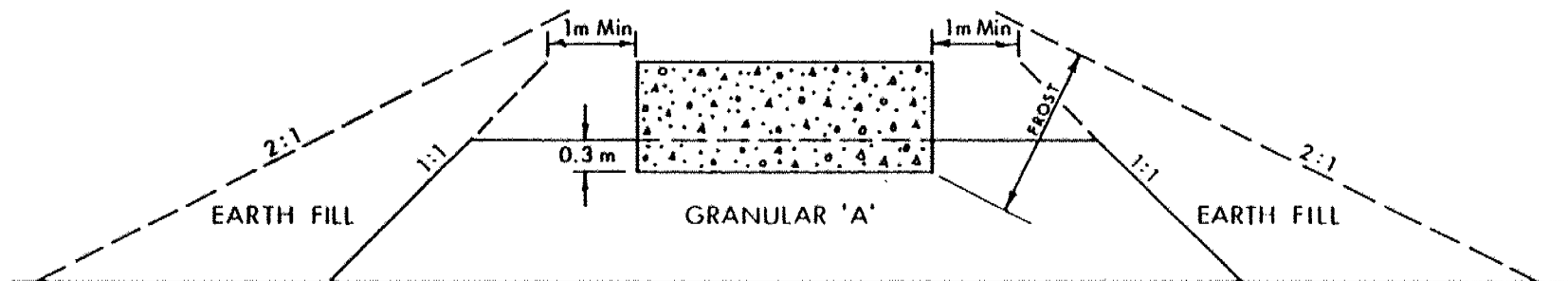
Ministry of  
Transportation

Ontario

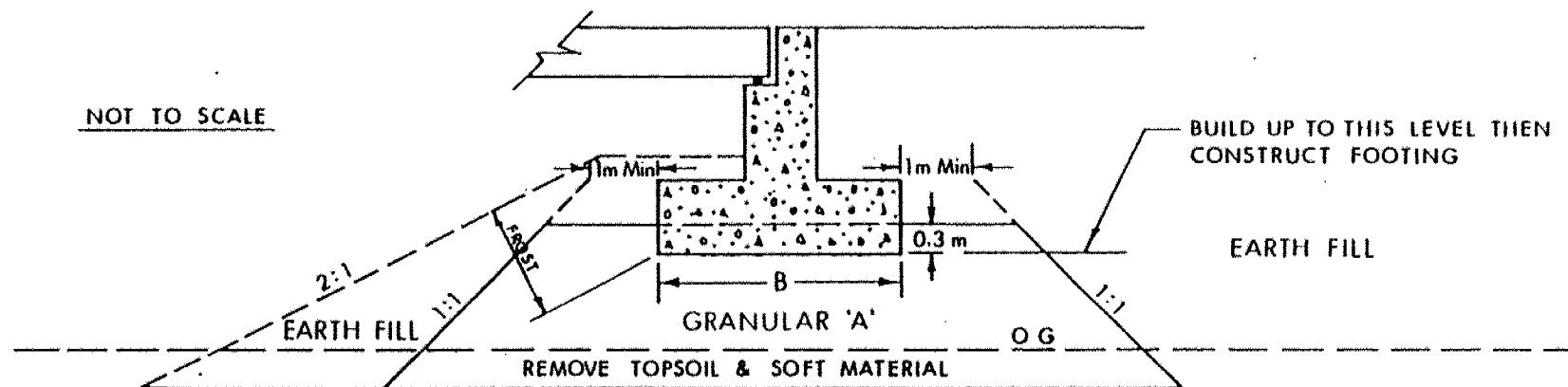
**PLASTICITY CHART**  
**HETEROGENEOUS MIXTURE OF SILT & SAND, CLAY & GRAVEL**  
 (GLACIAL TILL)

FIG No 4

W P 369-87-01/02



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1- REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2- PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.
- 3- CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



Ministry of  
Transportation

ABUTMENT ON COMPACTED FILL  
SHOWING GRANULAR 'A' CORE

FIG No 5

W P 369-87-01/02

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 088.0, E 293 210.5  
DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER  
DATUM GEODETTIC DATE 90/10/01  
ORIGINATED BY M.M.  
COMPILED BY M.M.  
CHECKED BY B.J.

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					
167.0	Ground Surface																
0.0																	
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		1	SS	62	/23cm	166										12 36 36 16
			2	SS	50	/5cm	165										
			3	SS	44		164										
163.4			4	SS	24		163										
3.6			5	SS	24		162										
	Heterogeneous mixture of Sand, Silt and Gravel, trace Clay (Glacial Till) Compact to Very Dense		6	SS	20		161										
			7	SS	120	/23cm	160										
			8	SS	120	/15cm	159										
158.4							158										
8.6			9	SS	60	/10cm	157										
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard						156										
156.9			10	SS	120	/10cm											
10.1																	
	Heterogeneous mixture of Sand, Silt and Gravel, trace Clay (Glacial Till) Very Dense																
155.9																	
11.1	End of Borehole																

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 106.5, E 293 189.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
167.2	Ground Surface																
0.0	Silty Sand trace Organics Compact		1	SS	12												26 51 18 5
165.6			2	SS	19												
1.6	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		3	SS	51												
164.3			4	SS	56												
2.9	Heterogeneous mixture of Silt, Sand and Gravel, Trace Clay (Glacial Till) Very Dense		5	SS	62												8 44 36 12
			6	SS	94												
161.7			7	SS	102												4 56 30 10
5.5	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		8	SS	60	/5cm											
			9	SS	120	/15cm											10 46 29 15
156.3			10	SS	120	/10cm											36 36 22 6
10.9	Heterogeneous mixture of Silt, Sand and Gravel, trace Clay (Glacial Till) Very Dense		11	SS	105	/23cm											
154.6																	
12.6	End of Borehole																



# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 389-87-01/02 LOCATION Coords: N 4 845 126.0, E 293 166.0 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
167.1	Ground Surface															
0.0	Heterogeneous mixture of Silt, Sand and Gravel, trace Clay (Glacial Till) Compact to Very Dense		1	SS	14											23 57 13 7
			2	SS	22											
			3	SS	94											7 43 36 14
			4	SS	81											
			5	SS	108											
162.7	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		6	SS	103										23.7	7 37 36 20
4.4			7	SS	120	/10cm										
			8	SS	130	/28cm										
157.5	End of Borehole		9	SS	130	/15cm										
9.6																

# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 122.5, E 293 241.0 ORIGINATED BY M.M.  
DIST 5 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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					
164.2	Wet Marsh - 400 mm Water Level																
0.0																	
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)																
	Firm to Hard		1	SS	4												0 17 63 20
	Sandy Silt																
	Firm Very Stiff																
			2	SS	16												
	Hard																
			3	SS	55												
158.7																	
5.5																	
	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till)		4	SS	60												24 45 26 5
	Very Dense																
			5	SS	73	/15cm											3 71 16 10
			6	SS	120	/15cm											
	Becoming Gravelly		7	SS	80	/15cm											
151.6			8	SS	115	/20cm											
12.6	End of Borehole																

# RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 142.0, E 293 218.5 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY B.J.

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					
164.1	Wet Marsh-- 400 mm Water Level																
0.0																	
	Sandy Silt		1	SS	2												0 29 56 15
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		2	SS	4												
161.6	Soft		3	SS	3												0 70 25 5
2.5			4	SS	24												8 20 64 8
	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till)		5	SS	46												
	Compact to Very Dense		6	SS	60												
			7	SS	56												6 47 36 11
			8	SS	110	/10cm											27 61 6 6
	Becoming Gravelly		9	SS	110	/18cm											
			10	SS	110	/18cm											
			11	SS	120	/25cm											
151.5																	
12.6	End of Borehole																

+3, x3: Numbers refer to  
Sensitivity

20  
15-20 (X) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 389-87-01/02 LOCATION N 4 845 162.0, E 293 196.0 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
164.2	SWAMP, 300 mm WATER LEVEL													
0.0							164							
	Sandy Silt						163							
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	5		162							0 31 59 10
	Firm to Very Stiff Brown Grey		2	SS	4		161							9 34 44 13
160.5			3	SS	34		160							
3.7			4	SS	31		159							
	Heterogeneous mixture of Silt and Sand Clay and Gravel (Glacial Till) Compact to Very Dense		5	SS	19		158							3 69 25 3
			6	SS	101		157							
			7	SS	109	/20cm	156							
			8	SS	101	/15cm	155							38 53 6 3
	Becoming Gravelly		9	SS	106	/15cm	154							
153.1														
11.1	End of Borehole													

+3, x3: Numbers refer to  
Sensitivity

20  
15-25 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 389-87-01/02 LOCATION Coords: N 4 845 158.0, E 293 274.5  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger ORIGINATED BY M.M.  
 DATUM GEODETTIC DATE 90/01/09 COMPILED BY M.M.  
 CHECKED BY B.I.

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>	WATER CONTENT (%) W	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						
164.1	Wet Marsh, 100 mm Water Level																	
0.0																		
	Brown		1	SS	3		163										17.8	0 26 62 12
	Grey		2	SS	2		162											
	Soft		3	SS	3		161											
	Very Stiff		4	SS	18		160										21.4	8 36 33 21
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		5	SS	4		159											
			6	SS	68		158											
158.5							157											
5.6							156											
	Heterogeneous mixture of Silt and Sand Clay and Gravel (Glacial Till) Very Dense		7	SS	107	/23cm	155											1.5 56 36 6.5
			8	SS	148		154											
	Becoming Gravelly		9	SS	129	/20cm	153											
			10	SS	125	/20cm	152											
			11	SS	118	/23cm	151											
148.9			12	SS	130	/15cm	150											1 76 16 7
14.2	End of Borehole																	

# RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 389-87-01/02 LOCATION Coords: N 4 845 180.0, E 293 250.0 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY M.M.  
 DATUM GEOIDETIC DATE 90/10/01 CHECKED BY B.J.

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					
164.0	Wet Marsh																
0.0																	
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	3		183									19.6	0 39 48 13
	Soft		2	SS	5		182										
	Very Stiff		3	SS	14		161										25 30 29 16
	Brown		4	SS	30		160										
	Gray		5	SS	33		159										25 30 29 16
159.6			6	SS	79		158										
4.4	Heterogeneous mixture of Silt and Sand Clay and Gravel (Glacial Till) Very Dense		7	SS	112	/23cm	157										
			8	SS	100	/15cm	156										
			9	SS	112	/23cm	155										
	Becoming Gravelly		10	SS	116	/25cm	154										
152.9							153										32 60 6 2
11.1	End of Borehole																

+3, x3: Numbers refer to  
Sensitivity

20  
13-5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 200.0, E 293 227.5 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.I.

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>	WATER CONTENT (%) w	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						
163.8	Ground Surface																	
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	2		163											0 44 44 12
	Soft		2	SS	2		162											
	Stiff		3	SS	15		161											4 62 28 6
	Brown		4	SS	62		160											
	Grey		5	SS	130		159											
	Hard		6	SS	80		158											13 44 29 14
158.3							157											
5.6	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till) Very Dense		7	SS	121	/20cm	156											1 86 9 4
			8	SS	90	/8cm	155											
	Becoming Gravelly		10	SS	100	/13cm	154											
152.7			11	SS	131		153											
11.1	End of Borehole																	

# RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 389-87-01/02

LOCATION Coords: N 4 845 196.0, E 293 307.0

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.I.

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					
172.0	Ground Surface																
0.0																	
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	27		171										
			2	SS	63		170										
			3	SS	53		169									22.8	7 26 37 30
			4	SS	52		168										3 34 36 27
			5	SS	49		167										
			6	SS	28		166									22.1	5 28 45 22
			7	SS	73	/15cm	165										
			8	SS	70	/15cm	164										17 38 31 14
			9	SS	107	/10cm	163										
			10	SS	80	/13cm	162										
160.9							161										7 36 39 18
11.1	End of Borehole																

+3, x5, Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 389-87-01/02

LOCATION Coords: N 4 845 216.0, E 293 280.0

ORIGINATED BY M.M.

DIST 5 HWY 407

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY M.M.

DATUM GEODETIC

DATE 90/10/01

CHECKED BY B.I.

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	IN' VALUES		20	40	60	80	100					
171.1	Ground Surface															
0.0																
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	17											7 25 43 25
			2	SS	38											
			3	SS	33											
			4	SS	49											
			5	SS	75	/5cm									23.0	7 23 39 31
			6	SS	100	/15cm										7 39 44 10
			7	SS	88											
			8	SS	100	/15cm										19 35 31 15
			9	SS	100	/15cm										
161.5																
9.6	End of Borehole															

# RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 236.0, E 293 258.0 ORIGINATED BY M.M.  
DIST 5 HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY M.M.  
DATUM GEODETIC DATE 90/10/01 CHECKED BY D.T.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	WATER CONTENT (%) w	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						
170.6	Ground Surface																	
0.0																		
	Heterogeneous mixture of Clayey Silt, Sand and Gravel  (Glacial Till)  Very Stiff to Hard		1	SS	26		170										20.6	3 17 42 38
			2	SS	49		169											
			3	SS	63		168											8 35 40 17
			4	SS	78		167											
							166										24.0	13 26 42 19
			6	SS	123		165											4 38 48 10
							164											
			7	SS	105		163											
							162											
161.0			8	SS	126													
9.6	End of Borehole																	

# RECORD OF BOREHOLE No 13

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 078.0, E 293 186.0 ORIGINATED BY M.M.  
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.  
DATUM GEODETTIC DATE 90/10/01 CHECKED BY B.I.

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					
167.4	Ground surface																
0.0	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till) Compact to Very Dense Brown ----- Grey		1	SS	19		167										2 53 35 10
			2	SS	34		166										
			3	SS	68		165										
			4	SS	54		164										
			5	SS	88		163										
			6	SS	83		162										0 54 44 2
161.9							161										
5.5	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	100	/15cm	160										
			8	SS	100	/10cm	159										
157.8			9	SS	150	/15cm	158									22.2	6 32 49 13
9.6	End of Borehole																

# RECORD OF BOREHOLE No 14

1 OF 1

METRIC

W.P. 369-87-01/02 LOCATION Coords: N 4 845 220.5, E 293 313.0 ORIGINATED BY M.M.  
 DIST 6 HWY 407 BOREHOLE TYPE Solid Stem Auger COMPILED BY M.M.  
 DATUM GEODETIC DATE 90/10/01 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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	w <sub>p</sub>	w	w <sub>L</sub>		
173.1	Ground surface																
0.0																	
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	38		172										0 18 40 42
			2	SS	30		171										3 11 41 45
			3	SS	68		170										
			4	SS	42		169										
			5	SS	30		168										
			6	SS	27		167										
			7	SS	122		166										
			8	SS	102		165										
			9	SS	70	/15cm	164										
163.5																	3 14 69 14
9.5	End of Borehole • Water level not encountered																

# RECORD OF BOREHOLE No 15

1 OF 1

METRIC

W.P. 369-87-01/02

LOCATION Coords: N 4 845 100.0, E 293 159.5

ORIGINATED BY M.M.

DIST 6 HWY 407

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY M.M.

DATUM GEODETTIC

DATE 90/10/01

CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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					W <sub>p</sub>	W	W <sub>L</sub>		
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL * LAB VANE 20 40 60 80 100									
							WATER CONTENT (%) 25 50 75										
167.5	Ground surface																
0.0	Heterogeneous mixture of Silt and Sand, Clay and Gravel (Glacial Till)  Loose ----- Very Dense  Brown ----- Grey		1	SS	6												
			2	SS	44							41				6 46 41 7	
			3	SS	59												
			4	SS	59												
			5	SS	31							10				1 38 54 7	
			6	SS	55												
162.0																	
5.5	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	90	/15cm						10				26 28 33 13	
			8	SS	126	/25cm											
			9	SS	120	/15cm										4 24 64 8	
157.9																	
9.6	End of Borehole																

1 OF 1

METRIC

**LOCATION**

Coords: N 4 845 245.5, E 293 282.0

ORIGINATED BY M.M.

DIST 6

HWY 407

BOREHOLE TYPE

### Hollow Stem Auger

COMPILED BY M.M.

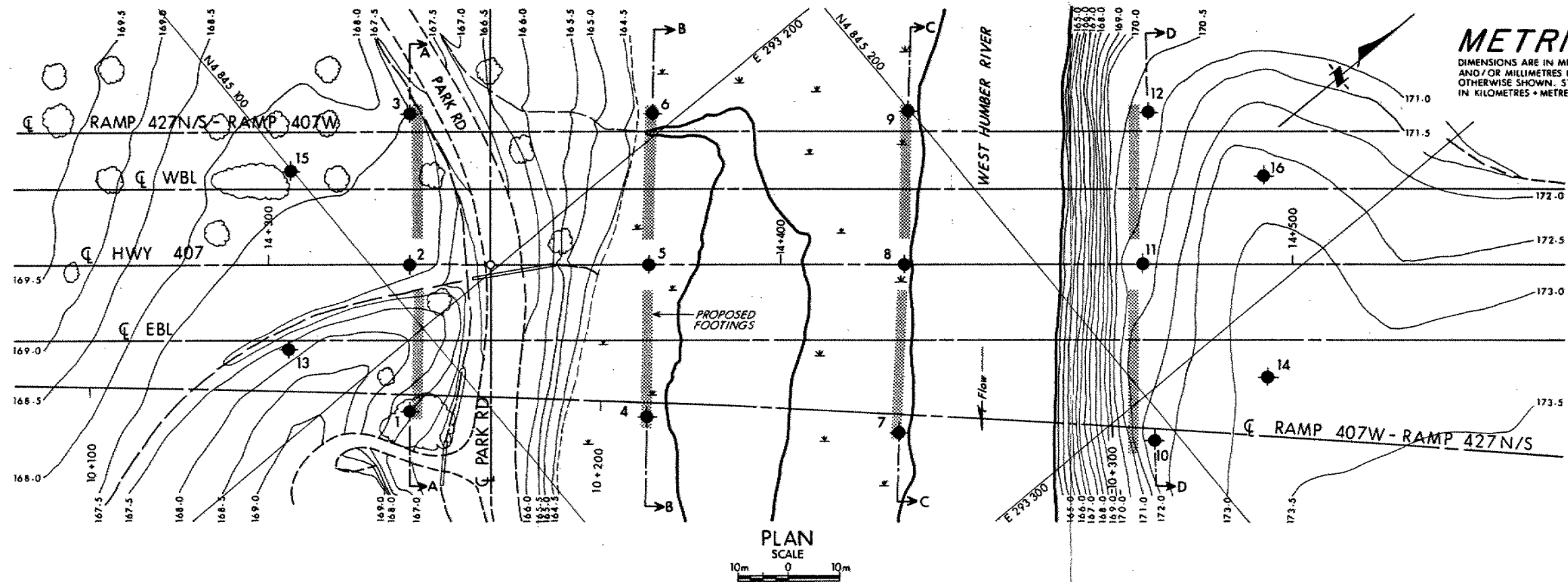
DATUM GEODETIK

DATE \_\_\_\_\_

90/10/01

— CHECKED BY B.I.

+3, x5: Numbers refer to Sensitivity



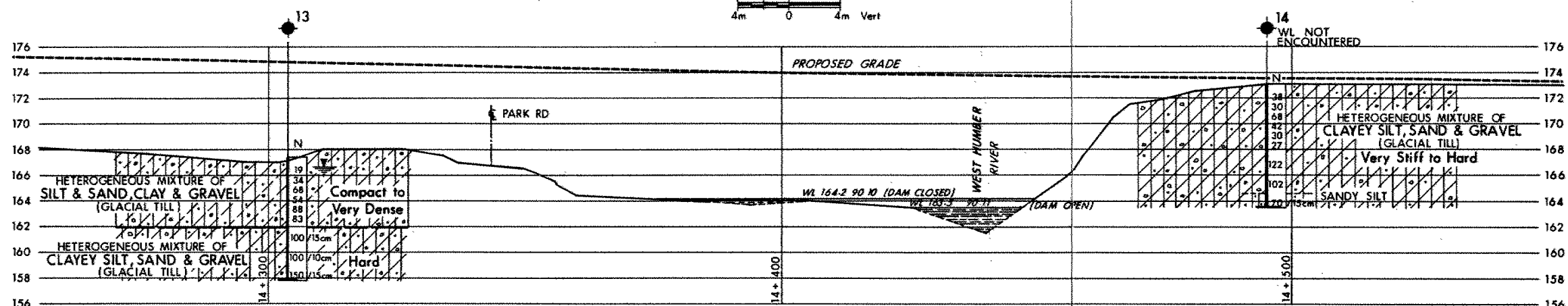
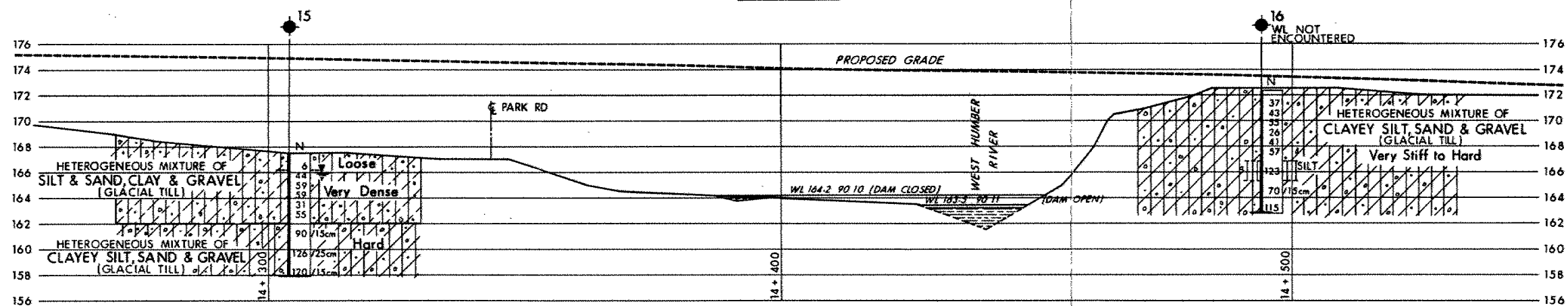
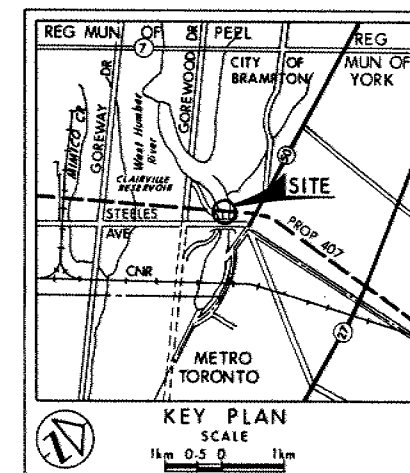
CONT No  
WP No 369-87-01/02

WEST HUMBER RIVER

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



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 90 10

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	167.0	4 845 088.0	293 210.5
2	167.2	4 845 106.5	293 189.0
3	167.1	4 845 126.0	293 166.0
4	164.2	4 845 122.5	293 241.0
5	164.1	4 845 142.0	293 218.5
6	164.2	4 845 162.0	293 196.0
7	164.1	4 845 158.0	293 274.5
8	164.0	4 845 180.0	293 250.0
9	163.8	4 845 200.0	293 227.5
10	172.0	4 845 196.0	293 307.0
11	171.1	4 845 216.0	293 280.0
12	170.6	4 845 236.0	293 258.0
13	167.4	4 845 078.0	293 186.0
14	173.1	4 845 220.5	293 313.0
15	167.5	4 845 100.0	293 159.5
16	172.4	4 845 245.5	293 282.0

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, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

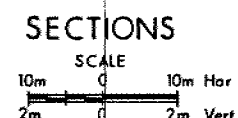
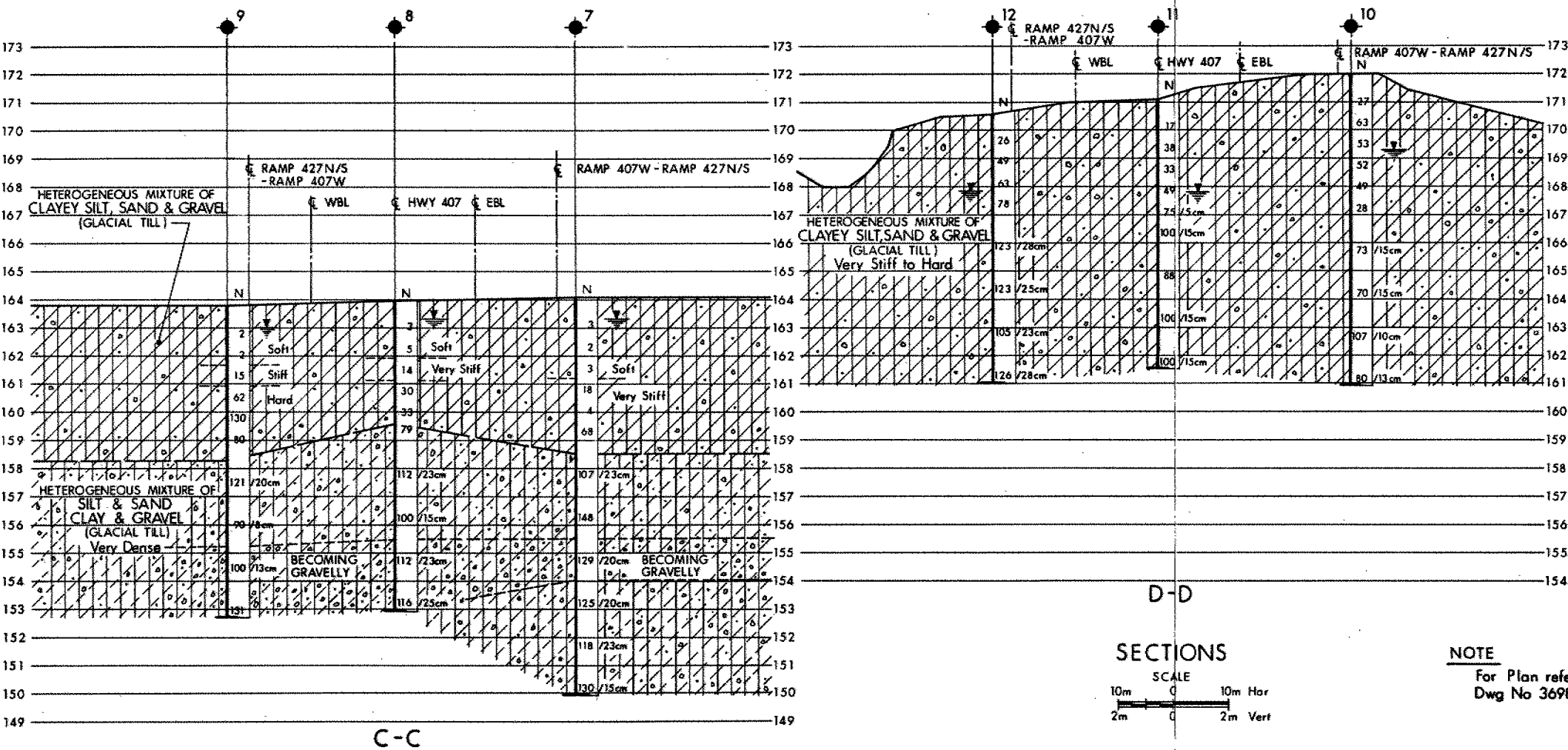
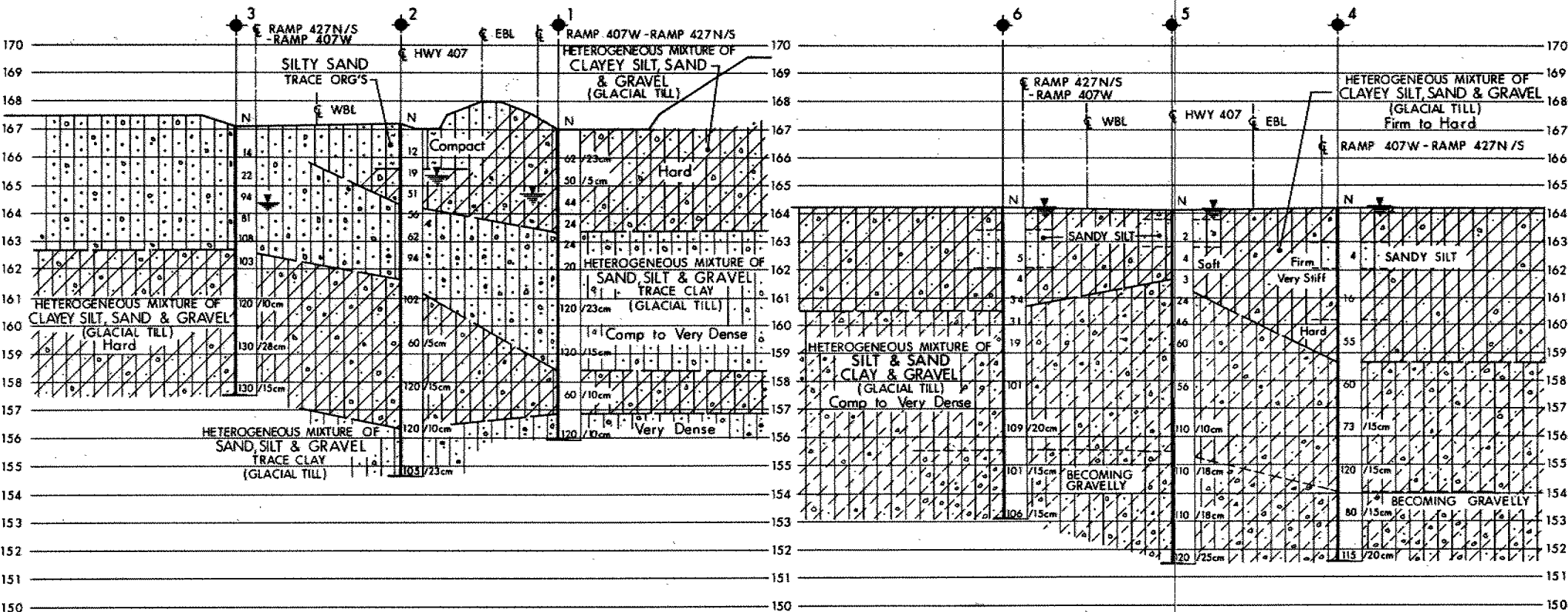
REV.	DATE	BY	DESCRIPTION

Geocres No 30M12-216

HWY No 407	SUBMD MM	CHECKED	DATE 91 03 11	DIST 6
DRAWN DT	CHECKED	APPROVED	SITE 24-653 A&B	DWG 369870102-A

NOTE:  
For Sections Refer to Dwg No 369870102-A

REF No E-199-407-6, 90 05



**NOTE**  
For Plan refer to  
Dwg No 369870102-A

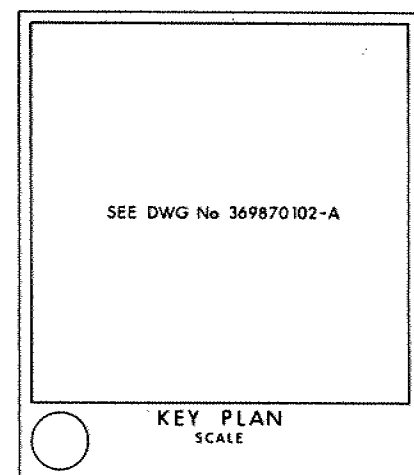
**METRIC**  
DIMENSIONS ARE IN METRES  
AND / OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 369-87-01/02

WEST HUMBER RIVER

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



- 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)
  - WL at time of investigation 90 10

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	167.0	4 845 088.0	293 210.5
2	167.2	4 845 106.5	293 189.0
3	167.1	4 845 126.0	293 166.0
4	164.2	4 845 122.5	293 241.0
5	164.1	4 845 142.0	293 218.5
6	164.2	4 845 162.0	293 196.0
7	164.1	4 845 158.0	293 274.5
8	164.0	4 845 180.0	293 250.0
9	163.8	4 845 200.0	293 227.5
10	172.0	4 845 196.0	293 307.0
11	171.1	4 845 216.0	293 280.0
12	170.8	4 845 236.0	293 258.0

**NOTE**  
The boundaries between soil strata have been established  
only at Bore Hole locations. Between Bore Holes the  
boundaries are assumed from geological evidence.

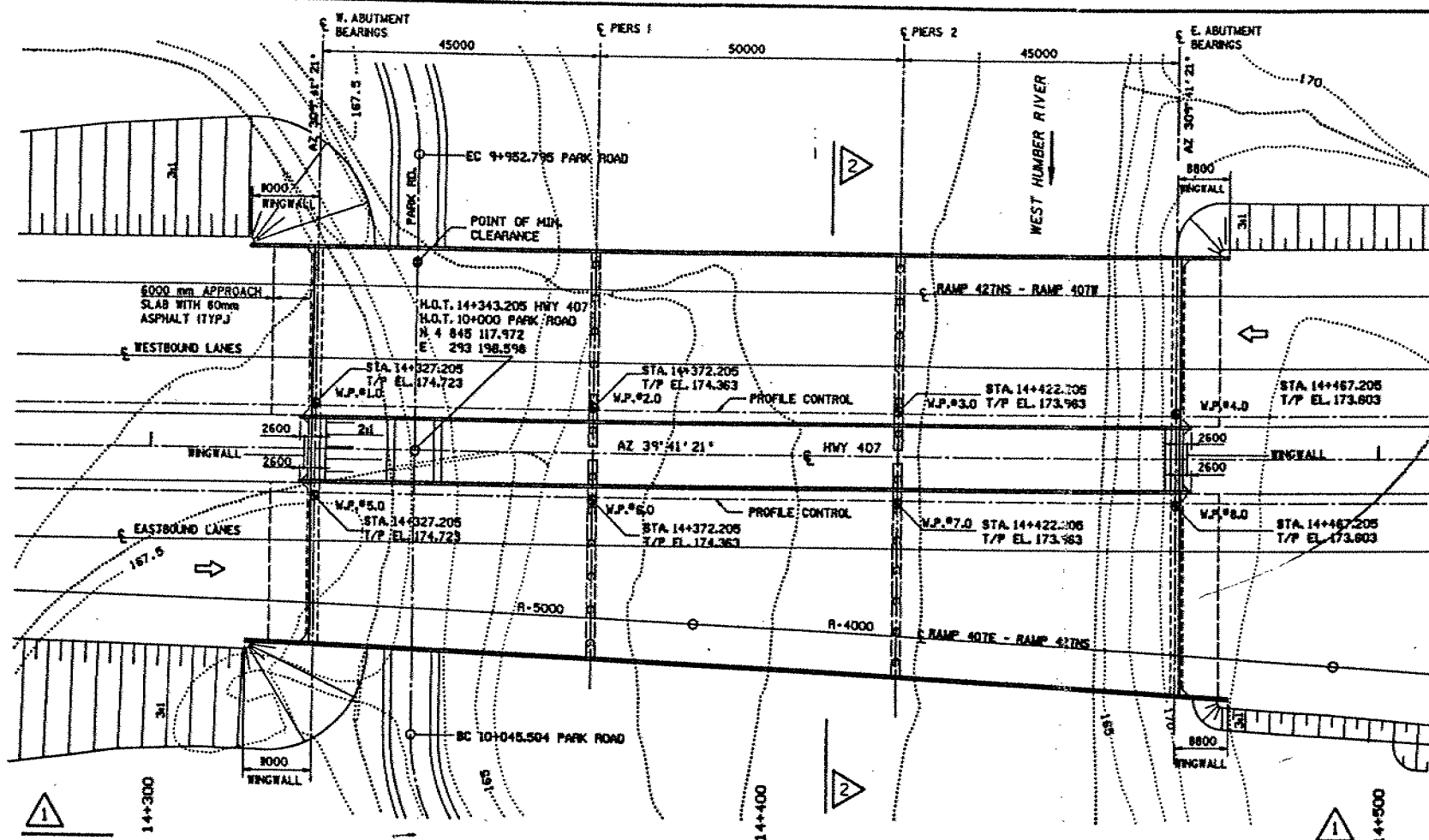
NOTE: The complete foundation investigation and design report for  
this project and other related documents may be examined at the  
Engineering Materials Office, Downsview. Information contained in  
this report and related documents is specifically excluded in  
accordance with the conditions of Section 102-2 of Form 100.

DATE	BY	DESCRIPTION

Geocres No 30M12-216

HWY No 407	DIST 6
SUBWD MM [CHECKED]	DATE 91 03 15
DRAWN DT [CHECKED]	APPROVED
	SITE 24-653A&B
	DWG 369870102-B





**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

DISTRICT 6  
CONT No  
WP No 369-87-01/02



**NOTE:**  
APPROACH SLABS, ASPHALT AND  
WATERPROOFING ARE NOT PART  
OF THIS CONTRACT

HWY 407-WEST HUMBER RIVER  
BRIDGES CONC. GIRDER SCHEME  
GENERAL ARRANGEMENT



**HATCH ASSOCIATES LTD.**  
**CONSULTING ENGINEERS AND ARCHITECTS**

NOTE

W.P.'S OFFSET FROM PROFILE CONTROL  
BY 500mm SEE 

### GENERAL NOTES

- 1. CLASS OF CONCRETE**
- PRECAST GIRDERS & PIER DIAPHR'S 45MPa
  - PIERS 35MPa
  - REMAINDER 30MPa
- 2. CLEAR COVER TO REINFORCING STEEL**
- FOOTINGS 100 ± 25 mm
  - ABUTMENTS & VIADUCTS
    - FRONT FACE 80 ± 20 mm
    - BACK FACE 70 ± 20 mm
  - PIERS 80 ± 20 mm
  - DECK
    - TOP 70 ± 20 mm
    - BOTTOM AND SIDES 40 ± 10 mm
  - REMAINDER 70 ± 20 mm
- UNLESS OTHERWISE SPECIFIED

### 3. REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400  
UNLESS OTHERWISE SPECIFIED. BAR MARKS  
WITH SUFFIX 'C' DENOTE COATED BARS.

#### 4. CONSTRUCTION NOTE

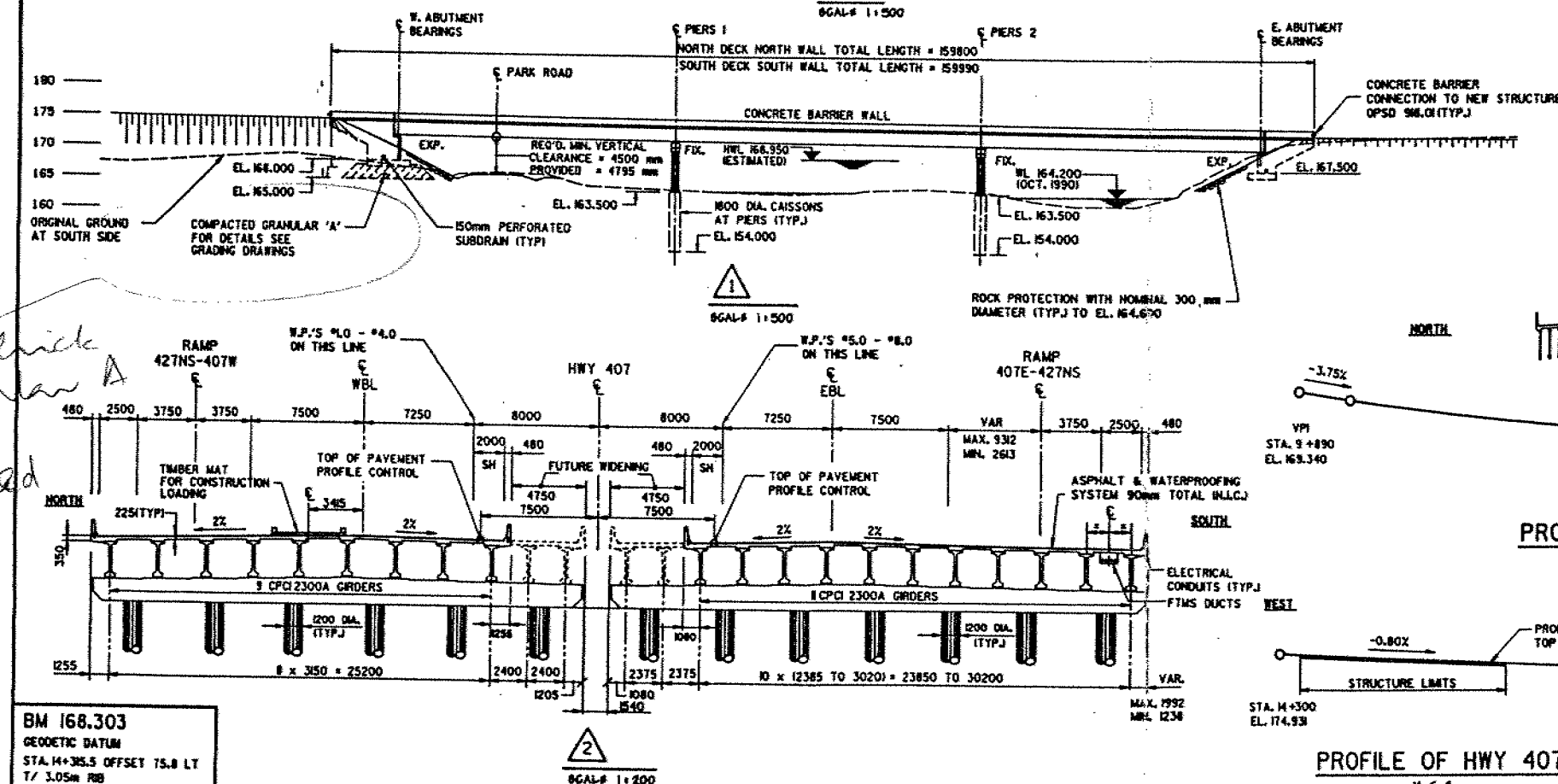
IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM THE ASSUMED HEIGHTS GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT THE ACTUAL HEIGHTS.

## LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOOTINGS LAYOUT AND PIERS
4. PIER CROSS-BEAMS
5. ABUTMENT FOOTINGS REINFORCING
6. VEST ABUTMENT I
7. VEST ABUTMENT II
8. VEST ABUTMENT III
9. EAST ABUTMENT I
10. EAST ABUTMENT II
11. EAST ABUTMENT III
12. GIRDER LAYOUT AND DETAILS
13. DIAPHRAGM DETAILS
14. 45m GIRDER DETAILS
15. 50m GIRDER DETAILS
16. NORTH DECK LAYOUT
17. NORTH DECK REINFORCING
18. SOUTH DECK LAYOUT
19. SOUTH DECK REINFORCING
20. JOINT ANCHORAGE AND ARMOURING
21. BARRIER WALL I
22. BARRIER WALL II
23. 6000mm APPROACH SLAB
24. AS CONSTRUCTED ELEVATIONS AND DIMENSIONS
25. STANDARDS
26. ELECTRICAL EMBEDDED WORK
27. METHOD OF DECK ERECTION
28. QUANTITIES - STRUCTURE I
29. QUANTITIES - STRUCTURE II

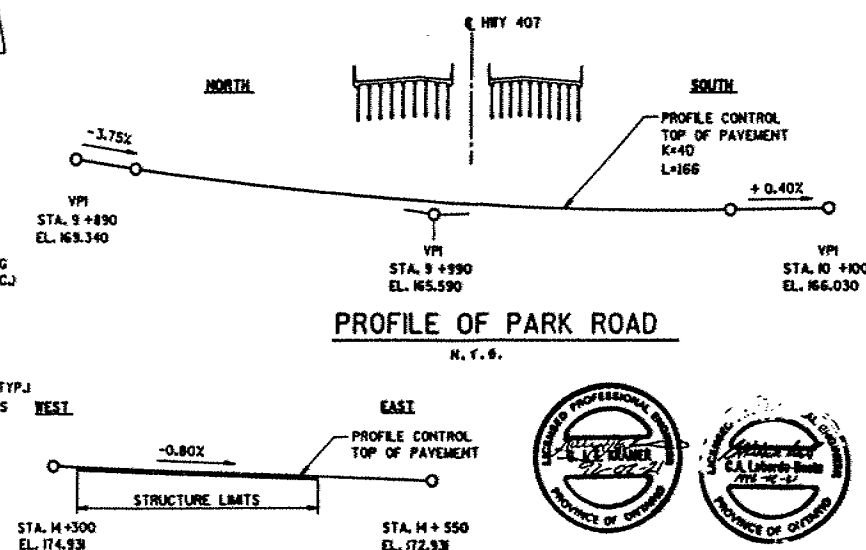
## STANDARD DRAWINGS

- 003201 - MAXIMUM LOADING CONSTRUCTION  
EQUIPMENT  
0PS0 3501.00 - GRANULAR BACKFILL REQUIREMENTS  
0PS0 410.01 - CONCRETE BARRIER CONNECTION TO NEW  
STRUCTURE



### LEGEND

W.P. - WORK POINT  
T/P - TOP OF PAVEMENT  
N.I.C. - NOT IN CONTRACT  
SH - SHOULDER



## PROFILE OF HWY 407

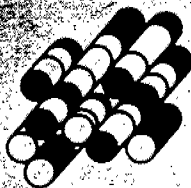
DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING

REVISIONS								
DATE	BY	DESCRIPTION						
DESIGN	6-JFK	CHK GAB	CODE 0110PG-03	LOADCLASS A	DATE APRIL 199			
DRAWN	JK	CHK T6	SITE 24-653	STRUCT	SCHEME 1	DWG. 1		





DRAWING NOT TO BE SCALED  
100mm ON ORIGINAL DRAWING



# Teraprobe Testing Ltd.

Construction and Materials Inspection and Testing

2565 Steeles Ave. E.  
Brampton, Ontario  
L6T 4L6  
(905) 793-2650  
FAX: 793-2655

April 29, 1994

Our File No. 949114

Graham Bros. Construction Ltd.  
290 Clarence Street  
Brampton, Ontario  
L6W 1T4

Attention: Mr. Dave Weltz, P.Eng.

---

**RE: FALSEWORK FOUNDATION INSPECTION  
HIGHWAY 50 UNDERPASS (MTO 93-100)  
BRAMPTON, ONTARIO**

---

Dear Sir:

This letter presents the results of our review of the subsurface soil conditions in the vicinity of the proposed falsework foundations, at the above project site.

It is our understanding that the mudsills are to be founded at an elevation of about 173.89 m and the maximum load that is to be applied to any one leg of the scaffolding is 65 kN (reference drawing No. TOA3530-01, by UMACS of Canada Inc). Considering the mudsill timbers are 0.3 m wide and the legs from the scaffolding are 1.8 m centre-to-centre, a bearing pressure of about 120 kPa will be applied to the underlying soils.

In reviewing the Foundation Investigation Report for the site that was prepared by the Ministry of Transportation (Report for Contract No. 93-100), native soils were encountered in the boreholes at the proposed foundation elevation of the mudsills (i.e., Elev. 173.89 m).

The results of our site inspection indicated that the native soils exposed in the excavations at this site consist of competent native clayey to sandy silt soils, and are similar to those indicated in the borehole logs. These soils are considered to be suitable for support

The vertical SLS TYPE II Capacity of a 1.8 m caisson installed to an elevation of 154 m will be of the order of 5500 Kn.

Reference should be made to the recommendations given in the foundation report regarding installation of caissons at pier locations.

If you have any questions, please do not hesitate to contact this office.

---

Dr. B. Iyer, P. Eng.  
Sr. Foundation Engineer