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W.P. No. 370-87-00
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CONT. No. _____

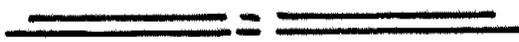
W. O. No. _____

STR. SITE No. _____

HWY. No. 407

LOCATION Hwy 427 to Airport Rd.
Proposed Deep cuts & High fills

No. of PAGES - _____



OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____



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Transportation

FILE No. _____ DATE _____

REMARKS

Lloyd Crowder

FILE



Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 370-87-00(F) DIST 6

HWY 407 STR SITE

Hwy. 407 Fills Between
Stations 13+320+ to 13+900+
(Goreway Drive to West Humber River)

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FOUNDATION INVESTIGATION REPORT
For
Hwy. 407 Fills Between
Stations 13+320± to 13+900±
(Goreway Drive to West Humber River)
W.P. 370-87-00 (F), Hwy. 407
District 6, Toronto

INTRODUCTION

Subsequent to requests submitted by the Central Region Geotechnical Section, an investigation was carried out by this office to determine foundation conditions for advanced structures East and West of the single span structures. Recommendations to facilitate the proposed fill material at the aforementioned site.

Fill embankments of 4 to 6 m will be required to satisfy the proposed Hwy. 407 profile grade. The proposed Hwy. 407 profile grade slopes at A-1.5% gradient from East to West elevations of 178 m at Station 13+920 to 177 m at Station 13+320. The natural ground surface is relatively flat to gently sloping, increasing slightly from 171 m to 173 m towards the east.

The investigating procedure, including the field work procedures and laboratory analysis and a detailed description of the subsurface conditions are also included in this report.

SITE DESCRIPTION AND GEOLOGY

The site is located $\frac{1}{4}$ km North of Steeles crossing 8th Line (Goreway Drive) running parallel to Steeles in the City of Brampton, Region of Peel. The area is partially residential with private homes on the West side and a conservation area that contains a single storey building to the East. 8th Line (Goreway Drive) is a narrow paved 2 lane road with drainage ditches beside both shoulders. The vegetation around the conservation building property consists of deciduous trees lining the side of the road and short wild grass behind the school house groomed for a picnic area. Behind the residential properties the vegetation consist of short wild grass and randomly placed deciduous trees, the terrain is flat to rolling.

Embankment boreholes were primarily located, to the east behind the conservation building in the Grasslands and the West behind the residential properties. The furthest two boreholes extended beyond the grass fields, beyond a grove of trees into a farmers field.

Physiographically, the site is located in the Geological Domain known as the "Peel Plain". The "Peel Plain" is the product of the advances and retreat of the Wisconsin 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 the 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 sizes 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 field work for the investigation was carried out between 90 06 27 to 90 07 07 and consisted of seven sampled boreholes located at 30 m offsets at 75 m intervals to the left and right from the centerline of the proposed Hwy. 407. Five boreholes to the west of Goreway Drive and two to the East.

All boreholes were advanced 13-15 m below natural ground surface.

Vanes and undisturbed shelby tube samples were taken when plastic cohesive material was encountered. The subsequent revision to the E-Plan of the Goreway

Drive Structure was taken into consideration when making recommendations. The foundation investigation, specifically the location of boreholes were based on the initial E-Plan provided.

Track mounted CME 55 equipment employing hollow stem and solid stem augering techniques was used to advance all boreholes in the overburden. In general, disturbed subsoil samples were retrieved at 0.75 m intervals for the surficial 4.5 m and 1.5 m thereafter. All samples were identified in the field and then returned to the laboratory for applicable testing.

Groundwater levels were obtained by monitoring the levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled at the completion of the field work.

Survey information related to the location and elevation of boreholes was provided by Giffels Engineering Consultants.

Laboratory Analysis

The following laboratory tests were carried out select soil samples:

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

Laboratory Test results have been summarized in the subsequent section of this report and are illustrated on corresponding figures and boreholes included in the attached Appendix.

SUBSURFACE CONDITIONS

General

The stratigraphy encountered consisted mainly of 2 layers of distinct material. Beginning at the ground level with a stiff to hard heterogeneous mixture of

clayey silt, sand and gravel and an underlying layer of clayey silt to silty clay, lacustrine deposit. These conditions are rather uniform throughout the site. Random interbedded layers of sandy silt were found to various depths.

The plan and location of borings and the stratigraphical profile are shown on DWG. No. 3708700-A in the attached Appendix. The obtained field and laboratory tests are plotted on the Record of Borehole Log sheets also in the Appendix of this report. A brief description of the different soil types is given below:

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

For all advanced structure boreholes, a cohesive heterogeneous mixture of clayey silt, sand and gravel material rests on the surface and is 3.78 to 6.81 m thick, primarily 5.3 m thick to an elevation of 164 m to 168 m.

Grain Size Distribution tests were carried out shown on Figure 1 in the Appendix, showing the results in envelope form. The clayey silt deposit is comprised primarily of 0-8% gravel, 6-14% sand, 31-48% silt and 38-62% clay.

The result from the Atterberg Limit test performed on cohesive material is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	8.5-21.5	5
Liquid Limit (w _L)	21-43	5
Plastic Limit (w _p)	12-18	5
Plastic Index (I _p)	9-25	5

From the Plasticity Chart (Figure 2), the layer can be classified as a silty clay (inorganic) to gravelly clay (CL-CI).

In this stratum the 'N' values ranged from 6 blows/10.3 m to 47 blows/0.3 m indicating the material ranged from stiff to hard.

Clayey Silt to Silty Clay (Glacial Lacustrine)

Under the above layer a moist clayey silt to silty clay, lacustrine deposit was encountered down to the end of the borehole.

Grain Size Distribution Tests were carried out shown on Figure 3 in the Appendix, showing the results in envelope form.

From the above figure it is evident that the layer can be classified as a fine clayey silt. The clayey silt to silty sand deposit is comprised of 0-4% gravel, 2-39% sand, 35-81% silts and 3-63% clays.

The result from the Atterberg Limit Test performed on cohesive material is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	22.5-34.5	7
Liquid Limit (w _L)	15-42	7
Plastic Limit (w _p)	12-21	7
Plastic Index (I _p)	17-23	7

From the Plasticity Chart (Figure 4), the layer can be classified as a silty clay of medium plasticity.

Undrained shear strength measurements (C_u) of the soil were obtained by conducting in situ vane tests. Sensitivity of the soil as defined by the ratio of the undrained strength in the undisturbed state to the undrained strength, at the same water content, in the remolded state was also determined by the Field Vane Tests and the results are identified on the Record of Borehole Log sheets.

Undrained shear strength values range from 52 to >130 kPa and can be classified as stiff to very stiff. Sensitivity values range from 1.3 to 3.2 indicating that the soil has low sensitivity.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 4 blows/0.3 m to 21 blows/0.3 m. Based on these 'N' values, the materials can be described as having a soft to very stiff consistency.

Sandy Silt, trace of Clay Interbeds

Interbedded within the cohesive lacustrine and glacial till deposits at various depths is a non-cohesive sandy silt, trace of clay with a thickness ranging from 0.75 m to 1.5 m.

Grain Size Distribution Tests were carried out shown on Figure 5 in the Appendix, showing the results in envelope form. From the above figure the material can be classified as fine to medium sand, with silt, clay and gravel.

Interpretation of Standard Penetration Test 'N' values within this material ranged from 14-130 blows/0.15 m, indicating a denseness ranging from compact to very dense. In general, however, the deposit can be characterized as dense to very dense.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater levels determined at the time of investigation were approximately 1 m-3.3 m below existing grade at the time of the investigation.

Groundwater levels in general, are subject to season fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct advanced structure embankments to conform to finished grade of the proposed Hwy. 407 at Goreway Drive. The finished grade is set at about 6 m above the existing grade, placing the fill material upon the surficial cohesive clayey silt till. No stability problems are anticipated constructed with a 2H:1V side slopes. The fill material should consist of well compacted acceptable material.

It is anticipated that approximately 60 mm of the total settlement can be realized as a result of elastic settlements induced within the fill itself and the elastic recompression of the native subsoil. It is expected that the majority of these settlements will be realized during or immediately following construction.

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

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, and M. Michalek, Engineering Trainee. Utilizing equipment owned and operated by Master Soil investigation and Malone's Soil Samples.

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



M. Michalek

M. Michalek
Engineering Trainee

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 (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	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

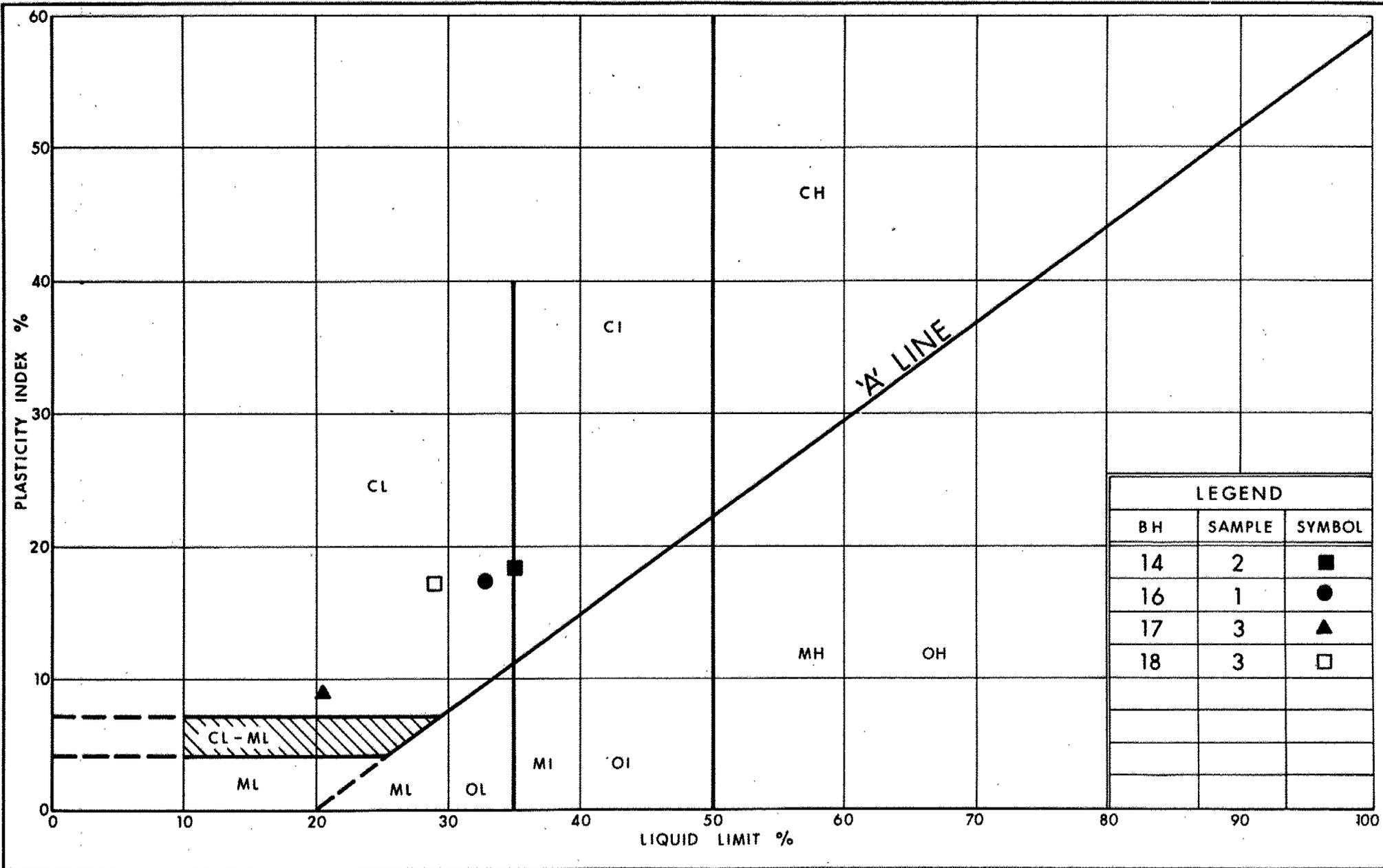
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

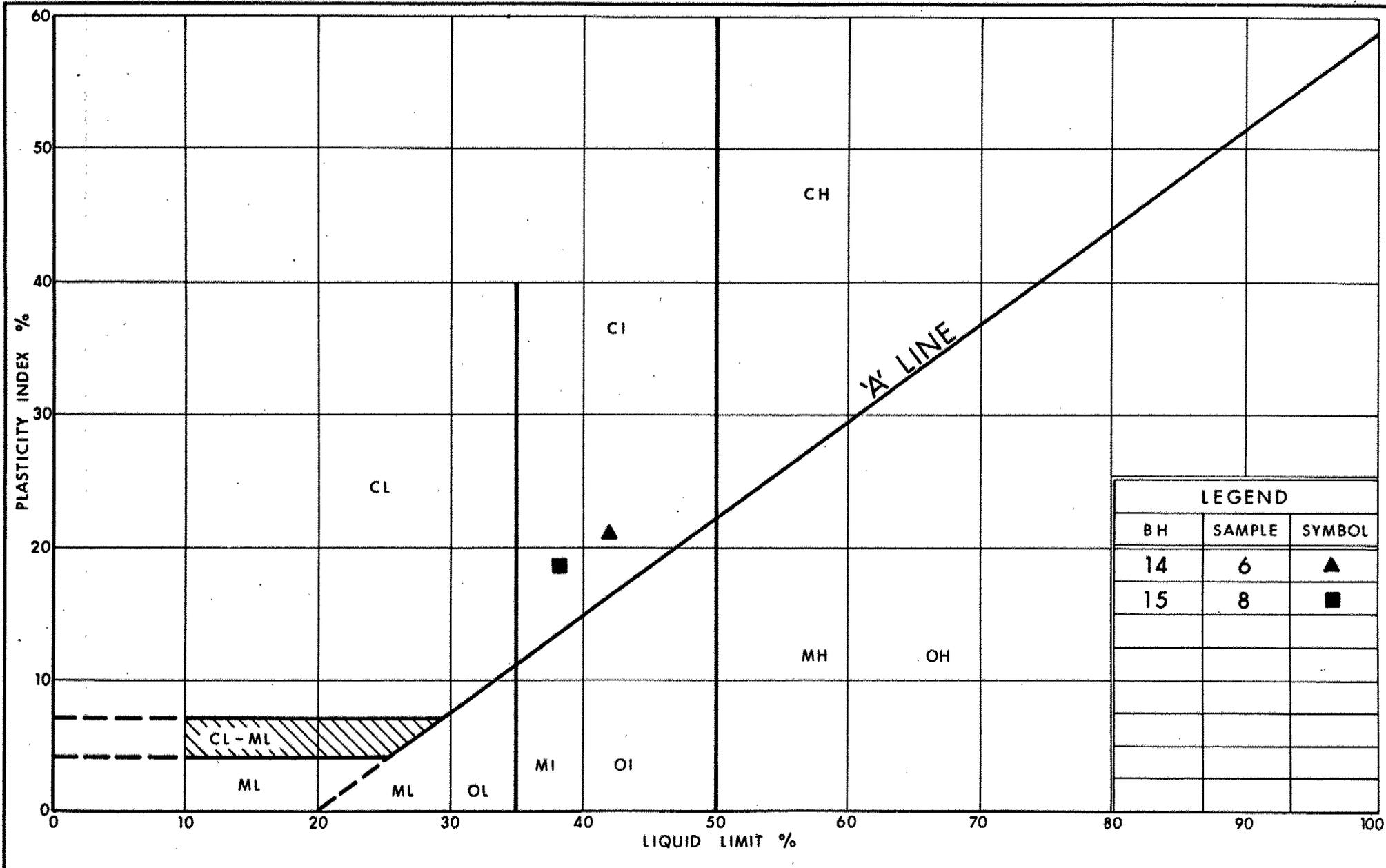
PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kn/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $\frac{w_L - w_p}{w - w_p}$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kn/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



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

FIG No 2
 W P 370-87-00(F)



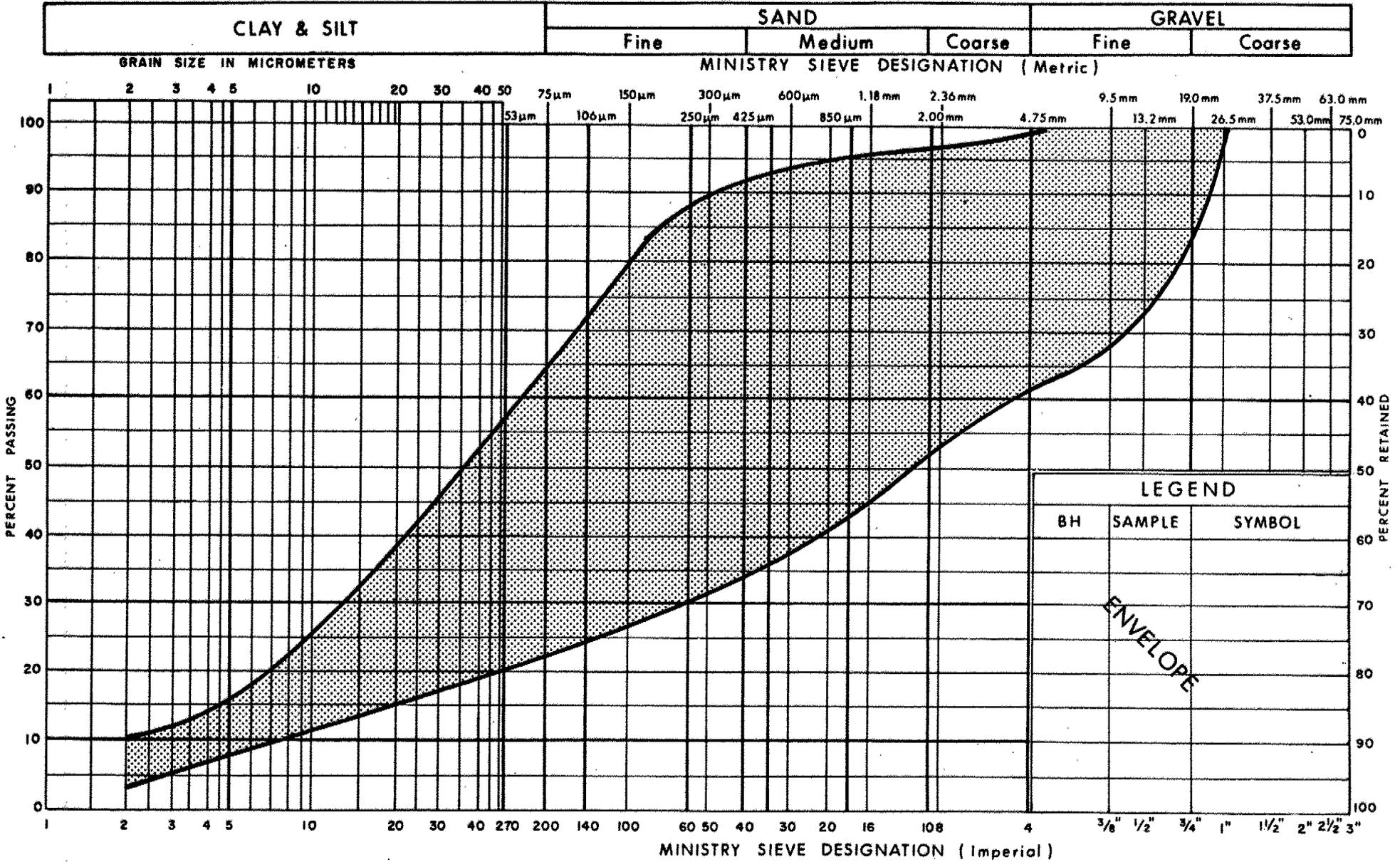
LEGEND		
BH	SAMPLE	SYMBOL
14	6	▲
15	8	■

PLASTICITY CHART
 CLAYEY SILT TO SILTY CLAY
 (LACUSTRINE)

FIG No 4
 W P 370-87-00(F)



UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND		
BH	SAMPLE	SYMBOL

ENVELOPE



GRAIN SIZE DISTRIBUTION
 SANDY SILT, TRACE CLAY INTERBEDDED WITH A
 HET MIXTURE OF SILT, SAND & GRAVEL

FIG No 5
 W P 370-87-00(F)

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

W.P. 370-87-00 (F) LOCATION Co-ords: N4 844 400, E 292 484 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE JULY 16, 1990 CHECKED BY B.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60						80
171.0	Ground Surface															
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff					DRY										
			1	SS	14											
			2	SS	30											
			3	SS	17											
165.7	Brown															
5.3	Grey															
	Clayey Silt to Silty Clay (Lacustrine) Firm to Stiff		4	SS	7											
			5	SS	7											
		6	SS	10												
		7	SS	20												
	seams of sand															
158.4		8	AS													
12.8	End of Borehole															

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

RECORD OF BOREHOLE No 14 1 OF 2 METRIC

W.P. 370-87-00 (F) LOCATION Co-ords: N4 844 371.5, E 292 542.5 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE JULY 16, 1990 CHECKED BY D.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
171.0	Ground Surface																
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel Brown ----- Grey (Glacial Till) Stiff to Very Stiff		1	SS	13												
167.2			2	SS	32									19.9	0 10 48 42		
3.8			3	SS	21												
			4	SS	16												
			5	SS	13												
	Clayey Silt to Silty Clay (Lacustrine) Firm to Very Stiff		6	SS	5												
			7	SS	6												
			8	SS	6												
			9	SS	6												
155.8																	

15.2 Continued

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

Continued

RECORD OF BOREHOLE No 15

1 OF 1

METRIC

W.P. 370-87-00 (F) LOCATION Co-ords: N4 844 481.5, E 292 575.0 ORIGINATED BY M.M.
 DIST 5 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE JULY 16, 1990 CHECKED BY B.I.

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
						20	40	60	80	100	20	40	60	kn/m ³	GR SA SI CL		
172.0	Ground Surface																
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Hard Brown ----- Grey																
			1	SS	42												
			2	SS	22												1 6 31 62
			3	SS	17												
			4	SS	15												
			5	SS	20												
			6	SS	32												
			7	SS	7												
183.4	Clayey Silt to Silty Clay (Locustrine) Firm to Very Stiff		8	TW	PH										18.9 0 2 35 63		
8.6																	
159.4	End of Borehole																
12.6																	

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

RECORD OF BOREHOLE No 16 1 OF 1 METRIC

W.P. 370-87-00 (F) LOCATION Co-ords: N4 844 507.5 E 292 891.0 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE JULY 16, 1990 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40					
171.3	Ground Surface												
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till)				DRY	171							
170.2						170							
1.1	Very Stiff Brown ----- Grey	1	SS	20		169							
		2	SS	30		168							
		3	SS	17		167							
166.0	seams of gravel and sand ----- Clayey Silt to Silty Clay (Lacustrine) Firm to Stiff	4	SS	13		166							
5.3		5	SS	12		165							
		6	SS	9		164							
		7	SS	7		163							
		8	TW	PH		162							
158.3						161							
						160							
						159							
13.0	End of Borehole												

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

RECORD OF BOREHOLE No 17 1 OF 1 METRIC

W.P. 370-87-00 (F) LOCATION Co-ords: N4 544 609.0, E 292 598.0 ORIGINATED BY M.M.
 DIST 5 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE JULY 16, 1990 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80						100
173.2	Ground Surface																
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard		1	SS	33												
	Brown																
	Grey																
			2	SS	27												
			3	SS	47												
167.6																	
5.6	seems of gravel and sand																
			4	SS	17												
	Clayey Silt to Silty Clay (Lacustrine) Soft to Stiff																
			5	SS	13												
			6	SS	9												
			7	TW	PH												
			8	SS	5												
160.2																	
13.0	End of Borehole																

+3, x³: Numbers refer to Sensitivity 20 15-5 (%) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No 18 1 OF 1 METRIC

W.P. 370-87-00 (F) LOCATION Co-ords: N4 844 744.5, E 292 841.0 ORIGINATED BY M.M.
 DIST 6 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETTIC DATE JULY 17, 1990 CHECKED BY B.J.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60						80
173.3	Ground Surface														
0.0	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Glacial Till) Very Stiff to Hard Brown Grey some sand	1	SS	27											
		2	SS	43											
		3	SS	25										22.7	7 14 41 38
		4	SS	33											
166.2	Clayey Silt to Silty Clay (Locustrine) Very Stiff	5	SS	14											
7.1		6	SS	8											
		7	TW	PH										22.8	2 11 42 45
		8	TW	PH											
160.3															
13.0	End of Borehole														

+3, x3: Numbers refer to Sensitivity 20
15 (x) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 19 1 OF 2 METRIC

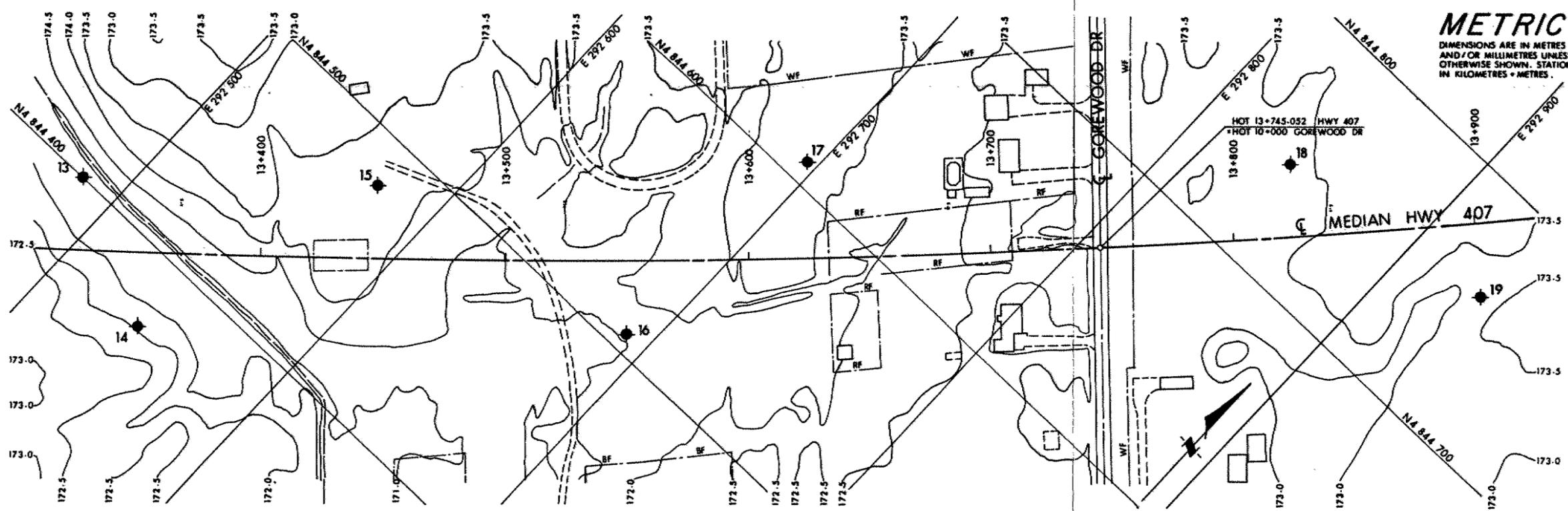
W.P. 370-87-00 (F) LOCATION Co-ord: N4 844 759.0, E 292 935.0 ORIGINATED BY M.M.
 DIST 5 HWY 407 BOREHOLE TYPE HS AUGER COMPILED BY M.M.
 DATUM GEODETIC DATE JULY 16, 1990 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20						40	60
173.2	Ground Surface														
0.0	Heterogeneous mixture of Clayey silt, Sand and Gravel (Glacial Till) Very Stiff Brown ----- Grey		1	SS	24										
					2	SS	16								
					3	SS	17								
167.6	Clayey Silt to Silty Clay (Locustrine) Firm trace gravel		4	SS	14										
5.6															
					5	SS	6								
					6	SS	7								
					7	SS	6								
					8	SS	6								
			9	SS	10										
158.0															
15.2															

Continued

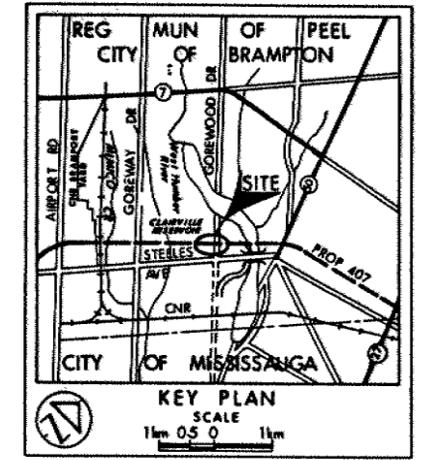
Continued

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

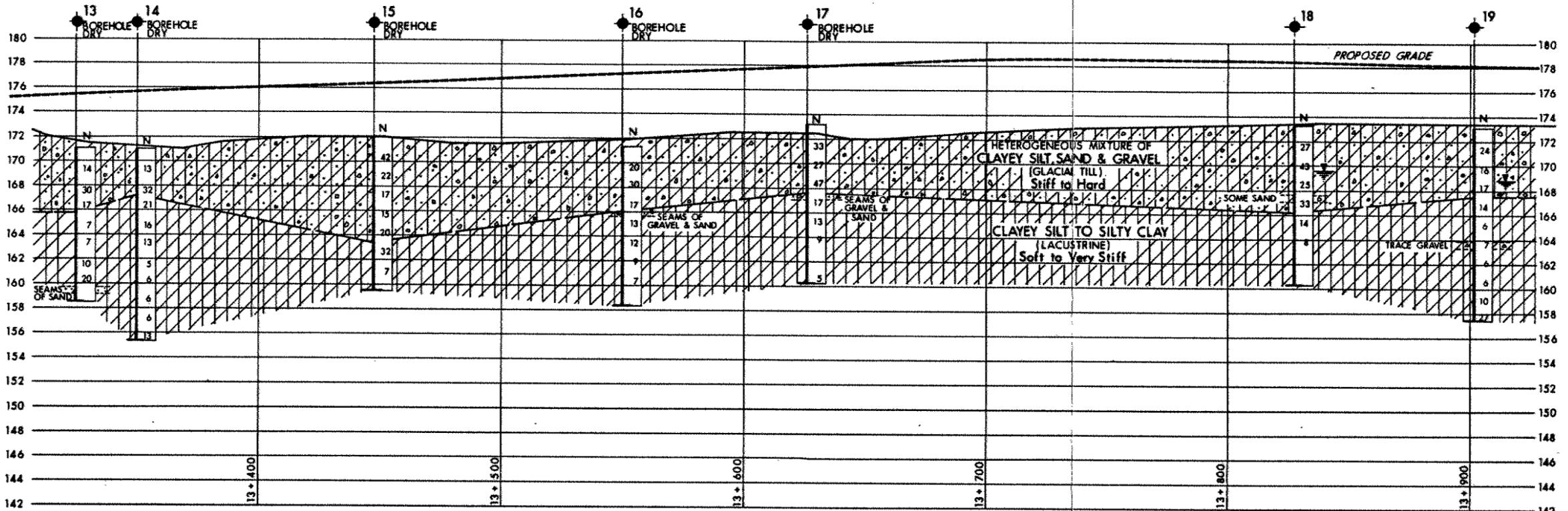


CONT No
WP No 370-87-00(F) SHEET

HWY 407 FILLS
BETWEEN STATIONS 13+320 TO 13+900
(GOREWAY DR TO WEST HUMBER RIVER)
BORE HOLE LOCATIONS & SOIL STRATA



- 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 07



No	ELEVATION	CO-ORDINATES NORTH	EAST
13	171.0	4 844 400.0	292 484.0
14	171.0	4 844 371.5	292 542.5
15	172.0	4 844 481.5	292 575.0
16	171.3	4 844 507.5	292 691.0
17	173.2	4 844 609.0	292 696.0
18	173.3	4 844 744.5	292 841.0
19	173.2	4 844 759.0	292 935.0

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 30M12-217

HWY No 407	DIST 6
SUBARD AMM CHECKED	DATE 91 05 02
DRAWN DT CHECKED	APPROVED
	DWG 3708700F-A

FILE



Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 370-87-00

DIST 6

HWY 407

STR SITE

Hwy 407 Excavation Cuts
Between

Hwy. 427 and Hwy. 50

(Stations 10+250 to 10+840 - Centreline Hwy. 407)

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GEOCRE 30M13-117

DATE JAN 21 1991

FOUNDATION INVESTIGATION REPORT

For

Hwy. 407 Excavation Cuts

Between

Hwy. 427 and Hwy. 50

(Stations 10+250 to 10+840 - Centreline Hwy. 407)

W.P. 370-87-00, Hwy. 407

District 6, Toronto

INTRODUCTION

This report summarizes the results of a geotechnical investigation conducted at the aforementioned site. In conjunction with the advancement of the Hwy. 407, excavation cuts and fills have been proposed for the highway and associated ramps within the area bounded by Stations 10+250 and 10+840 (along centre-line of Hwy. 407). The scope of this report includes recommendations for the design and construction of safe slope geometries for the excavation cuts exceeding 4.5 m within these boundary limits. This area includes the Hwy. 407 and Ramps 407W-Hwy. 427S and Hwy. 427S-Hwy. 407W.

The investigation procedure, including the fieldwork procedures and laboratory analyses, and a detailed description of the subsurface conditions are also included in this report.

SITE DESCRIPTION AND GEOLOGY

The site is located along the proposed Hwy. 407 bounded by the existing Hwy. 50 and the new Hwy. 427, the latter being under construction at the time of the investigation. The site is located approximately 0.5 km north of Steeles Avenue in the Town of Vaughan, Regional Municipality of York.

At the time of the investigation, an abandoned barn house was present at the southwest corner of the site whilst an inhabited residential home existed at the northwest boundary of the site. At the eastern limits of the site, construction equipment, materials and personnel had been mobilized as construction of the Hwy. 427-Hwy. 407 interchange complex proceeded.

The land between Stations 10+250 and approximately 10+550 is generally flat and slopes gently upward in an easterly direction. The land which is covered with grassland has a ground surface elevation ranging from 177.3 m to approximately 180 m. Beyond Station 10+550, an excavation cut has already been advanced that extends to the eastern boundary of the site. The excavation cut is approximately 7 m in depth and contains excavation slopes estimated to be a 3H:1V or flatter. No signs of slope instabilities were apparent. The slopes have a grassland vegetation cover.

At the time of the investigation, the land was not in use. Historically, the land appears to have been used for cattle grazing.

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 Wisconsin ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). It consists of a bevelled till plain with a gently undulating rolling surface and limit relief. At some locations, the till is overlain by thin deposits of varved clay.

Till sheets of varying composition comprise the Peel Plain. As characteristic of till material, these deposits contain a wide range of grain sizes 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 PROCEDURE

Field Investigation

The fieldwork for the investigation was carried out between 90 07 05 and 90 07 06 and consisted of ten (10) sampled boreholes advanced to depths ranging 12.6 m to 15.4 m below the natural ground surface. Two additional boreholes advanced

in conjunction with the Hwy. 427S-Hwy. 407W ramp (W.P. 368-87-01) have also been included in this report. The boreholes, BH 10 and 11 (formerly BH's 1 and 2), were advanced to depths ranging from 12.6 m to 14.2 m on 90 06 21. Track mounted CME 55 equipment employing hollow stem augering techniques was used to advance the boreholes in the overburden. Washboring techniques were required to remove soil cave-in which developed in the submerged cohesionless deposits at the site. In general, disturbed subsoil samples were retrieved at 1.5 m intervals. Sample retrieval was conducted in accordance with the Standard Penetration Test (ASTM D1586). All samples were identified in the field and then returned to the laboratory for applicable testing.

Groundwater levels were obtained by monitoring the levels in the open boreholes throughout the duration of the field investigation. All open boreholes were backfilled at the completion of the fieldwork.

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

Laboratory Analyses

To identify the behaviour, gradation and pertinent properties and characteristics of the soil, various laboratory tests were performed. These tests included:

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

Laboratory test results have been summarized in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on corresponding figures and boreholes included in the attached Appendix.

SUBSURFACE CONDITIONS

General

The elevation of the ground surface at the borehole locations ranged from 177.3 m to 182.1 m. In general, the subsoil stratigraphy at the site consists of a surficial veneer of a heterogeneous mixture of clayey silt, sand and gravel. This deposit is of glacial origin and exhibits a cohesive behaviour. The thickness of this deposit varies between 2.6 m and 4.1 m. This surficial deposit, however, was not found at BH 4.

The surficial heterogeneous mixture of clayey silt, sand and gravel is underlain by a cohesionless deposit ranging in gradation from sand, some silt to a silt with some sand. The deposit extends for thicknesses ranging from 7.6 m to 11.3 m.

Underlying the cohesionless sands and silts, a second glacial till deposit consisting of a heterogeneous mixture of clayey silt to silt, sand and gravel. This deposit varies in behaviour across the site from cohesive to cohesionless. The extent of this deposit was not determined during the investigation.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 3708700-A.

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

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

The surficial deposit across the site (except at BH 4), consists of a heterogeneous mixture of clayey silt, sand and gravel. The deposit extends for thicknesses ranging from 2.6 m to 4.1 m and has been oxidized, as evidenced by its brown colour, for its entire thickness. The deposit is a till deposit of

glacial origin and although not encountered during the investigation, boulders and cobbles are characteristic components of such till deposits and hence can exist within the deposit. A grain size distribution envelope derived from mechanical sieve and hydrometer analysis of representative samples of this material is illustrated in Figure 1 in the Appendix. The envelope illustrates a wide grain size distribution which is inherent of glacial till deposits. The fine grained portion of the deposit (less than 75 micrometers) constitutes approximately 65% to 75% of the material.

Atterberg Limit tests were carried out to evaluate the behaviour of the fine grained portion of the deposit and the results are tabulated in Table 1. below and illustrated on the plasticity chart on Figure 2 in the Appendix. Unit weights are also included in the table below.

Table 1

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content (w%)	12-15	6
Liquid Limit (w _L %)	25-31	6
Plasticity Index (I _p %)	9-15	6
Unit Weight (kN/m ³)	19.8-23.7	3

The results reveal that the fine grained portion of the deposit is of low plasticity and hence can be categorized as a clayey silt. It is this matrix of clayey silt that defines the cohesive behaviour of the deposit.

Based on Standard Penetration Test 'N' values ranging from 10 blows/0.3 m to 110 blows/0.3 m, the consistency of the soil ranges from stiff to hard. In general, however, the soil has a very stiff to hard consistency.

Sand, some Silt to Silt, some Sand

Underlying the heterogeneous mixture of clayey silt, sand and gravel, a cohesionless deposit consisting of Sand with some Silt to a Silt with some sand extends for thicknesses ranging from 7.6 m to 10.2 m. At BH 4, however, this

deposit is not overlain by the heterogeneous mixture of clayey silt, sand and gravel and exists from the surface to a depth of 11.3 m. At some borehole locations, the boreholes were terminated within this stratum and hence its extent was not verified.

The extent of oxidization of this deposit varies across the site. At boreholes located in the western portion of the site (BH's 1 to 4 inclusive), the stratum was oxidized and brown throughout the investigated depth which extended to elevations ranging from 164.7 m to 169.0 m. At the borehole locations situated at the crest of the existing excavation cuts in the eastern portion of the site, unoxidized material exists at elevations ranging from 166.5 m to 170 m and below and hence is grey in colour. The material above these elevations is brown in colour.

Grain size distribution envelopes illustrating the varying gradation of the material in this stratum is illustrated in Figure 3 in the Appendix. The envelopes reveal that the stratum varies in composition from a well graded fine to medium sand with some silt to a silt with some sand.

Based on Standard Penetration Test 'N' values ranging from 22 blows/0.3 m to 120 blows/0.01 m, the deposit can be categorized as having a compact to very dense state of denseness. In general, however, 'N' values exceed 30 blows/0.3 m and consequently the soil has a dense to very dense state of denseness.

Heterogeneous Mixture of Clayey Silt to Silt, Sand and Gravel (Glacial Till) - Lower

Underlying the cohesionless sand with some silt to silt with some sand stratum, a second lower glacial till deposit consisting of a heterogeneous mixture of a clayey silt to silt, sand and gravel is present. The deposit was encountered at elevations ranging from 165.4 m to 169 m and its extent was not determined during the investigation.

The composition of this deposit reflects the wide range of grain sizes typical of these types of glacial till deposits. Grain size distribution curves for this deposit are provided in Figure 4 in the Appendix. The curves reveal that

clay percentages for the cohesive till exceed 10% whilst for the cohesionless till, clay percentages are less than 5%. The gradation envelope includes particle sizes up to and including gravel. However, larger size boulders and cobbles are characteristic components of these deposits and hence can exist.

Atterberg Limit tests were carried out to evaluate the behaviour of the fine grained portion of the deposit and the results are plotted on the plasticity chart on Figure 5 in the Appendix and summarized in Table 2 below.

Table 2 - Clayey Silt to Silt

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Content (w%)	8-13	3
Liquid Limit (w _L %)	15-30	3
Plasticity Index (I _p %)	3-13	3

The results reveal that the fine grained portion of the deposit has a low plasticity and ranges from a plastic silt to a clayey silt.

Based on Standard Penetration Test 'N' values ranging from 53 blows/0.3 m to 120 blows/0.15 m, the deposit has a hard consistency or very dense denseness.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. The groundwater condition at each of the individual boreholes is indicated on the Record of Borehole sheets in the Appendix. In general, the groundwater levels determined at the time of the investigation were at an elevation ranging from 168.0 m to 172.6 m. These elevations correspond to depths of approximately 11.7 m to 7.1 m below the ground surface which coincides with the lower depths of the cohesionless Sand, some silt to Silt, some Sand deposit. Soil sloughing in the borehole took place when borehole advancement penetrated below the water level in this cohesionless deposit. Washboring techniques were required to facilitate borehole advancement and to counteract the unbalanced hydrostatic head present in the stratum.

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

In the construction of the Hwy. 407 between Hwy. 427 and Hwy. 50, excavation cuts up to approximately 8 m below existing grade will be required. Excavation cuts within the aforementioned boundary limits will also facilitate the advancement of Hwy. 407 associated ramps, namely the Hwy. 427N,S-Hwy. 407 W ramp and the Hwy. 407W-427S ramp.

The scope of this report includes the range of proposed excavation cuts that exceed 4.5 m in the areas described above. These areas are summarized in Table 3 below.

Table 3 - Excavation Cut Areas Exceeding 4.5 m

<u>Area</u>	<u>Stations</u>	<u>Dept of Cut (m)</u>
Hwy. 407	10+250 to 10+840	4.5-7.8
Ramp Hwy. 427N,S-Hwy. 407W	11+375 to 11+675	4.8-5.6
Ramp Hwy. 407W-Hwy. 427N,S	10+775 to 10+925	4.4-5.0

A plan illustrating the site of the proposed excavation cuts is shown on Drawing 3708700-A in the Appendix.

Recommendations pertaining to the following geotechnical considerations are contained in the purview of this report.

- 1) Excavated Slope Stability Design
- 2) Construction of Excavated Slopes

1) EXCAVATED SLOPE STABILITY DESIGN

The critical condition examined in the evaluation of cuts such as those proposed at the site location is the long term (drained) condition. Consequently, an effective stress analysis was implemented using Bishop's method on an in-house

mainframe program incorporating a factor of safety of 1.3. The properties of the subsoil and the geometry used in the analysis is summarized in Figure 6 in the Appendix. The analysis was carried out employing static loading conditions and circular slip surfaces.

The results of the analyses reveals that the proposed excavation for depths up to 8 m will be stable with 2H:1V or flatter slopes.

To facilitate the discharge of any slope surface runoff and any groundwater seepage, it is recommended that drainage ditches or trench drains be constructed at the toe of the slope. Trench drains can consist of a perforated pipe wrapped in a geotextile filter fabric and in turn surrounded by a suitable granular soil filter.

All slopes shall be protected against erosion. This erosion protection can be achieved by conventional sodding methods.

2) CONSTRUCTION OF EXCAVATED SLOPES

There are no major difficulties anticipated in the excavation of the surficial cohesive heterogeneous mixture of clayey silt, sand and gravel deposit and also the cohesionless sand, some silt to silt, some sand stratum above the groundwater table. However, a dewatering scheme will be required should the excavation intercept the groundwater table in the cohesionless materials. As stated in the factual section of this report, the groundwater table varied from an elevation of 168 m to 172.6 m at the time of the investigation but these levels are subject to seasonal fluctuation (see Groundwater Conditions). The proposed Hwy. 407 profile grade is at an approximate elevation of 174 m.

One method of advancing the excavation below the groundwater table is to employ a gravity drainage scheme by working from the centre of the proposed excavation and progressing laterally to either excavation slope. This can be accomplished by excavating sump pits and staging the excavation as illustrated in Figure 7 in the Appendix. The advantage of this gravity drainage method is that any soil sloughing created by seepage are effectively contained within the limits of the excavation.

Conventional earth removal equipment (backhoes, front end loaders and dozers) are applicable at the site.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano and M. Michalek, Foundation Engineers, and M. Iampietro, Engineering Student, utilizing equipment owned and operated by Malones Soil Samples and Master Soils Investigation.

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



A handwritten signature in black ink, appearing to read 'T. Sangiuliano'.

T. Sangiuliano, P.Eng.
Foundation Engineer

A handwritten signature in black ink, appearing to read 'M.S. Devata'.

M.S. 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

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

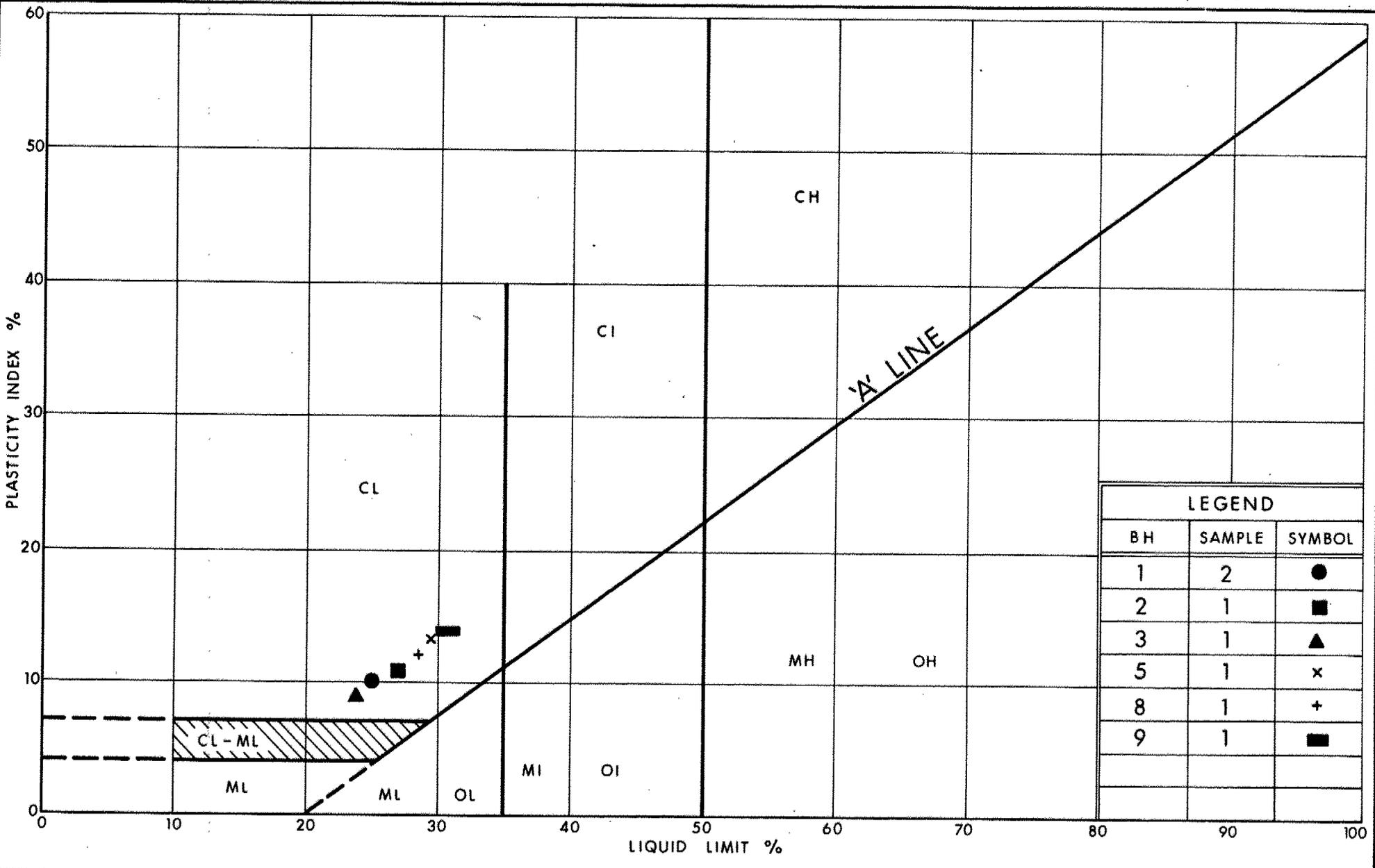
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_r	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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



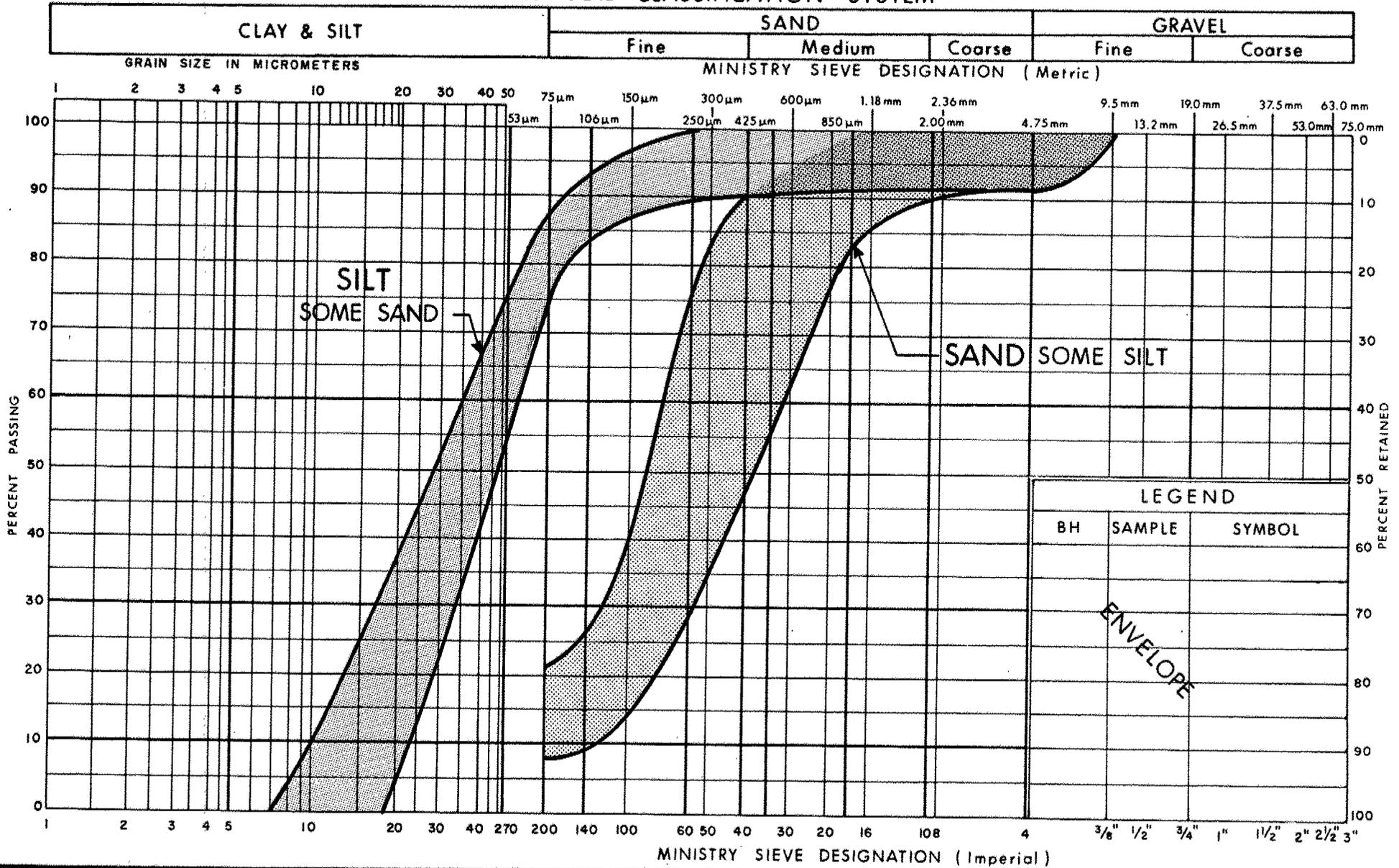
LEGEND		
BH	SAMPLE	SYMBOL
1	2	●
2	1	■
3	1	▲
5	1	x
8	1	+
9	1	▬



PLASTICITY CHART
HET MIXTURE OF CLAYEY SILT; SAND & GRAVEL
(GLACIAL TILL) UPPER

FIG No 2
 W P 370-87-00

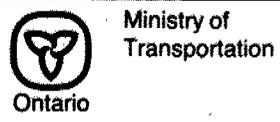
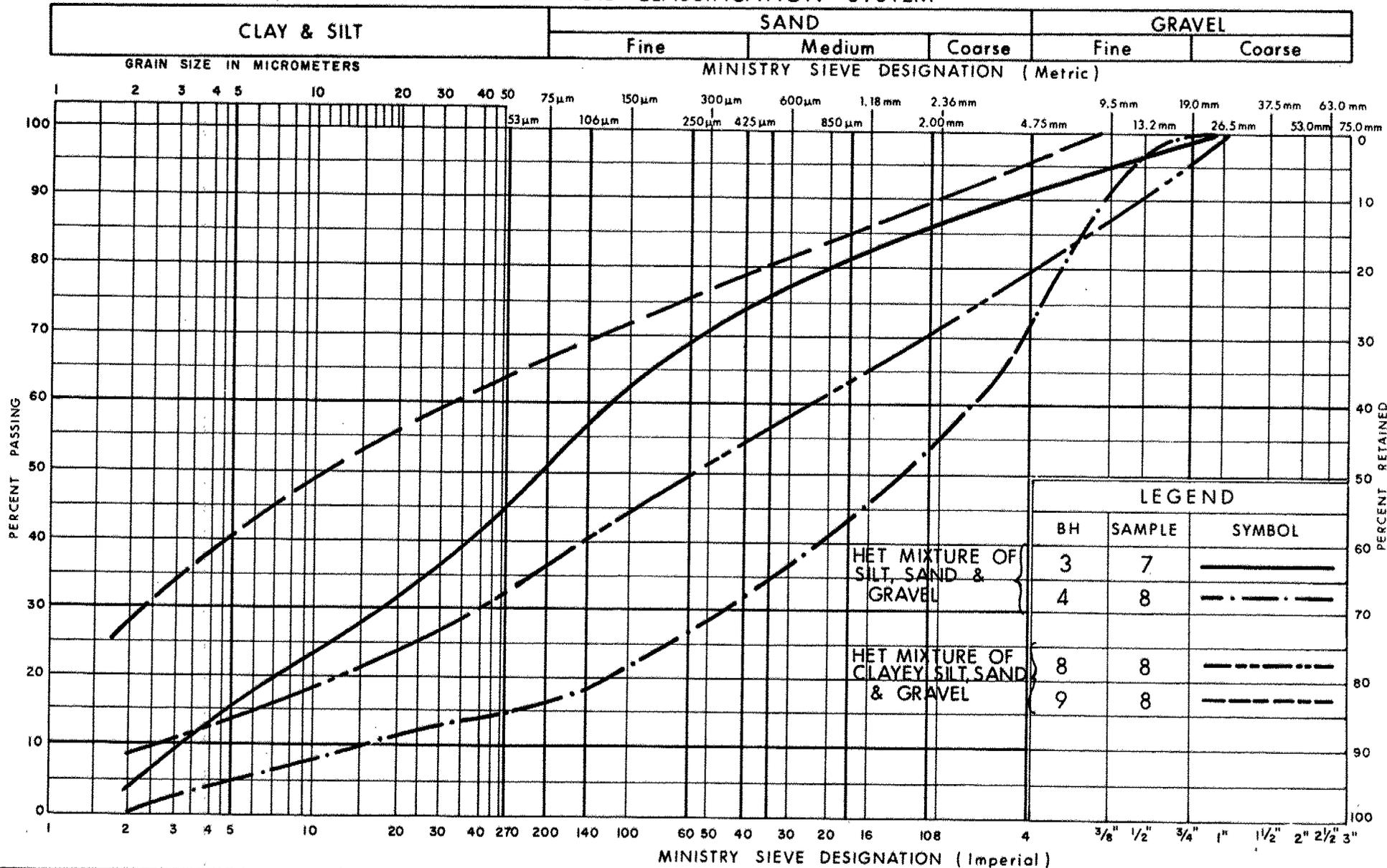
UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
SAND SOME SILT TO SILT SOME SAND

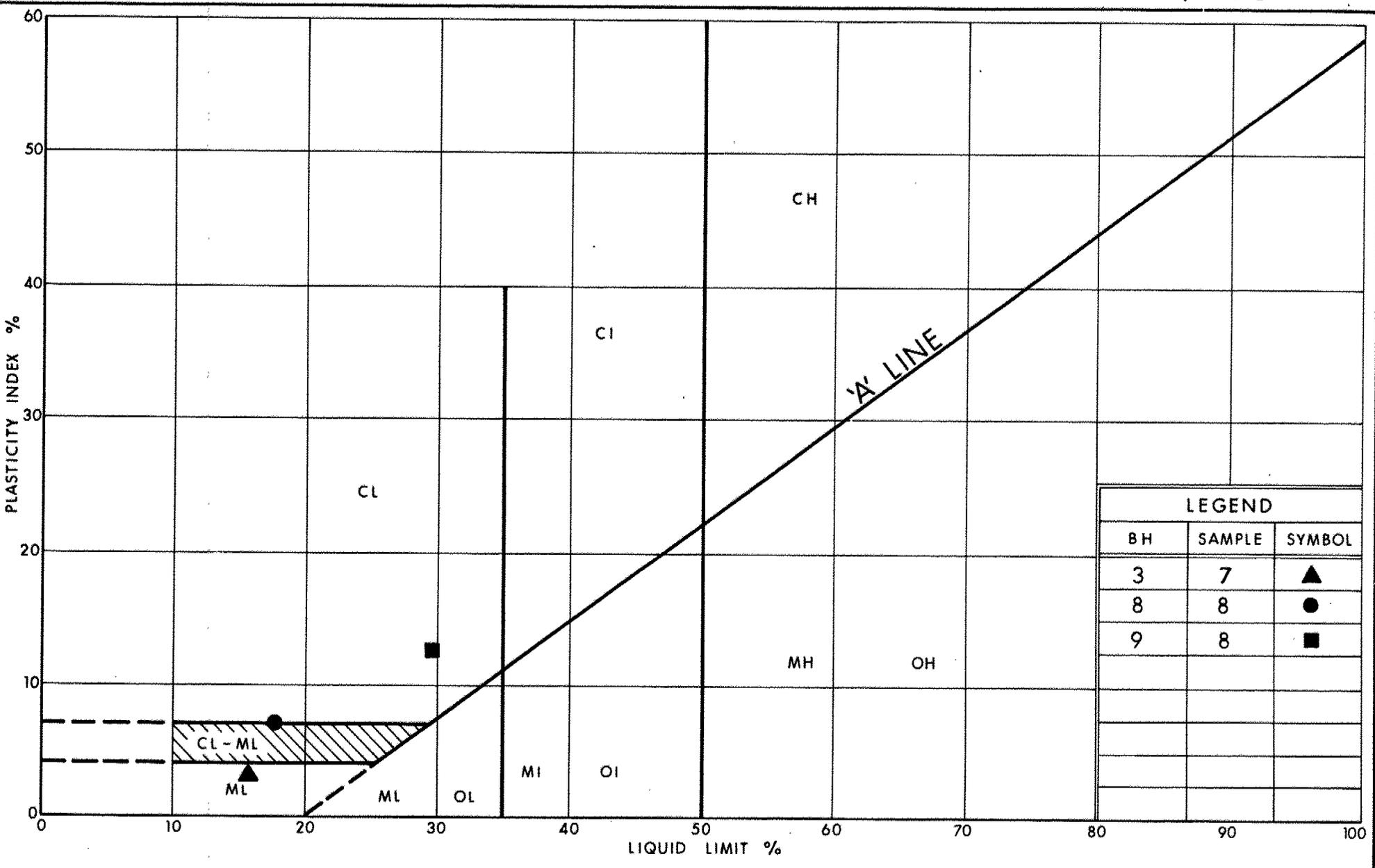
FIG No 3
 W P 370-87-00

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
HET MIXTURE OF CLAYEY SILT TO SILT, SAND & GRAVEL
 (GLACIAL TILL) LOWER

FIG No 4
 W P 370-87-00

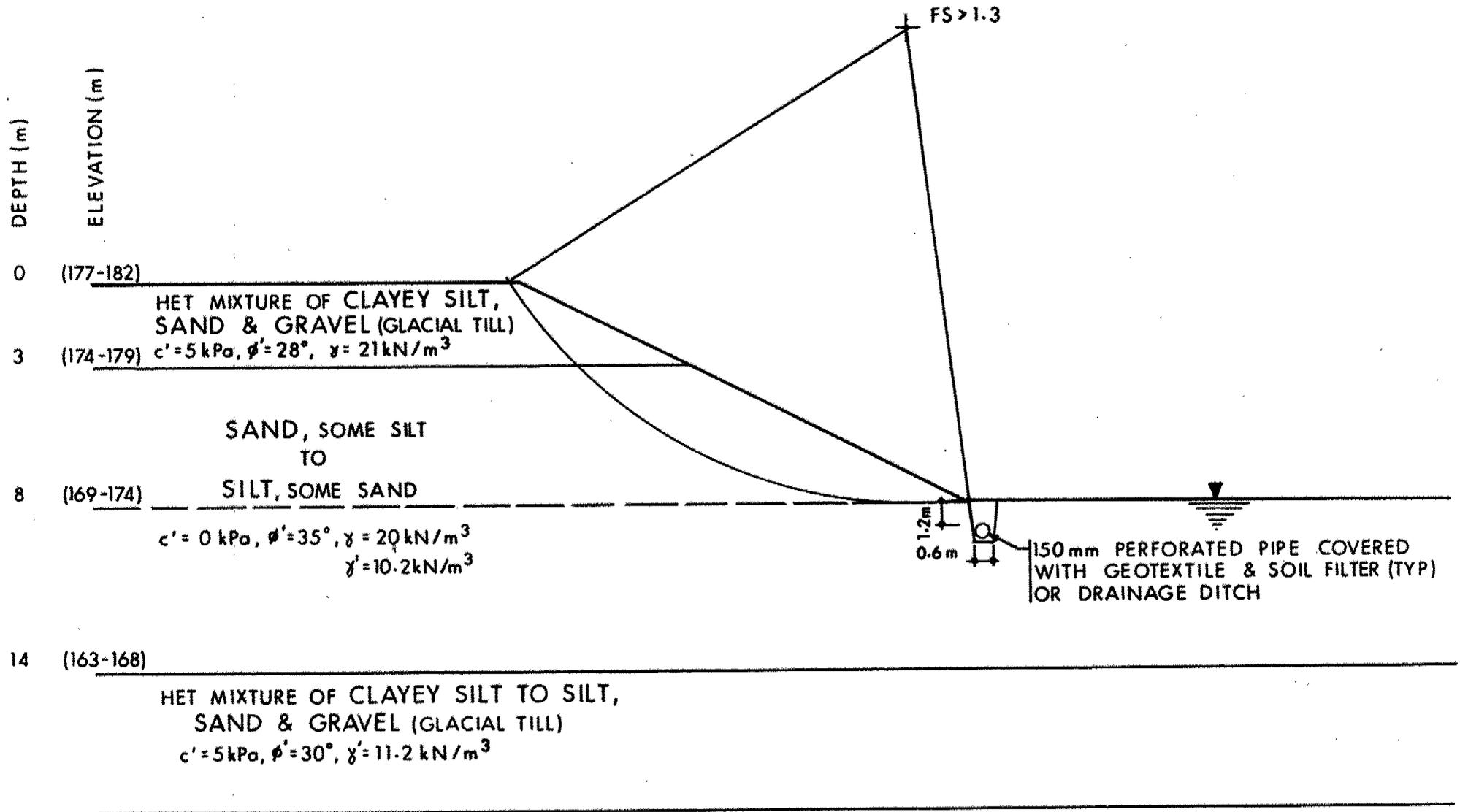


LEGEND		
BH	SAMPLE	SYMBOL
3	7	▲
8	8	●
9	8	■



PLASTICITY CHART
HET MIXTURE OF CLAYEY SILT TO SILT, SAND & GRAVEL
(GLACIAL TILL) LOWER

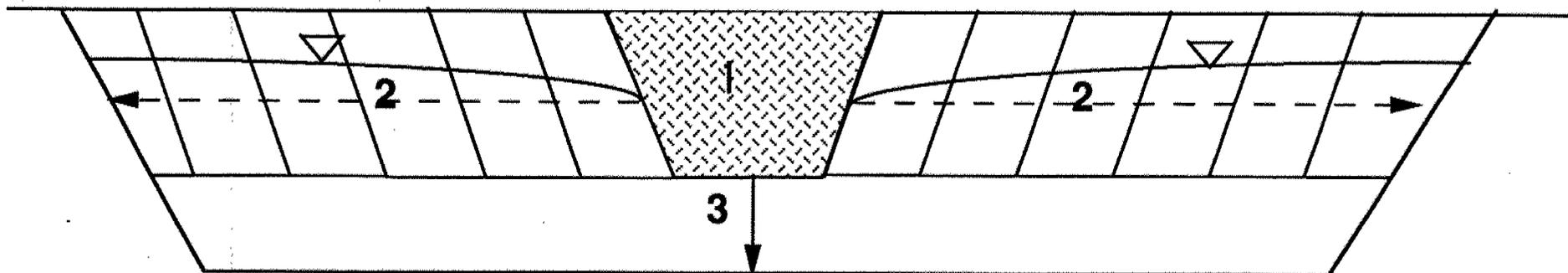
FIG No 5
 W P 370-87-00



EXCAVATED SLOPE STABILITY DESIGN

FIG 6
WP 370-87-00

**FIG. 7 - SLOPE EXCAVATION BELOW GROUNDWATER TABLE
HWY 407 (BETWEEN HWY 50 & HWY 427)**



- 1** EXCAVATE INITIAL SUMP PUMP TRENCH AND ALLOW GRAVITY DRAINAGE
- 2** EXCAVATE Laterally TO EDGE OF EXCAVATION, ALLOWING GRAVITY DRAINAGE IN PROCESS
- 3** PROGRESS TO DESIGNED DEPTH BY REPEATING (1) AND (2)

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 250 O/S 65 m Rt. (Centreline HWY 407)* ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										WATER CONTENT (%) 10 20 30
177.3	Ground Surface																	
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Stiff Hard		1	SS	10													
173.2			174	2	SS	49									21.7	2	23 55 20	
4.1	Sand, some silt Brown, V. Dense		3	SS	114											0	78 (22)	
			172	4	SS	88												
			170	5	SS	125												
			168	6	SS	120												
			166	7	SS	77												
164.7			166	8	SS	79												
12.6	End of Borehole • Co-ords: N 4 845 528.5 E 293 646																	

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

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 325 O/S 85 m Lt (Centreline HWY 407)* ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
178.6	Ground Surface															
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, V. Stiff to Hard		1	SS	33									19.8	5 27 43 25	
			2	SS	17											
174.5	Compact Dense		3	SS	22											
4.1			4	SS	40											0 87 (13)
	Sand, some silt Brown		5	SS	47											
			6	SS	38											0 87 (13)
			7	SS	34											
			8	SS	54											
166.0	End of Borehole															
12.6	*-- Cave-in at 9.14 m depth * Co-ords: N 4 845 690.5 E 293 609.0															

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

RECORD OF BOREHOLE No 2A 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 325 O/S 66 m Rt (Centreline HWY 407)* ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 05 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W			W _L	WATER CONTENT (%)
177.4																		
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till)		1	SS	25													
174.8	Brown, V. Stiff		2	SS	63													
2.6	Sand, some silt Brown, Dense to V. Dense		3	SS	65													
			4	SS	66													
			5	SS	54													
			6	SS	29													
			7	SS	45													
			8	SS	19													
164.8	End of Borehole																	
12.6	Co-ords: N 4 845 570.0 E 293 700.0																	

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 400 O/S 73 m Rt (Centreline HWY 407) ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa				W _p	W		
						20	40	60	80	100					GR SA SI CL
177.6	Ground Surface														
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard	[Diagonal Hatching]	1	SS	35									23.7	5 28 47 20
175.0															
2.6			2	SS	108										
	Sand, some silt Brown, V. Dense		3	SS	77										
		4	SS	81											
		5	SS	76											
		6	SS	95											
167.4															
10.2	Brown Grey Heterogeneous mixture of Silt, sand and gravel (Glacial Till) V. Dense	[Diagonal Hatching]	7	SS	115										4 84 (12)
165.0			8	SS	120										10 39 46 5
12.6	End of Borehole * - Water level not established * Co-ords: N 4 845 606.5 E 293 763.5														

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 475 O/S 100 m Lt (Centreline Hwy 407) ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa								
						20 40 60 80 100	20 40 60 80 100									
180.3	Ground Surface															
0.0																
	Compact Dense		1	SS	22											
			2	SS	32											0 5 (95)
			3	SS	38											
	Silt, some sand to Sand, some silt Brown		4	SS	32											0 91 (9)
			5	SS	36											
			6	SS	35											
169.0			7	SS	46											
11.3	Heterogeneous mixture of Silt, sand and gravel															
167.7	(Glacial Till), Brown, V. Dense		8	SS	120											29 54 17 0
12.6	End of Borehole															
	• Co-ords: N 4 845 795.5 E 293 734.5															

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 550 O/S 65 m Rt. (Centreline HWY 407)* ORIGINATED BY MI
 DIST 5 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80						100
179.2	Ground Surface															
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till)															
176.6	Brown, V. Stiff	1	SS	20										2	31 42 25	
2.6	Silt, some sand to Sand, some silt V. Dense Brown ----- Grey	2	SS	59												
		3	SS	61												
		4	SS	61												
		5	SS	61												0 24 (76)
		6	SS	66												
		7	SS	70												
		8	SS	86												
166.8		End of Borehole														
	*-- Water level not established. * Co-ords: N 4 845 684 E 293 885															

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

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 625 0/5 62 m LL.(Centreline HWY 407)* ORIGINATED BY MM
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L			7
179.7	Ground Surface																	
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard	[Hatched]	1	SS	35	/28cm												
			2	SS	80													
175.6	Silt, some sand to Sand, some silt V. Dense Brown Grey	[Dotted]	3	SS	78													
4.1			4	SS	81													
			5	SS	86													
			6	SS	64													
			7	SS	109													
			8	SS	109													
			9	SS	86													
165.4																		
14.3	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till), Grey, Hard	[Hatched]	10	SS	100	/13cm												
164.3																		
15.4	End of Borehole																	
	* Co-ords: N 4 845 828.0 E 293 896.0																	

+3, x5, Numbers refer to Sensitivity 20 15-0-9 (%) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 700 O/S 67 m Rt (Centreline HWY 407) ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
180.3	Ground Surface																
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard	1	SS	34													
176.2		2	SS	110													
4.1	Silt, some sand to Sand, some silt Brown Grey	3	SS	154													
176		4	SS	105													
174		5	SS	54													
172		6	SS	91													
170		7	SS	72													
167.7		8	SS	101													
12.6	End of Borehole * Co-ords: N 4 845 735.0 E 294 014.0																

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 770 O/S 62 m Rt. (Centreline HWY 407) ORIGINATED BY MM
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
180.0	Ground Surface															
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, V. Stiff	1	SS	25												1 24 47 28
177.4		2	SS	137												
2.6		3	SS	168												
	Silt, some sand to Sand, some silt Brown, V. Dense	4	SS	125	/23cm											9 16 (75)
		5	SS	75												
		6	SS	71												
		7	SS	155												0 90 (10)
168.3		8	SS	97												
11.7	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard	9	SS	120	/15cm											21 43 26 10
164.7		10	SS	120	/1cm											
15.3	End of Borehole * Co-ords: N 4 845 755 E 294 058															

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

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 840 O/S 62 m Lt (Centreline HWY 407) ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60
179.7	Ground Surface														
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till)		1	SS	25								2 24 42 32		
177.1	Brown, V. Stiff														
2.6	Silt, some sand to Sand, some silt		2	SS	62										
			3	SS	45										
			4	SS	37										2 9 (89)
			5	SS	39										
			6	SS	45										
168.4	Brown Grey Dense to V. Dense Compact		7	SS	26										
11.3	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till)														
167.1	Brown, Hard	8	SS	53									4 28 44 24		
12.8	End of Borehole														
	• Co-ords: N 4 845 901 E 294 106														

RECORD OF BOREHOLE No 10* 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 667 O/S 71 m Lt. (Centreline HWY 407)** ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W			W _L	7
182.1	Ground Surface																	
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Brown, Hard		1	SS	54													
			2	SS	110													
178.0	Silty Sand V. Dense Brown Grey		3	SS	100													
4.1			4	SS	89													
			5	SS	88													
			6	SS	120													
169.5	End of Borehole																	
12.6	* Formerly BH 1(WP368-87-01) ** Co-ords: N 4 845 854.5 E 293 934																	

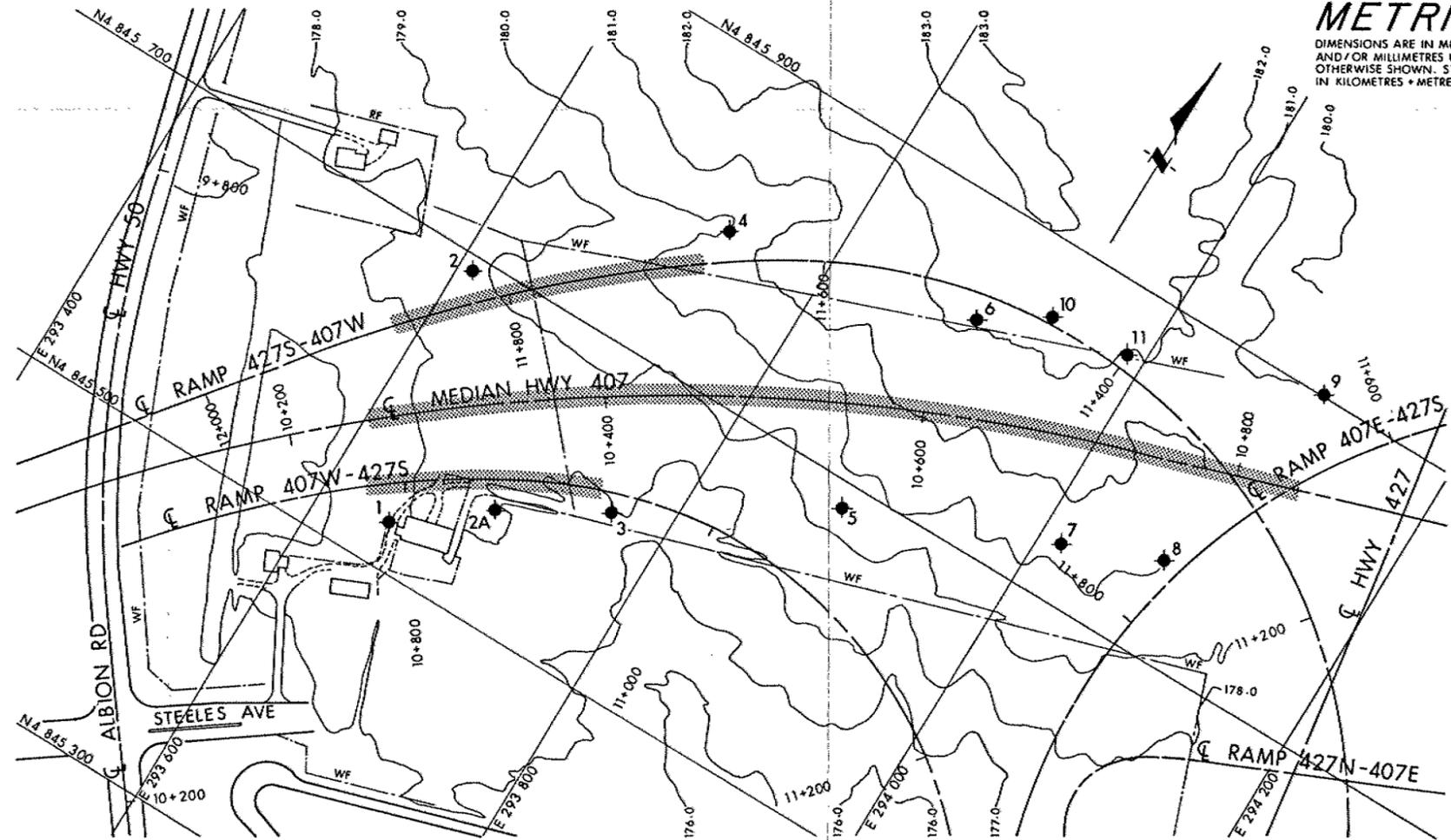
RECORD OF BOREHOLE No 11* 1 OF 1 METRIC

W.P. 370-87-00 LOCATION Sta. 10 + 720 O/S 57 m Lt. (Centreline HWY 407)** ORIGINATED BY MI
 DIST 6 HWY 407 BOREHOLE TYPE HS Auger COMPILED BY MI
 DATUM Geodetic DATE 90 07 06 CHECKED BY TS

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80					
181.9	Ground Surface															
0.0	Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) V. Stiff Hard		1	SS	21	DRY										
			2	SS	36											
179.0	Brown		3	SS	56										21.7	5 19 50 26
2.9			4	SS	110											0 38 (62)
			5	SS	120											
	Sandy Silt to Silty Sand		6	SS	100											
			7	SS	90											0 77 (23)
			8	SS	82											
	V. Dense		9	SS	72											
			10	SS	110											
	Brown Grey some gravel		11	SS	104											
			12	SS	120	/28cm										14 46 (40)
168.2																
167.7	***		13	SS	86											
14.2	End of Borehole * Formerly BH 2 (WP 368-87-01) ** Co-ords: N 4 845 858 E 293 986 *** Heterogeneous mixture of Clayey Silt, sand and gravel (Glacial Till) Hard															



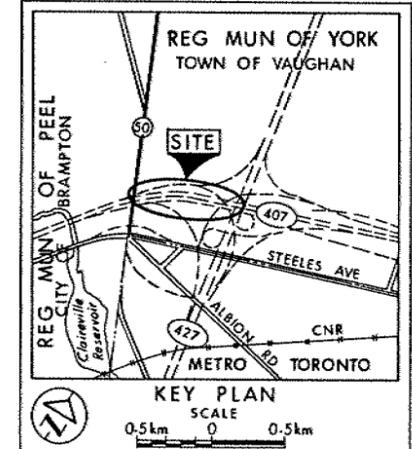
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.



NOTE:
Subsoil information for BH's 2, 10 & 11
Refer to Record of Borehole

PLAN
SCALE
40m 20 0 40m

EXCAVATION CUTS EXCEEDING 4.5m

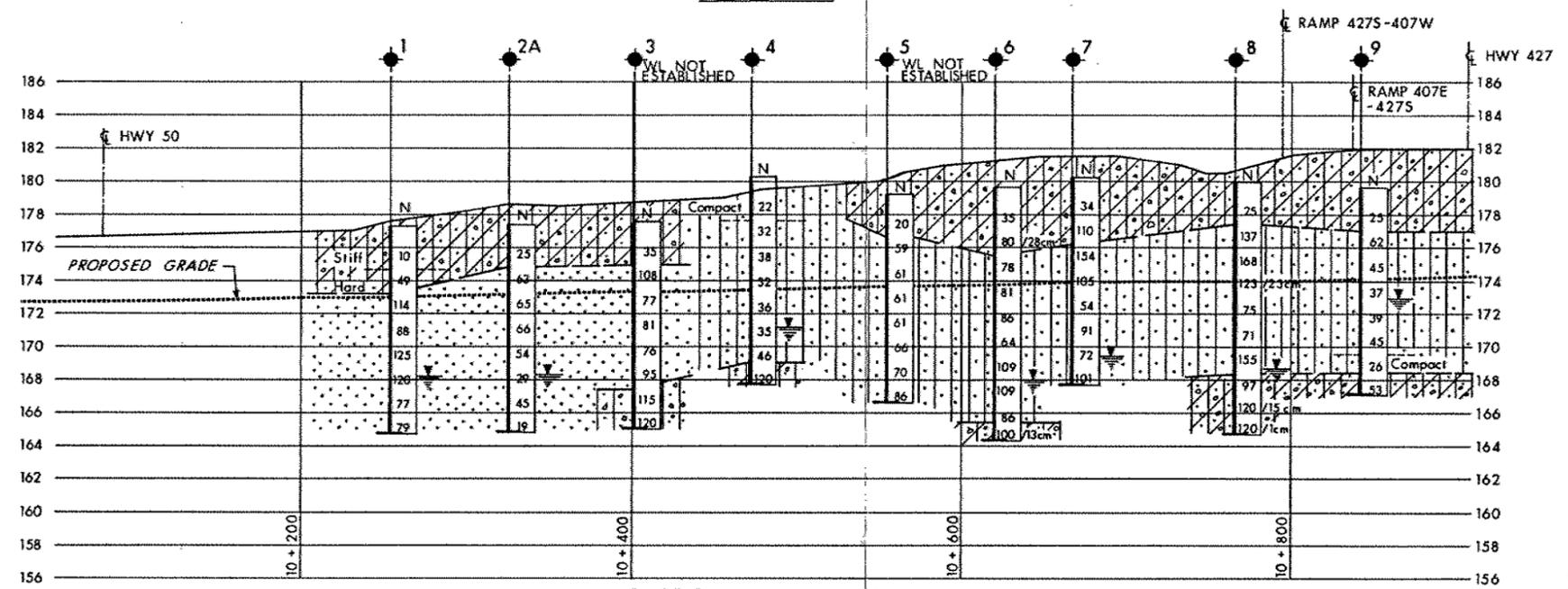


LEGEND

- 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 07

SOIL STRATIGRAPHY LEGEND

- HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (GLACIAL TILL)
Very Stiff to Hard / Very Dense
- SAND, SOME SILT
Dense to Very Dense
- SILT, SOME SAND TO SAND SOME SILT
Dense to Very Dense
- HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL (GLACIAL TILL)
Very Dense



PROFILE HWY 407

SCALE
40m 20 0 40m Hor
4m 2 0 4m Vert

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	177.3	4 845 528.5	293 646.0
2	178.6	4 845 690.5	293 609.0
2A	177.4	4 845 570.0	293 700.0
3	177.6	4 845 606.5	293 763.5
4	180.3	4 845 795.5	293 734.5
5	179.2	4 845 684.0	293 885.0
6	179.7	4 845 828.0	293 896.0
7	180.3	4 845 735.0	294 014.0
8	180.0	4 845 755.0	294 076.0
9	179.7	4 845 901.0	294 106.0
10	182.1	4 845 854.5	293 934.0
11	181.9	4 845 858.0	293 988.0

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 30M13-117

HWY No 407	DIST 6
SUBMD TS CHECKED	DATE 91 01 08
DRAWN DT CHECKED	APPROVED
SITE 37-1120	DWG 3708700-A