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DIST. 6 REGION

W.P. No. 40-77-02

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 89

LOCATION EMBANKMENT FILL

STA 12+980 to STA 13+630

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 40-77-02 DIST 6
HWY 89 EXT. STR SITE

Embankment Fill
Sta. 12 + 980 to 13 + 630

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FOUNDATION INVESTIGATION REPORT

For

W.P. 40-77-02

Hwy. 89 Extension

Sta. 12+980 to Sta. 13+630

Embankment Fill

District 6, Toronto

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above noted site between 86 02 24 and 86 03 07. The investigation consisted of 10 sampled boreholes advanced by a continuous flight auger machine equipped with hollow stem augers and BX casing. A dynamic cone penetration test accompanied each of the boreholes. The boreholes were advanced to depths ranging from 9.6 m to 33.5 m.

The scope of the investigation limits itself to the section of the proposed Hwy. 89 extension from Sta. 12+980 to Sta. 13+630.

SITE DESCRIPTION

The site is located south of Lake Simcoe along York Regional Road 32, approximately 4 km east of Hwy. 48. The site lies on the boundary between the Townships of Georgina and Uxbridge, in the Regional Municipality of York. A Key Plan is included on Dwg. 407702-A in the Appendix.

Physiographically, the site is located within the region known as the "Simcoe Lowlands" (see The Physiography of Southern Ontario, Chapman and Putnam, 1984). The area is characterized primarily by swampy sand and clay plains, with several areas of drumlinized till. The region is primarily covered by forest and/or swampy lowlands. Some scattered residential and agricultural properties also exist.

Specifically, the western segment of the investigated area (Sta. 12+980 to Sta. 13+220) lies within a flat and lightly wooded shallow swamp. From Sta. 13+250 to Sta. 13+630, the existing grade rises to the east, and land use is primarily agricultural.

SUBSURFACE CONDITIONS

General

A surficial cover of organic material is present across the entire site. The thickness of this material varies from 0.4 to 0.9 m. Underlying the surficial cover is generally a deposit of silty clay which is interrupted by a thick seam of silty sand to sandy silt (BH 1-7). Underlying the lower deposit of silty clay is the predominant deposit across the site: a glacial till described as a heterogeneous mixture of silty clay, sand, gravel. Bedrock was encountered at one location at Elev. 199.2.

Between Sta. 12+980 and 13+350 the groundwater level was encountered at the ground surface. East of these limits, the groundwater level is found between 0.3 and 3.1 m below the ground surface.

The boundaries between the various soil types, in-situ and laboratory test results, as well as groundwater conditions are shown on the Record of Borehole Sheets in the Appendix. The location of each borehole is shown in plan on Dwg. No. 407702-A, together with a longitudinal stratigraphical section.

The various soils encountered at this site are described as follows:

Organics

The entire section investigated was covered by a deposit of surficial organics. This material consists of either an organic silt or topsoil. The thickness of this material varies generally from 0.4 to 0.9 m. However, thicker isolated areas may be encountered. No field or laboratory testing was carried out on samples of this compressible material.

Silty Clay of Low Plasticity

Silty clay was encountered between Sta. 12+980 and Sta. 13+400 (BH 1-7). Two layers of this cohesive material were found. The two layers were interrupted by a seam of silty sand to sandy silt ranging in thickness between 5.3 and 7.9 m.

The upper limit of the upper layer was found to occur between Elev. 230.4 and 231.9. This layer extends down to between Elev. 227.3 and 228.3. The thickness of the upper layer ranges between 1.7 and 3.4 m.

The upper limit of the lower layer was found to occur between Elev. 219.8 and 224.0. This layer extends down to between Elev. 214.0 and 217.5. The thickness of the lower layer ranges between 5.3 and 7.9 m. The lower silty clay seam overlies a glacial till deposit which will be discussed later.

Atterberg Limits tests were carried out on 11 samples of this material. The results of the tests are shown on Figure 1 in the Appendix and are summarized as follows:

	<u>Range (%)</u>
Moisture Content (W)	20-28.5
Plastic Limit (W _p)	16-34.5
Liquid Limit (W _L)	12-19
Plasticity Index (I _p)	1-15.5

Based on these results, this material can be considered to be generally a silty clay of low plasticity, and therefore cohesive. However, it should be noted that in both the upper and lower layers occasional seams of non-cohesive material were encountered. In the upper layer, the non-cohesive seams consist primarily of silt, while in the lower layer, the non-cohesive material consists of sandy silt.

Based on the interpretation of the results of unconfined shear strength tests, in-situ vane tests, and Standard Penetration tests, the consistency of the upper layer of this deposit is considered to be soft to firm.

The lower layer of this material is considered to have a consistency ranging between stiff and hard based on the interpretation of Standard Penetration test results.

Grain size distribution tests were carried out on 5 samples of this material. The results are shown in envelope form on Figure 2 in the Appendix. The results indicate that this material consists of a silty clay, trace sand.

Silty Sand to Sandy Silt

A deposit of silty sand to sandy silt was encountered in all boreholes with the exception of BH 10. In BH 1-7, this deposit was encountered immediately below the silty clay of low plasticity stratum, at a depth ranging between 2.1 and 3.7 m below the ground surface. In BH 8 and 9, this deposit was encountered immediately below the surficial organic material. The thickness of this deposit varies from 1.7 m to 7.9 m.

The results of 6 grain size distribution tests are shown in envelope form on Figure 3 in the Appendix. The results can be summarized as follows:

	<u>Range (%)</u>
Gravel	0 - 1
Sand	12 - 92
Silt	6 - 85
Clay	1 - 6

Based on the results, and on Figure 3, this material can be considered to be a silty fine sand to a sandy silt. It should be noted that when this non-cohesive material is subjected to an unbalanced hydrostatic pressure, "boiling" will result.

Based on the interpretation of the Standard Penetration test 'N' values, this material is generally in a compact to dense state.

Heterogeneous Mixture of Silty Clay, Sand, Gravel (Glacial Till)

Glacial till was encountered in BH 2, 4, 5, 6, 8, 9 and 10. However, if the other boreholes would have been advanced to sufficient depths, this glacial deposit would have also been encountered.

From Sta. 12+980 to Sta. 13+400, this deposit is encountered at a depth of approximately 17 m below the existing ground surface. The full extent of this material was only explored at one location. At BH 6, this stratum was found to immediately overlie bedrock. The thickness of this glacial deposit at this particular location was determined to be 18.3 m.

Between Sta. 13+400 and 13+630, the grade rises to the east at a slope of approximately 2.6%. Within this section, the glacial till deposit is encountered at a depth ranging between 1 and 3 m below the existing ground surface. The full extent of this deposit within this section was explored only at BH 10. At this location, the glacial till was found to be 6.6 m thick and was underlain by silty clay of intermediate plasticity to clay of high plasticity.

Atterberg Limits tests were carried out on 7 samples of this material. The results are shown on Figure 4 in the Appendix, and can be summarized as follows:

	<u>Range (%)</u>
Moisture Content (W)	6.5 - 18
Plastic Limit (W _p)	10 - 14
Liquid Limit (W _L)	13.5 - 20.5
Plasticity Index (I _p)	1.5 - 9

The results indicate that the matrix of this glacial till deposit can be considered to be a silt of slight plasticity to a silty clay of low plasticity (ML - CL group).

The deposit can also be considered to generally be cohesive to slightly cohesive. However, several seams and zones of non-cohesive material were encountered randomly throughout the deposit.

Grain size distribution tests were carried out on 6 samples of this material. The results, shown on Figure 5 in envelope form are summarized as follows:

	<u>Range (%)</u>
Gravel	6 - 31
Sand	27 - 37
Silt	22 - 52
Clay	4 - 15

Based on these results and visual classification, the till can be described as a heterogeneous mixture of silty clay with sand, gravel. As previously mentioned, however, seams or zones of non-cohesive material such as silt or sand can be randomly encountered throughout the deposit. Occasional boulders may also be encountered.

Based on the interpretation of Standard Penetration Test 'N' values ranging between 3 and well over 100 blows/0.3m, this deposit can be considered to have a hard consistency.

Silty Clay of Intermediate to High Plasticity

A deposit of silty clay of intermediate to high plasticity was encountered in BH 10 beneath the glacial till stratum. The full lateral or vertical extent of this cohesive material was not investigated.

Atterberg Limits tests were carried out on 2 samples of this hard deposit with the following results:

	<u>Sample # 8-A</u>	<u>Sample # 8-B</u>
Moisture Content (W)	18.5%	18.9%
Plastic Limit (W _p)	19.0%	24%
Liquid Limit (W _L)	34.5%	60.5%
Plasticity Index (I _p)	15.5%	36.5%

The results indicate that the plasticity of this deposit ranges between intermediate and high (CI - CH).

Bedrock

Only BH 6 was advanced to a sufficient depth to bedrock. It is estimated that at this location bedrock is found at approximately Elev. 199.2. The upper 1 m± of the bedrock surface was penetrated using tri-cone and wash-boring methods. This would suggest that the upper zone is weathered. Rock cores were not obtained.

Bedrock across this site consists of limestone with occasional shale partings of the Lindsay Formation (Trenton and Black River Group).

Groundwater Conditions

The groundwater level was found to be at ground surface between Sta. 12+980 to Sta. 13+350. Between Sta. 13+350 and Sta. 13+630, the groundwater is found between 0.3 and 3.1 m below the ground surface.

An artesian condition was encountered in BH 6 immediately over the bedrock at about Elev. 199.5. The hydraulic head at this depth is at least at Elev. 231.7. Piezometers were not installed.

DISCUSSION AND RECOMMENDATIONS

In conjunction with the proposed extension of Hwy. 89 from York Road 12 to Hwy. 12, it is required to place up to 16 m of fill along Regional Road 32 so as to reduce the existing steep grade.

The recommendations presented in this report pertain only to the section of the proposed Hwy. 89 extension between Sta. 12+980 and Sta. 13+630. Within this section, fill ranging between 1 and 16 m in height is proposed.

A surficial cover of organic material is present across the entire site. The thickness of this material varies from 0.4 to 0.9 m. Underlying the surficial cover is generally a deposit of silty clay which is interrupted by a thick seam of silty sand to sandy silt (BH 1-7). Underlying the lower deposit of silty clay is the predominant deposit across the site: a glacial till described as a heterogeneous mixture of silty clay, sand, gravel. Bedrock was encountered at one location at Elev. 199.2.

Between Sta. 12+980 and 13+350 the groundwater level was encountered at the ground surface. East of these limits, the groundwater level is found between 0.3 and 3.1 m below the ground surface.

The following are our recommendations for the design and construction of the fill:

Stability

The stability of the proposed fill was analyzed utilizing Bishop's Total and Effective Stress methods. The following assumptions were made in the analysis:

1. The surficial organic material and underlying silty clay are subexcavated and replaced with well-compacted granular material. This is discussed later in detail.

2. It is recommended that the fills be constructed of granular-type material. Consequently, all analysis were based on this assumption. For the calculations the following properties were assigned to the fill material.

Effective angle of internal friction, $\phi' = 30^\circ$
 Maximum unit weight of soil, $\gamma = 20 \text{ kN/m}^3$

3. Pore pressure ratio, ru , was assumed to be 0.25 in the Effective Stress analysis.
4. For the founding material an angle of internal friction of 30° was assumed for the upper zones, and 35° for the lower zone.

Based on the results of the analysis and past experience with fills it is our opinion that mid-height berms should be provided in the high fill sections. The following table should be used in the design, provided that all slopes are constructed of granular-type material (except as later discussed) and at a slope of 2H:1V.

<u>Height of Fill, H</u>	<u>Mid-Height Berm Length, L (m)</u>
0 - 10.5 m	$L = 0$
10.5 - 13.5 m	$L = H/4$
13.5 - 16.5 m	$L = H/2$
16.5 m or higher	Contact Foundation Design Section

The berms should be provided with a nominal slope (15H:1V) away from the embankment so that surface water and run-off does not pond on the berm.

Granular-type (non-cohesive) material is required in the sections where the embankment will be greater than 8 m± in height. The use of granular-type material will minimize the pore-water pressure build-up in the fill.

In areas where the embankment is less than 8 m in height the fill could consist of any acceptable material. However, if cohesive material is used, long-term settlements may be experienced. This is covered later in the report.

Subexcavation

Within the limits of our investigation a surficial cover of organic material was encountered. This highly compressible material consists of organic silt or topsoil. At the locations investigated, the thickness of this material was found to vary between 0.4 and 0.9 m. However, thicker isolated areas may be encountered.

Prior to placing any fill, this material should be completely subexcavated.

Between Sta. 12+980 (west limit of investigation) and approximately Sta. 13+400 a soft to firm deposit of silty clay was encountered. The thickness of this compressible material was found to range between 2.1 and 4.5 m.

It is recommended that this material be completely subexcavated down to the silty sand to sandy silt stratum. The excavation should be backfilled with granular material.

This material should be removed within the plan limits of the embankment and extending to 2 m beyond the toe of slope.

The removal of this material is required in order to improve embankment stability and minimize post-construction settlements of the founding material.

Settlements

As previously discussed, the surficial organic material and underlying silty clay deposit should be completely subexcavated and replaced with granular-type material. It is therefore anticipated that any settlement of the founding material will be elastic in nature and will occur during construction.

As discussed earlier, the fill should consist of granular-type material in the sections where the embankment is 8 m or higher. Elsewhere, any acceptable fill material can be used. In the areas where granular-type material will be used,

the majority of the settlement will be elastic in nature and consequently, will occur during the construction. It is however recommended that these fill sections be left in place for at least 3 months after construction prior to paving.

If cohesive material is used in the areas where the fill is less than 8 m in height, longer-term settlements may be anticipated. It is estimated that cohesive fill will settle approximately 0.5% of the height. 90% of this total settlement will occur within the first six months after construction. It is therefore suggested that if cohesive material is used for the embankment, paving should not be undertaken for at least 6 months after construction.

If granular-type material is used for the entire length of the embankment, paving 1 month after construction will be sufficient for areas where fill is less than 7 m in height.

General

This Section would like to instrument the high fills. The Foundation Design Section should be kept informed of the scheduling of this project so that an instrumentation program can be implemented.

It is to be noted that a structure is required at the CNR crossing at approximately Sta. 13+240. This report should not be used for the design of that structure. When the structure alignment and geometry is determined a detailed subsurface investigation will be required at the site.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period from 86 02 24 to 86 03 07 under the supervision of D. Yeo, Project Foundations Engineer. The equipment used was owned and operated by Master Soil Investigations Ltd. of Toronto.

This report was prepared by L. Politano, with assistance from D. Yeo. This report was reviewed by M. Devata, Chief Foundations Engineer.



A handwritten signature in black ink, appearing to read "L. Politano", with a long horizontal stroke extending to the right.

L. Politano, P.Eng.
Project Foundations Engineer

A handwritten signature in black ink, appearing to read "M. Devata", with a large, stylized initial "M" and a long horizontal stroke extending to the right.

M. Devata, P.Eng.
Chief Foundations Engineer
(East)

June 1986

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:

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

MECHANICAL PROPERTIES OF SOIL

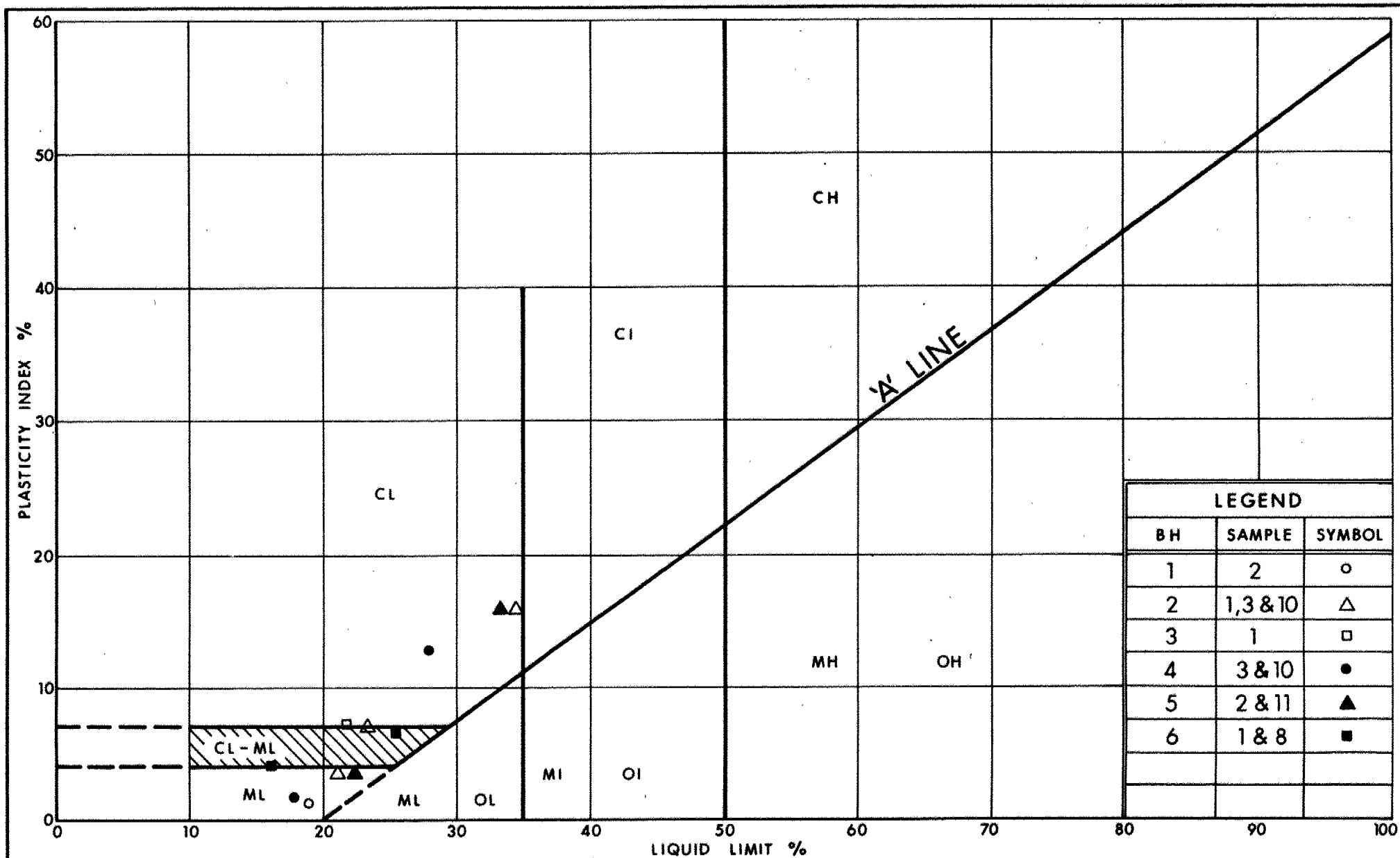
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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_r	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

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

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
P	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						



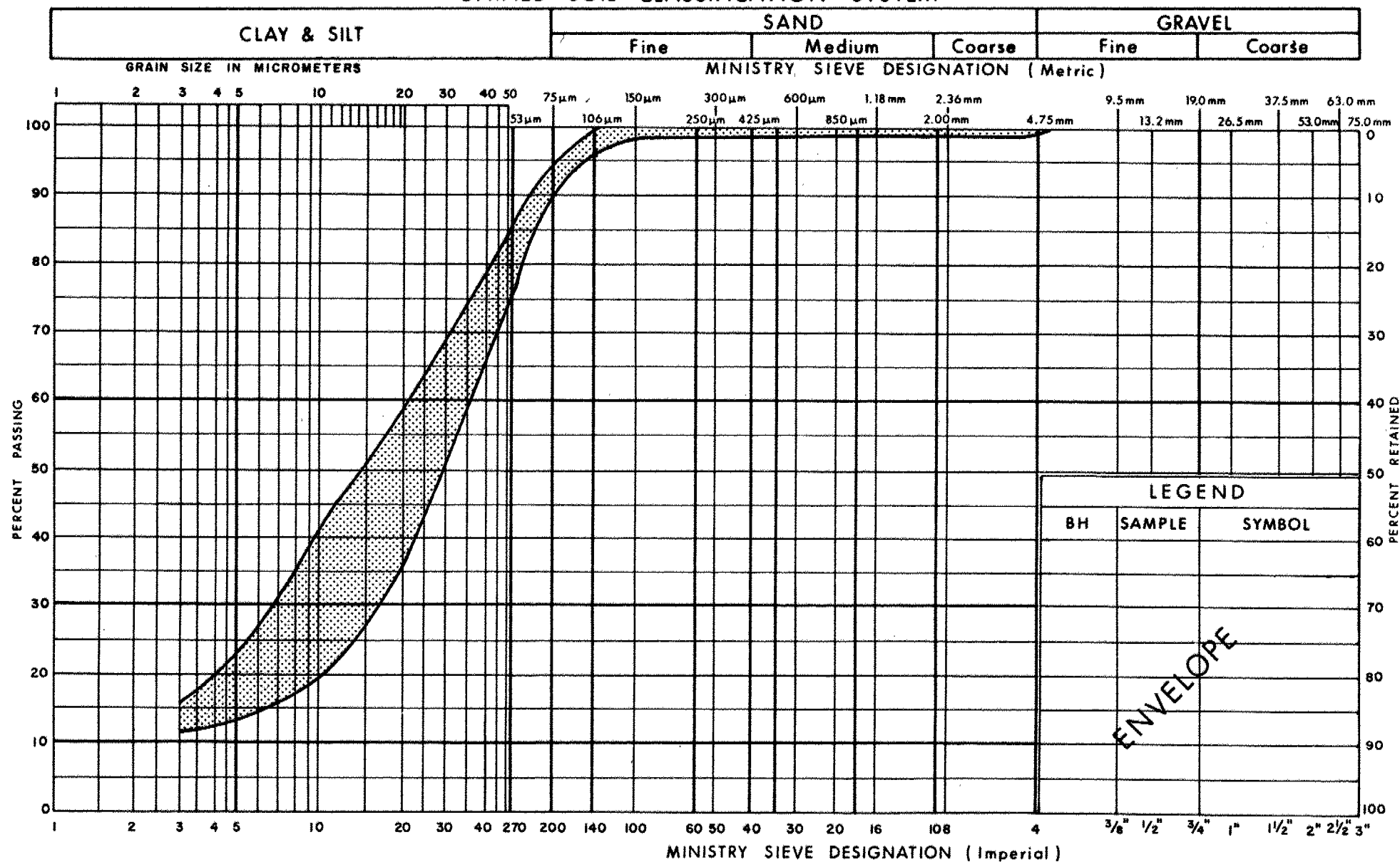
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PLASTICITY CHART SILTY CLAY OF LOW PLASTICITY

FIG No 1

W P 40 - 77 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

SILTY CLAY OF LOW PLASTICITY

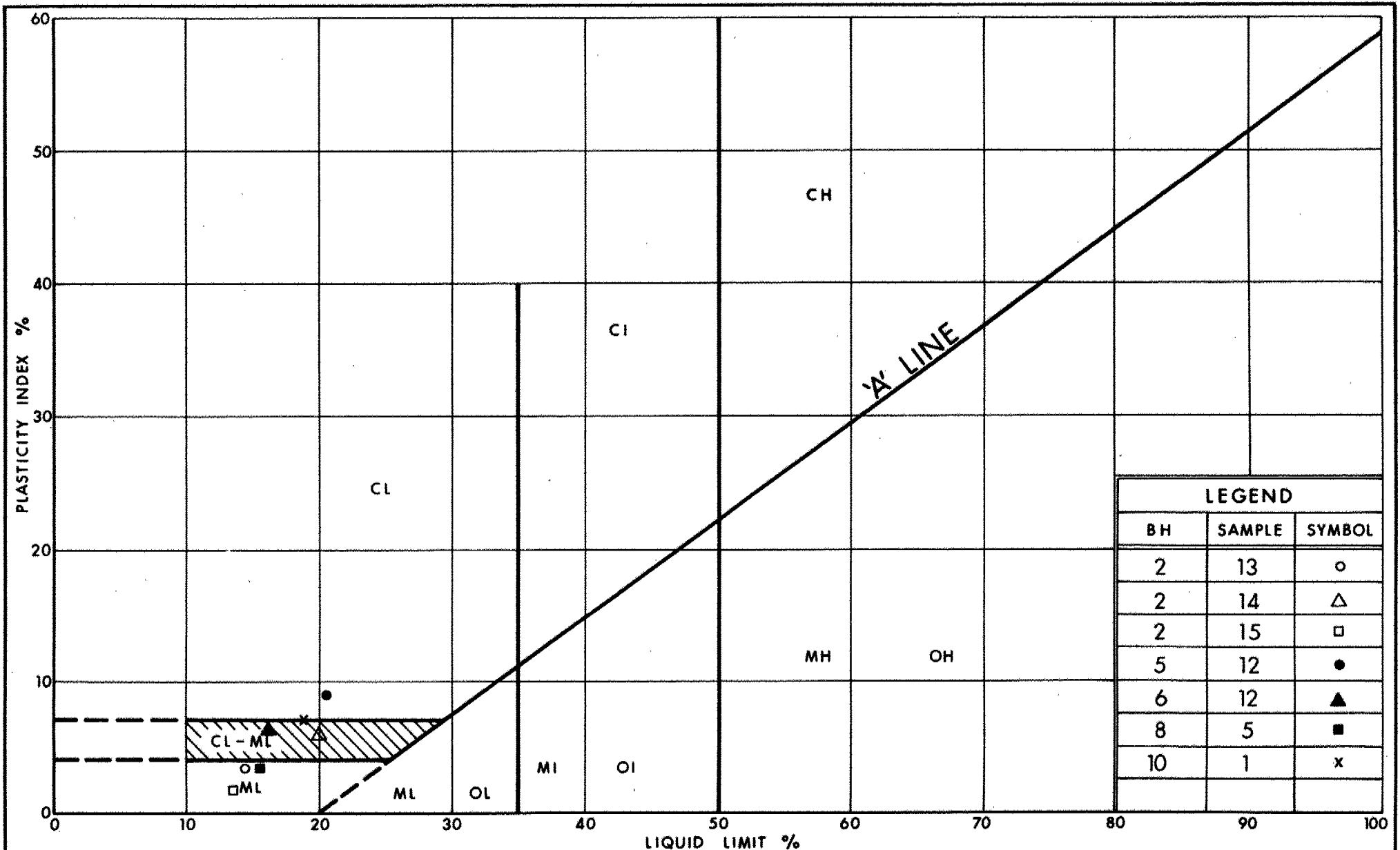
FIG No 2

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GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT

W P 40-77-02



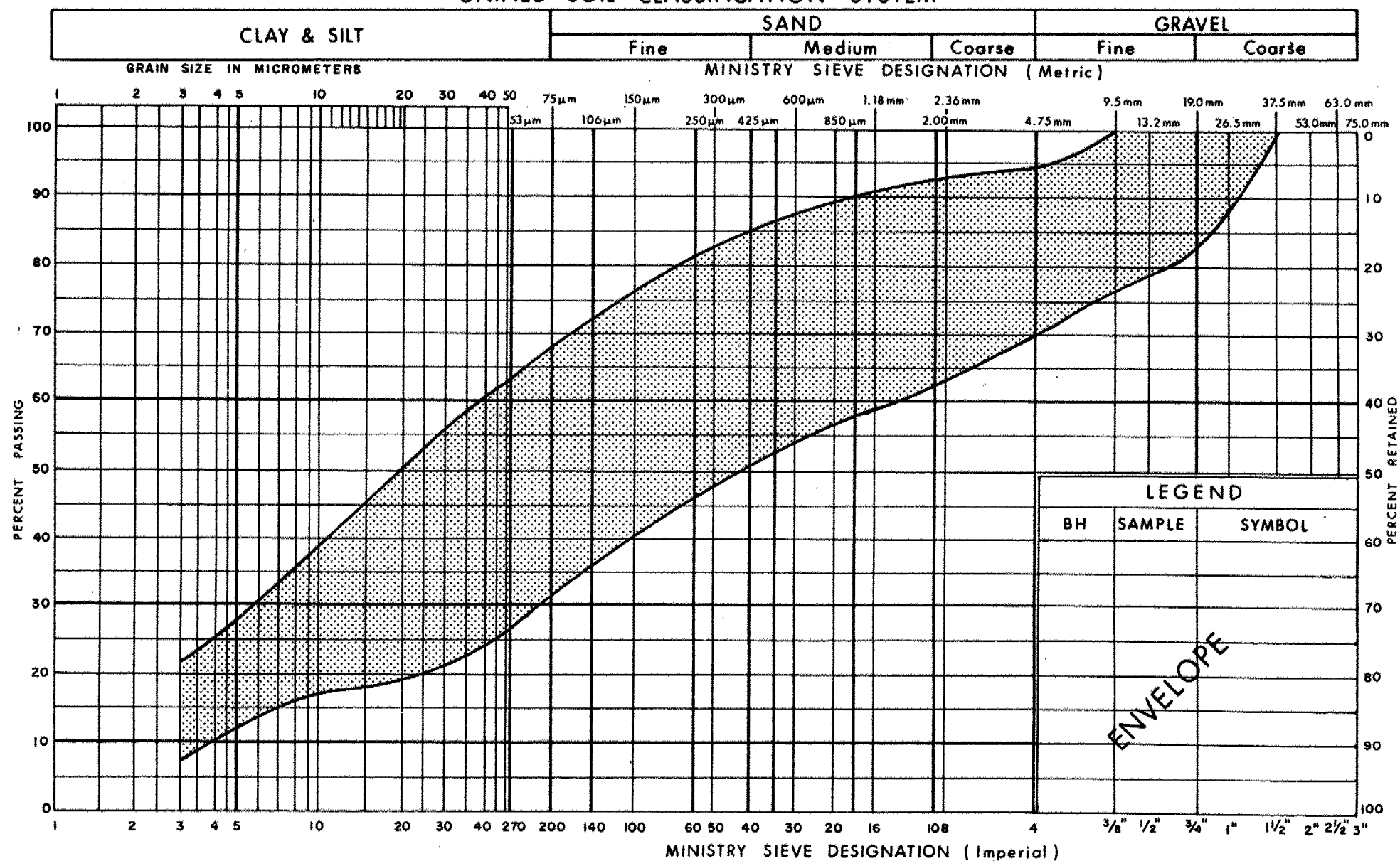
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PLASTICITY CHART
HETEROGENEOUS MIXTURE SILTY CLAY, SAND & GRAVEL
(GLACIAL TILL)

FIG No 4

W P 40-77-02

UNIFIED SOIL CLASSIFICATION SYSTEM

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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF SILTY CLAY
WITH SAND & GRAVEL (GLACIAL TILL)

FIG No 5

W P 40-77-02

RECORD OF BOREHOLE No 1

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 839.0; E 321 386.5 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 02 28 CHECKED BY

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 80 100					
231.0	Ground Surface												
230.4	Organic Silt												
0.6	Silty Clay of Low Plasticity with Layers of Silt		1	SS	4								0 6 85 9
	Soft		2	SS	3								
			3	SS	4								
227.3	Brown-Grey		4	SS	3								
3.7	Silty Sand to Sandy Silt												
	Compact to Dense		5	SS	35								
224.4	Grey-Brown		6	SS	26								
6.6	End of Borehole												
220.3													
10.7	End of Cone Test												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 862.0; E 321 457.5
 DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Auger, Cone Test
 DATUM Geodetic DATE 86 02 26 and 27
 ORIGINATED BY DY
 COMPILED BY DY
 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
231.1	Ground Surface												
230.6	Organic Silt												
0.5	Silty Clay of Low Plasticity with Layers of Silt		1	SS	7							0.3%	
	Soft		2	TW	PM								
228.0	Brown-Grey		3	SS	3							0.3%	
3.1	Silty Sand to Sandy Silt		4	SS	5								
	Loose		5	SS	7								1 92 6 1
	Dense		6	SS	35								0 22 73 5
			7	SS	28								
221.5	Grey-Brown		8	SS	21								
9.6	Silty Clay of Low Plasticity Occasional Seams of Sandy Silt		9	SS	27								0 9 80 11
	Stiff		10	SS	12								
			11	SS	16								
214.3	Grey												
16.8	Heterogeneous Mixture of Silty Clay, Sand, Gravel		12	SS	34								
	Hard (Glacial Till)												
	Occasional Non-Cohesive Zones		13	SS	35								7 37 52 4
	Stiff		14	SS	13								
203.2	Grey												
27.9	End of Borehole		15	SS	137								25 35 35 5

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



RECORD OF BOREHOLE No 3

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 877.5; E 321 505.5 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 02 28 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
231.3	Ground Surface										
230.9	Organic Silt										
0.6	Silty Clay of Low Plasticity with Layers of Silt		1	TW	PM		230	q	○	20.6	0 6 84 10
	Firm		2	SS	2			+4			
228.2	Brown-Grey		3	SS	5						
3.1	Silty Sand to Sandy Silt		4	SS	12		228				
	Compact		5	SS	15						
			6	SS	16		226				
			7	SS	18		224				
222.8	Grey-Brown										
8.5	Silty Clay of Low Plasticity Occasional Seams of Sandy Silt										
221.4	Hard		8	SS	47		222				
9.9	End of Borehole										

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 4

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 887.0; E 321 550.3 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 03 03 CHECKED BY _____

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 80 100	20 40 60 80 100					
231.4	Ground Surface													
231.1	Organic Silt													
0.3	Silty Clay of Low Plasticity with Layers of Silt		1	SS	2		230	6						0 6 84 10
	Firm		2	TW	PH									
			3	SS	2									
227.9	Brown-Grey		4	SS	5		228							
3.5	Silty Sand to Sandy Silt		5	SS	14		226							
	Compact Dense		6	SS	31		224							
			7	SS	26		222							0 12 85 3
	Grey-Brown		8	SS	40		220							
220.6			9	SS	63		218							
10.8	Silty Clay of Low Plasticity Occasional Seams of Sandy Silt		10	SS	9		216							
	Stiff to Hard		11	SS	19		214							
	Grey													
214.6														
16.8	Heterogeneous Mixture of Silty Clay, Sand, Gravel, Hard (Glacial Till) Occ. Non Cohesive Zones		12	SS	40									
212.7														
18.7	End of Borehole													

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 907.5; E 321 598.5 ORIGINATED BY DP
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 03 04 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
231.4	Ground Surface													
231.0	Organic Silt													
0.4	Silty Clay of Low Plasticity with Layers of Silt		1	SS	3		230		3				19.5	0 4 87 9
	Firm to Soft		2	TW	PM									
	Brown-Grey		3	SS	1									
227.7			4	SS	4		228							
3.7	Silty Sand to Sandy Silt		5	SS	13									
	Compact Dense		6	SS	43		226							
			7	SS	49		224							
	Brown-Grey		8	SS	59		222							
219.8			9	SS	23		220							
11.6	Silty Clay of Low Plasticity, Occasional Seams of Sandy Silt		10	SS	14		218							
	Stiff													
	Grey		11	SS	11		216							
214.0							214							
17.4	Heterogeneous Mixture of Silty Clay, Sand, Gravel		12	SS	101		212							25 30 34 11
	Stiff-Hard (Glacial Till) Occasional Non- Cohesive Zones													
209.6	Grey Silty Clay		13	SS	14		210							
21.8	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 6

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 921.0; E 321 640.5 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, BX Casing & Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 03 05 to 07 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
231.5	Ground Surface												
231.1	Topsoil												
0.4	Silty Clay of Low Plasticity with Layers of Silt		1	SS	3							ORG 0.6%	
	Firm to Very Soft		2	TW	PH								
228.3	Brown-Grey		3	SS	2								
			4	TW	PH								
3.2	Silty Sand to Sandy Silt												
	Compact to Dense		5	SS	--								0 61 35 4
	Brown		6	SS	21								
			7	SS	51								
223.0													
8.5	Silty Clay of Low Plasticity Occasional Seams of Sandy Silt		8	SS	29								
	Stiff to Very Stiff												
	Grey-Brown		9	SS	10								
			10	SS	15								
217.5													
14.0			11	SS	30								
	Heterogeneous Mixture of Silty Clay, Sand, Gravel		12	SS	57								31 37 22 10
	Hard (Glacial Till)												
	Occasional Non-Cohesive Zones		13	SS	119								
			14	SS	57								
	Grey												
			15	SS	120-15								
201.3													
30.2													

Continued

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

Continued



RECORD OF BOREHOLE No 6 Continued

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 921.0; E 321 640.5 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Auger, BX Casing & Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 03 05 to 07 CHECKED BY

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	100				
201.3	Continued														
30.2			16	SS	100	5cm									
199.2			17	SS	70	0.7cm									
32.3	Probable Bedrock (weathered)**														
198.0															
33.5	End of Borehole														
	*Artesian Conditions encountered at Elev. 199.5 m + Hydraulic Head up to Elev. 231.7														
	** Borehole advanced by tri-cone														

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



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Ontario

RECORD OF BOREHOLE No 7

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 946.5; E 321 719.5 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 02 24 CHECKED BY

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 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
232.3	Ground Surface															
231.9	Topsoil															
0.4	Silty Clay of Low Plasticity with Layers of Silt Firm Brown		1	SS	3										ORG 0.26%	
230.2																
2.1	Silty Sand to Sandy Silt Dense to Very Dense Brown		2	SS	13											
			3	SS	31											
			4	SS	44											
			5	SS	60											
224.0			6	SS	30											
8.3	Silty Clay of Low Plasticity Occ. Seams of Sandy Silt HARD															
222.7	Grey-Brown		7	SS	37											
9.6	End of Borehole															

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



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Ontario

RECORD OF BOREHOLE No 8

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 898 977.5; E 321 815.0 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 02 26 CHECKED BY

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 80 100	20 40 60 80 100					
234.4	Ground Surface						234							
234.0	Topsoil													
0.4	Silty Sand to Sandy Silt Compact Brown		1	SS	17		234							0 39 60 1
232.3			2	SS	14		232							
2.1			3	SS	8		232							
	Stiff		4	SS	16		230							10 35 45 10
	Heterogeneous Mixture of Silty Clay, Sand, Gravel		5	SS	70		228							
	Hard (Glacial Till)		6	SS	118		226							
	Occasional Non-Cohesive Zones		7	SS	106/15 cm		224							
			8	SS	100/13 cm									
	Brown-Grey		9	SS	120/13 cm									
222.1			10	SS	105/15 cm									
12.3	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 9

METRIC

W P 40-77-02 LOCATION CO-ORDS: N 4 899 000.5; E 321 886.0
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test
DATUM Geodetic DATE 86 02 25
ORIGINATED BY DY
COMPILED BY DY
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
241.4	Ground Surface											
0.0	Organic silt											
240.5	Silty Sand to Sandy Silt		1	SS	9		240				ORG 0.29%	0 42 52 6
0.9	Trace Clay		2	SS	3							
	Loose to Compact		3	SS	26							
238.4	Brown		4	SS	30		238					
3.0	Heterogeneous Mixture of Silty Clay, Sand, Gravel		5	SS	69		236					
	Hard (Glacial Till)		6	SS	90 / 8 cm		234					
	Occasional Non-Cohesive Zones		7	SS	100 / 15 cm							0 20 75 5
	Grey											
231.8	End of Borehole		8	SS	110		232					
9.6												

+3, x5: Numbers refer to Sensitivity

20
15 - 5 (%) STRAIN AT FAILURE
10



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RECORD OF BOREHOLE No 10

METRIC

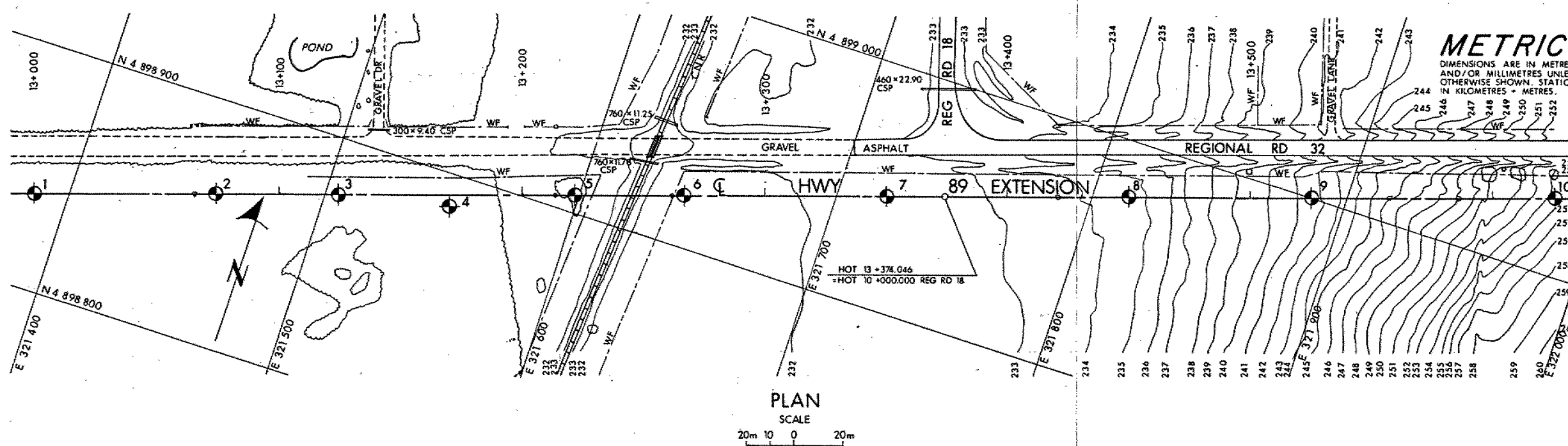
W P 40-77-02 LOCATION CO-ORDS: N 4 899 031.5; E 321 981.5 ORIGINATED BY DY
DIST 6 HWY 89 EXT'N BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY DY
DATUM Geodetic DATE 86 02 24 and 25 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
254.5	Ground Surface									
254.1	Organic Silt									
0.4	Heterogeneous Mixture of Silty Clay, Sand, Gravel		1	SS	43					6 27 52 15
	Hard (Glacial Till)		2	SS	61					
	Silty Clay		3	SS	94					1 10 44 45
	Occasional Non-Cohesive Zones Brown		4	SS	42					
			5	SS	88					
			6	SS	100	15 cm				
247.5	Silty Clay of Intermediate to High Plasticity		7	SS	134					
7.0	Hard									
244.9	Grey		8	SS	65					
9.6	End of Borehole									

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

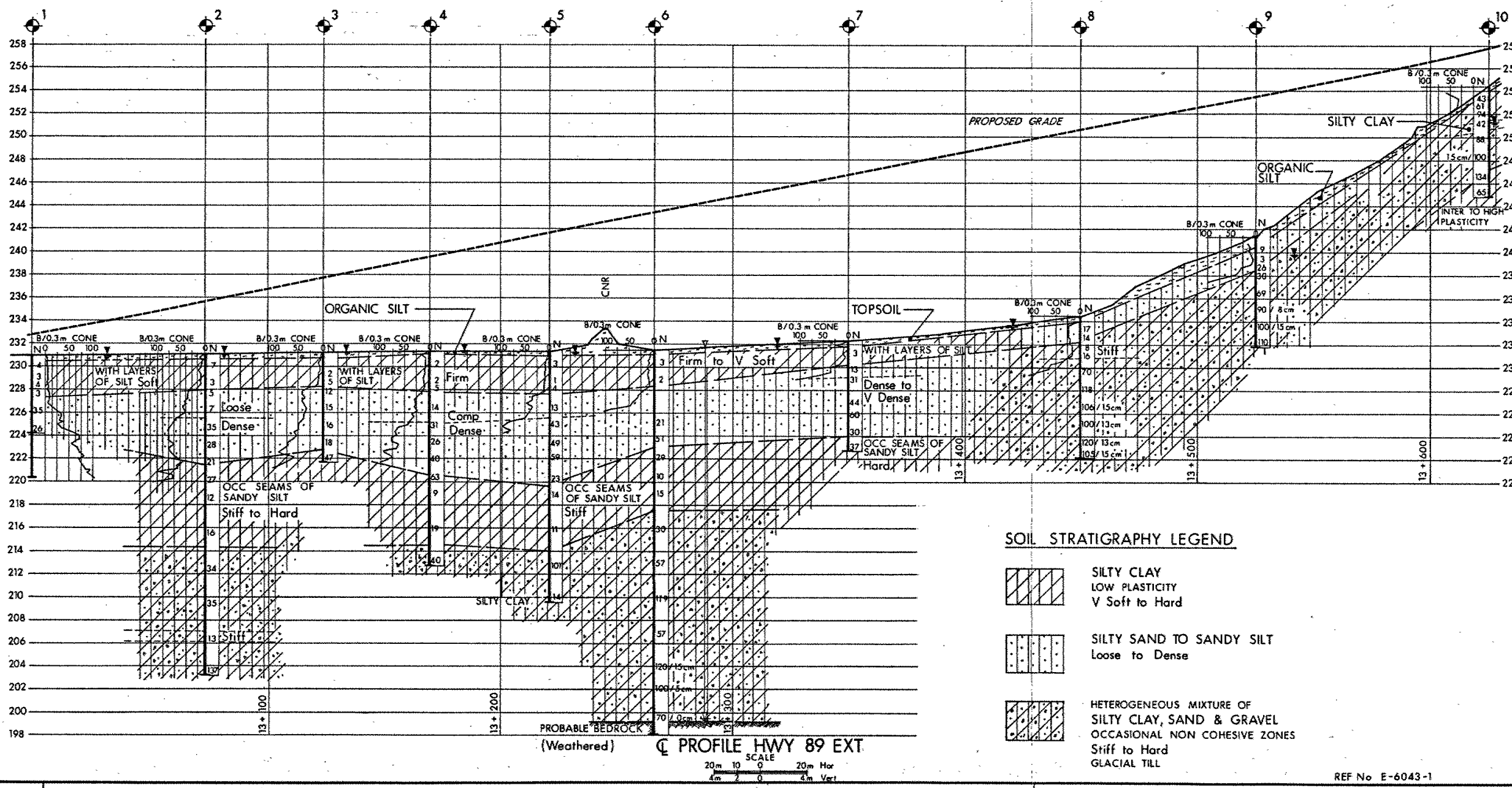
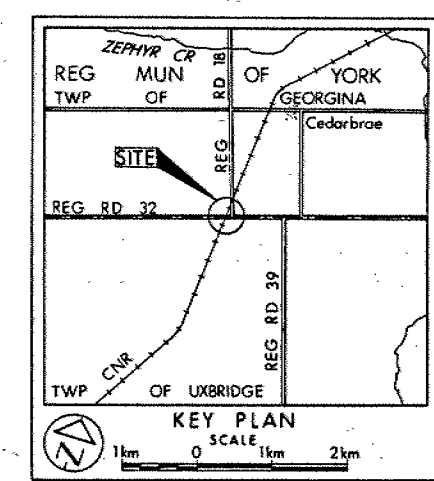
OFFICE REPORT ON SOIL EXPLORATION



CONT No
WP No 40-77-02

HWY 89 EXTENSION
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 86 02
- Head ARTESIAN WATER Encountered

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	231.0	4 898 839.0	321 386.5
2	231.1	4 898 862.0	321 457.5
3	231.3	4 898 877.5	321 505.5
4	231.4	4 898 887.0	321 550.3
5	231.4	4 898 907.5	321 598.5
6	231.5	4 898 921.0	321 640.5
7	232.3	4 898 946.5	321 719.5
8	234.4	4 898 977.5	321 815.0
9	241.4	4 899 000.5	321 886.0
10	254.5	4 899 031.5	321 981.5

SOIL STRATIGRAPHY LEGEND

	SILTY CLAY LOW PLASTICITY V Soft to Hard
	SILTY SAND TO SANDY SILT Loose to Dense
	HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL OCCASIONAL NON COHESIVE ZONES Stiff to Hard GLACIAL TILL

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 31D - 316

HWY No	89	DIST	6
SUBWD BY	CHECKED	DATE 86 06 04	SITE
DRAWN BY	CHECKED	APPROVED	DWG 407702-A

REF No E-6043-1