DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 316-204

DIST. 9 REGION

W.P. No. 23-87-03

CONT. No. 94-50

W. O. No.

STR. SITE No. 3-553

HWY. No. 416

LOCATION Hwy 416 & Bankfield Rd. Underpass

No. OF PAGES -

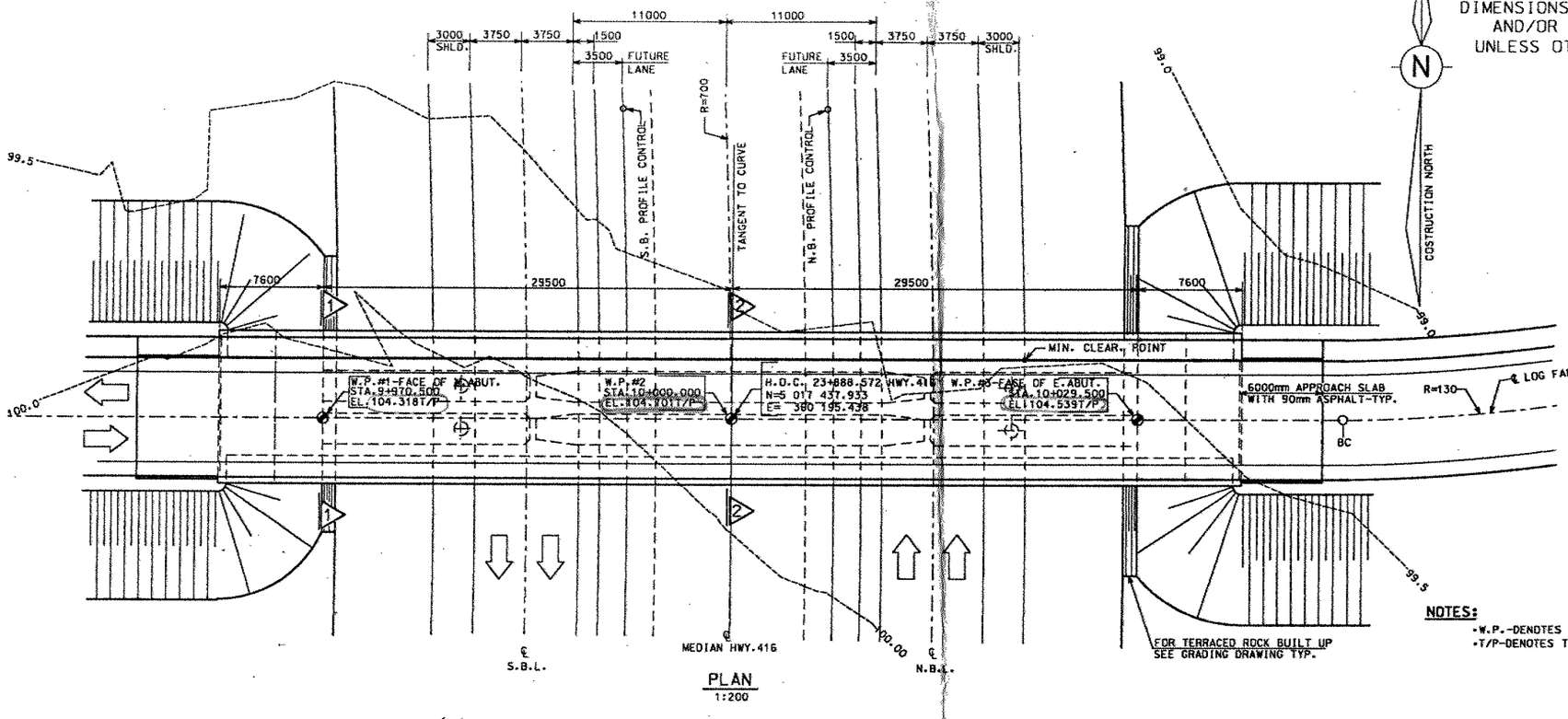
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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

DIST. 9
CONT No
WP No 122-87-03
SHEET

LOG FARM ACCESS ROAD
GENERAL ARRANGEMENT



PLAN
1:200

NOTES:
- W.P.-DENOTES WORKING POINTS
- T/P-DENOTES TOP OF ASPHALT PAV'T.

GENERAL NOTES:

CLASS OF CONCRETE:

DECK & ABUTMENTS.....35MPa
FOOTINGS & REMAINDER.....30MPa

CLEAR COVER TO REINFORCING STEEL:

FOOTINGS.....100±25
ABUTMENTS
  FRONT & BACK FACE.....70±20
DECK
  TOP SLAB-TOP.....70±20
  -BOTTOM.....40±10
  BOTTOM SLAB-TOP.....40±10
  -BOTTOM.....50±10
REMAINDER.....70±20
UNLESS OTHERWISE NOTED.

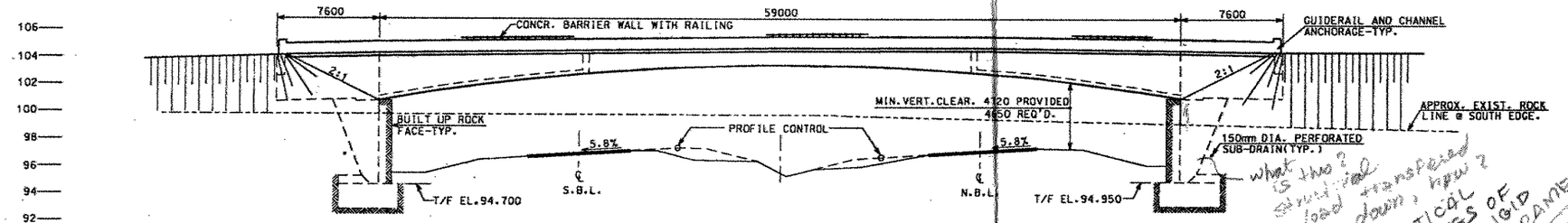
REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.

CONSTRUCTION NOTES:

BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 1000mm.

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BORE HOLE LOCATIONS & SOIL STRATA
3. FOOTING & FRAME DETAILS
4. DECK DETAILS
5. DECK REINFORCING I
6. DECK REINFORCING II
7. POST-TENSIONING DETAILS
8. BARRIER WALL WITH RAILING-I
9. BARRIER WALL WITH RAILING-II
10. RAILING FOR BARRIER WALL
11. 6000mm APPROACH SLAB
12. AS CONSTRUCTED ELEV. & DIM.
13. STANDARD DETAILS
14. QUANTITIES I



ELEVATION
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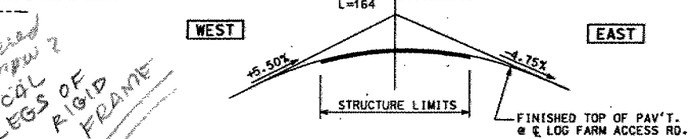
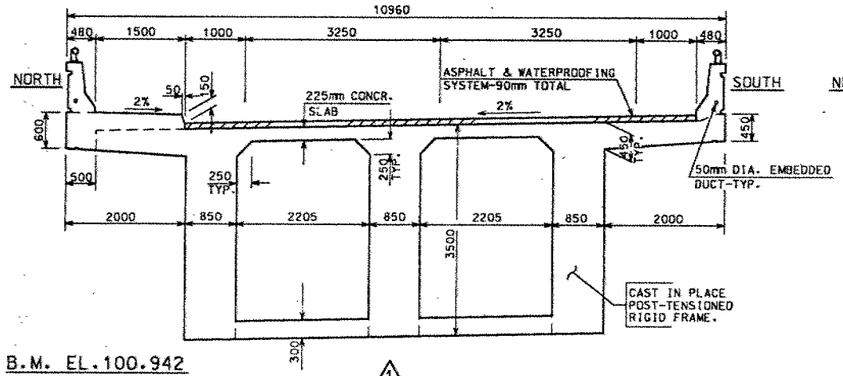
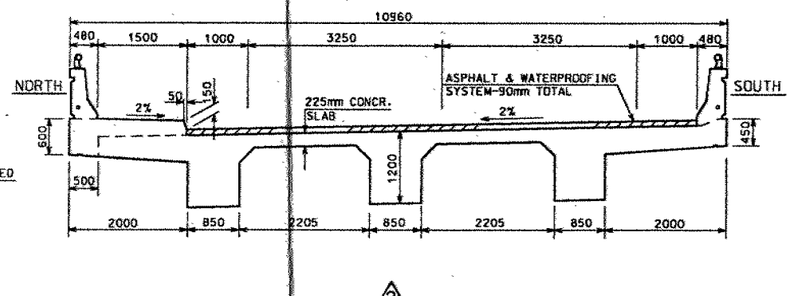


PROFILE OF LOG FARM ACCESS RD.
N.T.S.



B.M. EL.100.942
N.&W. IN ROOT OF 0.3 PINE
50.31 LT. 23+815.600

1
1:50



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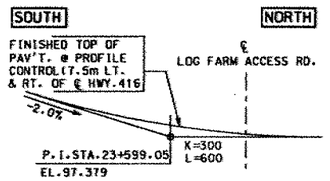
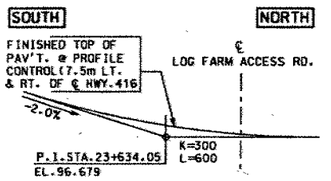


PROFILE OF HWY.416-S.B.L.
N.T.S.



PROFILE OF HWY.416-N.B.L.
N.T.S.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			DESCRIPTION

DESIGN D.B.	CHK	CODE OHBDC 83	LOAD CLASS A	DATE	
DRAWN J.C.	CHK	SITE 3-547	STRUCT	SCHEME	DWG 1

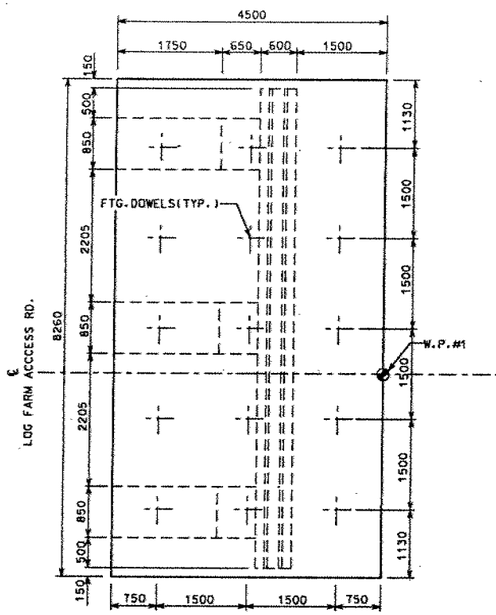
METRIC

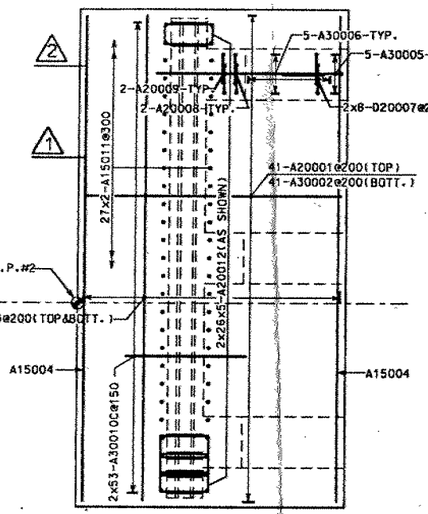
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 122-87-03

SHEET

LOG FARM ACCESS ROAD
FOOTING & FRAME DETAILS





PLAN
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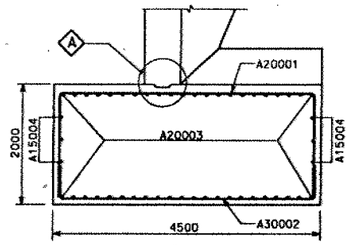

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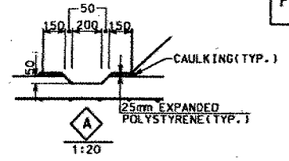

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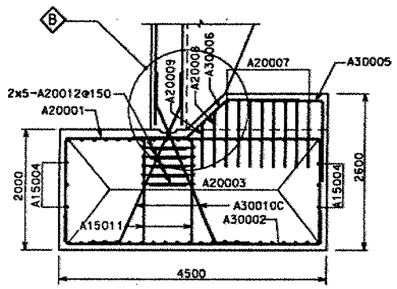

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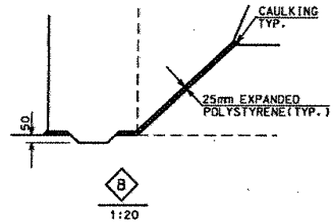
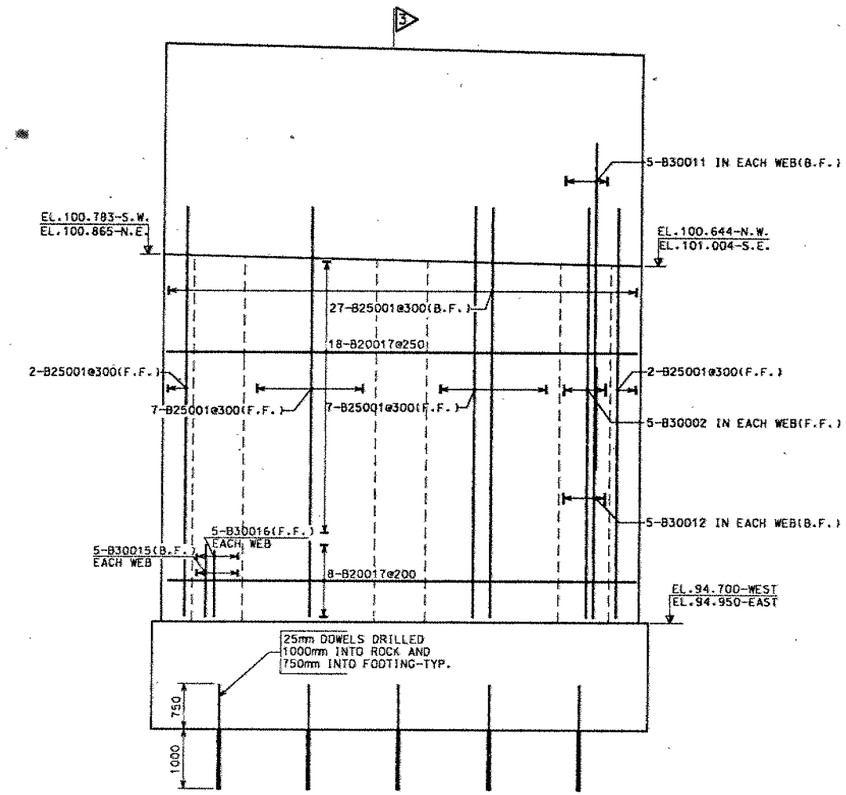


1:20

NOTES:

1. THE CONCRETE IN THE FOOTINGS IS TO BE PLACED AGAINST THE ROCK SURFACE.
2. EXCAVATION OF ROCK FOR ABUTMENT FOOTINGS ALONG THE TWO SURFACES SHOWN ON SECTION A SHALL BE CARRIED OUT USING LINE DRILLING AND BLASTING TECHNIQUE, WHICH WOULD NOT RESULT IN ANY OVER-BREAK BEYOND THE LINES AND GRADES SHOWN. THE ROCK EXCAVATION SHALL NOT FRACTURE OR OTHERWISE DEMAGE THE ROCK OUTSIDE THE LINES AND GRADES ALONG THESE TWO SURFACES.
3. EXCAVATION OF ROCK ALONG SURFACES NOT COVERED IN NOTE NO.2 SHALL BE CARRIED OUT TO THE LINES AND GRADES SHOWN ON THE DRAWING. ANY OVER-EXCAVATION OCCURING IN THESE AREAS SHALL BE FILLED WITH CONCRETE ON THE SAME CLASS AS FOOTING CONCRETE, AS APPROVED BY THE ENGINEER.
4. DIMENSIONS AND REINFORCEMENT SIMILAR FOR BOTH FRAME FOOTINGS.

ok



ELEVATION
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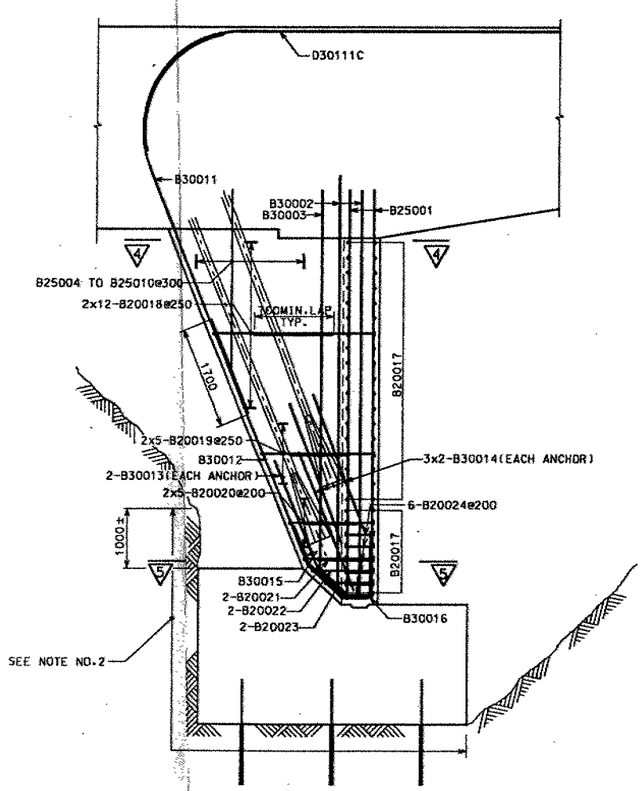

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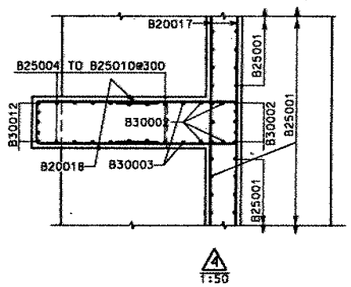

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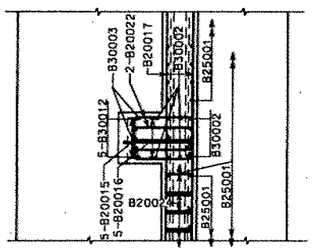

5
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DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS			DESCRIPTION				
DESIGN	O.B.	CHK	CODE	OHBDC 83	LOADCLASS	A	DATE
DRAWN	J.O.	CHK	SITE	3-547	STRUCT	SCHEME	DWG 3

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 94-50

Ontario

Ministry of
Transportation

INDEX

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

EXPLANATION OF TERMS USED IN REPORT

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
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

FOUNDATION INVESTIGATION REPORT
For
Hwy. 416 and Bankfield Road Underpass
W.P. 123-87-03 Site 3-553
Hwy. 416, District 9, Ottawa, Nepean

INTRODUCTION

This report summarizes the results of a foundation investigation carried out at the aforementioned site. A two lane, two span structure has been proposed to carry the east and west bound lanes of Bankfield Road over Hwy. 416. This report contains factual information obtained from this investigation pertaining to structural foundations and related earthworks.

SITE DESCRIPTION GEOLOGY

The site is located ¼ km east of Cedarview Road along Regional Road No. 8 (Bankfield Road) in the City of Nepean, Region of Ottawa-Carlton. The area consists of farmers fields to the north and south with radio towers located ½ km within the south field. Regional Road No. 8 (Bankfield Road) is a narrow paved two lane road with drainage ditches beside both shoulders. The terrain surrounding the site is flat with short wild grasslands.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence which are characterized by clay plains interrupted by ridges of rock or sand and gravel. The bedrock in the area is of the Gull River formation of the middle ordovician period. It consists of limestone with interbedded shale layers. The overburden is relatively thin and was deposited during and immediately following the Wisonsinan Glaciation. At which time the area was depressed from the effect of the Glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

INVESTIGATION PROCEDURES

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

Field Investigation

The fieldwork for this investigation was carried out between 91 01 23 and 91 01 30 and consisted of a total of 7 sampled boreholes. Five of these boreholes were located at the various structure locations. These boreholes were advanced to a maximum depth of 14.7 m to 16.5 m below existing grade. The two remaining boreholes were located at the approach embankments and were advanced to depths of 9.1 and 9.6 m below existing grade.

The boreholes were advanced using conventional hollow stem augering techniques. Both a track and truck mounted CME55 continuous flight auger drill rigs were employed for the operation. Conventional rock coring methods were applied in retrieving rock core samples. Standard BXL core barrels within BW casing were used. In general, subsoil samples were retrieved at 0.7 m intervals from the top 6 m depth and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586).

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

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

Survey information related to the location and elevation of boreholes was provided by the Surveys and Plans Section with Eastern Region, Kingston.

Laboratory Analysis

The following laboratory tests were carried out on selected soil samples:

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

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

Subsurface Conditions

General

In five of the seven boreholes put down at this site, a surficial layer of clayey silt (fill) was encountered for a thickness of 1.4 m to 1.8 m. In BH 8, located at the east abutment, the surficial layer consisted of a clayey silt deposit for about 1.4 m. Surficially in BH 2, located at the pier location and underlying the clayey silt layer in BH 8 and the fill in the remaining boreholes, a silt, some clay, trace of sand deposit was encountered. Underlying the silt deposit, a layer of heterogeneous mixture of silt, sand and gravel (Glacial Till) was found in all boreholes. Dolostone bedrock was encountered below the Glacial Till deposit at depths ranging from 12.5 to 14.0 m. Boulders and cobbles were also encountered in the Glacial Till deposit near the bedrock surface.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 1288703-A*, in the attached Appendix. The results of all field and laboratory tests are plotted on the Record of Borehole sheets, also included in the Appendix of this report. A brief description of the different soil strata is given below.

Clayey Silt some Sand (Fill)

The surficial layer at the site consisted of 1.4 m to 1.8 m of a clayey silt, some sand fill encountered at all boreholes except at BH's 2 and 8.

Results of Grain Size Distribution tests carried out on select samples are shown on Figure 1 in the Appendix in an envelope form. The deposit is comprised primarily of 0% gravel, 1-22% sand, and 62-87% silt and 12-20% clay.

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

* Drawing No 2 (Sheet 438) of the Contract Drawings.

	Range	No. of Tests
Natural Moisture Content (w)	17-31	4
Liquid Limit (w_L)	22-37	4
Plastic Limit (w_P)	14-20	4
Plastic Index (I_P)	8-17	4

From the plasticity chart (Figure 2), this deposit can be classified as clayey silt of low to intermediate plasticity. Unit weight measurements carried out on select samples from this stratum yield dry unit weights of 18.9 to 22.5 kN/m^3.

The 'N' values obtained from the Standard Penetration Test ranged from 5 blows/0.3 m to 6 blows/0.3 m indicating the material to have firm consistency.

Clayey Silt, some Sand

This deposit was encountered in BH 8 as a 1.4 m surficial layer.

Results of a Grain Size Distribution test carried out on a representative sample are shown on Figure 3 in the Appendix. Based on these test data, this deposit is comprised of 0% gravel, 16% sand, 68% silt and 16% clay.

The results from the Atterberg Limit test performed on the fine fraction of the above sample showed a Natural Moisture Content (w) of 29.5, a Liquid Limit (w_L) of 31, a Plastic Limit (w_P) of 19 and a Plasticity Index (I_P) of 12.

From the Plasticity Chart (Figure 4) this layer can be classified as clayey silt of low plasticity. Unit Weight measurements carried out on the sample yield dry Unit Weight of 18.9 kN/m^3.

The Standard Penetration Test revealed 'N' value of 10 blows/0.3 m. Based on this value, the material can be described as stiff.

Silt, trace of Sand, some Clay

A silt, trace of sand, some clay deposit was encountered, underlying the surficial layer in all boreholes at an elevation of 92.1 m to 93.3 m at

corresponding depths of 1.4 to 1.8 m. In BH 2, this deposit was encountered as a surficial layer of 5.6 m.

Results of Grain Size Distribution tests performed on this deposit are shown on Figure 5 in the Appendix, in an envelope form. Based on these test data, this deposit is comprised of 0-1% gravel, 2-54% sand, 40-87% silt, 6-14% clay.

Field observations in BH 5 also indicated that approximately the upper 1.4 m of the silt layer consists of clayey silt fill.

The results from the Atterberg Limit tests performed on this deposit are summarized as follows:

	Range	No. of Tests
Natural Moisture Content (w)	13-17.5	5
Liquid Limit (w_L)	17-21	5
Plastic Limit (w_P)	14-18	5
Plastic Index (I_P)	1-5	5

From the Plasticity Chart (Figure 6) the layer can be classified as a silt of low plasticity. Unit Weight measurements carried out on select samples from this stratum yield dry Unit Weights of 22.3-23.3 kN/m^3.

Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 5 blows/0.3 m to 44 blows/0.3 m. Based on these 'N' values, the material can be described as having a very loose to dense but generally from compact to dense state of relative density.

Heterogeneous mixture of Silt, Sand and Gravel with Boulders and Cobbles (Glacial Till)

Underlying the silt, trace of sand, some clay layer, a deposit of heterogeneous mixture of silt, sand and gravel (Glacial Till) was encountered at an elevation of 86.4 m to 89.0 m at corresponding depths of 5.6 m to 8.2 m.

Results of Grain Size Distribution tests carried out on select samples from this layer are shown on Figure 7 in the Appendix, in an envelope form. Based on these test data, this deposit is comprised of 9-67% gravel, 17-47% sand, 0-44% silt, and 0-7% clay.

Cobbles and boulders were also encountered in the Glacial Till deposit with numerous ones near the bedrock surface.

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

	Range	No. of Tests
Natural Moisture Content (w)	7.5-11	6
Liquid Limit (w_L)	13-14	3
Plastic Limit (w_P)	10-12	3
Plastic Index (I_P)	2-3	3

From the Plasticity chart (Figure 8), this deposit can be classified as silt of slight plasticity. Unit Weight measurements carried out on select samples from this stratum yield dry unit weights of 23.5 kN/m^3.

In this stratum the Standard Penetration resistance, 'N' values ranged from 18 blows/0.3 m to 107 blows/0.3 m indicating that the material had a compact to very dense state of relative density.

Bedrock

The glacial till deposit is directly underlain by dolostone bedrock of the Gull River Formation. The bedrock was cored in a BXL double core barrel at the structure foundation locations up to 2.6 m in length. The bedrock surface varies between elevation 80.7 m to 81.9 m which is equivalent to depths of 12.5 m to 14.0 m below the ground surface. The dolostone bedrock is generally fine grained and medium dark grey to light grey in colour. Dark grey shale was also found interbedded in the dolostone. Detailed descriptions of the bedrock are attached in Table 1 in the Appendix, entitled "Description of Rock Core".

Core recoveries and rock quality designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock core recoveries varied between 65 and 100% while RQD's varied between 31 and 64%.

GROUNDWATER CONDITIONS

Observations of the groundwater level were carried out by measuring the water level in open boreholes. Groundwater levels determined at the time of the investigation were approximately 1.5 m (elevation 93.2 m) to 3.0 m (elevation 90.9 m) depth. It is considered that the water levels observed in BH's 2 (88.6 m) and 7 (89.7 m) do not reflect stabilized ground water levels. Groundwater levels were also measured on April 12, 1991 (approximately 4 months after investigation) in BH's 1 and 7 and were found to be 0.46 m below ground surface. Based on the above observations it is considered that the water table at this site ranges between elevations 91 m and 93 m.

Soil cave-in was encountered in the boreholes upon penetration of the cohesionless silt below the prevailing groundwater due to unbalanced hydrostatic head. Wash boring techniques were employed to advance the boreholes thereafter.

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

MISCELLANEOUS

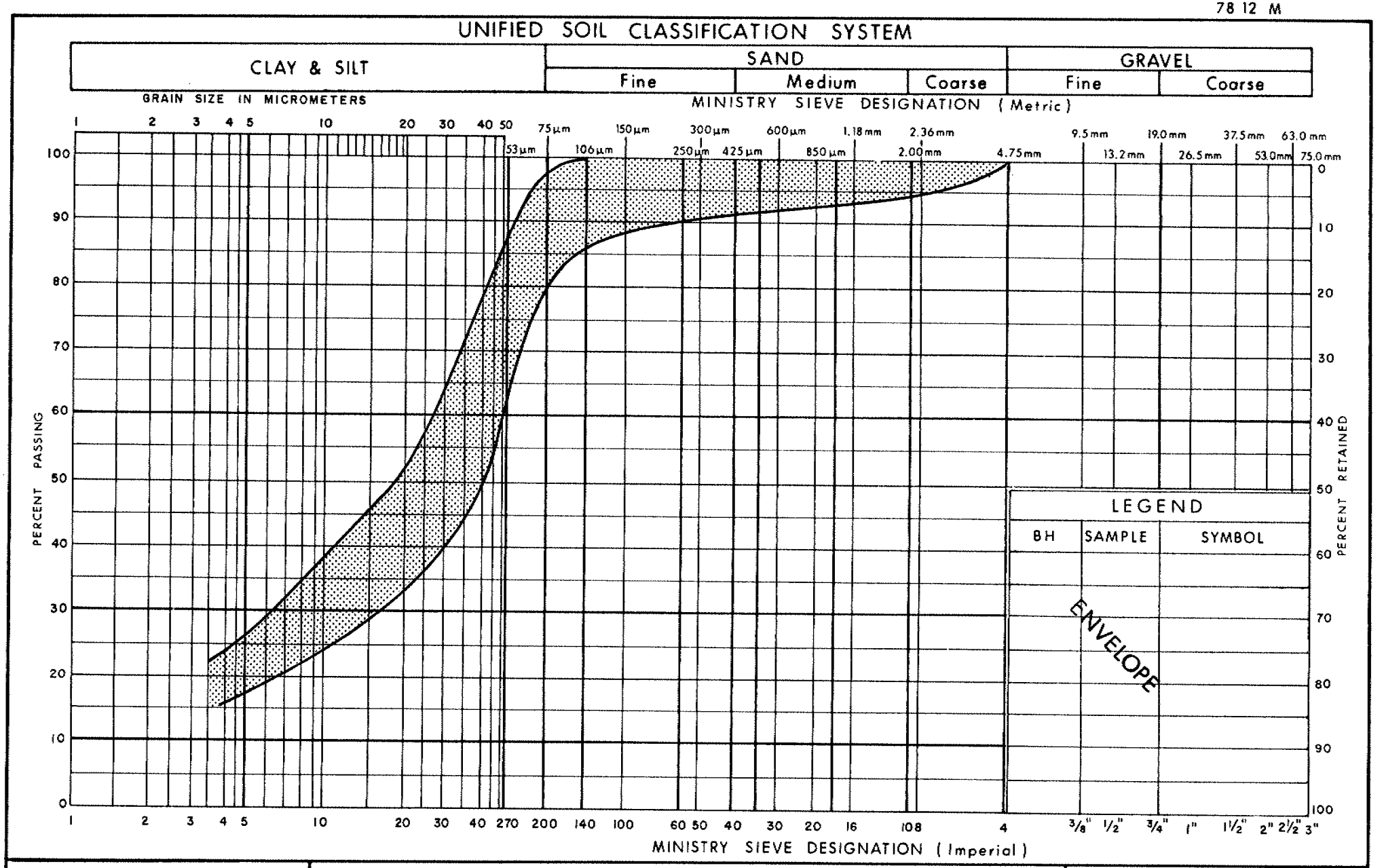
The fieldwork for this investigation was carried out under the supervision of M. Michalek, Junior Foundation Engineer, and F. Tannous, Trainee Engineer utilizing equipment owned and operated by Johnston Drilling Co.

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

B. Bennett, P. Eng.
Sr. Foundation Engineer
(Acting)

D. Dundas, P. Eng.
Chief Foundation Engineer
(Acting)

APPENDIX



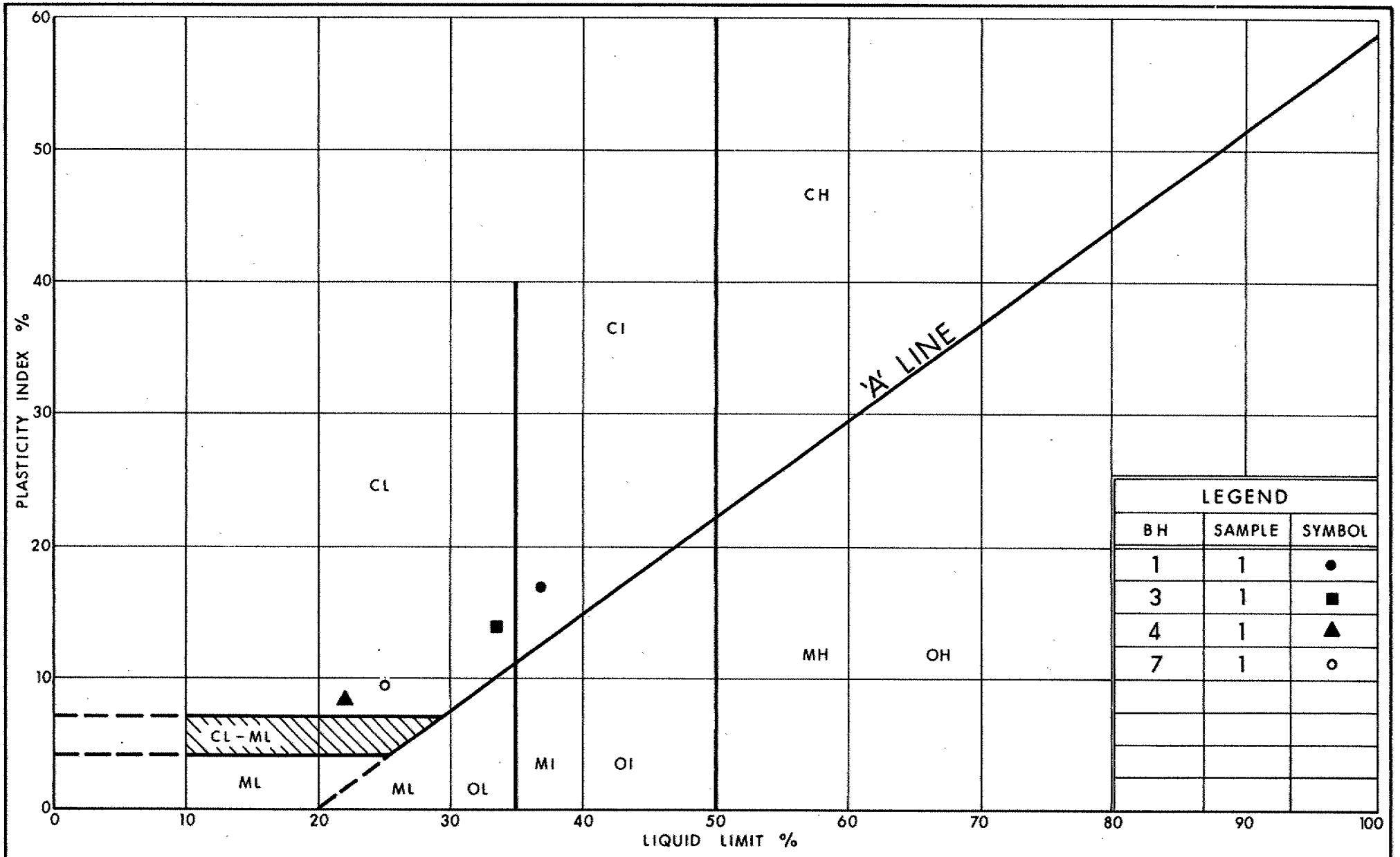
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT
(FILL)

FIG No 1

W P 123-87-03

12

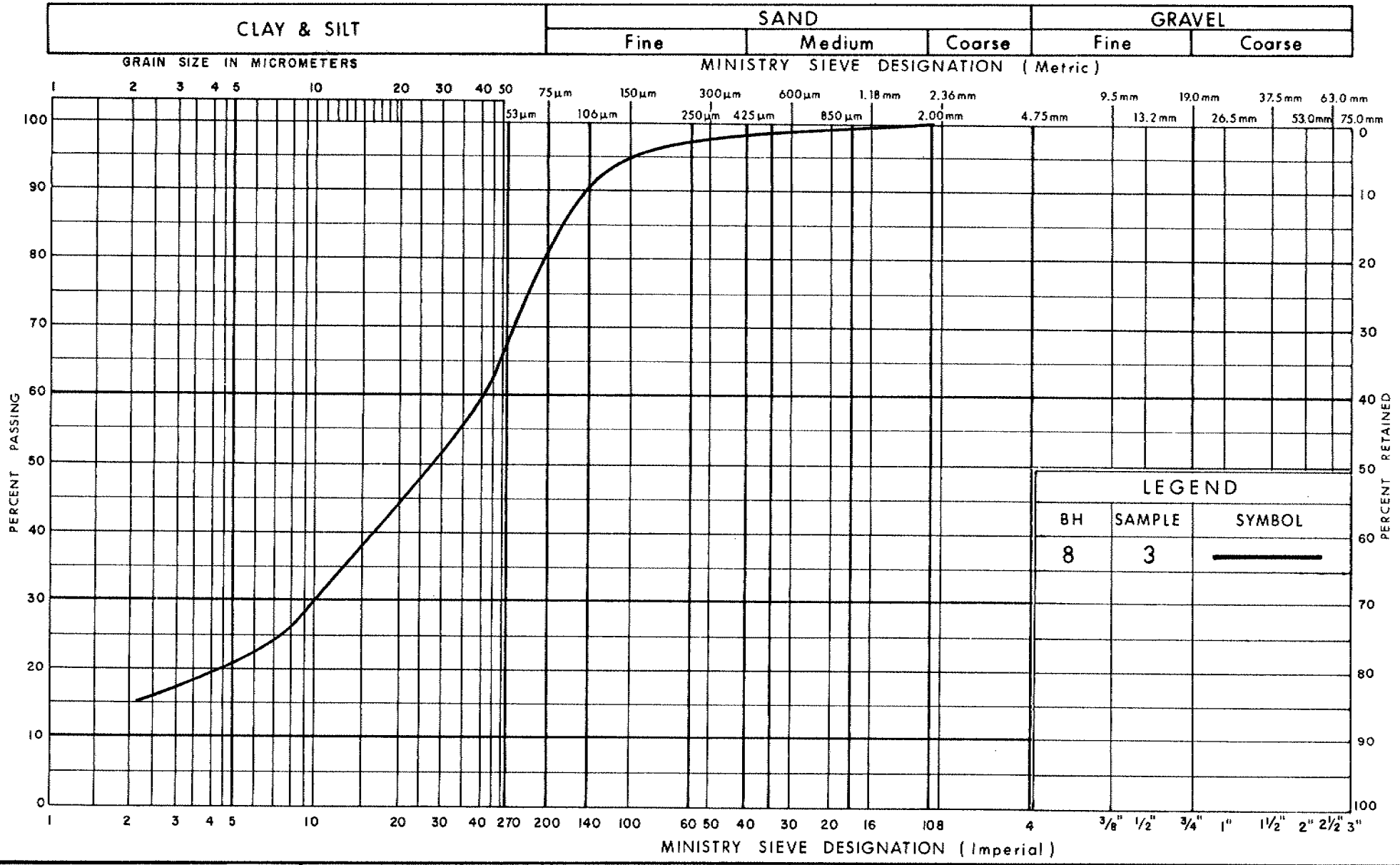


Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT, SOME SAND
(FILL)

FIG No 2
W P 123-87-03

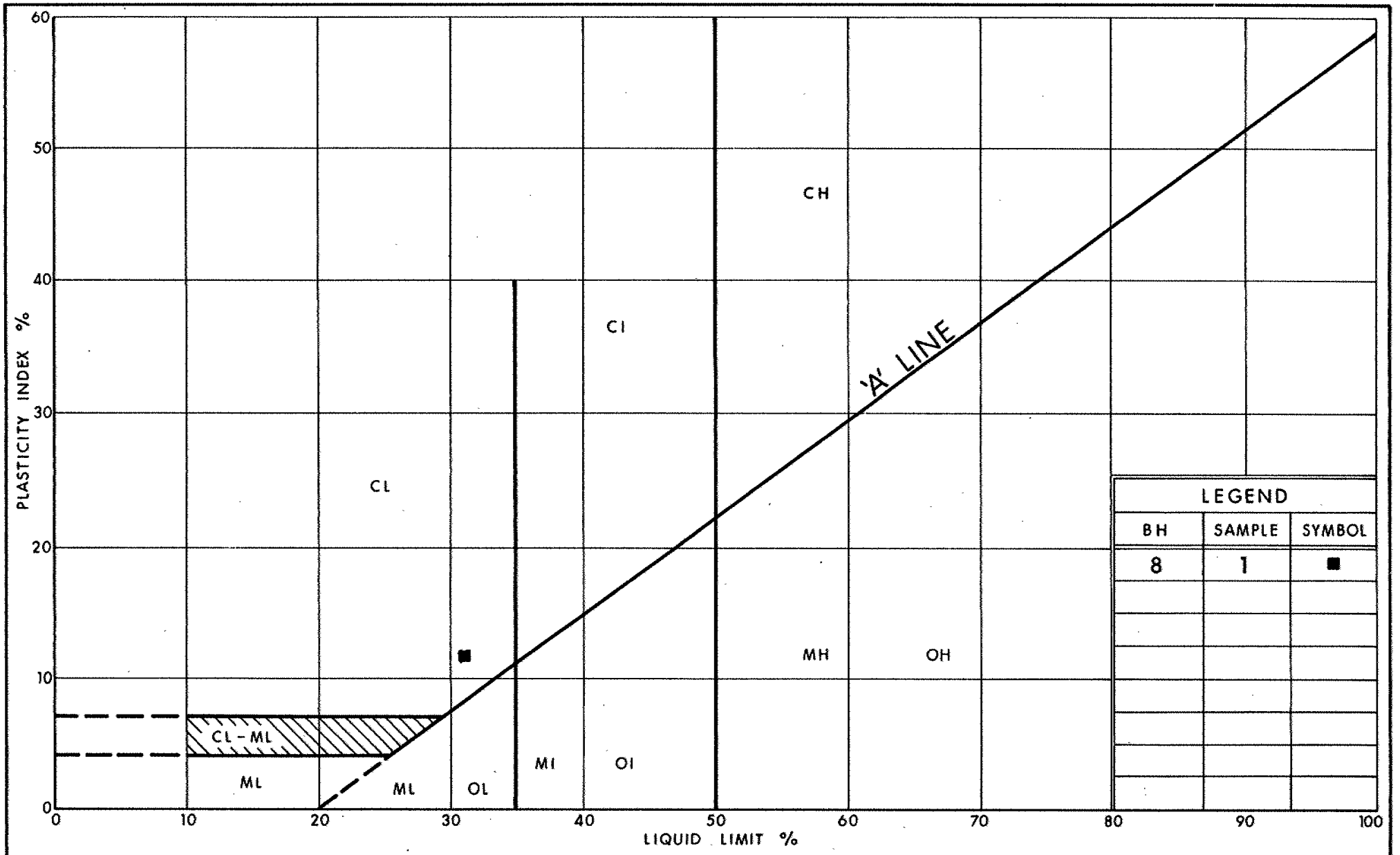
UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, SOME SAND

FIG No 3
W P 123-87-03



Ministry of Transportation
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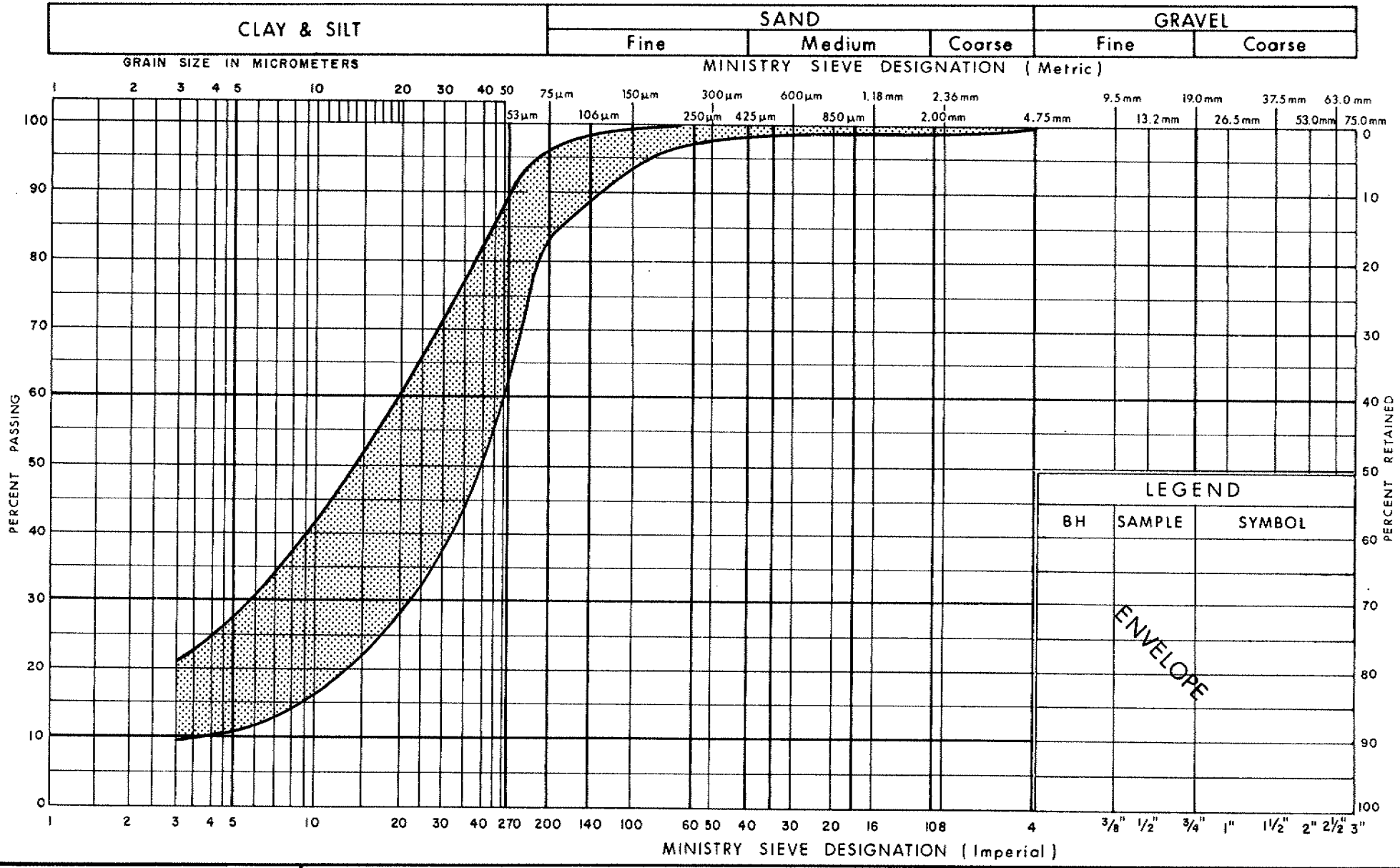
PLASTICITY CHART
CLAYEY SILT, SOME SAND

FIG No 4
W P 123-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM

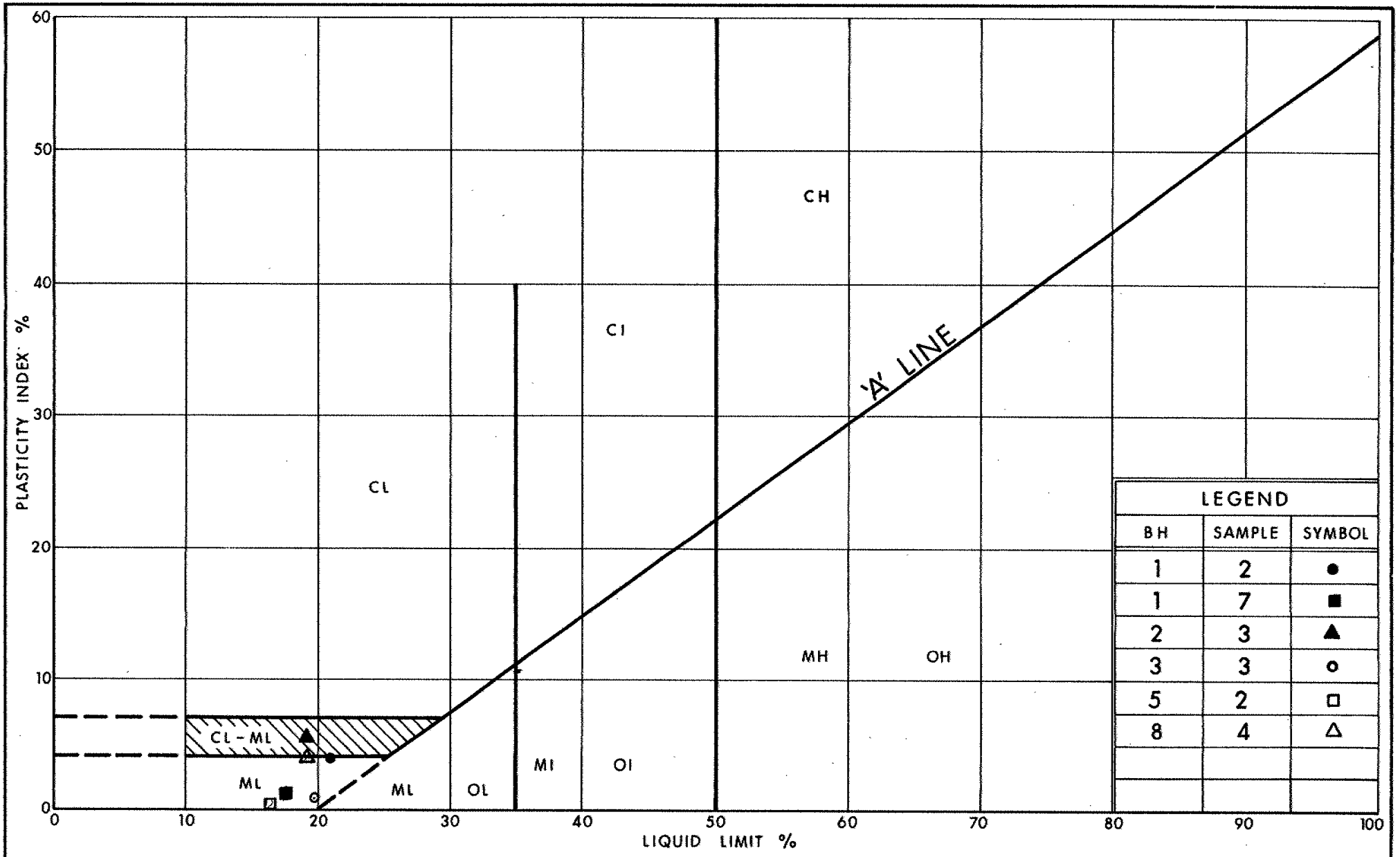


Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
SILT, TRACE SAND, SOME CLAY

FIG No 5
W P 123-87-03

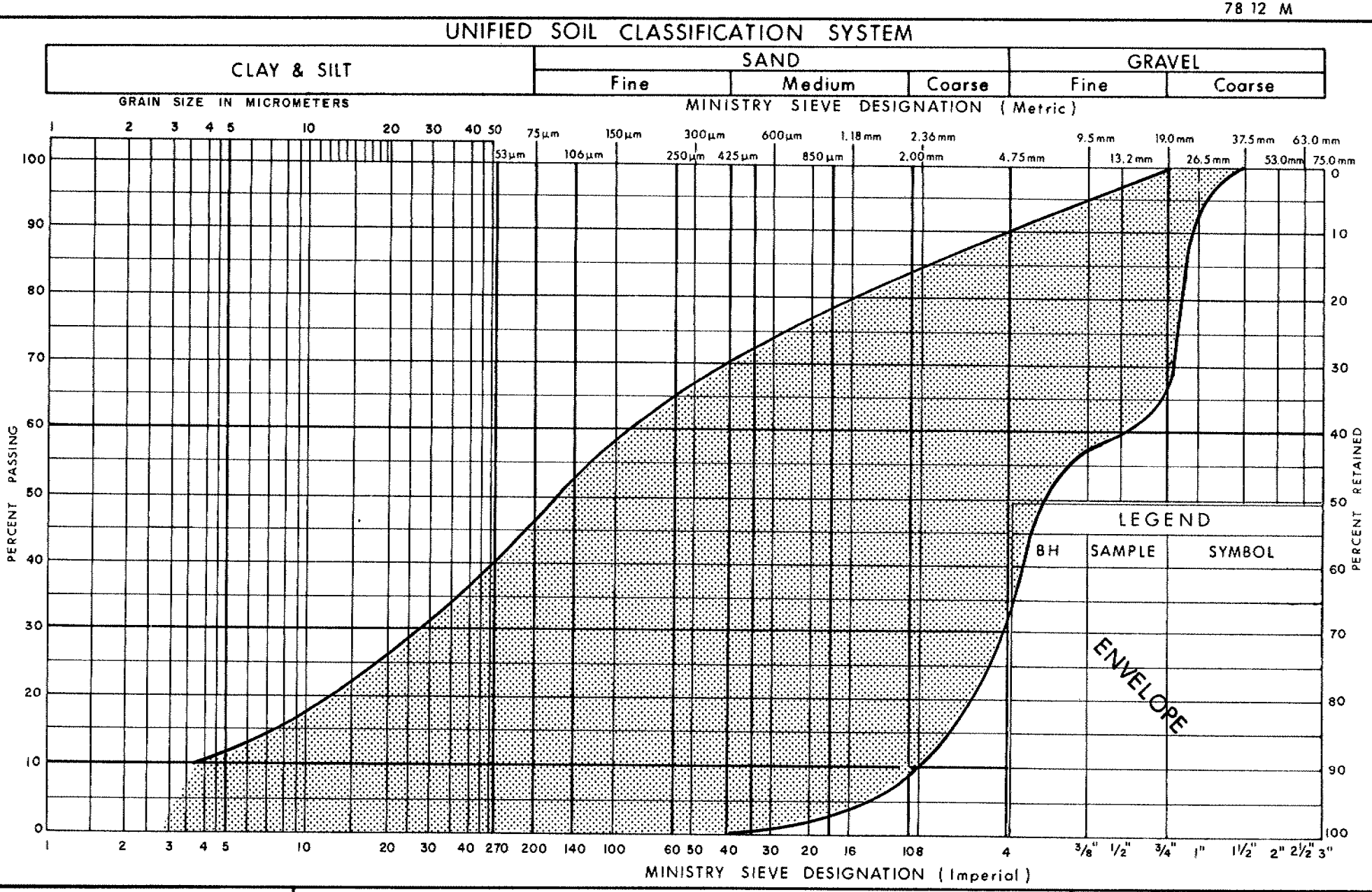
16



Ministry of Transportation
Ontario

PLASTICITY CHART
SILT, TRACE SAND, SOME CLAY

FIG No 6
W P 123-87-03



Ministry of Transportation
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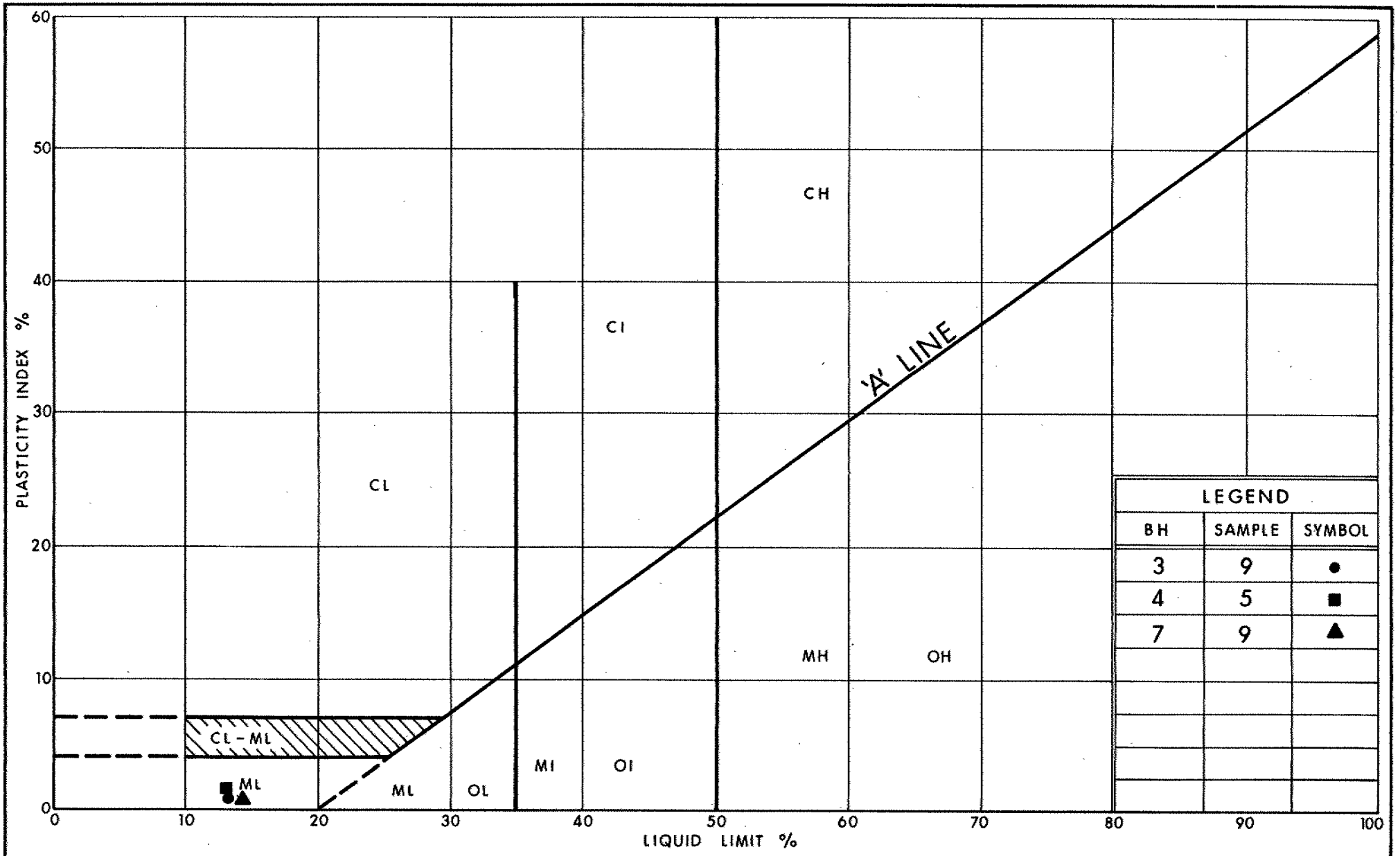
GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL WITH NUMEROUS COBBLES & BOULDERS (GLACIAL TILL)

FIG No 7

W P 123-87-03

18



Ministry of Transportation
Ontario

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

FIG No 8
W P 123-87-03

RECORD OF BOREHOLE No 1

METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 797.7, E 364 678.8 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 23, 1991 CHECKED BY B.I.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.7	Ground Surface						
0.0	Clayey Silt, some Sand, Brown, Firm (Fill)	1	SS	6		17.6	0 16 64 20
93.3 / 1.4	Silt, trace Sand, some Clay, Compact to Dense	2	SS	17	▼ (water level)		0 8 81 11
		3	SS	16			
	Brown	4	SS	22			
	Grey	5	SS	25			
		6	SS	26			0 2 84 14
		7	SS	36		22.6	0 3 87 10
		8	SS	46			
86.4 / 8.2	Heterogeneous mixtue of Silt, Sand and Gravel, Cobbles and Boulders (Glacial Till) Grey, Compact to very Dense	9	RC	REC	19%		RQD 15%
		10	SS	75			23 47 27 3
		11	SS	26			
	with numerous boulders	12	RC	REC	33%		RQD 0%
		13	SS	61			67 33 0 0
		14	RC	REC	100%		RQD 0%
		15	RC	REC	14%		RQD 0%
		16	RC	REC	17%		RQD 0%
80.7 / 14.0	Dolostone Bedrock, Unweathered to slightly weathered	17	RC	REC	100%		RQD 61%
		18	RC	REC	65%		RQD 40%

Elevation scale: 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 ◇ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 1 2 OF 2 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 797.7, E 364 678.8 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 23, 1991 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
30.5	Continued		18	RC	REC 65%		79				RQD 40%
78.1											
16.5	End of Borehole										

+^{3}, ×^{5} : Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 804.3, E 364 716.7 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 29, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) / WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.5	Ground surface									
0.0	Silt ,trace Sand, trace Clay Compact to Very Dense		1	SS	18		93			
	Brown		2	SS	15		92			
	Grey		3	SS	44		91		22.3	0 9 82 9
			4	SS	61		90			
			5	SS	25		89			
87.9			6	SS	7	▼	88			
5.6	Heterogeneous mixture of Silt, Sand and Gravel Cobbles and boulders (Glacial Till) Grey, Very Dense		7	RC	REC	33%				RQD 28%
			8	RC	REC	44%	87			RQD 27%
			9	SS	73		86			
	with numerous boulders		10	SS	100	/13cm	85			9 44 40 7
			11	RC	REC	10%	84			RQD 0%
			12	RC	REC	75%	83			RQD 38%
			13	RC	REC	42%				RQD 0%
			14	RC	REC	58%	82			RQD 46%
			15	RC	REC	96%				RQD 67%
80.7			16	RC	REC	54%	81			RQD 46%
12.8	Dolostone Bedrock Unweathered to slightly weathered		17	RC	REC	100%				RQD 0%
			18	RC	REC	100%	80			RQD 64%
78.6							79			
14.9	End of Borehole									

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 836.0, E 364 739.7 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.
DATUM Geodetic DATE Jan. 28, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.4	Ground Surface										
0.0	Clayey Silt with organics, some Sand Brown, Firm (Fill)		1	SS	5		94			19.2	0 14 71 15
93.0											
1.4	Silt, trace Sand, some Clay Compact to Dense		2	SS	14	▼	93				
			3	SS	24		92			22.9	0 10 82 8
	Brown		4	SS	20		91				
	Grey		5	SS	25						
			6	SS	41		90				
							89				
			7	SS	5		88				1 2 82 15
87.3											
7.1	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Compact		8	SS	16		87				
			9	SS	18		86				34 17 44 5
	with numerous boulders		10	RC	REC	87%	85				RQD 78%
			11	SS	100	/5cm	84				
			12	RC	REC	100%					RQD 0%
			13	RC	REC	100%	83				RQD 76%
81.9							82				
12.5	Dolostone Bedrock Unweathered to slightly weathered		14	RC	REC	62%					RQD 51%
			15	RC	REC	95%	81				RQD 47%
79.6							80				
14.8	End of Borehole										

+³, ×⁵ ; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 771.5 E 364 660.2 ORIGINATED BY F.T.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 24, 1991 CHECKED BY B.I.

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.9	Ground surface										
0.0	Clayey Silt, trace SAnd Brown, very Stiff (Fill)						93				
92.1			1	SS	28		92			22.5	0 1 87 12
1.8	Silt, some Clay, trace Sand Compact to Dense		2	SS	27	▼	91				
	Brown Grey		3	SS	28		90				
86.8			4	SS	31		89				
7.1	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Grey		5	SS	2*		88				23 41 30 6
84.8							87				
9.1	End of Borehole * disturbed sample						86				
							85				

+3, ×5 : Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 851.7 E 364 765.7 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 28, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.3	Ground surface										
0.0	Probable Fill					*	94				
	Silt, trace Sand, some Clay Compact to Dense Brown Grey		1	SS	25		93				
	Silty Sand		2	SS	23		92				0 54 40 6
			3	SS	31		91				
87.7			4	SS	100	/15cm	90				
6.6	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Grey, Very Dense		5	SS	83		89				
84.7			6	SS	107		88				21 37 35 7
9.6	End of Borehole * water level not established						87				
							86				
							85				

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 816.0, E 364 709.0 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 29, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.6	Ground surface										
0.0	Clayey Silt , some sand Brown, Firm (Fill)		1	SS	6		94		H	19.6	0 22 62 16
93.2											
1.4	Silt, some Sand, trace Clay Compact		2	SS	15		93				
			3	SS	20		92				
			4	SS	20		91				
	Brown		5	SS	17						1 11 81 7
	Grey		6	SS	4	▼	90				
89.0											
5.6	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Grey, Compact to Very Dense		7	SS	2		89				
			8	SS	29		88				
	with numerous boulders		9	SS	137	/20cm	87		o H	23.4	23 40 30 7
			10	RC	REC	14%	86				RQD 0%
			11	RC	REC	27%	85				RQD 16%
			12	RC	REC	53%	84				RQD 40%
			13	RC	REC	46%	83				RQD 0%
81.2			14	RC	REC	36%	82				RQD 0%
13.4	Dolostone Bedrock Unweathered to slightly weathered		15	RC	REC	75%	81				RQD 42%
			16	RC	REC	100%	80				RQD 44%
79.4											

15.2 End of Borehole

+^{3}, ×^{5}: Numbers refer to Sensitivity

$\frac{20}{15}$ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 822.1, E 364 748.0 ORIGINATED BY F.T.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 29, 1991 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
93.6	Ground surface										
0.0	Clayey Silt, trace Organics some sand					*	93				
	Black, Stiff		1	SS	10					18.9	0 16 68 16
92.2							92				
1.4	Silt, some Sand, trace Clay		2	SS	26						
	Compact to very Dense										
	Brown		3	SS	32		91				
	Grey										
			4	SS	27					23.2	0 10 81 9
			5	SS	28		90				
			6	SS	47		89				
			7	SS	56		88				
86.5							87				
7.1	Heterogeneous mixture of Silt, Sand and Gravel		8	SS	26		86				18 42 34 6
	(Glacial Till)										
	Grey, Compact to Dense		9	SS	41		85				
			10	SS	25		84			o	55 28 13 4
	with numerous boulders		11	RC	REC	92%	83				RQD 15%
80.9			12	RC	REC	96%	82				RQD 38%
12.7	Dolostone Bedrock						81				
	Unweathered to slightly weathered		13	RC	REC	69%	80				RQD 31%
78.9							79				
14.7	End of Borehole										
	* water level not established										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 123-87-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	1	8.23-8.92	19	15	8.23-14.02	**OVERBURDEN** (boulder till).
	2	11.89-12.19	33	0	14.02-16.54	**DOLOSTONE** (algal laminated and intraclastic in part), medium dark grey to
	3	12.65-12.80	100	0		medium light grey to light olive grey, with dark grey **SHALE** interbeds up to 10 cm
	4	12.80-13.72	14	0		thick (8%); fine crystalline; medium strong to weak; unweathered to slightly
	5	13.72-14.02	17	0		weathered; fractures moderately close to extremely close spaced, flat to near
	6	14.02-14.94	100	61		vertical, planar to undulating, smooth.
	7	14.94-16.54	65	40		
2	1	5.64-6.10	33	28	5.64-12.80	**OVERBURDEN** (boulder till).
	2	6.10-7.32	44	27	12.80-14.94	**DOLOSTONE** (algal laminated and intraclastic in part), medium dark grey to light
	3	9.14-10.36	10	0		grey, with dark grey **SHALE** interbeds up to 10 cm thick (15%); fine crystalline;
	4	10.36-10.67	75	38		medium strong to weak; unweathered to slightly weathered (moderately
	5	10.67-10.97	42	0		weathered, 12.80-13.49 m); fractures moderately close to extremely close
	6	10.97-12.19	58	46		spaced, flat to near vertical, planar to undulating, smooth.
	7	12.19-12.50	96	67		
	8	12.50-12.80	54	46		
	9	12.80-13.41	100	0		
	10	13.41-14.94	100	64		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 123-87-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
3	1	9.91-10.49	87	78	9.91-12.55	**OVERBURDEN** (boulder till).
	2	10.97-11.05	100	0	12.55-14.81	**DOLOSTONE** (slightly calcitic, algal laminated and intraclastic in part), medium
	3	11.05-12.19	100	76		dark grey to light grey, with dark grey **SHALE** interbeds up to 8 cm thick (8%); fine
	4	12.19-13.13	62	51		crystalline; medium strong to weak; unweathered to slightly weathered; fractures
	5	13.13-14.81	95	47		moderately close to extremely close spaced, flat to near vertical, planar to
						undulating, smooth.
7	1	9.45-10.36	14	0	9.45-13.41	**OVERBURDEN** (boulder till).
	2	10.36-11.48	27	16	13.41-15.19	**DOLOSTONE** (algal laminated and intraclastic in part), medium dark grey to
	3	11.48-12.24	53	40		medium light grey, with dark grey **SHALE** interbeds up to 8 cm thick (7%); fine
	4	12.24-12.85	46	0		crystalline; medium strong to weak; unweathered to slightly weathered
	5	12.85-13.41	36	0		(moderately weathered, 13.41-13.84 m); fractures moderately close to extremely
	6	13.41-13.72	75	42		close spaced, flat to near vertical, planar to undulating, smooth.
	7	13.72-15.19	100	44		
8	1	11.35-12.02	92	15	11.35-12.70	**OVERBURDEN** (boulder till).
	2	12.02-13.23	96	38	12.70-14.73	**DOLOSTONE** (slightly calcitic, algal laminated and intraclastic in part), medium
	3	13.23-14.73	69	31		dark grey to medium light grey, with dark grey **SHALE** interbeds up to 8 cm thick
						(6%); fine crystalline; medium strong to weak; unweathered to slightly weathered;
						fractures moderately close to extremely close spaced, flat to near vertical, planar to
						undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

FOUNDATION INVESTIGATION REPORT
For
Hwy. 416 and Realigned Old Hwy. 16 Underpass
(at Century Road)
W.P. 123-87-04, Site 3-554
Hwy. 416, District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. The report describes the subsurface conditions at the site.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately 200 metres west of the existing Hwy. 16 - Century Road intersection in the City of Nepean, Regional Municipality of Ottawa-Carleton. The existing Century Road is a two lane paved roadway that intersects the site location and continues for some distance on either side of this intersection.

A residential dwelling with an asphaltic driveway entrance from Century Road is located immediately north of the site. The home has been landscaped with trees and low lying shrubs. A medium dense forested area is located immediately south of the site.

The terrain at the site is generally flat adjacent to the existing Century Road. The Century Road roadway is elevated approximately 1-1.5 metres higher than the adjacent terrain.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The native subsoil consists of clay plains interrupted by ridges of rock or sand. Bedrock at the site is of the Oxford Formation and consists of dolostone.

Th overburden was deposited during and immediately following the Wisconsinan glaciation approximately 12,000 years ago during the Pleistocene Epoch. At that

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

INVESTIGATION PROCEDURES

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

Field Investigation

The fieldwork for the investigation was carried out between 90 12 19 and 91 01 16 and consisted of five sampled boreholes. The boreholes were advanced to depths ranging from 4.0 to 12.0 metres below the existing ground surface which corresponds to elevations ranging from 90.1 m to 82.6 m.

Track mounted CME equipment employing continuous hollow stem augering and casing-washboring techniques was used to advance the boreholes in the overburden. Samples in the overburden were retrieved using a split spoon sampler driven in accordance with the Standard Penetration Test (ASTM D1586). Conventional rock coring methods were applied in penetrating cobbles and boulders present within the overburden and in sampling the bedrock at the site. A standard BX core barrel within BW casing was used in the coring of rock.

All samples retrieved in the overburden and all rock core 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 the boreholes was provided by the Eastern Region Surveys and Plans Office.

Laboratory Analysis

To identify the behaviour and gradation of the overburden and to determine the physical index properties of the soil , some laboratory testing was performed. These tests included:

1) Atterberg Limit Tests
2) Grain Size Distributions
3) Natural Moisture Contents
4) Rock Core Logging

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 natural ground surface at the site is generally flat and has an elevation varying from 94.1 m to 95.1 m. The subsurface conditions are uniform across the site and consists of a cohesionless deposit comprised of a heterogeneous mixture of silt, sand, gravel, cobbles and boulders that extends to bedrock. Bedrock, consisting of a dolostone with interbedded shale was confirmed at one location of the site (BH 26-3) at a depth of 10.4 metres or equivalently at an elevation of 84.2 metres.

The boundaries between the soil and rock 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 a subsoil stratigraphical section is provided on Dwg. No. 1238704-A.*

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

* Drawing No 2 (Sheet 456) of the Contract Drawings.

Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till)

The surficial deposit at the site consists of a heterogeneous mixture of silt, sand, gravel, cobbles and boulders. This deposit which is of a glacial till origin was explored to a maximum thickness of 10.4 metres at which depth the underlying bedrock was encountered. A grain size distribution envelope illustrating the gradation of the deposit smaller than 75 mm is illustrated in Figure 1 in the Appendix. The envelope illustrates the wide range of grain sizes that are typical of glacial till deposits. Cobbles and boulders, however, are also present within the deposit, as verified by rock core samples retrieved in the deposit and inferred by auger refusal encountered within the deposit. The cobbles and boulders are present throughout the deposit.

The deposit is unsorted and unstratified which is characteristic of glacial till deposits. The deposit has been oxidized for depths ranging from 2.1 metres to 5.5 metres below the natural ground surface and hence is brown in colour within this depth. The deposit is unoxidized and grey in colour below this depth.

Although this deposit is a coarse grained material as defined by the MTO soil classification system (greater than 50% of the material coarser than 75 micrometers), Atterberg Limit tests were carried out to evaluate the behaviour of the fine grained portion of the deposit. The results revealed that the fine grained material, which is comprised primarily of silt with only minor traces of clay, varies from a non-plastic silt to a silt of low plasticity. Plasticity indices (I_p), as illustrated on the indivdual Record of Borehole sheets, were generally less than 3%.

Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 26 blows/0.3 m to 100 blows/.08 m indicating a denseness ranging from compact to very dense. However, a correction of the lower values due to disturbance created by unbalanced hydrostatic head during the sampling process and a correction for the higher 'N' values due to the gravel, cobble and boulder sizes limits this range of denseness from probable dense to very dense.

Bedrock

The surficial heterogeneous mixture of silt, sand, gravel, cobbles and boulders is underlain by dolostone bedrock of the Oxford Formation. The bedrock surface as identified at BH 26-3 by retrieving approximately 1.6 metres of BX core, exists at a depth of 10.4 metres below the ground surface or equivalently an elevation of 84.2 metres.

The dolostone bedrock is light in colour and contains dark grey shale interbeds up to 7 cm in thickness. The bedrock is generally unweathered to only slightly weathered and has moderately close to extremely close spaced fractures. The fractures are flat, planar to undulating and smooth in texture.

Core recoveries and Rock Quality Designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Recovery was 100% and the rock quality designation of the core was 75%. Based on these results and visual examination, the dolostone rock can be described as sound, good and medium strong with weak interbeds of shale.

A summary of core recoveries and descriptions is included on the Table entitled "Rock Core Description" in the Appendix.

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 the invesigation ranged from 1.5 metres to 3 metres below the natural ground surface, equivalent to elevations of 92.6 metres to 91.9 metres.

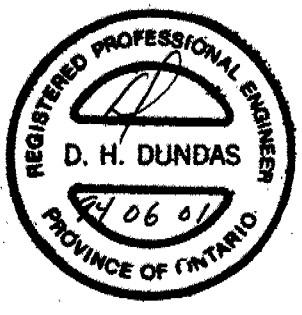
Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano and M. Michalek, Foundation Engineers, and F. Tannous, Engineer Trainee, utilizing equipment owned and operated by Johnston Drilling Ltd. and Marathon Drilling Ltd. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

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.

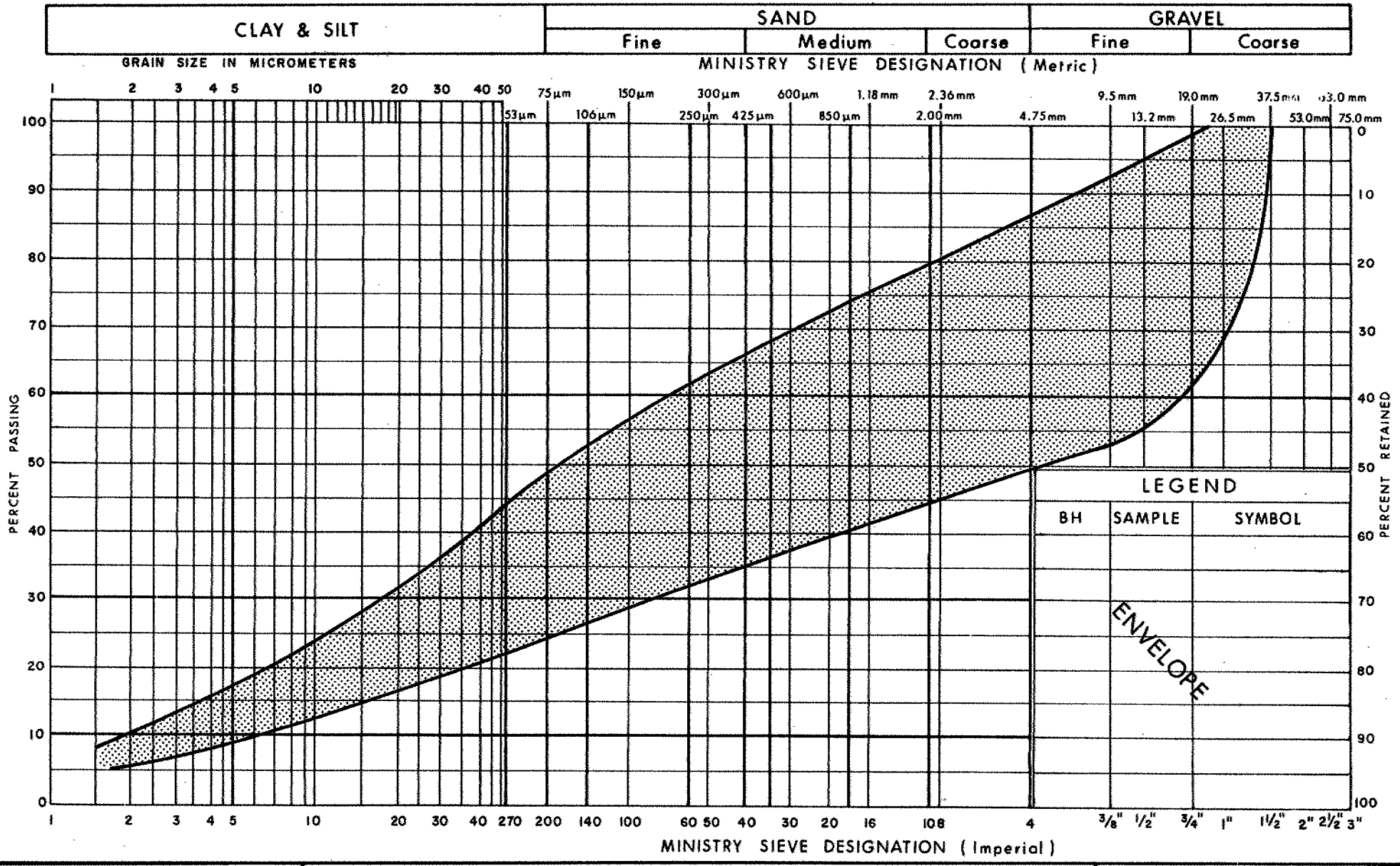
B. Bennett, P. Eng.
Sr. Foundation Engineer
(Acting)



D. Dundas, P. Eng.
Chief Foundation Engineer
(Acting)

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF SILT, SAND, GRAVEL, COBBLES & BOULDERS

FIG No 1

W P 123-87-04

37

RECORD OF BOREHOLE No 26-1 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 028.6 E 365 704 ORIGINATED BY TS

DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 90 12 21 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
94.1	Ground Surface										
0.0	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Brown, Very Dense		1	SS	120 /24cm	▼*	92		o⊢		13 39 40 8
			2	SS	100 /8cm						
90.1			3	SS	100 /8cm						
4.0	End of Borehole Auger Refusal (Probable Boulder) • 90 12 21										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 26-2 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 062 E 365 698 ORIGINATED BY MM

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS

DATUM Geodetic DATE 90 12 19-21 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE * QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
95.1	Ground Surface										
0.0	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Brown, Very Dense		1	SS	34	▼*	94				26 33 36 5
			2	SS	130						
			3	SS	100	/15cm					
			4	SS	59		92		PH		22 33 40 5
			5	SS	100	/5cm					
			6	RC	REC 32%						RQD = 24%
89.6			7	SS	52		90				
5.5	End of Borehole										
	* 90 12 21										

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 26-3 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 105.4 E 365 730 ORIGINATED BY MM

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS

DATUM Geodetic DATE 91 01 16 CHECKED BY TS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.6	Ground Surface										
0.0			1	SS	87		94				
			2	SS	113	▼* /25cm					
			3	SS	120	/28cm	92				
	Brown		4	SS	120	/15cm					
	Grey		5	RC	REC	= 50%					RQD = 43%
			6	SS	36						
			7	SS	46		90				RQD = 71 %
	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Dense to Very Dense		8	RC	REC	= 92%					
			9	SS	32		88				
			10	RC	REC	= 56%					RQD = 24 %
			11	SS	44						RQD = 0 %
			12	RC	REC	= 80%	86				
			13	SS	60	/5cm					
			14	RC	REC	= 100%					RQD = 40 %
84.2			15	RC	REC	= 45%					RQD = 41 %
10.4	Dolostone with interbedded Shale						84				
	Grey, Medium Strong Unweathered		16	RC	REC	= 100%					RQD = 75 %
82.6											
12.0	End of Borehole										
	* 91 01 16										

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 26-4 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 155 E 365 731 ORIGINATED BY TS

DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 91 01 15 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
94.9	Ground Surface										
0.0	Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders										
	Brown										
	Grey										
	(Glacial Till)										
	Dense to Very Dense		1	SS	42		94				
			2	SS	41						
			3	SS	104	▼*					
			4	SS	120	/28cm	92				
			5	SS	26						
	Compact		6	SS	29		90				
			7	SS	100	/15cm					
							88				
			8	SS	100	/15cm					
85.5			9	SS	100	/15cm	86				
9.4	End of Borehole										
	* 91 01 15										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \diamond^{20}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 26-5 1 OF 1 METRIC

W.P. 123-87-04 LOCATION Co-ords: N 5 006 196.8 E 365 764 ORIGINATED BY FT

DIST 9 HWY 416 BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 90 12 21 CHECKED BY TS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
94.5	Ground Surface										
0.0	Compact to Very Dense Heterogeneous Mixture of Silt, Sand, Gravel, Cobbles and Boulders (Glacial Till) Brown		1	SS	28	▼	94		○ H		50 25 20 5
			2	SS	111		92				
89.2			3	SS	111		90				
5.3	End of Borehole Auger Refusal (Probable Boulder) ▼ 90 12 21										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 123-87-04

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
3	5	3.56-3.91	50	43	3.56-10.16	**OVERBURDEN** (boulder till).
	8	4.57-5.18	92	71	10.16-11.96	**DOLOSTONE**, light olive grey to medium light grey to medium dark grey, with
	10	6.10-6.96	56	24		dark grey SHALE interbeds up to 7 cm thick (8%); fine crystalline; medium strong
	12	7.62-7.87	80	0		to weak; unweathered to slightly weathered; fractures moderately close to
	14	9.60-9.85	100	40		extremely close spaced, flat, planar to undulating, smooth.
	15	9.85-10.42	45	41		
	16	10.42-11.96	100	75		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 94-50

WP 123-87-03 DIST 9

HWY 416 STR SITE 3-553

Hwy. 416 and Bankfield Road Underpass

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FOUNDATION INVESTIGATION REPORT
For
Hwy. 416 and Bankfield Road Underpass
W.P. 123-87-03 Site 3-553
Hwy. 416, District 9, Ottawa, Nepean

INTRODUCTION

This report summarizes the results of a foundation investigation carried out at the aforementioned site. A two lane, two span structure has been proposed to carry the east and west bound lanes of Bankfield Road over Hwy. 416. This report contains factual information obtained from this investigation pertaining to structural foundations and related earthworks.

SITE DESCRIPTION GEOLOGY

The site is located ¼ km east of Cedarview Road along Regional Road No. 8 (Bankfield Road) in the City of Nepean, Region of Ottawa-Carlton. The area consists of farmers fields to the north and south with radio towers located ½ km within the south field. Regional Road No. 8 (Bankfield Road) is a narrow paved two lane road with drainage ditches beside both shoulders. The terrain surrounding the site is flat with short wild grasslands.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence which are characterized by clay plains interrupted by ridges of rock or sand and gravel. The bedrock in the area is of the Gull River formation of the middle ordovician period. It consists of limestone with interbedded shale layers. The overburden is relatively thin and was deposited during and immediately following the Wisonsinan Glaciation. At which time the area was depressed from the effect of the Glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

INVESTIGATION PROCEDURES

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

Field Investigation

The fieldwork for this investigation was carried out between 91 01 23 and 91 01 30 and consisted of a total of 7 sampled boreholes. Five of these boreholes were located at the various structure locations. These boreholes were advanced to a maximum depth of 14.7 m to 16.5 m below existing grade. The two remaining boreholes were located at the approach embankments and were advanced to depths of 9.1 and 9.6 m below existing grade.

The boreholes were advanced using conventional hollow stem augering techniques. Both a track and truck mounted CME55 continuous flight auger drill rigs were employed for the operation. Conventional rock coring methods were applied in retrieving rock core samples. Standard BXL core barrels within BW casing were used. In general, subsoil samples were retrieved at 0.7 m intervals from the top 6 m depth and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586).

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

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

Survey information related to the location and elevation of boreholes was provided by the Surveys and Plans Section with Eastern Region, Kingston.

Laboratory Analysis

The following laboratory tests were carried out on selected soil samples:

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

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

Subsurface Conditions

General

In five of the seven boreholes put down at this site, a surficial layer of clayey silt (fill) was encountered for a thickness of 1.4 m to 1.8 m. In BH 8, located at the east abutment, the surficial layer consisted of a clayey silt deposit for about 1.4 m. Surficially in BH 2, located at the pier location and underlying the clayey silt layer in BH 8 and the fill in the remaining boreholes, a silt, some clay, trace of sand deposit was encountered. Underlying the silt deposit, a layer of heterogeneous mixture of silt, sand and gravel (Glacial Till) was found in all boreholes. Dolostone bedrock was encountered below the Glacial Till deposit at depths ranging from 12.5 to 14.0 m. Boulders and cobbles were also encountered in the Glacial Till deposit near the bedrock surface.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 1288703-A, in the attached Appendix. The results of all field and laboratory tests are plotted on the Record of Borehole sheets, also included in the Appendix of this report. A brief description of the different soil strata is given below.

Clayey Silt some Sand (Fill)

The surficial layer at the site consisted of 1.4 m to 1.8 m of a clayey silt, some sand fill encountered at all boreholes except at BH's 2 and 8.

Results of Grain Size Distribution tests carried out on select samples are shown on Figure 1 in the Appendix in an envelope form. The deposit is comprised primarily of 0% gravel, 1-22% sand, and 62-87% silt and 12-20% clay.

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

	Range	No. of Tests
Natural Moisture Content (w)	17-31	4
Liquid Limit (w_L)	22-37	4
Plastic Limit (wp)	14-20	4
Plastic Index (Ip)	8-17	4

From the plasticity chart (Figure 2), this deposit can be classified as clayey silt of low to intermediate plasticity. Unit weight measurements carried out on select samples from this stratum yield dry unit weights of 18.9 to 22.5 kN/m^3.

The 'N' values obtained from the Standard Penetration Test ranged from 5 blows/0.3 m to 6 blows/0.3 m indicating the material to have firm consistency.

Clayey Silt, some Sand

This deposit was encountered in BH 8 as a 1.4 m surficial layer.

Results of a Grain Size Distribution test carried out on a representative sample are shown on Figure 3 in the Appendix. Based on these test data, this deposit is comprised of 0% gravel, 16% sand, 68% silt and 16% clay.

The results from the Atterberg Limit test performed on the fine fraction of the above sample showed a Natural Moisture Content (w) of 29.5, a Liquid Limit (w_L) of 31, a Plastic Limit (wp) of 19 and a Plasticity Index (Ip) of 12.

From the Plasticity Chart (Figure 4) this layer can be classified as clayey silt of low plasticity. Unit Weight measurements carried out on the sample yield dry Unit Weight of 18.9 kN/m^3.

The Standard Penetration Test revealed 'N' value of 10 blows/0.3 m. Based on this value, the material can be described as stiff.

Silt, trace of Sand, some Clay

A silt, trace of sand, some clay deposit was encountered, underlying the surficial layer in all boreholes at an elevation of 92.1 m to 93.3 m at

corresponding depths of 1.4 to 1.8 m. In BH 2, this deposit was encountered as a surficial layer of 5.6 m.

Results of Grain Size Distribution tests performed on this deposit are shown on Figure 5 in the Appendix, in an envelope form. Based on these test data, this deposit is comprised of 0-1% gravel, 2-54% sand, 40-87% silt, 6-14% clay.

Field observations in BH 5 also indicated that approximately the upper 1.4 m of the silt layer consists of clayey silt fill.

The results from the Atterberg Limit tests performed on this deposit are summarized as follows:

	Range	No. of Tests
Natural Moisture Content (w)	13-17.5	5
Liquid Limit (w_L)	17-21	5
Plastic Limit (wp)	14-18	5
Plastic Index (Ip)	1-5	5

From the Plasticity Chart (Figure 6) the layer can be classified as a silt of low plasticity. Unit Weight measurements carried out on select samples from this stratum yield dry Unit Weights of 22.3-23.3 kN/m^3.

Standard Penetration tests carried out in this deposit revealed 'N' values ranging from 5 blows/0.3 m to 44 blows/0.3 m. Based on these 'N' values, the material can be described as having a very loose to dense but generally from compact to dense state of relative density.

Heterogeneous mixture of Silt, Sand and Gravel with Boulders and Cobbles (Glacial Till)

Underlying the silt, trace of sand, some clay layer, a deposit of heterogeneous mixture of silt, sand and gravel (Glacial Till) was encountered at an elevation of 86.4 m to 89.0 m at corresponding depths of 5.6 m to 8.2 m.

Results of Grain Size Distribution tests carried out on select samples from this layer are shown on Figure 7 in the Appendix, in an envelope form. Based on these test data, this deposit is comprised of 9-67% gravel, 17-47% sand, 0-44% silt, and 0-7% clay.

Cobbles and boulders were also encountered in the Glacial Till deposit with numerous ones near the bedrock surface.

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

	Range	No. of Tests
Natural Moisture Content (w)	7.5-11	6
Liquid Limit (w_L)	13-14	3
Plastic Limit (wp)	10-12	3
Plastic Index (Ip)	2-3	3

From the Plasticity chart (Figure 8), this deposit can be classified as silt of slight plasticity. Unit Weight measurements carried out on select samples from this stratum yield dry unit weights of 23.5 kN/m^3.

In this stratum the Standard Penetration resistance, 'N' values ranged from 18 blows/0.3 m to 107 blows/0.3 m indicating that the material had a compact to very dense state of relative density.

Bedrock

The glacial till deposit is directly underlain by dolostone bedrock of the Gull River Formation. The bedrock was cored in a BXL double core barrel at the structure foundation locations up to 2.6 m in length. The bedrock surface varies between elevation 80.7 m to 81.9 m which is equivalent to depths of 12.5 m to 14.0 m below the ground surface. The dolostone bedrock is generally fine grained and medium dark grey to light grey in colour. Dark grey shale was also found interbedded in the dolostone. Detailed descriptions of the bedrock are attached in Table 1 in the Appendix, entitled "Description of Rock Core".

Core recoveries and rock quality designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock core recoveries varied between 65 and 100% while RQD's varied between 31 and 64%.

GROUNDWATER CONDITIONS

Observations of the groundwater level were carried out by measuring the water level in open boreholes. Groundwater levels determined at the time of the investigation were approximately 1.5 m (elevation 93.2 m) to 3.0 m (elevation 90.9 m) depth. It is considered that the water levels observed in BH's 2 (88.6 m) and 7 (89.7 m) do not reflect stabilized ground water levels. Groundwater levels were also measured on April 12, 1991 (approximately 4 months after investigation) in BH's 1 and 7 and were found to be 0.46 m below ground surface. Based on the above observations it is considered that the water table at this site ranges between elevations 91 m and 93 m.

Soil cave-in was encountered in the boreholes upon penetration of the cohesionless silt below the prevailing groundwater due to unbalanced hydrostatic head. Wash boring techniques were employed to advance the boreholes thereafter.

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

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct one two-span bridge structure to carry the east and westbound lanes of Bankfield Road over the proposed Hwy. 416. Approach fills, approximately 6 m in height will be required for the eastbound and westbound lanes with adjoining shoulders. A plan illustrating the proposed structure is shown on Drawing No. 1238703-A in the Appendix of this report.

The natural ground surface at abutment locations was fairly uniform with elevations of 94.5 m and 94.7 m. The elevation at the centreline of the proposed bridge will be 101.0 m and the proposed Hwy. 416 will have a centreline elevation of 94.5 m for the northbound and southbound lanes.

To facilitate the design and construction of the proposed structure foundations and related earthworks for the approach ramps over Bankfield Road, the following foundation and geotechnical recommendations are provided in the scope of this report.

1) Structure Foundations
2) Lateral Earth Pressures
3) Slope Stability
4) Construction Considerations

1) STRUCTURE FOUNDATIONS

The structure foundations could therefore be founded on one of the following alternatives a) Pile Foundations or B) Perched footings on compacted granular pad.

a) Pile Foundations

The structure foundations shall be supported on Steel H-piles driven to bedrock encountered at about 12.5 m to 14.0 m depth below existing grade.

For purpose of O.H.B.D.C., the design axial capacity for vertical piles are summarized in a Table 1 below.

Table 1 - Axial Capacities - Driven Steel H-piles

Pile Type	Bearing Capacity at S.L.S. Type II (kN)	Factored Capacity at U.L.S. (kN)	Estimate Pile Tip El.(m)
HP310x110	1150	1600	W. Abutment 80.7± E. Abutment 80.9-81.9 Pier 80.7-81.2

Pile spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. Lateral loads shall be supported by batter piles. All piles should be provided with the Standard MTO tip reinforcement.

B) Perched Footings

Considerations may be given to founding the two abutments on spread footings perched within compacted Granular 'A' pads.

This should be done by removing the fill material and then placing and compacting a minimum 2 m granular pad above existing native soil. The recommended design values for the perched footing constructed as above, is shown in Table 2 below.

Table 2 - Bearing Capacities for Perched Abutments

Structure	Bearing Capacity at S.L.S. Type II (kN)	Factored Capacity at U.L.S. (kN)
Abutment	350	700

Sliding resistance between the rough concrete footing and the Granular 'A' core can be calculated by assuming an unfactored angle of internal friction of 35°.

2) LATERAL EARTH PRESSURES ON STRUCTURE

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up. Design parameters of the soil are shown in Table 3 below.

Table 3 - Backfill Properties

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

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

The earth pressure coefficient at Rest is to be used in design if the abutments are rigid and unyielding.

The tabulated earth pressure coefficients are applicable to horizontal surfaces only. These values must be modified to represent sloping surfaces. Weep holes in the abutment walls should be designed to drain any accumulation of water in backfill.

3) SLOPE STABILITY

The approach fills rising to a maximum height of 6 m, shall be constructed using 2H:1V slopes. The fill material should consist of well compacted acceptable

material. No slope stability problems are anticipated with the above design. It is anticipated that approximately 60 mm of 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.

4) CONSTRUCTION CONSIDERATIONS

All pile caps and shallow spread foundations shall be protected against frost by providing a minimum 1.8 m of earth cover.

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

Excavations to about 1.5 m depth will be involved in the area of the pier. Such excavation and any temporary construction excavation may be carried out at 1.5H:1V slopes.

Special consideration should be given the pile cap construction at the pier location due to a high water table. Any excavation beneath the groundwater level in the silt deposit will require a dewatering scheme. Possible dewatering schemes could include using perimeter ditches or sheeting.

The most economical and practically feasible scheme should be selected for this purpose.

If pile foundation is choosen for the abutments, it is recommended that abutment pile caps be constructed as high as possible within the approach fill. This will eliminate the requirement for dewatering at these locations.

Although attempts should be made in all cases to drive the piles to the bedrock surface, some piles may terminate in the glacial till because of large size boulders which were encounterd during the investigation.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Michalek, Junior Foundation Engineer, and F. Tannous, Trainee Engineer. Utilizing equipment owned and operated by Johnston Drilling Co.

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

F. Tannous
Trainee Engineer

for

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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

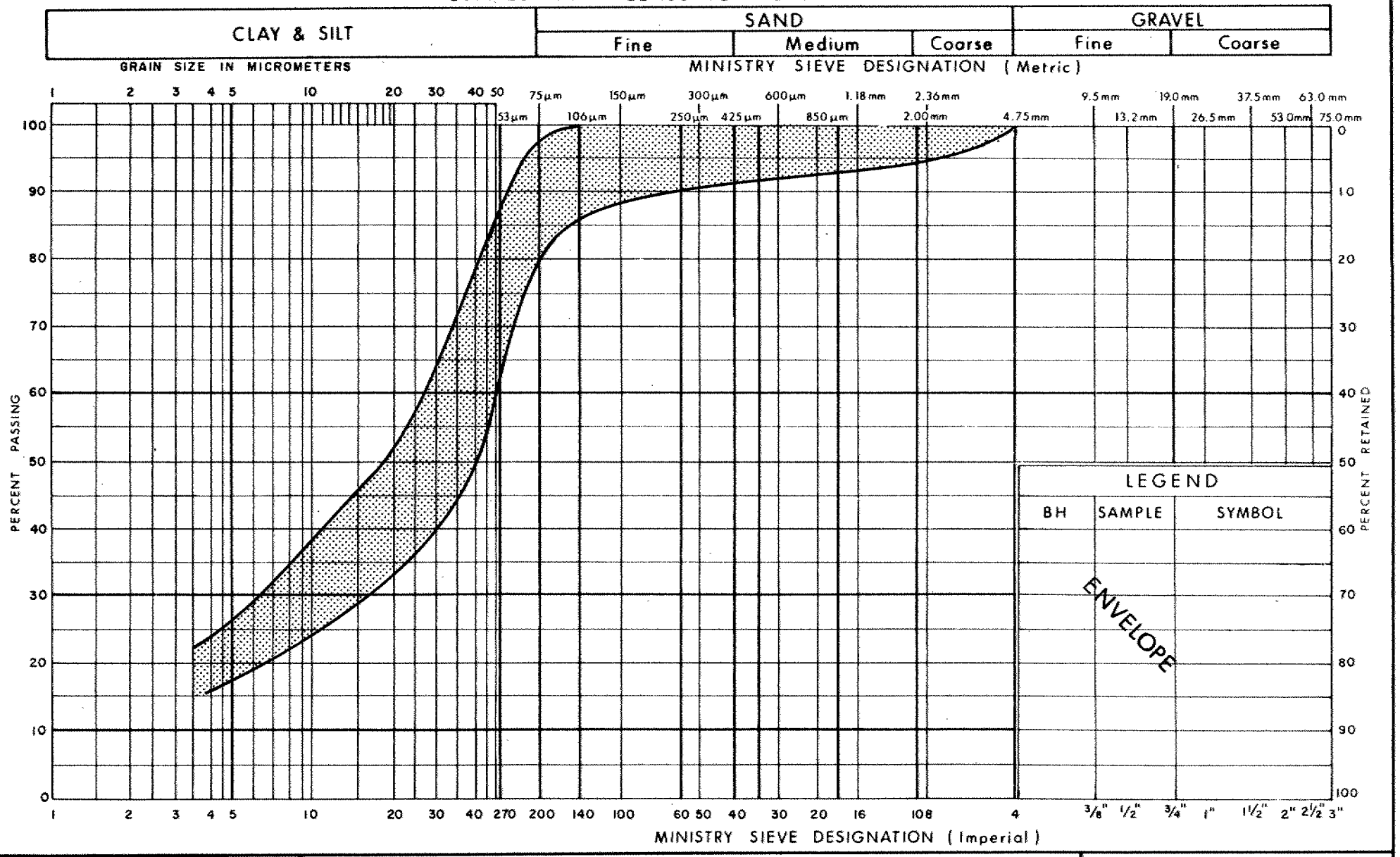
m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

UNIFIED SOIL CLASSIFICATION SYSTEM



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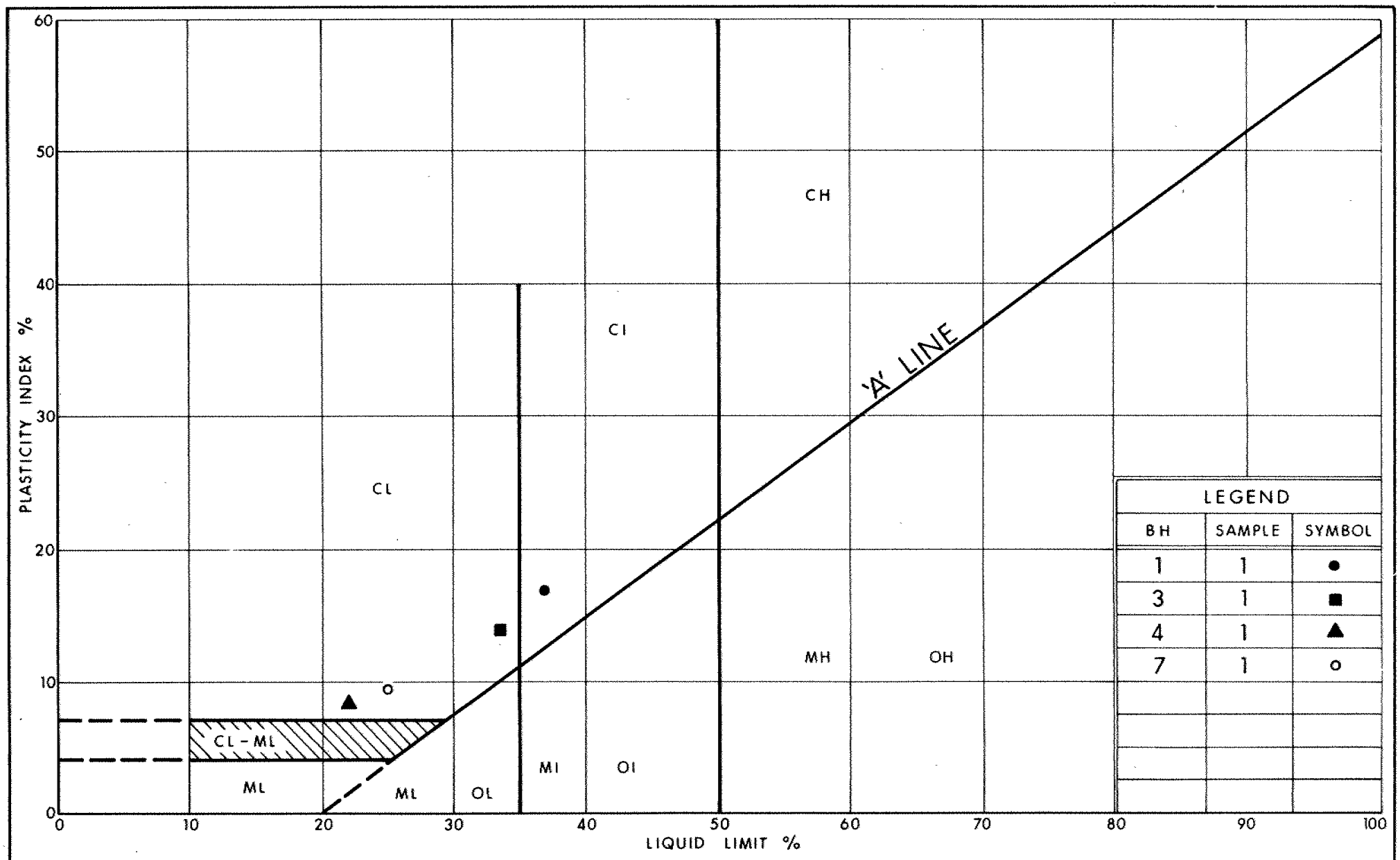
GRAIN SIZE DISTRIBUTION
CLAYEY SILT
(FILL)

FIG No 1

W P 123-87-03

Oct 75, FF-S-21



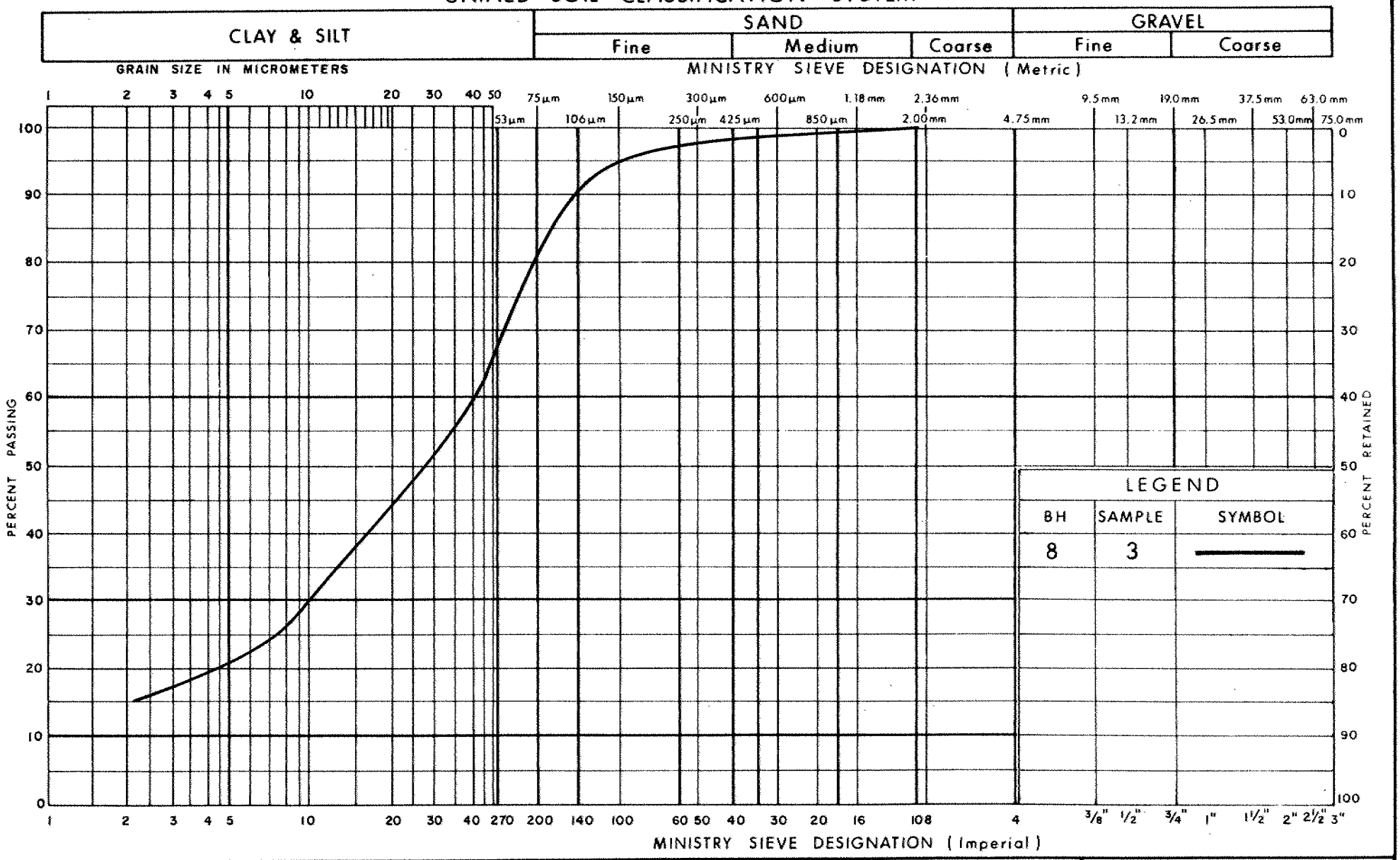
LEGEND		
BH	SAMPLE	SYMBOL
1	1	●
3	1	■
4	1	▲
7	1	o

Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT, SOME SAND
(FILL)

FIG No 2
W P 123-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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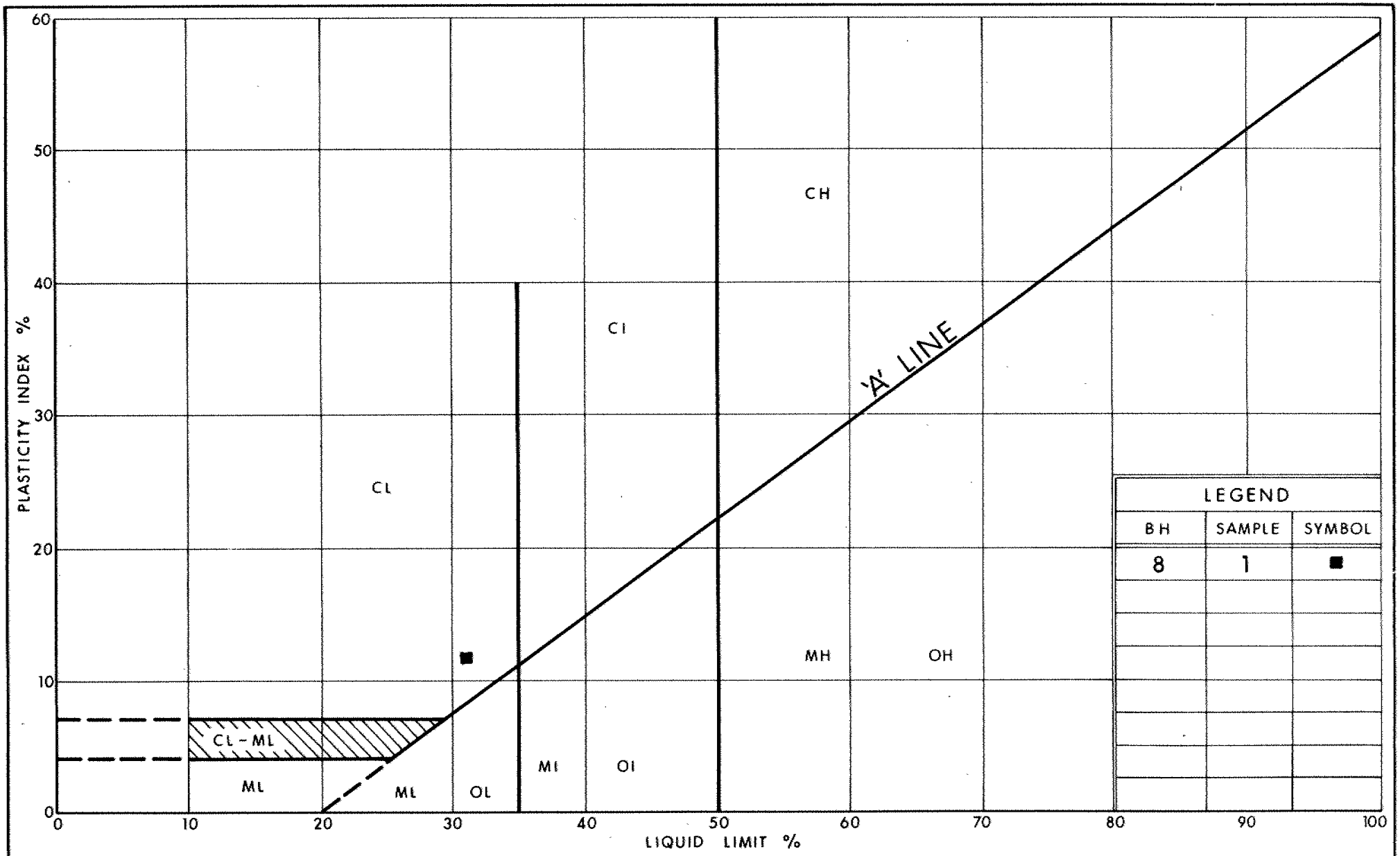
GRAIN SIZE DISTRIBUTION
CLAYEY SILT, SOME SAND

FIG No 3

W P 123-87-03



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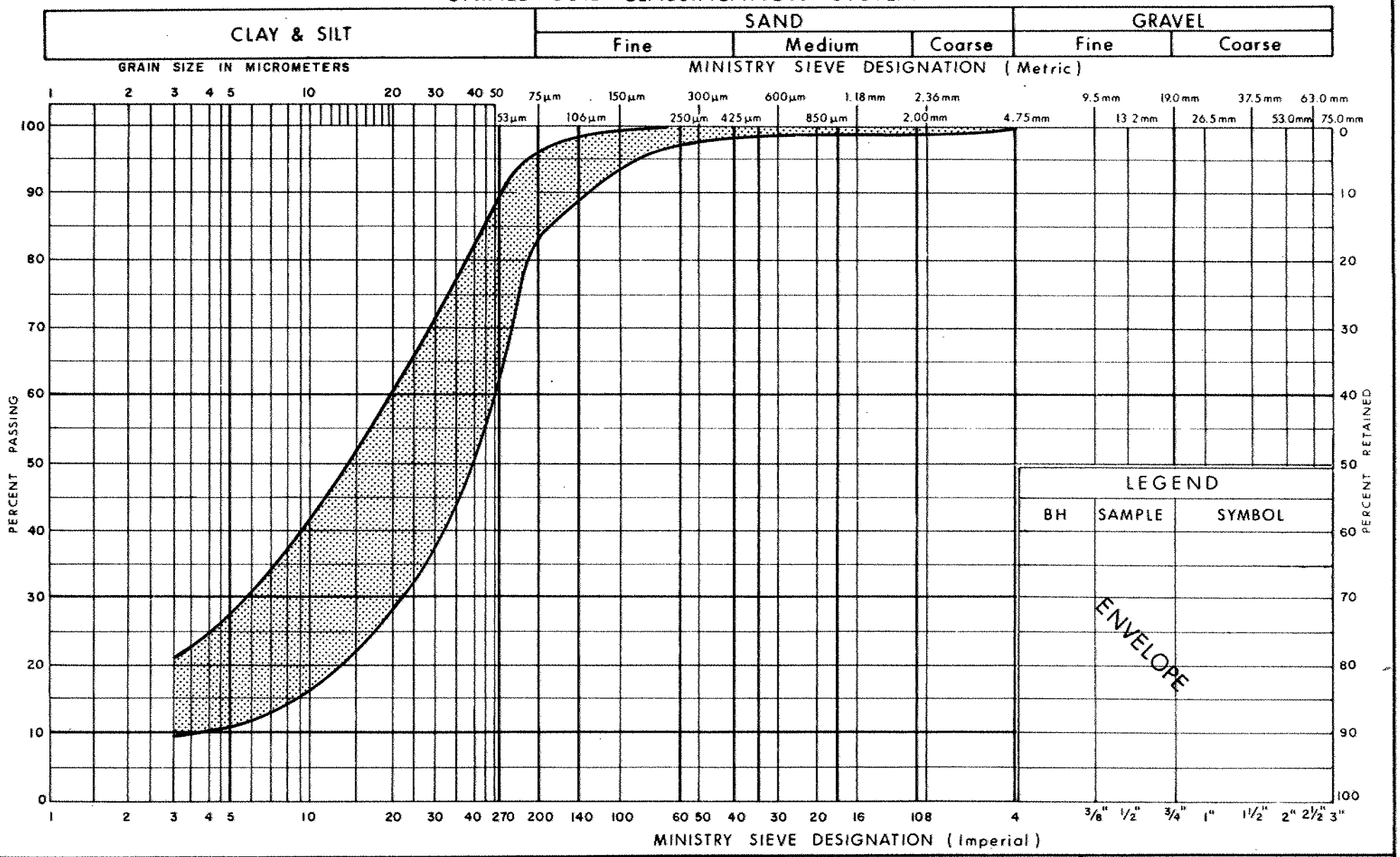
PLASTICITY CHART
CLAYEY SILT, SOME SAND

FIG No 4
W P 123-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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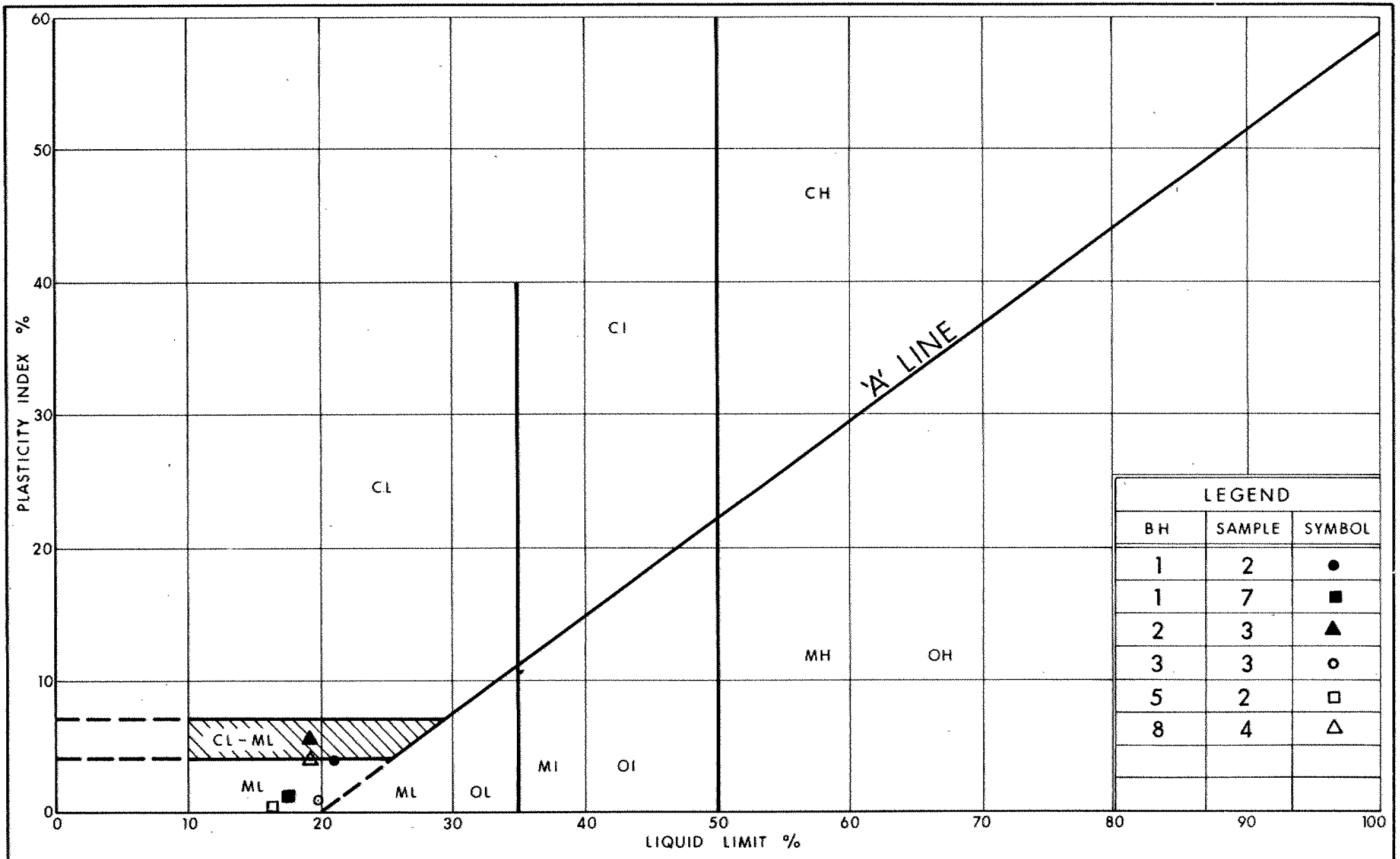
GRAIN SIZE DISTRIBUTION
SILT, TRACE SAND, SOME CLAY

FIG No 5

W P 123-87-03

Oct 75, FF-S-21



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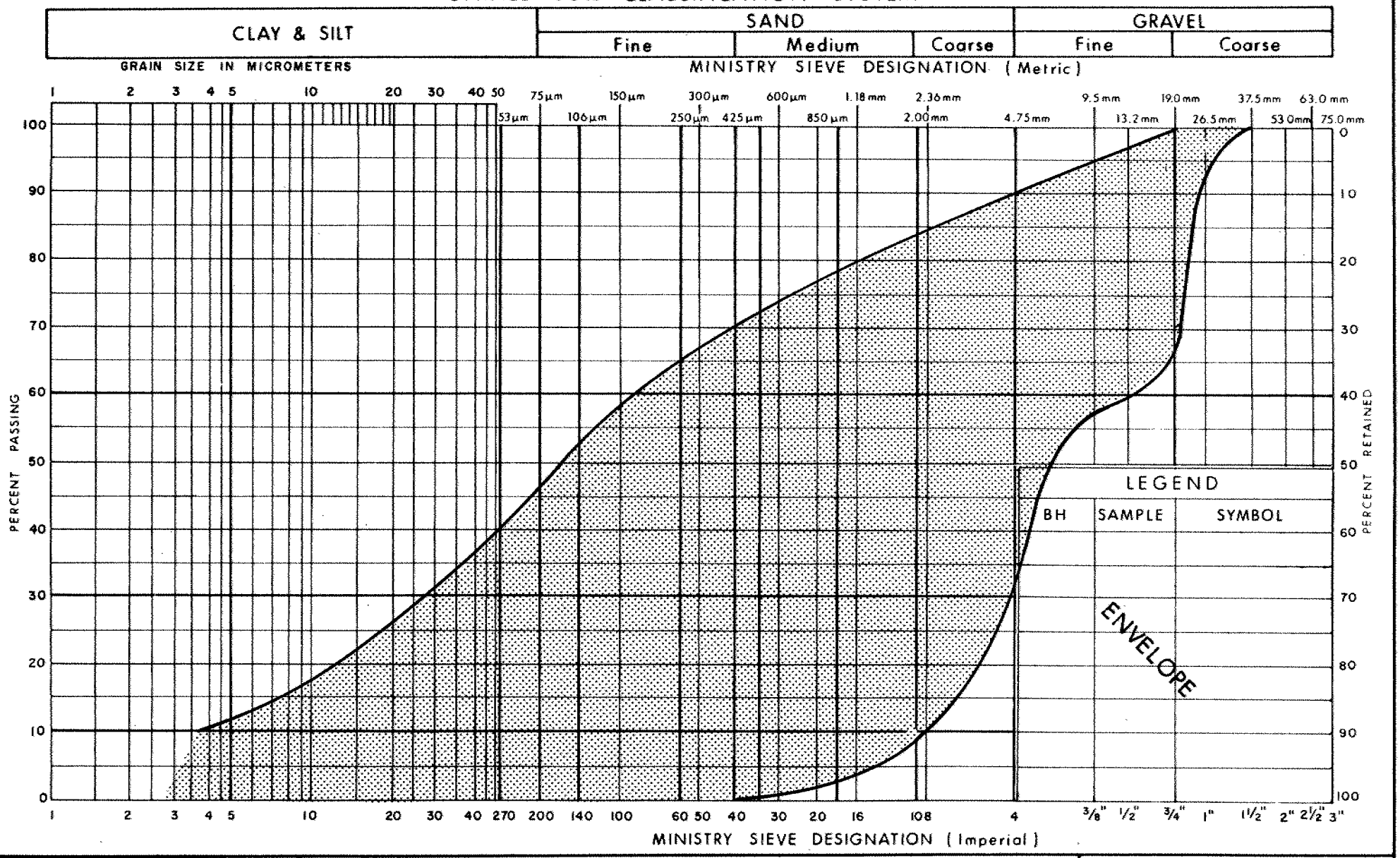
PLASTICITY CHART
SILT, TRACE SAND, SOME CLAY

FIG No 6
W P 123-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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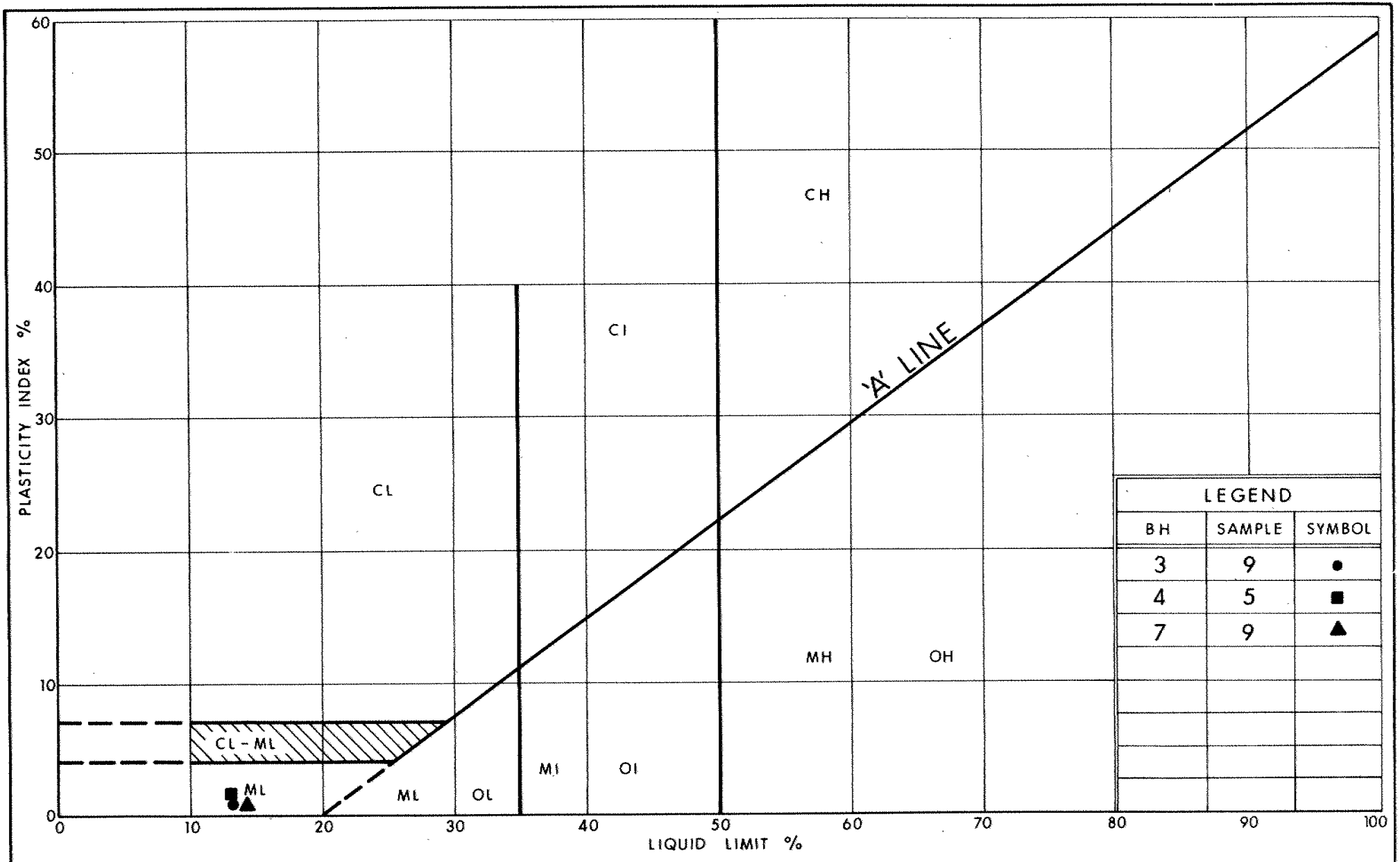
GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL
WITH NUMEROUS COBBLES & BOULDERS (GLACIAL TILL)

FIG No 7
W P 123-87-03



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

FIG No 8

W P 123-87-03

ROCK CORE DESCRIPTION
WP 123-87-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	1	8.23-8.92	19	15	8.23-14.02	**OVERBURDEN** (boulder till).
	2	11.89-12.19	33	0	14.02-16.54	**DOLOSTONE** (algal laminated and intraclastic in part), medium dark grey to
	3	12.65-12.80	100	0		medium light grey to light olive grey, with dark grey **SHALE** interbeds up to 10 cm
	4	12.80-13.72	14	0		thick (8%); fine crystalline; medium strong to weak; unweathered to slightly
	5	13.72-14.02	17	0		weathered; fractures moderately close to extremely close spaced, flat to near
	6	14.02-14.94	100	61		vertical, planar to undulating, smooth.
	7	14.94-16.54	65	40		
2	1	5.64-6.10	33	28	5.64-12.80	**OVERBURDEN** (boulder till).
	2	6.10-7.32	44	27	12.80-14.94	**DOLOSTONE** (algal laminated and intraclastic in part), medium dark grey to light
	3	9.14-10.36	10	0		grey, with dark grey **SHALE** interbeds up to 10 cm thick (15%); fine crystalline;
	4	10.36-10.67	75	38		medium strong to weak; unweathered to slightly weathered (moderately
	5	10.67-10.97	42	0		weathered, 12.80-13.49 m); fractures moderately close to extremely close
	6	10.97-12.19	58	46		spaced, flat to near vertical, planar to undulating, smooth.
	7	12.19-12.50	96	67		
	8	12.50-12.80	54	46		
	9	12.80-13.41	100	0		
	10	13.41-14.94	100	64		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 123-87-03

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
3	1	9.91-10.49	87	78	9.91-12.55	**OVERBURDEN** (boulder till).
	2	10.97-11.05	100	0	12.55-14.81	**DOLOSTONE** (slightly calcitic, algal laminated and intraclastic in part), medium
	3	11.05-12.19	100	76		dark grey to light grey, with dark grey **SHALE** interbeds up to 8 cm thick (8%); fine
	4	12.19-13.13	62	51		crystalline; medium strong to weak; unweathered to slightly weathered; fractures
	5	13.13-14.81	95	47		moderately close to extremely close spaced, flat to near vertical, planar to
						undulating, smooth.
7	1	9.45-10.36	14	0	9.45-13.41	**OVERBURDEN** (boulder till).
	2	10.36-11.48	27	16	13.41-15.19	**DOLOSTONE** (algal laminated and intraclastic in part), medium dark grey to
	3	11.48-12.24	53	40		medium light grey, with dark grey **SHALE** interbeds up to 8 cm thick (7%); fine
	4	12.24-12.85	46	0		crystalline; medium strong to weak; unweathered to slightly weathered
/	5	12.85-13.41	36	0		(moderately weathered, 13.41-13.84 m); fractures moderately close to extremely
	6	13.41-13.72	75	42		close spaced, flat to near vertical, planar to undulating, smooth.
	7	13.72-15.19	100	44		
8	1	11.35-12.02	92	15	11.35-12.70	**OVERBURDEN** (boulder till).
	2	12.02-13.23	96	38	12.70-14.73	**DOLOSTONE** (slightly calcitic, algal laminated and intraclastic in part), medium
	3	13.23-14.73	69	31		dark grey to medium light grey, with dark grey **SHALE** interbeds up to 8 cm thick
						(6%); fine crystalline; medium strong to weak; unweathered to slightly weathered;
						fractures moderately close to extremely close spaced, flat to near vertical, planar to
						undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

RECORD OF BOREHOLE No 1 — 1 OF 2 — METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 797.7, E 364 678.8 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 23, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.7	Ground Surface										
0.0	Clayey Silt, some Sand Brown, Firm (Fill)		1	SS	6		94			17.6	0 16 64 20
93.3											
1.4	Silt, trace Sand, some Clay Compact to Dense		2	SS	17	▼	93				0 8 81 11
			3	SS	16		92				
	Brown		4	SS	22						
	Grey		5	SS	25		91				
			6	SS	26		90				0 2 84 14
			7	SS	36		89			22.6	0 3 87 10
			8	SS	46		88				
86.4							87				
8.2	Heterogeneous mixtue of Silt, Sand and Gravel Cobbles and Boulders (Glacial Till) Grey, Compact to very Dense		9	RC	REC	19%	86				RQD 15%
			10	SS	75						23 47 27 3
			11	SS	26		85				
	with numerous boulders		12	RC	REC	33%	84				RQD 0%
			13	SS	61		83				67 33 0 0
			14	RC	REC	100%	82				RQD 0%
			15	RC	REC	14%					RQD 0%
80.7			16	RC	REC	17%	81				RQD 0%
14.0	Dolostone Bedrock Unweathered to slightly weathered		17	RC	REC	100%	80				RQD 61%
			18	RC	REC	65%					RQD 40%

Continued

Continued

+³, ×³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 1 2 OF 2 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 797.7, E 364 678.8 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 23, 1991 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
30.5	Continued										
			18	RC	REC	65%	79				RQD 40%
78.1											
16.5	End of Borehole										

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 2 — 1 OF 1 — METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 804.3, E 364 716.7 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 29, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.5	Ground surface								
0.0	Silt ,trace Sand, trace Clay Compact to Very Dense		1	SS	18		93		
	Brown		2	SS	15		92		
	Grey		3	SS	44		91	22.3	0 9 82 9
			4	SS	61		90		
			5	SS	25		89		
87.9			6	SS	7	▼	88		
5.6	Heterogeneous mixture of Silt, Sand and Gravel Cobbles and boulders (Glacial Till) Grey, Very Dense		7	RC	REC	33%			RQD 28%
			8	RC	REC	44%	87		RQD 27%
			9	SS	73		86		
			10	SS	100	/13cm	85		9 44 40 7
	with numerous boulders		11	RC	REC	10%	84		RQD 0%
			12	RC	REC	75%	83		RQD 38%
			13	RC	REC	42%			RQD 0%
			14	RC	REC	58%	82		RQD 46%
			15	RC	REC	96%			RQD 67%
80.7			16	RC	REC	54%	81		RQD 46%
12.8	Dolostone Bedrock Unweathered to slightly weathered		17	RC	REC	100%			RQD 0%
			18	RC	REC	100%	80		RQD 64%
78.6							79		
14.9	End of Borehole								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

+3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 836.0, E 364 739.7 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 28, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.4	Ground Surface										
0.0	Clayey Silt with organics, some Sand Brown, Firm		1	SS	5		94				0 14 71 15
93.0	(Fill)									19.2	
1.4	Silt, trace Sand, some Clay Compact to Dense		2	SS	14	▼	93				
			3	SS	24		92			22.9	0 10 82 8
	Brown		4	SS	20		91				
	Grey		5	SS	25		90				
			6	SS	41		89				
			7	SS	5		88				1 2 82 15
87.3											
7.1	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Compact		8	SS	16		87				
			9	SS	18		86				34 17 44 5
	with numerous boulders		10	RC	REC	87%	85				RQD 78%
			11	SS	100	/5cm	84				
			12	RC	REC	100%					RQD 0%
			13	RC	REC	100%	83				RQD 76%
81.9											
12.5	Dolostone Bedrock Unweathered to slightly weathered		14	RC	REC	62%	82				RQD 51%
			15	RC	REC	95%	81				RQD 47%
79.6							80				
14.8	End of Borehole										

$+^3$, $\times^5$; Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4 — 1 OF 1 — METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 771.5 E 364 660.2 ORIGINATED BY F.T.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 24, 1991 CHECKED BY B.I.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.9	Ground surface										
0.0	Clayey Silt, trace SAnd Brown, very Stiff (Fill)						93				
92.1			1	SS	28		92			22.5	0 1 87 12
1.8	Silt, some Clay, trace Sand Compact to Dense		2	SS	27	▼	91				
	Brown Grey		3	SS	28		90				
86.8			4	SS	31		89				
7.1	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Grey		5	SS	2*		88				23 41 30 6
84.8							87				
							86				
							85				
9.1	End of Borehole * disturbed sample										

+³, ×³: Numbers refer to Sensitivity

15 10 20 ◇ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 851.7 E 364 765.7 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 28, 1991 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
94.3	Ground surface										
0.0	Probable Fill					*	94				
	Silt, trace Sand, some Clay Compact to Dense Brown Grey		1	SS	25		93				
	Silty Sand		2	SS	23		92				0 54 40 6
			3	SS	31		91				
87.7			4	SS	100	/15cm	90				
6.6	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Grey, Very Dense		5	SS	83		89				
84.7			6	SS	107		88				21 37 35 7
9.6	End of Borehole * water level not established						87				
							86				
							85				

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 816.0, E 364 709.0 ORIGINATED BY M.M.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

DATUM Geodetic DATE Jan. 29, 1991 CHECKED BY B.I.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.6	Ground surface							
0.0	Clayey Silt, some sand Brown, Firm (Fill)		1	SS	6		19.6	0 22 62 16
93.2								
1.4	Silt, some Sand, trace Clay Compact		2	SS	15			
			3	SS	20			
			4	SS	20			
	Brown / Grey		5	SS	17			1 11 81 7
			6	SS	4	▼		
89.0								
5.6	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Grey, Compact to Very Dense		7	SS	2			
			8	SS	29			
	with numerous boulders		9	SS	137	/20cm	23.4	23 40 30 7
			10	RC	REC	14%		RQD 0%
			11	RC	REC	27%		RQD 16%
			12	RC	REC	53%		RQD 40%
			13	RC	REC	46%		RQD 0%
81.2			14	RC	REC	36%		RQD 0%
13.4	Dolostone Bedrock Unweathered to slightly weathered		15	RC	REC	75%		RQD 42%
			16	RC	REC	100%		RQD 44%
79.4								
15.2	End of Borehole							

ELEVATION SCALE: 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

+^{3}, ×^{5} : Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 123-87-03 LOCATION Co-ords: N 5 007 822.1, E 364 748.0 ORIGINATED BY F.T.

DIST 9 HWY 416 BOREHOLE TYPE HS Auger, BXL Core Barrel COMPILED BY F.T.

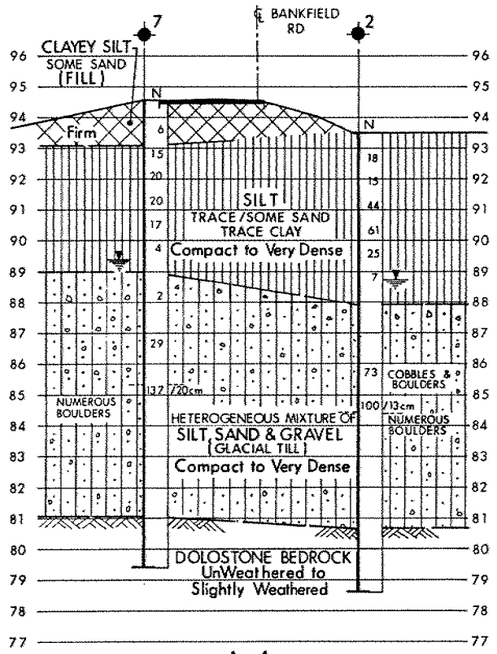
DATUM Geodetic DATE Jan. 29, 1991 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
93.6	Ground surface										
0.0	Clayey Silt, trace Organics some sand					*	93				
	Black, Stiff		1	SS	10					18.9	0 16 68 16
92.2							92				
1.4	Silt, some Sand, trace Clay		2	SS	26						
	Compact to very Dense										
	Brown		3	SS	32		91				
	Grey										
			4	SS	27					23.2	0 10 81 9
							90				
			5	SS	28						
							89				
			6	SS	47						
							88				
			7	SS	56						
86.5							87				
7.1	Heterogeneous mixture of Silt, Sand and Gravel										
	(Glacial Till)		8	SS	26		86				18 42 34 6
	Grey, Compact to Dense										
							85				
			9	SS	41						
							84				
			10	SS	25		83		○		55 28 13 4
	with numerous boulders										
			11	RC	REC	92%	82				RQD 15%
80.9											
12.7			12	RC	REC	96%	81				RQD 38%
	Dolostone Bedrock										
	Unweathered to slightly weathered						80				
			13	RC	REC	69%					RQD 31%
78.9							79				
14.7	End of Borehole										
	* water level not established										

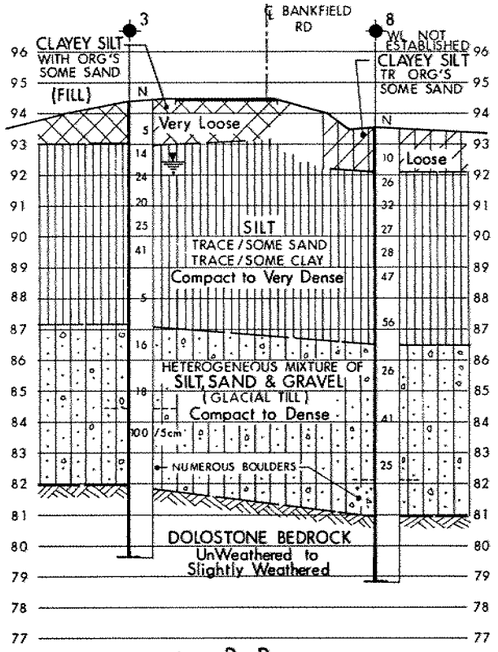
$+^3$, $\times^3$; Numbers refer to Sensitivity

$\frac{20}{15}\diamond^5_{10}$ (%) STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 86 10



A-A



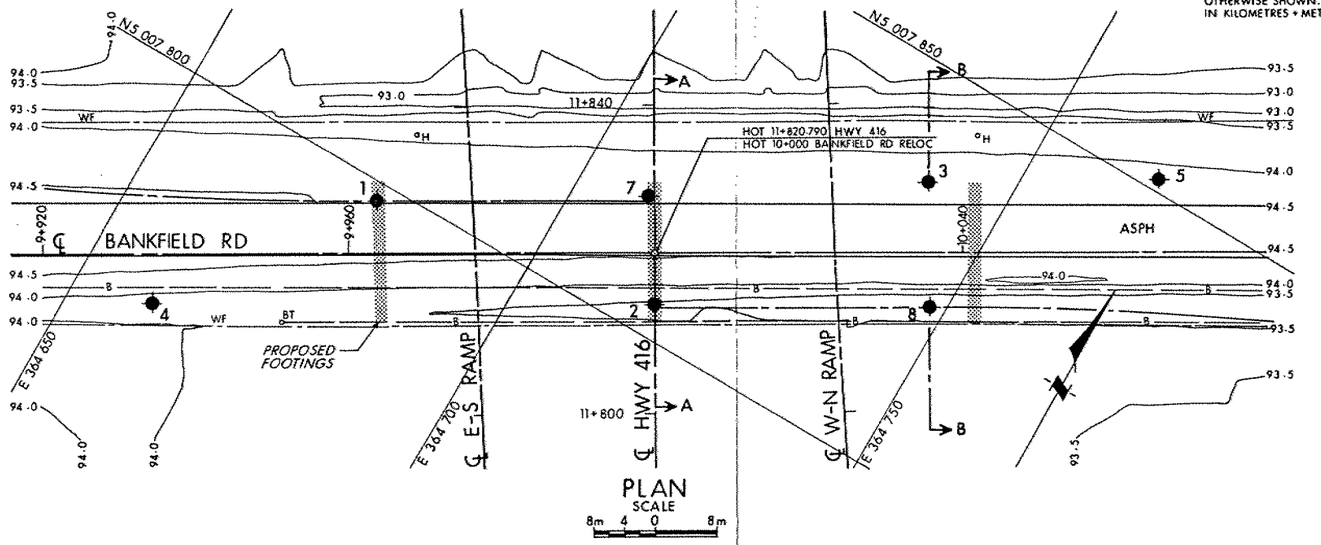
B-B

SECTIONS

SCALE

4m 2 0 4m Hor

2m 1 0 2m Vert



PLAN

SCALE

8m 4 0 8m

℄ PROFILE BANKFIELD RD

SCALE

8m 0 8m Hor

4m 0 4m Vert

METRIC

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

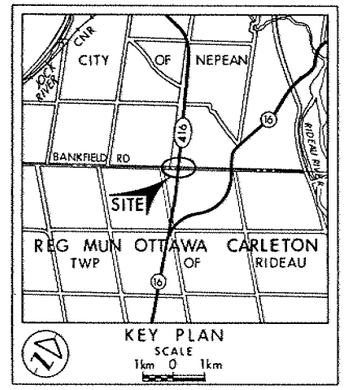
CONT No

WP No 123-87-03

BANKFIELD RD

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 91 01

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	94.7	5 007 797.7	364 678.8
2	93.5	5 007 804.3	364 716.7
3	94.4	5 007 836.0	364 739.7
4	93.9	5 007 771.5	364 660.2
5	94.3	5 007 851.7	364 765.7
7	94.6	5 007 816.0	364 709.0
8	93.6	5 007 822.1	364 748.0

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 31G-204

HWY No 416			DIST 9
SUBM'D MM	CHECKED	DATE 91 04 26	SITE 3-553
DRAWN DT	CHECKED	APPROVED	DWG 1238703-A

REF No E-52-416-6, 90 10