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W. O. No.

STR. SITE No. 38-57

HWY. No. 546

LOCATION Hwy 546 & Little White River

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 89-239



Ontario

Ministry of  
Transportation and  
Communications

## I N D E X

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NOTE: For the purposes of this contract, this report supersedes all other reports prepared by or for the Ministry in connection with the above-noted project.

## EXPLANATION OF TERMS USED IN REPORT

2

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

**FOUNDATION INVESTIGATION REPORT**  
**FOR**  
**LITTLE WHITE RIVER BRIDGE**  
**WP321-85-01, SITE 38-57**  
**HIGHWAY 546, DISTRICT 17, SUDBURY**

**1.0 INTRODUCTION**

This report contains the results of a foundation investigation carried out at the site of the above mentioned project.

The investigation and study was undertaken by Geo-Canada Ltd. on behalf of the Ontario Ministry of Transportation under Consultants Agreement No. 4238-9087-186.

The purpose of the investigation was to determine the subsurface and foundation conditions at the proposed bridge abutment locations and to provide the necessary geotechnical input for the foundation design of the proposed new structure.

The field work was carried out during the period of 1988 02 04 to 15, and consisted of two sampled boreholes (one drilled on each side of the river), a cone penetration test adjacent to one of the boreholes, two cone penetration tests extended from the base of the boreholes, and two separate cone penetration tests. The borings were advanced by washboring and rotary drilling (tri-coning) techniques to depths ranging between 14.3 and 24.1 m below the existing ground surface. With the additional cone tests, which were put down from the bottom of the boreholes, the depth of exploration was extended to 21.6 and 34.2 m respectively.

## 2.0 DESCRIPTION OF SITE AND GEOLOGY

The site is located on Secondary Highway 546, near its junction with Highway 639, approximately 40 km north of the Town of Elliot Lake. At present, the Highway is carried over the Little White River on a single span double Bailey bridge. The river, at the points of the existing and proposed crossings follows a generally east to west course.

The topography of the general area is very hilly to small mountainous with steep sided rock formations rising above numerous lakes and small streams and rivers. Several wide valleys wind through the area. In one of these valleys lies the aforementioned bridge site.

.../...

Locally, the river valley is approximately 300 m wide and runs generally in a north-east to south-west direction and the Little White River winds its way through this valley. At the bridge site, the river is approximately 25 m wide and 0.7 m deep at its centre at the time of our drilling. The current is fast and the river bed is lined with cobbles of diameters ranging from 60 to 180 mm (average 125 mm) in size.

At the inside of the river bends, including the north abutment location, berms or narrow ridges consisting of cobble and coarse sand have been deposited to heights of approximately 2.5 m above the river or ice level. At the outside bends of the river (e.g. at the south abutment location) the banks show signs of some scouring and slight undercutting.

The vegetation in the area consists of coniferous (spruce) and deciduous (poplar) mature forests with some sumac and sage brush around the river and wet areas.

Approximately 80 m to the east of the proposed bridge location the existing alignment of Highway 546 crosses the river over a double Bailey bridge. This structure, approximately 30 m long and one lane wide, is supported on large timber cribs at each abutment. The cribs are rock

.../...

filled and appear to be free from the effects of scour and settlement.

The nearest rock outcrop is about 250 m to the east of the proposed bridge and is part of a steep sided ridge of rock running in a north-east to south-west direction. Two outcrops at this location, approximately 50 m apart, were examined by us. One of the outcrops was composed of metasedimentary rock, high in quartzite and was fairly intact and massive. It had nearly horizontal medium spaced bedding planes and two joints, one nearly vertical and the other about 60 degrees to the horizontal. The rock exposed in the other outcrop was more igneous in nature, also high in quartzite and feldspar, and was badly weathered and fractured. It had no apparent bedding plane and no regular joint pattern.

Geologically, the site is located on the Canadian Pre-Cambrian Shield. Geological maps indicate that the Little White River is near the boundary between the early Pre-Cambrian predominantly granitic rocks to the north and the Middle Pre-Cambrian metasedimentary rocks of the Huronian Super Group which comprise conglomerates, metamorphosed sandstones and siltstones to the south. There is a major east-west oriented fault line approximately 10 km south of

.../...

the site, and another north-south fault line about 15 km to the north. During Pleistocene times the area was covered by glaciers which left a mantle of overburden consisting of glacial drift.

### 3.0 SUMMARIZED SUBSURFACE CONDITIONS

**\*\***

#### 3.1 General

The general subsurface profile at the site consists of a 3 to 4 m thick surficial layer of cobbles, gravel and sand underlain by a deep, over 30 m thick deposit of fine sand. The surface of the Pre-Cambrian bedrock was not encountered at any of the test locations, i.e. within a depth of 34 m (Elevation 269 m) at the north-west quadrant of the site.

The groundwater table at the boreholes was encountered at shallow depths and its level (Elevations 302.3 to 302.4 m) coincided with the river level which at the time of the investigation was at Elevation 302.4 m.

The subsurface conditions are described in detail on the individual borehole logs and the main characteristics of the soil types encountered are discussed briefly in the following sections.

**\*\*NOTE:** Refer to BH # 1 to # 4 (Appendix) for specific conditions at each borehole. Refer to Drawing No. 2 of the Contract Drawings for borehole locations and stratigraphical profiles.  
.../...

### 3.2 Cobbles, Gravel and Sand

The surficial soil deposit encountered in the boreholes is a 3 to 4.3 m thick (average 3 m) coarse granular deposit consisting of cobbles, gravel and coarse sand with the occasional boulder. Grain size analyses performed on particles smaller than 38 mm indicate 72 to 46% gravel, 51 to 26% sand, and 2 to 3% soil fines. The soil fines are non-plastic silt. Grading curves are shown on Figure 1. The cobble size particles range generally between 60 and 180 mm (average 125 mm). The frequency of the cobbles decreases with depth.

The standard penetration resistances in the deposit ranged between 3 and 68 blows per 0.3 m (average > 30), indicating a loose to very dense, but generally dense compactness condition. As some of the high penetration resistances ("N"-values) were undoubtedly affected by the gravel or larger particle sizes, the compactness condition of the deposit is probably less than that inferred from the standard penetration tests.

### 3.3 Fine Sand

Below the surficial cobble and gravel deposit is a thick bed of fine sand. Its thickness at the test locations is in

.../...

excess of 20 to 30 m.

Near its surface, the deposit consists mainly of fine to medium sand with some gravel (13 to 25%) and a trace of silt (1 to 3%). The results of the grain size analyses performed on two representative samples obtained from this zone are attached as Figure 2.

With depth the sand becomes finer textured and the silt content also increases. The results of the grain size analyses are presented graphically on Figure 3, showing 77 to 98% sand, and 2 to 23% silt.

In Borehole 4, interbedded with the sand at about Elevation 282 m, an approximately 1.0 m thick layer of silt was encountered. The particle size distribution of this material is shown on Figure 4 indicating 25% fine sand and 75% silt.

The standard penetration tests (SPT) performed in the sand gave "N" values ranging from 4 to 29 blows per 0.3 m, but typically between 10 and 15. These values indicate a loose to compact, but generally compact deposit. It is believed that some if not most of the SPT results were affected by the washboring operations and the inevitable disturbance of the soil by the drilling and sampling techniques used. For this

.../...

reason, we are of the opinion that the compactness condition of the sand is higher than that inferred from the SPT results.

### 3.4 Groundwater

It is expected that the position of the groundwater table in the shallow banks adjacent to the river is governed by the water level in the river. At the time of the investigation the river level was at Elevation 302.4 m, and the free standing water level in the boreholes was recorded between Elevations 302.3 and 302.4 m.

**NOTE:** The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Geo-Canada Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.



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

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

## A P P E N D I X

RECORD OF BOREHOLE No 1										METRIC						
W P 321 - 85 - 00		LOCATION Sta 13+377, O/S 6.3 m Rt. d Hwy 546, Line 'B'					ORIGINATED BY D.W.									
DIST 17 HWY 546		BOREHOLE TYPE Tri-Cone; Washboring - Nx Casing; & Cone Test					COMPILED BY D.W.									
DATUM Geodetic		DATE 1988 02 04 to 09					CHECKED BY I.P.L.									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80
303.9	Ground Surface															
0.0	COBBLES GRAVEL AND SAND occasional boulder brown compact to very dense		1	SS	100											
			2	SS	17											
			3	SS	56											
			4	SS	68											
299.6			5	SS	32											
4.3	FINE SAND trace gravel some silt greyish brown loose to compact		6	SS	8											
			7	SS	10											
			8	SS	10											
			9	SS	4											
			10	SS	18											
			11	SS	6											
			12	SS	13											
			13	SS	14											
289.6	END OF BOREHOLE															
14.3	SAND compact (inferred)															
282.3	END OF CONE TEST															
21.6																

OFFICE REPORT ON SOIL EXPLORATION

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





# RECORD OF BOREHOLE No 4

METRIC

W P 321 - 85 - 00 LOCATION Sta. 13+422; O/S 5.0 m Lt. & Hwy 546, Line 'B' ORIGINATED BY D.W.  
 DIST 17 HWY 546 BOREHOLE TYPE Tri-Cone & Cone Test COMPILED BY D.W.  
 DATUM Geodetic DATE 1988 02 10 to 14 CHECKED BY I.P.L.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
303.3	Ground Surface									
0.0	COBBLES GRAVEL AND SAND occasional boulder loose to very dense		1	SS	3					
			2	SS	56					
300.3			3	SS	30					
3.0	FINE SAND trace gravel some silt compact		4	SS	22					
			5	SS	16					
			6	SS	11					
			7	SS	10					
			8	SS	12					
			9	SS	15					
			10	SS	10					
			11	SS	15					
			12	SS	25					
			13	WS	-					
			14	SS	9					
			15	SS	15					
			16	WS	-					
	silt		17	SS	15					
			18	WS	-					
			19	SS	26					
			20	WS	-					
279.2			21	SS	29					
24.1	END OF BOREHOLE fine sand compact (inferred)									
274.3										
29.0	CONTINUED									

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4 (CONT.)

METRIC

W P 321 - 85 - 00 LOCATION Sta. 13+422; O/S 5.0 m Lt. & Hwy 546, Line 'B' ORIGINATED BY D.W.  
DIST 17 HWY 546 BOREHOLE TYPE Tri-Cone & Cone Test COMPILED BY D.W.  
DATUM Geodetic DATE 1988 02 10 to 14 CHECKED BY I.P.L.

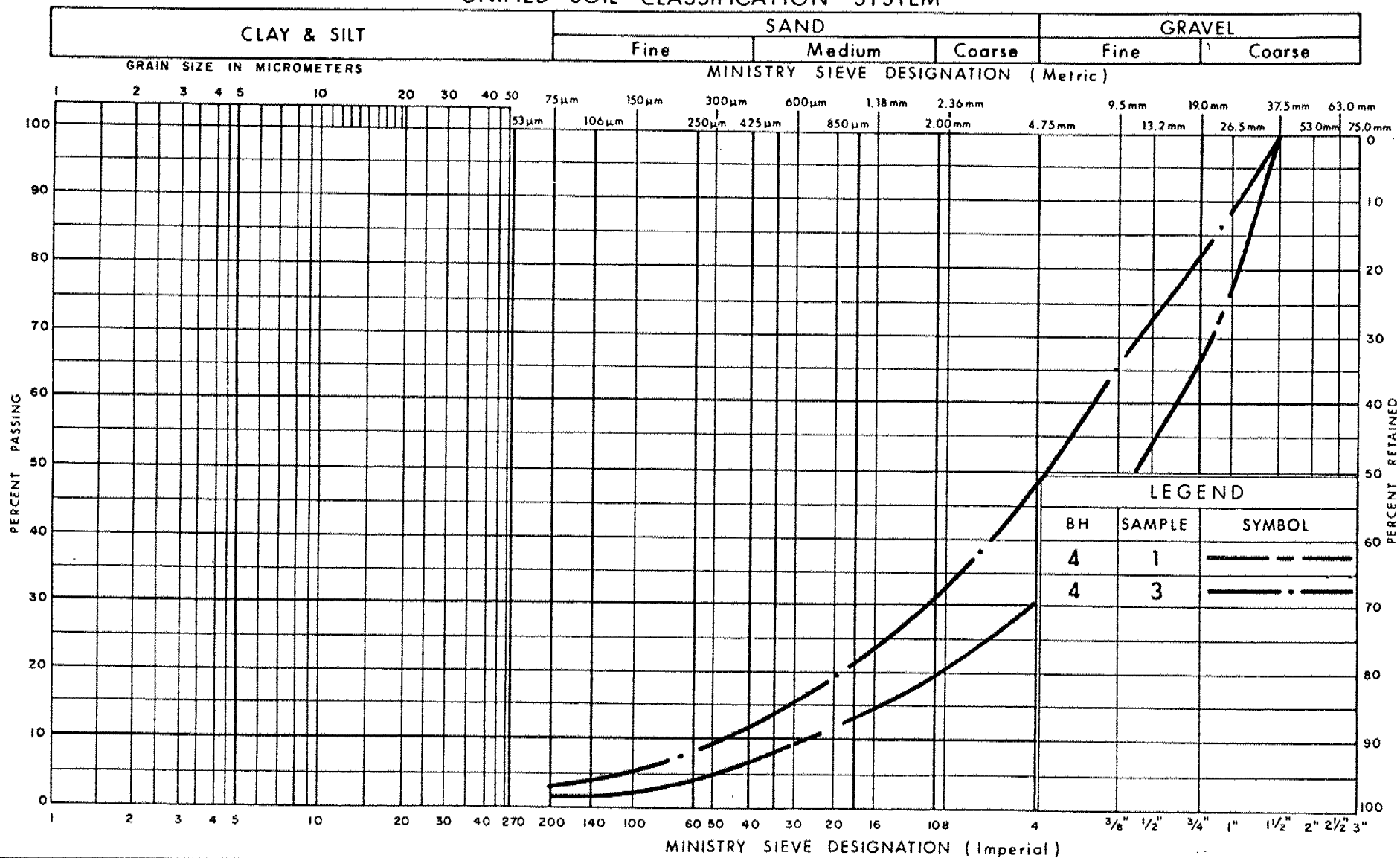
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
274.3	CONTINUATION												
29.0	FINE SAND compact to dense (inferred)						274						
							272						
							270						
269.1													
34.2	END OF CONE TEST												

OFFICE REPORT ON SOIL EXPLORATION

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

20  
15 5 (%) STRAIN AT FAILURE  
10

## UNIFIED SOIL CLASSIFICATION SYSTEM



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## GRAIN SIZE DISTRIBUTION

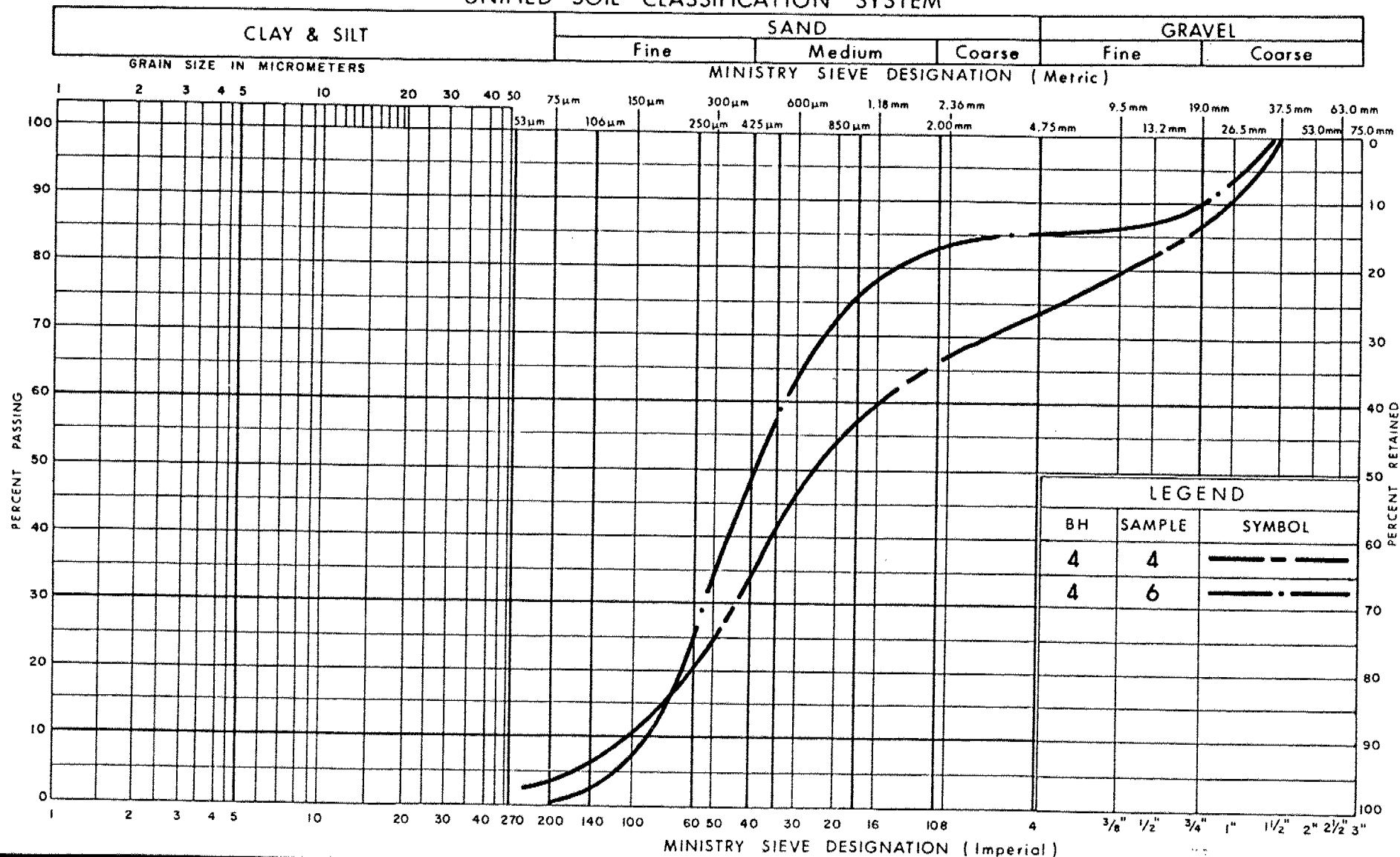
### SAND AND GRAVEL

FIG No 1

W P 321- 85-00

Febr. 1988

## UNIFIED SOIL CLASSIFICATION SYSTEM



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## GRAIN SIZE DISTRIBUTION

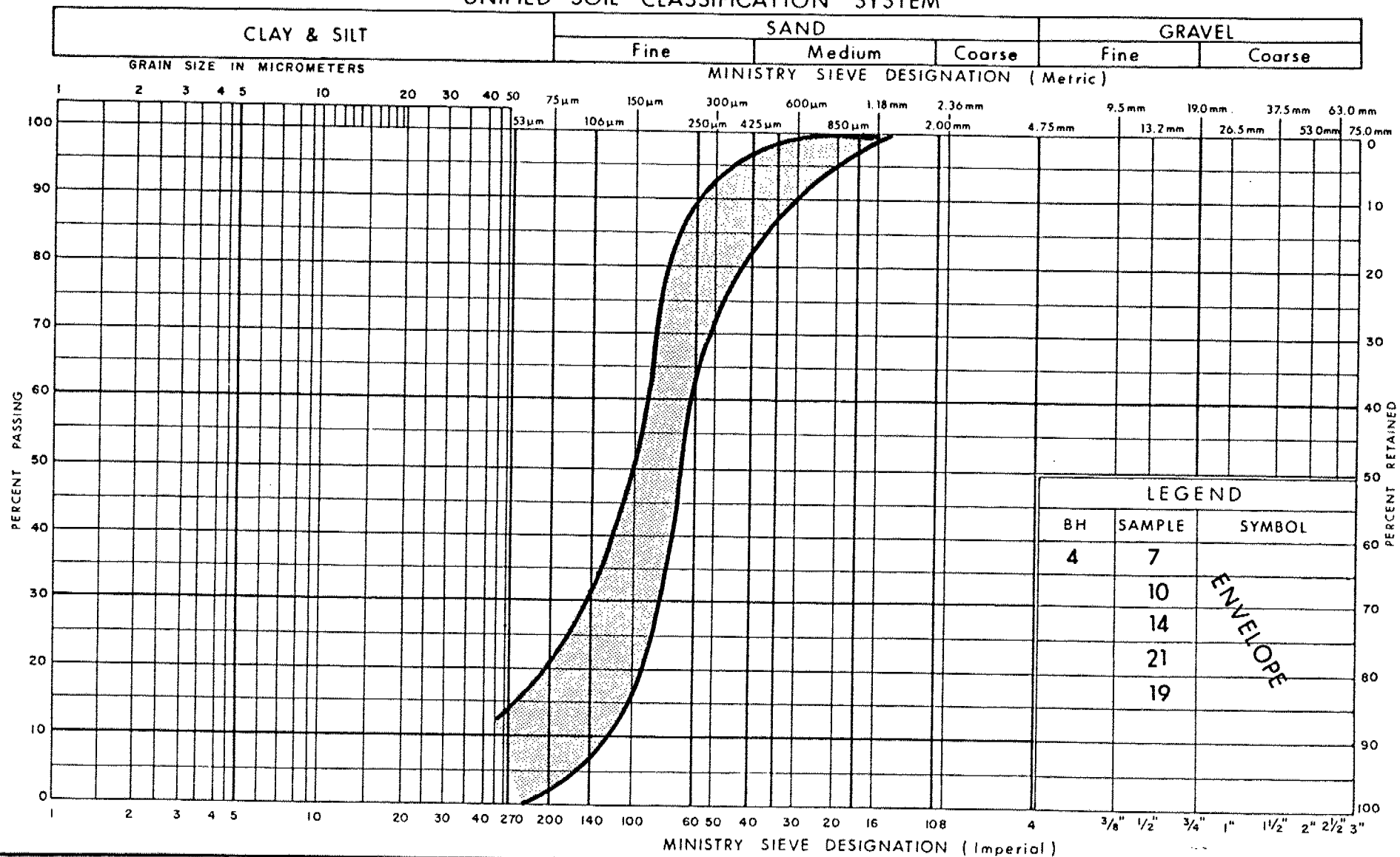
SAND  
fine to medium, some gravel

FIG No 2

W P 321-85-00

Febr. 1988

## UNIFIED SOIL CLASSIFICATION SYSTEM



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## GRAIN SIZE DISTRIBUTION

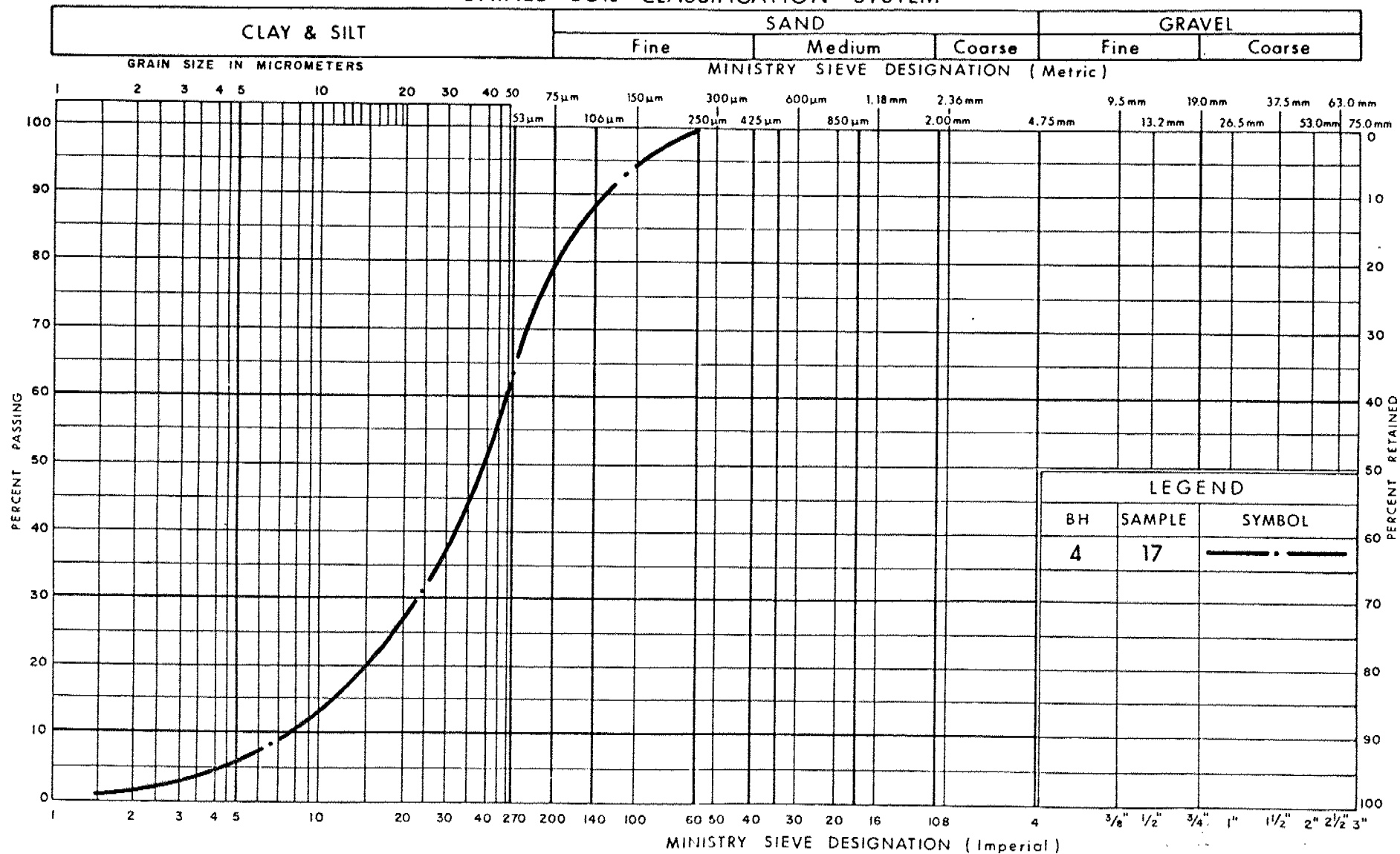
FINE SAND  
trace to some silt

FIG No. 3

W P 321-85-00

Febr. 1988

## UNIFIED SOIL CLASSIFICATION SYSTEM



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## GRAIN SIZE DISTRIBUTION

SILT  
Some fine sand

FIG No 4

W P 321-85-00

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20



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**FOUNDATION INVESTIGATION REPORT  
FOR  
LITTLE WHITE RIVER BRIDGE  
WP321-85-00, SITE 38-57  
HIGHWAY 546, DISTRICT 17, SUDBURY**

Ref. No. G-88.0105  
April 1988

Prepared for:

Ministry of Transportation  
Foundation Design Section  
Central Building  
Room 315  
1201 Wilson Avenue  
Downsview, Ontario  
M3N 1J8

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## A P P E N D I X

STATEMENT OF LIMITATION.....	Appendix "A"
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## E N C L O S U R E S

BOREHOLE LOCATIONS & SOIL STRATA....	Dwg. 3218500-A
BOREHOLE LOGS.....	Encl. 1-4A inclusive
GRAIN SIZE DISTRIBUTION CURVES.....	Fig. 1-4 inclusive

FOUNDATION INVESTIGATION REPORT  
FOR  
LITTLE WHITE RIVER BRIDGE  
WP321-85-00, SITE 38-57  
HIGHWAY 546, DISTRICT 17, SUDBURY

1.0 INTRODUCTION

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The investigation and study was undertaken by Geo-Canada Ltd. on behalf of the Ontario Ministry of Transportation under Consultants Agreement No. 4238-9087-186.

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The topography of the general area is very hilly to small mountainous with steep sided rock formations rising above numerous lakes and small streams and rivers. Several wide valleys wind through the area. In one of these valleys lies the aforementioned bridge site.

.../...

Locally, the river valley is approximately 300 m wide and runs generally in a north-east to south-west direction and the Little White River winds its way through this valley. At the bridge site, the river is approximately 25 m wide and 0.7 m deep at its centre at the time of our drilling. The current is fast and the river bed is lined with cobbles of diameters ranging from 60 to 180 mm (average 125 mm) in size.

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The vegetation in the area consists of coniferous (spruce) and deciduous (poplar) mature forests with some sumac and sage brush around the river and wet areas.

Approximately 80 m to the east of the proposed bridge location the existing alignment of Highway 546 crosses the river over a double Bailey bridge. This structure, approximately 30 m long and one lane wide, is supported on large timber cribs at each abutment. The cribs are rock

.../...

filled and appear to be free from the effects of scour and settlement.

The nearest rock outcrop is about 250 m to the east of the proposed bridge and is part of a steep sided ridge of rock running in a north-east to south-west direction. Two outcrops at this location, approximately 50 m apart, were examined by us. One of the outcrops was composed of metasedimentary rock, high in quartzite and was fairly intact and massive. It had nearly horizontal medium spaced bedding planes and two joints, one nearly vertical and the other about 60 degrees to the horizontal. The rock exposed in the other outcrop was more igneous in nature, also high in quartzite and feldspar, and was badly weathered and fractured. It had no apparent bedding plane and no regular joint pattern.

Geologically, the site is located on the Canadian Pre-Cambrian Shield. Geological maps indicate that the Little White River is near the boundary between the early Pre-Cambrian predominantly granitic rocks to the north and the Middle Pre-Cambrian metasedimentary rocks of the Huronian Super Group which comprise conglomerates, metamorphosed sandstones and siltstones to the south. There is a major east-west oriented fault line approximately 10 km south of

.../...

the site, and another north-south fault line about 15 km to the north. During Pleistocene times the area was covered by glaciers which left a mantle of overburden consisting of glacial drift.

### 3.0 SUMMARIZED SUBSURFACE CONDITIONS

#### 3.1 General

The general subsurface profile at the site consists of a 3 to 4 m thick surficial layer of cobbles, gravel and sand underlain by a deep, over 30 m thick deposit of fine sand. The surface of the Pre-Cambrian bedrock was not encountered at any of the test locations, i.e. within a depth of 34 m (Elevation 269 m) at the north-west quadrant of the site.

The groundwater table at the boreholes was encountered at shallow depths and its level (Elevations 302.3 to 302.4 m) coincided with the river level which at the time of the investigation was at Elevation 302.4 m.

The subsurface conditions are described in detail on the individual borehole logs and the main characteristics of the soil types encountered are discussed briefly in the following sections.

.../...

### 3.2 Cobbles, Gravel and Sand

The surficial soil deposit encountered in the boreholes is a 3 to 4.3 m thick (average 3 m) coarse granular deposit consisting of cobbles, gravel and coarse sand with the occasional boulder. Grain size analyses performed on particles smaller than 38 mm indicate 72 to 46% gravel, 51 to 26% sand, and 2 to 3% soil fines. The soil fines are non-plastic silt. Grading curves are shown on Figure 1. The cobble size particles range generally between 60 and 180 mm (average 125 mm). The frequency of the cobbles decreases with depth.

The standard penetration resistances in the deposit ranged between 3 and 68 blows per 0.3 m (average > 30), indicating a loose to very dense, but generally dense compactness condition. As some of the high penetration resistances ("N"-values) were undoubtedly affected by the gravel or larger particle sizes, the compactness condition of the deposit is probably less than that inferred from the standard penetration tests.

### 3.3 Fine Sand

Below the surficial cobble and gravel deposit is a thick bed of fine sand. Its thickness at the test locations is in

.../...

excess of 20 to 30 m.

Near its surface, the deposit consists mainly of fine to medium sand with some gravel (13 to 25%) and a trace of silt (1 to 3%). The results of the grain size analyses performed on two representative samples obtained from this zone are attached as Figure 2.

With depth the sand becomes finer textured and the silt content also increases. The results of the grain size analyses are presented graphically on Figure 3, showing 77 to 98% sand, and 2 to 23% silt.

In Borehole 4, interbedded with the sand at about Elevation 282 m, an approximately 1.0 m thick layer of silt was encountered. The particle size distribution of this material is shown on Figure 4 indicating 25% fine sand and 75% silt.

The standard penetration tests (SPT) performed in the sand gave "N" values ranging from 4 to 29 blows per 0.3 m, but typically between 10 and 15. These values indicate a loose to compact, but generally compact deposit. It is believed that some if not most of the SPT results were affected by the washboring operations and the inevitable disturbance of the soil by the drilling and sampling techniques used. For this

.../...

reason, we are of the opinion that the compactness condition of the sand is higher than that inferred from the SPT results.

#### 3.4 Groundwater

It is expected that the position of the groundwater table in the shallow banks adjacent to the river is governed by the water level in the river. At the time of the investigation the river level was at Elevation 302.4 m, and the free standing water level in the boreholes was recorded between Elevations 302.3 and 302.4 m.

#### 4.0 DISCUSSION AND RECOMMENDATIONS

##### 4.1 General

The proposed new crossing of Highway 546 over the Little White River is located about 80 m upstream (west) of an existing single span double Bailey bridge. The new bridge will be a 28 m long, 10 m wide single span structure. The proposed structural system consists of either concrete or steel girders with a concrete bridge deck resting on reinforced concrete abutments. The height of the approach embankment on the north and south sides will be approximately 3 to 4.5 m

In summary, the investigation established that the general soil profile consists of a 3 to 4 m thick generally dense layer of cobbles, gravel and sand with the occasional boulder. Underlying this is an over 30 m thick layer of compact sand, and the surface of the bedrock was not encountered to a depth of 34 m.

The inferred subsurface profiles are shown on Drawing 3218500-A.

#### 4.2 Foundations

For the support of the structure the following foundation options can be considered:

- a) spread footings on the compacted rock approach fills
- b) timber piles
- c) steel-H piles

These alternatives will be discussed separately below.

##### a) Spread Footings on Compacted Rock Fill

Consideration could be given to founding the abutments on spread footings resting on the rock fill approach embankments.

For spread footings founded on rock fill the factored bearing capacity at Ultimate Limit State (ULS) is 600 kPa, and at Servicibility Limit State Type II (SLS II) is 250 kPa. The structure should be designed to accommodate total and differential settlements of 50 mm and 25 mm respectively.

The footings should be provided with a minimum of 1.5 m thick earth cover for frost protection.

.../...

Resistance to sliding of the abutment footings can be calculated assuming an unfactored angle of friction ( $\phi$ ) of  $35^\circ$  between the underside of the concrete footing and the rock fill. The rock fill pad should extend laterally a minimum of 3.0 m beyond the edge of the footing all around its perimeter. From this point the rock fill could be sloped at an angle not steeper than 1.5 horizontal in 1.0 vertical as shown on Figure 4.2.a.

Before placing the rock fill, the existing material under the plan limits of the rock fill should be subexcavated to Elevation 302 m  $\pm$  (i.e. to the water level). The quality, the placing and the compaction of the rock fill material should conform to current MOT Standards and practice.

We suggest that upon reaching the proposed foundation level the surface of the rock fill in the plan area of the footing be covered with a thin (75 mm) layer of skim coat of lean concrete.

For the spread footing alternative the adequate protection of the embankment and river channel from scour is of utmost importance. The design of the scour protection measures should be based on hydrological requirements.

.../...

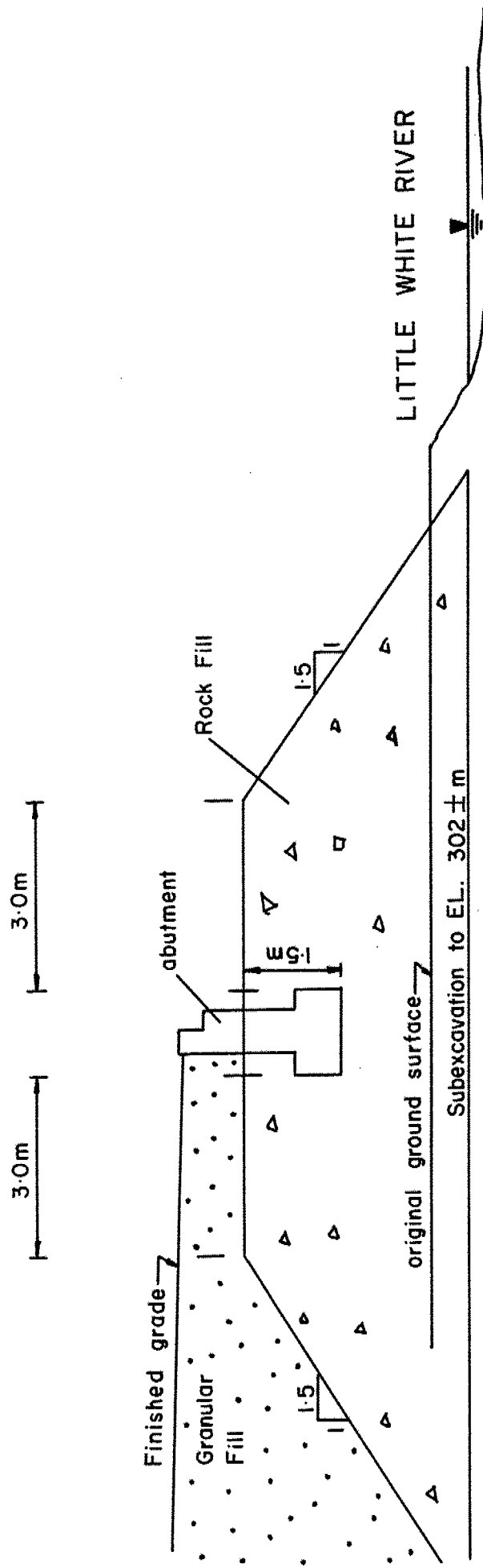


FIG. 4.2.a

## FOOTINGS ON ROCK FILL

b) Timber Piles

The capacity of Size 36 timber piles driven to a toe elevation of 290 m is estimated to be as follows:

at ULS - 375 kN

at SLS II - 250 kN

The timber should be pressure treated.

The timber piles, in our opinion, could not be driven through the upper cobble and gravel deposit without the risk of damage. This surficial layer should, therefore, be removed from within the area of the abutments and pile driving. Since the cobble layer is generally only 3 m thick and as the frequency of the cobbles decreases with depth, the depth of subexcavation should not be excessive. The excavation could be carried out under water with ordinary construction equipment. The removed material should be replaced, also under water, with sand and gravel fill in which the maximum particle size is limited to 50 mm. The excavated material, if screened to remove the large particles, could be reused.

.../...

Unbalanced lateral forces should be resisted by battered piles.

Pile driving should be controlled by Ministry of Transportation Standards SS103-10 assuming an ultimate capacity of 750 kN.

c) Steel-H Piles

It is estimated that HP310x79 steel pile sections, if driven to a toe elevation of 275 m, will be able to develop the following capacities:

at ULS - 650 kN

at SLS II - 400 kN

It is possible that higher capacities could be developed, however, these would have to be confirmed by a full scale load test in the field.

Unbalanced lateral forces should be resisted by battered piles.

.../...

Pile driving should be controlled by Ministry of Transportation Standards SS103-11 assuming an ultimate capacity of 1200 kN.

As the driving of the piles could temporarily set up high pore pressures in the fine grained granular deposits present near the pile toe elevation, the initial driving resistance may be lower. In view of this, it is recommended that the piles be retapped 24 hours after initial driving and that the set observed for the first few full blows of the hammer during redriving should be used to determine the capacity of the piles. The use of the Hiley formula is acceptable for the control of the pile driving, however, it would be prudent to carry out a full scale load test not only to confirm, but possibly also to increase the design capacity of the piles.

Although hard driving conditions are expected in the upper cobble and gravel deposit, we believe that it will be possible to drive the steel-H piles through this stratum. It is, however, suggested that at the outset of the project a short test pile be driven and, if considered necessary, the cobble layer be removed from the area of the pile driving similar to that discussed for the timber piles.

In case of perched abutments within the area of the pile driving, the maximum size of particles used for embankment construction should be limited to 75 mm. In anticipation of hard driving conditions, the tips of the piles should be reinforced in accordance with the current MOT standard.

#### 4.3 Lateral Earth Pressures

Backfill to structures should consist of granular material in accordance with Ministry of Transportation Standard Special Provision #121 (83 10).

Computation of earth pressures should be in accordance with Section 6-6.1.2.1 of the O.H.B.D.C. The active condition will govern earth pressure design for the yielding condition while the at-rest condition will govern earth pressure design for the unyielding condition. The following properties for backfill are recommended for design:

Material	$\varphi$	$\gamma$	$K_A$	$K_o$
Granular "A"	35°	22.8 kN/m <sup>3</sup>	0.27	0.43
Granular "B"	30°	21.2 kN/m <sup>3</sup>	0.33	0.50
Rock Fill	35°	18.1 kN/m <sup>3</sup>	0.27	0.43

#### 4.4 Approach Fills

We do not foresee stability problems for the proposed 3 to 4.5 m high approach embankments. The sides of the embankments, therefore, could be constructed with 2 horizontal in 1 vertical side slopes if granular earth fill material is used, or 1.5 horizontal in 1 vertical slopes if rock fill is used. In case of earth fill, the face of the embankment should be adequately protected against surface erosion and where the toe of the fill extends below the anticipated high water level the face of the embankment should also be protected with rip-rap against river scour.

We do not anticipate problems due to the long term settlement of the approach fills as this is estimated to be less than 50 mm.

#### 4.5 Conclusions

In summary, the investigation has established that the bridge site is underlain by a generally 3 m thick layer of cobbles, gravel and sand followed by a deep deposit of compact fine sand which is known to extend to a depth in excess of 34 m.

.../...

The use of spread footings on rock fill, or deep foundations consisting of timber or steel-H piles can be considered as possible foundation alternatives. The most cost efficient alternative should be adopted.

4.6 Miscellaneous

The field work for the investigation was carried out under the supervision of David C. Wismath, P.Eng., using drilling equipment from Canadian Longyear. The report was prepared by Ivan P. Lieszkowszky, P.Eng.

5.0 STATEMENT OF LIMITATION

The Statement of Limitation, as quoted in Appendix "A", is an integral part of this report.

GEO-CANADA LTD.

*Ivan P. Lieszkowszky*  
Ivan P. Lieszkowszky, P.Eng.



IPL:esp

A P P E N D I X

APPENDIX  
"A"  
Statement of Limitation

The conclusions and recommendations in this report are based on information determined at the borehole locations. Soil and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the soil investigation.

The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the boreholes. In cases where these recommendations are not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the design engineer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work.

ENCLOSURES

RECORD OF BOREHOLE No 1										METRIC			
W P 321 - 85 - 00		LOCATION Sta 13+377, O/S 6.3 m Rt. d. Hwy 546, Line 'B'					ORIGINATED BY D.W.						
DIST 17 HWY 546		BOREHOLE TYPE Tri-Cone; Washboring - Nx Casing; & Cone Test					COMPILED BY D.W.						
DATUM Geodetic		DATE 1988 02 04 to 09					CHECKED BY I.P.L.						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH					
303.9	Ground Surface												
0.0	COBBLES GRAVEL AND SAND occasional boulder brown compact to very dense		1	SS	100								Soil frozen to 0.9 m  ↑ Tri-Cone ↓ Wash-boring
			2	SS	17								
			3	SS	56								
			4	SS	68								
299.6			5	SS	32								
4.3	FINE SAND trace gravel some silt greyish brown loose to compact		6	SS	8								
			7	SS	10								
			8	SS	10								
			9	SS	4								
			10	SS	18								
			11	SS	6								
			12	SS	13								
289.6			13	SS	14								
14.3	END OF BOREHOLE												
	SAND compact (inferred)												
282.3													
21.6	END OF CONE TEST												

OFFICE REPORT ON SOIL EXPLORATION





# RECORD OF BOREHOLE No 4

METRIC

W P 321 - 85 - 00 LOCATION Sta. 13+422; O/S 5.0 m Lt. & Hwy 546, Line 'B' ORIGINATED BY D.W.  
DIST 17 HWY 546 BOREHOLE TYPE Tri-Cone & Cone Test COMPILED BY D.W.  
DATUM Geodetic DATE 1988 02 10 to 14 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES							
303.3	Ground Surface											
0.0	COBBLES GRAVEL AND SAND occasional boulder loose to very dense		1	SS	3	W.L. 302.4	302				72 26 2 -	
			2	SS	56							46 51 3 -
300.3			3	SS	30							25 72 3 -
3.0	FINE SAND trace gravel some silt compact		4	SS	22		300					
			5	SS	16							
			6	SS	11							
			7	SS	10							
			8	SS	12							
			9	SS	15							
			10	SS	10							
			11	SS	15							
			12	SS	25							
			13	WS	-							
			14	SS	9							
			15	SS	15							
			16	WS	-							
			17	SS	15							
			18	WS	-							
			19	SS	26							
			20	WS	-							
279.2					21	SS	29					
24.1	END OF BOREHOLE fine sand compact (inferred)						278					
274.1							276					
29.0	CONTINUED											

OFFICE REPORT ON SOIL EXPLORATION



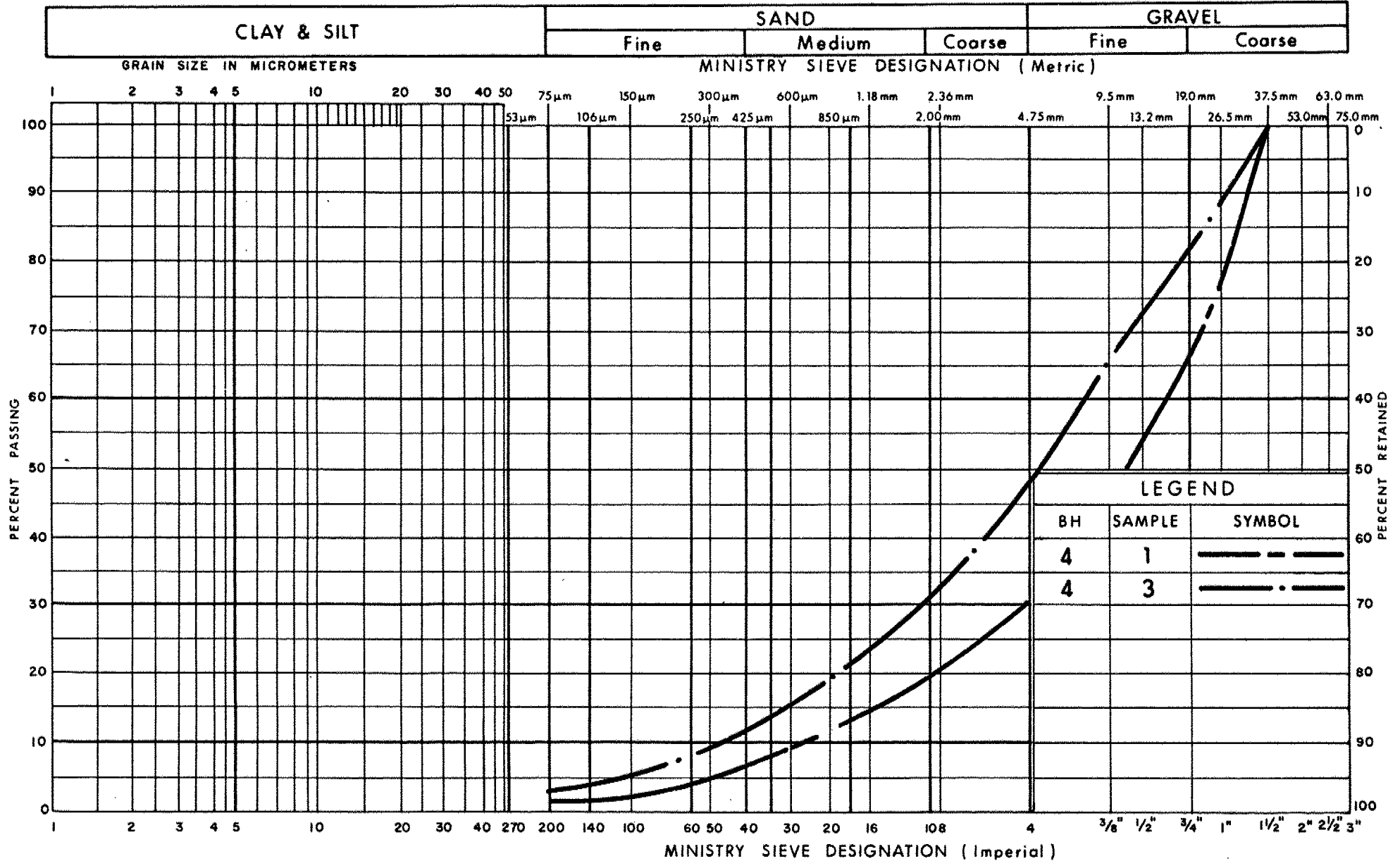
RECORD OF BOREHOLE No 4 (CONT.)

METRIC

W P 321 - 85 - 00 LOCATION Sta. 13+422; O/S 5.0 m Lt. & Hwy 546, Line 'B' ORIGINATED BY D.W.  
DIST 17 HWY 546 BOREHOLE TYPE Tri-Cone & Cone Test COMPILED BY D.W.  
DATUM Geodetic DATE 1988 02 10 to 14 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
274.3	CONTINUATION										
29.0	FINE SAND compact to dense (inferred)						274				
							272				
							270				
269.1											
34.2	END OF CONE TEST										

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

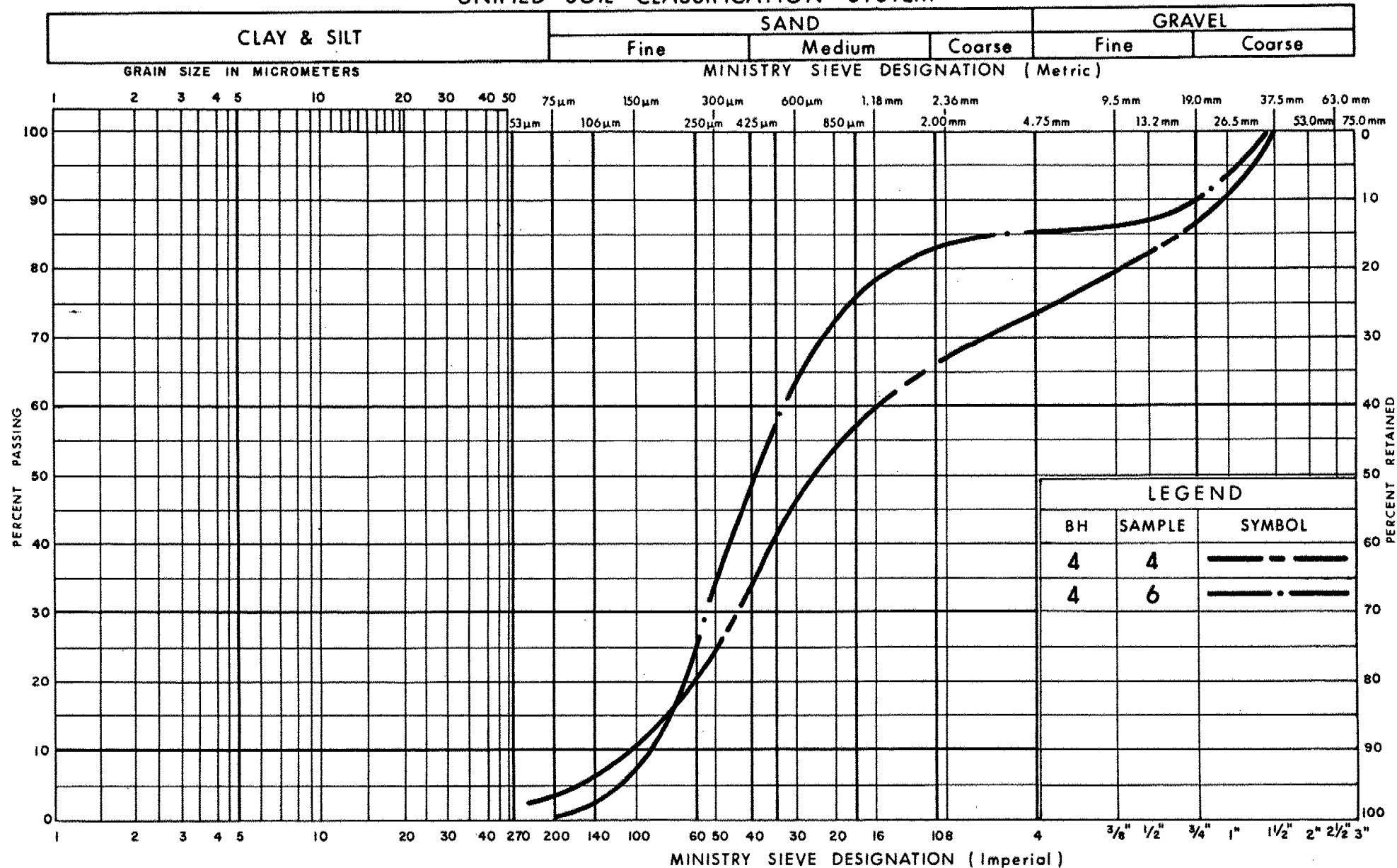
## GRAIN SIZE DISTRIBUTION SAND AND GRAVEL

FIG No 1

W P 321-85-00

Febr. 1988

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

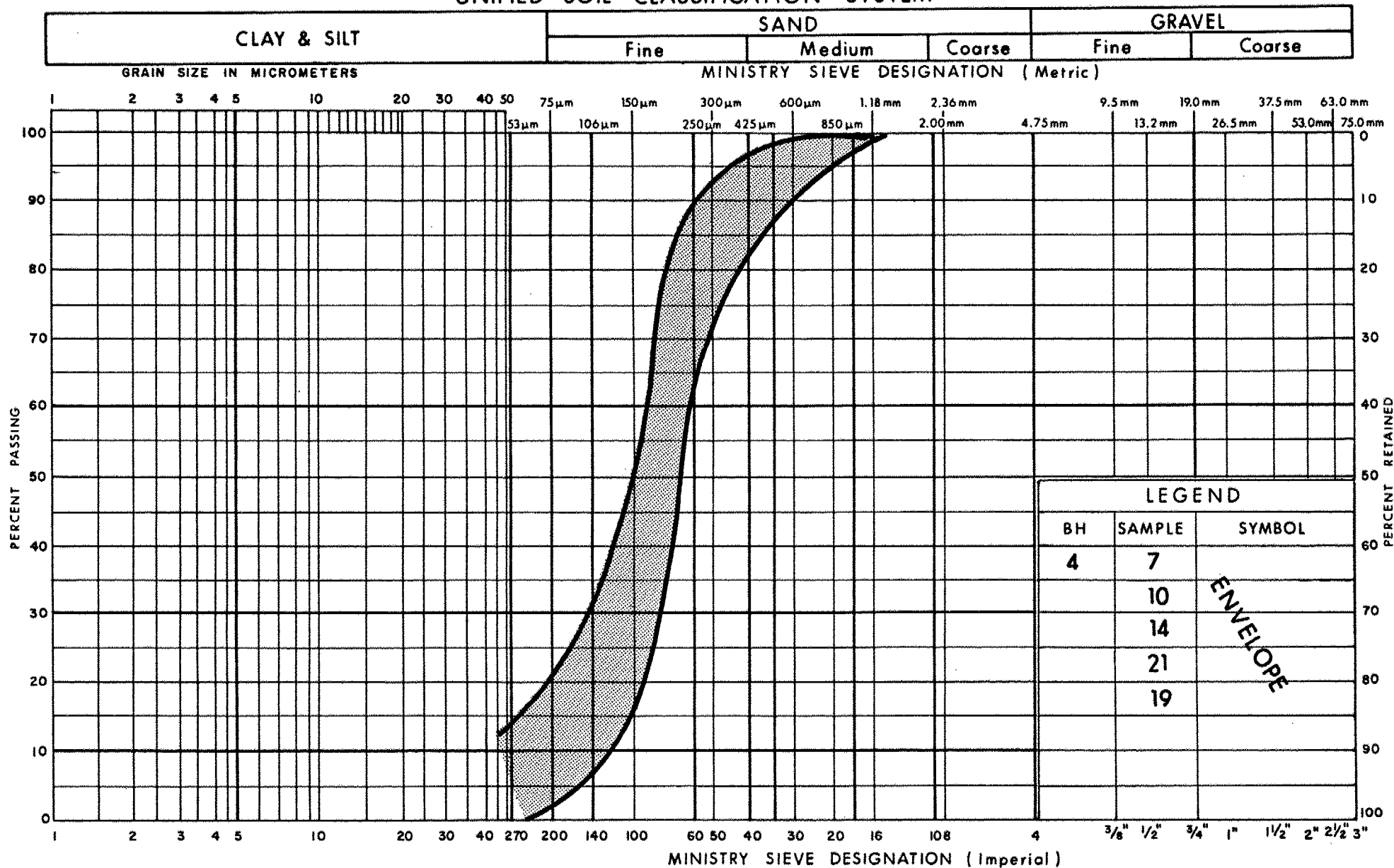
GRAIN SIZE DISTRIBUTION  
SAND  
fine to medium, some gravel

FIG No 2

W P 321-85-00

Febr. 1988

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of  
Transportation

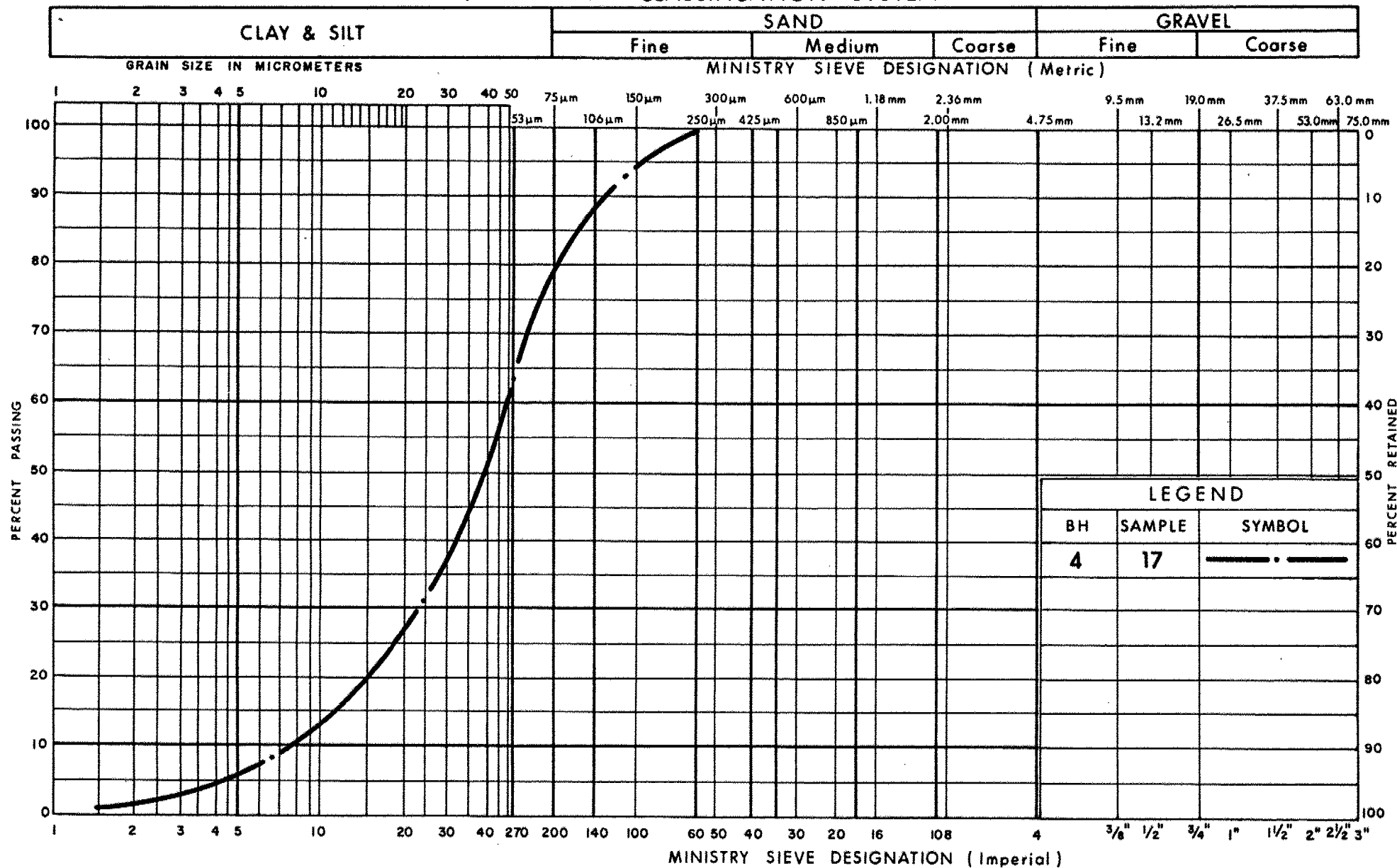
**GRAIN SIZE DISTRIBUTION**  
**FINE SAND**  
 trace to some silt

FIG No 3

W P 321-85-00

Febr. 1988

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

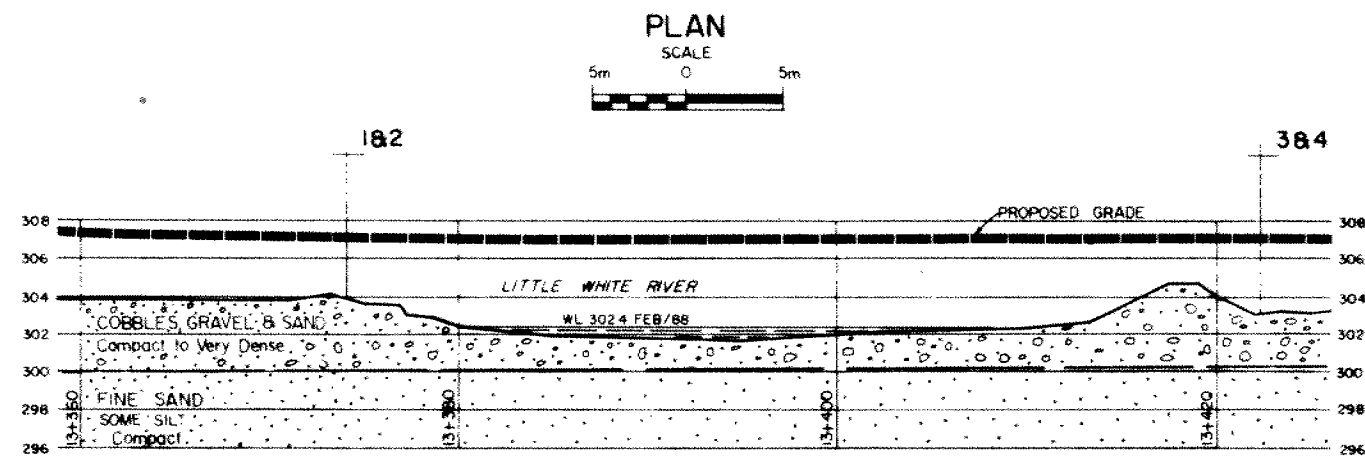
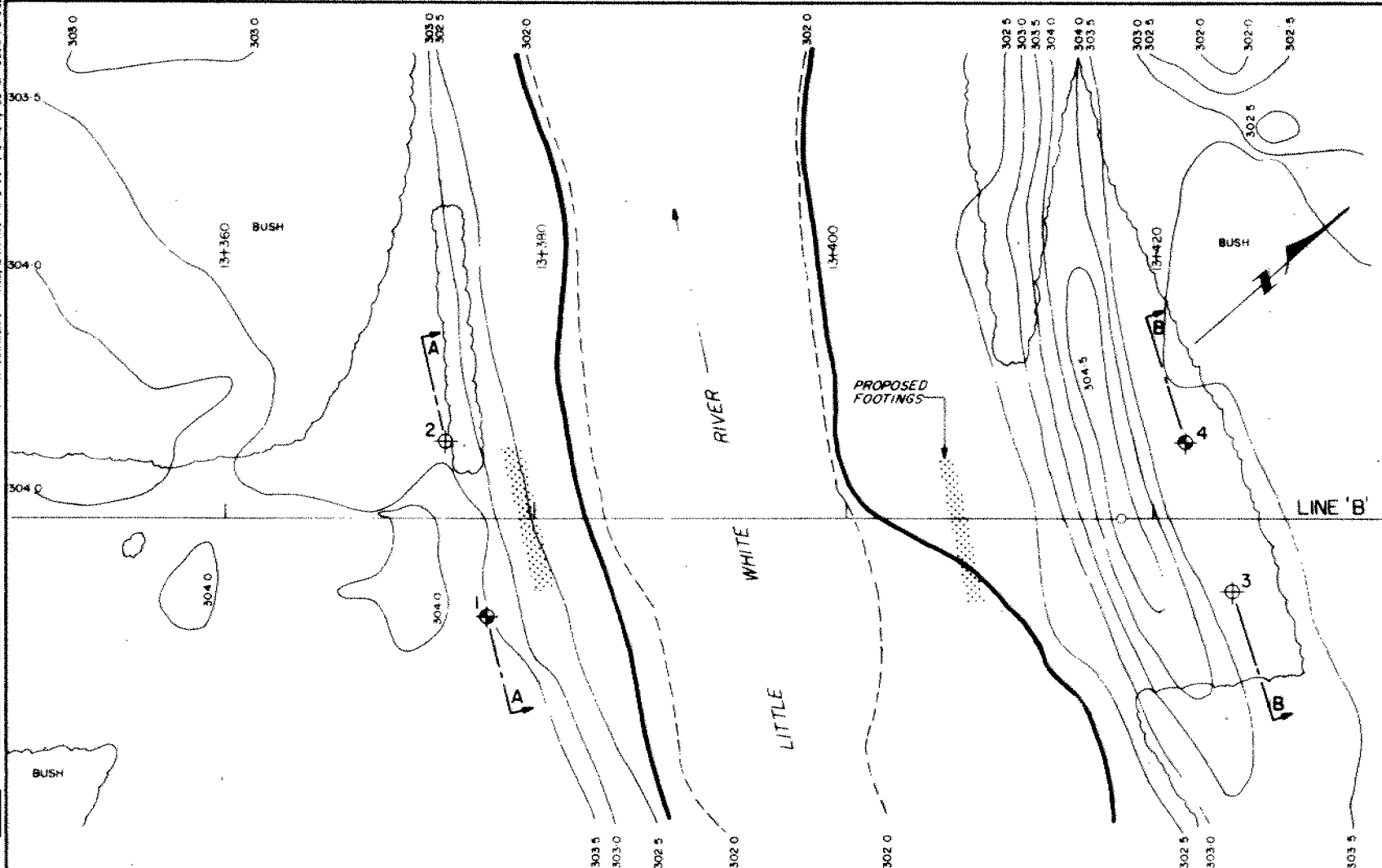
## GRAIN SIZE DISTRIBUTION

SILT  
Some fine sand

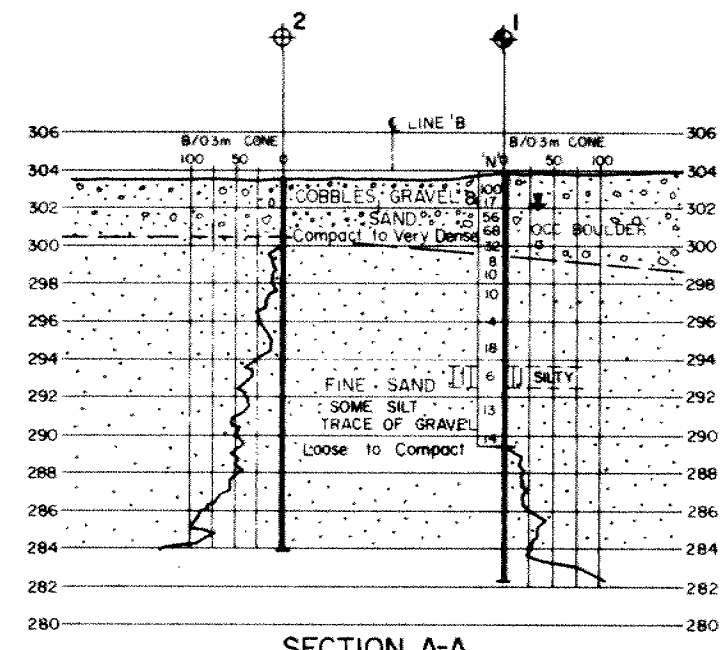
FIG No 4

W P 321-85-00

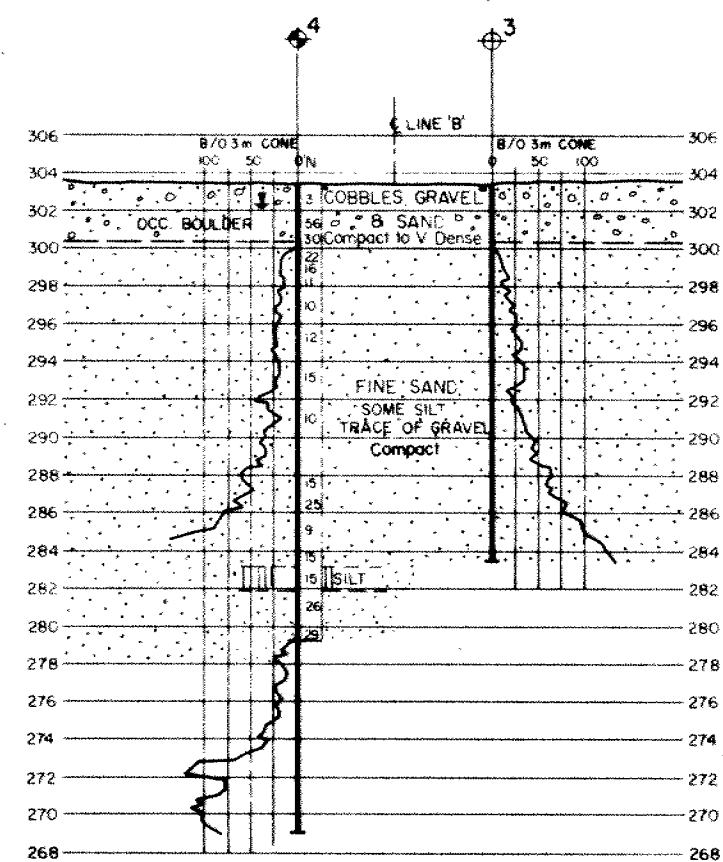
Febr. 1988



PROFILE LINE 'B'



SECTION A-A



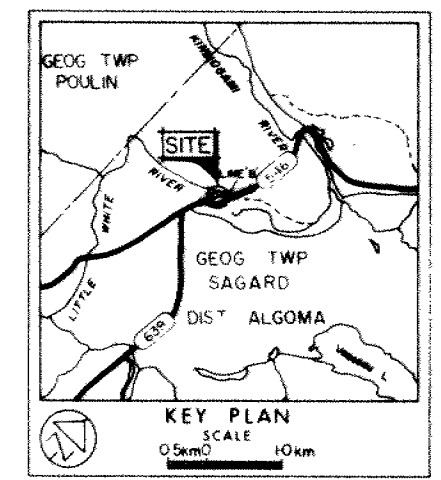
SECTION B-B

CONT No  
WP No 321-85-00

LITTLE WHITE RIVER BRIDGE  
BORE HOLE LOCATIONS & SOIL STRATA



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LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation Feb 1988

No	ELEVATION	STATION	OFFSET
1	303.9	13+377.0	6.3m Rt
2	303.5	13+374.5	5.0m Lt
3	303.3	13+425.0	4.7m Rt
4	303.3	13+422.0	5.0m Lt

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 41J-48

HWY No 54E	DIST 17
SUBM'D D.W. CHECKED L.R. DATE Feb 1988	SITE 38-57
DRAWN H.A. CHECKED APPROVED	DWG 3218500-A

METRIC

ST. 17

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
WP No 321-85-01

LITTLE WHITE RIVER BRIDGE

SHEET

GENERAL ARRANGEMENT

NOTE

EXISTING BAILEY BRIDGE  
LOCATED APPROXIMATELY  
80 m UPSTREAM.

LIST OF DRAWINGS

- 38-57-1 GENERAL ARRANGEMENT
- 2 BORE HOLE LOCATIONS & SOIL STRATA
- 3 FOOTING LAYOUT & DETAILS
- 4 ABUTMENTS
- 5 STRUCTURAL STEEL
- 6 SPICE DETAILS & BEARINGS
- 7 DECK LAYOUT & DETAILS
- 8 BARRIER WALL
- 9 JOINT ANCHORAGE AND ARMOURING
- 10 6000 mm APPROACH SLAB
- 11 BRIDGE DATE & SITE NUMBER DATA
- 12 PILE DRIVING- STEAM & DIESEL HAMMERS
- 13 AS CONSTRUCTED ELEV. & DIM.
- 14 STANDARD DETAILS
- 15 QUANTITIES - STRUCTURE - I
- 16 QUANTITIES - STRUCTURE - II

NOTES:

REINFORCING STEEL

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

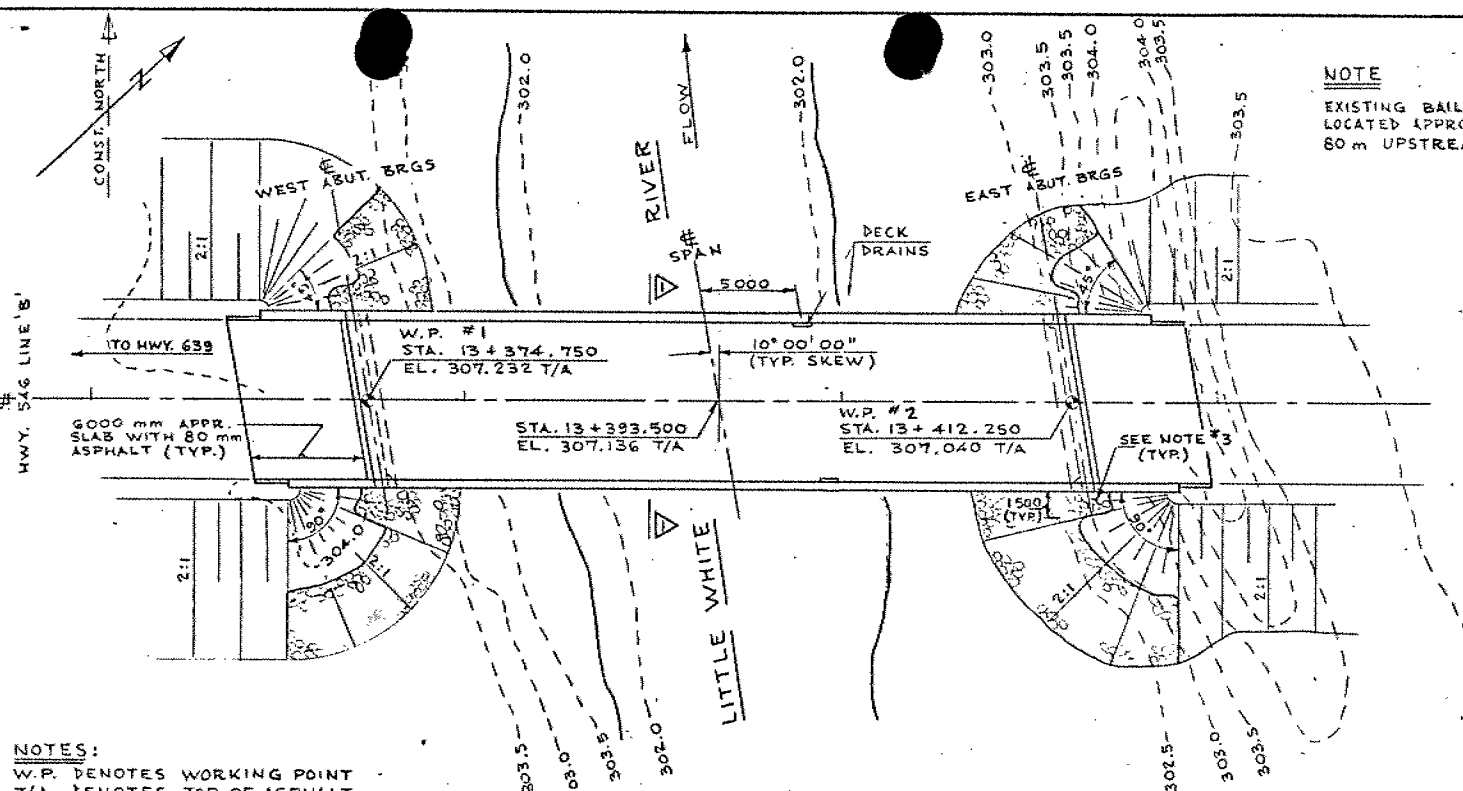
CLASS OF CONCRETE

FOOTINGS 30 MPa  
REMAINDER 20 MPa

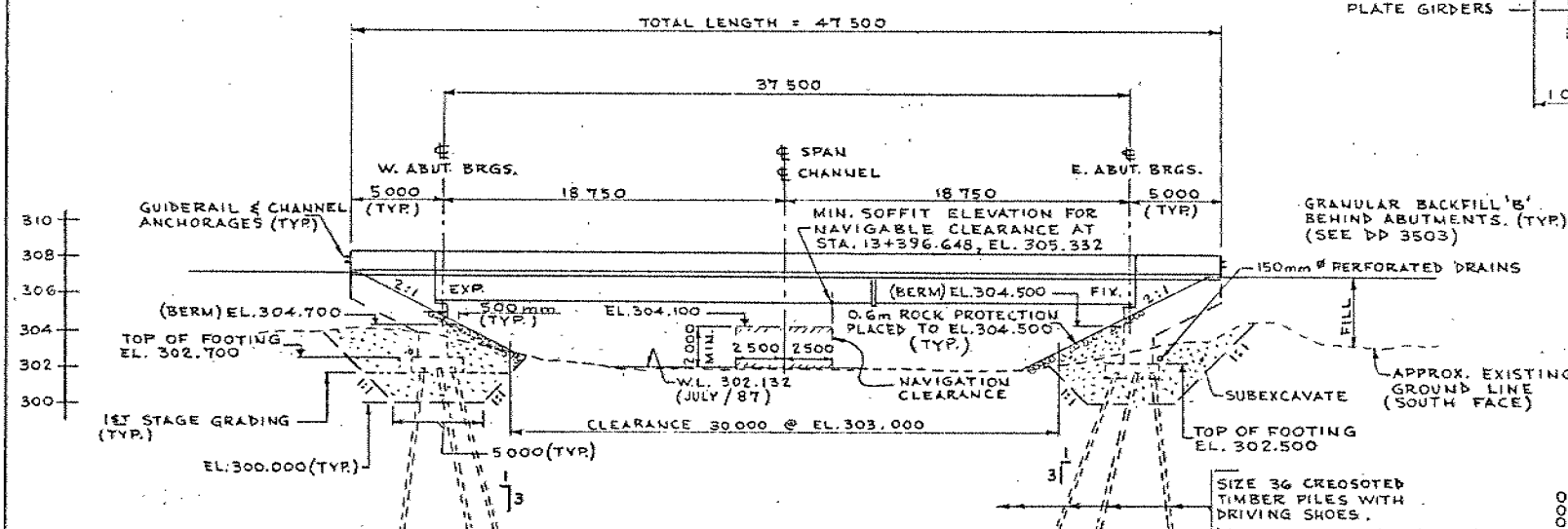
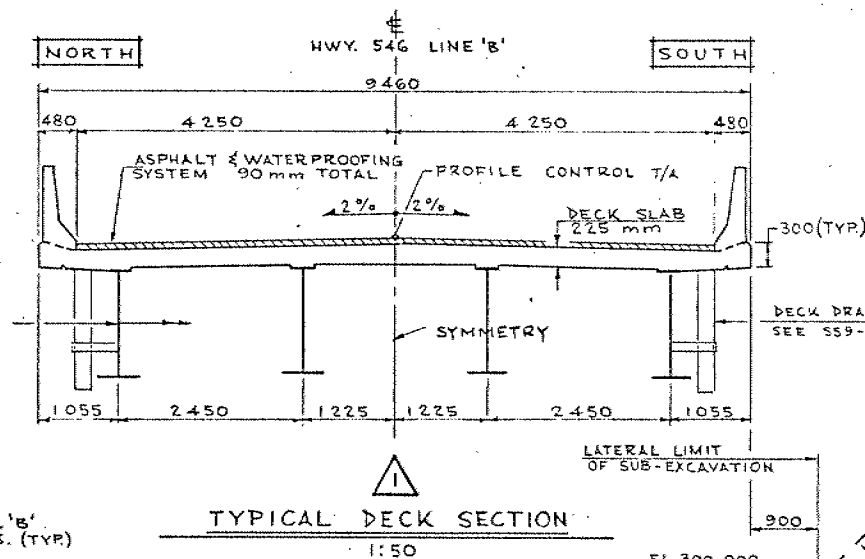
CLEAR COVER TO REINFORCING STEEL

FOOTINGS 100 ± 25 mm  
ABUTMENTS & WINGWALLS  
FRONT FACE 80 ± 20 mm  
BACK FACE 70 ± 20 mm  
DECK TOP 70 ± 20 mm  
BOTTOM 40 ± 10 mm  
BARRIER WALLS 70 ± 20 mm  
APPROACH SLABS 80 ± 20 mm

UNLESS OTHERWISE NOTED ON DRAWINGS.



NOTES:  
W.P. DENOTES WORKING POINT  
T/A DENOTES TOP OF ASPHALT.  
BM DENOTES BENCH MARK



- NOTES
- #1 TO FACILITATE PILE DRIVING SUBEXCAVATE TO EL. 300.000 AND BACKFILL WITH SAND AND GRAVEL. (MAX. PARTICLE SIZE 50mm DIA.) (SEE GRADING DRAWINGS)
  - #2 FOR LATERAL TRANSVERSE LIMIT OF SUB-EXCAVATION SEE SECTION A-A
  - #3 PROVIDE ROCK PROTECTION TO EL. 305.400 AND FOR A HORIZONTAL DISTANCE OF 1.5 m FROM EXPANSION JOINT DOWNSPOUT DRAINS. (SEE DWG. 14)

BM 304.154  
RAILWAY SPIKE IN FACE 0.3 SPRUCE  
36.2 LT. 13+344.0

PROFILE AT HWY. 546 LINE 'B'  
N.T.S.

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

APPLICABLE STANDARD DRAWINGS

- OPS 508.02 (BRIDGE DECK WATERPROOFING)
- DD-3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS





DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40P2-48

DIST. 2 REGION                     

W.P. No. 511-90-01

CONT. No. 92-18

W. O. No.                     

STR. SITE No. 23-443

HWY. No. 401

LOCATION  Hwy 401 / W-N/S Ramp &   
 Cedar Creek

No. of PAGES -                     

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 511-90-01 DIST 2  
HWY 401 STR SITE 23-443  
Cedar Creek W-N/S Ramp Bridge

*CONT 92-18*

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## FOUNDATION INVESTIGATION REPORT

For

Cedar Creek W-N/S Ramp Bridge  
W.P. 511-90-01, Site No. 23-443  
Hwy. 401, District 2, London

### INTRODUCTION

This report contains the results of a site investigation carried out at the above mentioned site to provide information for the design and construction of the proposed bridge at the Cedar Creek crossing.

The field work for this project was carried out between 91 03 26 and 91 04 03, and comprised of two sampled boreholes and Dynamic Cone Penetration Test adjacent to these holes.

Boreholes were advanced to a maximum depth of 17.9 m below the existing ground level (El. 266.7 m) using a continuous flight hollow stem auger and BW casing. Rock cores were obtained in both boreholes using BXL size core barrel.

### SITE DESCRIPTION

The site under investigation is located about 120 m south of the existing bridge at the crossing of Hwy. 401 and Cedar Creek in the City of Woodstock.

The topography of the site with the exception of the existing crossing (embankment) and the flood plain of the Creek is generally undulating with drumlins to the south. The site as well as the alignment of the Creek was modified to the present condition by the construction of the existing bridge and prior to the construction of this bridge, the Creek was meandering at this location. Physiographically the area is located in the region known as the "Oxford Till Plain".

## SUBSURFACE CONDITIONS

The underlying subsoil at this site consists of loose to compact alluvial sand with varying proportions of gravel underlain by stiff to very stiff clayey silt with occasional sand and silt seams. The clayey silt layer is underlain by dense to very dense gravelly sand which overlies the limestone bedrock. For classification purposes, the soils encountered at this site can be divided into six different zones.

- a) Surficial Deposits
- b) Gravelly Sand, trace of Silt
- c) Sand, trace of Silt
- d) Clayey Silt
- e) Gravelly Sand, some Silt
- f) Limestone Bedrock

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole sheets contained in the Appendix of this report. A stratigraphical profile is shown on Drawing No. 5119001-A. This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

Initially, it was planned to widen the bridge at the crossing of Hwy. 401 and Cedar Creek, and to provide information for the design of foundation, a site investigation was carried out in April of 1990. The Record of Borehole sheets of this investigation are also appended to this report.

### Surficial Deposits

This surficial sandy silt to organic silt deposit was encountered immediately below the existing ground level. The west side of the creek is slightly marshy and the organic content was observed to be more on this side. The thickness of this deposit varies from 0.9 m to 1.1 m and extends to elevation 283.9 m to 283.7 m.

Gravelly Sand, trace of Silt

This alluvial gravelly sand layer was encountered immediately below the surficial deposit. The thickness of this layer is about 2.7 m and extends to elevation 281.2 m to 281.0 m. The results of the Gradation Test carried out on representative soil samples are shown on Figure 1 in an envelope form. These test results indicate 40% to 47% gravel, 45% to 52% sand and 8% silt. The Standard Penetration Test results were observed to vary between 16 blows/0.3 m and 27 blows/0.3 m and these results indicate that this stratum is in a compact state of compaction.

Sand, trace of Silt

The gravelly sand deposit is underlain by this stratum. The thickness of this layer varies from 1.3 m to 1.6 m and extends to elevation 279.6 m. The result of Gradation Test carried out on a representative soil sample is shown on Figure 2 and this result indicates sand content in the order of 92%. The Standard Penetration Test results were observed to vary between 7 blows/0.3 m and 21 blows/0.3 m. These test results indicate loose to compact state of compaction.

Clayey Silt

The sandy deposit is underlain by this clayey stratum. The thickness of this layer varies from 5.1 m to 5.6 m and extends to elevation 274.5 m to 274.1 m. Occasional sand and silt seams varying in thickness from a few millimetres to a maximum of 1.0 m were also intercepted in this stratum. The natural moisture content was observed to vary from 16.5% to 24% with an average value of 20.5%. The Atterberg Limits determined for the representative soil samples of this deposit are shown on Figure 3. The Standard Penetration Test results were observed to vary from 6 blows/0.3 m to 12 blows/0.3 m. However, the in situ Vane Shear Test results were observed to vary from 58 kPa to over 100 kPa. The shear strength values indicate stiff to very stiff consistency.

### Gravelly Sand, some Silt

The clayey silt is underlain by this deposit. The thickness of this deposit varies from 4.0 m to 4.2 m and extends to elevation 270.3 m to 270.1 m. The Grain Size Distribution Test results are shown on Figure 4 in an envelope form. These results indicate about 37% gravel, 42% to 43% sand and 20% to 21% silt. The Standard Penetration Test results indicate that this stratum is in dense to very dense state of compaction (N-values 40 blows/0.3 m to over 100 blows/0.3 m).

### Bedrock

The project area is underlain by limestone bedrock of the Detroit River Group. The thickness of the weathered rock was observed in the range of 100 mm to 300 mm and the elevation of the unweathered rock is expected to be in the depth range of elevation 270.2 m to 269.8 m.

The RQD values measured from BX size cores (0% to 22%) indicate that the bedrock up to the depth of coring may be classified as very poor quality rock.

The detail description of the bedrock is included in the Appendix of this report.

### Groundwater Conditions

The groundwater level was observed at or near the creek water level (elevation 284.7 m to 284.1 m). However, artesian condition was encountered at about elevation 269.2 m to 269.4 m in the fractured zone of the bedrock and the water level rose to about 0.4 m to 0.5 m above the existing ground level (ie elevation 285.0 m to 285.5 m). Seasonal fluctuation of the groundwater level may be expected. The groundwater level at each borehole location is as follows:

<u>Borehole No.</u>	<u>Elevation</u>	<u>Remarks</u>
201	284.1 m	Water level rose to 0.4 m above ground level (i.e. elevation 285.0 m)
202	284.7 m	Water level rose to 0.5 m above ground level (i.e. elevation 285.5 m)

## DISCUSSION AND RECOMMENDATIONS

### General

It is proposed to accommodate one future lane on either side of Hwy. 401 without widening the bridge at the crossing of Cedar Creek. As a part of this plan, the existing W-N/S Ramp will be relocated and this will involve construction of a new bridge at the crossing of Cedar Creek and the new ramp.

The proposed bridge will be a single span reinforced concrete integral abutment structure. The clear span between the face of the abutment will be about 25.4 m. The profile grade of the ramp is set at about elevation 289.5± m. The new structure will be located approximately 120 m south of the existing bridge at the crossing of Hwy. 401 and Cedar Creek.

### Structure Foundations

Considering the subsoil conditions at this site and high water level, it is recommended that the abutments and wing walls be supported on steel H-piles driven to bedrock which will be encountered around elevation 270.0 m.

The maximum allowable load for the steel H-pile section selected may be used for the design purposes. For the purposes of the O.H.B.D.C., the following values are recommended:

	<u>HP310x110</u>	<u>HP310x79</u>
Factored Bearing Capacity at U.L.S.	1600 kN	1150 kN
Bearing Capacity at S.L.S. Type II	1150 kN	900 kN

Earth pressure should be computed as per Section 6.1.2.2 of the O.H.B.D.C., and an unyielding foundation condition may be assumed for the computations. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	Granular <u>'A'</u>	Granular <u>'B'</u>
Angle of Internal Friction	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight (kN/m <sup>3</sup> )	$\gamma = 22.8$	$\gamma = 21.2$

The pile caps should have a minimum of 1.2 m earth cover to protect against the frost penetration.

#### Approach Embankment

The proposed finished grade of the W-N/S Ramp is set at about elevation 289.5± m and the maximum height of approach fill above the existing ground level will be about 5.0 m. If the fill height is limited to 5.0 m, no major stability problems are anticipated for the approach embankments constructed with 2H:1V side slopes. The fill material should consist of well compacted acceptable material. The topsoil as well as any spongy or soft area observed within the base width of the embankment should be removed. In addition, the organic silt and other soft materials on the west side of the creek should be subexcavated up to a depth of about 0.9 m below the existing ground level before the placement of fill.

#### Other Considerations

The pile tips should be reinforced with pile driving shoe as per MTO Standard. The pile caps for the closed-end abutments at this site will have to be constructed below the creek water level which may be expected to fluctuate. Considering the presence of gravelly sand to sandy material up to the anticipated depth of excavation, a gravity drainage system may be used for dewatering during construction.

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Mr. M. Vasavithasan, Foundation Engineer. The equipment used was owned and operated by London Soil Test Ltd. This report was prepared by Mr. M. Vasavithasan, reviewed by Mr. P. Payer, Senior Foundation Engineer, approved by Mr. M. Devata, Chief Foundation Engineer.



*M. Vasavithasan*

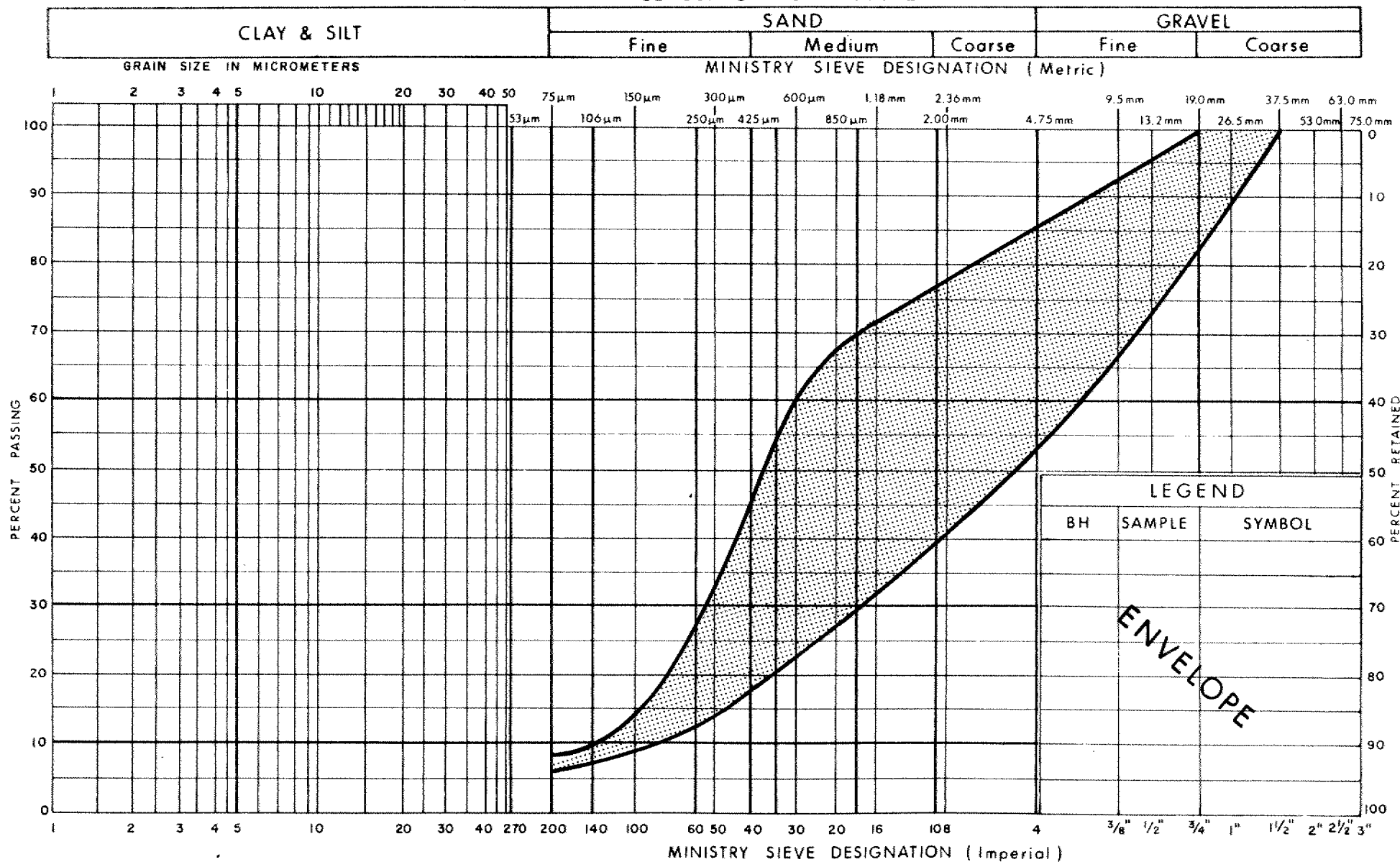
M. Vasavithasan, P.Eng.  
Foundation Engineer

*M. Devata*

M. Devata, P.Eng.  
Chief Foundation Engineer

## APPENDIX

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
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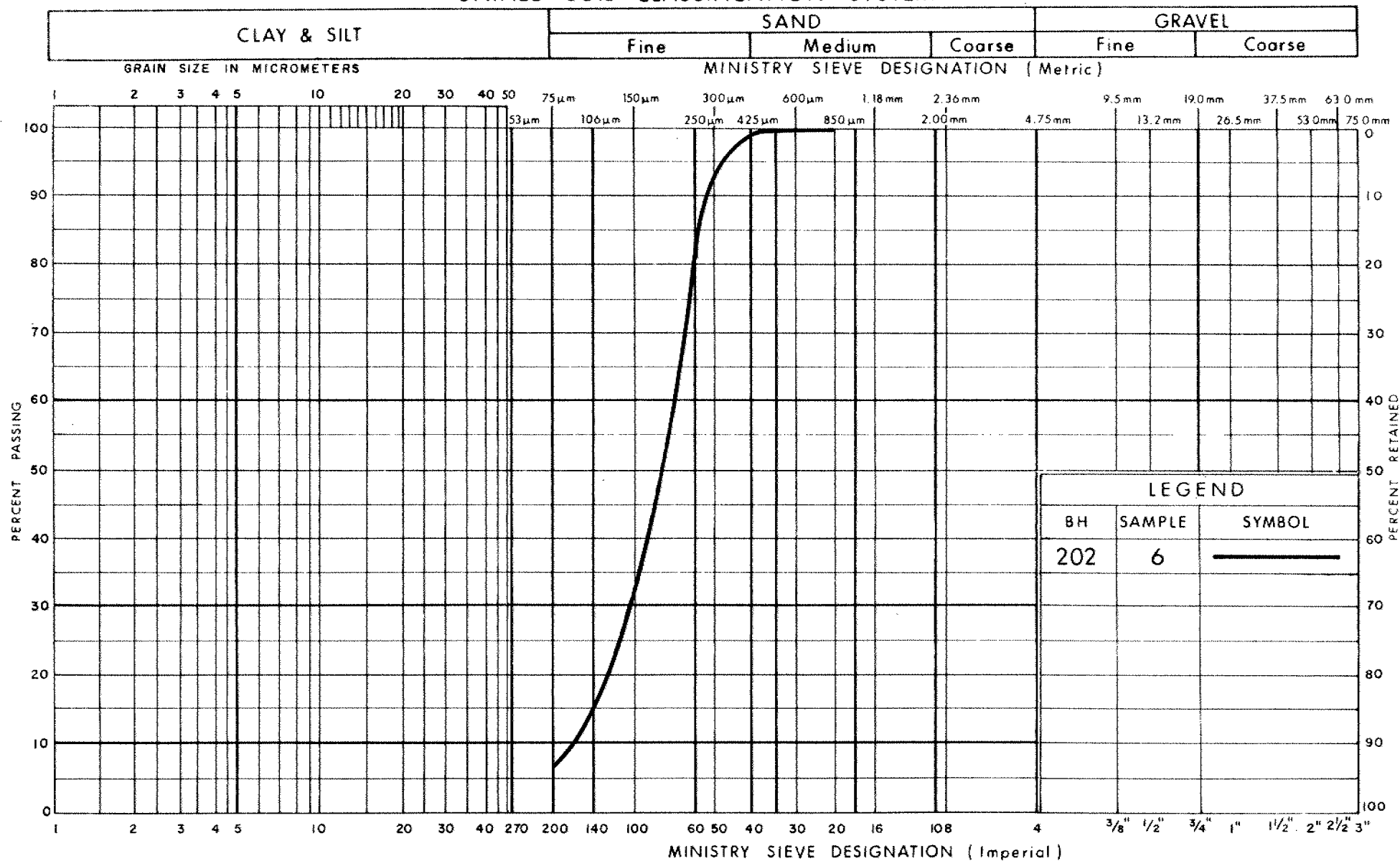
## GRAIN SIZE DISTRIBUTION

### GRAVELLY SAND, TRACE OF SILT

FIG No 1

W P 511-90-01

## UNIFIED SOIL CLASSIFICATION SYSTEM

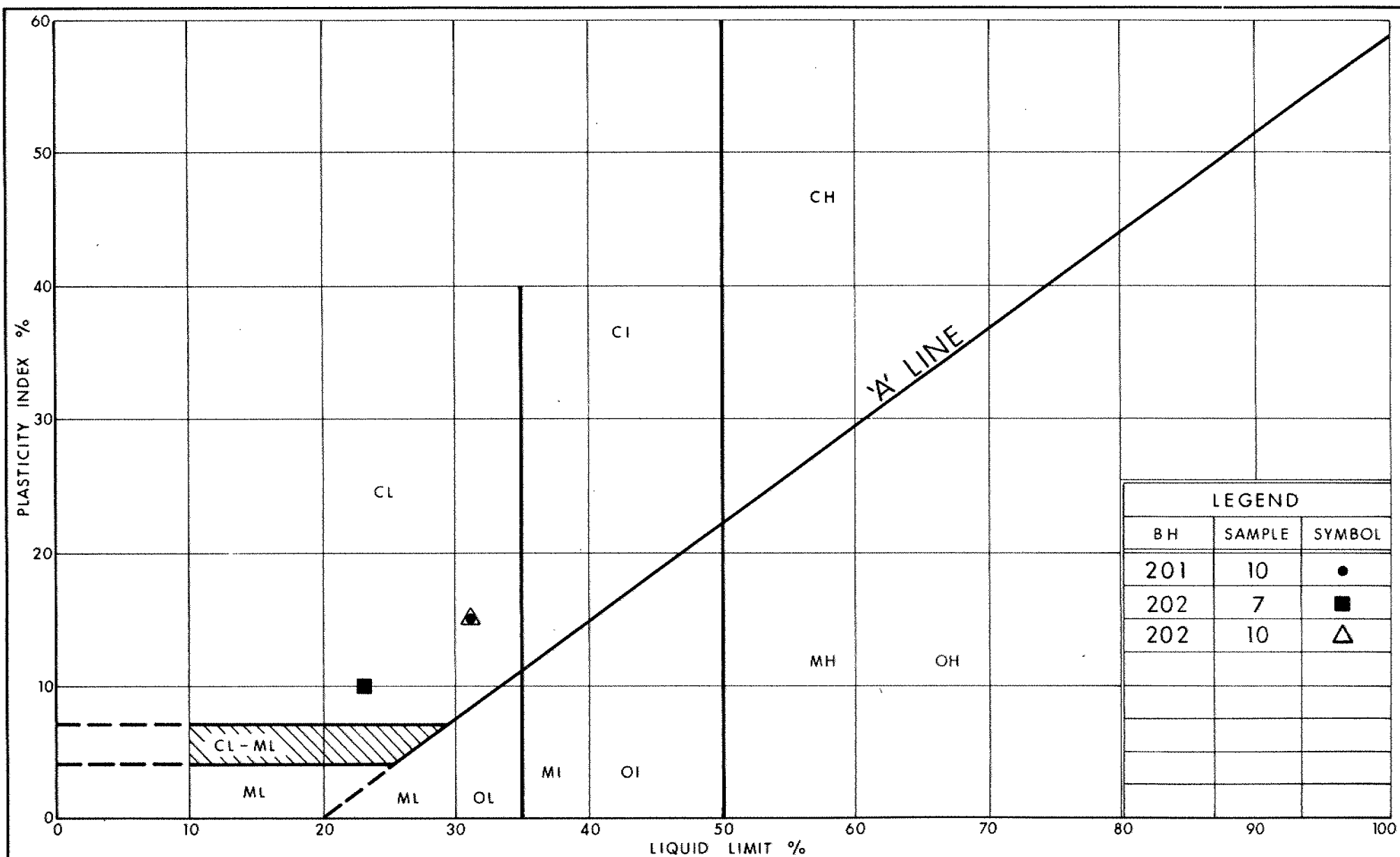

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## GRAIN SIZE DISTRIBUTION

### SAND, TRACE OF SILT

FIG No 2

W P 511-90-01



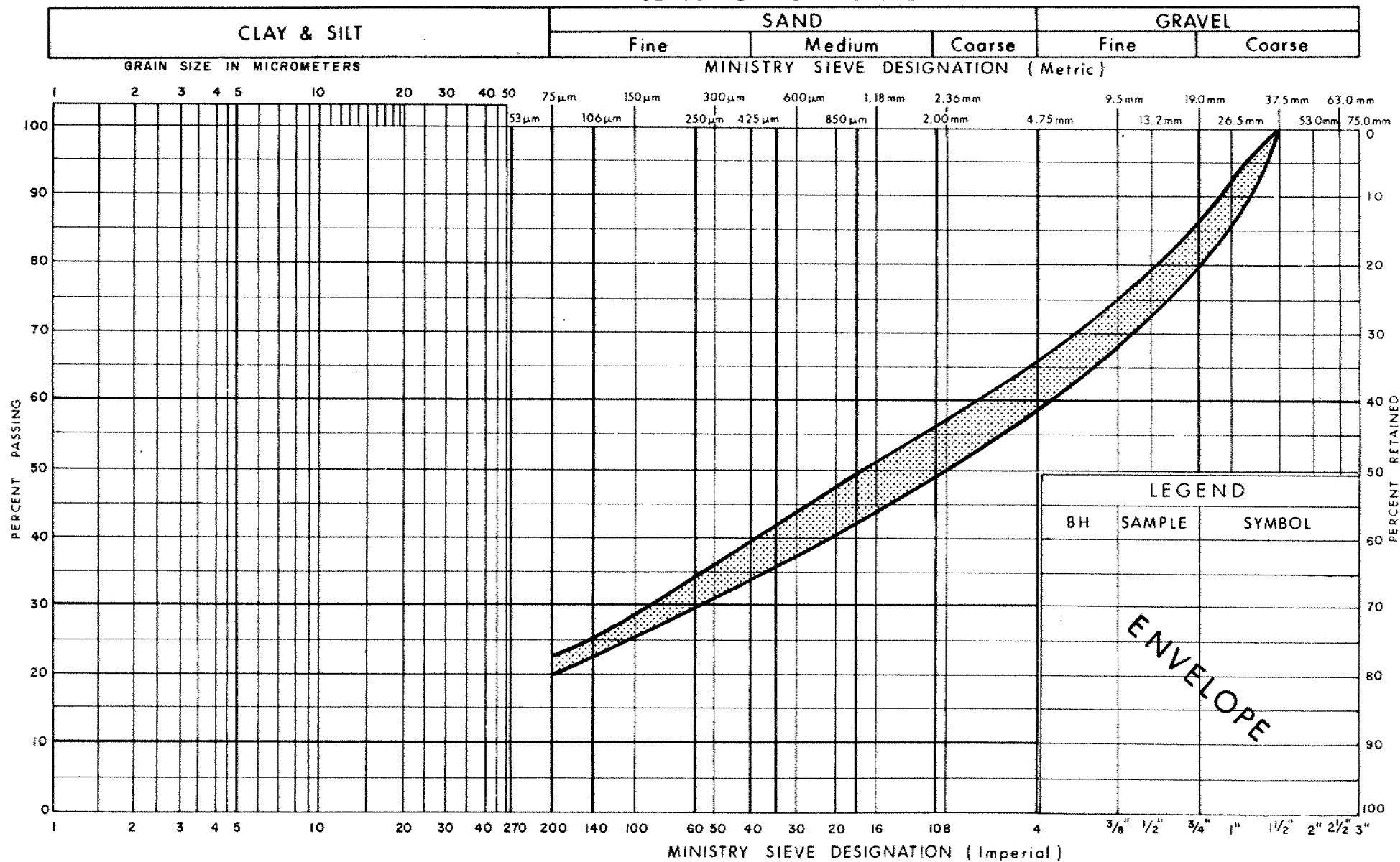
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## PLASTICITY CHART CLAYEY SILT

FIG No 3

W P 511-90-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION  
GRAVELLY SAND, SOME SILT

FIG No 4

W P 511-90-01

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No 201

1 OF 1

METRIC

W.P. 511 - 90 - 01 LOCATION CO - ORDS: N 4 774 804.5; E 203 966.2 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST, H.S. AUGER & B.W. CASING COMPILED BY M V  
DATUM GEODETIC DATE 91 04 02 & 91 04 03 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC UNIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID UNIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
284.6	Ground Surface													
0.0 283.7	ORGANIC SILT, With Sand													
0.9	GRAVELLY SAND, Trace of Silt, Compact		1	SS	19									47 45 (8)
			2	SS	27									
			3	SS	16									
281.0			4	SS	17									14 79 (7)
3.6 279.7	SAND, Trace of Silt, Loose to Compact		5	SS	7									
4.9	CLAYEY SILT, With Occasional Silt and Sand Seams, Stiff to Very Stiff		6	SS	19									
			7	SS	9									
			8	SS	7									
			9	SS	8									
			10	SS	12									
274.1			11	SS	43									37 43 20
10.5	GRAVELLY SAND, Some Silt, Dense to Very Dense		12	SS	94									
270.1	Weathered													
14.5	LIMESTONE BEDROCK Unweathered		13	RC BX	REC 95%									RQD 20%
266.7			14	RC BX	REC 98%									RQD 22%
17.9	End of Borehole													
	* Note: Artesian Condition Encountered at About El: 269.4 in the Fractured Zone of the bedrock. Water Level Rose to 0.4m Above the Ground Level ( ie El:285.0 )													

# RECORD OF BOREHOLE No 202

1 OF 1

METRIC

W.P. 511 - 90 - 01 LOCATION CO - ORDS: N 4 774 812.2; E 203 991.0 ORIGINATED BY M V

DIST 2 HWY 401 BOREHOLE TYPE CONE TEST, H.S. AUGER & B.W. CASING COMPILED BY M V

DATUM GEODETIC DATE 91 03 26 & 91 03 28 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
285.0	Ground Surface												
0.0	SANDY SILT, Some Gravel, Trace of Clay and Organics		1	SS	7								
283.9	Organics		2	SS	22								
1.1	GRAVELLY SAND, Trace of Silt, Compact		3	SS	18								
281.2			4	SS	17								
3.8	SAND, Trace of Silt, Compact		5	SS									
279.6			6	SS	21								
5.4	Silt, Some Sand		7	SS	7								
			8	SS	9								
274.5	CLAYEY SILT, With Occasional Silt and Sand Seams, Stiff to Very Stiff		9	SS	6								
			10	SS	6								
10.5	GRAVELLY SAND, Some Silt, Dense to Very Dense		11	SS	40								
			12	SS	123								
270.3													
14.7	Weathered		13	RC	55%								
	LIMESTONE BEDROCK		14	RC	REC								
	Unweathered		15	RC	REC								
267.9				RC	97%								
				RC	98%								
17.1	End of Borehole												
	<p>* Note: Artesian Condition Encountered at About El: 269.2 in the Fractured Zone of the Bedrock. Water Level Rose to 0.5m Above the Ground Level ( ie El:285.5 )</p>												

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 511 - 90 - 01 LOCATION CO - ORDS. N 4 774 818.2; E 203 958.5 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V  
DATUM GEODETTIC DATE 90 04 04 & 90 04 05 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
285.3	Ground Surface													
0.0	Organic Silt & Clay, Soft													
0.7	SAND and GRAVEL. Some Silt, Trace of Organics, Compact to Dense		1	SS	13		284							45 47 (8)
			2	SS	25									
			3	SS	49									
281.6			4	SS	27		282							33 53 (14)
3.7	CLAYEY SILT, With Intermittent Sand and Silt Seams, Stiff to Very Stiff		5	SS	20									0 2 71 27
			6	SS	12									
			7	SS	17									
			8	SS	10									
			9	SS	12									
275.1			10	SS	17		276							0 0 62 38
10.2	SAND and GRAVEL. Some Silt, Dense to Very Dense		11	SS	44		274							
			12	SS	59									
270.5			13	SS	96	/15cm	272							38 43 (19)
14.8	LIMESTONE BEDROCK						270							
267.0							268							
18.3	End of Borehole													
	Note: Below El:270.5 Borehole was Advanced With Bi-Cone  Formerly BH# 1 of W.P. 481 - 89 - 04.													

+3, x5: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 511 - 90 - 01 LOCATION CO - ORDS. N 4 774 830.5; E 203 973.4 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST, HOLLOW STEM AUGER & BW CASING COMPILED BY M V  
DATUM GEODETIC DATE 90 04 05 & 90 04 09 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
285.0	Ground Surface													
0.0	SAND, Some Silt, Some Gravel, Trace of Organics, Compact		1	SS	22		284							24 62 (14)
			2	SS	20									
			3	SS	14									
			4	SS	26									
281.0			5	SS	23		282							
4.0	CLAYEY SILT, With Intermittent Sand and Silt Seams, Soft to Firm		6	SS	6		280							
			7	SS	1									
			8	SS	7									
			9	SS	7		278							
			10	SS	11									
			11	SS	8		276							
274.9			12	SS	41		274							0 1 57 42
10.1	SAND and GRAVEL, Some Silt, Dense to Very Dense		13	SS	80		272							51 39 (10)
			14	SS	100									
270.8			15	RC BX	REC 98%		270							RQD 0%
14.2	Boulders & Weathered Rock  LIMESTONE BEDROCK, Unweathered		16	RC BX	REC 87%		268							RQD 0%
267.8														
17.2	End of Borehole													
	Note: Formerly BH# 2 of W.P. 481 - 89 - 04													

# **ROCK CORE DESCRIPTION** **WP 511-90-01**

Page 1 of 1

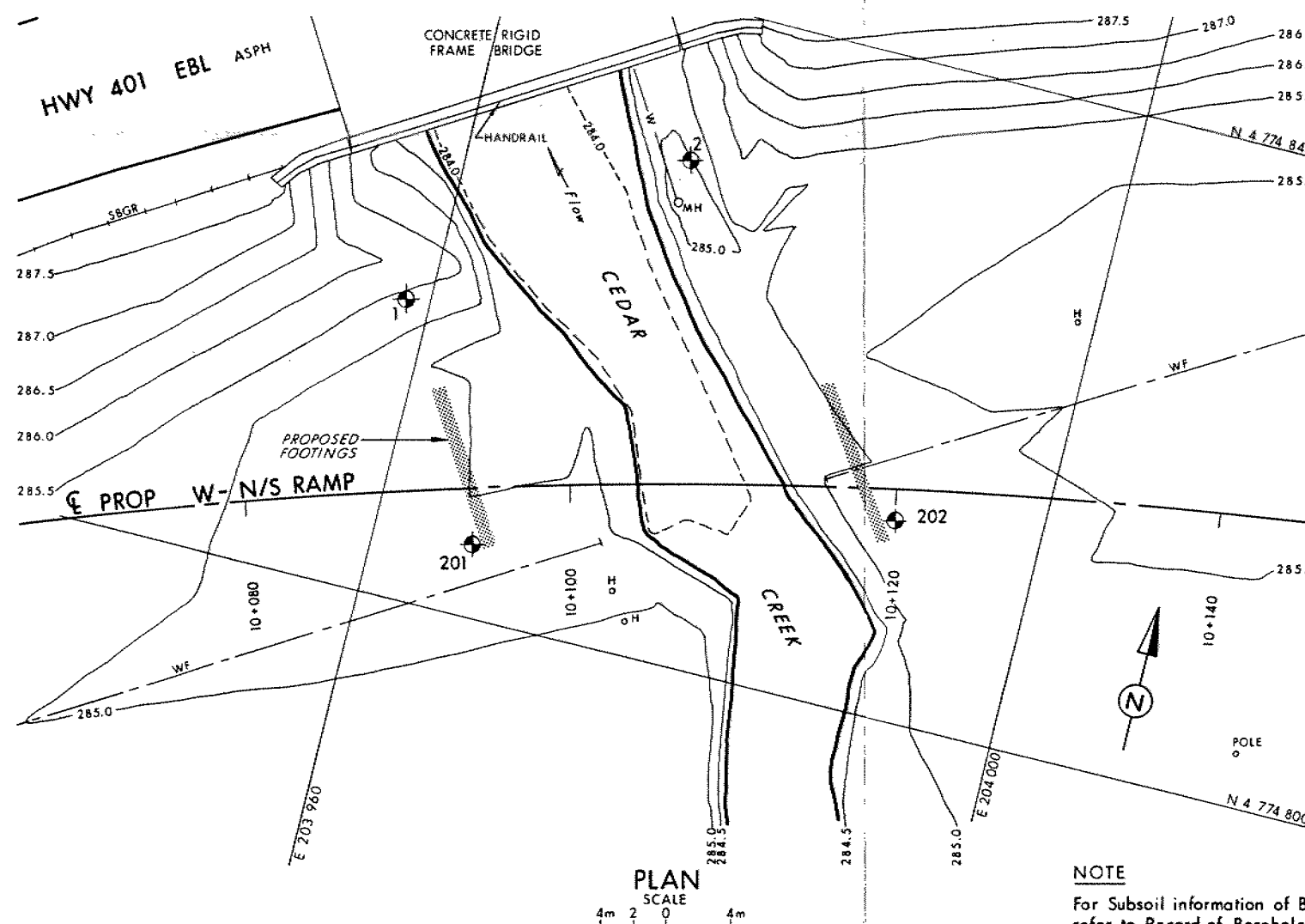
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
201	13	14.78-16.36	95	20	14.78-17.88	LIMESTONE with chert nodules and abundant fossils (corals, stromatoporoids), pale yellowish brown (matrix) to white (fossils); medium crystalline; medium strong; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating, smooth to rough.
	14	16.36-17.88	98	22		
202	13	14.81-15.06	55	0	14.81-17.07	LIMESTONE with chert nodules and abundant fossils (corals, stromatoporoids), pale yellowish brown (matrix) to white (fossils); medium crystalline; medium strong; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating, smooth to rough.
	14	15.06-15.98	97	0		
	15	15.98-17.07	98	0		

\*CR = CORE RECOVERY

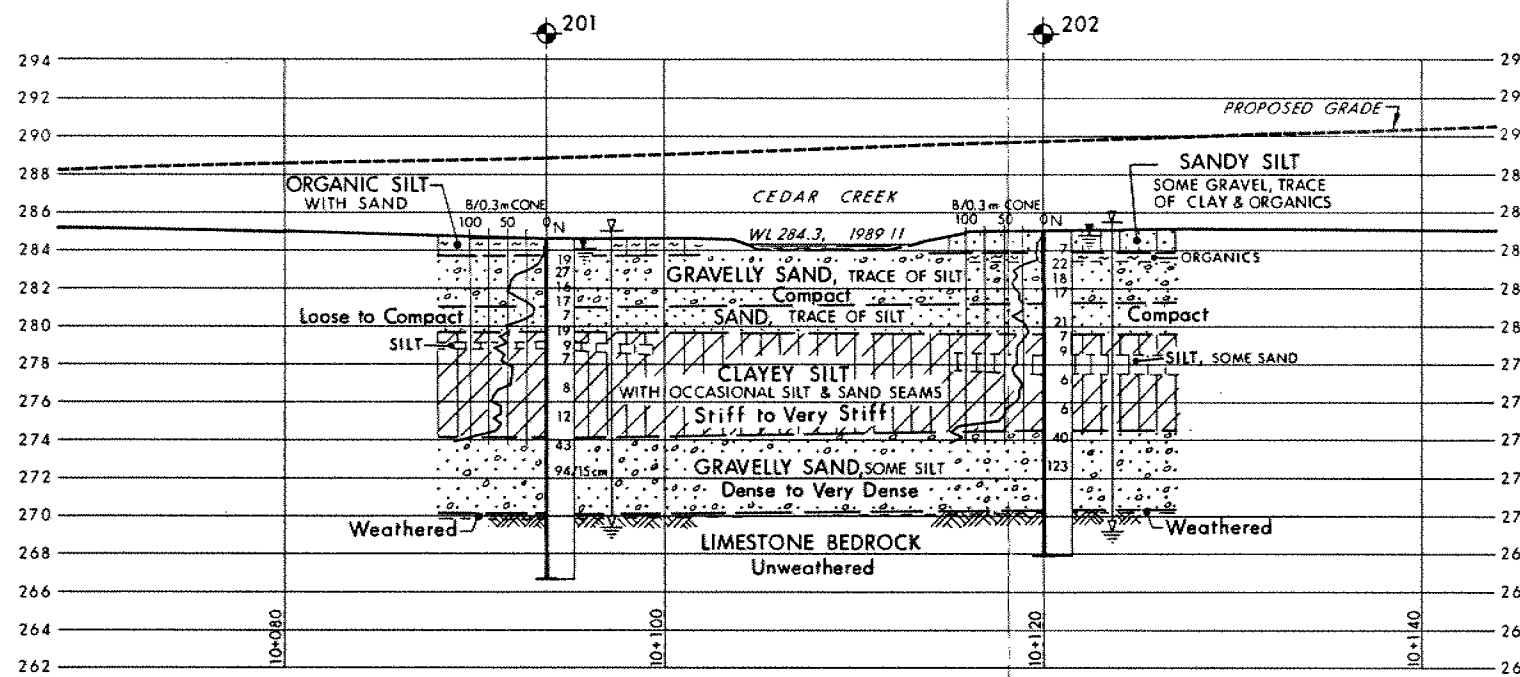
\*RQD = ROCK QUALITY DESIGNATION

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

Logged by: DAW, Soils and Aggregates Section



**NOTE**  
For Subsoil information of BH's 1 & 2 refer to Record of Borehole Sheets.



PROFILE PROPOSED W-N/S RAMP

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

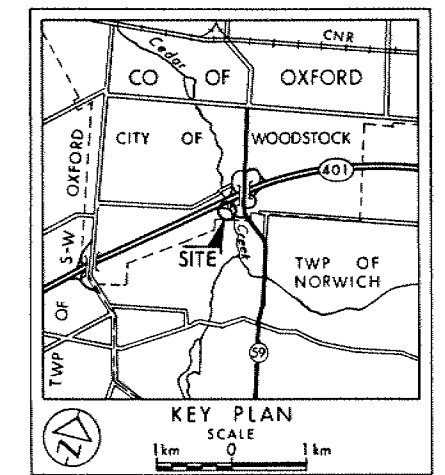
CONT No  
WP No 511-90-01

CEDAR CREEK

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 1991 03 & 04
- Head ARTESIAN WATER Encountered

No	ELEVATION	CO-ORDINATES NORTH	EAST
201	284.6	4 774 804.5	203 966.2
202	285.0	4 774 812.2	203 991.0
1990 04 WP 481-89-04			
1	285.3	4 774 818.2	203 958.5
2	285.0	4 774 830.5	203 973.4

**NOTE**

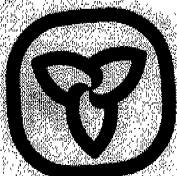
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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

DATE	BY	DESCRIPTION
1990 04	WP 481-89-04	
1991 05 16		
1991 05 16		
1991 05 16		

G.I.-30 SEPT. 1976

GEOCRES No. 40P2-45DIST. 2 REGION           W.P. No. 481-89-03CONT. No. 92-18W. O. No.           STR. SITE No. 23-170HWY. No. 401LOCATION Hwy 401 & Hwy 59No of PAGES -=====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.           REMARKS:



Ontario

Ministry  
of  
Transportation

HWY 59

Use Contract NO

S89-0147

FILE No. \_\_\_\_\_ DATE \_\_\_\_\_

REMARKS

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Walt 519-649-3015



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## **FOUNDATION DESIGN SECTION**

**foundation  
investigation and  
design report**

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 481-89-03 DIST 2  
HWY 401 STR SITE 23-170

Hwy. 59 Underpass and  
Athlone Ave. (N/S - W Ramp)

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# FOUNDATION INVESTIGATION REPORT

For

Hwy. 59 Underpass and

Athlone Avenue (N/S-W Ramp)

W.P. 481-89-03, Site 23-170

Hwy. 401, District 2, London

## INTRODUCTION

This report contains the results of a soils investigation carried out at the above mentioned site to provide information for the design and construction of the proposed replacement bridge and the retaining wall along the new Athlone Avenue (N/S-W Ramp).

The fieldwork for this project was carried out between 1990 04 17 and 1990 04 27, and comprised of seven sampled boreholes and Dynamic Cone Penetration Test adjacent to six of the boreholes. In addition, Cone Penetration tests were carried out at two locations in the area where the underpass is proposed.

Boreholes were advanced to a maximum depth of El. 271.2 m using a continuous flight hollow stem auger and BW casing.

## SITE DESCRIPTION

The site under investigation is located at the crossing of Hwy. 401 and Hwy. 59 in the City of Woodstock.

The topography of the site with the exception of the existing crossing (embankment) is generally undulating with drumlins to the south and southeast. Physiographically, the area is located in the region known as the "Oxford Till Plain".

## SUBSURFACE CONDITIONS

The subsurface conditions at the bridge site was observed to vary from the area where the retaining wall is proposed. As such, the subsoil conditions are discussed separately.

The subsurface conditions encountered during the course of the investigation, together with field and laboratory test results are shown on the Record of Borehole sheets contained in the the Appendix of this report.

#### Hwy. 59 Underpass Bridge

The underlying subsoil at this site consists of fill and topsoil underlain by natural soil predominantly composed of very stiff to hard clayey silt to silty clay which overlies very dense silty sand to sandy silt with varying proportions of gravel content. Despite the geological history of this area, glacial till was encountered in two holes near the terminal depth. For classification purposes, the soils encountered at this site can be divided in to three different zones.

- a) Embankment Fill.
- b) Clayey Silt to Silty Clay
- c) Silty Sand to Sandy Silt

A stratigraphical profile section is shown on Drawing No. 4818903-A. This drawing also shows the locations and elevations of the borings. Description of the strata encountered at this site are given below.

#### Embankment Fill

This fill which was placed to raise the finished grade of the Hwy. 59 predominantly composed of sand with varying proportions of silt and gravel content. The thickness of the granular fill varies from 5.7 m to 5.9 m. The Standard Penetration Test results indicate that this sandy fill is in a compact to dense state of compaction (N-values 14 blows/30 cm to 37 blows/30 cm).

#### Clayey Silt to Silty Clay

This clayey deposit was encountered in all the boreholes immediately below the fill and topsoil. The thickness of this layer varies from 1.8 m to 7.0

m and extends to El. 293.0 to 288.6. The natural moisture content was observed to vary from 12% to 25% with an average value of 17.8%. The results of the Grain Size Distribution Test are shown on Figure 1 in an envelope form. The Atterberg Limits determined for the representative soil samples of this deposit are shown on Figure 2. The consistency of this stratum was observed to be very stiff to hard, however, the Standard Penetration Test results were observed to vary very widely (N-values 15 blows/30 cm to 88 blows/30 cm).

#### Silty Sand to Sandy Silt

The clayey silt to silty clay layer is underlain by this deposit. The Grain Size Distribution Test results are shown on Figure 3 in an envelope form. These results indicate 0% to 22% gravel, 17% to 75% sand and 23% to 78% silt. The natural moisture content was observed to vary widely (6% to 21%) depending on the silt content. The Standard Penetration Test results of this deposit vary from 34 blows/30 cm to over 100 blows/30 cm indicating dense to very dense state of compaction. The full extent of this deposit was not proven, however, in BH's 3 and 5, this layer is underlain by a cohesive glacial till deposit.

#### Groundwater Conditions

The groundwater was encountered in all the boreholes, and was observed between El. 289.2 m and 292.0 m. The groundwater level at each borehole location is as follows:

<u>Borehole No.</u>	<u>Elevation (m)</u>
1	289.2 not stabilized
3	291.8
4	290.3 not stabilized
5	292.0
7	289.5 not stabilized

### Athlone Avenue (N/S-W Ramp) Retaining Wall

The boreholes were located in the existing unpaved parking area which is under construction. The underlying subsoil at this site consists of stratified glacial deposit predominantly composed of clayey silt to silt with varying proportions of sand and occasional sand seams.

A stratigraphical profile section is shown on Drawing No. 4818903-B. This drawing also shows the locations and elevations of the borings. Description of the soils encountered at this site are given below.

### Clayey Silt to Silt with sand (Glacial Till)

The gravel subbase material is underlain by this glacial deposit consisting of clayey silt to silt with varying proportions of sand and gravel content and occasional sand seams varying in thickness from a few centimeters to a maximum of 1.3 m. The Grain Size Distribution Test results are shown on Figure 4 in an envelope form. These results indicate 11% to 22% clay, 41% to 61% silt, 17% to 34% sand and 0% to 6% gravel. The Atterberg Limit Test results are shown on Figure 5. The natural moisture content varies between 8% and 11% with an average value of 9.4%. The Standard Penetration Test results vary from 19 blow/30 cm to over 100 blows/30 cm indicating very stiff to hard consistency. This layer extends to the depth probed (i.e. El. 289.1 m). This glacial deposit is underlain by a very hard stratum, however, this was not probed to identify the material.

### Groundwater Conditions

The groundwater table was encountered in both boreholes, and was observed between 3.6 m and 4.2 m below the existing ground level. The groundwater level at each borehole location is as follow:

<u>Borehole No.</u>	<u>Elevation (m)</u>
R1	294.5
R2	293.3 not stabilized

## DISCUSSION AND RECOMMENDATIONS

### General

It is proposed to widen Hwy. 401 to a divided eight lane facility and the existing bridge will be replaced with four span (approximately 16 m end spans and 24 m centre spans) structure. In addition, it is proposed to relocate the N/S-W Ramp north of the existing location and to construct a retaining wall along the new Athlone Avenue (N/S-W Ramp).

The existing bridge is a single span reinforced concrete rigid frame structure. The clear span between the face of the abutments is about 34.4 m. The structure as well as the slope of the approach fill and ramp are in very good condition. However, the reinforcement of the deck has been exposed and corroded at several locations.

It appears from the structural drawings that the abutments of the existing bridge as well as the wing walls are supported on spread footings founded at about El. 293.6±.

### Structure Foundations

Considering the subsoil conditions at this site, it is recommended that the piers be supported on spread footings placed at about El. 293.0±. The foundation for the abutments may be founded on engineered fill placed on competent ground. The existing approach fill as well as any spongy or soft areas observed within the base width of the proposed embankment should be removed before placing the engineered fill. The engineered fill should be placed as per Figure 6 Appended to this report.

The following bearing capacity values are recommended for the design of the abutment foundations placed on engineered fill:

Factored Bearing Capacity at U.L.S. = 900 kPa  
Bearing Capacity at S.L.S. Type II = 350 kPa

The design of the pier foundations placed at a level not higher than El. 293.0 m may be carried out assuming the following bearing capacity:

Factored Bearing Capacity at U.L.S. = 700 kPa

Bearing Capacity at S.L.S. Type II = 300 kPa

The allowable bearing pressures recommended above are based on the assumption that the footings will be at least 2.5 m wide and will be placed not less than 1.5 m below the finished grade. The total settlement for these allowable bearing pressures is expected to be within 25 mm.

The earth pressure for the design of the abutments should be computed as per Section 6.1.2.2 of the O.H.B.D.C., and an unyielding foundation condition may be assumed for the computations. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight ( $\text{kN/m}^3$ )	$\gamma = 22.8$	$\gamma = 21.2$

If the footings are placed on compacted granular backfill, an unfactored coefficient of friction value of  $\tan 30^\circ$  may be assumed for the estimation of the sliding resistance.

#### Retaining Wall

The subsoil conditions encountered at this site is not expected to impose any restriction on selection of the type of retaining wall. However, reinforced earth wall will require more space than the conventional type retaining walls (at least 0.7 times the height of the wall).

If conventional type retaining wall is proposed, it is recommended that the retaining wall be supported on spread footing placed at a level not higher than El. 296.0 m. The following bearing capacity values are recommended for the design:

Factored Bearing Capacity at U.L.S. = 700 kPa

Bearing Capacity at S.L.S. Type II = 300 kPa

The total settlement for the allowable bearing pressure recommended above is expected to be within 25 mm.

The earth pressure for the design of the retaining wall should be computed as per section 6.1.2.2 of the O.H.B.D.C., and yielding foundation condition may be assumed for the computations. The Granular 'A' or 'B' backfill should be in accordance with Special Provision No. 109F03. The following parameters are recommended for the Granular fill:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight ( $\text{kN/m}^3$ )	$\gamma = 22.8$	$\gamma = 21.2$

An unfactored coefficient of friction value of  $\tan 26^\circ$  may be assumed for the estimate of the sliding resistance.

If adequate space is available for the construction of reinforced earth wall, it may be considered instead of conventional type retaining wall. Considering the competent subsoil conditions, no global instability problems are anticipated for the reinforced earth wall, however, internal instability should be checked at the design stage.

#### Approach Embankment

Considering the subsoil conditions at this site, no stability problems are anticipated for the approach embankment constructed with 2H:1V side slopes. The embankment fill should consist of well compacted acceptable material. The topsoil as well as any spongy or soft areas observed within the base width of the embankment should be removed before placing the fill.

Other Considerations

The footings should have a minimum of 1.2 m earth cover to protect against the frost penetration.

Considering the proposed founding level and the groundwater table, no dewatering problems are anticipated at this site.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. M. Vasavithasan, Foundation Engineer. The equipment used was owned and operated by London Soil Test. This report was prepared by Mr. M. Vasavithasan, Foundation Engineer, reviewed by Mr. P. Payer, Senior Foundation Engineer, and approved by Mr. M. Devata, Chief Foundation Engineer.



A handwritten signature in cursive script, reading "M. Vasavithasan".

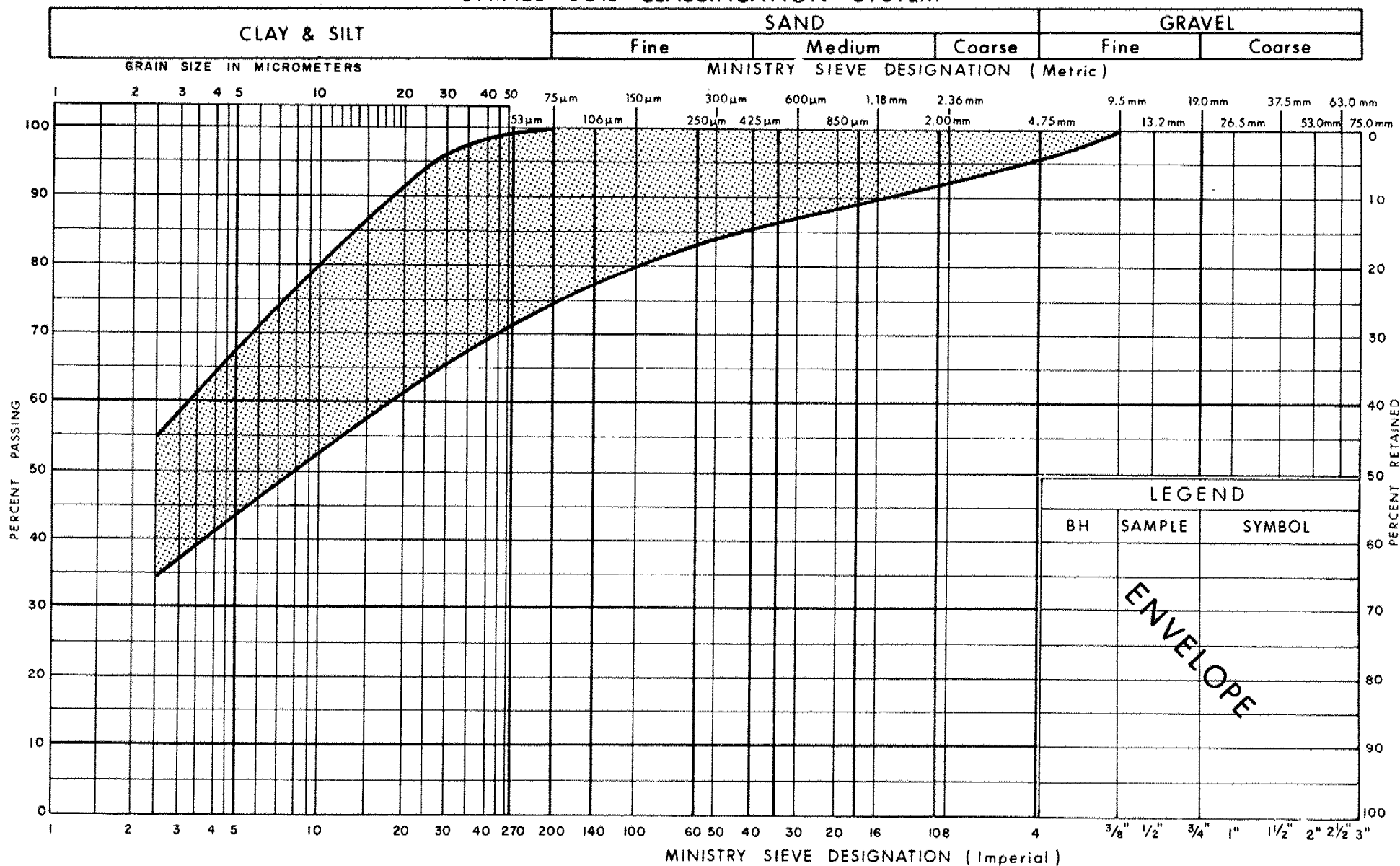
M. Vasavithasan, P.Eng.  
Foundation Engineer

A handwritten signature in cursive script, reading "M. Devata".

M. Devata, P.Eng.  
Chief Foundation Engineer

## **APPENDIX**

## UNIFIED SOIL CLASSIFICATION SYSTEM

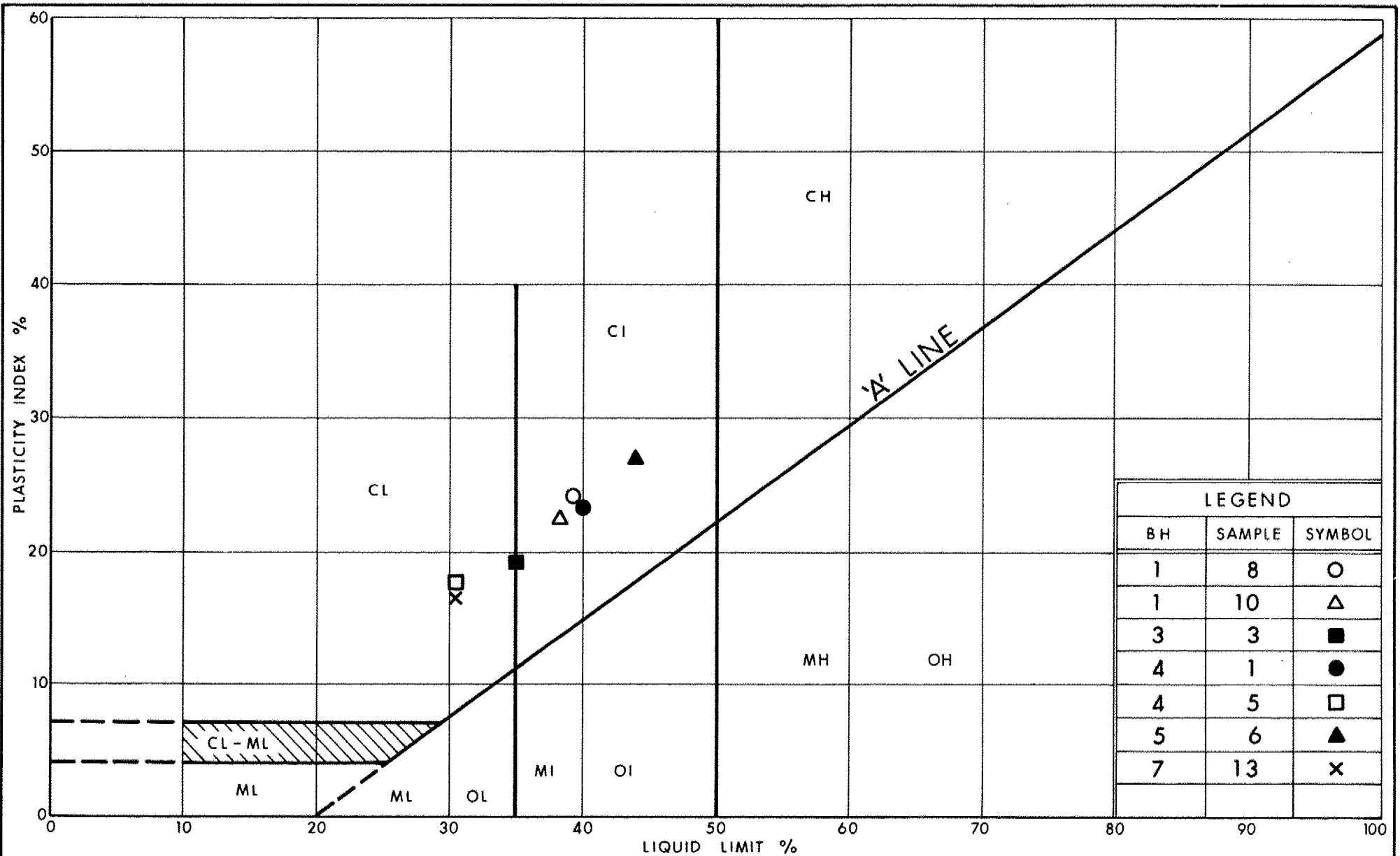


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**GRAIN SIZE DISTRIBUTION**  
**CLAYEY SILT TO SILTY CLAY**  
 TRACE OF SAND & GRAVEL

FIG No 1

W P 481-89-03



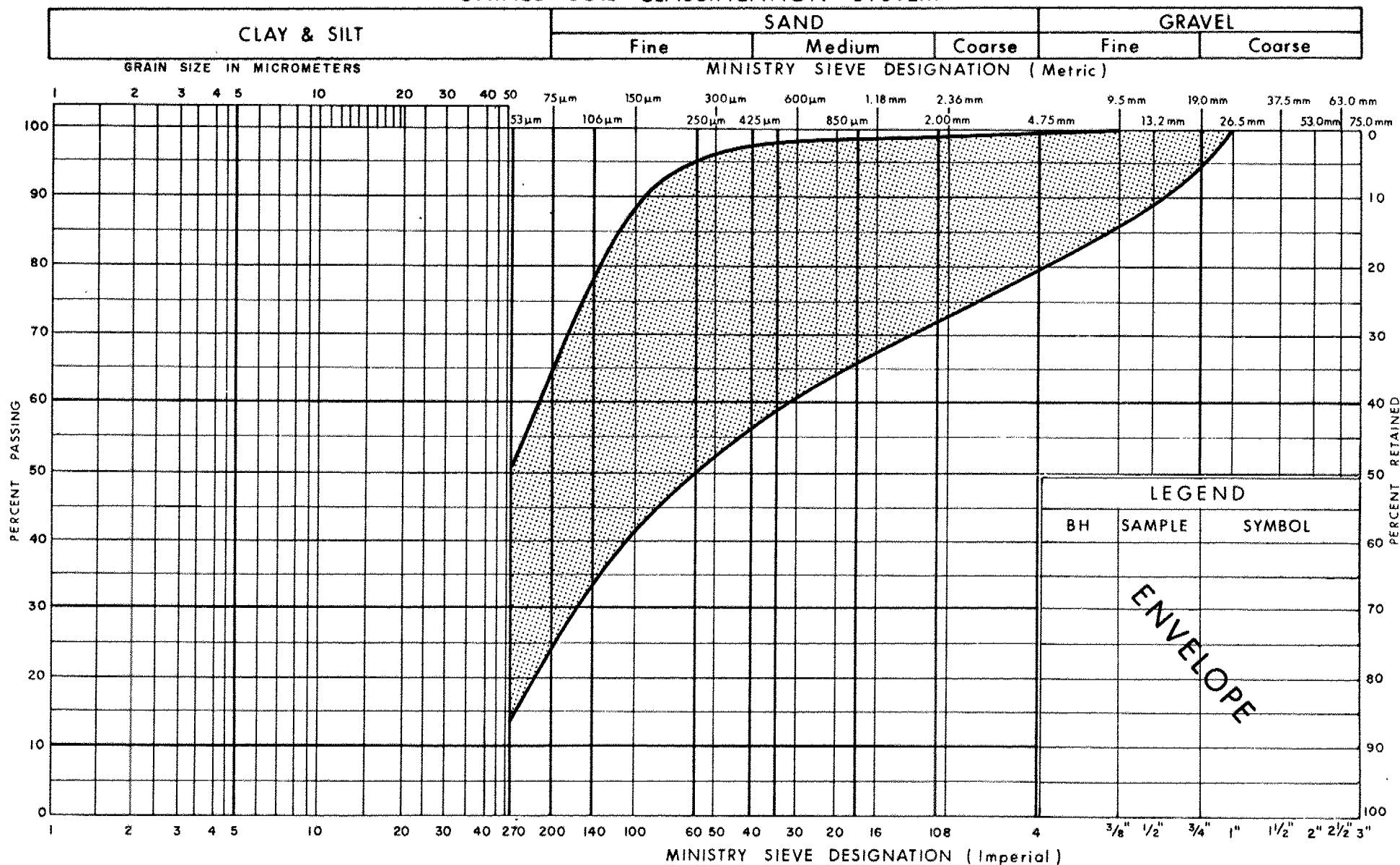
Ministry of  
Transportation

PLASTICITY CHART  
CLAYEY SILT TO SILTY CLAY  
TRACE OF SAND & GRAVEL

FIG No 2

W P 481-89-03

## UNIFIED SOIL CLASSIFICATION SYSTEM



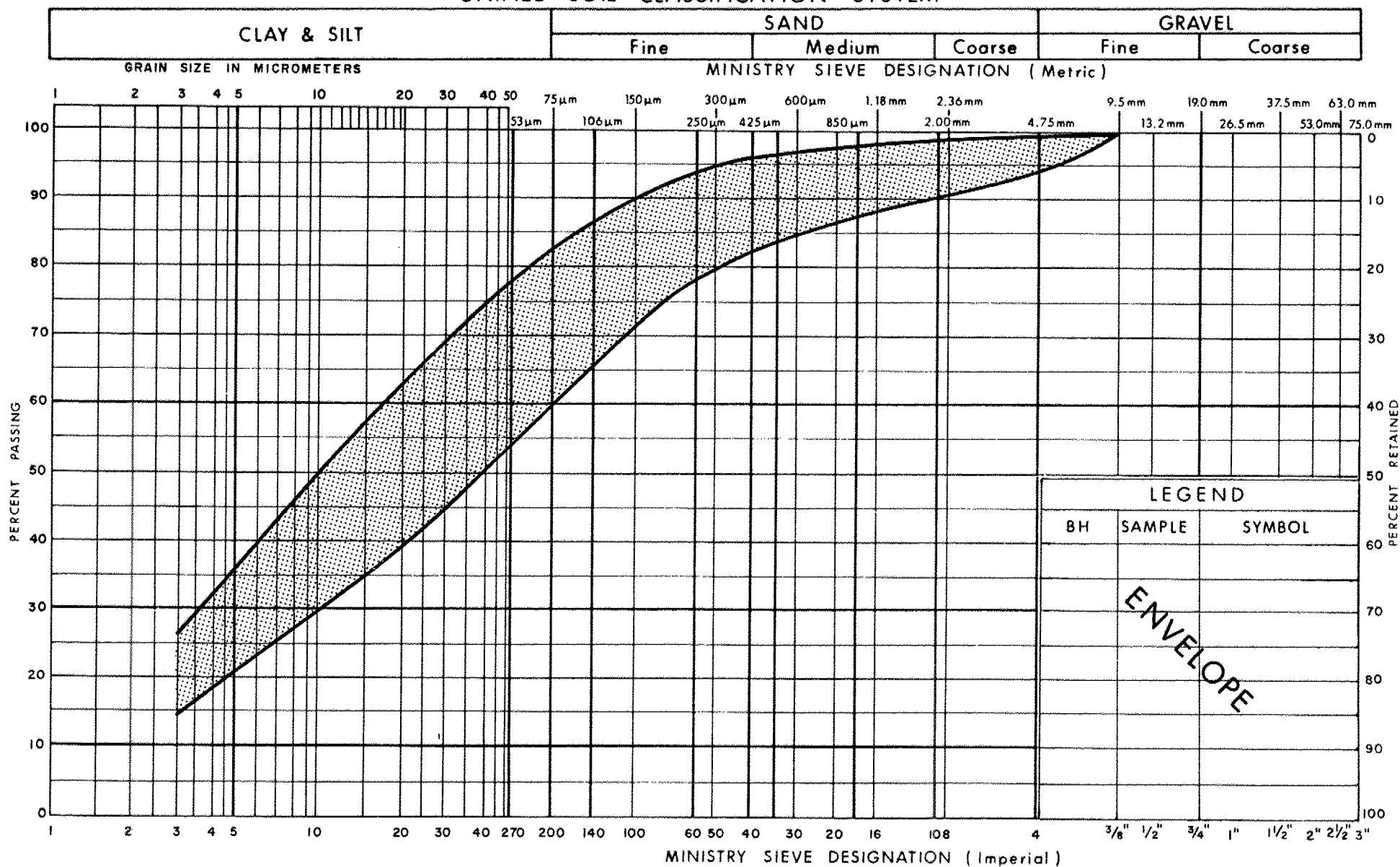
Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**SILTY SAND TO SANDY SILT**  
 TRACE TO SOME GRAVEL

FIG No 3

W P 481-89-03

## UNIFIED SOIL CLASSIFICATION SYSTEM

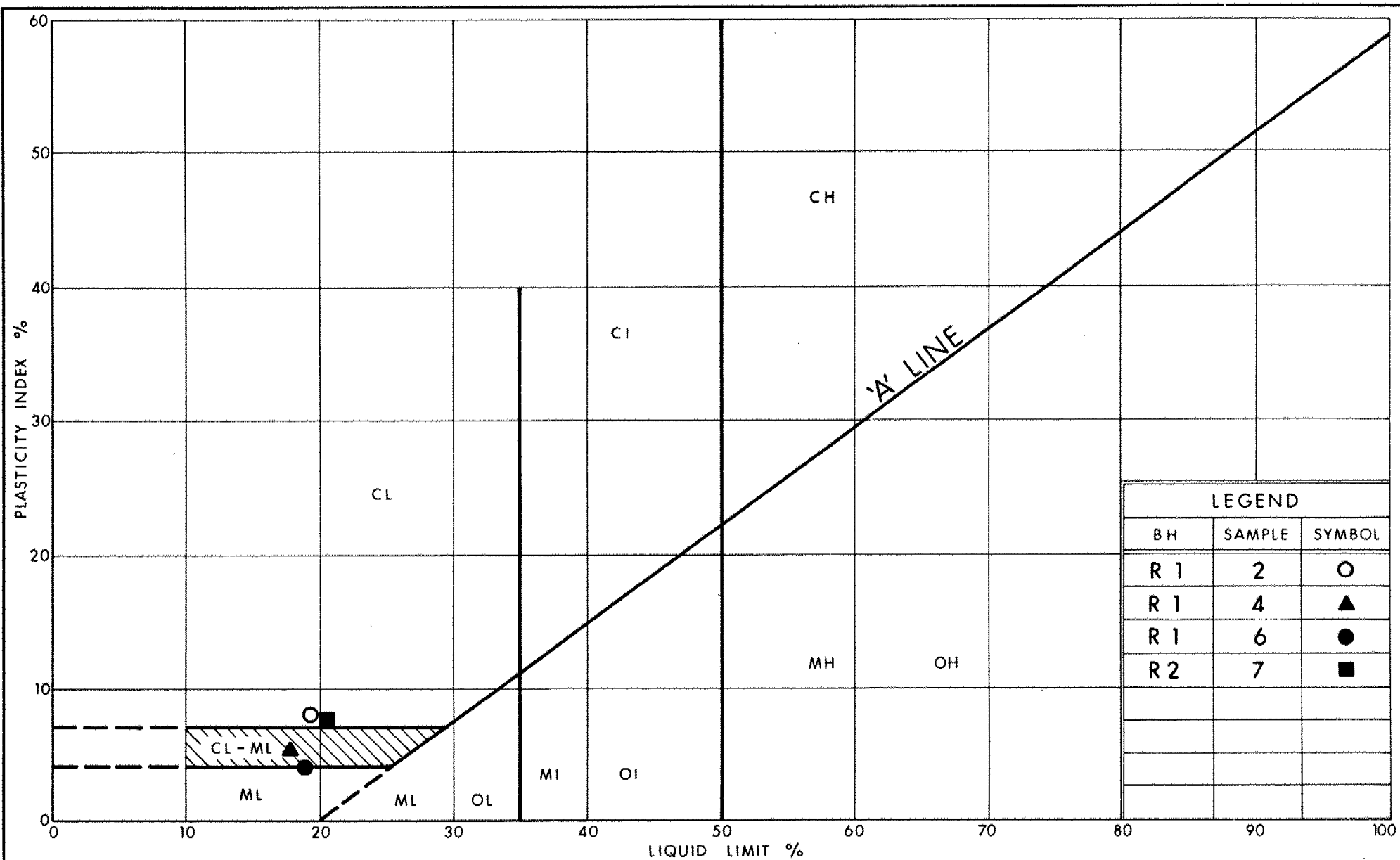


Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**CLAYEY SILT TO SILT**  
 WITH SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 4

WP 481-89-04



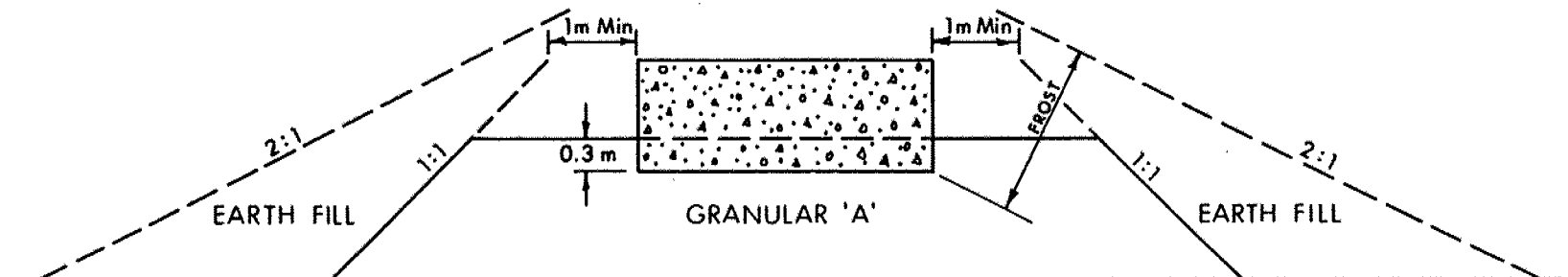
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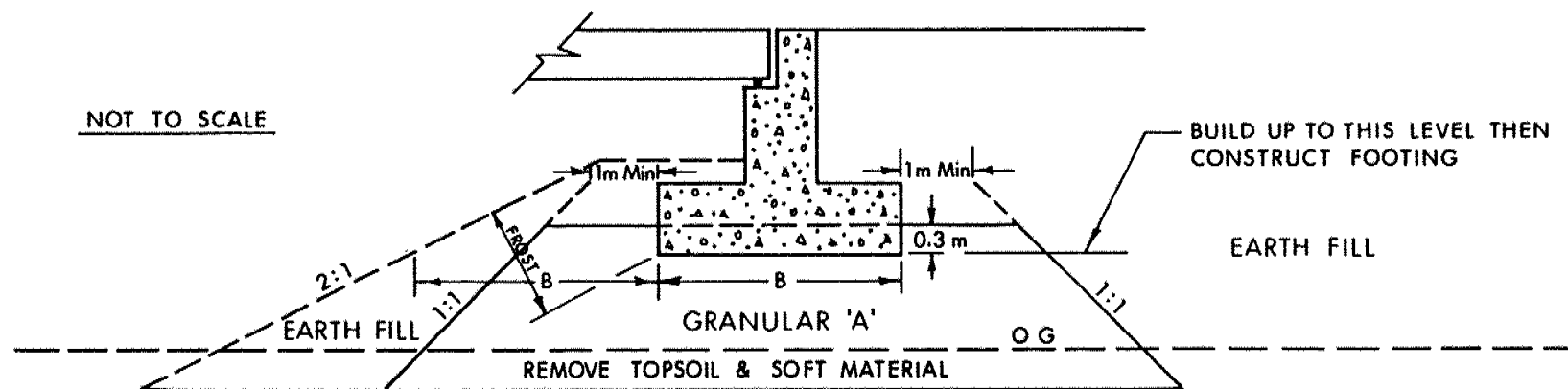
PLASTICITY CHART  
CLAYEY SILT TO SILT  
WITH SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 5

W P 481-89-03



X SECTION



LONGITUDINAL SECTION

NOTES:

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



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ABUTMENT ON COMPACTED FILL  
SHOWING GRANULAR 'A' CORE

FIG No 6

W P 481-89-03

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 775 051.1; E 204 202.2 ORIGINATED BY M.V.  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M.V.  
DATUM GEODETIC DATE 90 04 24 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
304.0	Hwy. 59 Shoulder													
0.0			1	SS	96	/15cm								
			2	SS	17									
			3	SS	15									
			4	SS	14									
298.3	Sand, Some Silt, Some Gravel, Compact ( Fill )		5	SS	102									
5.7	Silty Sand, Trace of Gravel, Very Dense		6	SS	107									
296.5			7	SS	83									
7.5	Silty Clay, Trace of Sand, Trace of Gravel, Hard		8	SS	67									
			9	SS	67									
			10	SS	88									
293.0			11	SS	56									
11.0			12	SS	50	/5cm								
			13	SS	75	/8cm								
			14	SS	100	/8cm								
			15	SS	75	/15cm								
	Sandy Silt, Trace of Gravel, Very Dense		16	SS	91	/15cm								
			17	SS	100	/10cm								
282.4			18	SS	81	/15cm								
21.6	End of Borehole													
	* Water Level Not Stabilized													

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 775 030.4; E 204 171.0 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
 DATUM GEODETIC DATE 90 04 20 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
296.3	Ground Surface											
0.0												
293.9												
2.4	End of Cone Test											

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 775 007.0; E 204 176.8 ORIGINATED BY M V  
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V  
DATUM GEODETIC DATE 90 04 20 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
295.2	Ground Surface													
0.0	Topsoil													
294.1	Sand, Some Silt, Compact		1	SS	18									
1.1	Clayey Silt, Trace of Sand, Trace of Gravel, Very Stiff		2	SS	27									
292.3			3	SS	28									
2.9			4	SS	75	10cm								
			5	SS	65	/15cm								
	Sandy Gravel, Some Silt		6	SS	110	/23cm								
			7	SS	102	/3cm								
			8	SS	93									
	Silty Sand, Trace of Gravel, Very Dense		9	SS	67	/15cm								
			10	SS	100	/13cm								
284.6			11	SS	100	/25cm								
10.6			12	SS	100	/15cm								
			13	SS	111	/23cm								
	Heterogeneous Mixture of Clayey Silt, Sand & Gravel, Hard ( Glacial Till )													
276.5			14	SS	103									
18.7	End of Borehole													

# RECORD OF BOREHOLE No 4

1 OF 1 METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 774 989.5; E 204 191.8 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY M V  
 DATUM GEODETIC DATE 90 04 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
295.1	Hwy. 401 Median													
294.8	Sand And Organic Silt		1	SS	18		294							1 8 43 48
0.7	Silty Clay to Clayey Silt, Trace of Sand, Trace of Gravel, Very Stiff to Hard		2	SS	21									
			3	SS	42		292							
			4	SS	35									
290.6			5	SS	47									
4.5			6	SS	50	8cm	290							7 22 38 33
			7	SS	39									
			8	SS	76	/15cm								3 44 (53)
			9	SS	100	/14cm	288							
			10	SS	113		286							
			11	SS	100	/15cm	284							
			12	SS	102	/15cm								
	Sandy Silt, Trace of Gravel, Dense to Very Dense		13	SS	34		282							
			14	SS	102	/23cm	280							5 17 (78)
274.2							278							
20.9	End of Borehole						276							
	• Water Level Not Stabilized													

# RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 774 955.2; E 204 186.7 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST, HOLLOW STEM AUGER & BW CASING COMPILED BY M V  
 DATUM GEODETIC DATE 90 04 17 TO 90 04 19 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT UNIT		UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%) 10 20 30		
284.3	Ground Surface						294						
0.0	Topsoil												
292.9	Sand And Silt, Trace of Gravel, Loose		1	SS	3		292						
1.4	Silty Clay, Trace of Sand, Trace of Gravel, Very Stiff to Hard		2	SS	36								
			3	SS	31								
			4	SS	49								
			5	SS	39								
			6	SS	19								
289.0			7	SS	92	/15cm	290						
5.3	Sand And Gravel          Sandy Silt, Some Gravel, Occasional Gravel Seams, Very Dense		8	SS	131	/15cm	288						0 1 46 53
			9	SS	107	/15cm	286						
			10	SS	85	/15cm	284						
			11	SS	51		282						45 47 (8)
			12	SS	100	/8cm	280						
			13	SS	100	/10cm	278						
			14	SS	100	/5cm	276						
			15	SS	102	/15cm	274						
			16	SS	100	/10cm	272						
272.5	Heterogeneous Mixture of Clayey Silt, Sand and Gravel, Hard ( Glacial Till )												
21.8													
271.2													0 38 (62)
23.1	End of Borehole												16 45 (39)

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 774 932.0; E 204 191.6 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST COMPILED BY M V  
 DATUM GEODETIC DATE 90 04 19 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
293.7	Ground Surface												
0.0													
290.1													
3.6	End of Cone Test												

# RECORD OF BOREHOLE No 7

1 of 1 METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 774 943.0; E 204 207.3 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V  
 DATUM GEODETIC DATE 90 04 25 & 90 04 25 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
301.5	Hwy. 59 Shoulder							20 40 60 80 100		W <sub>p</sub> W W <sub>L</sub>	10 20 30			
0.0	Sand, Some Silt, Some Gravel, Compact to Dense ( Fill )		1	SS	30									
			2	SS	37									
			3	SS	18									
			4	SS	17									
295.6	Sand, Some Silt, Some Gravel		5	SS	69									
5.9			6	SS	39									
			7	SS	14									
			8	SS	15									
			9	SS	35									
			10	SS	39									
			11	SS	29									
			12	SS	29									
			13	SS	20									
288.5			Clayey Silt, Trace of Sand, Trace of Gravel, Very Stiff to Hard		14	SS	93							
12.9	15	SS			104	/15cm							0 0 63 37	
	16	SS			110								22 45 (33)	
	17	SS			90	/15cm								
	18	SS			100	/8cm								
	19	SS			84	/15cm								
	20	SS			101	/15cm							46 41 (13)	
	Sand And Gravel													
275.6	End of Borehole		21											
25.9			22											
	• Water Level Not Stabilized													

# RECORD OF BOREHOLE No R1

1 OF 1

METRIC

W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 775 135.0; E 204 146.0 ORIGINATED BY M.V.  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M.V.  
 DATUM GEODETIC DATE 90 04 26 & 90 04 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
288.7	Unpaved Parking Area												
0.0	Gravel Fill		1	SS	23		298						
			2	SS	19								3 31 50 16
			3	SS	51		296						6 34 45 15
			4	SS	44								
			5	SS	51								
			6	SS	106		294						2 27 60 11
			7	SS	102	/23cm	292						
			8	SS	120		290						
289.1	Sand, Some Silt, Very Dense		9	SS	76	/13cm							
9.6	End of Borehole												
	Note: Borehole was Terminated Due to Presence of Very Hard Strata												

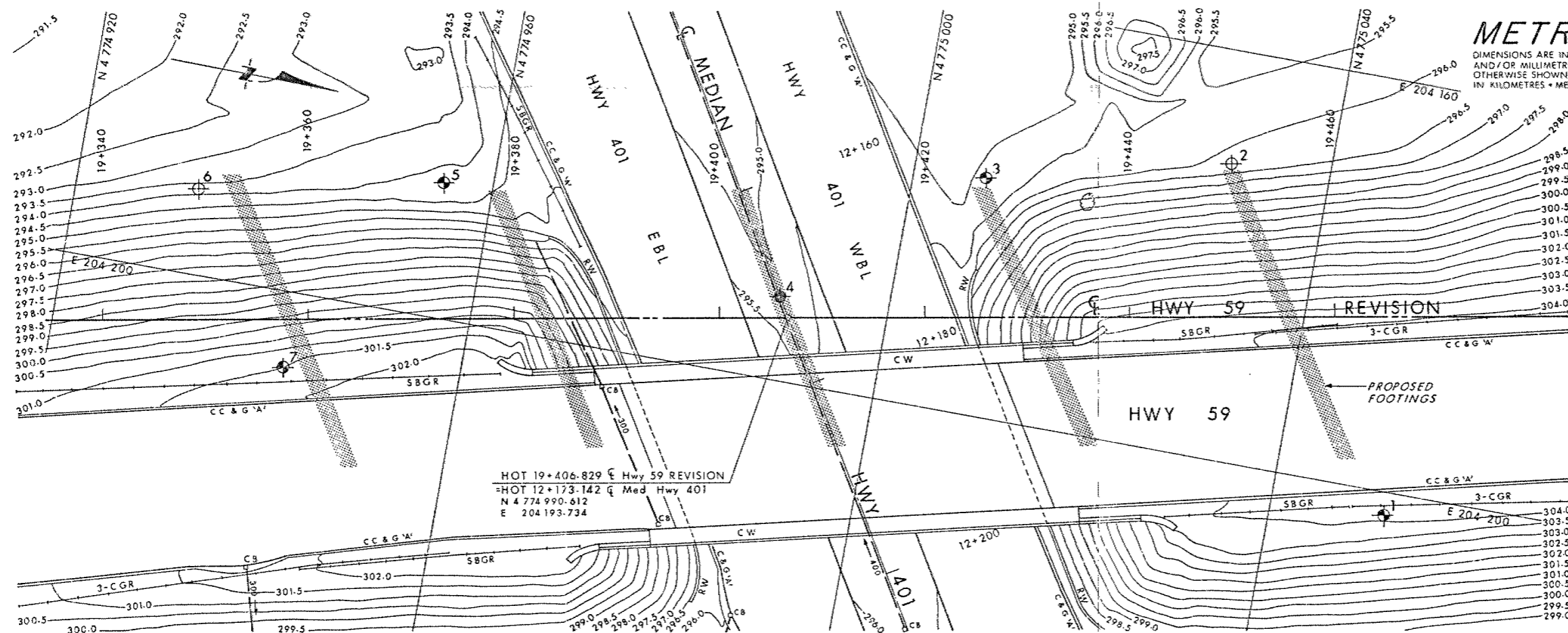
# RECORD OF BOREHOLE No R2

1 OF 1

METRIC

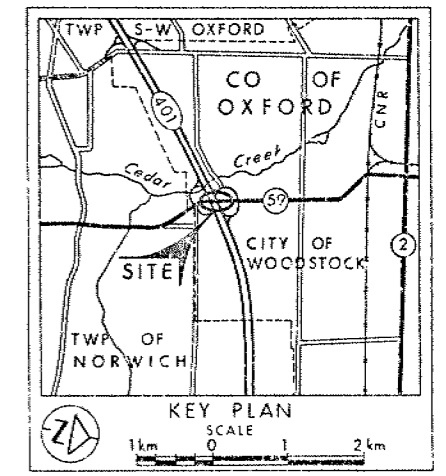
W.P. 481 - 89 - 03 LOCATION CO-ORDS. N 4 775 107.0; E 204 094.0 ORIGINATED BY M V  
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V  
 DATUM GEODETIC DATE 90 04 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
296.9	Unpaved Parking Area												
0.0	Gravel Fill		1	SS	36								
			2	SS	46								
	Gravelly Sand, Some Silt, Very Dense		3	SS	60								
			4	SS	70								
			5	SS	122								
	Clayey Silt to Silt, Some Sand, Trace of Gravel, Occasional Sand Seams, Hard ( Glacial Till )		6	SS	76	/15cm							
			7	SS	125								
289.1			8	SS	55	/3cm							
7.8	End of Borehole												
	Note: Borehole Was Terminated Due to Presence of Very Hard Strata												
	* Water Level Not Stabilized												

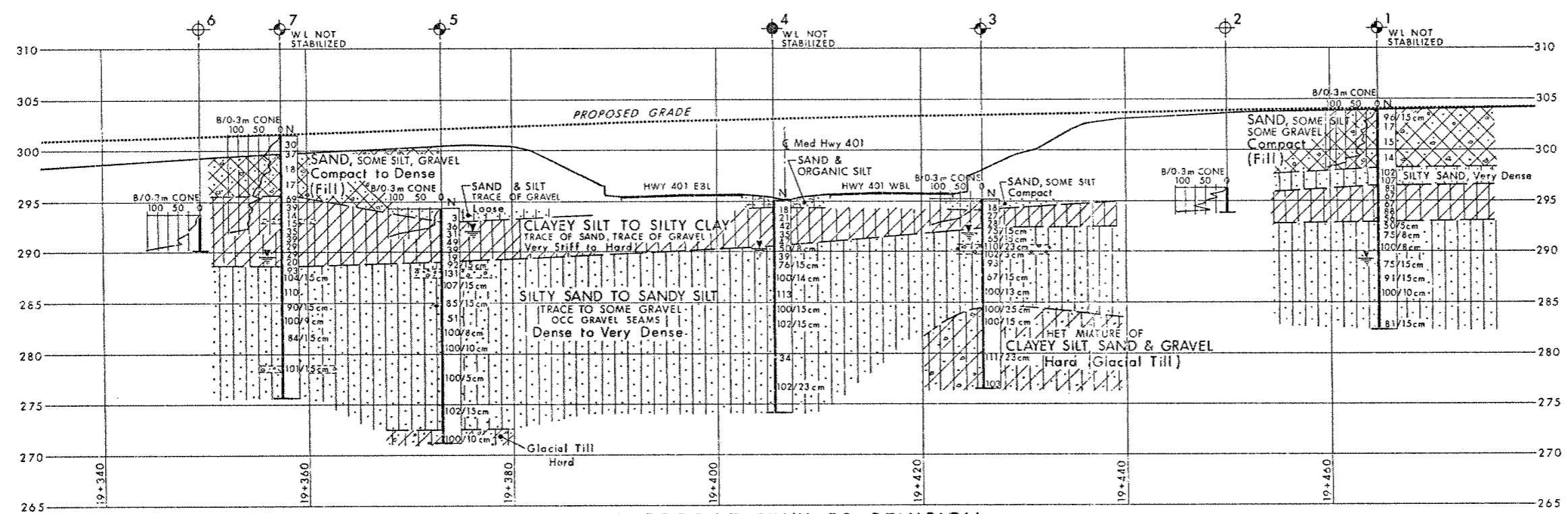


**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 481-89-03  
HWY 59 UNDERPASS  
BORE HOLE LOCATIONS & SOIL STRATA



- LEGEND**
- Bore Hole
  - Dynamic Cone Penetration Test (Cone)
  - Bore Hole & Cone
  - N Blows/0.3m (Std Pen Test, 475 J/blow)
  - CONE Blows/0.3m (60° Cone, 475 J/blow)
  - WL at time of investigation 1990 04



No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	304.0	4775051.1	204 202.2
2	296.3	4775030.4	204 171.0
3	295.2	4775007.0	204 176.8
4	295.1	4774 989.5	204 191.8
5	294.3	4774 955.2	204 186.7
6	293.7	4774 932.0	204 191.6
7	301.5	4774 943.0	204 207.3

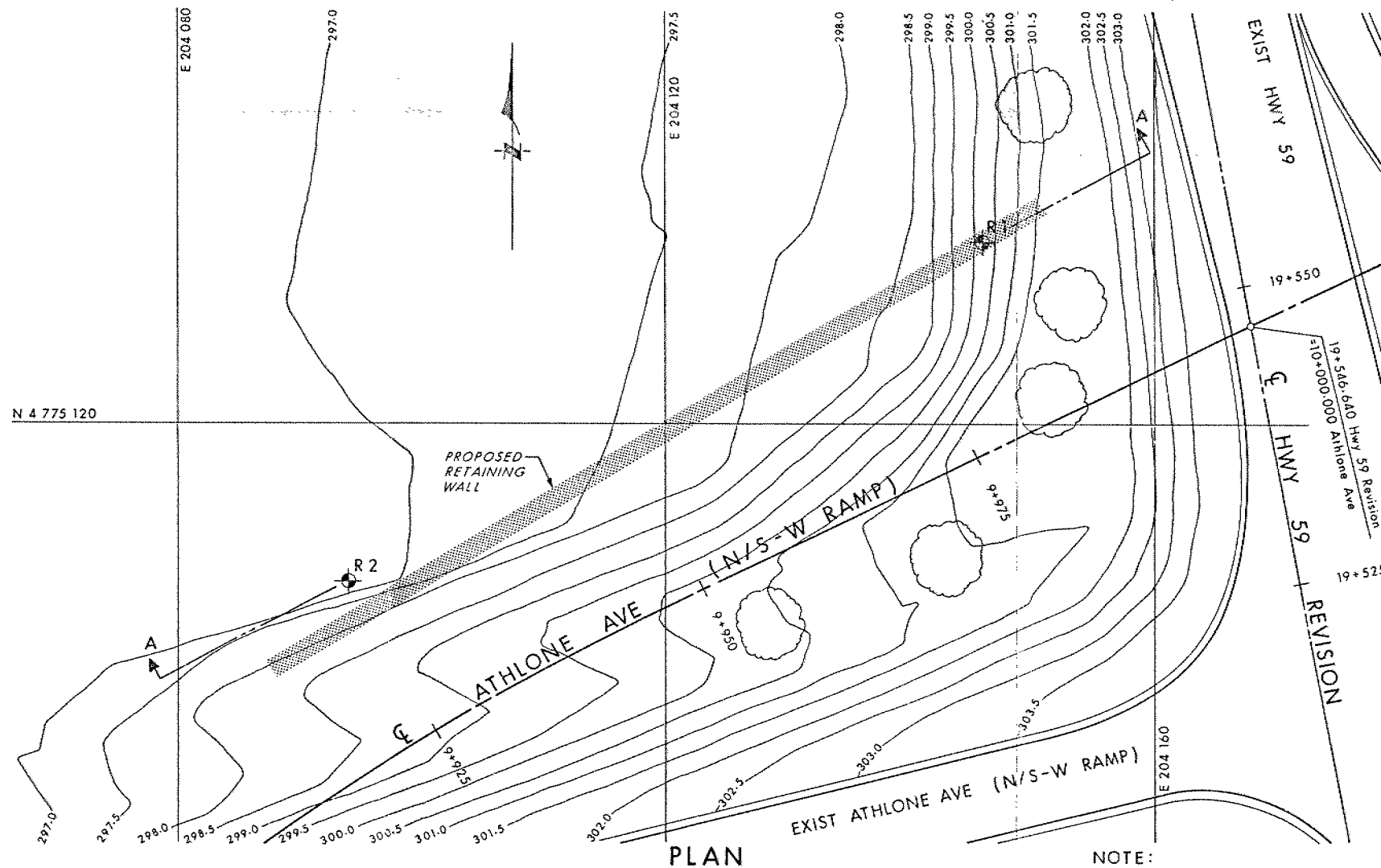
**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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.

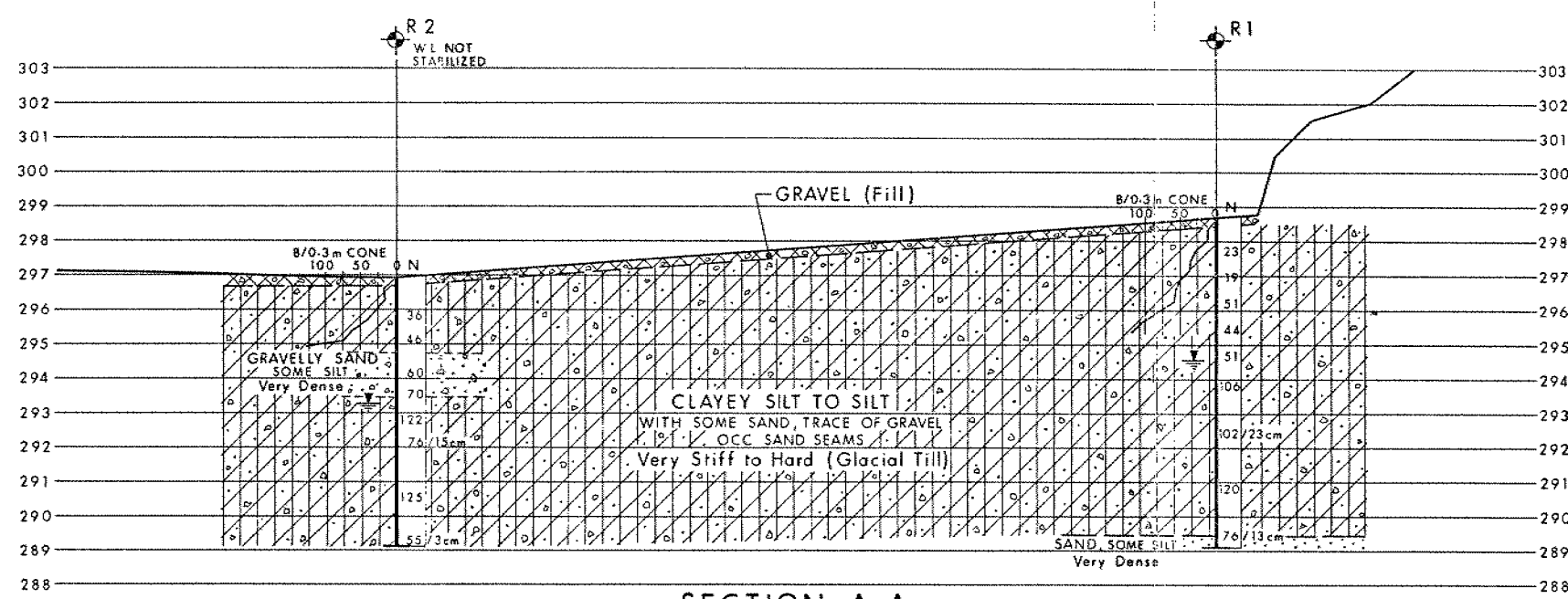
REV	DATE	BY	DESCRIPTION

Geocres No 40P2-45

HWY No 401	DIST 2
SUBMITTED BY: CHECKED: DATE 1990 09 12	SITE 23-170
DRAWN: CHECKED: APPROVED:	DWG 4818903-A



NOTE:  
Contours in the area of retaining wall location do not reflect actual conditions encountered at time of field investigation.

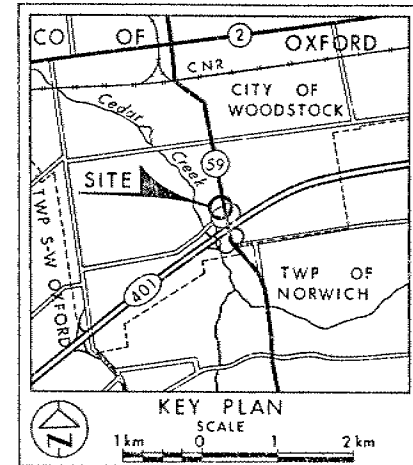


**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

CONT No  
WP No 481-89-03  
ATHLONE AVE (N/S-W RAMP)  
RETAINING WALL  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1990 04

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
R1	298.7	4 775 135.0	204 146.0
R2	296.9	4 775 107.0	204 094.0

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 42 P2-45

HWY No 401/59 DIST 2  
SUBMIT: M.V. CHECKED: DATE 1990 09 14 15 TE  
DRAWN: CHECKED: APPROVED: DWS 4818903-B