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W. O. No.

STR. SITE No. 385-111

HWY. No. 17

LOCATION Hwy 17 & Echo Bay Bridge

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-218



Ministry of
Transportation

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

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

REPORT
ON
GEOTECHNICAL INVESTIGATION
FOR
PROPOSED CROSSING
AT
ECHO-BAY AND HIGHWAY 17
DISTRICT NO. 18 (SAULT STE. MARIE)
W.P. 185-79-01
SITE NO. 38S-111

1.0 INTRODUCTION

The investigation described in this report was carried out at the request of the Ministry of Transportation, Foundation Design Section, for the purpose of providing geotechnical input for the design of a permanent bridge and a temporary detour structure on Highway 17 at Echo Bay, near Sault Ste. Marie,

The investigation was authorized by Engineering Agreement No. 4238-9089-237 dated August 14, 1989. The scope of the investigation was proposed by Geo-Canada Ltd. and accepted by the Foundation Design Section of M.T.O. It was to consist of eight (8) boreholes taken to about 18 m to 20 m depth, two

.../...

(2) of which would be on the lake, using a raft. Due to the unexpected thickness of the soft deposit at the site, the boreholes were extended to between 37.5 and 37.8 m, and dynamic cone penetration tests were performed in selected boreholes to depths of 48.8 m. In view of the uniform conditions found to a great depth, it was also decided, in consultation with M.T.O., to delete the two boreholes on the lake.

The field work for the investigation was carried out between September 28 and October 23, 1989, using a bombardier mounted mobile B-57 auger drill rig. An engineer from our office supervised the fieldwork and logged the soil conditions.

All the boreholes were drilled using hollow stem augers. Soil samples were taken at 0.76 m to 3 m intervals of depth by the standard penetration test method. Below each sample, in the clay deposit in situ vane shear tests were performed to evaluate the undrained shear strength of the clay. Boreholes 1, 3 and 6 were extended by a dynamic cone penetration test in order to assess the consistency of the clay at greater depth and to probe for a possible deeper lying bearing stratum for end-bearing piles. Dynamic cone penetration tests were also performed in the surface sand .../...

layer adjacent to Boreholes 2 and 5.

In addition to the boreholes, we also performed probings of the lake bed at the location of the piers of the temporary bridge structure to detect any boulder or other obstructions at shallow depth. The probings were performed manually using a 75 mm wide by 25 mm steel channel. The maximum depth of probing was 450 mm.

The soil samples were brought to our laboratory where they were selectively tested. The tests included natural moisture contents, grain size distribution, consistency (Atterberg) limits, unconsolidated undrained triaxial tests, and consolidation tests.

During the drilling of Borehole 4, the driller miscounted the number of drill rods. Because of this, the standard penetration blow counts of Samples 15 to 18, as well as the vane shear results immediately below these samples probably do not reflect the true soil condition at that depth.

Drawing No. 1857901-A* shows the borehole locations. The borehole elevations were established by surveying with reference to geodetic Benchmark No. 627 located in the abutment of the existing railway bridge just .../...

* DWG NO 2 OF THE CONTRACT DWG'S

north of the site. The geodetic elevation of this benchmark is 181.369 m.

2.0 DESCRIPTION OF THE SITE

The site is located about 20 km east of the City of Sault Ste. Marie, at the position where Echo Bay widens into Lake George. The terrain along the lakeshore is generally relatively flat, lying between about Elevations 178 m and 180 m ±.

Highway 17 is carried across Echo Bay partly by a bridge and partly by two earth embankments (causeways). The existing bridge is a three span structure with concrete deck on steel girders, and is about 47 m long. The bridge deck is at Elevation 180.5 m ±. At the time of the field investigation, the lake level dropped from Elevation 176.6 to 176.2 m. At the deepest point along the existing bridge the lake bed is at Elevation 170.4 m.

The foundation details of the existing bridge are not known, except that about ten years ago the pier supports were strengthened with additional timber piles.

Geological references indicate that the Sault Ste. Marie area

.../...

is underlain by thick deposits of clay and silt (varved clay) laid down some 10,000 years ago when the glacial Lake Algonquin flooded the whole area. Interbedded with the varved clay are layers of stratified silts and sands deposited in various stages as the land mass gradually rose and the lake receded. In more recent times alluvial deposits of sand were added by the St. Mary's River and its tributaries.

3.0 SUBSURFACE CONDITIONS

3.1 General

The general soil stratigraphy is comprised of sand and sand fill overlying a thick deposit of silty (varved) clay. A second layer of (silty) fine sand and a layer of silt were found embedded in the varved clay in many of the boreholes. In general, the sand deposits are very loose to compact, and the silty (varved) clay is firm, becoming stiff at greater depth.

Three of the boreholes were drilled at the lake bottom (i.e. under water). In the other three boreholes the groundwater table also coincided with the lake level which at the time of the investigation was between Elevations 176.2 and 176.6 m.

.../...

The subsurface conditions are described in detail on the individual borehole logs. The main characteristics of the soil types encountered are discussed briefly in the following sections, and are summarized in Table 1.

3.2 Fill

Fill was identified in Borehole 6 to a depth of 6.6 m (Elevation 173.8 m). In Borehole 1 the upper portion of the sand, to about 2.5 m depth, is likely to be fill, and the near surface sand materials found in the other boreholes could also be fill.

The fill is composed mainly of sand and a trace of silt. Two typical samples of the fill were analysed and found to contain 96 to 98% sand, and 2 to 4% silt. These grading curves are shown in Figure 1. The moisture contents of the fill range from 6 to 28%. Below the water table the fill is saturated.

Eight standard penetration tests were performed in the fill, with "N" values ranging from 1 to 38 blows per 0.3 m.

3.3 Fine Sand

This deposit was contacted in all the boreholes below the
.../...

fill or at the lakebed and extends to between Elevations 170.0 m and 167.7 m.

The sand is a poorly graded soil, containing just a trace of silt. The results of the grain size analyses indicate that the sand is composed of 0 to 4% gravel, 93 to 99% sand, and 0 to 3% silt. Gravel was found in only three of the ten samples tested. These results are shown plotted in Figure 2. The sand is mostly saturated, with moisture contents of 18 to 28% (17 samples) except the first sample in Borehole 2, which is above the lake and has 3% moisture.

The "N" values obtained in the sand varied between 0 (i.e. the sampler sank into the sand under the weight of the drill rods) to 24 blows per 0.3 m, indicating very loose to compact conditions.

3.4 Silty (Varved) Clay

This soil unit constitutes the majority of the soil profile. It underlies the fine sand in every borehole. Its upper surface lies between Elevations 167.7 and 170.4 m. The clay can be divided into two or three sub-units, separated by a sand, silty sand, and/or a clayey silt layer. The full thickness of the clay deposit was not penetrated. The

.../...

maximum depth of the boreholes was 37.8 m, and a cone was driven to 48.8 m depth in three of the boreholes without encountering refusal or a noticeable increase in driving resistance. From this it is inferred that the silty (varved) clay extends to at least 48.8 m depth (Elevation 128.0 m).

The clay has a layered (varved) structure, consisting of alternate thin layers of silty clay and clayey silt. In most cases the silt seams are very thin (less than 2 mm), but occasionally silt seams (and a sand seam) of up to 150 mm were found.

Five grain size analyses were performed on representative, but composite samples of the clay-silt soil. The results are plotted in Figure 3. The tested samples contain 0 to 1% sand, 7 to 35% silt, and 65 to 82% clay.

The plasticity of the clay was evaluated by 38 Atterberg limits tests. Its liquid limits are between 42 and 81%; its plastic limits are 17 to 31%; and its plasticity indices are 25 to 53, except for one sample which has liquid limit, plastic limit and plasticity indices of 25%, 13% and 12 respectively. Thus, in general, the clay has high plasticity. The natural moisture contents of the clay are 42 to 84%, most of which are close to the liquid limit of the

.../...

soil. The liquidity indices range from 1.4 near the surface of the clay to 0.6 at greater depths. The sand and silt seams in the clay have moisture contents of 20 to 42%.

The standard penetration test blow counts obtained in the clay are from 0 to 16 blows per 0.3 m, but the average value of the 70 SPT performed in the deposit is only 2.3. The undrained shear strength (S_u) of the clay was evaluated by in situ vane shear tests. The values ranged from as low as 9 kPa (very soft) to 106 kPa (very stiff). Some of the low values in Borehole 4 are probably due to the clay being inadvertently disturbed when the driller miscounted the number of drill rods. Discounting these low values, the remaining S_u values are between 21 kPa and 106 kPa, i.e. the consistency of the clay is firm to very stiff, but mostly firm to stiff. The sensitivity of the clay (i.e. the ratio of undisturbed to remoulded shear strength) was found to be between 1.2 and 5.7, i.e. low sensitivity.

The undrained shear strength of the clay was further evaluated by four unconsolidated undrained triaxial tests on relatively undisturbed thin wall tube samples. The results range from 18 to 48 kPa.

A plot summarizing the variations of the undrained shear

.../...

strength values with depth (elevation) are presented on Figure 8.

Two consolidation tests were performed on the clay, and the results are shown on Figures 6 and 7. The compression indices of the samples tested are 1.34 and 0.52. Their bulk unit weights and initial void ratios are 15.5 and 17.3 kN/m³, and 2.08 and 1.41, respectively. The preconsolidation pressures are found to be the same as the effective overburden pressure, i.e., the clay appears to be normally consolidated.

3.5 Lower Sand

In Boreholes 2, 3, 5 and 6, a layer of sand was contacted at Elevations between 165 and 162 m. The thickness of this lower sand layer is between 1.8 and 4.6 m.

This sand layer is very similar in composition to the sand layer at the surface of the boreholes. Figure 4 shows three grading curves of the lower sand. These samples contain 91 to 97% sand and 3 to 9% silt. It has moisture contents of 20 to 32%, and "N" values of 3 to 22 blows per 0.3 m, which indicate very loose to compact conditions.

.../...

3.6 Clayey Silt

A 2.4 to 3.1 m thick layer of clayey silt to silt exists in Boreholes 1 and 5 at about Elevations 157 and 159 m respectively. A typical sample of the silt is found to be composed of 4% sand, 69% silt and 27% clay (see Figure 5). Its liquid limits, plastic limits, and plasticity indices are 19% to 23%, 16 to 17%, and 2 to 7 respectively. Its natural moisture contents are between 22% and 35%.

Standard penetration tests gave "N" values of 0 and 9 blows per 0.3 m. In situ vane shear tests indicated undrained shear strength of 35 to 59 kPa with sensitivity of 2.0 to 4.0. Thus, the silt is firm to stiff.

3.7 Groundwater

It is expected that the position of the groundwater table at the borehole locations will fluctuate with the lake level, which during the time of the field investigation dropped from Elevation 176.6 m to Elevation 176.2 m.

Records kept by the Marine Environmental Data Service, Department of Fisheries and Oceans, indicate that the highest daily average water level in Lake Huron was 177.4 m, while the lowest daily average was 175.4 m.

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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.

A P P E N D I X

TABLE 1
SUMMARY OF SOIL PROPERTIES

Material	"N"	Moisture Content (%)	W L (%)	W P (%)	I p	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
Sand Fill	1 to 38	6 to 28				0	96 - 98	2 - 4	--
Fine Sand	0 to 24	6 to 28				0 - 4	93 - 99	0 - 3	--
Silty Clay	0 to 16	42 to 84	25 - 81	13 - 31	12 - 53	0	0 - 2	17 - 35	65 - 82
Lower Sand	4 to 22	20 to 32				0	20 - 97	3 - 72	0 - 8
Clayey Silt	0 to 9	22 to 35	19 - 23	16 - 17	2 - 7	0	4	69	27

RECORD OF BOREHOLE No 1

METRIC

W P 185-79-01 LOCATION Sta. 10 + 004, O/S 14.5 m RT C/L HWY 17
DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test
DATUM Geodetic DATE 1989 10 01 to 04

ORIGINATED BY JN

COMPILED BY JN

CHECKED BY IPL

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
176.8	Ground Level												GR SA SI CL
0.0	wood pieces FINE SAND		1	SS	35/0	176							
	wood pieces		2	SS	4								
	trace of silt poorly graded saturated brown very loose to compact (possibly fill to 2.5 m depth)		3	SS	23	174							
			4	SS	18								
			5	SS	24	172							0 98 2 -
			6	SS	6								0 98 2 -
			7	SS	19	170							
			8	SS	5								
			9	SS	18	168							0 99 1 -
167.7													
9.1	SILTY (VARVED) CLAY		10	SS	7								
	interbedded with thin silt seams high plasticity red/brown firm		11	SS	3	166	3.0						1 27 72 -
			12	SS	3	164	4.0						
			13	SS	1	162	4.0						
			14	SS	0	160	2.5						
			15	SS	0	158	4.0						
			16	SS	0	156	3.5						
157.0													0 4 69 27
19.8	CLAYEY SILT		17	SS	0	154	4.0						
	slightly plastic saturated grey firm		18	SS	0	152	3.0						
153.9													
22.9	SILTY (VARVED) CLAY		19	SS	0								
	interbedded with thin silt seams high plasticity		20	SS	0		3.5						
150.9													
25.9	Continued												

+3, x5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 1 (CONT.)

METRIC

W P 185-79-01 LOCATION Sta. 10 + 004, O/S 14.5 m RT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test COMPILED BY JN
DATUM Geodetic DATE 1989 10 01 to 04 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
150.9	Continuation						20 40 60 80 100		20 40 60					GR SA SI CL	
25.9	SILTY (VARVED) CLAY interbedded stiff with thin silt firm seams high plasticity		21	SS	0		150	2.5							
			22	SS	0		148	2.8							
			23	SS	9		146	2.5							
			24	SS	7		144	2.3							
			25	SS	*		142	2.3							
	red/brown grey		26	SS	*		140	2.3							
			27	SS	7									0 0.35 65	
	firm very stiff		28	SS	16										
139.3	END OF BOREHOLE														
37.5	SILTY CLAY firm to stiff (inferred)						138								
							136								
							134								
							132								
							130								
128.0															
48.8	END OF CONE TEST														
	* Drilling rod slipped, sampler penetrated more than 1 m into soil at bottom of hole														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 185-79-01 LOCATION Sta . 10 +034.5, O/S 3.5 m LT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger, wash boring and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 20 to 23 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
180.6	Bridge Deck													GR SA SI CL
0.0							180							
176.9	Ground Surface						178							
3.7	FINE SAND trace of silt, gravel some wood poorly graded saturated brown very loose to compact		1	BS			176							1 99 0 - Encountered boulder at 4 m. moved hole 450 mm S.E.
							174							
							172							
							170							
169.2			2	WS			168							
			3	SS	17		166							
			4	WS			164							
11.4	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity red firm		5	SS	0		162							
			6	SS	0		160							
			7	SS	0		158							
			8	SS	0		156							
162.5							154							
18.1	FINE SAND trace of silt saturated red loose to compact		9	SS	7		152							
			10	WS			150							
			11	SS	17		148							
159.1							146							
21.5	SILTY (VARVED) CLAY interbedded with thin silt sand seam seams high sand seam plasticity sand seam stiff silt seam		12	SS	0		144							
			13	SS	8		142							
			14	SS	0		140							
154.7							138							
25.9	Continued						136							

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2 (CONT.)

METRIC

W P 185-79-01 LOCATION Sta. 10 +034.5, O/S 3.5 m LT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger, wash boring and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 20 to 23 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
154.7	Continuation							SHEAR STRENGTH kPo						
								O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE						
								20	40	60	80	100		
								WATER CONTENT (%)						
								20	40	60				
25.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity stiff		15	SS	0		154							
							152			4.2				
							150							
			16	SS	0		148			3.4				
							146							
			17	SS	0		144			3.8				
142.8	red grey		18	SS	0					4.7				
37.8	END OF BOREHOLE													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 185-79-01 LOCATION Sta. 10 + 042, 0/S 4.3 m RT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 13 to 16 CHECKED BY IPL

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40							60	80	100
180.7	Bridge deck																	
0.0							180											
							178											
176.2	Water						176							2 97 1 -				
4.5																		
176.7	FINE SAND		1	SS	4													
4.6	trace of silt, gravel poorly graded brown		2	SS	2		174											
			3	SS	2		172							0 99 1 -				
	very loose																	
	loose																	
	brown		4 ^A	SS	6		170											
	pink																	
	loose																	
	compact		5	SS	18									0 99 1 -				
168.8																		
11.9	SILTY (VARVED) CLAY		6 ^A	SS	5		168											
	silt seam																	
	interbedded with		7	TW			166							15.3				
	thin silt seams																	
	high plasticity																	
	red		8	SS	0		164							84				
	firm to stiff																	
			9	SS	0													
162.4																		
18.3	SILTY FINE SAND		10	TW			162											
	poorly graded																	
	dilatant		11 ^A	SS	22		160							0 91 9 -				
	red/pink																	
	clayey		12 ^A	SS	19													
	compact																	
	silt to sand																	
157.8							158							0 20 72 8				
22.9	SILTY (VARVED) CLAY		14 ^A	SS	14		156											
	silt																	
	high plasticity																	
	stiff		15	SS	0													
	silt seams																	
154.8																		
25.9	Continued																	

RECORD OF BOREHOLE No 3 (CONT.)

METRIC

W P 185-79-01 LOCATION Sta. 10 + 042, O/S 4.3 m RT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 13 to 16 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
154.8	Continuation													
25.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity		16	SS	7		154							
							152	2.0						
		firm stiff					150						15.7	
			17	TW										
							148							
			18	SS	5									
							146	3.7						
		red grey					144							
143.1			19	SS	4									
37.6	END OF BOREHOLE SILTY (VARVED) CLAY stiff (inferred)						142							
							140							
							138							
							136							
							134							
131.9							132							
48.8	END OF CONE TEST													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 185-79-01 LOCATION Sta. 10 + 068, O/S 4.0 m LT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger COMPILED BY JN
 DATUM Geodetic DATE 1989 09 28 to 30 CHECKED BY IPL

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
180.7	Bridge deck												GR SA SI CL
0.0							180						
							138						
176.6													
4.1	WATER						176						
175.1	Lake bottom												
5.6	FINE SAND trace of silt poorly graded saturated						174						
	wood pieces		1	SS	0								
	very loose		2	SS	1								
			3	SS	5		172						0 99 1 -
	loose		4	SS	8								
	compact		5	SS	16								
170.0							170						
10.7	SILTY (VARVED) CLAY		6	SS	0			4.0					
	interbedded with thin silt seams		7	SS	0			+ 4.0					
	high plasticity		8	SS	0		168						
	red firm							+ 2.7					
			9	SS	0		166						
								+ 3.0					
			10	SS	0								
							164						
			11	SS	0			2.7					
							162						
			12	SS	0			+ 4.0					
							160						
			13	SS	0			+ 4.0					
							158						
			14	SS	0			+ 3.5					
							156						
			15	SS	0			+ 3.5					
								+ 1.5					
			16	SS	0			+ 2.0					
154.8													
25.9	Continued												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

probably
disturbed
due to
miscount of
drill rods

RECORD OF BOREHOLE No 4 (CONT.)

METRIC

W P 185-79-01 LOCATION Sta. 10 + 068, O/S 4.0 m LT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow steam auger COMPILED BY JN
DATUM Geodetic DATE 1989 09 28 to 30 CHECKED BY IPL

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

METRIC

W P 185-79-01 LOCATION Sta. 10 + 073, O/S 4.2 m RT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger, wash boring and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 17 to 19 CHECKED BY IPL

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
180.6	Bridge deck						20	40	60	80	100	20	40	60	GR SA SI CL			
0.0																		
176.2	Lake bottom																	
4.4	FINE SAND trace of organics trace of silt saturated brown loose to compact		1	SS	2	W.L.= 176.2									Encountered boulder at El.174.5 m moved hole 4 93 3 0			
			2	SS	12													
			3	WS											0 98 2 0			
169.9															wash boring			
10.7	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity red firm		4	SS	0													
			5	TW														
			6	SS	0													
			7	SS	0													
164.1																		
16.5	SILT																	
163.4			8	SS	0													
17.2	FINE SAND to SANDY SILT very loose		9	SS	3													
160.9																		
19.7	SILTY (VARVED) CLAY high plasticity pink firm to stiff		10	SS	5													
			11	TW														
157.7																		
22.9	CLAYEY SILT grey/red stiff		12	SS	0													
155.1																		
25.5			13	SS	9													
154.7	SILTY (VARVED) CLAY																	
25.9	Continued																	

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

RECORD OF BOREHOLE No 5 (CONT.)										METRIC						
W P 185-79-01		LOCATION Sta. 10 + 073, O/S 4.2 m RT C/L HWY 17				ORIGINATED BY JN										
DIST 18 HWY 17		BOREHOLE TYPE Hollow stem auger, wash boring and cone test				COMPILED BY JN										
DATUM Geodetic		DATE 1989 10 17 to 19				CHECKED BY IPL										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
154.7	Continuation							20	40	60	80	100				
25.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity stiff						154									
			14	SS	5		152									
			15	SS	5		150									
							148									
			16	SS	5		146									
							144									
143.1			17	TW												
37.5	END OF BOREHOLE															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

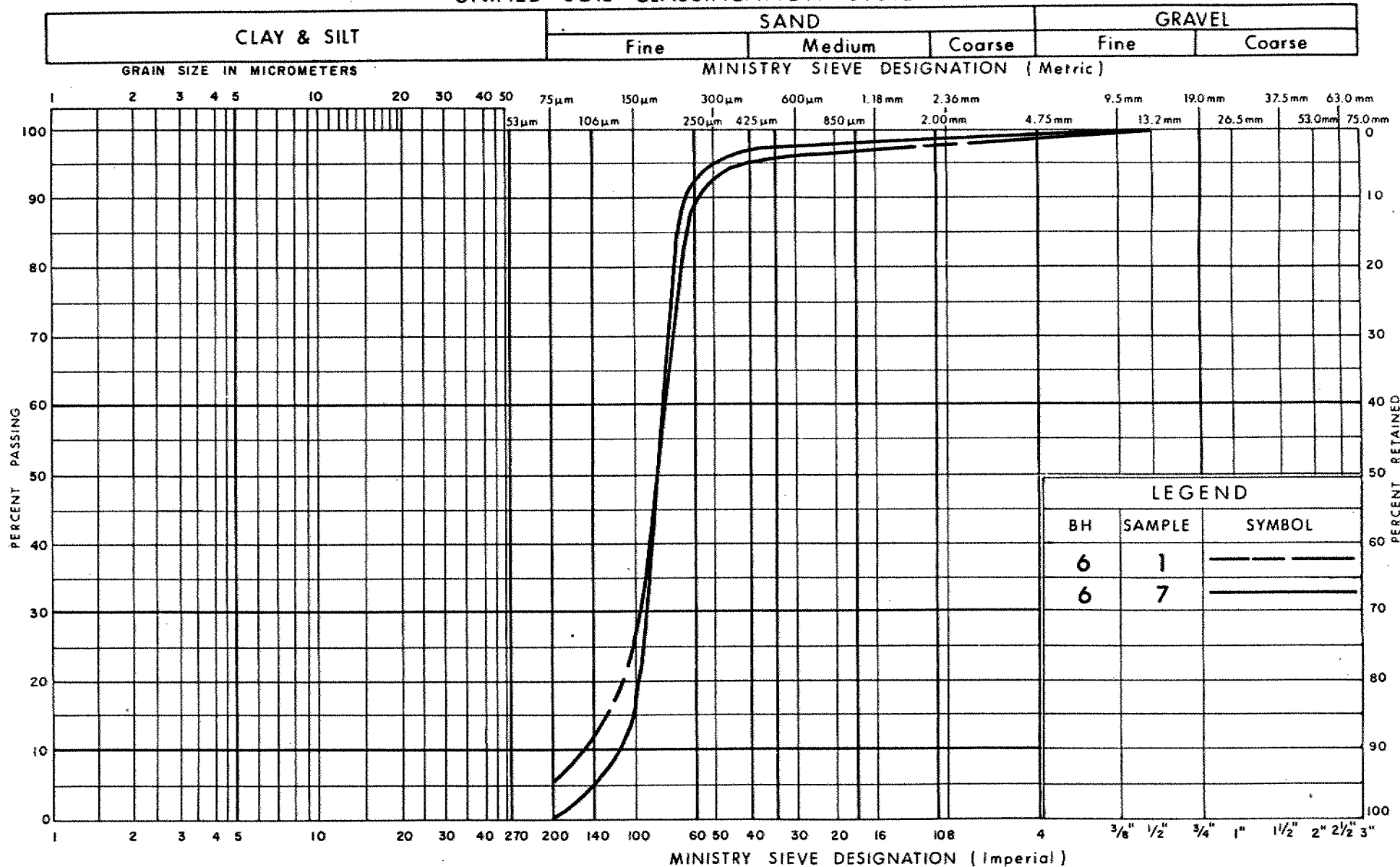
METRIC

W P 185-79-01 LOCATION Sta. 10 + 101, O/S 4.2 m RT HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow Stem auger and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 05 to 12 CHECKED BY IPL

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%)		
								SHEAR STRENGTH kPa							20 40 60		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
							20 40 60 80 100					20 40 60			GR SA SI CL		
180.4	Ground Level																
0.0	175 mm Asphalt		1	SS	30		180							0 96 4 -			
	FILL		2	SS	34												
	fine sand		3	SS	5		178										
	trace of silt		4	SS	4												
	brown		5	SS	1		176										
	very loose to dense		6	SS	19									0 98 2 -			
	saturated		7	SS	7												
173.8			8	SS	38		174										
6.6	FINE SAND		9	SS	11												
	trace of silt		10	SS	7		172										
	poorly graded		11	SS	16												
	saturated						170										
	pink																
	loose to compact						168		2.6								
	some wood																
170.0																	
10.4	SILTY (VARVED) CLAY		12	SS	0		166										
	interbedded with		13	SS	0												
	thin silt seams		14	SS	0												
	high plasticity						164										
	red																
	firm																
165.0														0 97 3 -			
15.4	SILTY FINE SAND		15	SS	4		162										
	red																
163.2	very loose		16	SS	0		160										
17.2	sand seam																
	SILTY (VARVED) CLAY																
	silt seam		17	SS	5		158										
	high plasticity																
	red		18	SS	0												
	firm						156										
	stiff																
	silt seam		19	SS	6												
			20	SS	0												
			21	SS	0												
154.5																	
25.9	Continued																

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

SAND FILL

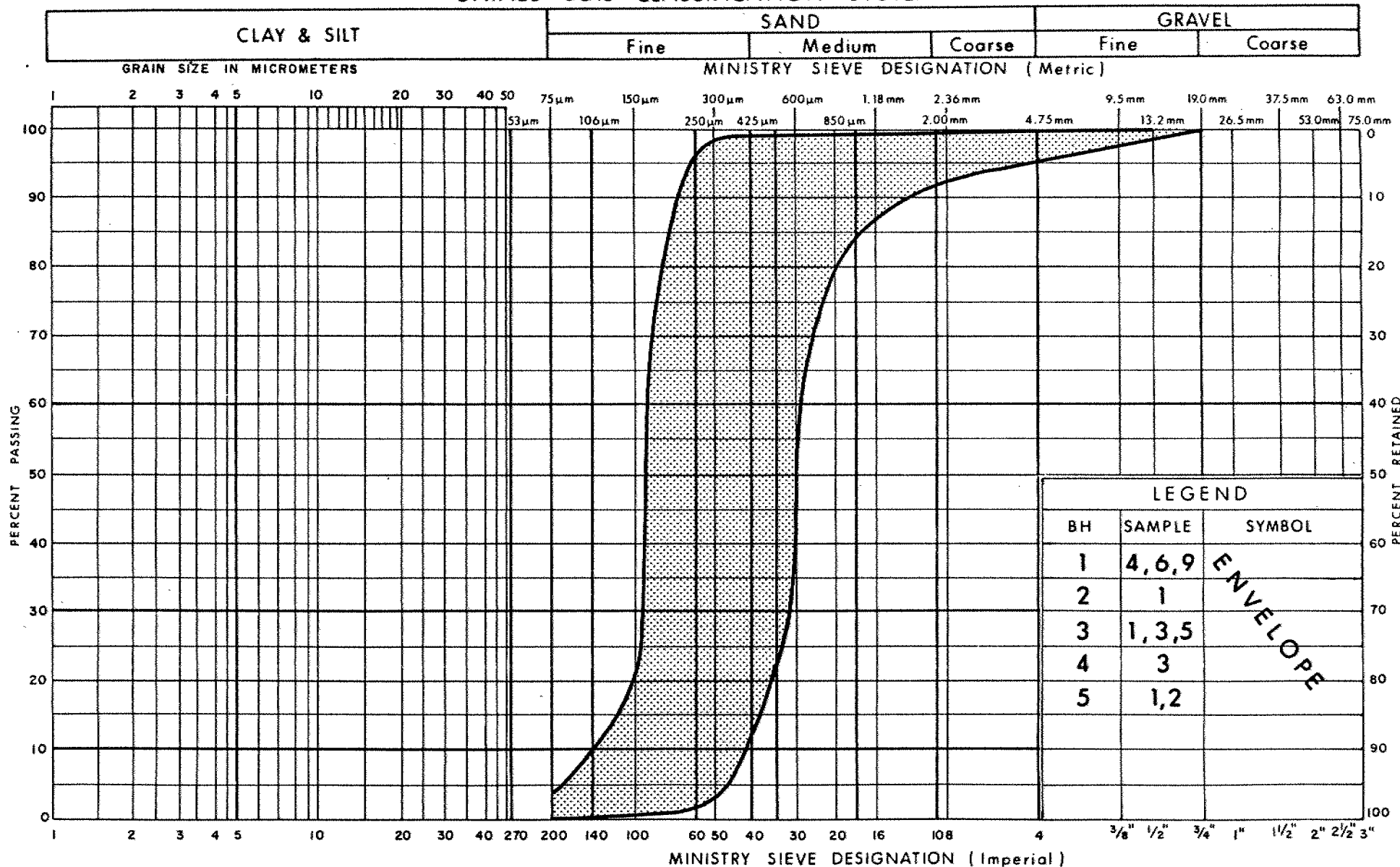
FIG No 1

W P 185 - 79 - 01

DATE Nov. 89

29

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
TransportationGRAIN SIZE DISTRIBUTION
FINE SAND

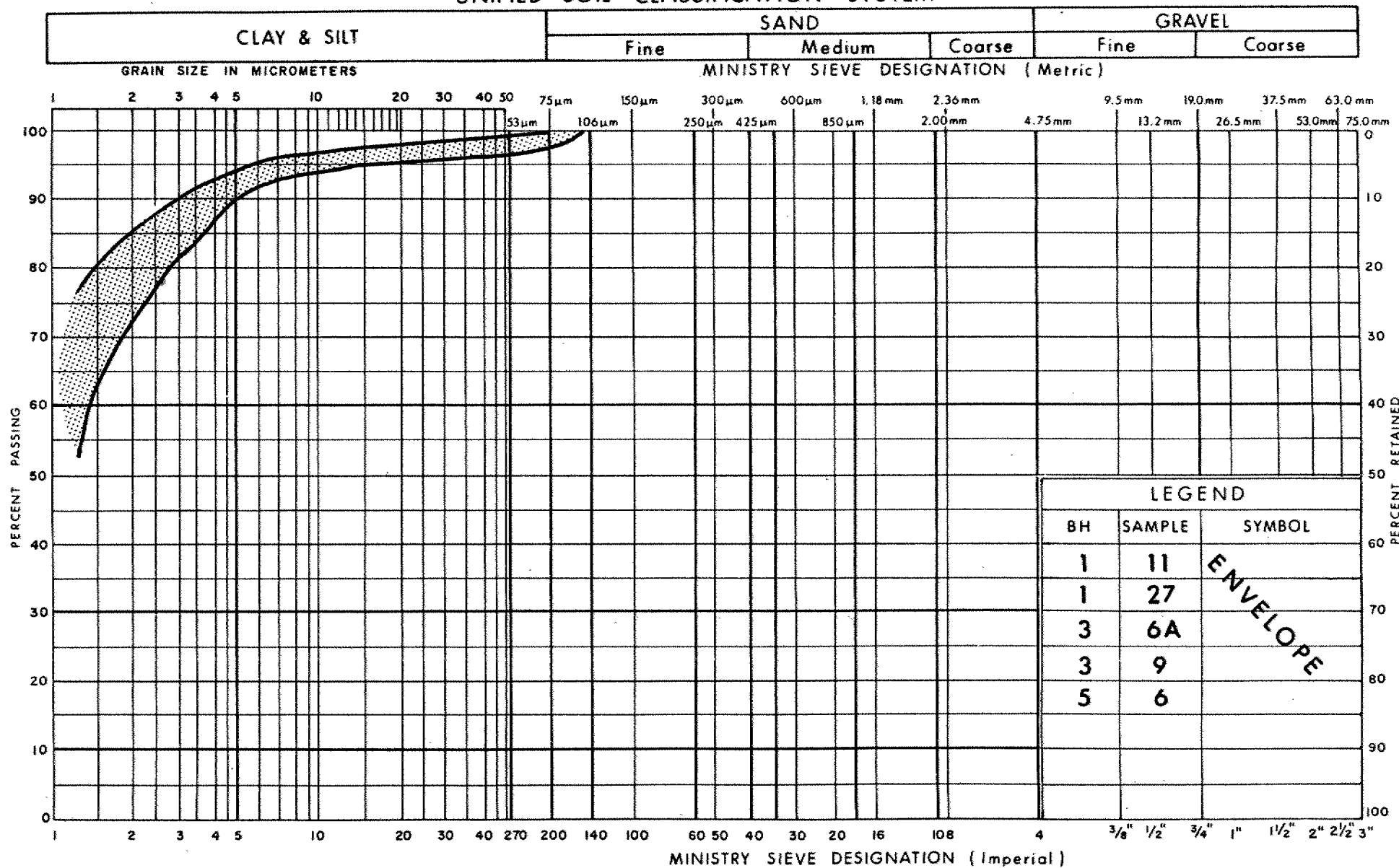
FIG No 2

WP 185-79-01

DATE Nov. 89

30

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

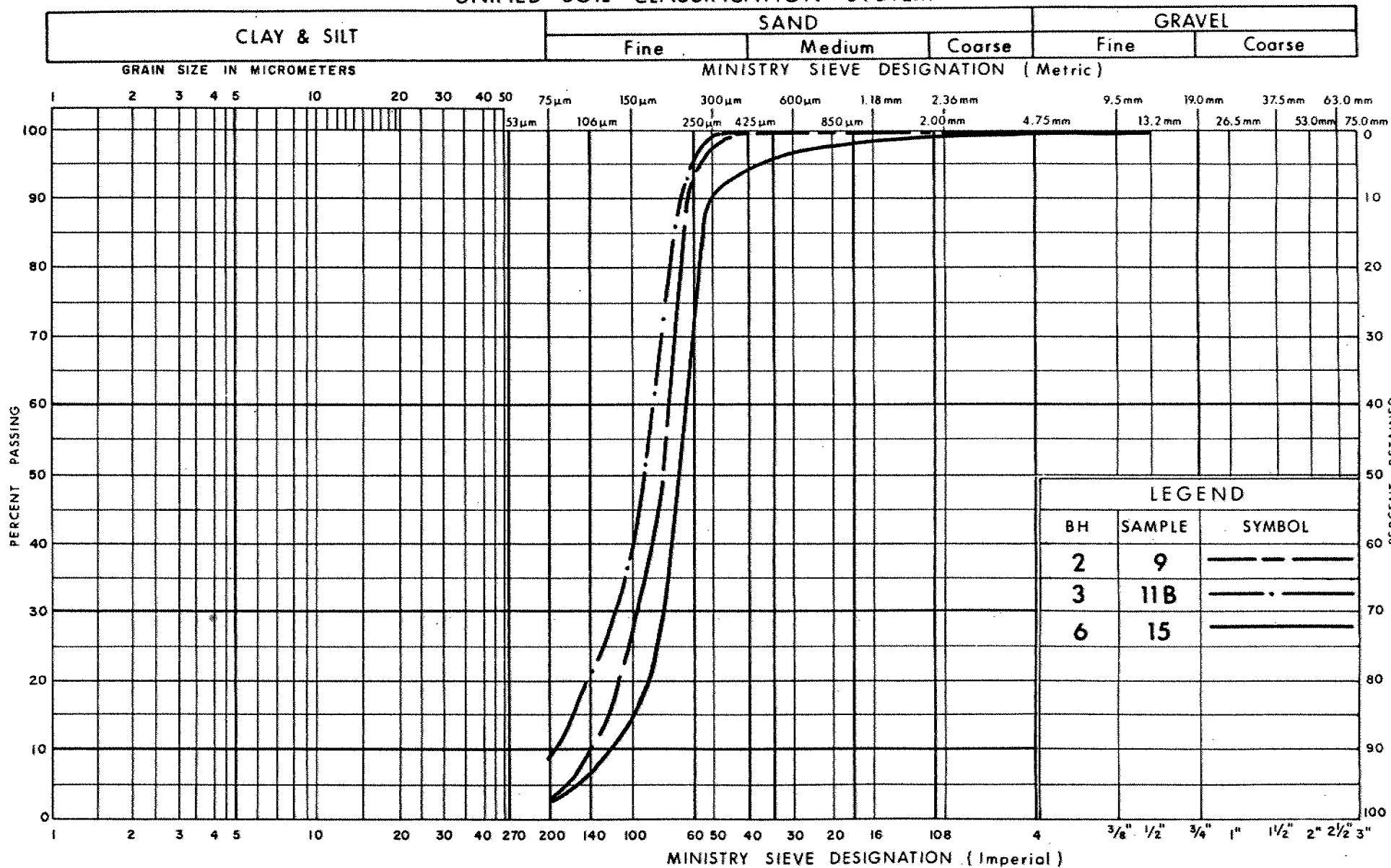
SILTY CLAY

FIG No 3

W P 185 - 79 - 01

DATE Nov. 89

UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

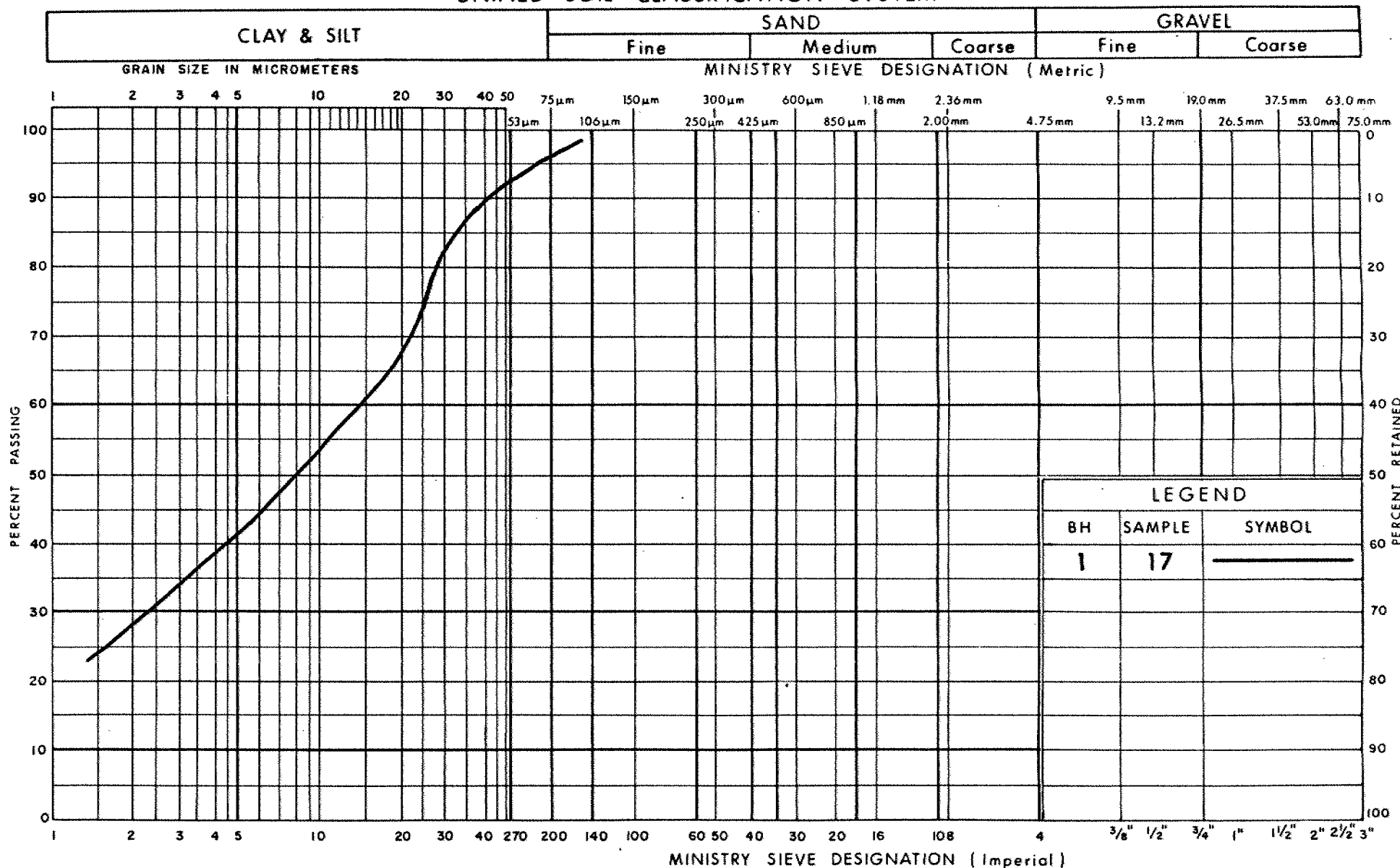
GRAIN SIZE DISTRIBUTION LOWER SAND

FIG No 4

W P 185 - 79 - 01

DATE Nov. 89

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

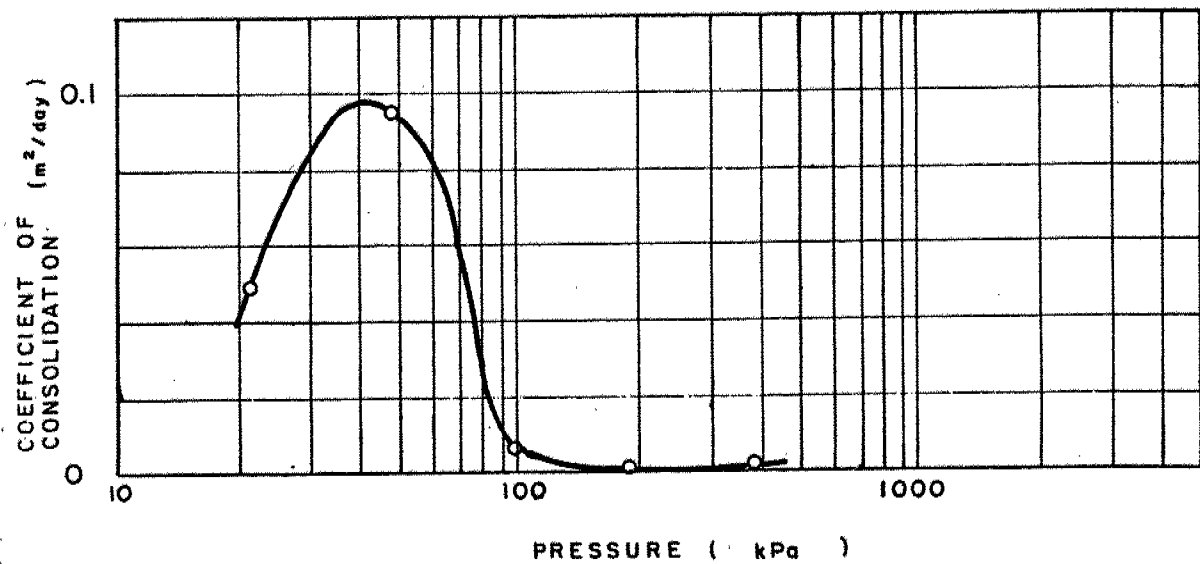
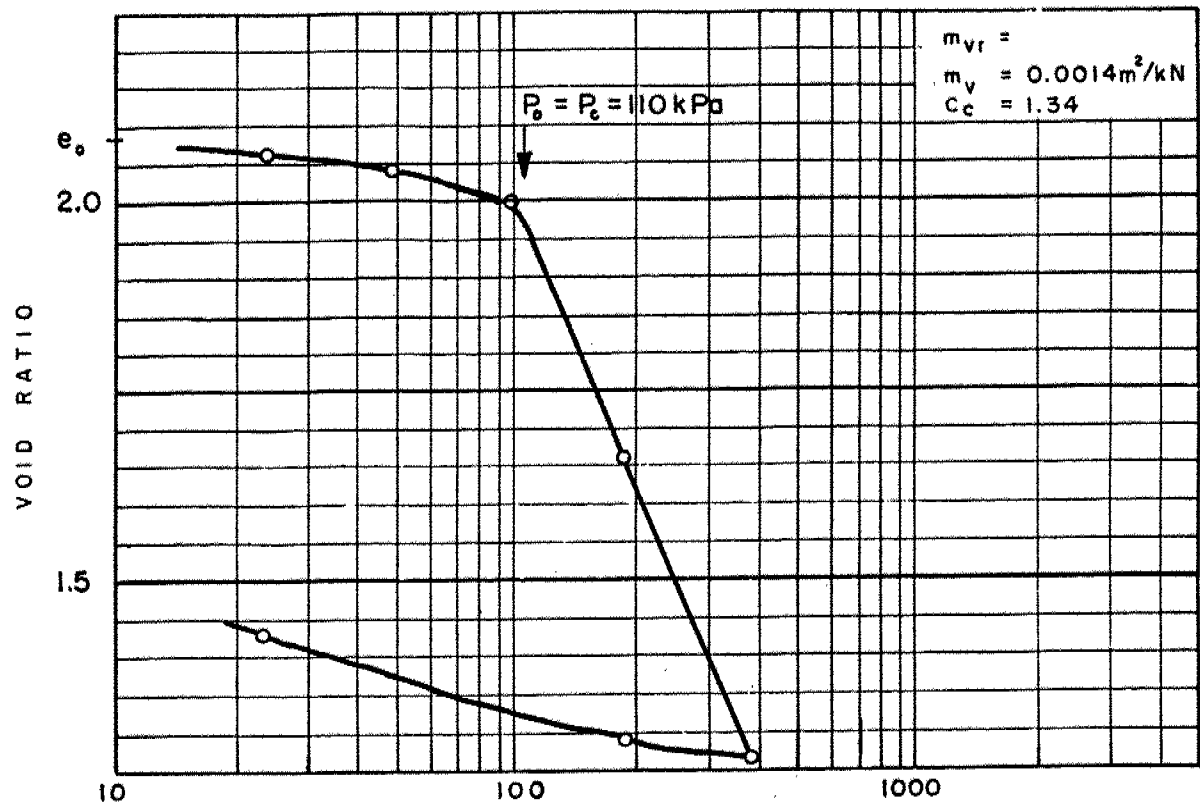
GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No 5

WP 185 - 79 - 01

DATE Nov. 89

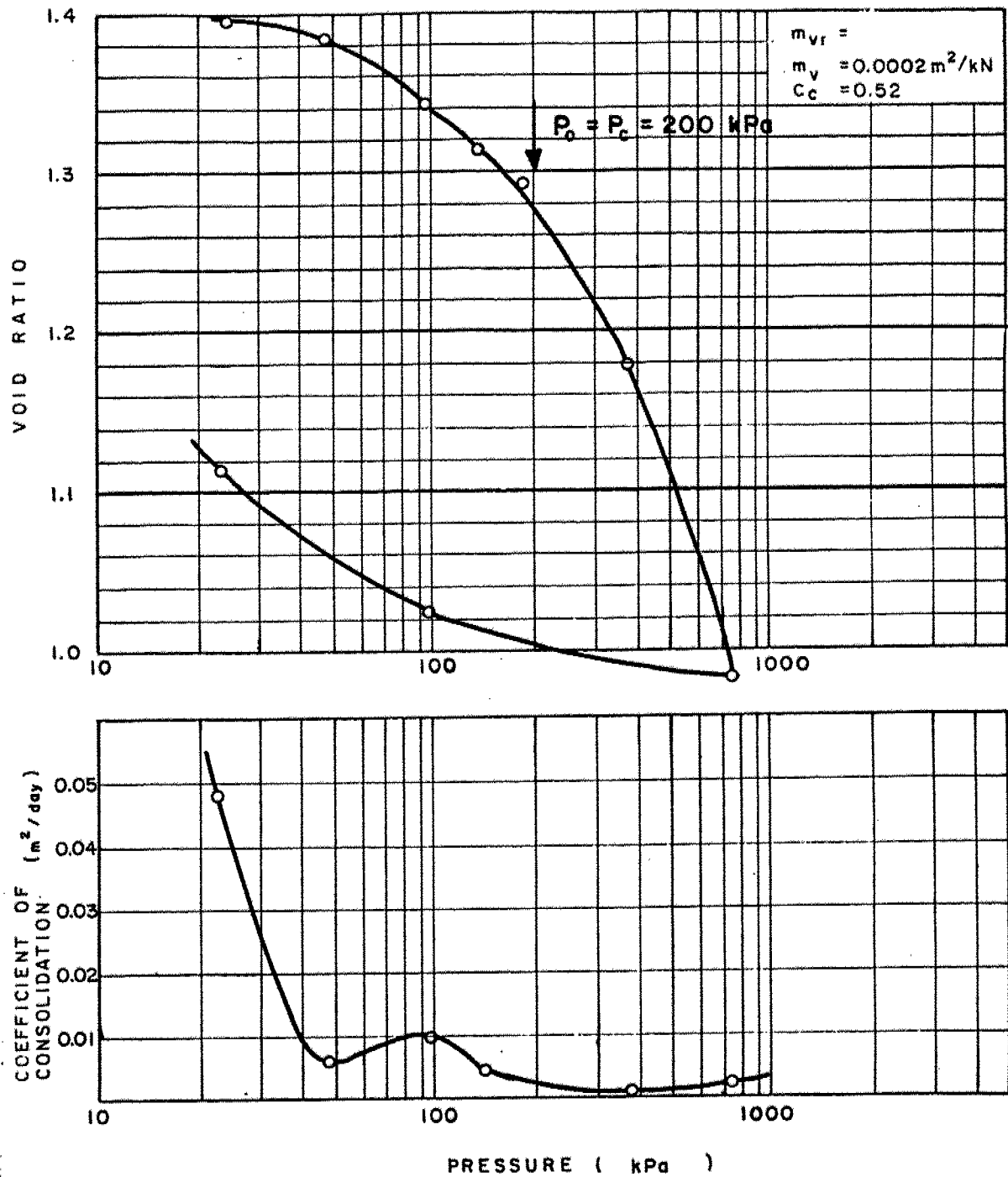


BOREHOLE 3
 SAMPLE 7
 DEPTH / ELEV. 9.7 / 166.5m

CONSOLIDATION TEST

WP185-79-01

FIGURE 6

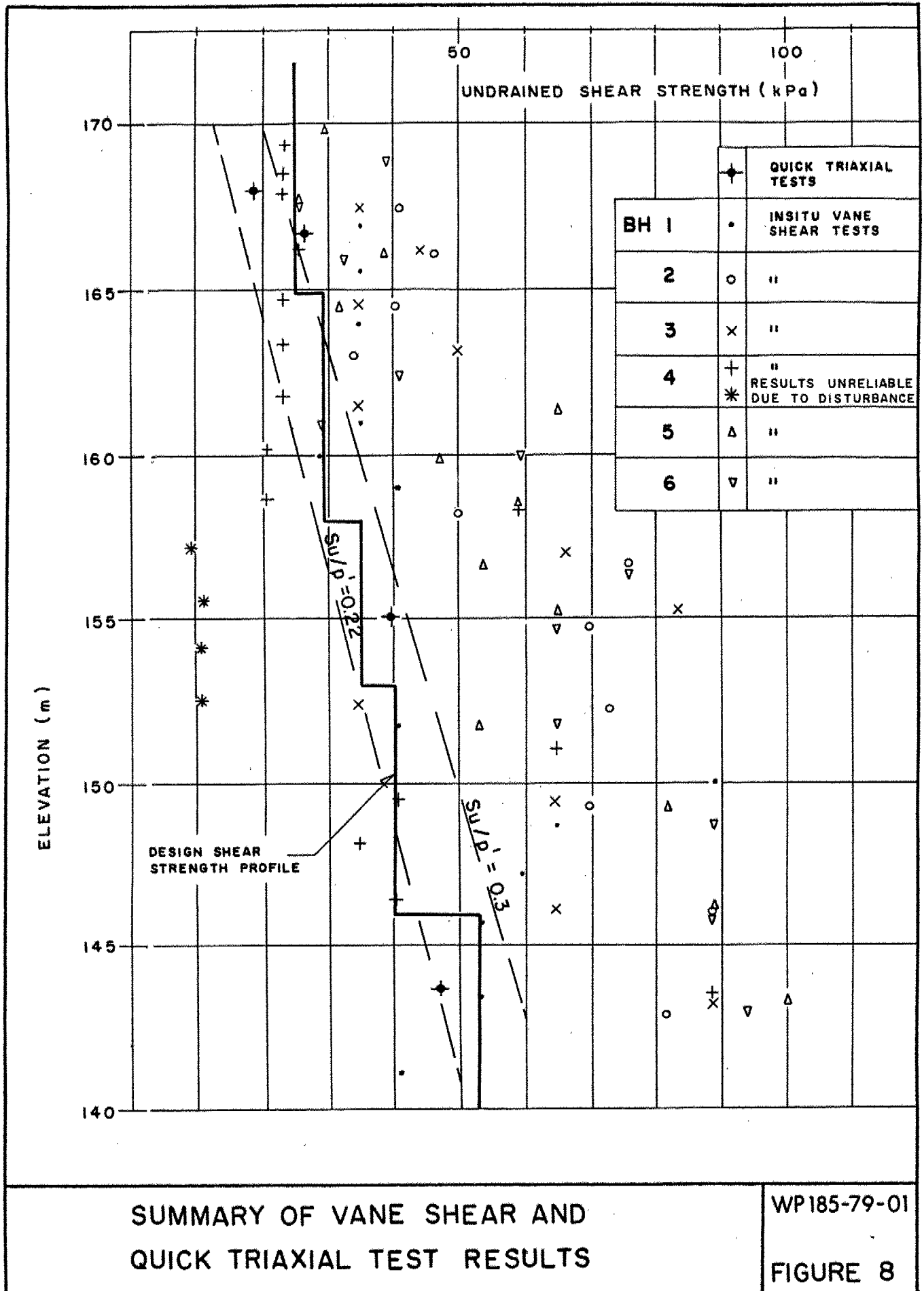


BOREHOLE 5
 SAMPLE 17
 DEPTH / ELEV. 36.9 / 143.7

CONSOLIDATION TEST

WP185-79-01

FIGURE 7



WP185-79-01

FIGURE 8

FOUNDATION INVESTIGATION REPORT

For

W. P. 279-85-01

Root River Bridge, Hwy. 17

District #18, Sault Ste. Marie

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-noted site.

The fieldwork for this project was carried out during the period from 86 04 01 to 86 04 11 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollowstem augers and 60 mm I.D. B-Casing. Also, a diamond drill equipped with 60 mm I.D. B-Casing and 76 mm I.D. N-Casing was utilized. The investigation consisted of 7 sampled boreholes [numbered BH#1 to BH#7] supplemented with Cone Penetration Tests. The boreholes ranged in depth from 9.1 m [BH#1] to 34 m [BH#3].

SITE DESCRIPTION AND GEOLOGY

The site is located about 1 km east of the Sault Ste. Marie City Limits, within Garden River Indian Reserve #14 in the District of Algoma. The Ministry's Right-of-Way is bounded by the Garden River Indian Reserve on the south side and the Canadian Pacific Railway Right-of-Way on the north side of the highway.

Topography at the site is gently rolling with some hills in the surrounding vicinity. The Root River is a shallow, medium to fast flowing river at the site crossing. It has a relatively wide valley, but is not well incised. Water elevation was fairly constant during the time of the investigation, but may fluctuate depending on the season.

Geologic references indicate that the site lies within a lacustrine deposit. In the Pleistocene epoch a glacio-alluvial belt of "beach like" sand was deposited across this region. This belt abuts the hills of the Precambrian Shield to the north and the St. Mary's River to the south. Sedimentary bedrock of the Jacobsville Formation underlies the lacustrine deposit at a depth ranging between 50-100 m.

In the vicinity of the site, land use is primarily rural residential with some limited industrial development.

SUBSURFACE CONDITIONS

General

The subsurface conditions can be summarized briefly as follows: Underlying a veneer of topsoil, the area is predominantly covered with deposits of poorly graded sand with a thickness of about 30 m. This granular deposit is underlain by a stratum of silty clay to clay whose thickness was not established in this investigation.

The boundaries of the subsoil types, in-situ and laboratory test results, as well as groundwater levels are shown on the Record of Borehole Sheets in the Appendix. The location of each borehole is shown in plan on Dwg. No. 2798501-A* together with 3-stratigraphical sections.

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

Fill

A boundary between the native soil and the embankment fill was not distinctly apparent. However, the upper zones of the fill material consisted of sand with occasional isolated pockets of gravel, clay, or organics. Occasional cobbles were also encountered.

It is evident that the material used for the embankment construction was local material obtained from a location relatively close to the site.

Topsoil

The site is covered by a veneer of topsoil generally in the order of 150 mm in thickness. However, the thickness of this organic deposit may vary across the site. No sampling or testing of this material was carried out.

Sand

The predominant deposit across this site consists of sand. The thickness of this deposit ranges between a minimum of 6.6 m in the area of BH#6, to 28.3 m in the vicinity of BH#3. These thicknesses include the depth of the fill which essentially is the same composition.

* DWG NO 2 OF THE CONTRACT DWG'S

Grain size distribution testing was carried out on 14 samples of this non-cohesive deposit. Three slightly different compositions are evident: sand trace silt; sand some silt; and sand trace silt, gravel. Generally, the silt content increases slightly with depth. In the vicinity of BH#7, the sand deposit was found to include trace gravel.

Of the 14 samples tested, 10 were composed of sand trace silt. The results of these tests are shown in envelope form on Figure #1 in the Appendix and can be summarized as follows:

	<u>Gravel</u>	<u>Sand</u>	<u>Silt</u> <u>Clay</u>
Range %	0	85 - 99	(1-15)*
Average%	0	95	(5)*

* % of silt and clay size particles combined

Figure #2 in the Appendix illustrates the results of gradation tests carried out on 2 samples of the sand deposit [BH#7, #1 and #6] which contained trace gravel, silt.

Figure #3 in the Appendix illustrates the results of gradation tests carried out on 2 samples of the sand deposit [BH#4, #15 and BH#6, #3] which contained some silt (up to 21%).

It should be noted, however, that the composition of the sand deposit may vary randomly with depth and location. Figures #1, #2 and #3 serve only to illustrate the results of the samples tested. Cohesive seams may also be encountered occasionally and randomly throughout the deposit.

Based on the results of the grain-size distribution tests it is evident that the sand sized particles in this deposit can be described as medium to fine size.

Based on the interpretation of Standard Penetration Test "N" values, this non-cohesive deposit is generally in a loose to compact state. With depth, however, the deposit becomes more dense.

It should be noted that when this material is subjected to an unbalanced hydrostatic pressure, "boiling" may result.

Silty Clay to Clay

In BH#3, a deposit of silty clay to clay was encountered at a depth of 28.3 m below the ground surface. The full lateral or vertical extent of this deposit was not established.

The results of 3 Atterberg Limits Tests carried out on samples from BH#3 are shown on Figure #4 in the Appendix and are summarized as follows:

<u>Sample #</u>	<u>W %</u>	<u>W_L %</u>	<u>W_p %</u>	<u>I_p %</u>
8	37.5	53	19	34
9	29.5	42	14	28
10	41	62	20	42

Based on these results, the deposit can be described as a silty clay of intermediate plasticity (CI group) to a clay of high plasticity (CH group).

The results of laboratory shear strength tests indicate that with the area investigated, the consistency of the deposit ranges from stiff to firm.

The unit weight of this cohesive material was measured to be 18.7 and 17.9 kN/m³ in two "undisturbed" samples.

Occasional seams of sand were encountered within this deposit.

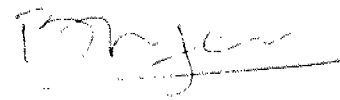
Groundwater Conditions

Stabilized groundwater levels were measured in open boreholes. The measurements indicate that the groundwater elevation, at the time of investigation, varied between 177.3 m and 179.6 m. Generally, it can be assumed that the groundwater level across the site is governed by the water level in Root River. At the time of the investigation, the water level in the river was found to be at Elevation 177 m.

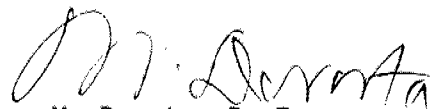
MISCELLANEOUS

The fieldwork for this investigation was carried out during the period from 86 04 01 to 86 04 11 under the supervision of D. Protulipac and J. Fellenius (Student Engineers). The equipment used was owned and operated by Dominion Soil Investigation Inc. of Toronto, and by Marathon Drilling Inc. of Ottawa.

This report was prepared by L. Politano and D. Protulipac, and was reviewed by M. Devata, Chief Foundations Engineer.



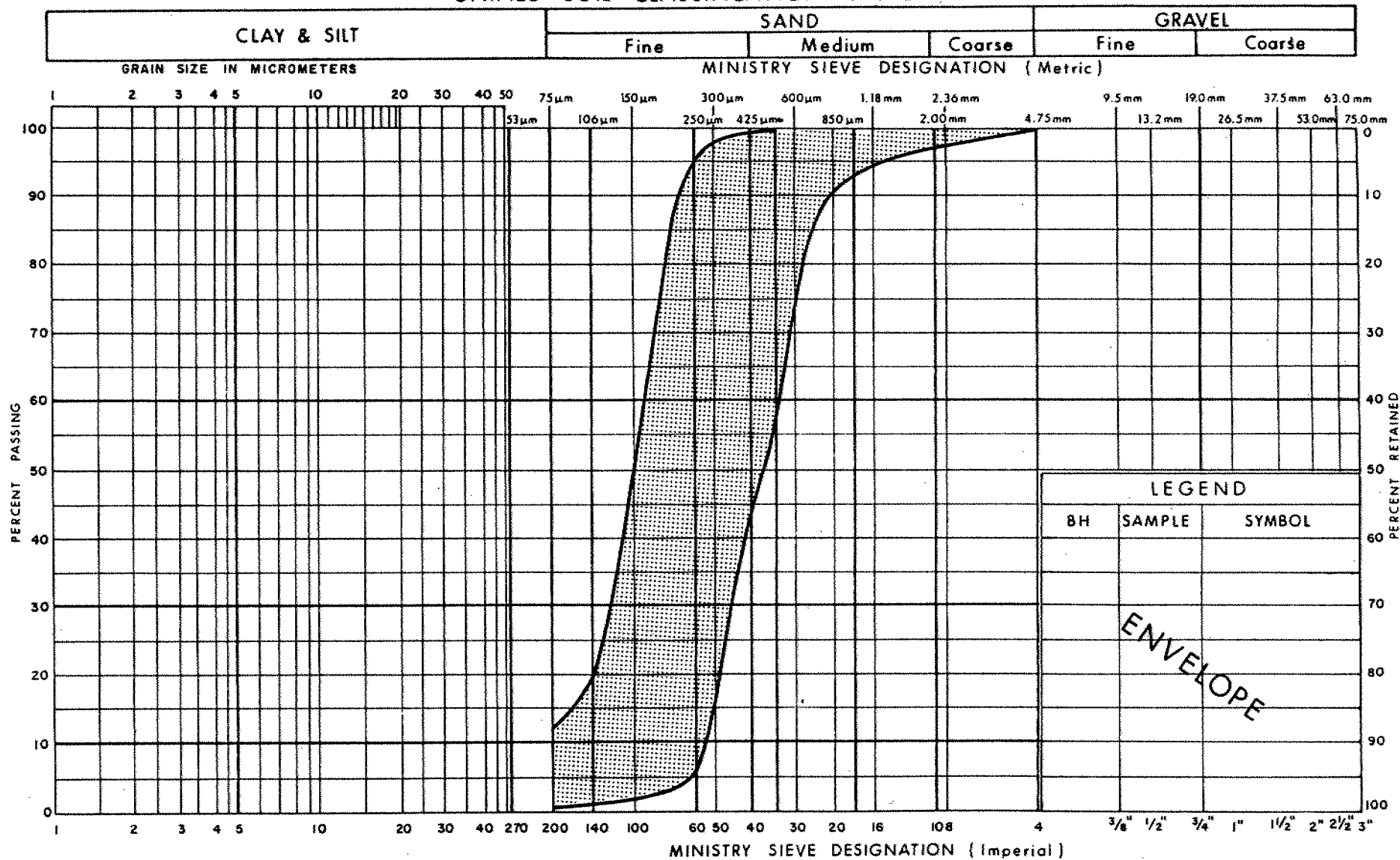
Dr. B. Iyer, P. Eng.
Senior Foundation Engineer



M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX
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UNIFIED SOIL CLASSIFICATION SYSTEM



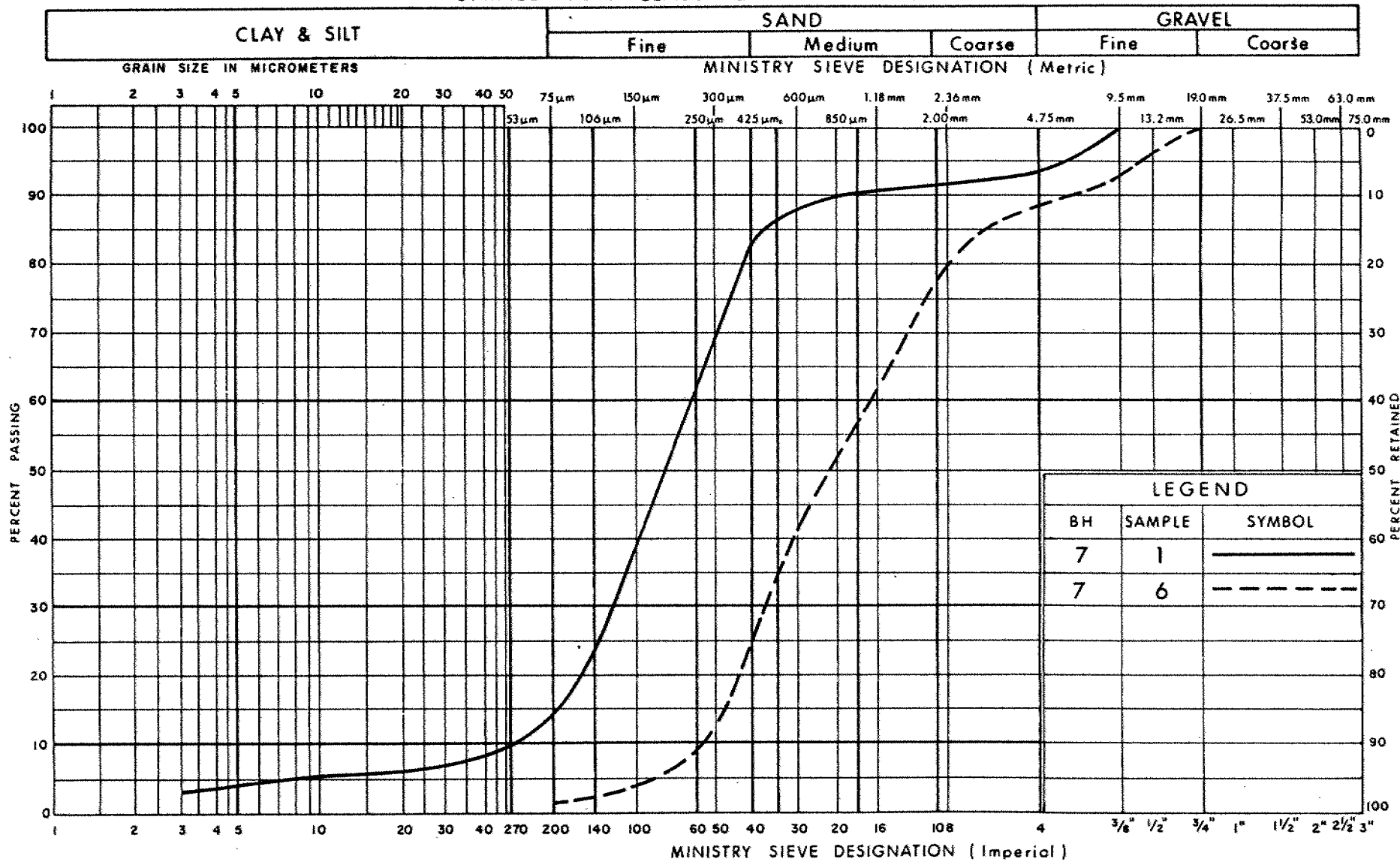
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Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SAND, TRACE OF SILT

FIG No 1

W P 279-85-01

UNIFIED SOIL CLASSIFICATION SYSTEM



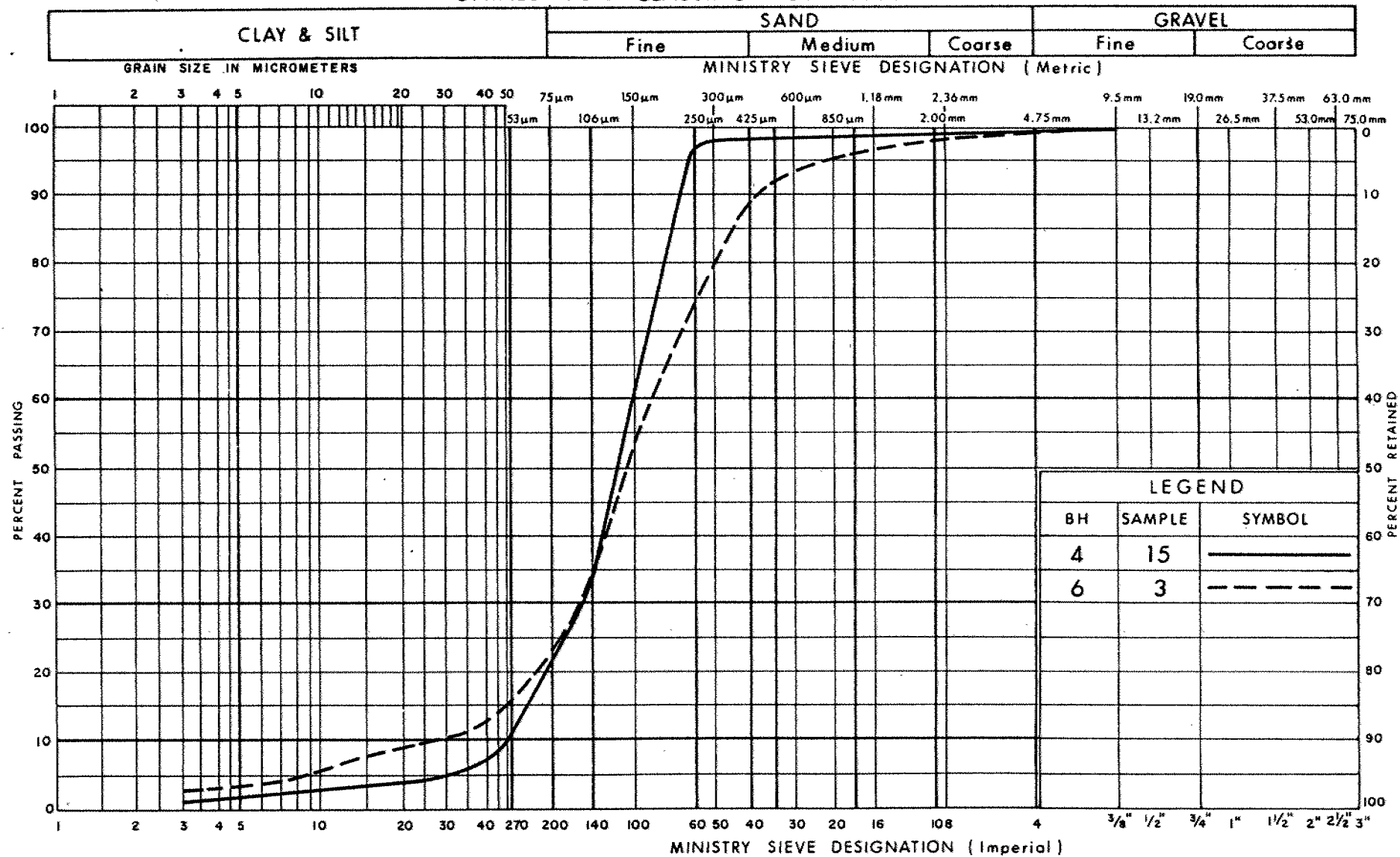
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Communications

GRAIN SIZE DISTRIBUTION
SAND, TRACE OF GRAVEL, SILT

FIG No 2

WP 279-85-01

UNIFIED SOIL CLASSIFICATION SYSTEM

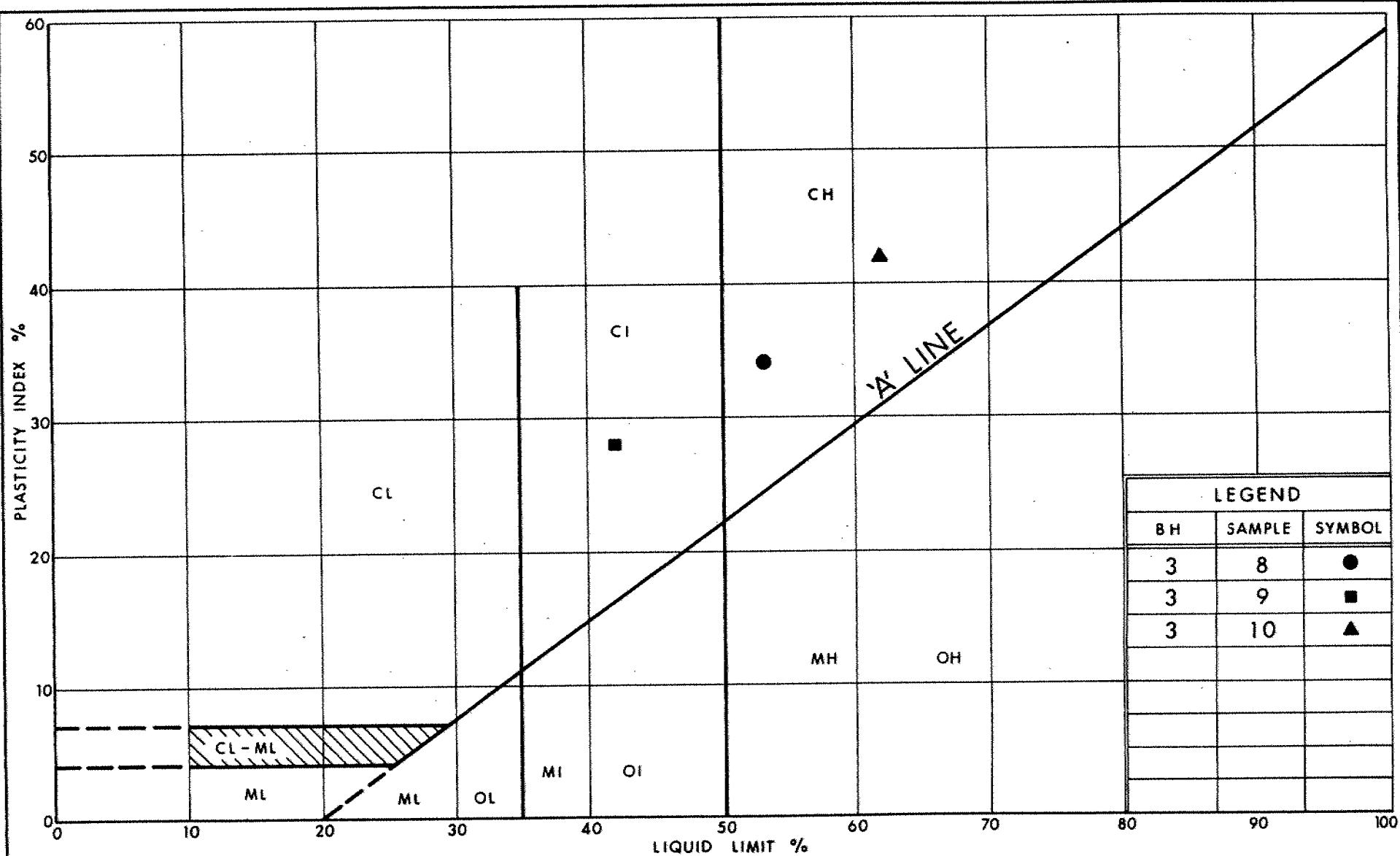


Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SAND, SOME SILT

FIG No 3

W P 279 - 85 - 01



Ontario

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Communications

PLASTICITY CHART SILTY CLAY TO CLAY

FIG No 4

W P 279-85-01

RECORD OF BOREHOLE No 1										METRIC				
W P 279-85-01		LOCATION STA. 10 + 987.5; 0/s 8.6mL. C Hwy. 17				ORIGINATED BY JF								
DIST 18 HWY 17		BOREHOLE TYPE BW-NW Casing, Washboring and Cone Test				COMPILED BY DP								
DATUM Geodetic		DATE 86 04 07				CHECKED BY <i>DP</i>								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT	NUMBER	TYPE			'N' VALUES	20	40					
184.1	Ground Surface													
0.0	Topsoil Medium to Fine Sand, Trace Silt Compact-Dense Brown		1	AS	*									
			2	SS	18									0 98 (2)
			3	SS	20									
			4	SS	9									
			5	SS	7									
			6	SS	22									
			7	SS	35									0 97 (3)
			8	SS	13									
176.0			9	SS	9									
8.1	End of Borehole													
175.0														
9.1	End of Cone Test													
	* Auger Tip Sample													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 279-85-01 LOCATION STA. 10 + 993.2; 0/s 8.6 m Lt. C Hwy. 17 ORIGINATED BY JF
 DIST 18 HWY 17 BOREHOLE TYPE BW-NW Casing, Washboring and Cone Test COMPILED BY DP
 DATUM Geodetic DATE 86 04 01 to 07 CHECKED BY EF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
184.0	Ground Surface											
0.0	Medium to Fine Sand, Trace Silt Loose-Compact Brown		1	SS	2							
			2	SS	1							
			3	SS	1							
			4	SS	2							
			5	SS	6							
			6	SS	16							
			7	SS	10							
			8	SS	8							0 94 (6)
			9	SS	20							
			10	SS	6							
			11	SS	7							
			12	SS	7							0 99 (1)
			13	SS	16							
			14	SS	14							
			15	SS	18							
	Dense to Very Dense		16	SS	56							
			17	SS	56							0 96 (4)
160.7			18	SS	20							
23.3	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3 (1 of 2) METRIC

W P 279-85-01 LOCATION STA. 11 + 055.2; 0/s 6.6 m Lt. C Hwy. 17 ORIGINATED BY JF
 DIST 18 HWY 17 BOREHOLE TYPE H-S Augers, BW Casing Washboring and Cone Test COMPILED BY DP
 DATUM Geodetic DATE 86 04 08 to 10 CHECKED BY *DP*

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
183.8	Ground Surface									
0.0	Topsoil									
	Probable Medium to Fine Sand									
	Medium to Fine Sand, Trace Silt		1	SS	11					
	Compact		2	SS	29					
	Brown		3	SS	33					
	Silty Clay		4	SS	28					0 98 (2)
			5	SS	29					0 29 54 17
			6	SS	21					
			7	SS	37					
155.5			8	SS	PH					
28.3	Silty Clay of Intermediate Plasticity to Clay of High Plasticity									0 28 16 56
153.6										
30.2										

Continued

+3, x5. Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE Continued

RECORD OF BOREHOLE No 3 (2 of 2) METRIC

W P 279-85-01 LOCATION STA. 11 + 055.2; 0/s 6.6 m Lt. C Hwy. 17 ORIGINATED BY JF
DIST 18 HWY 17 BOREHOLE TYPE H-S Auger, BW Casing Washboring and Cone Test COMPILED BY DP
DATUM Geodetic DATE 86 04 08 to 10 CHECKED BY CP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
153.6	Continued															
30.2	Silty Clay of Intermediate Plasticity to Clay of High Plasticity Occasional Sand Seams Stiff to Firm		9	TW	PH										18.7	0 49 9 42
			10	TW	PH										17.9	0 0 26 74
149.8			11	SS	16											
34.0	End of Borehole															
	* Groundwater level not established															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 279-85-01 LOCATION STA. 10 + 996.0; 0/s 7.0 m Rt. C Hwy. 17 ORIGINATED BY JF
DIST 18 HWY 17 BOREHOLE TYPE BW-NW Casing, Washboring and Cone Test COMPILED BY DP
DATUM Geodetic DATE 86 03 25 and 26 CHECKED BY ef

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
184.1	Ground Surface												
0.0	Topsoil												
	Medium to Fine Sand, Trace Silt		1	SS	13								
			2	SS	5								
	Very Loose to Loose		3	SS	9								
	Gravel with Sand		4	SS	7								65 27 7 1
			5	SS	2								
	Brown		6	SS	16								
			7	SS	7								
			8	SS	22								
			9	SS	12								
	Compact		10	SS	14								
			11	SS	15								
			12	SS	10								
			13	SS	34								
	Silty Fine Sand Very Dense		14	SS	105								
			15	SS	115								0 80 19 1
162.8	Brown		16	SS	143								
21.3	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 279-85-01 LOCATION STA. 11 + 054.6; σ/s 7.3 m Rt. C Hwy. 17 ORIGINATED BY JF
 DIST 18 HWY 17 BOREHOLE TYPE BW-NW Casing, Washboring and Cone Test COMPILED BY DP
 DATUM Geodetic DATE 86 04 03 and 04 CHECKED BY *DP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
183.8	Ground Surface										
0.0	Topsoil		1	SS	3						
	Medium to Fine Sand, Trace Silt		2	SS	2						
	Very Loose - Loose		3	SS	19						
			4	SS	5						
			5	SS	5						
	Brown		6	SS	5						
			7	SS	11						0 92 (8)
			8	SS	6						
			9	SS	15						
			10	SS	13						
			11	SS	12						
			12	SS	10						
			13	SS	14						
			14	SS	27						
	Compact-Dense		15	SS	18						
			16	SS	76						
			17	SS	175						
160.5			18	SS	34						0 93 (7)
23.3	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 279-85-01 LOCATION STA. 11 + 065.3; 0/s 7.4 m Rt. C Hwy. 17 ORIGINATED BY JF
 DIST 18 HWY 17 BOREHOLE TYPE BW-NW Casing, Washboring and Cone Test COMPILED BY DP
 DATUM Geodetic DATE 86 04 02 CHECKED BY GP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
183.8	Ground Surface												
0.0	Medium to Fine Sand, Some Silt		1	SS	5								
			2	SS	8								
			3	SS	4								
	Very Loose - Loose		4	SS	3								
			5	SS	5								
	Brown		6	SS	8								
177.2			7	SS	13								
6.6	End of Borehole												
174.6													
9.2	End of Cone Test												

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RECORD OF BOREHOLE No 7

METRIC

W P 279-85-01 LOCATION STA. 11 + 038.8; D/s 12.2 m Rt. Q Hwy. 17 ORIGINATED BY JF
 DIST 18 HWY 17 BOREHOLE TYPE BW-NW Casing, Washboring and Cone Test COMPILED BY DP
 DATUM Geodetic DATE 86 04 01 and 02 CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
180.7	Ground Surface										
0.0	Topsoil										
	Medium to Fine Sand		1	SS	5						7 79 11 3
	Trace Silt, Gravel		2	SS	3						
	Very Loose - Loose		3	SS	4						
			4	SS	3						0 97 (3)
			5	SS	4						
	Brown		6	SS	12						12 87 (1)
			7	SS	6						
			8	SS	12						
			9	SS	5						
			10	SS	6						
			11	SS	8						
			12	SS	81						
165.7	Very Dense		13	SS	151						
15.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION



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GEOTECHNICAL INVESTIGATION
FOR
PROPOSED CROSSING
AT
ECHO-BAY AND HIGHWAY 17
DISTRICT NO. 18 (SAULT STE. MARIE)
W.P. 185-79-01
SITE NO. 38S-111
CONT 91-218
GEOCRES No. 41K-46

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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

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**REPORT
ON
GEOTECHNICAL INVESTIGATION
FOR
PROPOSED CROSSING
AT
ECHO-BAY AND HIGHWAY 17
DISTRICT NO. 18 (SAULT STE. MARIE)
W.P. 185-79-01
SITE NO. 38S-111**

1.0 INTRODUCTION

The investigation described in this report was carried out at the request of the Ministry of Transportation, Foundation Design Section, for the purpose of providing geotechnical input for the design of a permanent bridge and a temporary detour structure on Highway 17 at Echo Bay, near Sault Ste. Marie,

The investigation was authorized by Engineering Agreement No. 4238-9089-237 dated August 14, 1989. The scope of the investigation was proposed by Geo-Canada Ltd. and accepted by the Foundation Design Section of M.T.O. It was to consist of eight (8) boreholes taken to about 18 m to 20 m depth, two

.../...



(2) of which would be on the lake, using a raft. Due to the unexpected thickness of the soft deposit at the site, the boreholes were extended to between 37.5 and 37.8 m, and dynamic cone penetration tests were performed in selected boreholes to depths of 48.8 m. In view of the uniform conditions found to a great depth, it was also decided, in consultation with M.T.O., to delete the two boreholes on the lake.

The field work for the investigation was carried out between September 28 and October 23, 1989, using a bombardier mounted mobile B-57 auger drill rig. An engineer from our office supervised the fieldwork and logged the soil conditions.

All the boreholes were drilled using hollow stem augers. Soil samples were taken at 0.76 m to 3 m intervals of depth by the standard penetration test method. Below each sample, in the clay deposit in situ vane shear tests were performed to evaluate the undrained shear strength of the clay. Boreholes 1, 3 and 6 were extended by a dynamic cone penetration test in order to assess the consistency of the clay at greater depth and to probe for a possible deeper lying bearing stratum for end-bearing piles. Dynamic cone penetration tests were also performed in the surface sand
.../...



layer adjacent to Boreholes 2 and 5.

In addition to the boreholes, we also performed probings of the lake bed at the location of the piers of the temporary bridge structure to detect any boulder or other obstructions at shallow depth. The probings were performed manually using a 75 mm wide by 25 mm steel channel. The maximum depth of probing was 450 mm.

The soil samples were brought to our laboratory where they were selectively tested. The tests included natural moisture contents, grain size distribution, consistency (Atterberg) limits, unconsolidated undrained triaxial tests, and consolidation tests.

During the drilling of Borehole 4, the driller miscounted the number of drill rods. Because of this, the standard penetration blow counts of Samples 15 to 18, as well as the vane shear results immediately below these samples probably do not reflect the true soil condition at that depth.

The enclosed Drawing No. 1857901-A shows the borehole locations. The borehole elevations were established by surveying with reference to geodetic Benchmark No. 627 located in the abutment of the existing railway bridge just

.../...



north of the site. The geodetic elevation of this benchmark is 181.369 m.

2.0 DESCRIPTION OF THE SITE

The site is located about 20 km east of the City of Sault Ste. Marie, at the position where Echo Bay widens into Lake George. The terrain along the lakeshore is generally relatively flat, lying between about Elevations 178 m and 180 m \pm .

Highway 17 is carried across Echo Bay partly by a bridge and partly by two earth embankments (causeways). The existing bridge is a three span structure with concrete deck on steel girders, and is about 47 m long. The bridge deck is at Elevation 180.5 m \pm . At the time of the field investigation, the lake level dropped from Elevation 176.6 to 176.2 m. At the deepest point along the existing bridge the lake bed is at Elevation 170.4 m.

The foundation details of the existing bridge are not known, except that about ten years ago the pier supports were strengthened with additional timber piles.

Geological references indicate that the Sault Ste. Marie area

.../...



is underlain by thick deposits of clay and silt (varved clay) laid down some 10,000 years ago when the glacial Lake Algonquin flooded the whole area. Interbedded with the varved clay are layers of stratified silts and sands deposited in various stages as the land mass gradually rose and the lake receded. In more recent times alluvial deposits of sand were added by the St. Mary's River and its tributaries.

3.0 SUBSURFACE CONDITIONS

3.1 General

The general soil stratigraphy is comprised of sand and sand fill overlying a thick deposit of silty (varved) clay. A second layer of (silty) fine sand and a layer of silt were found embedded in the varved clay in many of the boreholes. In general, the sand deposits are very loose to compact, and the silty (varved) clay is firm, becoming stiff at greater depth.

Three of the boreholes were drilled at the lake bottom (i.e. under water). In the other three boreholes the groundwater table also coincided with the lake level which at the time of the investigation was between Elevations 176.2 and 176.6 m.

.../...



The subsurface conditions are described in detail on the individual borehole logs. The main characteristics of the soil types encountered are discussed briefly in the following sections, and are summarized in Table 1 following Page 11.

3.2 Fill

Fill was identified in Borehole 6 to a depth of 6.6 m (Elevation 173.8 m). In Borehole 1 the upper portion of the sand, to about 2.5 m depth, is likely to be fill, and the near surface sand materials found in the other boreholes could also be fill.

The fill is composed mainly of sand and a trace of silt. Two typical samples of the fill were analysed and found to contain 96 to 98% sand, and 2 to 4% silt. These grading curves are shown in Figure 1. The moisture contents of the fill range from 6 to 28%. Below the water table the fill is saturated.

Eight standard penetration tests were performed in the fill, with "N" values ranging from 1 to 38 blows per 0.3 m.

3.3 Fine Sand

This deposit was contacted in all the boreholes below the

.../...



fill or at the lakebed and extends to between Elevations 170.0 m and 167.7 m.

The sand is a poorly graded soil, containing just a trace of silt. The results of the grain size analyses indicate that the sand is composed of 0 to 4% gravel, 93 to 99% sand, and 0 to 3% silt. Gravel was found in only three of the ten samples tested. These results are shown plotted in Figure 2. The sand is mostly saturated, with moisture contents of 18 to 28% (17 samples) except the first sample in Borehole 2, which is above the lake and has 3% moisture.

The "N" values obtained in the sand varied between 0 (i.e. the sampler sank into the sand under the weight of the drill rods) to 24 blows per 0.3 m, indicating very loose to compact conditions.

3.4 Silty (Varved) Clay

This soil unit constitutes the majority of the soil profile. It underlies the fine sand in every borehole. Its upper surface lies between Elevations 167.7 and 170.4 m. The clay can be divided into two or three sub-units, separated by a sand, silty sand, and/or a clayey silt layer. The full thickness of the clay deposit was not penetrated. The

.../...



maximum depth of the boreholes was 37.8 m, and a cone was driven to 48.8 m depth in three of the boreholes without encountering refusal or a noticeable increase in driving resistance. From this it is inferred that the silty (varved) clay extends to at least 48.8 m depth (Elevation 128.0 m).

The clay has a layered (varved) structure, consisting of alternate thin layers of silty clay and clayey silt. In most cases the silt seams are very thin (less than 2 mm), but occasionally silt seams (and a sand seam) of up to 150 mm were found.

Five grain size analyses were performed on representative, but composite samples of the clay-silt soil. The results are plotted in Figure 3. The tested samples contain 0 to 1% sand, 7 to 35% silt, and 65 to 82% clay.

The plasticity of the clay was evaluated by 38 Atterberg limits tests. Its liquid limits are between 42 and 81%; its plastic limits are 17 to 31%; and its plasticity indices are 25 to 53, except for one sample which has liquid limit, plastic limit and plasticity indices of 25%, 13% and 12 respectively. Thus, in general, the clay has high plasticity. The natural moisture contents of the clay are 42 to 84%, most of which are close to the liquid limit of the

.../...



soil. The liquidity indices range from 1.4 near the surface of the clay to 0.6 at greater depths. The sand and silt seams in the clay have moisture contents of 20 to 42%.

The standard penetration test blow counts obtained in the clay are from 0 to 16 blows per 0.3 m, but the average value of the 70 SPT performed in the deposit is only 2.3. The undrained shear strength (S_u) of the clay was evaluated by in situ vane shear tests. The values ranged from as low as 9 kPa (very soft) to 106 kPa (very stiff). Some of the low values in Borehole 4 are probably due to the clay being inadvertently disturbed when the driller miscounted the number of drill rods. Discounting these low values, the remaining S_u values are between 21 kPa and 106 kPa, i.e. the consistency of the clay is firm to very stiff, but mostly firm to stiff. The sensitivity of the clay (i.e. the ratio of undisturbed to remoulded shear strength) was found to be between 1.2 and 5.7, i.e. low sensitivity.

The undrained shear strength of the clay was further evaluated by four unconsolidated undrained triaxial tests on relatively undisturbed thin wall tube samples. The results range from 18 to 48 kPa.

A plot summarizing the variations of the undrained shear
.../...



strength values with depth (elevation) are presented on Figure 8.

Two consolidation tests were performed on the clay, and the results are shown on Figures 6 and 7. The compression indices of the samples tested are 1.34 and 0.52. Their bulk unit weights and initial void ratios are 15.5 and 17.3 kN/m³, and 2.08 and 1.41, respectively. The preconsolidation pressures are found to be the same as the effective overburden pressure, i.e., the clay appears to be normally consolidated.

3.5 Lower Sand

In Boreholes 2, 3, 5 and 6, a layer of sand was contacted at Elevations between 165 and 162 m. The thickness of this lower sand layer is between 1.8 and 4.6 m.

This sand layer is very similar in composition to the sand layer at the surface of the boreholes. Figure 4 shows three grading curves of the lower sand. These samples contain 91 to 97% sand and 3 to 9% silt. It has moisture contents of 20 to 32%, and "N" values of 3 to 22 blows per 0.3 m, which indicate very loose to compact conditions.

.../...



3.6 Clayey Silt

A 2.4 to 3.1 m thick layer of clayey silt to silt exists in Boreholes 1 and 5 at about Elevations 157 and 159 m respectively. A typical sample of the silt is found to be composed of 4% sand, 69% silt and 27% clay (see Figure 5). Its liquid limits, plastic limits, and plasticity indices are 19% to 23%, 16 to 17%, and 2 to 7 respectively. Its natural moisture contents are between 22% and 35%.

Standard penetration tests gave "N" values of 0 and 9 blows per 0.3 m. In situ vane shear tests indicated undrained shear strength of 35 to 59 kPa with sensitivity of 2.0 to 4.0. Thus, the silt is firm to stiff.

3.7 Groundwater

It is expected that the position of the groundwater table at the borehole locations will fluctuate with the lake level, which during the time of the field investigation dropped from Elevation 176.6 m to Elevation 176.2 m.

Records kept by the Marine Environmental Data Service, Department of Fisheries and Oceans, indicate that the highest daily average water level in Lake Huron was 177.4 m, while the lowest daily average was 175.4 m.

.../...



TABLE 1
SUMMARY OF SOIL PROPERTIES

Material	"N"	Moisture Content (%)	W _L (%)	W _p (%)	I _p	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
Sand Fill	1 to 38	6 to 28				0	96 - 98	2 - 4	--
Fine Sand	0 to 24	6 to 28				0 - 4	93 - 99	0 - 3	--
Silty Clay	0 to 16	42 to 84	25 - 81	13 - 31	12 - 53	0	0 - 2	17 - 35	65 - 82
Lower Sand	4 to 22	20 to 32				0	20 - 97	3 - 72	0 - 8
Clayey Silt	0 to 9	22 to 35	19 - 23	16 - 17	2 - 7	0	4	69	27



4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Proposed Construction

It is proposed to replace the existing bridge with a new bridge. Two options are being considered: a three span bridge with a centre span of 26 m and total length of 54 m, or a single span bridge of 42 m. The new bridge will be wider (15 m), but is expected to be at the same elevation as the existing bridge (Elevation 180.5 m \pm).

Before the existing bridge is demolished, a temporary detour bridge (Bailey bridge) will be constructed south of the existing structure. It will be 15 m wide, with three 30.48 m long spans, and will be at Elevation 179.5 m \pm .

The loading for the single span bridge is expected to be 8950 kN at serviceability limit, and 11300 kN at ultimate limit. Those for the three span bridge are 9850 kN (SLS), 12500 kN (ULS) for the piers, and 5150 and 6450 kN respectively for the abutments.

4.2 Engineering Evaluation of Subsurface Conditions

In summary, the stratigraphy is comprised of very loose to compact fine sand overlying a thick deposit of firm to stiff

.../...



silty varved clay. A discontinuous sand layer and a silt layer were found interbedded in the clay.

The upper native fine sand stratum does not appear to contain boulders and only occasional gravels. The surface of the existing road embankment, however, is protected by boulders as large as 1 m in diameter. Some of these boulders apparently rolled down the embankments and became buried under more fills. Boreholes 2 and 5 encountered some of these boulders at depths of 1.5 to 1.7 m below the ground surface or lake bottom, and the boreholes had to be relocated, but after passing these boulders there were no further obstructions encountered. The results of the hand probings at the locations of the piers of the detour bridge also indicated no surface obstructions.

The silty (varved) clay is a highly plastic clay of firm to stiff consistency. Figure 8 is a summary plot of all the vane shear test results. Some of the results obtained in Borehole 4 are probably non-representative due to the soil being disturbed. Apart from these values there is a general trend of increasing shear strength with depth. The recommended pile capacities given in Section 4.3 of this report are based on the design shear strength profile shown on Figure 8, after applying a correction factor to allow for

.../...



the plasticity of the clay. The average plasticity index of the clay is 39, and according to Bjerrum⁽¹⁾, the field vane test correction factor is 0.83. Also shown on Figure 8 are two lines which represent undrained shear strength to effective overburden pressure ratio (S_u/p') of 0.22 to 0.3.

The full thickness of the silty (varved) clay is unknown. The dynamic cone penetration tests performed below the bottom of the boreholes indicate an almost linear increase in the blow counts, which is probably due to the build up of skin friction on the surface of the drill rods and the increased proportion of the driving energy absorbed by the long string of drilling rods. There was no abrupt increase in penetration resistance which would indicate a change in the soil strength or soil type. It is thus inferred that the clay extends to at least Elevation 128 m.

4.3 Foundation

The very loose sand and the soft and compressible clay found near ground surface are not suitable to carry the proposed structures on spread footing type foundations. The structures should, therefore, be supported on piles. Due to the lack of a dense bearing stratum within the depth (48 m) of investigation, end-bearing piles are not considered to be .../...

⁽¹⁾ BJERRUM L. (1972) "Embankments on Soft Ground", Proceedings of the Speciality Conference, ASCE Vol. 2



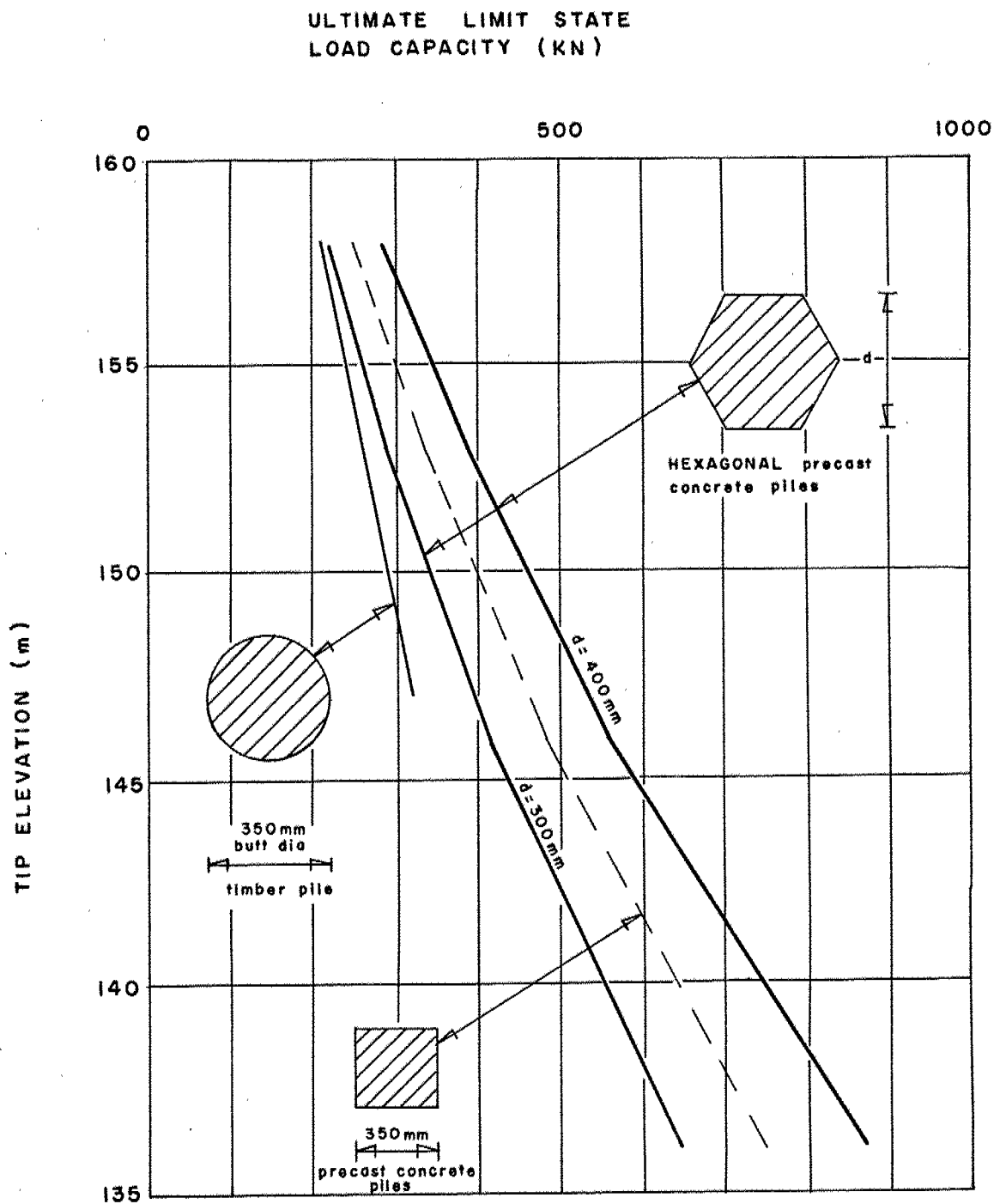
practical and, therefore, the proposed structures should be supported on friction piles driven into the silty (varved) clay.

Timber piles have excellent properties as friction piles, but their lengths are limited to about 28 m and will, therefore, have limited load capacities. Another type of pile that has been successfully used in the Sault Ste. Marie area is the precast concrete pile. These piles are available in square or hexagonal sections and in various lengths and can be easily spliced, if necessary, and therefore can be driven to great depth. The factored load capacities of timber and precast concrete piles at Ultimate Limit State driven to various depths into the clay are shown on Figure A following this page.

Steel H piles and steel pipe piles can also be used, but a reduction factor (about 0.8 for tube piles) will have to be applied to the skin friction value.

The ULS capacity of a group of friction piles can be taken as the sum of the capacities of the individual piles, provided that the spacing of the piles is not less than the minimum values given later in this report.

.../...



Note : Cut off at 176 m



The pile load capacity at Serviceability Limit State (SLS) Type II is a function of the amount of settlement that the structures can tolerate. The capacity of a single pile at SLS in this case is probably irrelevant since the settlement will be governed by the size of the pile group and/or the settlement induced by the approach embankments.

We estimate that for a 4 x 8 group of concrete piles at 2.0 m centre to centre spacing, driven to Elevation 136 m, each loaded to 308 kN (9850 kN total), the settlement could be 210 mm. One year after construction the settlement is expected to be about 80 mm. The settlement can be reduced by increasing the number or the length of piles. In view of the anticipated large settlements, it is recommended that the structure should not be designed as a continuous, but rather a simply supported structure.

Since the serviceability limit will likely govern the design of the proposed bridges, a more detailed settlement analysis based on the size of the pile group and the length of the piles should be carried out before finalizing the design.

Lateral loads should be resisted with raking piles.

The centre to centre spacing of the piles should not be less

.../...



than $0.02 D + 2.5 d$, where D is the embedment length, and d is the average diameter or the width of the piles. This is to minimize the risk of physical interference of the piles during installation. The head of the piles should be monitored for vertical and lateral movements during the installation of all subsequent piles. If vertical movements (heave) are detected, the piles should be redriven. If lateral movements are found, the piles should be investigated for possible damage.

The concrete piles should be driven with a hammer having a ram mass of not less than 2000 kg, and the drop of the ram should be limited to 400 mm to avoid tension in the piles. The ram drop may have to be further reduced during the initial driving of the piles.

Some boulders could be found around the existing embankments at shallow depths below the lake bed. These boulders can be easily removed. No other obstruction is expected in the native soils at greater depths. Possible interference from existing piles, particularly if these were driven on a batter, should be given consideration.

.../...



4.4 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 (K_A) will govern earth pressure design for the yielding condition while the at-rest condition (K_o) will govern earth pressure design for the unyielding condition. The following properties for the backfills are recommended for design:

Material	ϕ	Unit Weight	Serviceability Limit State		Ultimate Limit State	
			K_A	K_o	K_A	K_o
			(for horizontal backfill)			
Granular "A"	35°	22.8 kN/m ³	0.27	0.43	0.35	0.51
Granular "B"	30°	21.2 kN/m ³	0.33	0.50	0.40	0.58
Rock Fill	35°	18.1 kN/m ³	0.27	0.43	0.35	0.51

4.5 Approach Embankments

An approximately 3 m high by 16.6 m wide embankment will be required for the approach road leading to the detour bridge. The embankment will be founded on very loose to compact sand which is underlain by silty (varved) clay. Using an undrained shear strength of 20 kPa for the clay and assuming .../...



2 to 1 (horizontal to vertical) side slopes for the embankments, we estimate that the factor of safety against rotational failure of the embankment is 1.5. Thus, a stability problem is not expected. This embankment is expected to settle 270 mm due to the consolidation of the underlying clay, about 60 mm of which is expected to occur during the first year after construction.

The approach embankments leading to the permanent bridge will be widened by about 1 to 1.5 m on each side. No stability problem is envisaged, and the new fills are expected to settle about 100 mm ultimately.

The final slope angles of the embankments should not be steeper than 2 to 1. Below the lake level, the fills will probably stabilize at a flatter angle due to wave action. The faces of the embankments should be adequately protected from surface erosion, such as by seeding, rip rap, etc. Below lake level, armour stones or other means may be employed to protect the embankment from scouring and wave action.

The sloping surfaces of the existing approach embankments should be benched to receive the new fills, in accordance with Ontario Provincial Standard (OPSD - 208.01). All fills

.../...



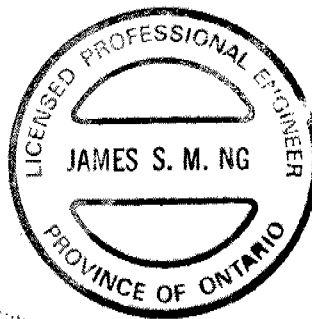
above the lake level should be compacted to a 95% of their standard Proctor maximum dry density. The existing embankments in the areas of the proposed abutments or piers may have to be cleared of boulders or cobbles before driving the piles.

5.0 STATEMENT OF LIMITATION

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

GEO-CANADA LTD.

James Ng, P.Eng.



Ivan P. Lieszkowsky, P.Eng.

JN/IPL:uo



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.

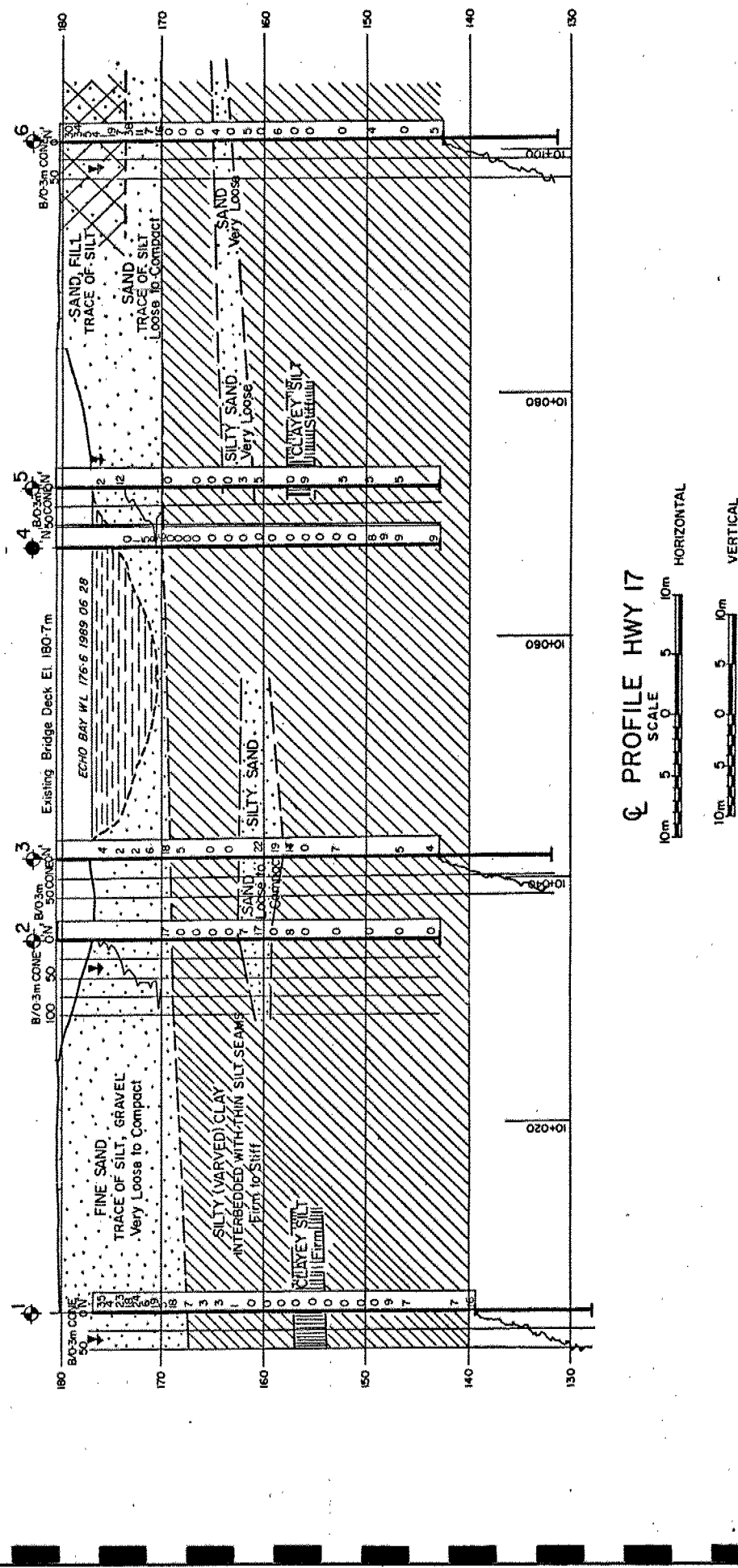
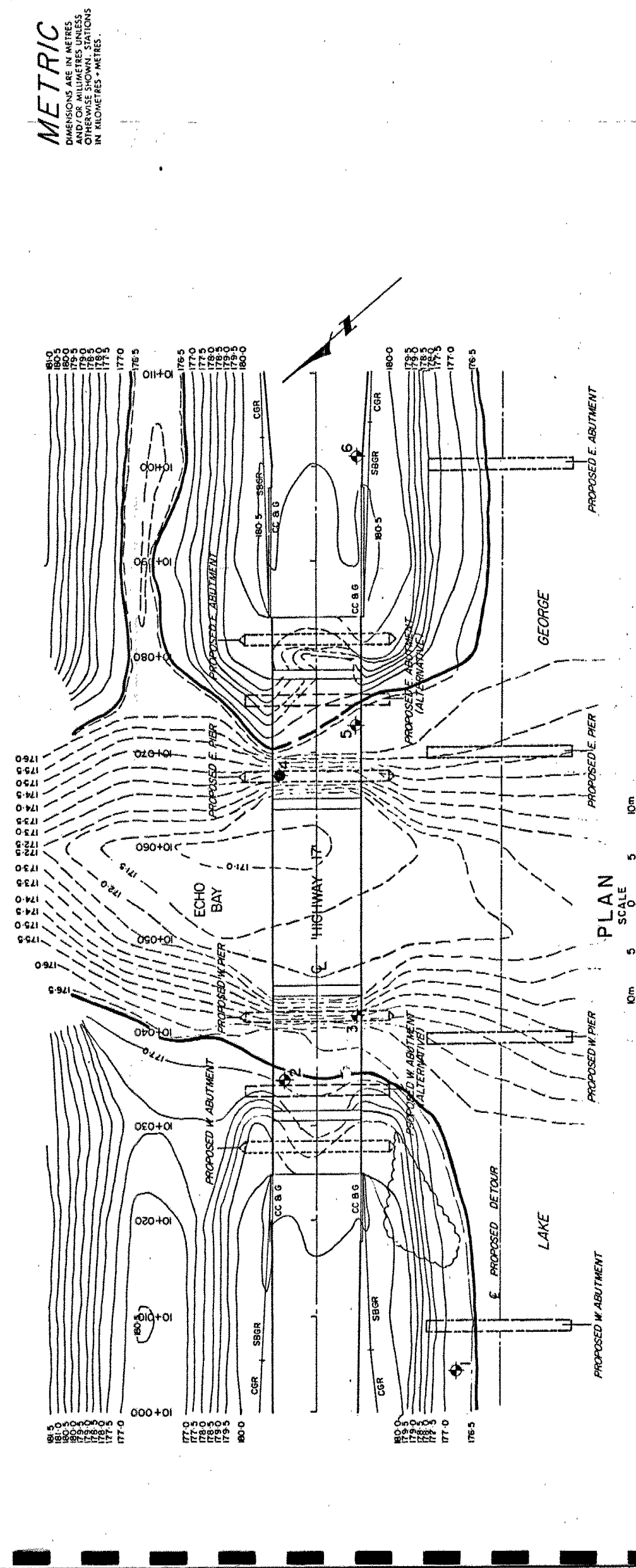
The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain 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



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 1989 09 and 1989 10		

No	ELEVATION	STATION	OFFSET
1	176.8	10+004.0	14.5m Rt
2	180.6	10+034.5	3.5m Lt
3	180.7	10+042.0	4.3m Rt
4	180.7	10+068.0	4.0m Lt
5	180.6	10+073.0	4.2m Rt
6	180.4	10+101.0	4.2m Rt

=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
MM	DD	MM	DD	
Geacres No 41K-46				
HWY No 17				
SUBNO J.N.	CHECKED	P.L.	DATE	DIST 18 SITE 38S-III
DRAWN H.A.	CHECKED	J.P.	ATTACHED	DWG 1857901-A

RECORD OF BOREHOLE No 1

METRIC

W P 185-79-01 LOCATION Sta. 10 + 004, D/S 14.5 m RT C/L HWY 17 ORIGINATED BY JN
 DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test COMPILED BY JN
 DATUM Geodetic DATE 1989 10 01 to 04 CHECKED BY IPL

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100					
176.8	Ground Level															
0.0	wood pieces FINE SAND		1	SS	3570	W.L. =176.3										
	wood pieces		2	SS	4											
	trace of silt poorly graded saturated brown		3	SS	23											
	very loose to compact (possibly fill to 2.5 m depth)		4	SS	18											0 98 2 -
			5	SS	24											0 98 2 -
			6	SS	6											
			7	SS	19											
			8	SS	5											
			9	SS	18											
167.7																0 99 1 -
9.1	SILTY (VARVED) CLAY		10	SS	7											
	interbedded with thin silt seams high plasticity red/brown firm		11	SS	3		3.0									
			12	SS	3		4.0									1 27 72 -
			13	SS	1		4.0									
			14	SS	0		2.5									
			15	SS	0		4.0									
			16	SS	0		3.5									
157.0			17	SS	0		3.0									0 4 69 27
19.8	CLAYEY SILT slightly plastic saturated grey firm		18	SS	0		4.0									
153.9			19	SS	0		3.0									
22.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity		20	SS	0		3.5									
150.9	firm stiff						3.5									
25.9	Continued															



METRIC

W P 185-79-01 LOCATION Sta. 10 + 004, O/S 14.5 m RT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test COMPILED BY JN
DATUM Geodetic DATE 1989 10 01 to 04 CHECKED BY IPL

[illegible]

+3, x5; Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2										METRIC				
W P 185-79-01		LOCATION Sta. 10 +034.5, O/S 3.5 m LT C/L HWY 17						ORIGINATED BY JN						
DIST 18 HWY 17		BOREHOLE TYPE Hollow stem auger, wash boring and cone test						COMPILED BY JN						
DATUM Geodetic		DATE 1989 10 20 to 23						CHECKED BY 1PL						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
180.6	Bridge Deck													GR SA SI CL
0.0							180							
176.9	Ground Surface						178							1 99 0 -
3.7	FINE SAND trace of silt, gravel some wood poorly graded saturated brown very loose to compact		1	BS		W.L.= 176.3	176							Encountered boulder at 4 m. moved hole 450 mm S.E.
							174							
			2	WS			172							
			3	SS	17		170							1 wash boring
			4	WS										
169.2														
11.4	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity red firm		5	SS	0		168							82
			6	SS	0		166		2.3					
			7	SS	0		164		+ 5.3					
			8	SS	0		162		+ 3.5					
			9	SS	7		160		+ 3.8					
162.5			10	WS			158							0 97 3 -
18.1	FINE SAND trace of silt saturated red loose to compact		11	SS	17		156							
159.1			12	SS	0									
21.5	SILTY (VARVED) CLAY interbedded with thin silt sand seam seams high sand seam plasticity stiff silt seam		13	SS	8				2.8					
			14	SS	0				2.4					
154.7									+ 4.0					
25.9	Continued													

RECORD OF BOREHOLE No 2 (CONT.)

METRIC

W P 185-79-01 LOCATION Sta. 10 +034.5, O/S 3.5 m LT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger, wash boring and cone test COMPILED BY JN
DATUM Geodetic DATE 1989 10 20 to 23 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
154.7	Continuation																
25.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity stiff		15	SS	0		154										
							152			4.2							
							150										
			16	SS	0												
							148			3.4							
							146										
			17	SS	0												
							144										
			18	SS	0												
142.8		red grey															
37.8	END OF BOREHOLE																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 185-79-01 LOCATION Sta. 10 + 042, O/S 4.3 m RT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger and cone test COMPILED BY JN
DATUM Geodetic DATE 1989 10 13 to 16 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
180.7	Bridge deck																GR SA SI CL
0.0							180										
							178										
176.2	Water						176										2 97 1 -
4.5	FINE SAND		1	SS	4												
176.1	trace of silt, gravel		2	SS	2												
4.6	poorly graded brown		3	SS	2												0 99 1 -
	very loose						172										
	loose		4A	SS	6												
	brown pink						170										0 99 1 -
	loose compact		5	SS	18												
168.8	SILTY (VARVED) CLAY		6A	SS	5		168										
11.9	silt seam		7	TW													
	interbedded with thin silt seams		8	SS	0		166										
	high plasticity red		9	SS	0												
	firm to stiff						164										
162.4																	
18.3	SILTY FINE SAND		10	TW			162										
	poorly graded dilatant		11A	SS	22												
	red/pink clayey compact		12A	SS	19		160										0 91 9 -
	silt to sand		13	WS													
157.8			14A	SS	14		158										0 20 72 8
22.9	SILTY (VARVED) CLAY		15	SS	0		156										
	high plasticity stiff																
	silt seams																
154.8																	
25.9	Continued																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3 (CONT.)										METRIC				
W P 185-79-01		LOCATION Sta. 10 + 042, O/S 4.3 m RT C/L HWY 17						ORIGINATED BY JN						
DIST 18 HWY 17		BOREHOLE TYPE Hollow stem auger and cone test						COMPILED BY JN						
DATUM Geodetic		DATE 1989 10 13 to 16						CHECKED BY IPL						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
154.8	Continuation													
25.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity		16	SS	7		154							
							152	2.0						
							150						15.7	
			17	TW										
							148							
			18	SS	5		146	3.7						
							144							
			19	SS	4									
143.1														
37.6	END OF BOREHOLE SILTY (VARVED) CLAY stiff (inferred)						142							
							140							
							138							
							136							
							134							
							132							
131.9														
48.8	END OF CONE TEST													

RECORD OF BOREHOLE No 4										METRIC					
W P 185-79-01		LOCATION Sta. 10 + 068, O/S 4.0 m LT C/L HWY 17						ORIGINATED BY JN							
DIST 18 HWY 17		BOREHOLE TYPE Hollow stem auger						COMPILED BY JN							
DATUM Geodetic		DATE 1989 09 28 to 30						CHECKED BY IPL							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60					
180.7	Bridge deck														
0.0							180								
							138								
176.6	4.1 WATER						176								
175.1	Lake bottom						174								
5.6	FINE SAND trace of silt poorly graded saturated		1	SS	0		172								
	wood pieces		2	SS	1										
	very loose		3	SS	5										
	loose		4	SS	8										
	compact		5	SS	16		170								
170.0	10.7 SILTY (VARVED) CLAY		6	SS	0		168	4.0					82		
	interbedded with thin silt seams		7	SS	0			4.0							
	high plasticity		8	SS	0			2.7							
	red firm		9	SS	0		166	3.0							
			10	SS	0		164	2.7					84		
			11	SS	0			4.0							
			12	SS	0		162	4.0							
			13	SS	0		160	3.5							
			14	SS	0		158	3.5							
			15	SS	0			1.5							
	silt seams		16	SS	0		156	2.0							
154.8															
25.9	Continued														

OFFICE REPORT ON SOIL EXPLORATION

probably
disturbed
due to
miscount of
drill rods



METRIC

W P 185-79-01 LOCATION Sta. 10 + 068, O/S 4.0 m LT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow steam auger COMPILED BY JN
DATUM Geodetic DATE 1989 09 28 to 30 CHECKED BY IPL

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5										METRIC			
W P 185-79-01		LOCATION Sta. 10 + 073, O/S 4.2 m RT C/L HWY 17						ORIGINATED BY JN					
DIST 18 HWY 17		BOREHOLE TYPE Hollow stem auger, wash boring and cone test						COMPILED BY JN					
DATUM Geodetic		DATE 1989 10 17 to 19						CHECKED BY IPI					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)			
180.6	Bridge deck												
0.0													
176.2	Lake bottom												
4.4	FINE SAND trace of organics trace of silt saturated brown loose to compact		1	SS	2	W.L. = 176.2							
			2	SS	12								
			3	WS									
169.9													
10.7	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity red firm		4	SS	0								
			5	TW									
			6	SS	0								
			7	SS	0								
164.1													
16.5	SILT		8	SS	0								
163.4													
17.2	FINE SAND to SANDY SILT very loose		9	SS	3								
160.9													
19.7	SILTY (VARVED) CLAY high plasticity pink firm to stiff		10	SS	5								
			11	TW									
157.7													
22.9	CLAYEY SILT grey/red stiff		12	SS	0								
155.1													
25.5			13	SS	9								
154.7	SILTY (VARVED) CLAY												
25.9	Continued												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5 (CONT.)

METRIC

W P 185-79-01 LOCATION Sta. 10 + 073, O/S 4.2 m RT C/L HWY 17 ORIGINATED BY JN
DIST 18 HWY 17 BOREHOLE TYPE Hollow stem auger, wash boring and cone test COMPILED BY JN
DATUM Geodetic DATE 1989 10 17 to 19 CHECKED BY IPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
154.7	Continuation																
25.9	SILTY (VARVED) CLAY interbedded with thin silt seams high plasticity stiff						154										
			14	SS	5		152										
			15	SS	5		150										
							148										
			16	SS	5		146										
							144										
			17	TW													
143.1																	
37.5	END OF BOREHOLE																

OFFICE REPORT ON SOIL EXPLORATION

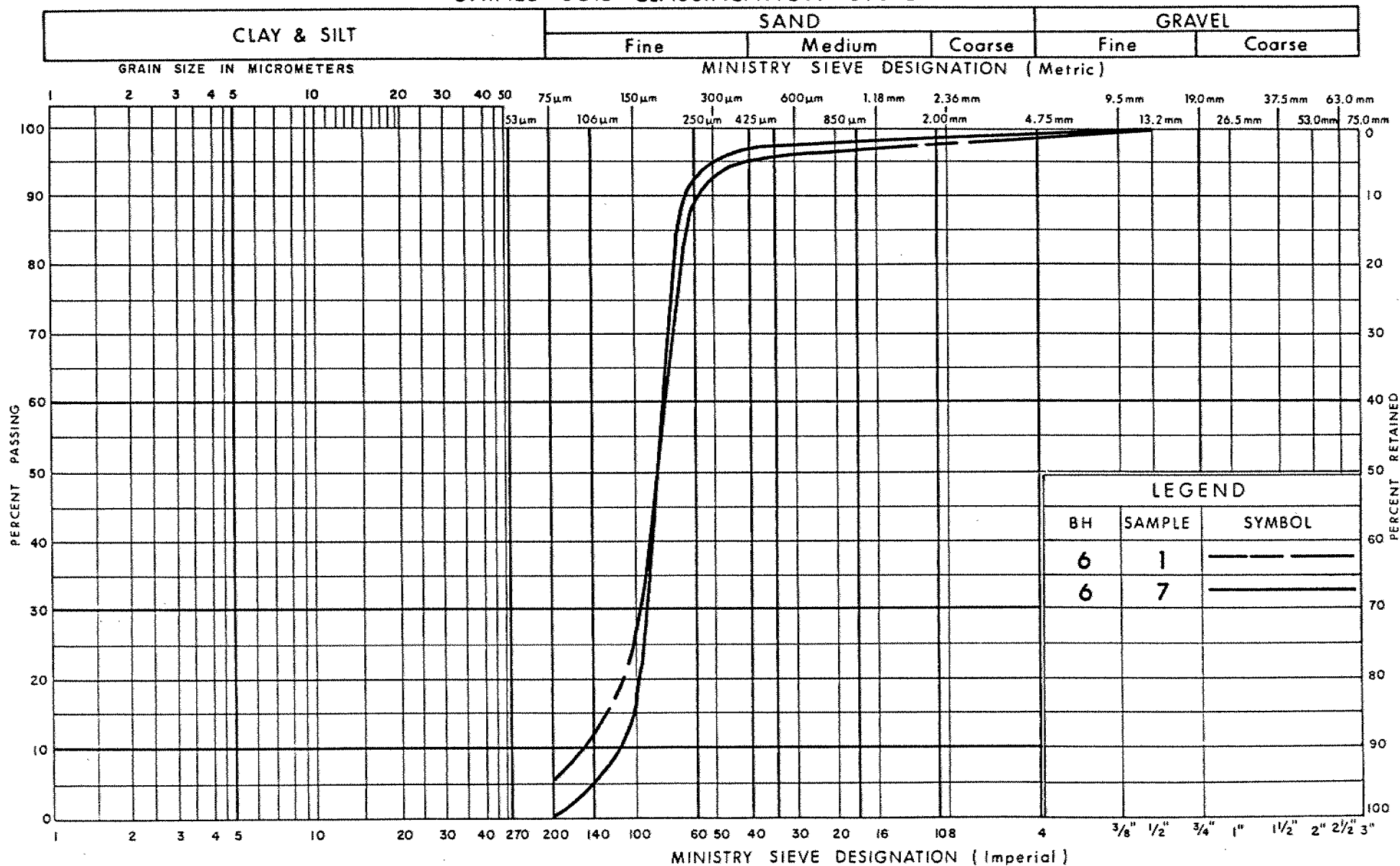
RECORD OF BOREHOLE No 6										METRIC				
W P 185-79-01		LOCATION Sta. 10 + 101, O/S 4.2 m RT HWY 17						ORIGINATED BY JN						
DIST 18 HWY 17		BOREHOLE TYPE Hollow Stem auger and cone test						COMPILED BY JN						
DATUM Geodetic		DATE 1989 10 05 to 12						CHECKED BY PL						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40						60
180.4	Ground Level													
0.0	175 mm Asphalt		1	SS	30									0 96 4 -
	FILL		2	SS	34									
	fine sand		3	SS	5									
	trace of silt		4	SS	4									
	brown		5	SS	1									
	very loose to dense		6	SS	19									0 98 2 -
	saturated		7	SS	7									
173.8			8	SS	18									
6.6	FINE SAND		9	SS	11									
	trace of silt		10	SS	7									
	poorly graded		11	SS	16									
	saturated													
	pink													
	loose to compact													
	some wood													
170.0														
10.4	SILTY (VARVED) CLAY		12	SS	0									
	interbedded with		13	SS	0									
	thin silt seams		14	SS	0									
	high plasticity													
	red													
	Firm													
165.0														
15.4	SILTY FINE SAND		15	SS	4									0 97 3 -
	red													
163.2	very loose		16	SS	0									
17.2	sand seam		17	SS	5									
	SILTY (VARVED) CLAY		18	SS	0									
	silt seam		19	SS	6									
	high plasticity		20	SS	0									
	red		21	SS	0									
	firm													
	stiff													
	silt seam													
154.5														
25.9	Continued													

OFFICE REPORT ON SOIL EXPLORATION

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6 (CONT.)										METRIC				
W P 185-79-01		LOCATION Sta. 10 +101, O/S 4.2 m RT HWY 17				ORIGINATED BY JN								
DIST 18 HWY 17		BOREHOLE TYPE Hollow stem auger and cone test				COMPILED BY JN								
DATUM Geodetic		DATE 1989 10 05 to 12				CHECKED BY IPL								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
154.5	Continuation													
25.9	SILTY (VARVED) CLAY high plasticity stiff		22	SS	0		154							
							152							
			23	SS	4		150							
							148							
			24	SS	0		146							
							144							
			25	SS	5		142							
142.9														
37.5	END OF BOREHOLE						140							
							138							
							136							
							134							
							132							
131.6														
48.8	END OF CONE TEST													

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

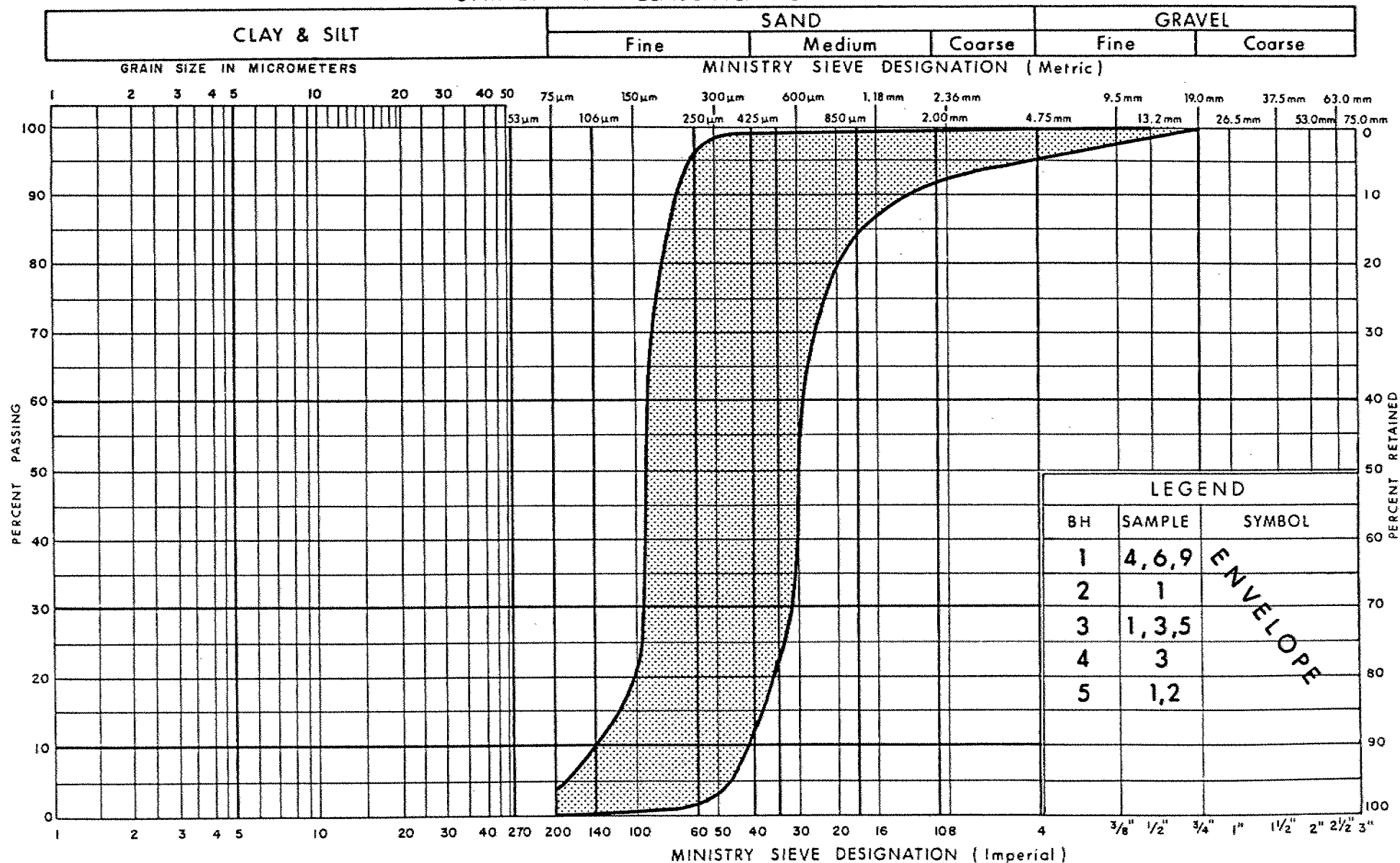
SAND FILL

FIG No 1

W P 185 - 79 - 01

DATE Nov. 89

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

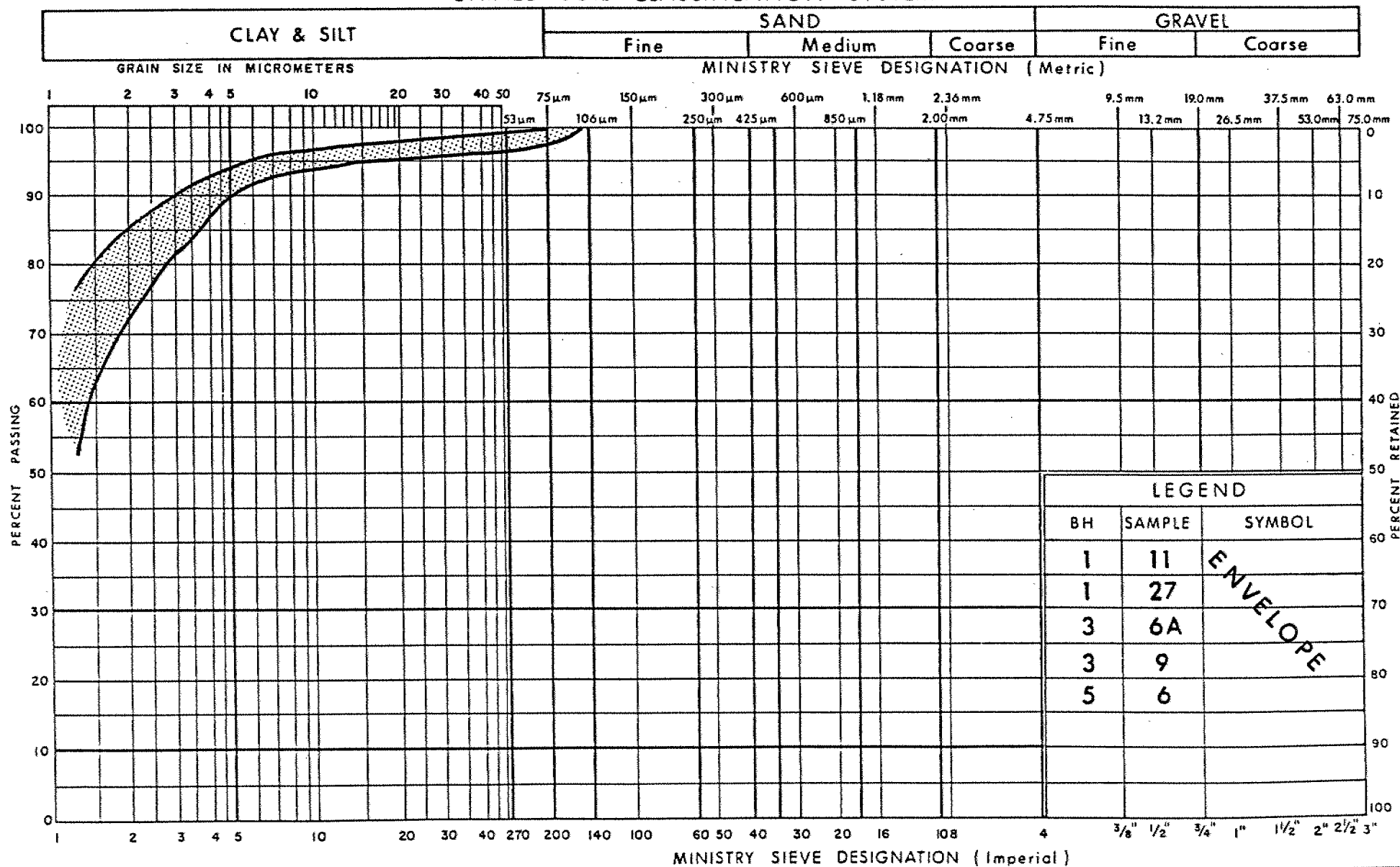
GRAIN SIZE DISTRIBUTION
FINE SAND

FIG No 2

W P 185-79-01

DATE Nov. 89

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

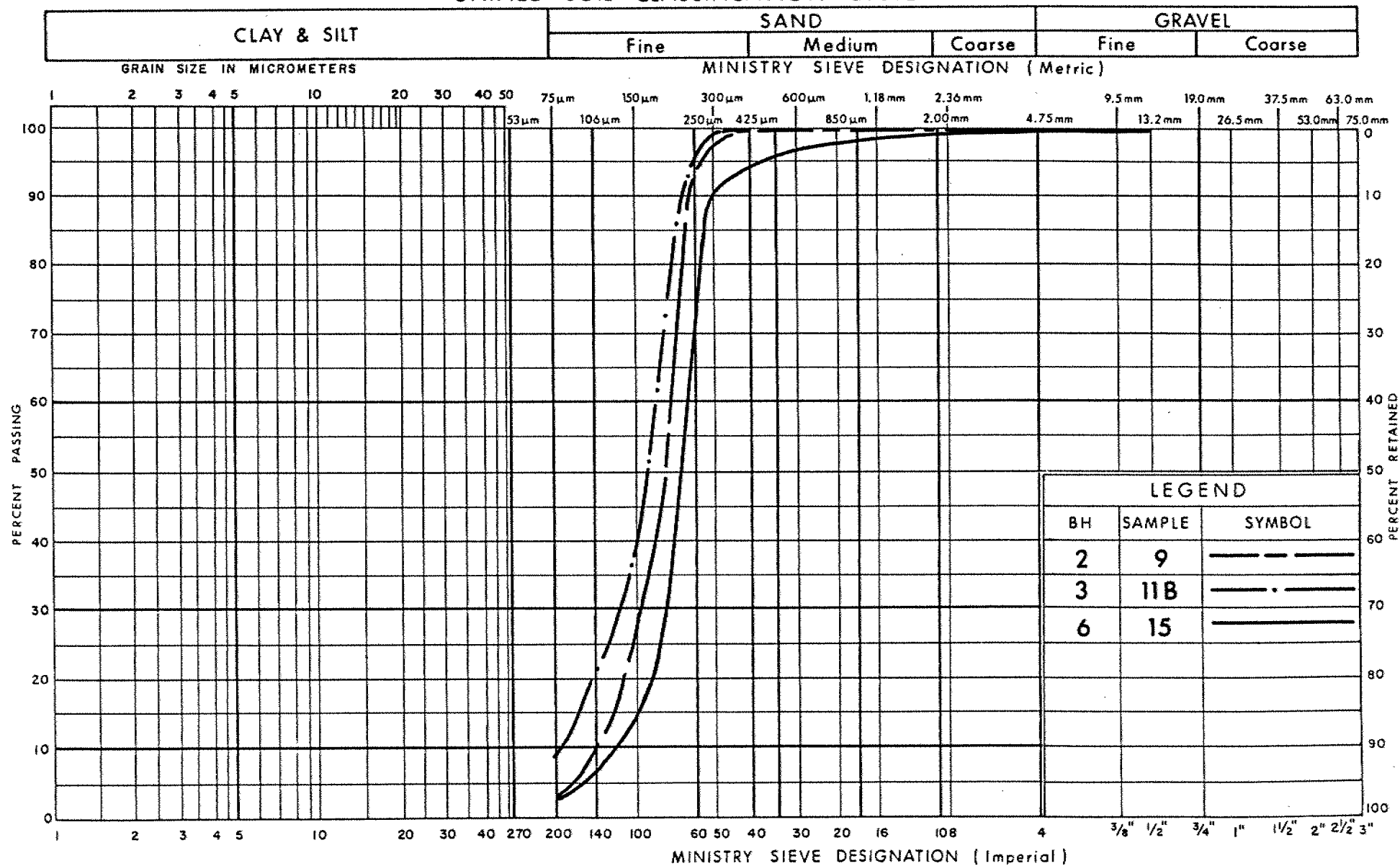
SILTY CLAY

FIG No 3

W P 185 - 79 - 01

DATE Nov. 89

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

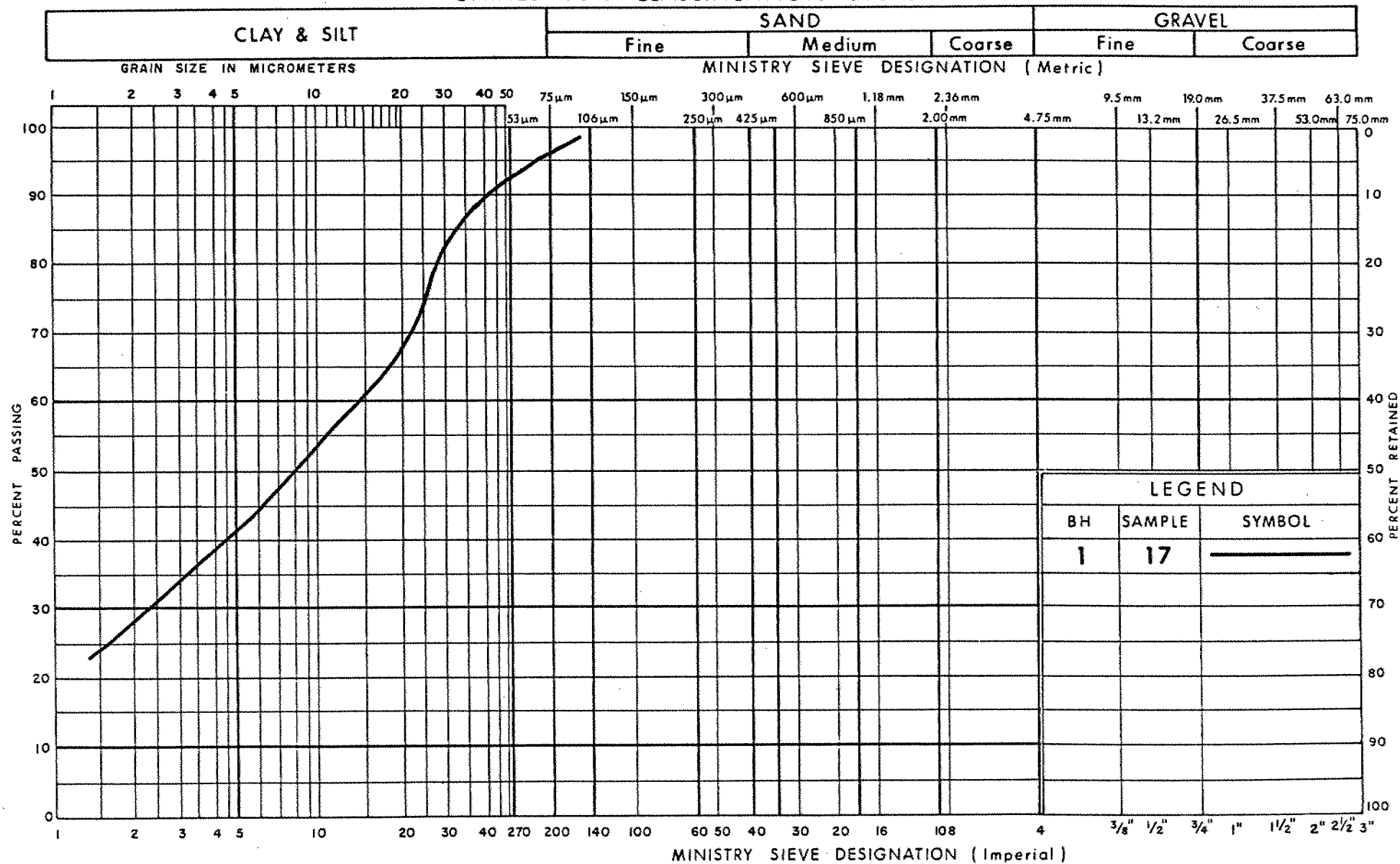
GRAIN SIZE DISTRIBUTION LOWER SAND

FIG No 4

WP 185-79-01

DATE Nov. 89

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

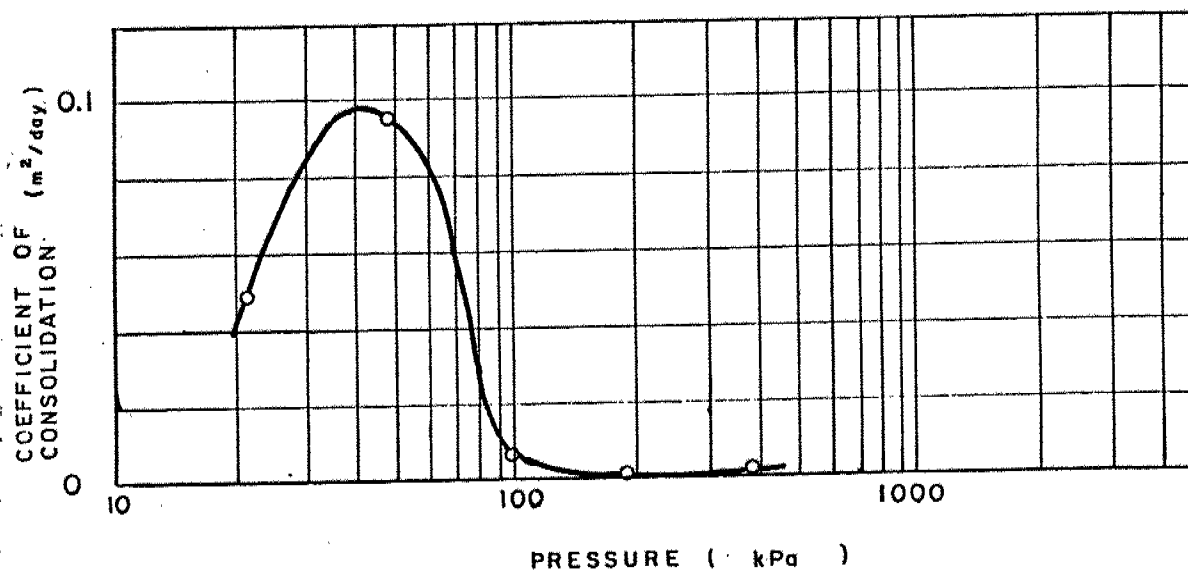
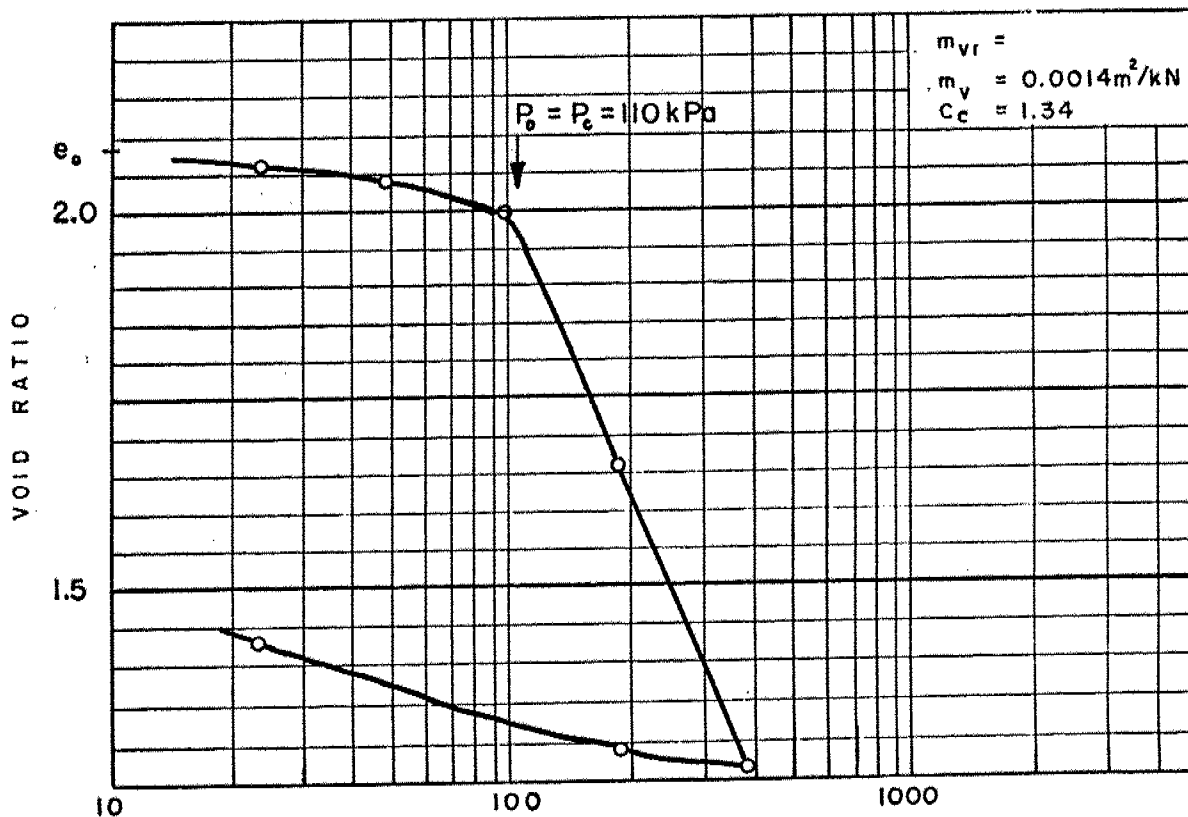
GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIG No 5

W P 185 - 79 - 01

DATE Nov. 89

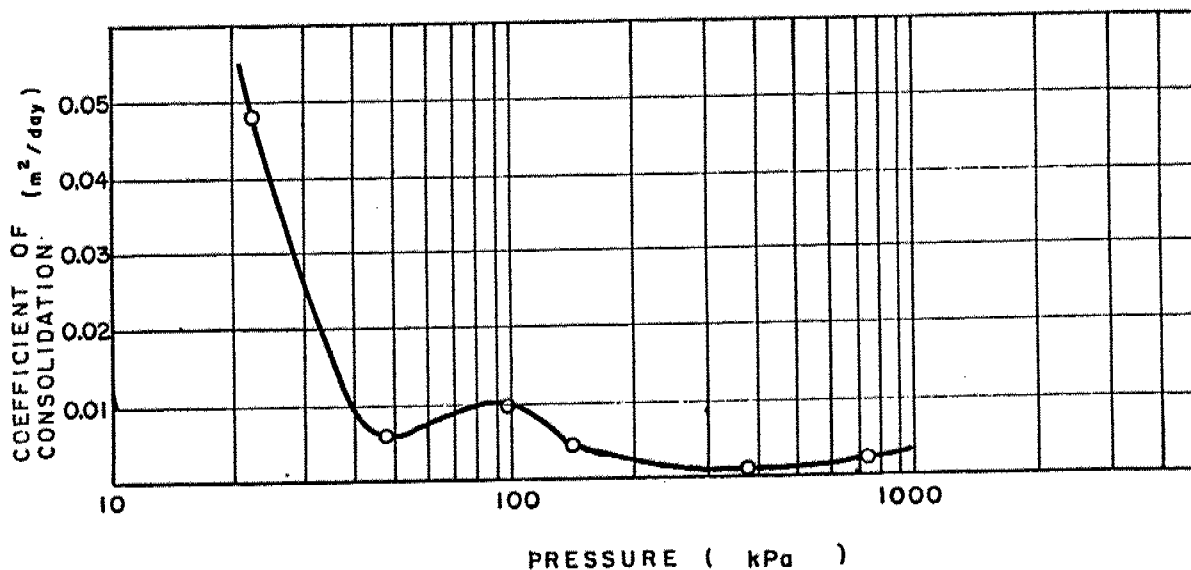
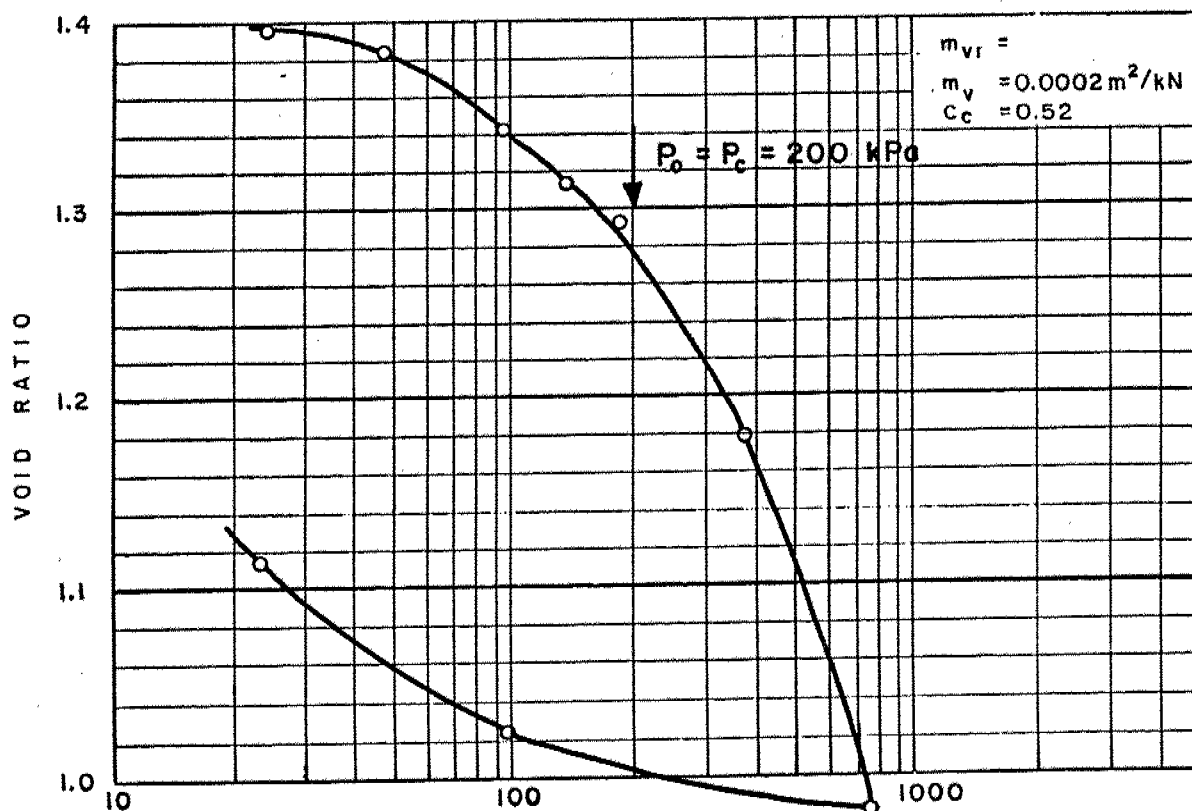


BOREHOLE 3
 SAMPLE 7
 DEPTH / ELEV. 9.7 / 166.5m

CONSOLIDATION TEST

WP185-79-01

FIGURE 6

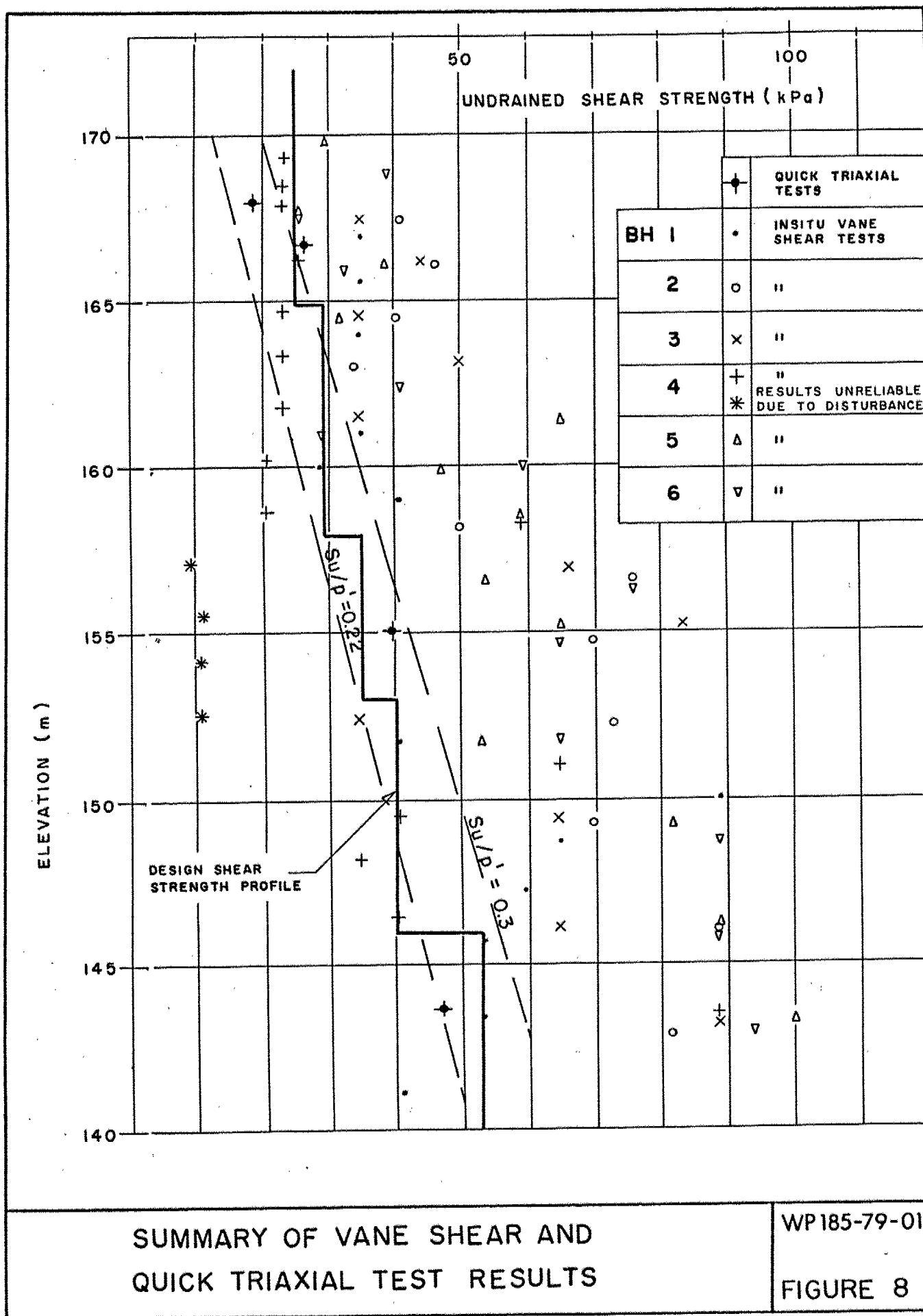


BOREHOLE 5
 SAMPLE 17
 DEPTH / ELEV. 36.9 / 143.7

CONSOLIDATION TEST

WP185-79-01

FIGURE 7



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

DIST. No. 18
CONT. No.
WP. No. 185-79-01



**ECHO BAY BRIDGE
HIGHWAY 17**

SHEET

GENERAL ARRANGEMENT

DILLON
Engineering & Construction

GENERAL NOTES

CLASS OF CONCRETE

- ALL CONCRETE 30 MPa

REINFORCING STEEL

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

COVER TO REINFORCING STEEL

- FOOTINGS 100mm
- ABUTMENTS AND WINDWALLS FRONT FACE 80mm
- BACK FACE 70mm
- DECK TOP 10mm
- BOTTOM 40mm
- REMAINDER (UNLESS OTHERWISE NOTED) 70mm

CONSTRUCTION NOTE

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

LIST OF DRAWINGS

- GENERAL ARRANGEMENT
- BARE HOLE LOCATION AND SOIL STRATA
- FOOTING LAYOUT AND REINFORCING
- ABUTMENTS
- WINDWALLS
- STRUCTURAL STEEL I
- STRUCTURAL STEEL II
- STRUCTURAL STEEL III
- DECK LAYOUT
- DECK REINFORCING
- STEEL BARRIER RAIL DETAILS
- PEDESTRIAN HANDRAIL
- 600mm APPROACH SLAB
- AS CONSTRUCTED PLAN AND ELEVATION
- JOINT UNDERPINNING AND ANCHORING
- DETAILS
- QUANTITIES - STRUCTURE

LIST OF ABBREVIATIONS

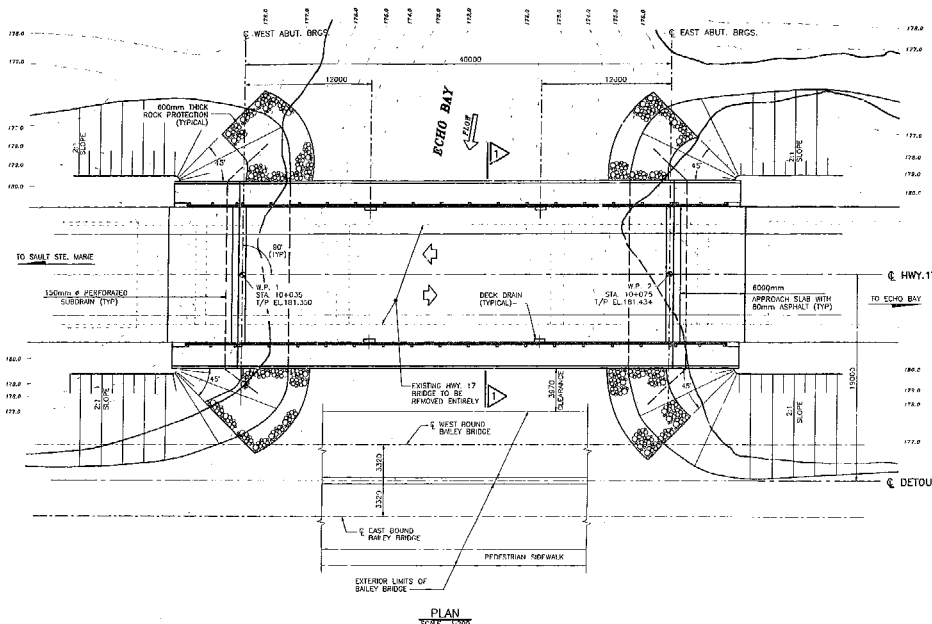
- W.P. DENOTES WORKING POINT
- T/P DENOTES TOP OF PAVEMENT
- T/F DENOTES TOP OF FOOTING
- W.L. DENOTES WATER LEVEL

APPLICABLE STANDARD DRAWINGS

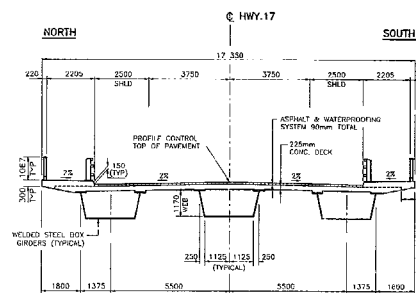
- SS 8-20 BRIDGE DECK WATERPROOFING

DATE	BY	DESCRIPTION
DESIGN	CHK.	CODE: 0800-43 ROAD CROSS A DATE: 1998
DRAWN	CHK.	SIZE: 300-111 STRUCT. TECHNIQUE: (WKS)

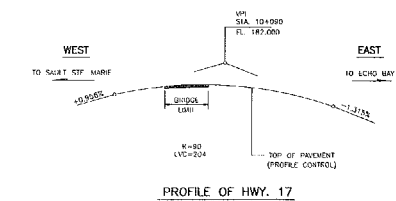
Design File: 0800-43
Job No.: 2345-01
Date Issued: July 19, 1999



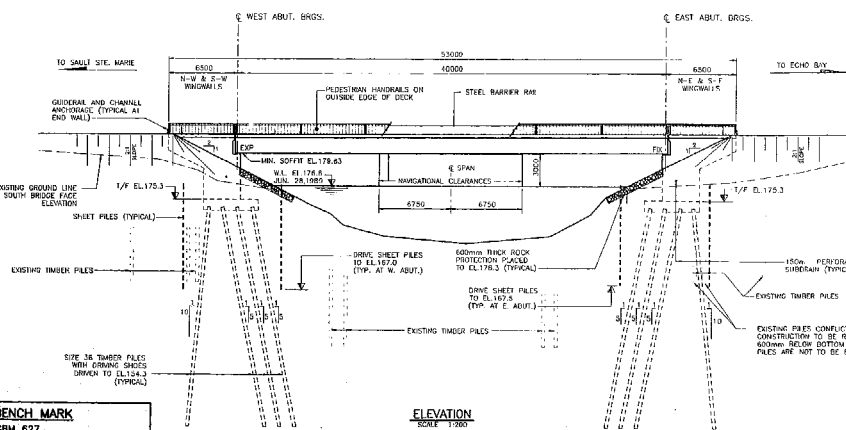
PLAN
SCALE 1:200



PROFILE OF HWY. 17
SCALE 1:100



PROFILE OF HWY. 17
NOT TO SCALE



ELEVATION
SCALE 1:200

BENCH MARK

CBM 627
EL. 181.369
BASS TABLE IN CONCRETE ABUTMENT
25.0 (1.00m)
QIND 4024 LINE 260

DRAWING NOT TO BE SCALED
100 mm OR ORIGINAL DRAWING