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DIST. 17 REGION                     

W.P. No. 122-79-02  
(18-79-00)

CONT. No. 86-206

W. O. No.                     

STR. SITE No.                     

HWY. No. 637

LOCATION Wanapiteik River Crossing

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 86-206



Ministry of  
Transportation and  
Communications

I N D E X

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Note: For the purpose of this contract this report supercedes all other foundation reports prepared by or for the Ministry in connection with the above mentioned project.

## EXPLANATION OF TERMS USED IN REPORT

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**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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

## FOUNDATION INVESTIGATION REPORT

For

Wanapitei River Crossing

W.P. 122-79-02, Site 46-203

Hwy. 637, Line 'D'

District 17, SudburyINTRODUCTION:

This report summarizes the factual information obtained from three foundation investigations carried out at the site mentioned above. The most recent fieldwork consisted of 13 sampled boreholes ranging in depth from 4.4 to 14.0 m and 2 dynamic cone tests, carried out between 84-03-26 and 84-04-04. The boreholes were advanced by means of hollow stem augers on land and wash boring techniques on the river.

Previous drilling at this site included 7 sampled boreholes and 11 dynamic cone penetration tests carried out from 82 03 15 to 82 03 18 and 80 09 05 to 80 09 06. The boreholes were advanced by means of hollow stem augers and washboring techniques. Bedrock was proven in 5 boreholes by obtaining up to 3.5 m of BXL rock core. The boreholes and cone tests ranged in depth from 4.7 to 17.9 m.

SITE DESCRIPTION

The site is located 10 km west of Hwy. 69 at the crossing of Hwy. 637 over the Wanapitei River, in the Geographic Township of Waldie, District of Sudbury. The proposed crossing is located on a slow flowing relatively wide 60 m section of the river flanked by a flat swampy floodplain to the west. The proposed structure site is approximately 300 m upstream of the existing crossing. The present crossing consists of two Bailey bridges founded on bedrock outcrops. The rock outcrops at the existing structures control the upstream water level.

The regional topography is typical Canadian Shield terrain consisting of knobby hills and rock ridges interspersed with hollows and swamps. Several rock outcroppings and scraps are evident in the area and tend to control the course of the river.

## SUBSURFACE CONDITIONS

### General

The subsurface conditions across the site are generally uniform. A 1.2 to 1.8 m surficial layer of soft to firm inorganic silt of slight plasticity to silty clay was generally encountered within the flood plain of the river. The dominant deposit across the site is a soft to stiff organic silt to organic silty clay. This organic stratum ranges in thickness from 3 to 12.2 m. Underlying the organic deposit is either granite bedrock or a 0.3 to 2.5 m layer of compact to very dense silty sand.

Two borings were advanced through the east and west approach embankments and 3.7 to 5.5 m of silty clay fill material was encountered. The eastern approach fill is underlain by subsoils as described above. The western approach fills are underlain by subsoils which vary from those encountered across the rest of the site. The silty clay fill at the west approach is underlain by 3 m of sand fill. Underlying the sand fill is a 3.7 m layer of organic silty clay, and a 1.8 m deposit of silty clay with sand some gravel. Overlying bedrock is a 1.7 m stratum of sand with silt some gravel.

The boundaries between the various soil types, insitu and laboratory test results are shown on the attached Record of Borehole Sheets. The locations and elevations of the boreholes and estimated stratigraphical profile and sections based on the borehole data are shown on Drawing No. 2 & 2A of the Contract structure drawings.

The various subsoil types encountered are described in the following paragraphs.

### Fill - Silty Clay some Sand trace Gravel

A cohesive fill material was encountered in the east and west approach embankments. The thickness of the fill varies from 3.7 to 5.5 m at the borehole locations (BH 800 & 809). The approach embankments were constructed under Ministry Contract No. 83-213.

The fill material is generally comprised of silty clay with occasional pockets of sand. Atterberg limit testing on samples from the fill indicate the silty clay to vary from a low to intermediate plasticity. The results of the Atterberg tests are plotted on Fig. 1.

A grain size distribution test carried out on a sample from the deposit is shown graphically on Fig. 2.

Standard Penetration Test 'N' values ranging from 6 to 18 indicate the fill has been subjected to a moderate degree of compaction.

#### Fill - Sand trace of Gravel and Silt

This granular fill material was encountered immediately below the cohesive fill in the most westerly investigated area of the site (BH 800). The stratum is 3.0 m thick and appears to be backfill for the muskeg excavation carried out under the west approach fill.

This fill material is predominantly sand containing traces of gravel and silt. Occasional pockets of silt and silty clay were encountered within the deposit. One grain size distribution test was carried out on a sample and the results are plotted on Fig. 2.

Based on 'N' values ranging from 2 to 3, it appears that the fill was not subjected to any compaction.

#### Inorganic Silt to Silty Clay

The surficial deposit of inorganic silt to silty clay was generally encountered across the site except within the river channel and a few locations on the river banks. The deposit varies from a silt of slight plasticity to a silty clay of low plasticity, and appears to be an alluvial deposit. Traces of sand and root structures were generally found within the stratum.

An atterberg limit test carried out on a sample from this deposit indicates the material to be a silt of slight plasticity (ML zone). The results of this test are plotted on Fig. 1.

Results of grain size distribution tests completed on samples from this stratum are plotted on Fig. 3.

Generally the deposit is assessed to be of a cohesive nature with consistency ranging from soft to firm based on Standard Penetration Test 'N' values ranging from 2 to 6.

#### Organic Silt to Organic Silty Clay

This cohesive stratum is the dominant deposit across the site and was encountered at the surface or immediately below the surficial deposits of inorganic silt to silty clay or fill material. The thickness of the stratum varies from 3.0 to 12.2 m. The deposit is comprised of organic silt with traces of sand in the upper portion and changing to an organic silty clay with depth. Lenses or pockets of black organics were encountered throughout the deposit.

The results of Atterberg Limit Tests carried out on samples from the organic silt and organic silty clay are shown on the Plasticity Chart, Fig. 4 and are summarized below.

#### Organic Silt of Low Plasticity trace of Sand

			<u>Range</u>	<u>Average</u>
Natural Moisture Content (w)	%		24-48	40%
Liquid Limit (w <sub>L</sub> )	%		25-35	31%
Plastic Limit (w <sub>p</sub> )	%		21-32	25%
Plasticity Index (I <sub>p</sub> )	%		2-10	6%

#### Organic Silty Clay

			<u>Range</u>	<u>Average</u>
Natural Moisture Content (w)	%		35-53	45%
Liquid Limit (w <sub>L</sub> )	%		35-52	42%
Plastic Limit (w <sub>p</sub> )	%		24-38	27%
Plasticity Index (I <sub>p</sub> )	%		6-29	15%



The Atterberg Limits indicate that the deposit is organic and generally varies from a low to medium plasticity. In addition, testing to determine the percentage of organic matter by weight was carried out on 12 samples. This testing yielded organic contents ranging from 1.9 to 7.3% with an average of 3.8%, indicating the deposit is highly organic in nature.

The consolidation characteristics of this deposit were determined by means of five one-dimensional consolidation tests. The results are plotted on Fig. 5 and 6 for 3 tests with a summary for all tests listed below.

	<u>Range</u>	<u>Average</u>
Preconsolidation Pressure ( $P_c$ ) kPa	34 - 78	59
Compression Index ( $C_c$ )	0.18 - 0.33	0.28
Initial Void Ratio ( $e_o$ )	1.03 - 1.311	1.163

Grain size distribution testing carried out on samples from this deposit are plotted on Fig. 7.

Undrained shear strengths as measured by in-situ vane testing were found to range from 15 to 97 kPa in extreme cases, but generally ranged from 25 to 55 kPa with an average strength of 35 kPa. Undrained shear strengths determined by triaxial tests are somewhat lower averaging 24 kPa and generally ranging from 12 to 33 kPa with an extreme case of 42 kPa. Based on the undrained shear strength testing the deposit is assessed to range from a soft to stiff consistency, generally being firm.

#### Sand with Silt some Gravel

A 0.3 to 2.5 m deposit of sand with silt some gravel was encountered in various locations overlying bedrock. The stratum does not appear to be continuous across the site with no generally observed patterns. Occasional cobbles or boulders were encountered within this deposit on the east side (BH #13, 10, and 810).

Grain size distribution tests carried out on samples from this stratum are plotted on Fig. 8 and indicate the deposit to be composed of a coarse grained granular material.

Based on Standard Penetration Test 'N' values ranging from 5 to 39 the deposit has a denseness ranging from loose to dense but is generally compact.

### Silty Clay with Sand some Gravel

This stratum was only encountered at the most westerly investigated portion of the site (BH 800), and was found between the organic silty clay and the sand with silt. The deposit is 1.8 m thick.

An atterberg test carried out on a sample indicates the deposit to be silty clay of medium plasticity. The results are plotted on Fig. 1.

Interpretation of an 'N' value of 22 blows indicates the consistency of the deposit is very stiff.

### Bedrock

The bedrock varies in elevation considerably over the site and is steeply sloping in the vicinity of the river banks. The bedrock elevation ranges from 177.5 to 189.1 with the lowest elevations being encountered within the river and the highest elevations on the west bank.

Bedrock slopes in the area of the river banks calculated from available data indicate dips ranging from 50° at the west river bank to 30° at the east river bank. The bedrock dips outside the limits of the river banks appear to be much more modest, approximately 15 to 20°.

The sloping nature of the bedrock was evidenced during drilling by the bending of drill rods and a tendency for augers to corkscrew upon contact with bedrock.

The bedrock is a fine to medium grained rock of possible meta-sedimentary origin. Intrusive felsic stringers and dykes are also present within the rock, notably at BH 2 where they constituted the entire 1.5 m core run.

The rock is generally of sound quality with minor fracturing and jointing. Some weathering is also evident particularly within the intrusive felsic rock of borehole 2. The rock quality designation (RQD) ranges from approximately 50 to 90 percent.

### Groundwater

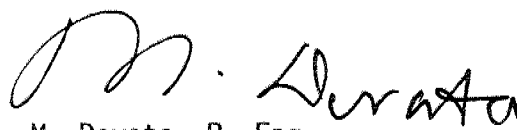
The groundwater levels recorded were generally slightly above or below the river level at elevation 193.2. The groundwater level is probably controlled by the river level.

MISCELLANIOUS

The "Foundation Investigation and Design Report" for this project was prepared by H. Sturm, P.Eng., of the MTC Foundation Design Section. This report contains only the factual information from that report.



L. Politano, P. Eng.  
Project Foundations Engineer



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

A P P E N D I X

RECORD OF BOREHOLE No 1

METRIC

W P 122-79-02 LOCATION Sta. 12 + 190, E Hwy. 637 Line "n" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 15 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
194.0	Top of snowpack																
0.0	250mm snow, Organic silt Firm Mottled Brown to dark gray with clayey zones		1	SS	2		192									17.8	Om=2.6Z
			2	TW	PH											Po=34.1kPa	
			3	SS	2											so = 1.18	
			4	TW	PH											cc = 0.33	Om=7.3Z
			5	SS	2		190										
			6	TW	PH											17.4	Om=4.0Z
			7	SS	1												0 2 (98)
			8	TW	PH		188										
186.8			9	SS													
7.2	Granitized Meta- sediment, Fine to Med. Grained Felsic Stringers Sound		10	RC Bx	100% Rec		186										RQD=67Z
			11	RC Bx	100% Rec		184										RQD=97Z
183.3																	
10.7	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5  
0  
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 122-79-02 LOCATION Sta. 12 + 197.5 o/s 5.0 Lt & Hwy. 637 Line "D" ORIGINATED BY B.D.  
DST 17 HWY 637 BOREHOLE TYPE Cone Test + 8x Rock Core COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 16 CHECKED BY C.H.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	
193.8	Ground Level											
0.0	Probable Organic silt											
188.2												
5.6	Intrusive felsic dyke, Fractured and weathered		1	RC Bx	100% Rec							
186.6												RQD=82%
7.2	End of Borehole											

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 3

METRIC

W P 122-79-02 LOCATION Sta. 12 + 193.5 o/s 5.0 Rt 6 Hwy.637 Line "D" ORIGINATED BY S.D.  
DIST 17 HWY 637 BOREHOLE TYPE Cone Test & Auger COMPILED BY S.D.  
DATUM Geodetic DATE 1982 03 16 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
193.9	Top of Snowpack												
0.0	250mm snow												
	Probable Organic silt												
185.0													
8.9	Auger refusal												
183.2	Probable Bedrock												
10.7	Cone refusal												
	Lower 3 meter rod severely bent												

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

## METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity



RECORD OF BOREHOLE No 5										METRIC			
W P 122-79-02		LOCATION Sta. 12 + 217 o/s 4.0 Lt & Hwy. 637 Line "D"						ORIGINATED BY B.D.					
DIST 17 HWY 637		BOREHOLE TYPE Cone Test						COMPILED BY B.D.					
DATUM Geodetic		DATE 1982 03 17						CHECKED BY C.M.					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
193.0	Ice Surface						192						
0.0	Water						190						
188.0	River Bottom						188						
5.0	Probable Organic Silt						186						
							184						
							182						
181.0													
180.7	Probable Sand, gravel												
12.3	Refusal Probable Bedrock												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 122-79-02 LOCATION Sta. 12 + 220.6 o/s 2.5 Lt & Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Cone Test COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 17 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
193.0	Ice Surface												
0.0													
	Water												
185.3	River Bottom												
7.7													
	Probable Organic silt												
179.5													
13.5	Probable Silty sand and gravel												
178.5													
14.5	Refusal Probable Bedrock												

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5  
0  
5  
10  
15  
20  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 7

METRIC

W P 122-79-02 LOCATION Sta. 12 + 214.6 o/s 2.5 Rt & Hwy. 637 Line "D" ORIGINATED BY B.D.  
 DIST 17 HWY 637 BOREHOLE TYPE Cone Test COMPILED BY B.D.  
 DATUM Geodetic DATE 1982 03 16 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
192.0	Ice Surface												
0.0													
	Water						192						
							190						
188.0	River Bottom												
5.0							188						
	Probable Organic silt						186						
							184						
							182						
179.3							180						
178.7	Probable sand and gravel												
14.3	Refusal Probable Bedrock												

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 122-79-02 LOCATION Sta. 12 + 218 o/s 4.0 Rt & Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Wash Bore, Bx Rock Core COMPILED BY B.D.  
DATUM Geodetic DATE 1982-03 15 & 16 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20	40	60	80	100		
193.0	Ice Surface													
0.0							192							
	Water						190							
							188							
185.8	River Bottom						186							
7.2	Organic Silt, occ. fine sand seams Traces of Wood and Peat, soft, Brown to Grey		1	SS	0		184							
			2	SS	0		182							
			3	SS	0		180							
			4	SS	1									
			5	SS	5									
178.5	Silty Sand & Gravel						178							30 60 (10)
177.5	Compact Brown		6	SS	22									RQD = 70%
15.5	Granitized Meta- sediment, felsic Stringers & Dykes Minor Fracturing Sound		7	RC Bx	100% Rec		176							RQD = 50%
175.1			8	RC Bx	100% Rec									
17.9	End of Borehole													

+3, x5 : Numbers refer to  
Sensitivity

20  
15  $\div$  5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 9

METRIC

W P 122-79-02 LOCATION Sta. 12 + 256.6 o/s 3.0 Lt @ Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Wash Bore, Cone Test and Bx Rock Core COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 17 & 18 CHECKED BY C.H.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT MATTHESS MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PROF.	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
193.0	Ice Surface																
0.0	Water						192										
							190										
							188										
186.2	River Bottom						186										
6.8	Organic silt Soft Brown to Grey						184										
			1	SS	0												
			2	SS	0												
			3	SS	0												
			4	SS	13												
179.0							180										
14.0	Silty Sand & Gravel						178										
177.9	Compact, Brown																
15.1	Granitized Meta- sediment, Fine to Medium grained		5	RC	Rec 100%												
	Felsic Stringers		6	Bx	100% Rec												
175.4	Hard, Fractured						176										
17.6	End of Borehole Lower 3M Rod bent during driving of cone																

RECORD OF BOREHOLE No 10

METRIC

W P 122-79-02 LOCATION Sta. 12 + 260.6 o/s 2.5 L.R. 6 Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Cone Test COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 17 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
193.0	Ice Surface												
0.0													
	Water						192						
							190						
188.3	River Bottom						188						
4.8							186						
	Probable Organic silt						184						
181.0							182						
12.0	Probable Silty Sand and Gravel						180						
178.5													
14.5	Refusal Probable Bedrock												

OFFICE REPORT ON SOIL EXPLORATION

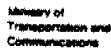
RECORD OF BOREHOLE No 11

METRIC

W P 122-79-02 LOCATION Sta. 12 + 254.6 o/s 2.5 Rt. 6 Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Cone Test COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 17 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
193.0	Ice Surface												
0.0													
	Water												
186.3	River Bottom												
6.7													
	Probable Organic silt												
179.7													
13.3	Probable Silty												
178.9	Sand and Gravel												
14.1	Refusal												
	Probable Bedrock												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 12								METRIC					
W P 122-79-02		LOCATION Sta. 12 + 258 o/s 4.0 Rt & Hwy. 637 Line "D"						ORIGINATED BY S.D.					
DIST 17 HWY 637		BOREHOLE TYPE Cone Test						COMPILED BY S.D.					
DATUM Goadaric		DATE 1982 03 17						CHECKED BY C.M.					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
193.0 0.0	Ice Surface						192						
	Water						190						
188.2 4.8	River Bottom						188						
	Probable Organic Silt						186						
182.8 10.2	Probable Silty Sand and Gravel						184						
181.4 11.6	Refusal Probable Bedrock						182						
								50/0mm					

+3, x5: Numbers refer to Sensitivity



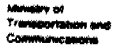
# RECORD OF BOREHOLE No 13

METRIC

W P 122-79-02 LOCATION Sta. 12 + 272.5 @ Hwy. 637 Line "D" ORIGINATED BY B.D.  
 DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger COMPILED BY B.D.  
 DATUM Geodetic DATE 1982 03 17 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
194.3	Top of Snowpack															
0.0	250mm snow Organic Silt Soft Mottled Brown to Dark Grey Occ. plant remains		1	SS	2		194									0 15 (85)
			2	TW	PH										18.9	Om=2.5Z
			3	SS	2		192									Om=5.6Z
			4	TW	PH											Om=3.5Z
			5	SS	1		190									Po=53.6kPa e <sub>o</sub> =1.03 c <sub>c</sub> =0.18
			6	TW	PH											
			7	SS	1		188									
			8	TW	PH											
			9	SS	0											0 1 (99)
186.0			10	TW	PH		186									
8.3	Silty Sand & Gravel Occ. Cobble, Compact Brown		11	SS	18											
184.7																
9.6	Refusal to Augering Spoon bent at bottom sample. Probable Bedrock															

OFFICE REPORT ON SOIL EXPLORATION

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 15

METRIC

W P 122-79-02 LOCATION Sta. 12 + 277.6 o/s 5.0 Rt 6 Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Cone Test COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 17 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
194.2	Top of Snowpack													
0.0	250mm snow													
	Probable Organic silt													
188.0														
6.2	Probable silty sand and gravel													
186.7														
7.5	Refusal Probable Bedrock													

RECORD OF BOREHOLE No 16

METRIC

W P 122-79-02 LOCATION Sta. 12 + 285 @ Hwy. 637 Line "D" ORIGINATED BY B.D.  
DIST 17 HWY 637 BOREHOLE TYPE Cone Test COMPILED BY B.D.  
DATUM Geodetic DATE 1982 03 17 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
194.1	Top of Snowpack												
0.0	250mm Snow												
	Probable Organic silt												
189.4													
4.7	Refusal												
	Possible boulder												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 103 (Formerly BH #3) METRIC

W P 122-79-02 LOCATION Sta. 12 + 198.4, @ Hwy. 637 Line "D" ORIGINATED BY R.B.  
DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core & Cone Test COMPILED BY R.B.  
DATUM Geodetic DATE 1980 09 05 CHECKED BY C.V.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
193.5	Ground Surface												
0.0	Organic Silty Clay												
	Stiff to Firm		1	SS	5								
			2	SS	2								
			3	TW	PH								
			4	SS	2								
187.5			5	TW	PH								
6.3			6	SS	4.5/15cm								
185.6	Granite Bedrock		7	BXL RC	Rec 90%								
7.9	End of Borehole												

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

RECORD OF BOREHOLE No 104 (Formerly BH #4) METRIC

W P 122-79-02 LOCATION Sta. 12 + 282.8, o/s 1.8m Rt. of Hwy. 637 Line "D" ORIGINATED BY R.B.  
DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core & Cone Test COMPILED BY R.B.  
DATUM Geodetic DATE 1980 09 06 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
183.7	Ground Level												
0.0	Organic Silty Clay												
	Stiff to Firm												
			1	SS	6								0.9 80 11
			2	SS	3								
			3	TW	PH								0.9 85 6
			4	SS	2								$e_0 = 1.106$
			5	TW	PH								$P_c = 65 \text{ kPa}$
187.7	Boulder		6	RC	Rec								$C_c = 0.273$
187.0	Silty Fine Sand		7	SS	5								$O_m = 2.77$
185.8	Loose		8	SS	41/81cm								
7.9	Granite Bedrock		9	BXL RC	Rec 80%								RQD = 95%
184.2													
9.5	End of Borehole												

\*3, \*5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 800

METRIC

W P 122-79-02 LOCATION Sta. 12 + 166.0; 4 Hwy. 637 Line D ORIGINATED BY DT & ES  
DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DT  
DATUM Geodetic DATE 84 03 26 - 27 CHECKED BY CP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
195.5	Ground Surface															
0.0	Silty Clay (Fill) some sand trace gravel Occasional Pockets of Sand  Firm to Stiff		1	SS	9											
			2	SS	8											
			3	SS	15											
191.8			4	SS	6											
3.7	Sand (Fill) trace gravel and silt Occasional Pockets of Silty Clay Very Loose		5	SS	2											
			6	SS	2											
188.8			7	SS	3											
6.7	Organic Silty Clay  Soft		8	SS	3											
			9	SS	3											
185.1			10	SS	22											
10.4	Silty Clay with Sand some gravel Very Stiff															
183.3			11	SS	6											
12.2	Sand with silt Loose some gravel Very Dense															
181.6			12	SS	45/150											
13.9	End of Borehole Refusal to Auger Probable Bedrock															

RECORD OF BOREHOLE No 801

METRIC

W P 122-79-02 LOCATION Sta. 12 + 174.0; O/S 150 m RT & Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger COMPILED BY DT  
DATUM Geodetic DATE 84 03 29 CHECKED BY *GP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60					
193.5	Ground Surface													
0.0	Inorganic Silt some sand trace clay Firm		1	SS	5									0 13 81 6
192.1			2	SS	2									
1.4	Organic Silt trace sand to Organic Silty Clay  Firm		3	TW	PH								17	
183.0														
10.5	Sand, some gravel some silt Dense		4	SS	39									18 60 22 0
181.8														
11.7	End of Borehole Refusal to Auger Probable Bedrock													

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





RECORD OF BOREHOLE No 802

METRIC

W P 122-79-02 LOCATION Sta. 12 + 184.0; O/S 16.0 m RT & Hwy. 637 Line D  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger  
DATUM Geodetic DATE 84 03 28  
ORIGINATED BY DT & HS  
COMPILED BY DT  
CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
193.2	Ground Surface															
0.0	Inorganic Silt some sand trace clay & roots	1	SS	2												0 15 77 8
191.7	Soft															
1.5	Organic Silt trace sand	2	SS	2												
	to	3	FW	PH												
	Organic Silty Clay Occasional Pockets of Black Organics															
	Firm	4	SS	3												
181.6																
11.6	End of Borehole Refusal to Auger Probable Bedrock															

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 803

METRIC

W P 122-79-02 LOCATION Sta. 12 + 180.0; O/S 30.0 m RT & Hwy. 637 Line D ORIGINATED BY DT & HS  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger COMPILED BY DT  
DATUM Geodetic DATE 1984 03 28 CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20	40	60	80	100					
193.3	Ground Surface																
0.0	Inorganic Silt some sand trace clay & roots Soft		1	SS	2		192			24				0			0 15 76 9
191.8																	
1.5	Organic Silt trace sand to Organic Silty Clay Occasional lenses of Black Organics		2	SS	2		190			6				1	0		O.M. * = 3.9%
			3	FW	PH		188			4						15.9	
							186			4							
							184			4							
							182			4							
181.9	End of Borehole Refusal to Auger Probable Bedrock * O.M. = percentage of organic matter by weight																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 804

METRIC

W P 122-79-02 LOCATION Sta. 12 + 170.0; O/S 26.0 m RT & Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger COMPILED BY DT  
DATUM Geodetic DATE 84 03 29 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
193.6	Ground Surface																
0.0	Inorganic Silt some sand trace clay		1	SS	3												
192.1	Soft																
1.5	Organic Silt trace of sand to Organic Silty Clay		2	SS	2												
			3	SW	PH												
	Firm																
180.5																	
13.1	Sand some gravel																
179.6	some silt Compact		4	SS	29												19 55 23 3
14.0	End of Borehole Refusal to Auger Probable Bedrock																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 805

METRIC

W P 122-79-02 LOCATION Sta. 12 + 176.0; O/S 38.3 m RT & Hwy. 637 Line D  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger  
DATUM Geodetic DATE 84 03 28  
ORIGINATED BY DT & HS  
COMPILED BY DT  
CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
193.6	Ground Surface												
0.0	Inorganic Silt trace sand and fibrous organics		1	SS	4								
191.8	Firm												
1.8	Organic Silt trace sand to Organic Silty Clay		2	SS	2								
			3	SS	4								
	Firm to Stiff												
181.3	End of Borehole Refusal to Auger Probable Bedrock												
12.3	* O.M. = percentage of organic matter by weight												

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

20  
15  
10  
5  
0  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 806

METRIC

W P 122-79-02 LOCATION Sta. 12 + 175.0; O/S 10.0 m LT & Hwy. 637 Line D  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger  
DATUM Geodetic DATE 84 03 30  
ORIGINATED BY DT  
COMPILED BY DT  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
193.9	Ground Surface																
0.0	Inorganic Silty Clay some sand trace gravel pieces of wood Firm		1	SS	6	*											
192.5			2	SS	3												
1.4	Organic Silt trace sand to Organic Silty Clay  Firm		3	TW	PH											17.0	
185.4			4	SS	100A	50 mm											
8.5	Sand, some gravel some silt Dense		5	SS	31												
184.3	End of Borehole Refusal to Auger Probable Bedrock  * Note: Groundwater Level not established																
9.6																	

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

20  
15  
10  
5  
0  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 807

METRIC

W P 122-79-02 LOCATION Sta. 12 + 184.0; O/S 10.0 m LT & Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger COMPILED BY DT  
DATUM Geodetic DATE 84 04 02 CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
193.7	Ground Surface																
0.0	Inorganic Silty Clay some sand, trace fibrous organics Firm		1	SS	5	*											
192.5																	
1.2	Organic Silt trace sand to Organic Silty Clay Pockets of Organics Stiff to Firm		2	SS	3		192										O.M. = 4.0%
			3	SW	PH		190									17.4	
187.5			4	SS	100	100mm	188										
6.2	End of Borehole Refusal to Auger Probable Bedrock  * Note Groundwater Level not established  ** O.M. = Percentage of organic matter by weight																

\*3, \*5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 808

METRIC

W P 122-79-02 LOCATION Sta. 12 + 200.0; O/S 10.0 m LT & Hwy. 637 Line D  
 DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger  
 DATUM Geodetic DATE 84 04 02  
 ORIGINATED BY DT  
 COMPILED BY DT  
 CHECKED BY *CP*

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
193.5	Ground Surface															
0.0	Inorganic Silt, some sand, trace of roots		1	SS	2	*										GR SA SI CL
192.1	Soft															
1.4	Organic Silt trace sand to Organic Silty Clay		2	SS	2											0 5 90 5
	Stiff															
189.1	some gravel		3	SS	76/180											
4.4	End of Borehole Refusal to Auger Probable Bedrock															
	* Note: Groundwater Level not established															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 809

METRIC

W P 122-79-02 LOCATION Sta. 12 + 297.6; 4 Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger COMPILED BY DT  
DATUM Geodetic DATE 84 04 04 CHECKED BY [Signature]

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
199.0	Ground Surface															
0.0	Silty Clay (Fill) some sand trace gravel trace of fibrous organics  Stiff to Very Stiff		1	SS	18											
			2	SS	10											
193.5			3	SS	15											
5.5	Organic Silt trace of wood and fibrous organics to Organic Silty Clay  Soft to Stiff		4	SS	17											
			5	SS	3											
186.8																
12.2	Probable Sand some gravel															
185.4																
13.6	End of Borehole Refusal to Auger Probable Bedrock  * Note: Groundwater level not established  ** O.M. = percentage of organic matter by weight															

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE





RECORD OF BOREHOLE No 810

METRIC

W P 122-79-02 LOCATION Sta. 12 + 270.5; O/S 6.1 m RT Q. Hwy. 637 Line D  
DIST 17 HWY 637 BOREHOLE TYPE Solid Stem Auger  
DATUM Geodetic DATE 84 04 04  
ORIGINATED BY DT  
COMPILED BY DT  
CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
194.1	Ground Surface																
0.0	Inorganic Silt trace sand & roots Soft		1	SS	2		194										
192.7																	
1.4	Organic Silt trace sand occasional pockets of Black organics to Organic Silty Clay  Soft to Stiff		2	TW	PH		192									16.5	P <sub>c</sub> = 78 kPa e <sub>0</sub> = 1.311 C <sub>c</sub> = 0.300
			3	SS	2		190										
							188										
			4	SS	2		186										
							184										
183.6	Sand some gravel Occasional cobbles Very Dense		5	SS	100/25 mm												
10.5																	
182.5	End of Borehole Refusal to Auger Probable Bedrock																
11.6																	

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 811

METRIC

W P 122-79-02 LOCATION Sta. 12 + 193.4; O/S 16.0 m RT 4 Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Wash Bore COMPILED BY DT  
DATUM Geodetic DATE 84 04 02 - 03 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	γ		
193.2	Water Surface													
0.0	Water													
192.6														
0.6	Organic Silt trace sand		1	SS	1		192	+5						
	to Soft		2	SS	1			+3						
	Organic Silty Clay		3	TW	PH		190						17.3	
	Firm							+3						
	Occasional pockets of Black organics						188							
								+3						
							186							
								+3						
							184							
								+3						
							182							
180.4								+3						
12.8	End of Borehole													
	Probable Bedrock													
	* O.M. = percentage of organic matter by weight													

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

RECORD OF BOREHOLE No 812

METRIC

W P 122-79-02 LOCATION Sta. 12 + 208.6; O/S 4.5 m RT Q. Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Dynamic Cone Test COMPILED BY DT  
DATUM Geodetic DATE 84 04 02 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
193.2 0.0	Water Surface Water										
191.1 2.1	River Bottom										
	Probable Organic Silt to Organic Silty Clay										
181.2 12.0	End of Cone Test Probable Bedrock										

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

## RECORD OF BOREHOLE No 813

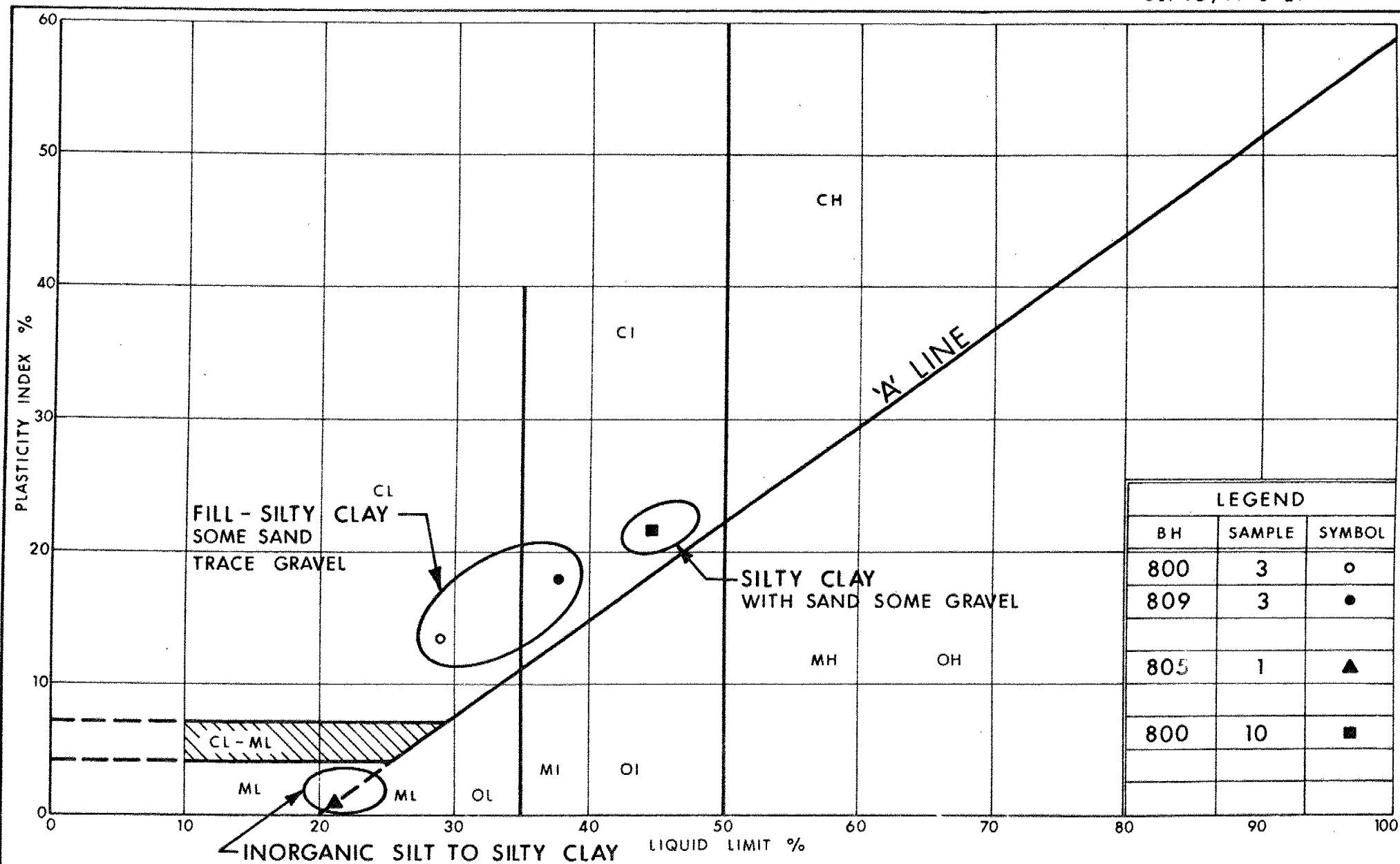
METRIC

W P 122- 79-02 LOCATION Sta. 12 + 205.2; O/S 4.6 m LT & Hwy. 637 Line D ORIGINATED BY DT  
DIST 17 HWY 637 BOREHOLE TYPE Wash Bore COMPILED BY DT  
DATUM Geodetic DATE 84 04 03 CHECKED BY CP

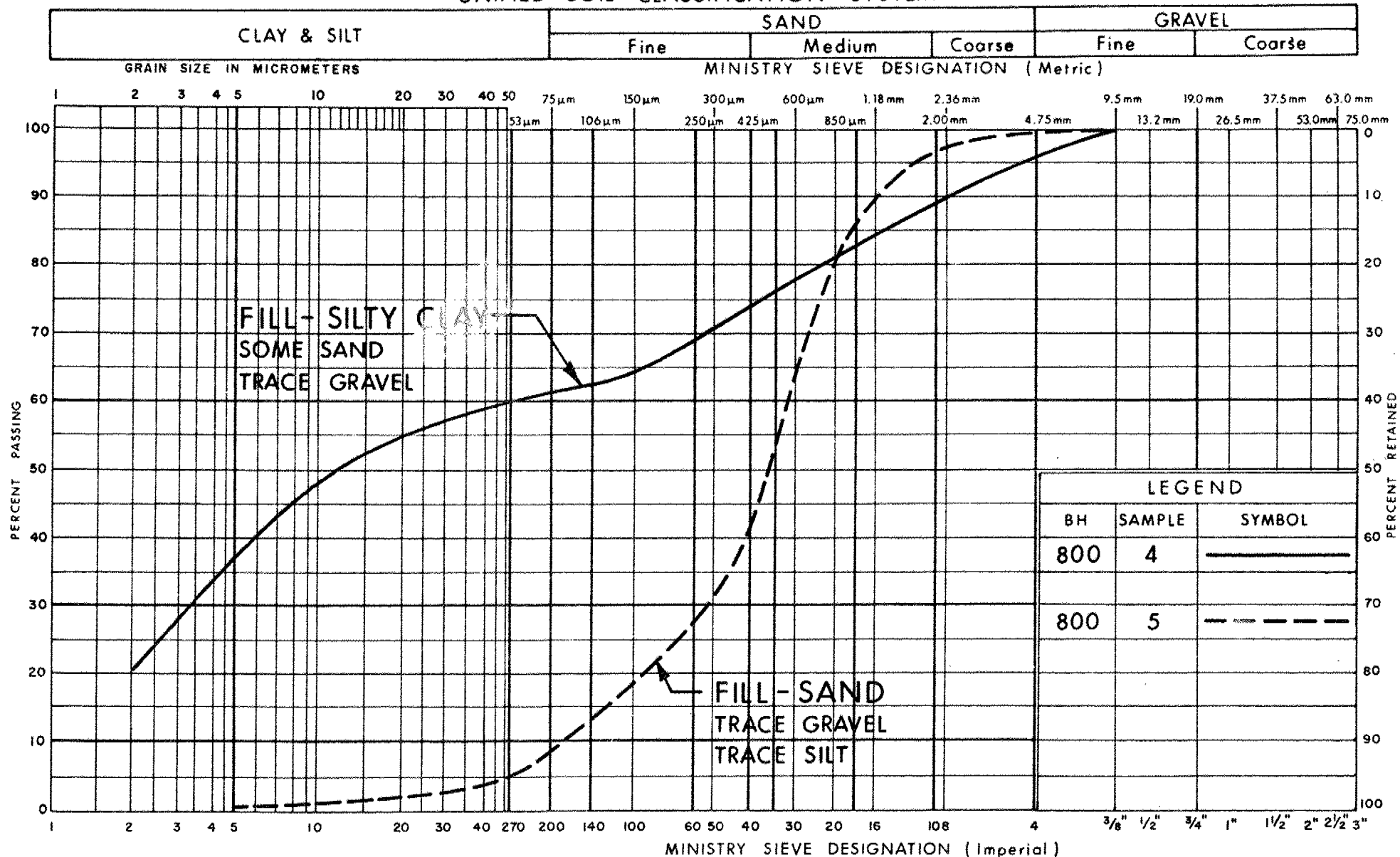
[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 814										METRIC		
W P 122-79-02		LOCATION Sta. 12 + 267.8; O/S 10.6 m Lt & Hwy. 637 Line D				ORIGINATED BY DT						
DIST 17 HWY 637		BOREHOLE TYPE Dynamic Cone Test				COMPILED BY DT						
DATUM Geodetic		DATE 84 04 03				CHECKED BY <i>[Signature]</i>						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
193.2	Water Surface											
0.0	Water											
190.2	River Bottom											
3.0	Probable Organic Silt to Organic Silty Clay						cone sank under the weight of the rods					
179.6	End of Cone Test Probable Bedrock							125	200	mm		



## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

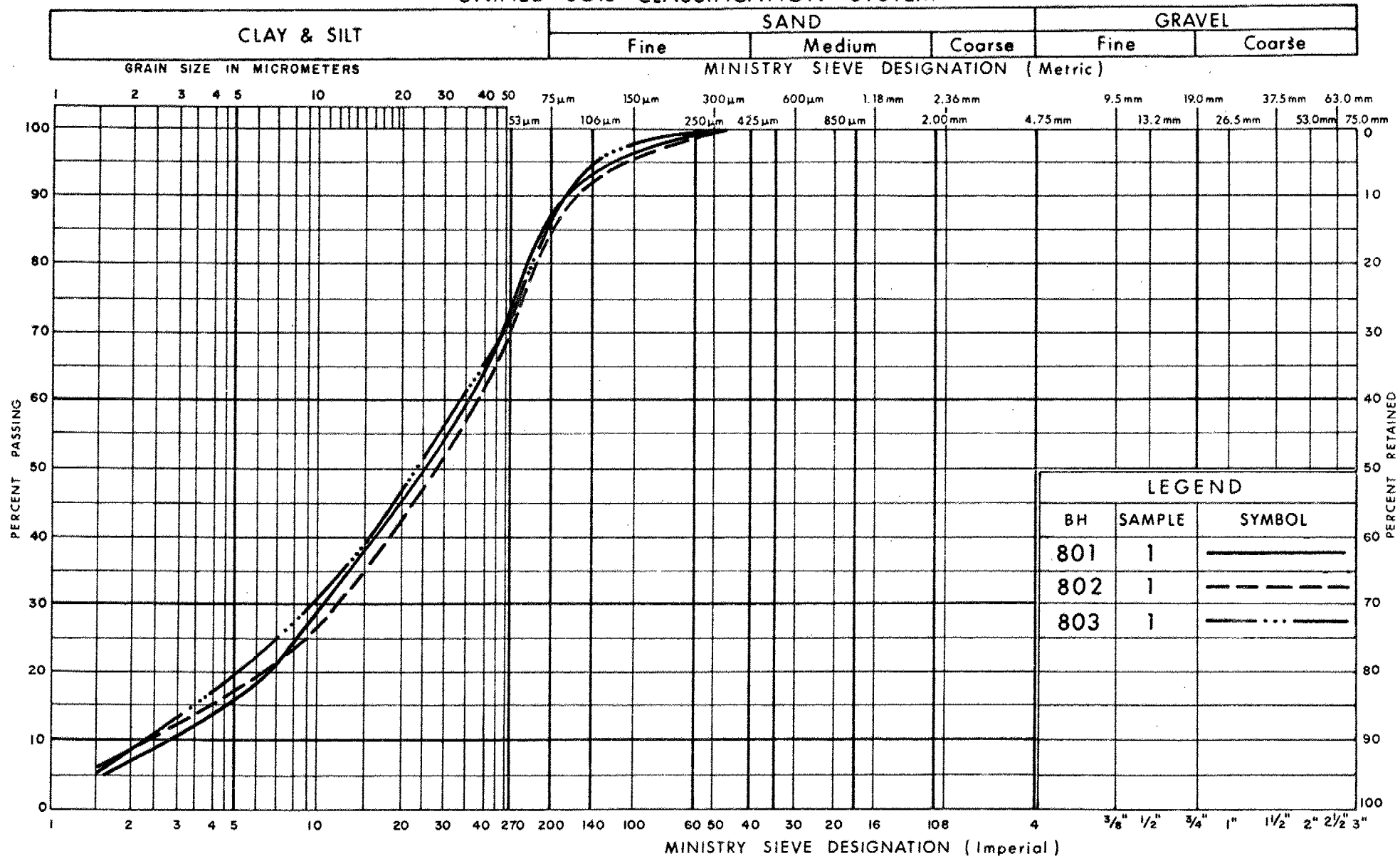
 Ministry of  
Transportation and  
Communications

## GRAIN SIZE DISTRIBUTION

FIG No 2

W P 122-79-02

## UNIFIED SOIL CLASSIFICATION SYSTEM



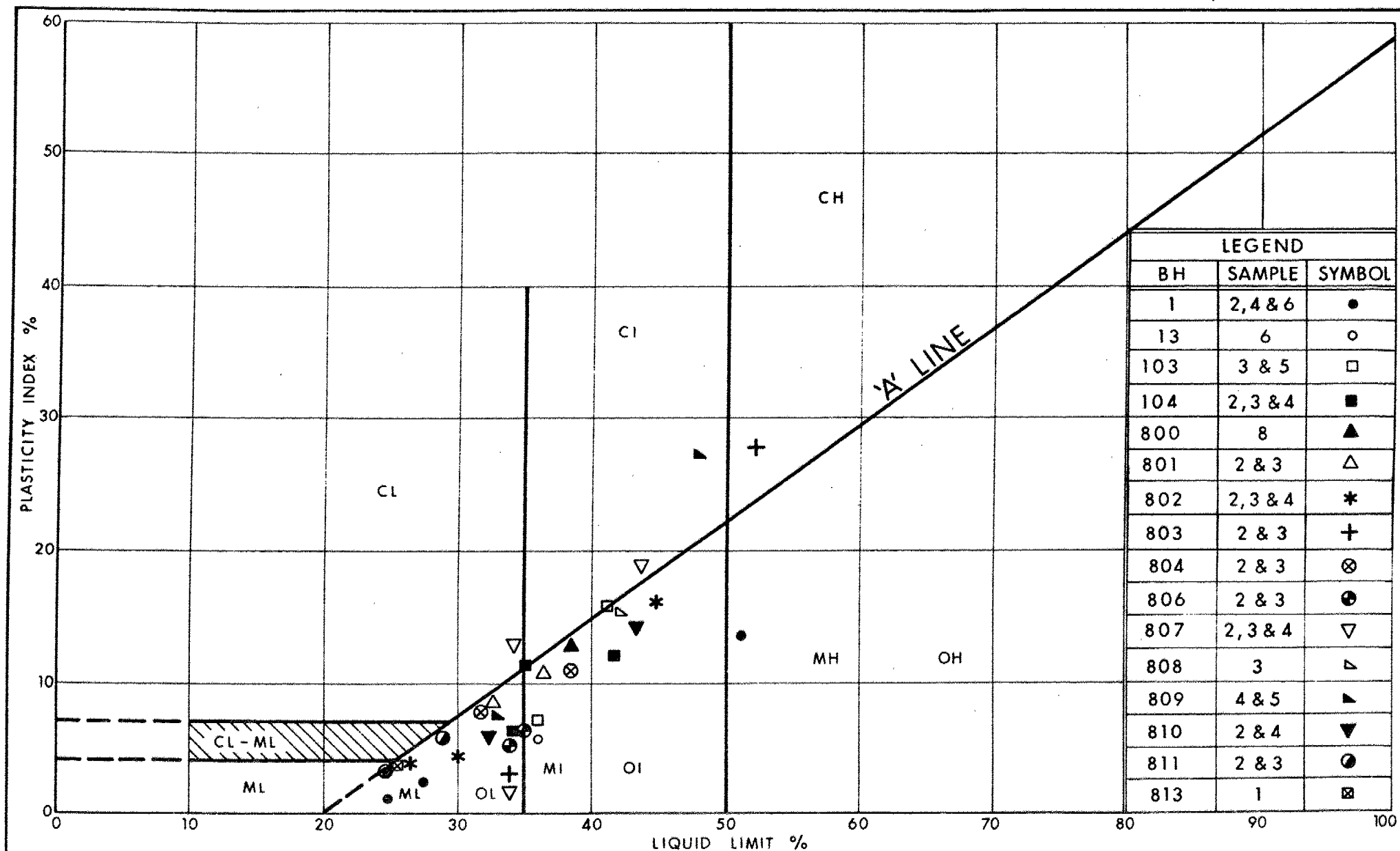
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
INORGANIC SILT TO SILTY CLAY

FIG No 3

W P 122-79-02





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# PLASTICITY CHART ORGANIC SILT TO ORGANIC SILTY CLAY

FIG No 4

W P 122-79-02

# VOID RATIO - PRESSURE CURVES

48

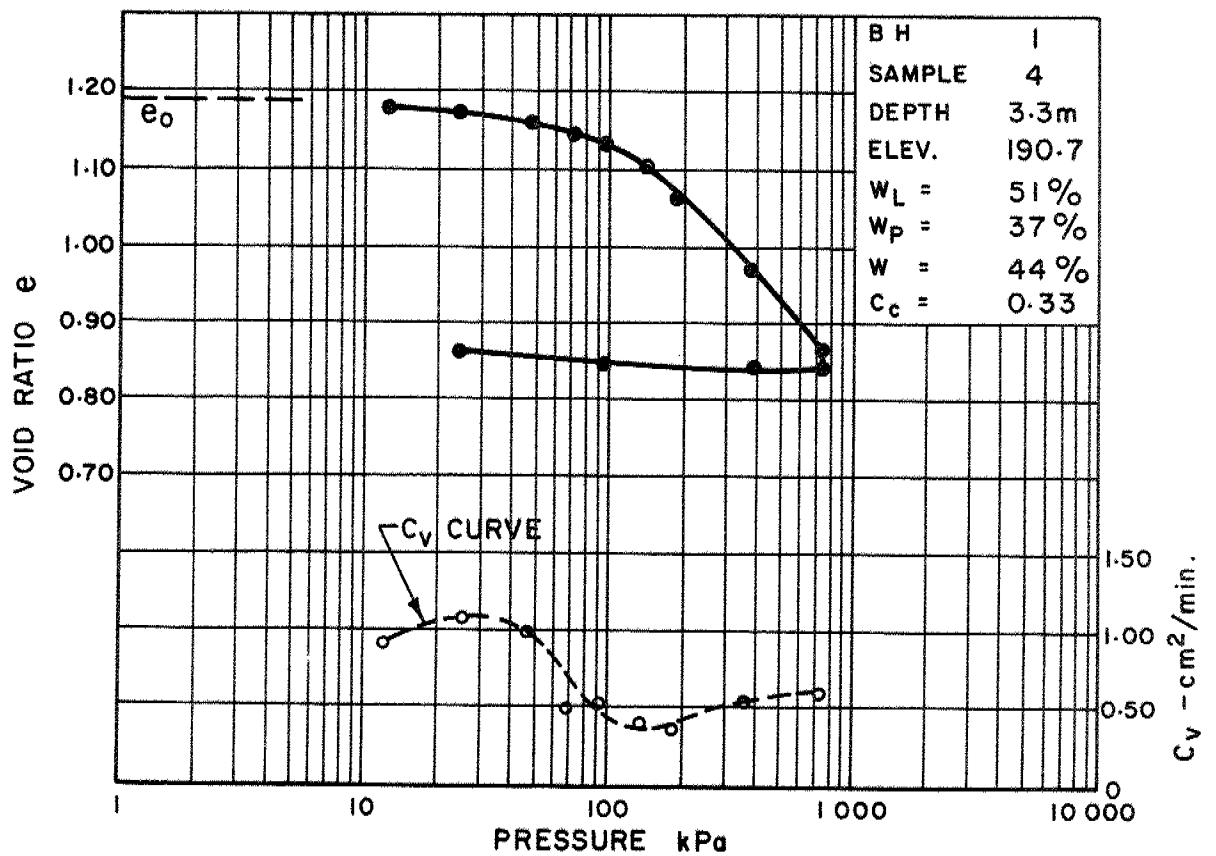
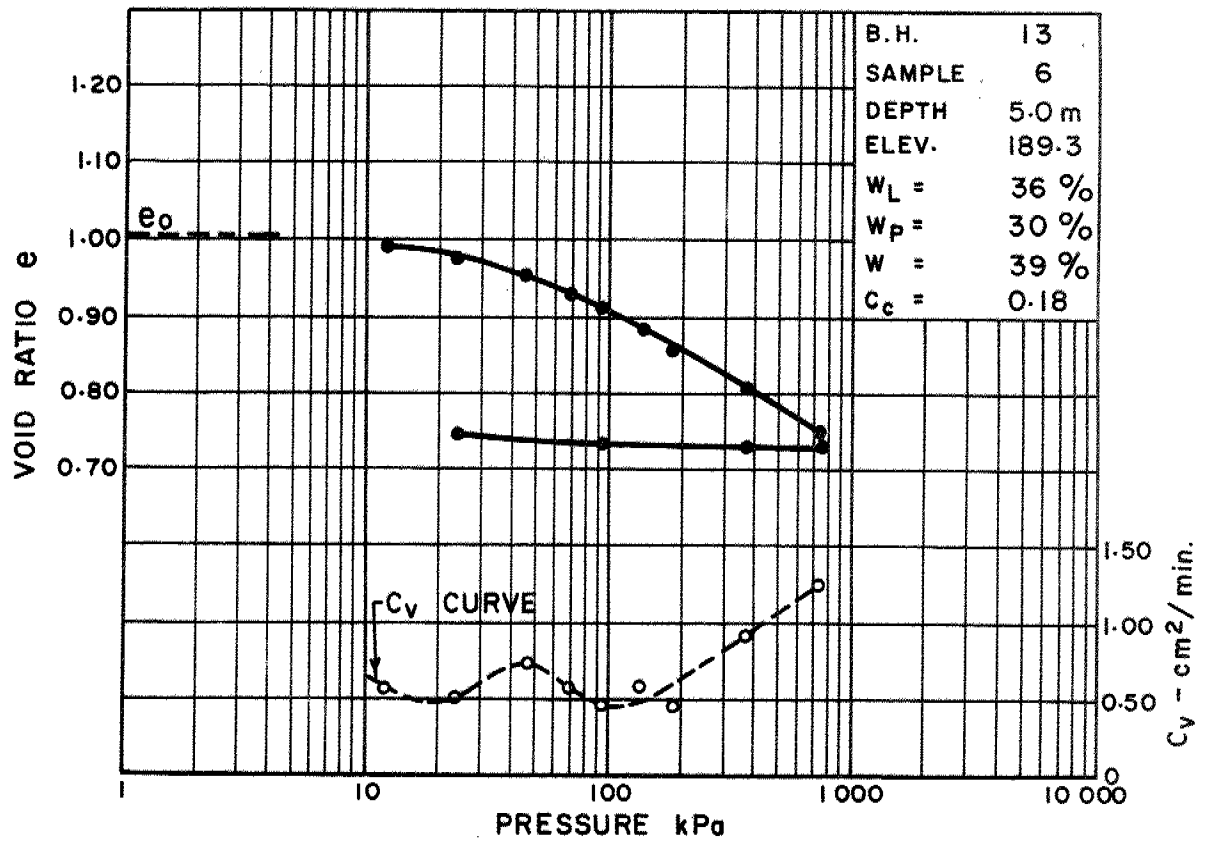


Fig. No. 5

WP 122-79-02

# VOID RATIO - PRESSURE CURVE

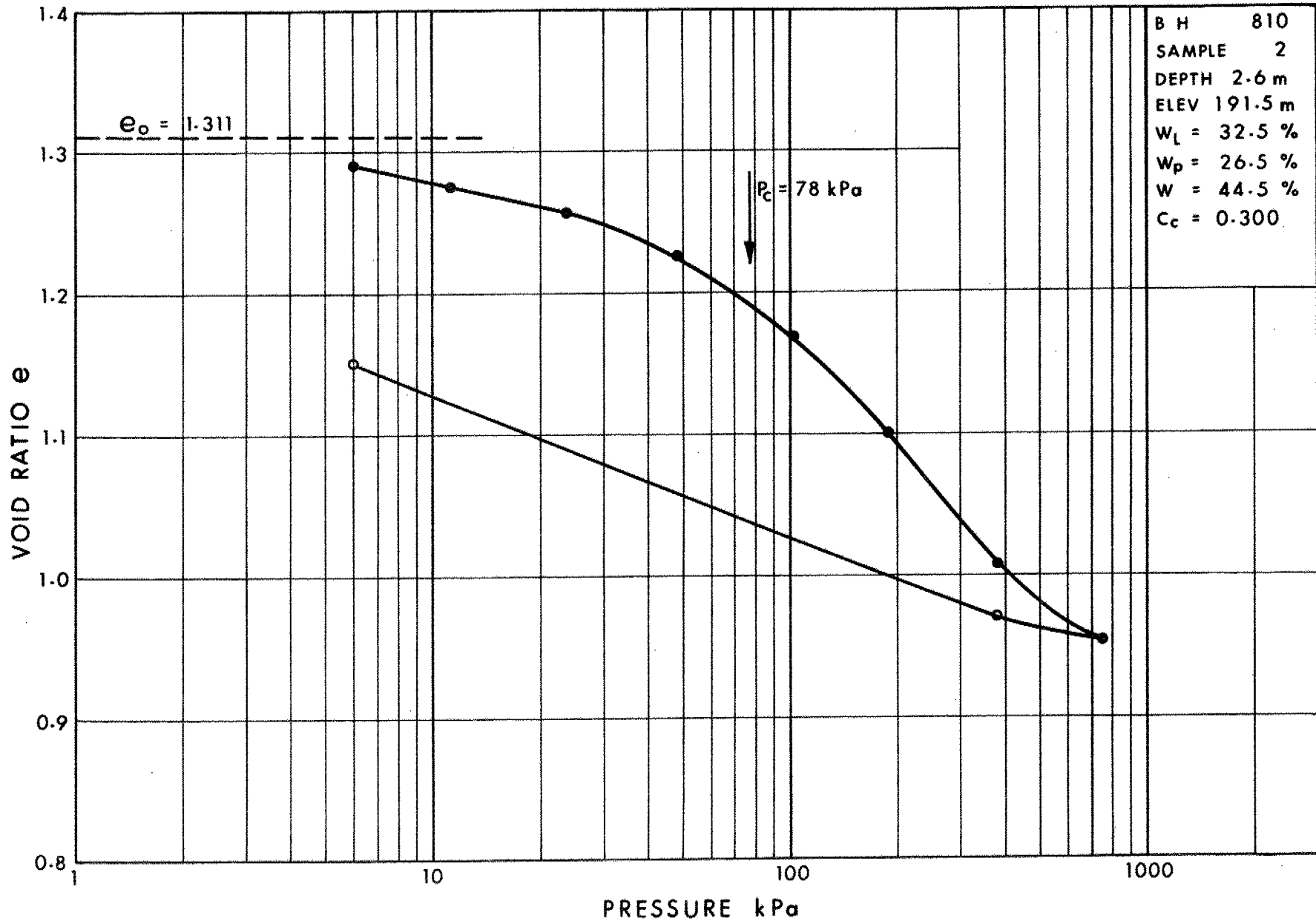
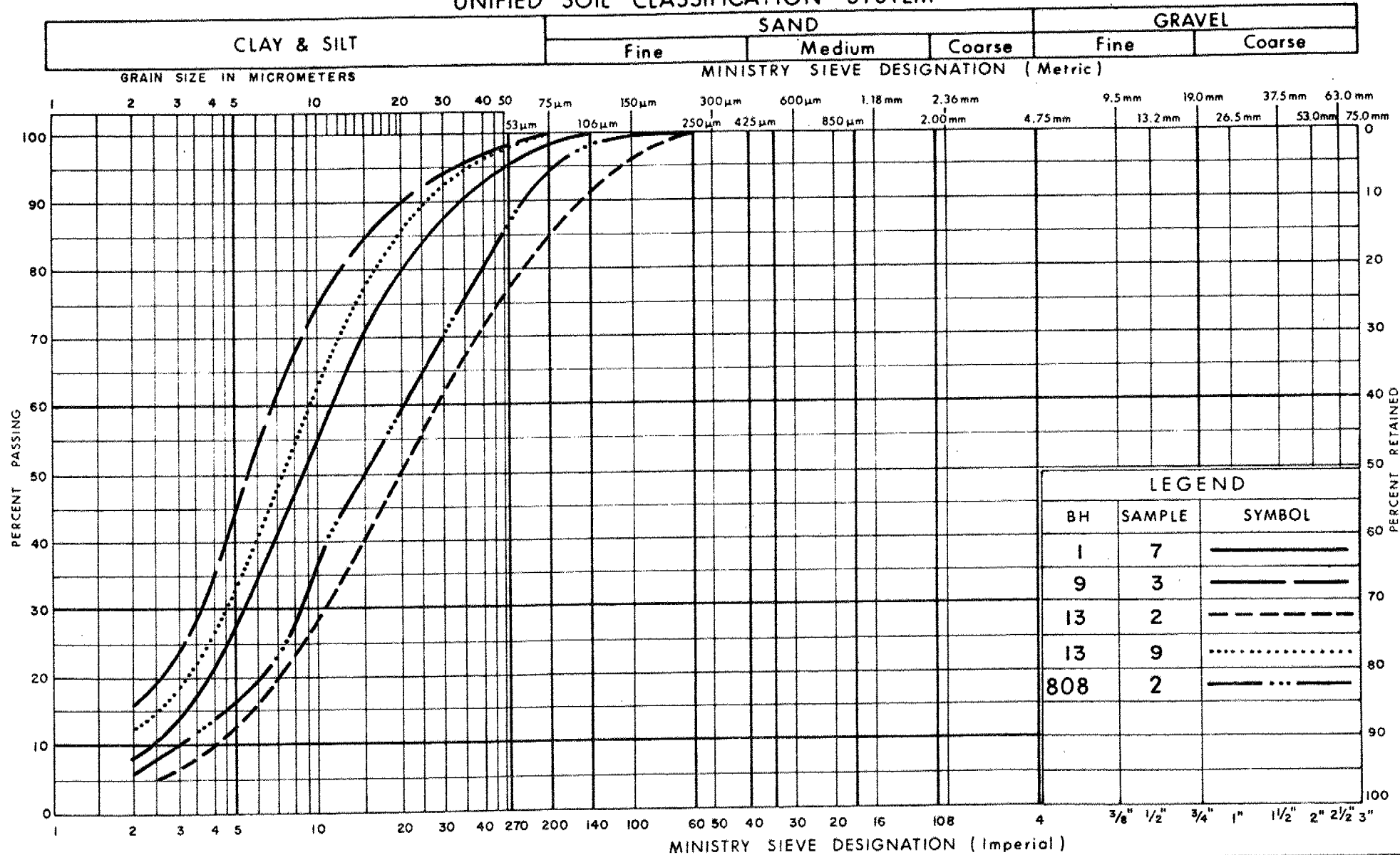


FIG 6

## UNIFIED SOIL CLASSIFICATION SYSTEM



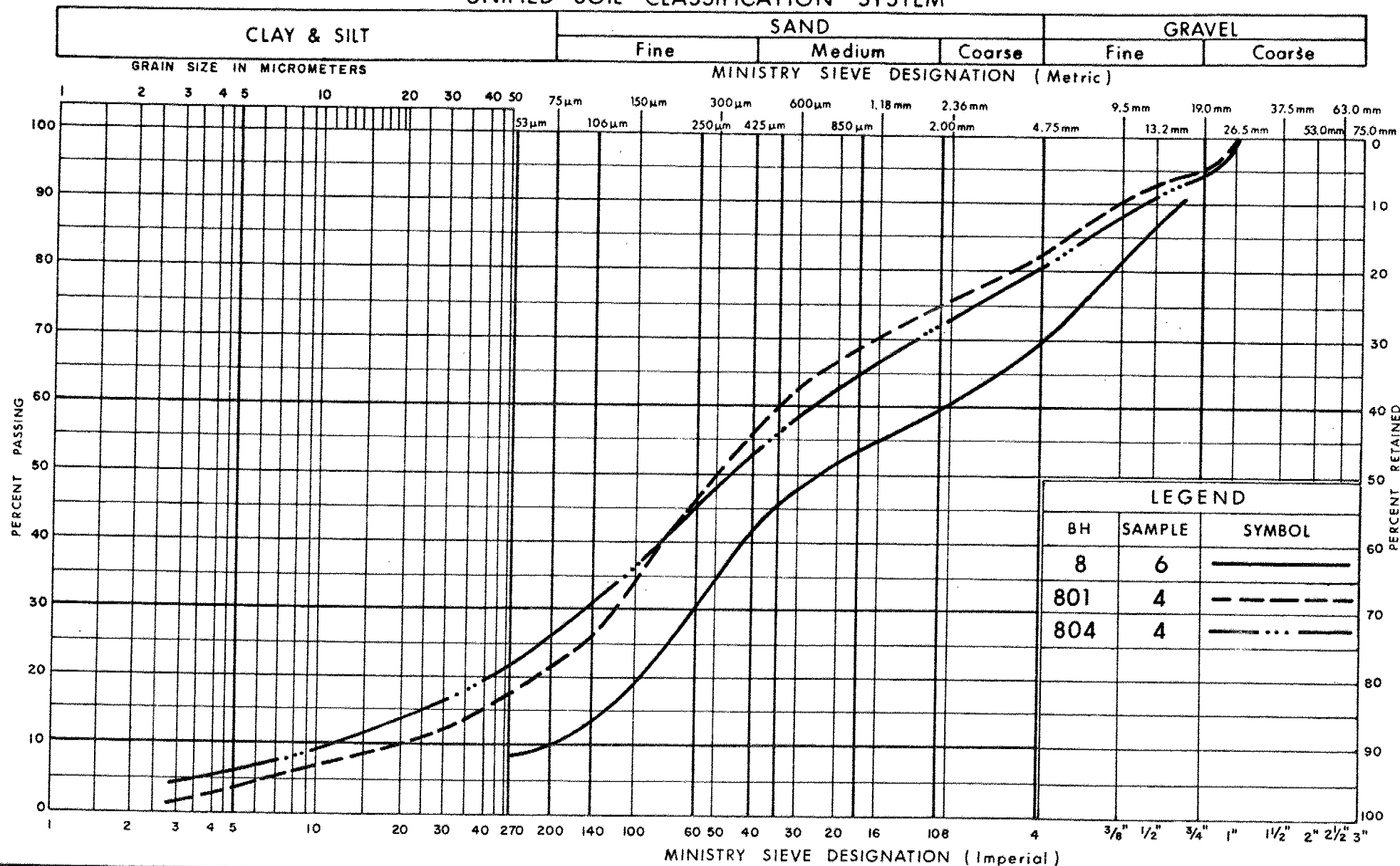
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GRAIN SIZE DISTRIBUTION  
ORGANIC SILT TO ORGANIC SILTY CLAY

FIG No 7

WP 122-79-02

## UNIFIED SOIL CLASSIFICATION SYSTEM



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Communications

GRAIN SIZE DISTRIBUTION  
SAND, WITH SILT SOME GRAVEL

FIG No 8

W P 122-79-02

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 18-79-00

DIST 17

HWY 637

STR SITE

Wanapitei River Crossing

DISTRIBUTION

S. McCombie (2)  
B. MacKinnon  
G. Ricker  
J.M. Bernhardt (2)  
E. Van Beilen  
B.J. Giroux

R. Hore

L. Argo )  
J. Anderson ) Cover only  
T.J. Kovich )

Files

## FOUNDATION INVESTIGATION REPORT

For

Wanapitei River Crossing  
W.P. 18-79-00, Highway 637  
District 17, Sudbury

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### INTRODUCTION

This report contains the results of a preliminary foundation investigation of 2 alternative crossings of the Wanapitei River by Highway 637. The more southerly line referred to as Line 'R' crosses just north of the existing bailey bridge. Line 'B' crosses the Wanapitei River some 300 metres further upstream. Field work consisted of 4 sampled boreholes advanced with a track mounted auger machine during the period September 4th to 6th, 1980.

### SITE DESCRIPTION

The site is located approximately 10 km west of Highway 69 where Highway 637 crosses the Wanapitei River. The surrounding area consists of rock ridges outcropping through the shallow till overburden.

In the area of the crossings the Wanapitei River is slow flowing, with a width of approximately 60 metres. The water level is controlled by a rock ridge located downstream of the present crossing. The flood plain east of the river is narrow and intermittent while to the west it forms a continuous strip of low swampy ground.

### SUBSOIL AND RECOMMENDATIONS

#### Line 'B' West Approach

The proposed embankment grade at this location is 196.8 requiring a fill height of about 3 metres.

### SUBSURFACE CONDITIONS

Subsoil consists of about 6 metres of stiff to firm organic silty clay which overlies granite bedrock. The organic silty clay has

an undrained shear strength, as measured by field vane, ranging from 25 to in excess of 50 kPa. A plot of plastic index versus liquid limit (Figure 1) indicates the material to be an organic soil of low to intermediate plasticity. Moisture content varies from 30 to 45 percent. Boundaries between soil strata as well as a summary of all field and laboratory tests performed are shown on Record of Borehole Sheet No. 4 in the Appendix.

Groundwater was encountered approximately 1 metre below the ground surface and corresponds to the river level.

### RECOMMENDATIONS

#### Foundations

It is recommended that the abutment be supported on H-piles driven to bedrock at elevation 187. Loads equal to the structural capacity of the section chosen may be employed.

#### Approach Fill

The approach fill may be constructed with 2 horizontal to 1 vertical side slopes. The forward slope should be constructed at 2 horizontal to 1 vertical with a 2 metre wide berm at existing ground level as shown in Figure 2. Rip rap should extend into the river for a minimum of 12 metres to protect the forward slope from steepening due to scour. It is estimated that settlement of the subsoil under the embankment will not exceed 240 mm.

#### Line 'B' East Approach

The proposed embankment grade at this location is about 197.5 requiring a fill height of 3.5 to 4 metres.

### SUBSURFACE CONDITIONS

Subsoil consists of 6 metres of stiff to firm organic silty clay overlying 2 metres of loose silty sand which in turn overlies granite bedrock. The undrained shear strength of the organic silty clay, as measured by field vane tests, ranges from 25 to 50 kPa. A plot of plastic index versus liquid limit (Figure 1) shows the layer to be organic and of low to intermediate plasticity. Moisture content



ranges from 22 to 40 percent. Boundaries between soil strata as well as a summary of all field and laboratory tests performed are on Record of Borehole Sheet No. 4 in the Appendix.

Groundwater was encountered at a depth of approximately 1 metre which corresponds with the prevailing river water level.

#### RECOMMENDATIONS

##### Foundations

The abutment should be supported on steel H-piles driven to bedrock at elevation 186. Loads equal to the structural capacity of the pile section chosen may be employed.

##### Approach Fill

The approach embankment may be constructed with 2 horizontal to 1 vertical side slopes. The forward slope should be constructed at 2 horizontal to 1 vertical with a 9 metre wide berm at the existing ground level as shown in Figure 3. A rip rap blanket should extend into the river for a minimum of 12 metres to prevent steepening of the forward slope by scour. Settlement of the subsoil underlying the embankment will not exceed 250 mm.

##### Line 'R' West Approach

The proposed grade in this area is about 197.1 requiring a fill height of about 2 metres.

#### SUBSURFACE CONDITIONS

Granite bedrock outcrops to form the western shore of the river in this area.

#### RECOMMENDATIONS

The west abutment would be founded on the bedrock with a design loading of up to 5 MPa. Requirements for benching or dowling of the rock would be assessed when the exact location of the abutment was determined. No stability problems exist in this area.

##### Line 'R' East Approach

The proposed profile grade at this abutment is about 198.7 requiring an approach fill of approximately 5.5 metres.

## SUBSURFACE CONDITIONS

Subsoil consists of 7 to 8 metres of organic silty clay overlying 1 to 5 metres of loose to compact fine silty sand which in turn overlies granite bedrock. The organic silty clay has a stiff to firm consistency with an undrained shear strength, as measured by field vane, of from 25 to 50 kPa. A plot of liquid limit versus plastic index (Figure 1) shows this layer to be organic and of low to intermediate plasticity. Moisture content varies from 42 to 47 percent. Boundaries between soil types as well as a summary of all field and laboratory tests performed are shown on Record of Borehole Sheets 1 and 2 located in the Appendix.

Groundwater was encountered at a depth of approximately 1 metre which corresponded to the prevailing river level.

## RECOMMENDATIONS

### Foundations

The east abutment should be supported on steel H-piles driven to bedrock with design loads equal to the structural capacity of the section chosen. The rock surface varies from elevation 185.6 at  $\phi$  to 180.7 some 11 metres to the north.

### Approach Fill

The east approach fill may be constructed with 2 horizontal to 1 vertical side slopes. The forward slope should be 2 horizontal to 1 vertical with an 18 metre wide berm at approximately the existing ground level as shown in Figure 4. The relationship between fill height and berm length is shown in Figure 5 for this abutment (e.g. a grade reduction of 2 metres would reduce the required berm length to 9 metres.) Rip rap should extend for a minimum of 12 metres into the river to prevent scour steepening the forward slope. Settlement of the subsoil underlying the embankment will not exceed 250 mm.

### Line 'R' East Channel

Granite bedrock is exposed in the area of this crossing. Any structure in this area would be founded on bedrock.

## SUMMARY

### Line 'B'

Subsoil on both approaches consists of approximately 6 metres of organic silty clay overlying bedrock. The structure abutments would be supported on steel H-piles driven to bedrock. To insure embankment stability in the forward direction a 2 metre wide berm on the west bank and a 9 metre wide berm on the east bank would be required.

### Line 'R'

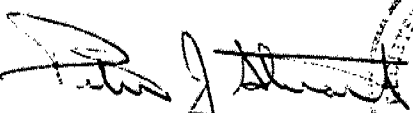
The west abutment will be located in an area of a bedrock outcrop. In the area of the east approach subsoil consists of 7 to 8 metres of organic silty clay overlying up to 5 metres of silty sand which in turn overlies bedrock.

The west abutment will be founded on spread footings on bedrock while the east abutment will be supported on steel H-piles to bedrock. No stability problems exist in the area of the west abutment but an 18 metre wide berm in the forward direction will be required to insure the east approach stability. Alternatively, a reduction of the grade in this area by 2 metres will allow the berm length to be reduced to 9 metres.

## GENERAL

The stability of the approaches in the forward direction is dependent on the height of fill; the soil strength; as well as the depth of the river and the steepness of the underwater slopes. These slopes are generally steeper and therefore less favourable along the eastern shore.

The recommendations provided in this report are preliminary in nature and are intended for planning and estimating purposes only. Some modification of these recommendations could result from a more extensive final investigation.

  
P.J. Stuart, P. Eng.  
Foundations Engineer



M. Devata, P. Eng.  
Senior Foundations Engineer

## APPENDIX

# RECORD OF BOREHOLE No 1

W P 18-79-00 LOCATION Sta. 52+751.2 @ Line 'R' ORIGINATED BY R.B.  
DIST 17 HWY 637 BOREHOLE TYPE Auger, B Casing, BXL Core, Cone Test COMPILED BY R.B.  
DATUM Geodetic DATE 80/09/04 CHECKED BY P.J.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
193.9	Ground Level													
0.0	Organic Silty Clay  Stiff to Firm		1	SS	2									
			2	SS	2									
			3	SS	1/37									
			4	SS	1/46									
			5	SS	2									
			6	SS	1/37									
186.7	Silty Fine Sand Compact		7	SS	2									
185.6			8	SS	19									
8.3	Granite Bedrock		9	BXL RC	REC 80%									
184.1														
9.8	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

W P 18-79-00 LOCATION Sta. 52+753.4 9.0 m Lt. Line 'R'  
DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger  
DATUM Geodetic DATE 80/09/04  
ORIGINATED BY R.B.  
COMPILED BY R.B.  
CHECKED BY P.J.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y t/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
193.8	Ground Level																
0.0																	
	Organic Silty Clay		1	TW	PH		192										
	Stiff to Firm		2	TW	PH		190									1.76	Om = 3.3 La = 1.024 Pc = 58 kPa Cc = 0.182
			3	TW	PH		188									1.76	
			4	TW	PM		186									1.71	Om = 2.8 La = 1.314 Pc = 71 kPa Cc = 0.560
185.6			5	SS	2		184										
8.2	Silty Fine Sand Loose to Compact		6	SS	8		182										1 60 38 1
			7	SS	11												
			8	SS	21/	3 cm											
180.7	Boulders																
13.1	Refusal to Augers Probable Bedrock End of Borehole						180										

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 3

W P 18-79-00 LOCATION Sta. 52+795.5 @ Line 'B' ORIGINATED BY R.B.  
 DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger, BXL Core, Vane & Cone Test COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/05 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y t/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
193.5	Ground Surface						20 40 60 80 100									
0.0	Organic Silty Clay		1	SS	5		192						1.76	0 5 89 6 L <sub>o</sub> = 1.186 P <sub>c</sub> = 65 kPa C <sub>c</sub> = 0.323		
	Stiff to Firm		2	SS	2		190									
			3	TW	PH		188									
			4	SS	2		186									
			5	TW	PH		184									
167.3			6	SS	43								1.74			
6.3	Granite Bedrock		7	BXL RC	REC 90%									RQD = 60%		
185.6																
7.9	End of Borehole															

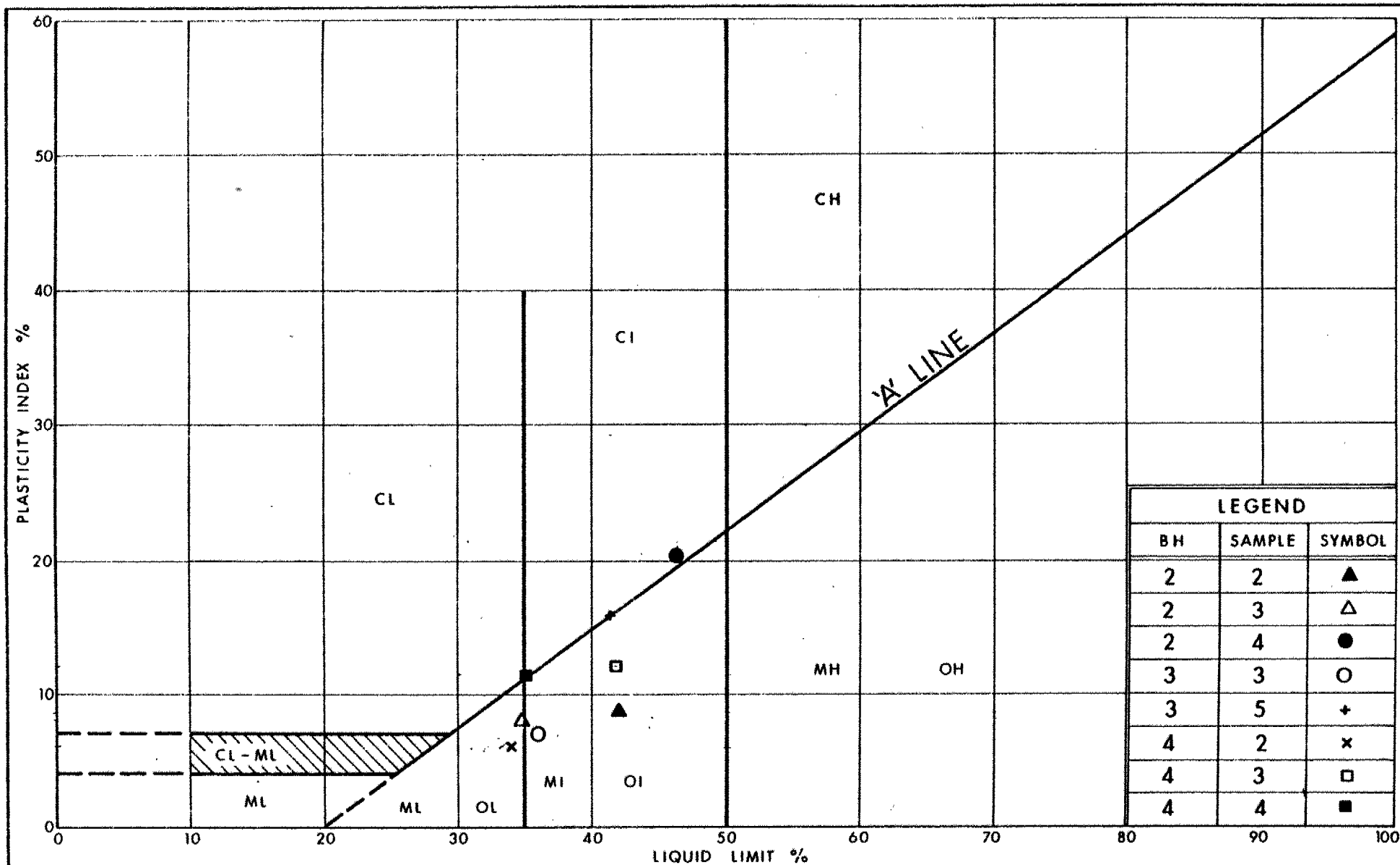
+3, x5: Numbers refer to Sensitivity  
 20  
 15 5 (%) STRAIN AT FAILURE  
 10

# RECORD OF BOREHOLE No 4

W P 18-79-00 LOCATION Sta. 52+894.0 1.8 m Lt. Line 'B' ORIGINATED BY R.B.  
 DIST 17 HWY 637 BOREHOLE TYPE Hollow Stem Auger, BXL Core, Vane & Cone Tests COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/06 CHECKED BY P.J.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
193.7	Ground Level													
0.0														
	Organic Silty Clay		1	SS	6									0 9 80 11
			2	SS	3									
	Stiff to Firm		3	TW	PH									0 9 85 6 L <sub>a</sub> = 1.106 P <sub>c</sub> = 65 kPa C <sub>c</sub> = 0.273 Om = 2.77
			4	SS	2									
187.7			5	TW	PH									
6.0	Boulder		7	RC	REC 90%									
187.0			8	SS	5									
6.7	Silty Fine Sand Loose		9	SS	41/13									
185.8			10	BXL RC	REC 80%									
7.9	Granite Bedrock													RQD = 95%
184.2														
9.5	End of Borehole													



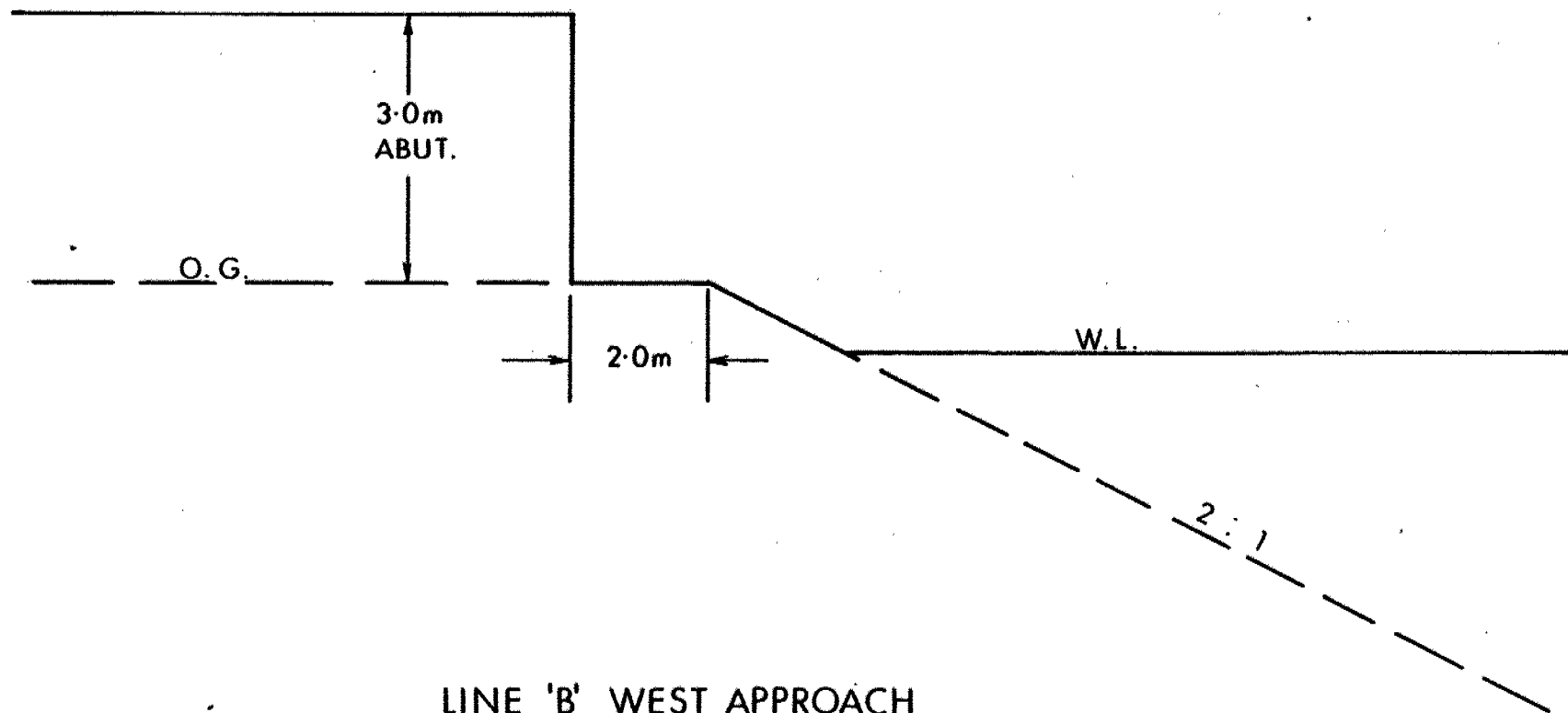


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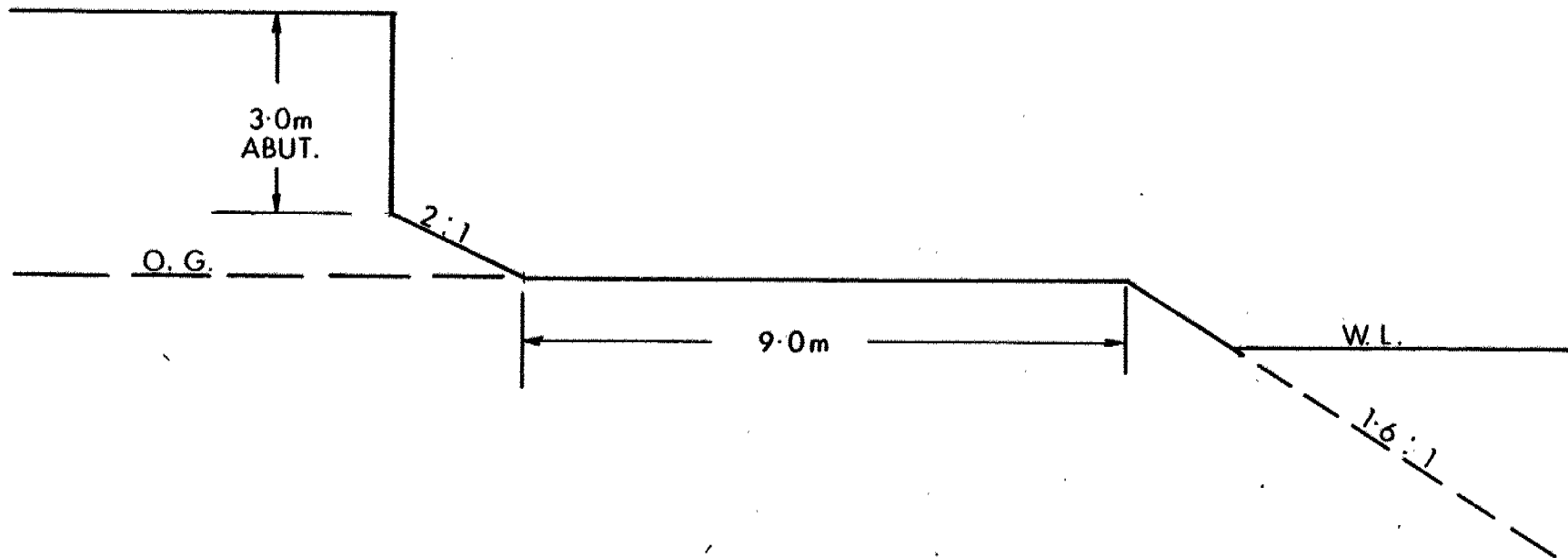
# PLASTICITY CHART ORGANIC SILTY CLAY

FIG No 1

W P 18-79-00



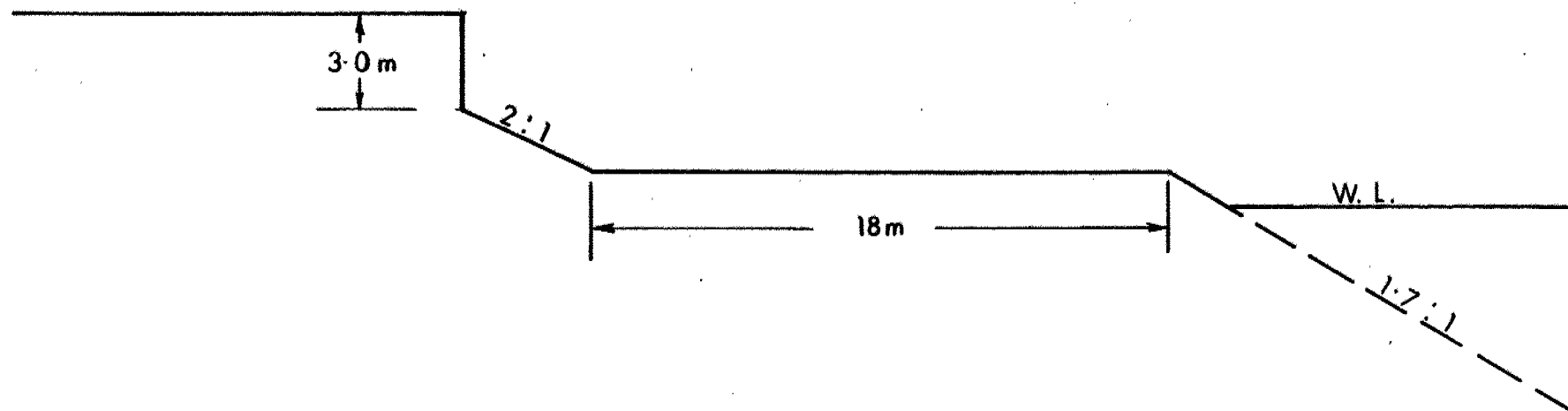
LINE 'B' WEST APPROACH



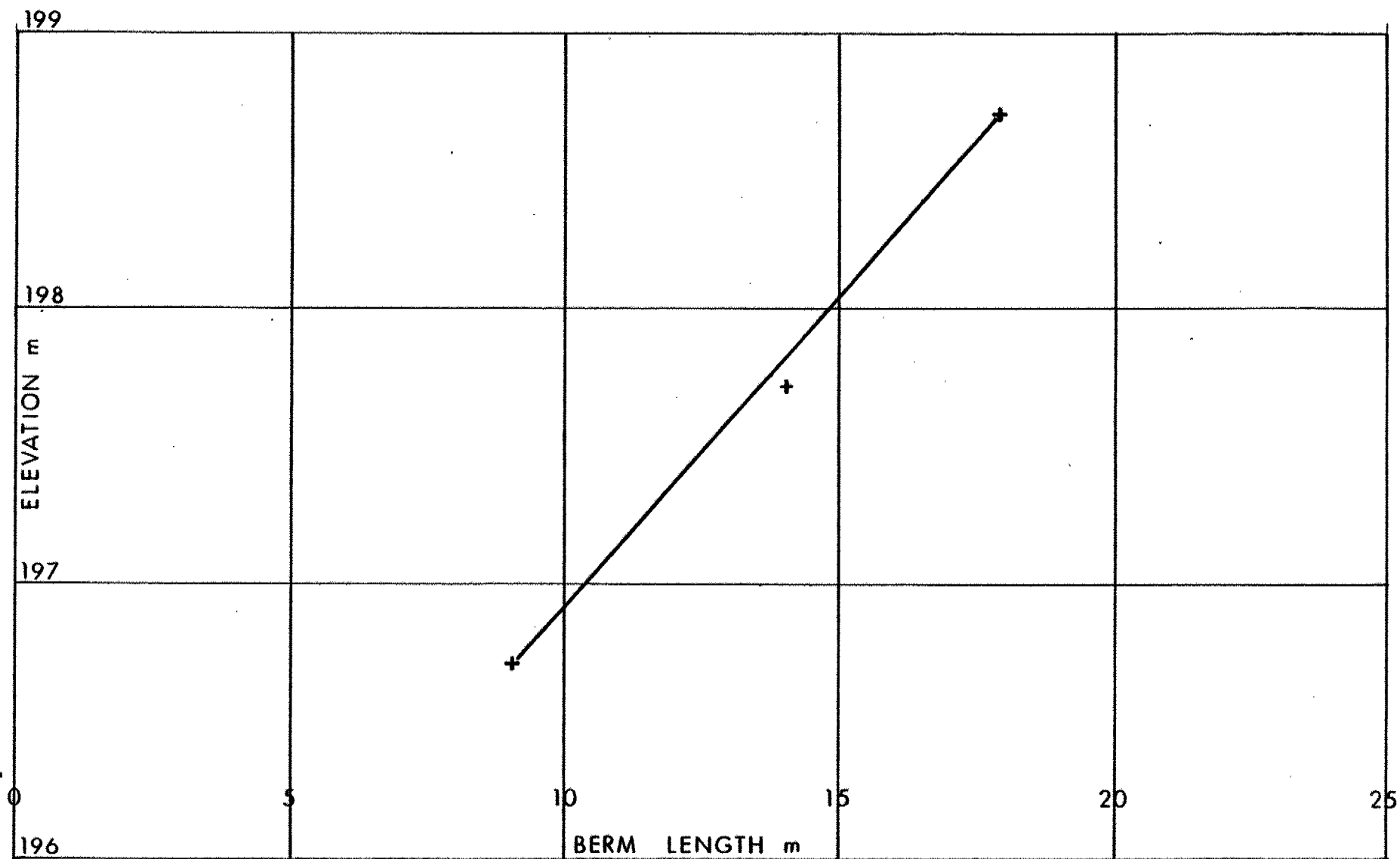
LINE B EAST APPROACH

FIG. 3

W. P. 18-79-00



LINE 'R' EAST APPROACH



GRADE vs BERM LENGTH EAST APPROACH LINE 'R'

FIG. 5

W.P. 18-79-00

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

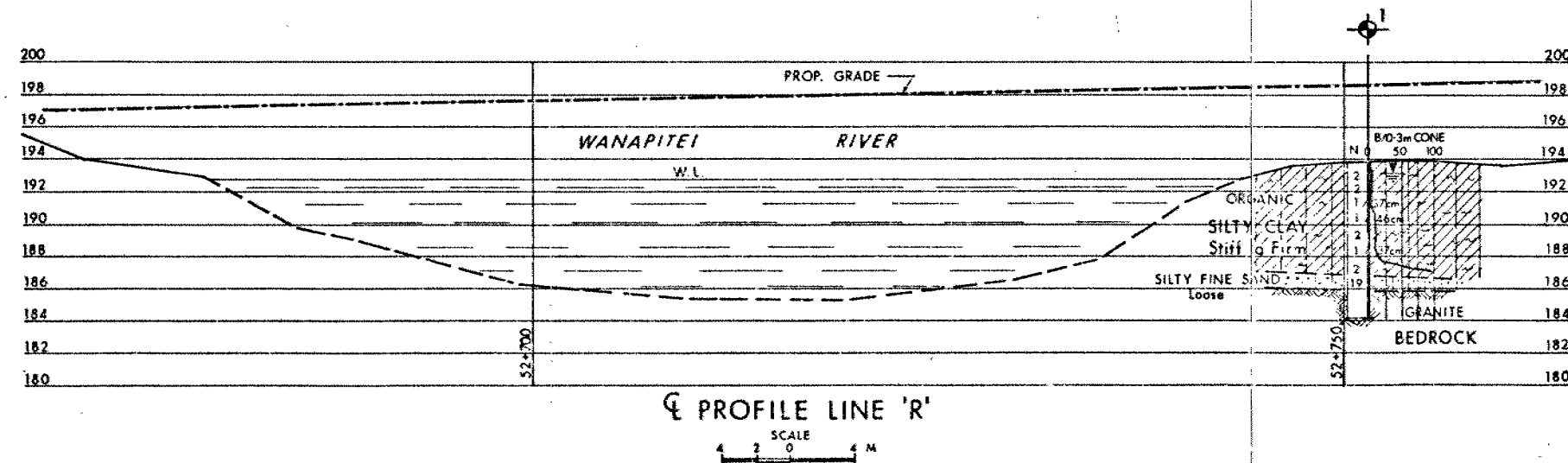
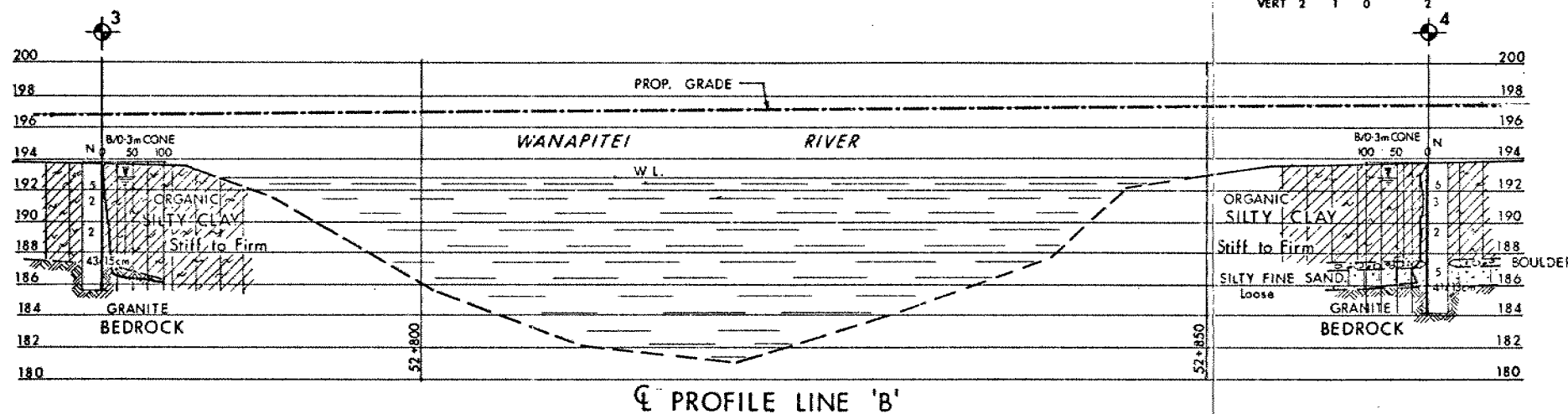
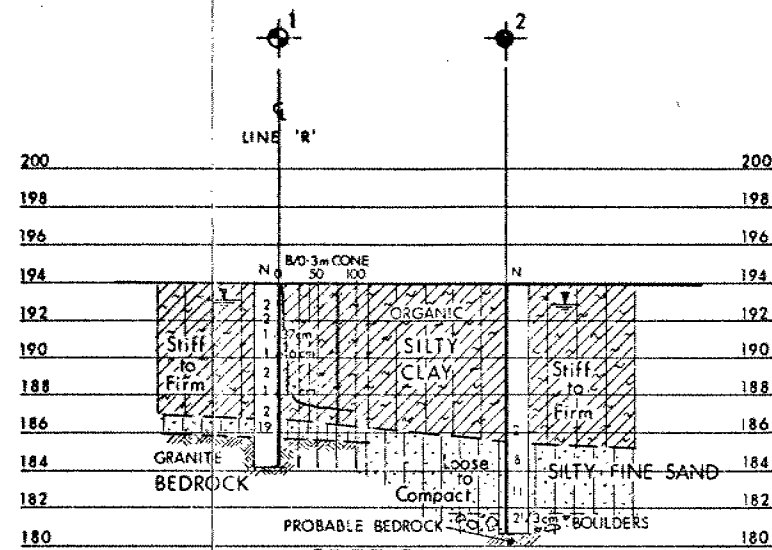
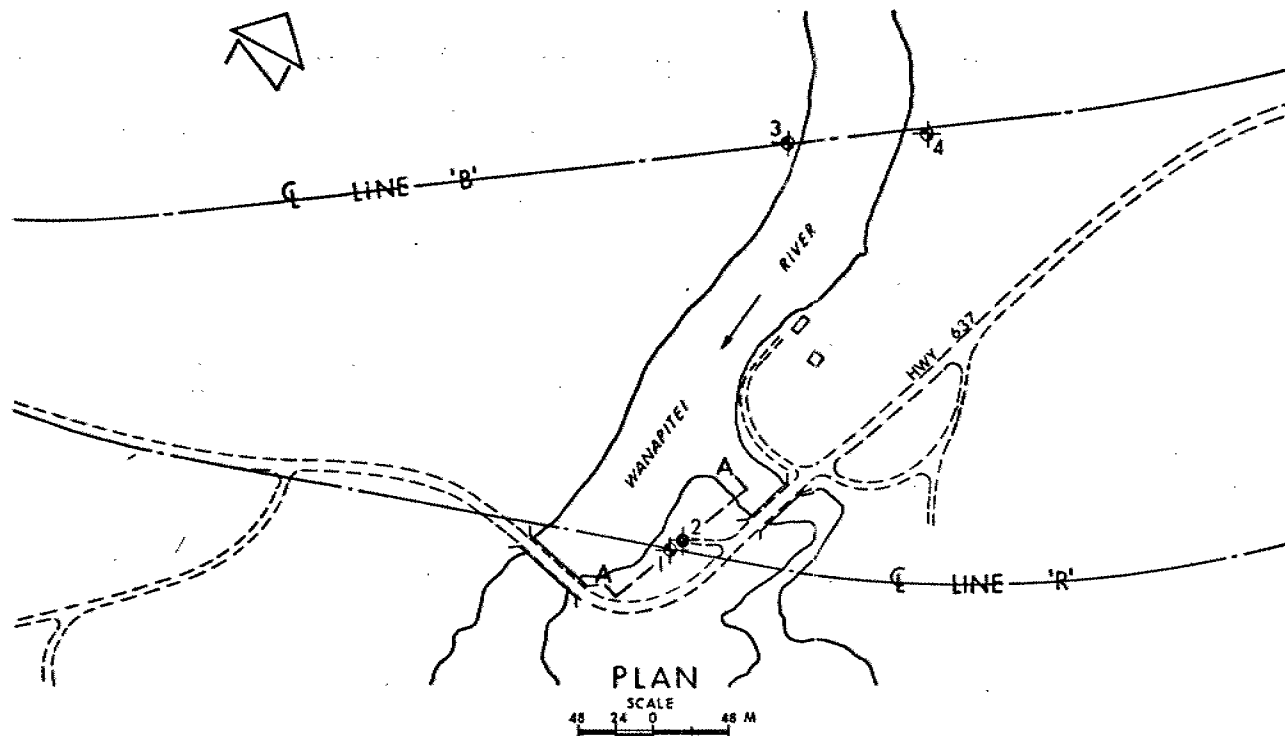
$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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



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

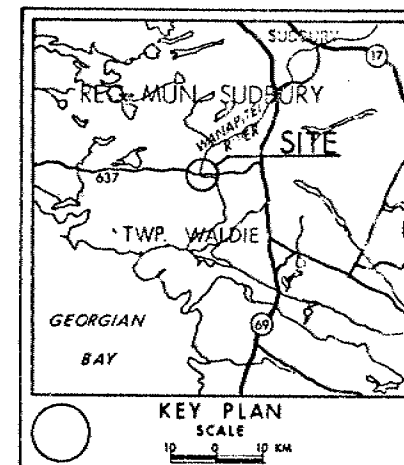
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WP No 18-79-00

WANAPITEI RIVER CROSSING

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 80 09 05

No	ELEVATION	STATION	OFFSET
1	193.9	52+751.2	LINE 'R'
2	193.8	52+753.4	9.0 LT. LINE 'R'
3	193.5	52+795.5	LINE 'B'
4	193.7	52+894.0	1.8 LT. LINE 'B'

NOTE

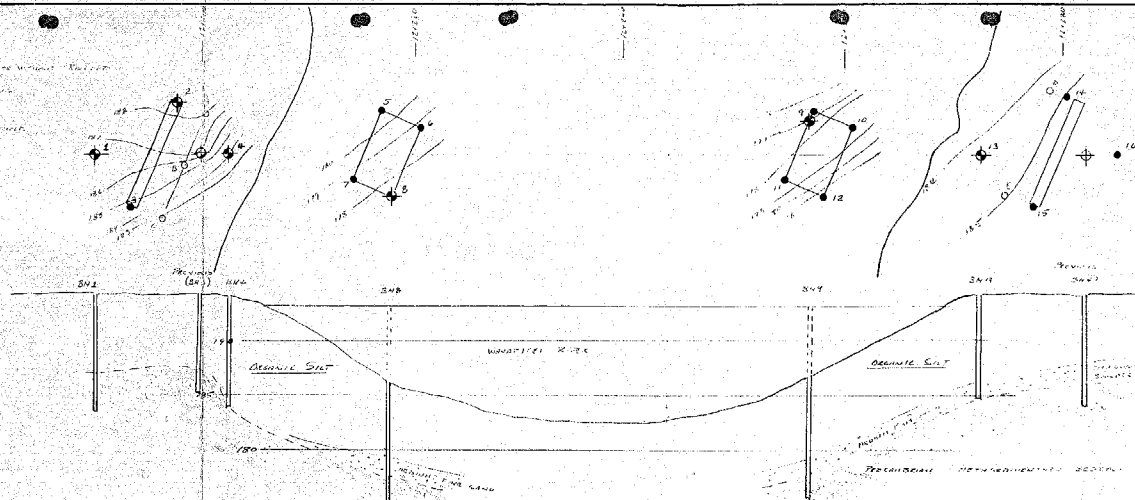
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No	411-115
HWY No	637
SUBMDP S	CHECKED
DRAWNOL	CHECKED
DATE	80 12 18
DIST	17
SITE	
APPROVED	
DWG	187900-A

SYMBOLS

- ◆ Borehole (with or without casing)
- Borehole (without casing)
- Sample Location
- ⊕ Previous Boundary



DESCRIPTION OF BOREHOLE (with or without casing)

1. 100' DEPTH
2. 100' DEPTH
3. 100' DEPTH
4. 100' DEPTH
5. 100' DEPTH
6. 100' DEPTH
7. 100' DEPTH
8. 100' DEPTH
9. 100' DEPTH
10. 100' DEPTH
11. 100' DEPTH
12. 100' DEPTH
13. 100' DEPTH
14. 100' DEPTH
15. 100' DEPTH

REFERENCES

ORIG. NO.	DESCRIPTION	DATE

WATER RESOURCES DIVISION  
UNIVERSITY OF CALIFORNIA  
DAVIS, CALIF. 95616  
INTERPRETED BY: J. H. HENRY  
REVIEWED BY: J. H. HENRY

Warnock Hensley Professional Services Ltd.

DATE	SCALE	DRAWN BY
1/1/77	1"=100'	J. H. HENRY
APPROVED BY		
DRAWING NO.		