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W.P. No. 34-81-01

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W. O. No.

STR. SITE No. 3-436

HWY. No. 17

LOCATION Hwy 17 & Moody Creek Culvert

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-31



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.

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

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	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						

FOUNDATION INVESTIGATION
PROPOSED CULVERT EXTENSION - MOODY CREEK
HIGHWAY 17 AND MCGEE ROAD
OTTAWA, ONTARIO
W.P. 34-81-01 SITE NO. 3-436
DISTRICT 9 EASTERN REGION

1. INTRODUCTION

Terraprobe Limited was authorized by the Foundation Design Section of the Ministry of Transportation Ontario (MTO), to undertake a foundation investigation for a proposed culvert extension located on Highway 17. The site is located east of McGee Road in the City of Kanata, Ontario. The details of the project were discussed with the Foundation Design Section of the MTO, during December 1989, in order to define the appropriate scope of work for the geotechnical investigation.

A field investigation for the project was conducted on December 20 and 21, 1989, when three boreholes were advanced.

2. SITE AND GEOLOGY

The site is located on Highway 17, east of McGee Road in the City of Kanata, Ontario. There is an existing concrete box culvert at the site through which the Moody Creek flows in a northerly direction beneath existing Highway 17. At this location, Highway 17 is a two lane paved road with gravel shoulders. The culvert passes through an earth embankment which has a total height of approximately 2 m in this area. We understand the existing culvert is approximately 6 m wide, 37 m long, and 1.5 m in deep.

In the vicinity of the site, the Moody Creek channel is approximately 3 to 4 m wide. The depth of the creek could not be measured at the time of our investigation, due to the creek being frozen. However, based on the information we have received on the culvert dimensions, it was estimated that there was flow in the channel to a depth of about 0.5 to 1 m.

The site is situated in a geologic area consisting of a clay plain. In the vicinity of the site, the overburden materials are characterized by relatively thick and extensive deposits of clayey soils. The ground surface in the vicinity of the site is quite flat and at an elevation of approximately 117 to 118 m (Geodetic). Areas surrounding the site are covered with isolated bush and open field. Based on the review of local Ministry of Environment water well records, the depth the bedrock in the area may be on the order of 20 to 30 m.

Existing geologic mapping indicates that the bedrock materials underlying the site consist predominantly of limestone of the Trenton and Black River groups.

3. SUBSURFACE CONDITIONS

Details of the subsurface conditions encountered at the site are summarized below and also presented on the accompanying borehole logs. *

A summary of the results of laboratory and field tests are presented on the Borehole Logs and on Figures 1 to 4 inclusive.

It should be noted that the subsurface conditions are confirmed at the borehole locations only, and may vary at other locations. The boundaries between the various strata shown on the borehole logs and sections, are based on non continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise claim of geologic change.

In summary, the three borings generally encountered a thin layer of topsoil near the ground surface. Fill materials were noted to a depth of about 1.5 m in the vicinity of the toe of the existing embankment (Borehole 1). Beneath the topsoil and fill, native silty clay soils were noted, extending to the base of the borings at 3.5 to 6.6 m. The groundwater level was generally within about 2.3 m of the ground surface.

* For borehole location and section, see Drawing A & B in the appendix.

3.1 Topsoil

Topsoil was encountered at the ground surface at Boreholes 2 and 3 and was approximately 150 to 200 mm in thickness. The topsoil consisted of dark brown silty material with traces of organic matter including roots. The topsoil was frozen at the time of investigation.

3.2 Fill

Fill soils were encountered at the ground surface of Borehole 1, extending to a depth of approximately 1.5 m. The fill consisted of dark brown sandy silt with some organic matter including roots and topsoil. The fill was frozen to a depth of approximately 0.6 m.

The water content of a sample of the fill was approximately 52 percent. The standard penetration resistance of the material was 6 to 7 blows per 300 mm, indicating a relatively loose state.

Borehole 1 was drilled near the toe of the existing roadway embankment. This suggests that the fill material encountered is likely associated with the construction of the embankment.

3.3 Silty Clay

Native silty clay soils were encountered beneath the topsoil and fill material in each of the boreholes, and extended to the base of the holes at 3.5 to 6.6 m below existing grades. These stratum ranged in composition from silty clay to clayey silt, with a trace of sand. Occasional fine embedded gravel was noted in some of the samples. Two selected samples of this stratum were subjected to grain size analysis, the results of which are presented on Figure 1.

The moisture content of the clay ranged from about 25 to 42 percent, with an average of about 35 percent. The consistency of the clay was determined on the basis of field vane tests, unconfined compression testing, and standard penetration resistances. Measured field vane undrained shear strengths of the clay were generally greater than 150 kPa, except near the base of Boreholes 1 and 2 (depth of approximately 6 m), where undrained shear strengths of 58 and 124 kPa were measured. The silty clay is considered to have a firm to stiff consistency. The remoulded undrained shear strength of the clay was considerably less, with sensitivities ranging from about 4 to 16. This clay would be classified as extrasensitive, typical of marine clays.

The six samples taken with thin walled samplers were tested in our laboratory for their Atterberg Limits, bulk unit weight, unconfined compressive strength, laboratory penetrometer shear strength. The following table presents the results of that testing:

Sample	Atterberg Limits			Bulk Unit Weight (kN/cu.m)	Unconfined Shear Strength (kPa)	Laboratory Penetrometer Shear (kPa)
	w _L	w _p	w			
BH1 Sa3	49	23	42	17.9	52	50 - 75
BH1 Sa5	43	23	38	18.1	37	50 - 75
BH1 Sa6	36	19	35	18.8	41	75
BH2 Sa3	49	22	41	18.0	57	50 - 75
BH2 Sa4	42	24	37	18.6	83	75 - 100
BH2 Sa5	40	21	40	18.4	31	75

It is noted that the shear strengths determined by unconfined compressive testing and laboratory penetrometer testing, were much lower than those determined in the field using a shear vane. It is considered that this is the result of slight disturbance of the sensitive silty clay soils, during the preparation for these tests.

The results of the Atterberg Limit tests are plotted on the accompanying plasticity charts shown on Figure 2. The results of the tests consistently plot above the 'A' line, indicating a clay of intermediate plasticity.

One dimensional consolidation tests were conducted on two selected samples. The results of the testing are summarized on the accompanying Figures 3 and 4. In summary, the following data was obtained from the tests:

Sample	Depth (m)	Cr	Cc		OCR
BH1 Sa5	1.5	0.025	0.300	290 kPa	6
BH2 Sa3	0.8	0.030	0.410	335 kPa	14

The results of the testing indicate the material is generally overconsolidated by about 6 to 14 times, near the ground surface.

3.4 Groundwater

Minor seepage was noted into each of the borings during drilling. Standpipes were installed in the borings, and the water levels were measured on December 22, 1989 (1 day following completion of drilling). The following water level depths were noted:

Borehole 1	-	1.0 m
Borehole 2	-	0.9 m
Borehole 3	-	1.3 m

Due to the expected low permeability of the native clayey soils, it is likely that the groundwater levels had not stabilized when the measurements were taken.

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

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 34-81-01 LOCATION Co-ordinates N 5 016 974 E 342 657 ORIGINATED BY RP
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RP
 DATUM Geodetic DATE December 20, 1989 CHECKED BY KJ

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 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
117.3	Ground Surface													
0.0	Sandy Silt, some organics (Fill)		1	SS	7									
	Loose Dark Brown		2	SS	6									
115.8														
1.5	Silty Clay trace sand and gravel, occasional cobble.		3	TW	PH									
	Soft to Firm		4	SS	10									
	Grey		5	TW	PH									
			6	TW	PH									
111.1			7	SS	55/6'									
6.2	End of Borehole													

RECORD OF BOREHOLE No 2

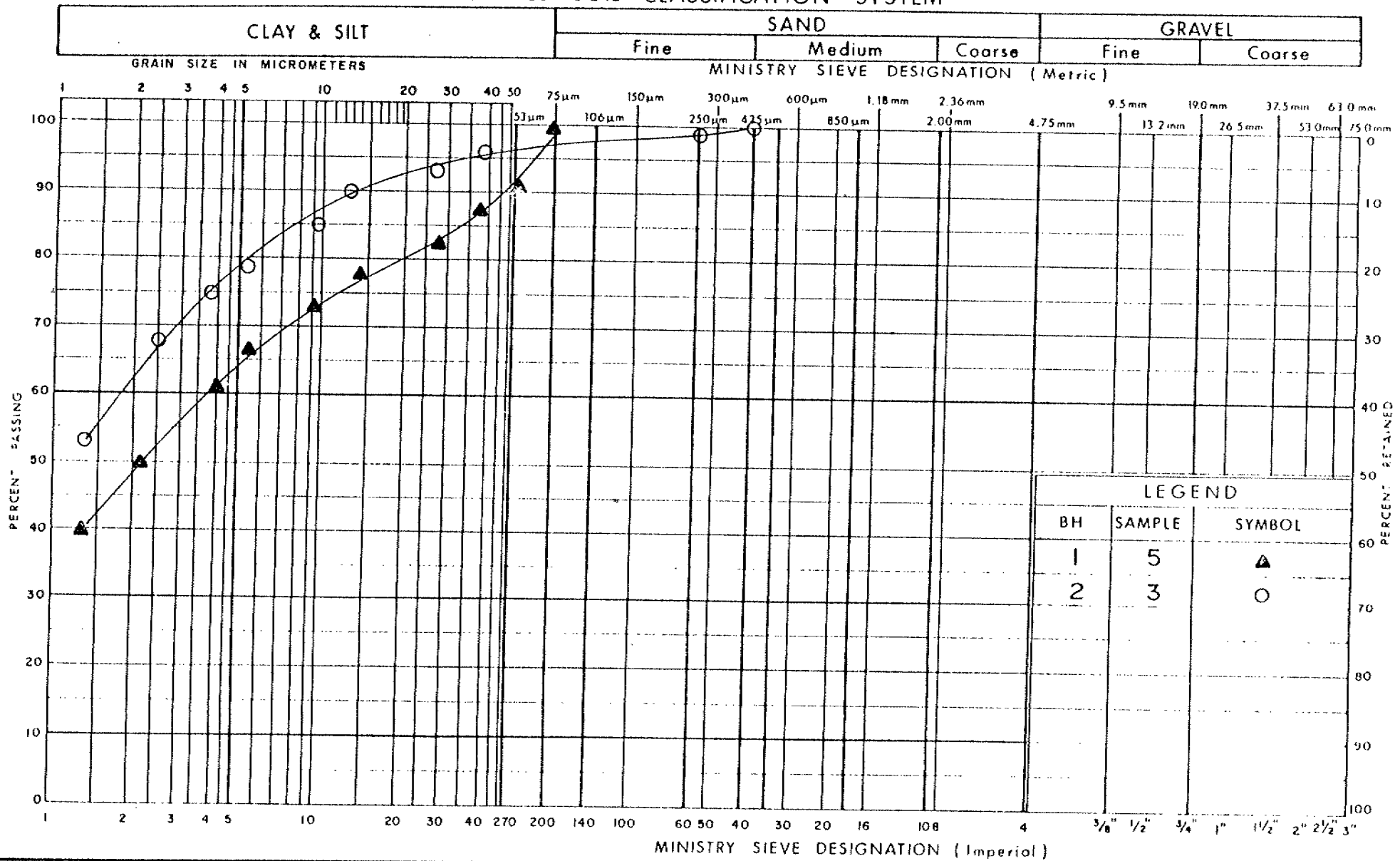
METRIC

W P 34-81-01 LOCATION Co-ordinates N 5 016' 966 E 342 635 ORIGINATED BY RP
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RP
 DATUM Geodetic DATE December 21, 1989 CHECKED BY KJ

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					
117.3	Ground Surface													
0.0	Topsoil						117							
0.2	Silty Clay		1	SS	6		Seal							
	trace sand and gravel occasional cobble.		2	SS	5		Water Level							
							Dec. 22/89							
	Firm to Stiff		3	TW	PH		116						18.1	0 8 44 48
	Grey						115							
							Dec. 21/89							
			4	TW	PH		114						18.6	
							113							
			5	TW	PH		112						18.4	
							111							
110.7	End of Borehole		6	SS	13		Standpipe							
6.6							110							

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

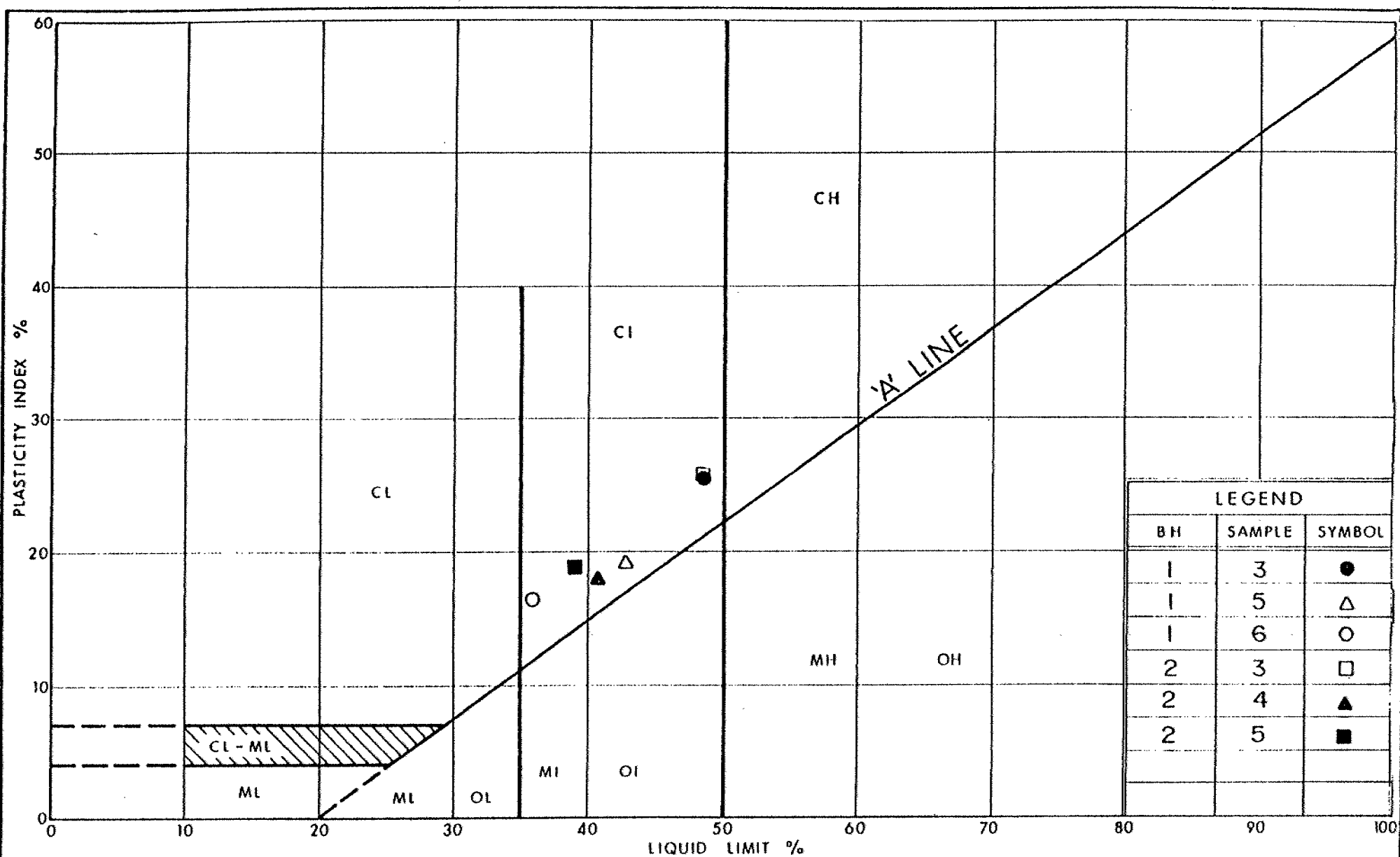
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GRAIN SIZE DISTRIBUTION

SILTY CLAY (CI)

FIG No 1

W P 34-81-01



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PLASTICITY CHART
SILTY CLAY TRACE SAND (CI)

FIG No 2

W P 34-81-01

3

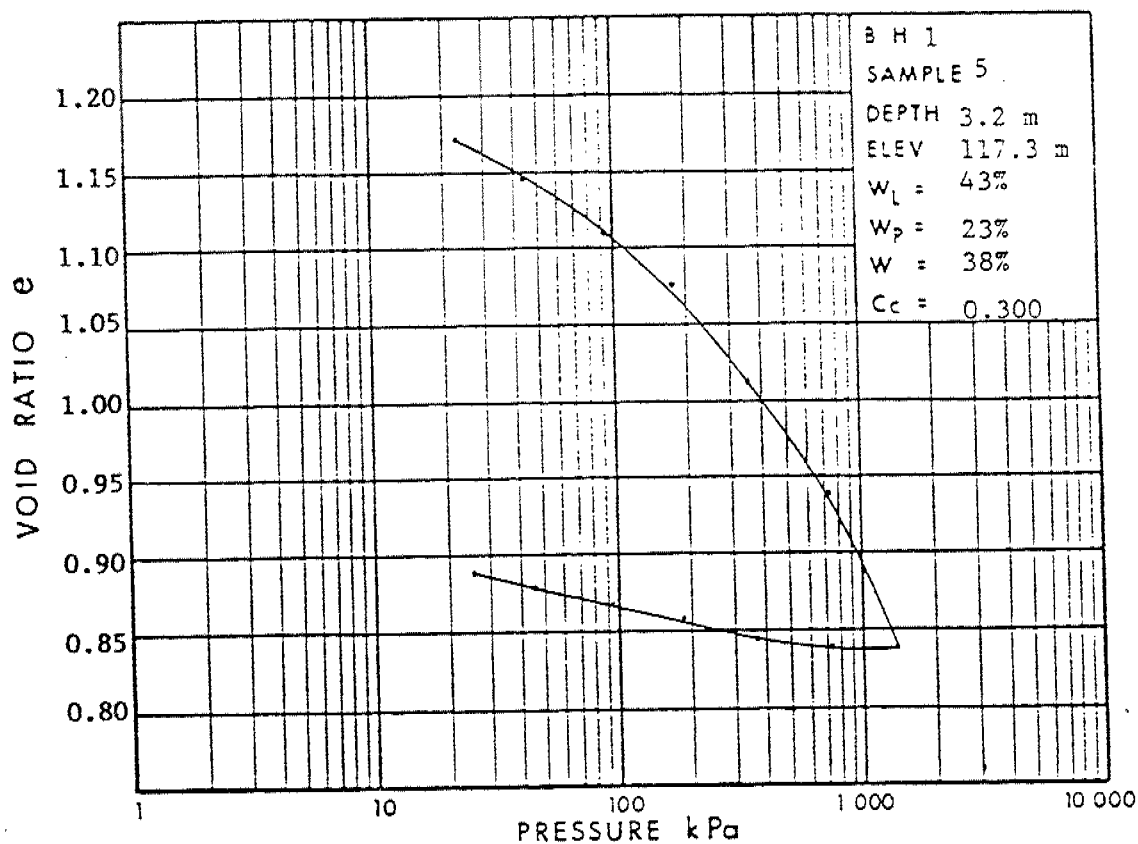


FIGURE 3

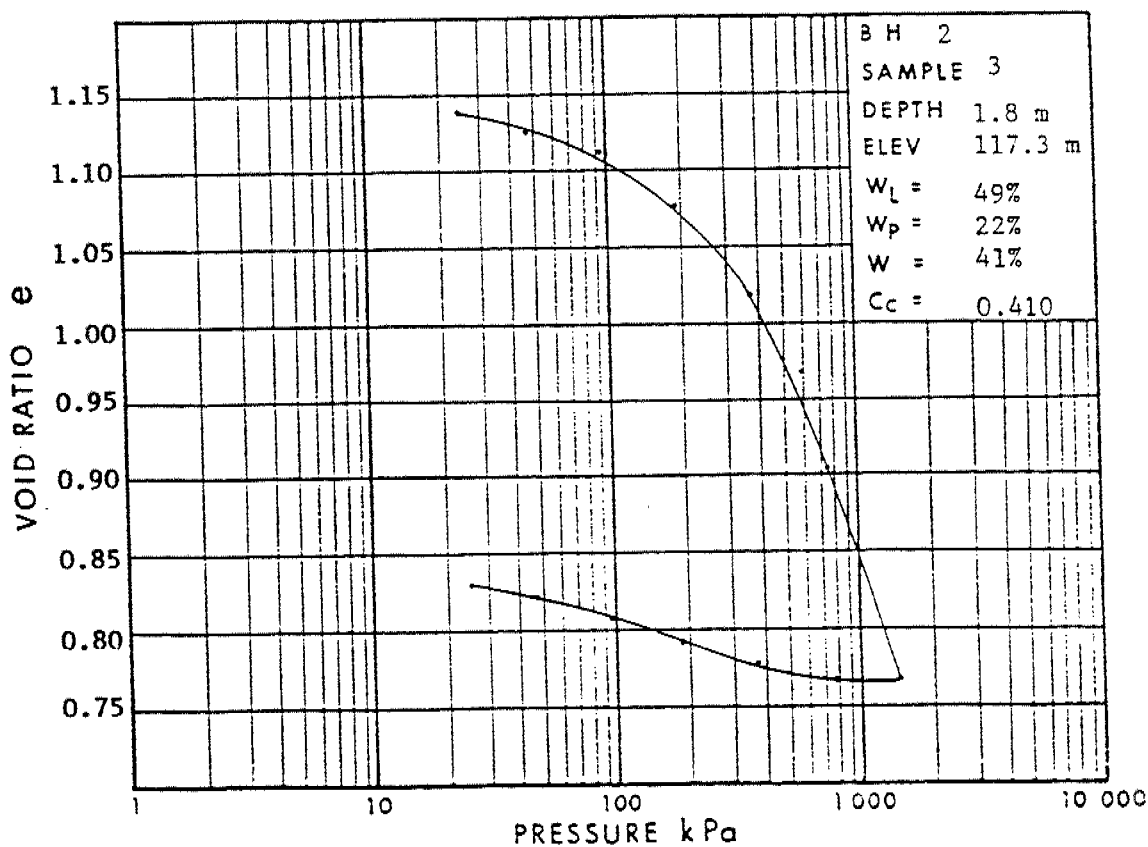
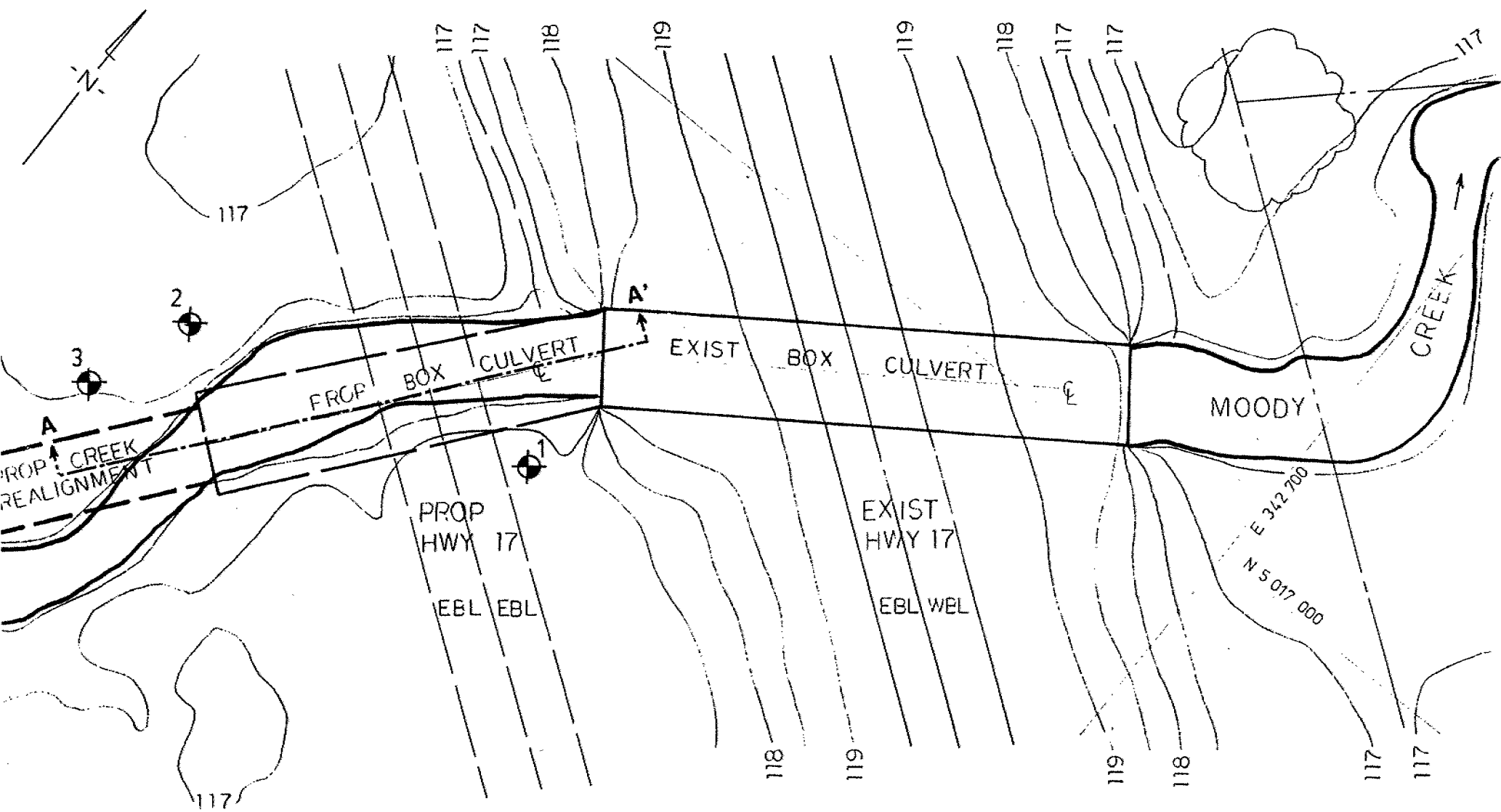


FIGURE 4



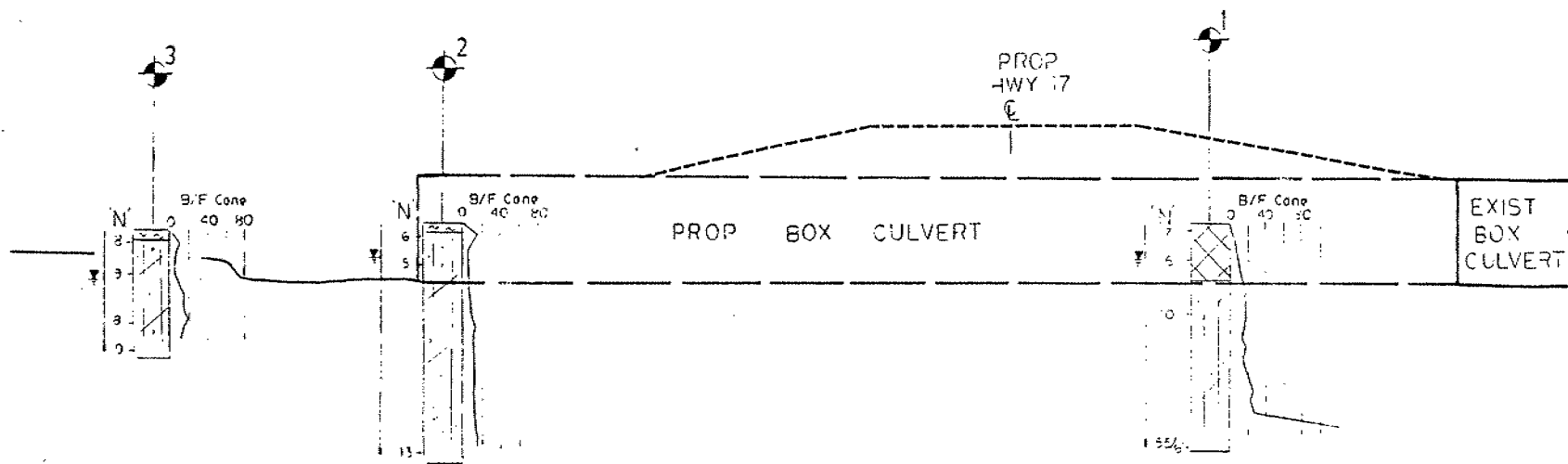
PLAN

DWG A

15

ELEVATION (m)

120
115
110



120
115
110

SECTION A-A'

LEGEND



TOPSOIL



FILL



SILTY CLAY



WATER LEVEL - DECEMBER 22 1983



STANDPIPE



STANDARD PENETRATION TEST



BOREHOLE & CONE TEST

DWG B

FOUNDATION INVESTIGATION
PROPOSED UNDERPASS STRUCTURE
HIGHWAY 17 (417) AND MCGEE ROAD
SITE 3-569, W.P. 34-81-03
DISTRICT 9
TOWNSHIP OF WEST CARLETON, ONTARIO

1.0 INTRODUCTION

Dominion Soil Investigation Inc., Consulting Geotechnical Engineers, was retained by the Ontario Ministry of Transportation to carry out a foundation investigation for a proposed underpass structure at Highway 17 (417) and McGee Road in the Township of West Carleton (west of Ottawa).

The field work was carried out during the period of December 4 to 12, 1989 and consisted of ten sampled boreholes and three dynamic cone penetration tests (augered through dense strata). The plan locations of boreholes and cone tests, and stratigraphic sections are shown on Drawing No.2&3.* Details of subsurface conditions encountered at each borehole location, including results of in situ testing, are presented on the Record of Borehole sheets. The results of field and laboratory work, are presented in this report.

* DWG NO 2 & 3 OF THE CONTRACT DWG'S

2.0 SITE DESCRIPTION & PHYSIOGRAPHY

The proposed underpass site is located approximately 30 km west of Ottawa, at the intersection of Highway 17 and McGee Road. The topography in the general area is flat, with a mild relief to the south. The existing road pavement is about 1.2 to 1.5 m higher than the adjacent general ground surface level. The south-western (construction north) quadrant of the site has a light bush cover. The remaining areas have tree growth, outside the right-of-way limits. At the time of our field work the general site area was snow covered.

In general, the Ottawa Region is known to be underlain by 2 to 4 m thick fine grained sand followed by sensitive marine clays. These clays, known as Champlain Sea or Leda clays, are believed to have been deposited during the late stages of the Wisconsin glaciation when the Champlain Sea invaded a significant portion of the South-eastern Ontario including the St. Lawrence lowlands and the Ottawa Valley. It is believed that while these clays were deposited in a marine environment, the influx of fresh waters from Lake Ojibway-Barlow, due to isostatic rebound, progressively decreased the salinity of the regressing sea, some 12 to 15 thousand years ago. This gave way to a leached, open, flocculated structure of the marine clay. Consequently, these clays are characterized by generally high sensitivity, low shear strength and a high compressibility beyond a threshold stress range. While the

thickness of these clays can be extensive at most areas, it can also vary significantly, generally depending on the elevation of the ground and bedrock. Relatively thin deposits occur west of Stittsville where bedrock outcrops and granular deposits are frequent. Between the bedrock and the clay a layer of glacial till deposit is also commonly encountered.

The bedrock in the Region is known to consist of a faulted sequence of limestones and shales of the Ordovician Period. Published information shows that at the intersection of Highway 17 and McGee Road the bedrock consists of interbedded sublithographic to fine crystalline limestone and calcarenite, known as the Bobcaygeon Formation of the Upper Ordovician Period of the Palaeozoic Era. The intersection however is very close to the interface of other limestone deposits known as Gull River and Verulam Formations. All of these formations are known to belong to the Simcoe (Trenton-Black River) Group.

3.0 SUBSURFACE CONDITIONS

The subsurface conditions were explored at ten borehole locations and were inferred at the locations of three dynamic cone penetration tests. The locations of the boreholes and cone penetration tests are shown on the Plan and Profile Dwg. No. 2 & 3.*

Details of the stratigraphy encountered in the boreholes are given on the individual record of Borehole Sheets. The subsurface conditions can be summarized as follows:

The site is generally underlain, below a 1 to 2 m thick fill deposit, by a 0.2 to 0.7 m thick layer of topsoil and/or somewhat organic sand and silt which are in turn underlain by a deposit of stratified silty sand extending to depths ranging between 2.9 and 5.6 m below the ground surface. These surficial soils are underlain by a major deposit of silty clay with sand and silt interbeds. This deposit is 4.5 to 7.4 m thick and is underlain at some of the borehole locations by a 0.2 to 2.7 m thick gravelly sand deposit immediately above the bedrock. The surface of the limestone bedrock was contacted or inferred at depths ranging between 10.2 and 13.1 m below the ground surface or between Elevations 109.1 and 106.1 m indicating that it generally slopes down from west to east with an elevation difference of 3 m over a horizontal distance of about 100 m.

The individual strata are briefly described in the following paragraphs.

a) Fill: Pavement materials consisting of asphaltic concrete over a thin granular base were encountered in the majority of the boreholes. These were found to overlie a sub-base fill deposit of brown sand with some gravel extending to a depth of 1.1 to 2.1 m below the ground surface.

b) Topsoil: Beneath the granular fill Boreholes 1 and 4 contacted a 0.2 to 0.3 m thick layer of topsoil.

c) Organic Sand and Silt: Underlying the fill and/or topsoil a deposit of dark brown to grey sand or silt with organics was encountered in Boreholes 1, 101, 103, 4 and 5. At the borehole locations this deposit extends to depths ranging from 1.5 to 2.1 m below the ground surface and its thickness ranges from 0.2 to 0.4 m. From 'N'-values of between 7 and 50 blows/0.3 m, the deposit is described as loose to dense.

d) Silty Sand: Below the surficial fill and organic materials, a stratum of silty sand was encountered in all the boreholes ranging in thickness from 1.4 m (B.H.5) to 4.4 m (B.H.102), i.e. to depths ranging between 2.9 and 5.6 m below the ground surface, respectively.

These sands are believed to have been deposited by fluvial activity after the withdrawal of the Champlain Sea. The contact between the sand and the underlying clay is rather gradational and is not well defined.

The material was moist to wet and moisture content determinations carried out on samples from this material measured values ranging from 15 to 22%. Grain-size analyses carried out on selected representative samples showed that the material is comprised of 49 to 65% sand, 21 to 41% silt and 10 to 14% clay size particles. (Fig. No. 1).

Standard penetration resistances, 'N'-values, measured in this deposit randomly vary between 14 and 81 blows/0.3 m and based on these values this deposit is described as compact to very dense.

e) Silty Clay: A major deposit of silty clay to clayey silt, interbedded with silt and sand, was encountered in all the boreholes directly below the silty sand stratum. The thickness of this deposit, including the interbeds and lenses ranges from 4.5 m (B.H.102) to 7.4 m (B.H.103). These interbeds range in thickness from several millimetres to 3.4 m.

Atterberg Limits tests carried out in the laboratory gave the following index values:

Liquid Limit: 18 - 39%
Plastic Limit: 14 - 24%
Plasticity Index: 4 - 15

These values are characteristic of clayey soils of low to intermediate plasticity. The lower plasticity indices generally represent the silt and clayey silt zones in the deposit. The measured moisture contents range from 20 to 48% and are generally near or above the liquid limits.

The undrained in-situ shear strength of the silty clay as measured by field vane tests ranges from 17 to 179 kPa and are generally in the 25 to 50 kPa range. The variation of in-situ shear strength with elevation is plotted in Figures No. 9 and 10. Several undrained quick triaxial tests were also performed in the laboratory to determine the undrained shear strength of the soil but these are not considered to be representative of the actual field strengths due to the failure of the test samples through the random silt and sandy silt to silty sand zones and lenses that were present in the samples.

The unique properties of the Champlain Sea clay are its blocky, fissured structure and its extreme sensitivity to remoulding. The sensitivity of the soil, determined as the ratio of the peak shear strength to the remoulded shear strength of the in-situ vane test data ranges from 1.3 to 16.7 with an average value of 5.5. In general however the measured sensitivity ranges from 3.5 to 8.0 and these values indicate a generally low to sensitive clay.

The compressibility and consolidation characteristics of the clay were determined in the laboratory by conventional oedometer tests. The test results are shown in Fig. 6 and 7 which suggest that the clay is slightly preconsolidated and highly compressible.

The measured bulk unit weight of the soil ranges between 18 and 20 kN/m³ .

The clay is frequently interlayered and interbedded with silt and sand seams or lenses of various thicknesses, ranging from several millimetres to several metres in thickness. In some instances the thicknesses of such zones showed great variations in between boreholes drilled close to each other (e.g. Boreholes 3 and 103) indicating random deposition modes. The grain size distribution of samples from these silt and sand zones are presented on Fig. Nos. 2, 3 and 4.

Standard Penetration resistances measured in these silt and sand interbeds gave 'N'-values of 7 to over 50 blows/0.3 m advance indicating a highly variable relative density ranging from loose to very dense. These zones/layers were found to be wet and water bearing.

f) **Silty Sand:** A 0.2 to 2.7 m thick lower sand stratum with silt and gravel content was contacted in the majority of the boreholes immediately overlying the bedrock.

A grain-size distribution analysis performed on a sample from this deposit showed 25% gravel, 51% sand, 20% silt and 4% clay size particles (Fig. No.5). This deposit was wet and from 'N'-values of 11 to 22 blows/0.3 m it is considered compact.

g) **Bedrock:** Bedrock was proven by diamond drilling and rock coring in Boreholes 1, 2, 3 and 103, and it was inferred from refusal to augering or dynamic cone penetration tests at the other exploration locations.

At the proposed abutment locations, the surface of the rock was contacted at depths ranging between 10.7 m below the ground surface (or at Elevation 108.7 m, at Borehole 101) at the west abutment location and 13.1 m (or Elevation 106.1 m, at Borehole 2) at the east abutment location. This indicates that the surface of the rock is relatively level with an elevation drop of 2.6 m from west to east over a horizontal distance of 62 m.

The rock was cored for a vertical distance of 3.0 m, 3.1 m, 1.2 m and 1.9 m at Boreholes 1, 2, 3 and 103, respectively. The core samples show that the rock consists of grey limestone with frequent highly argillaceous zones and thin shale seams. It is generally horizontally bedded and does not contain major fractures or solution cavities where it was cored. The percentage of recovery of the rock cores ranged from 89 to 97% and R.Q.D. values of between 13 and 40% were recorded. From these observations and high percentage of recovery, the rock is described as generally sound. The low R.Q.D. values however indicate that it is of poor quality mainly due to the presence of weak shale zones.

4.0 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and at the completion of each borehole. Standpipe piezometers were installed in Boreholes 6 and 101 to enable us to monitor the groundwater levels over a prolonged period of time without interference from surface water. In each of these boreholes two piezometers were installed, one at a depth of 3 m in the upper sand deposit and second one at 6 m depth in the underlying soil strata.

The recorded values, presented on the individual borehole log sheets, indicate that there is a perched water table in the upper sand which at the time of our investigation was generally at a depth of about 1.8 to 2.0 m below the ground surface. The water level in the underlying clay was generally 3 to 4 m below the ground surface.

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

ENCLOSURES

RECORD OF BOREHOLE No 1

METRIC

W P 34-81-03 LOCATION Sta. 10 + 031, 0/S 1.8m RT ORIGINATED BY AAK
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger, NXL Rock Core COMPILED BY AAK
 DATUM Geodetic DATE 89 12 05 CHECKED BY ZSO

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					
119.2	GROUND LEVEL																
0.0	0.1 m Crushed Stone -		1	AS													
117.8	FILL brown sand, some gravel		2	SS	15*												
1.4	TOPSOIL																
1.7	SAND somewhat organic		3	SS	7												
2.1	Loose, grey																
	SILTY SAND dense, grey, moist to wet		4	SS	32												
115.6			5	SS	35												
3.6			6	SS	5												
	silty sand interbeds		7	TW	PH												
			8	SS	8												
	SILTY CLAY soft to stiff grey		9	SS	9												
			10	TW	PH												
			11	SS	4												
108.1	some gravel		12	TW	PH												
11.1																	
	grey Limestone BEDROCK		13	RC													
105.1																	
14.1	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

TIME W.C.
(m)
Dec.5/89 1.5
(completion)
Dec.6/89 1.5

RECORD OF BOREHOLE No 2										METRIC						
W P 34-81-03		LOCATION Sta. 9 + 969, 0/S 4.8 LT				ORIGINATED BY AAK										
DIST 9 HWY 17		BOREHOLE TYPE Hollow Stem Auger, NXL Rock Core				COMPILED BY AAK										
DATUM Geodetic		DATE 89 12 06				CHECKED BY ZSO										
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					
119.2	GROUND LEVEL															
0.0	0.05 m ASPHALT FILL		1	AS												
0.08	0.08 m Granular Base		2	SS	52											
117.4	Sand, some gravel brown		3	SS	32											
1.8	SILTY SAND brown with silt seams grey compact to v. dense wet		4	SS	56											
115.6			5	SS	81											
3.0	SILTY CLAY firm, grey		6	SS	7											
			7	TW	PH											
113.2			8	SS	7											
6.0	SILTY SAND some clay loose grey		9	SS	78											
110.4			10	SS	38*											
8.8	SILTY CLAY soft to stiff, grey															
108.3			11	SS	22											
10.9	SILTY SAND some gravel compact, grey															
106.1			12	NXL	RC											
13.1	grey Limestone BEDROCK															
103.0																
16.2	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

TIME W.L.
(m)
Dec. 6/89 1.4
(completion)
Immediately
after rock
coring

RECORD OF BOREHOLE No 3

METRIC

W P 34-81-03

LOCATION Sta. 10 + 000 O/S 4.8 LT

ORIGINATED BY AAK

DIST 9 HWY 17

BOREHOLE TYPE Hollow Stem Auger, NXL Rock Core

COMPILED BY AAK

DATUM Geodetic

DATE 89 12 07

CHECKED BY ZSO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	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 (%)
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
119.6	GROUND LEVEL													
0.0	0.05m Asphalt 0.08m Granular Base		1	AS										
	FILL sand, some gravel brown		2	SS	50	15cm								
117.5			3	SS	29									
2.1			4	SS	36									
	SILTY SAND compact to very dense grey, wet		5	SS	54									
			6	SS	26									
114.9	SILTY CLAY		7	SS	7									
114.5	Firm grey													
5.1			8	SS	14						+ s=3.6 + s=2.7			
	SANDY SILT with clay seams compact grey													
112.5			9	SS	50	15cm								
7.1	SILTY SAND very dense, grey													
111.1			10	SS	wt of rods									
8.5														
	SILTY CLAY firm to stiff, grey		11	TW	PH						+ s=2.7 + s=3.5			
108.0											+ s=10.6	17.4		
11.6	grey Limestone BEDROCK		12	NXL RC	REC 89%									
106.8													RQD = 18%	
12.8	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 34-81-03 LOCATION Sta. 10 + 051 @ c/r. ORIGINATED BY AAK
DIST 9 HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY AAK
DATUM Geodetic DATE 89 12 08 CHECKED BY ZSO

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					
119.2	GROUND LEVEL																
0.0	0.05m Asphalt																
	0.1 m Granular base																
117.8	FILL sand, some gravel		1	SS	40												
1.4	TOPSOIL																
1.6	SAND somewhat organic		2	SS	37												
1.9	compact, grey		3	SS	25												
	SILTY SAND		4	SS	43												
	compact to dense,		5	SS	30												
114.8	grey		6	SS	9*												
4.4			7	SS	7												
	SILTY CLAY		8	SS	5												
	soft to stiff		9	SS	5												
	grey																
108.7	some gravel																
10.5	End of Borehole																
	Refusal to Augering																
	Probable Bedrock																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

TIME W.L.
(m)
Dec. 8/89 2.3
(completion)

RECORD OF BOREHOLE No 5

METRIC

W P 34-81-03 LOCATION Sta. 10 + 071 @ C/L ORIGINATED BY AAK
DIST 9 HWY 17 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY AAK
DATUM Geodetic DATE 89 12 08 CHECKED BY ZSO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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	W _p W W _L	WATER CONTENT (%)				
119.3	GROUND LEVEL													
0.0	0.05m Asphalt													
118.2	0.1 m Granular fill FILL, sand some gravel brown													
1.1	SAND somewhat organic brown		1	SS	50									
1.5	SAND somewhat organic brown		2	SS	47									
116.4	SILTY SAND brown thin silty clay seams very dense to compact		3	SS	17									
2.9	SILTY CLAY sand seam		4	SS	15									
	very stiff to trace firm grey sand		5	SS	13									
			6	SS	10									
112.7			7	SS	6									
6.6	End of Borehole Dynamic Cone Penetration Test performed from 6.6 to 10.2 m SILTY CLAY, soft (INFERRED)													
109.1														
10.2	End of Dynamic Cone Penetration Test Refusal to Dynamic Cone Penetration @ 10.2 m Probable Bedrock													

OFFICE REPORT ON SOIL EXPLORATION

TIME W.L.
(m)
Dec. 8/89 1.8
(completion)

RECORD OF BOREHOLE No 6

METRIC

W P 34-81-03 LOCATION Sta. 9 + 949 @ C/L. ORIGINATED BY AAK
DIST 9 HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY AAK
DATUM Geodetic DATE 89 12 09 CHECKED BY ZSO

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					
119.0	GROUND LEVEL													
0.0	0.08m Asphalt 0.12m Granular fill FILL sand, some gravel brown		1	SS	21									
117.6			2	SS	26									
1.4	SILTY SAND with silt seams brown compact, moist grey to wet		3	SS	17									- 65 21 14
115.4			4	SS	14									
3.6	SILTY CLAY firm to stiff, grey sand interbeds		5	SS	11									
113.4			6	TW	PH									
5.6	SILTY SAND some clay compact to very dense, grey		7	SS	22									- 53 32 15
110.4			8	SS	71									
8.6	SILTY CLAY firm to stiff, grey		9	SS	19*									* rods rebounding spongy
108.4														
10.6	SILTY SAND some gravel, compact, grey		10	SS	11									
106.5			11	SS	85/	20cm								
12.5	End of Borehole (Probable Bedrock)													
														TIME W.I.. (m) (STANDPIPE) No.1 No.2 Dec.9,89 Dry 2.7 Dec.10/89 Dry 1.8 Dec.11/89 a.m. 4.5 2.3 p.m. 3.9 2.2 Dec.12/89 3.8 2.2

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



RECORD OF BOREHOLE No 7

METRIC

W P 34-81-03 LOCATION Sta. 9 + 929 @ C/I. ORIGINATED BY AAK
DIST 9 HWY 17 BOREHOLE TYPE Solid Stem Auger & Cone Test COMPILED BY AAK
DATUM Geodetic DATE 89 12 10 CHECKED BY ZSO

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					
118.8	GROUND LEVEL																
0.0	0.05m Asphalt																
117.6	FILL sand some gravel brown		1	AS	-												
1.2	SILTY SAND brown grey compact to v. dense moist to wet		2	SS	65												
			3	SS	47												
			4	SS	20												
			5	SS	14												
115.0	SILTY CLAY firm to stiff, grey		6	SS	11												
3.0			7	SS	5												
			8	SS	5												
111.4	End of Borehole Dynamic Cone Penetration Test performed from 7.4 to 11.0m																
109.8	SILTY CLAY (INFERRED)																
9.0	SILTY SAND some gravel (INFERRED)																
107.8	End of Dynamic Cone Penetration Test Refusal @ 11.0m Probable Bedrock																
11.0																	

TIME W.L.
(m)
Dec. 10/89 1.8
(completion)

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 101										METRIC				
W P 34-81-03		LOCATION Sta. 10 + 031.0/S 4.8 LT				ORIGINATED BY AAK								
DIST 9 HWY 17		BOREHOLE TYPE Solid Stem Auger				COMPILED BY AAK								
DATUM Geodetic		DATE 89 12 09				CHECKED BY ZSO								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	WL	WATER CONTENT (%)		
119.4	GROUND LEVEL													
0.0	0.05m Asphalt 0.2 m Granular Fill													
118.0	FILL sand, some gravel brown													
1.4	SAND somewhat organic grey		1	SS	38									
1.6	SILTY SAND brown dense, wet grey		2	SS	32									
115.4	Silty sand interbeds		3	TW	PH									
4.0	SILTY CLAY firm to stiff, grey		4	SS	8									
			5	SS	4									
			6	SS	4									
			7	SS	50/3cm									
108.7	End of Borehole Refusal to Augering and sampling Probable Bedrock													
10.7														
													TIME	W.L. (m)
													(STANDPIPE)	
													No.1	No.2
													Dec.9/89	5.2 1.9
													Dec.10/89	2.3 1.8
													Dec.11/89	
													a.m.	3.4 1.8
													p.m.	3.2 1.9
													Dec.12/89	3.2 1.9

RECORD OF BOREHOLE No 102

METRIC

W P 34-81-03 LOCATION Sta. 9 + 969, O/S 2m RT ORIGINATED BY AAK
DIST 9 HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY AAK
DATUM Geodetic DATE 89 12 10 CHECKED BY ZSO

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					
119.1	GROUND LEVEL																
0.0	0.04m Asphalt																
117.9	FILL sand some gravel brown																
1.2	brown grey SILTY SAND with silt seams v. dense to loose wet		1	SS	46												
			2	SS	64												
			3	TW	PH												
113.5																	
5.6	SILTY CLAY firm, grey sand interbeds		4	TW	PH												
112.4																	
6.7	SILTY SAND some clay v.dense, grey		5	SS	55/	15cm											
110.9																	
8.2	SILTY CLAY soft to stiff, grey		6	SS	12*												
109.0																	
10.1	SILTY SAND some gravel compact, grey		7	SS	17												
106.3																	
12.8	End of Borehole Refusal to Augering Probably Bedrock																

OFFICE REPORT ON SOIL EXPLORATION

TIME W.L.
(m)
Dec 10/89 1.5
(completion)

METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

METRIC

OFFICE REPORT ON SOIL EXPLORATION

[illegible]

+3, x⁵: Numbers refer to Sensitivity

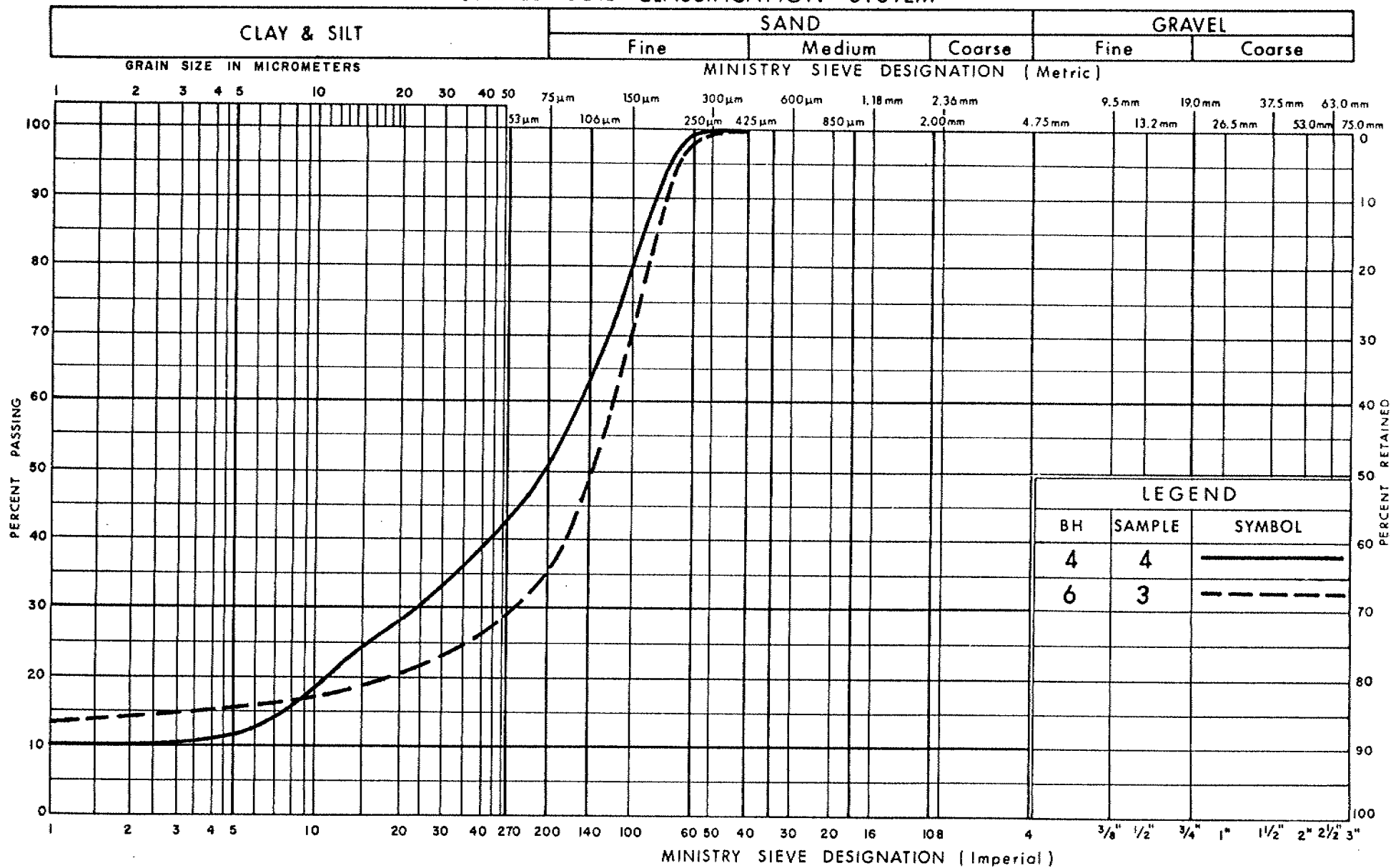
METRIC

OFFICE REPORT ON SOIL EXPLORATION

[illegible]

+3, x⁵: Numbers refer to Sensitivity

UNIFIED SOIL CLASSIFICATION SYSTEM



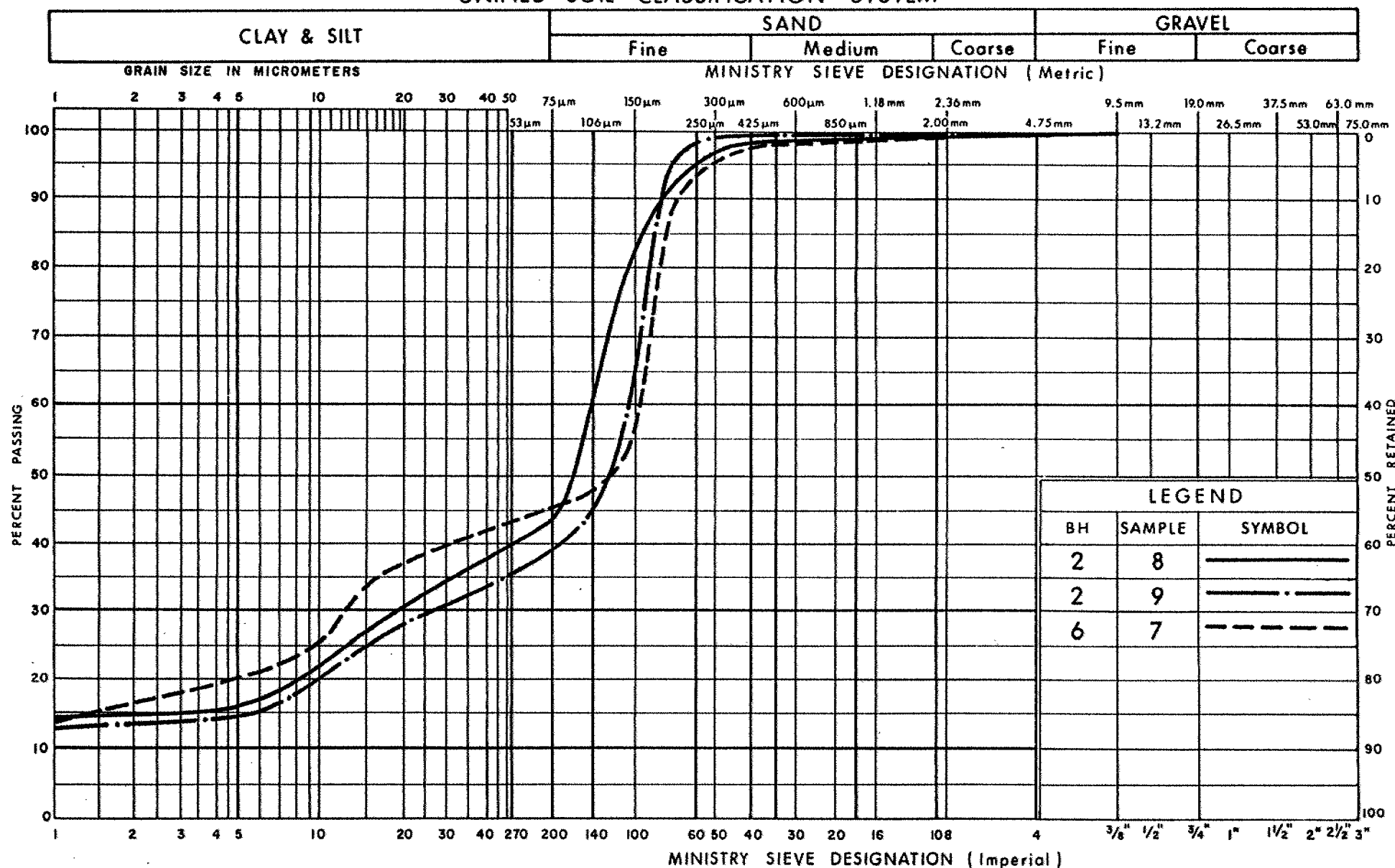
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE OF CLAY

FIG No 1

W P 34-81-03

UNIFIED SOIL CLASSIFICATION SYSTEM



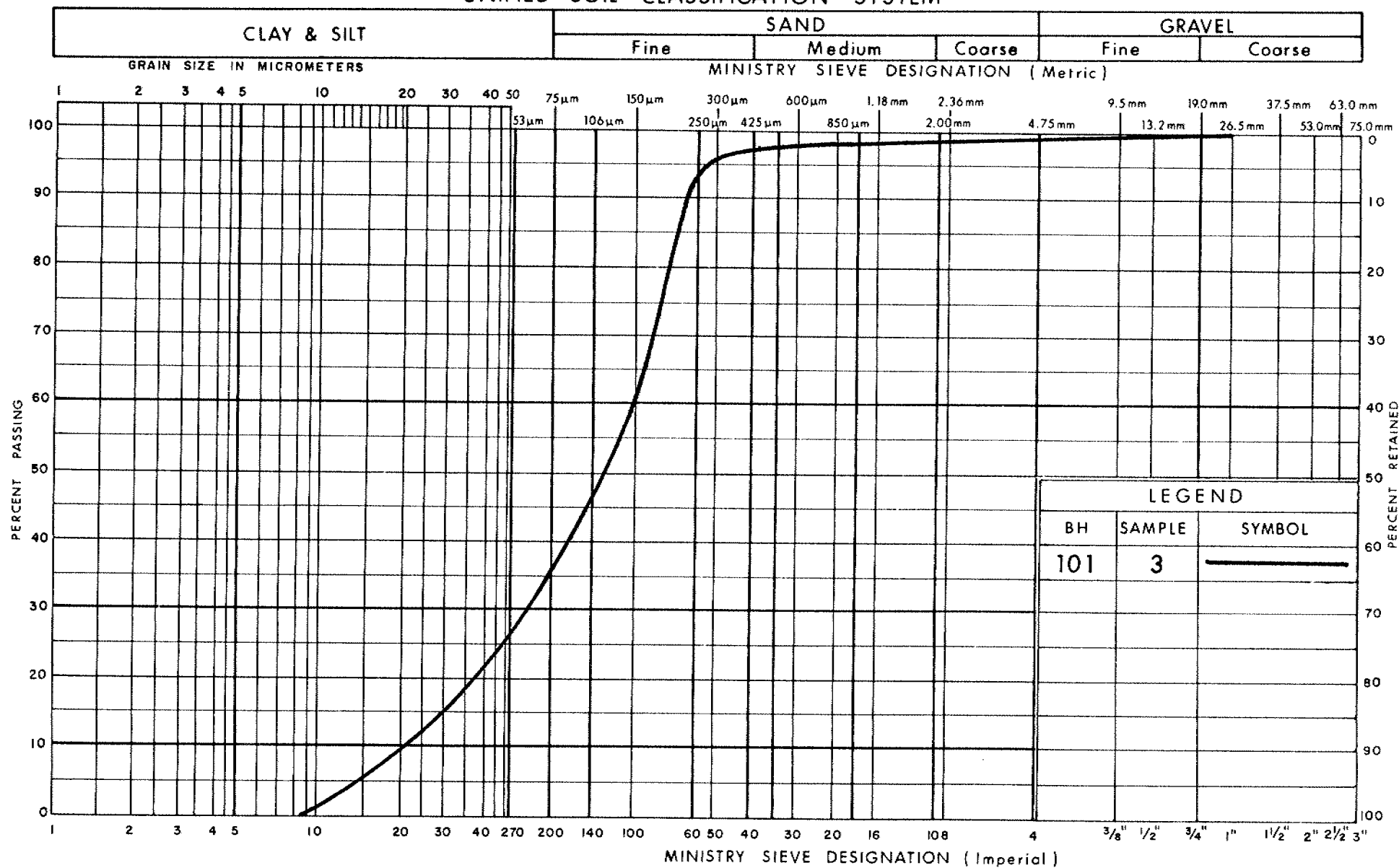
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND, SOME CLAY

FIG No 2

WP 34-81-03

UNIFIED SOIL CLASSIFICATION SYSTEM



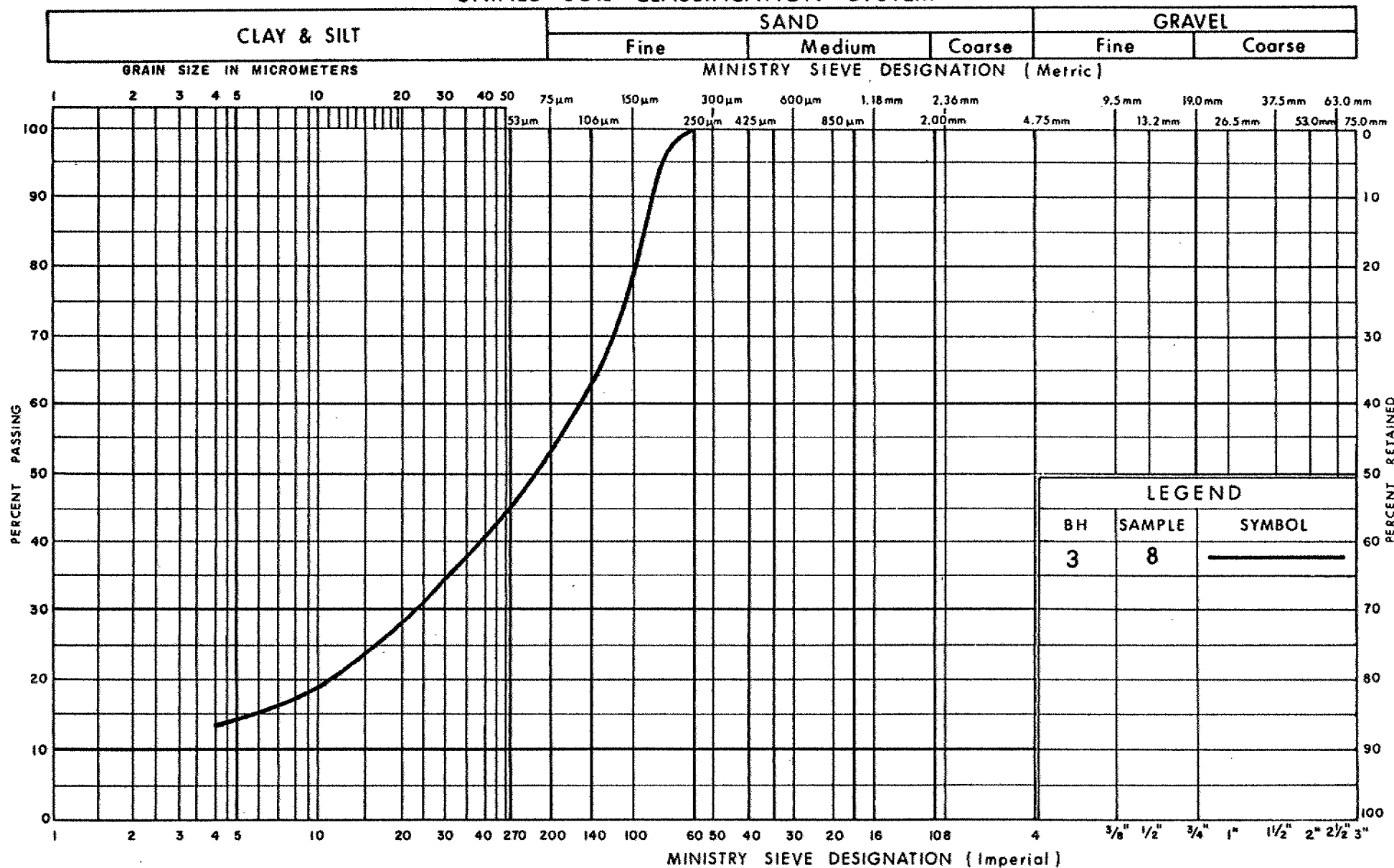
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Transportation

GRAIN SIZE DISTRIBUTION SILTY SAND (INTERBED)

FIG No 3

W P 34-81-03

UNIFIED SOIL CLASSIFICATION SYSTEM



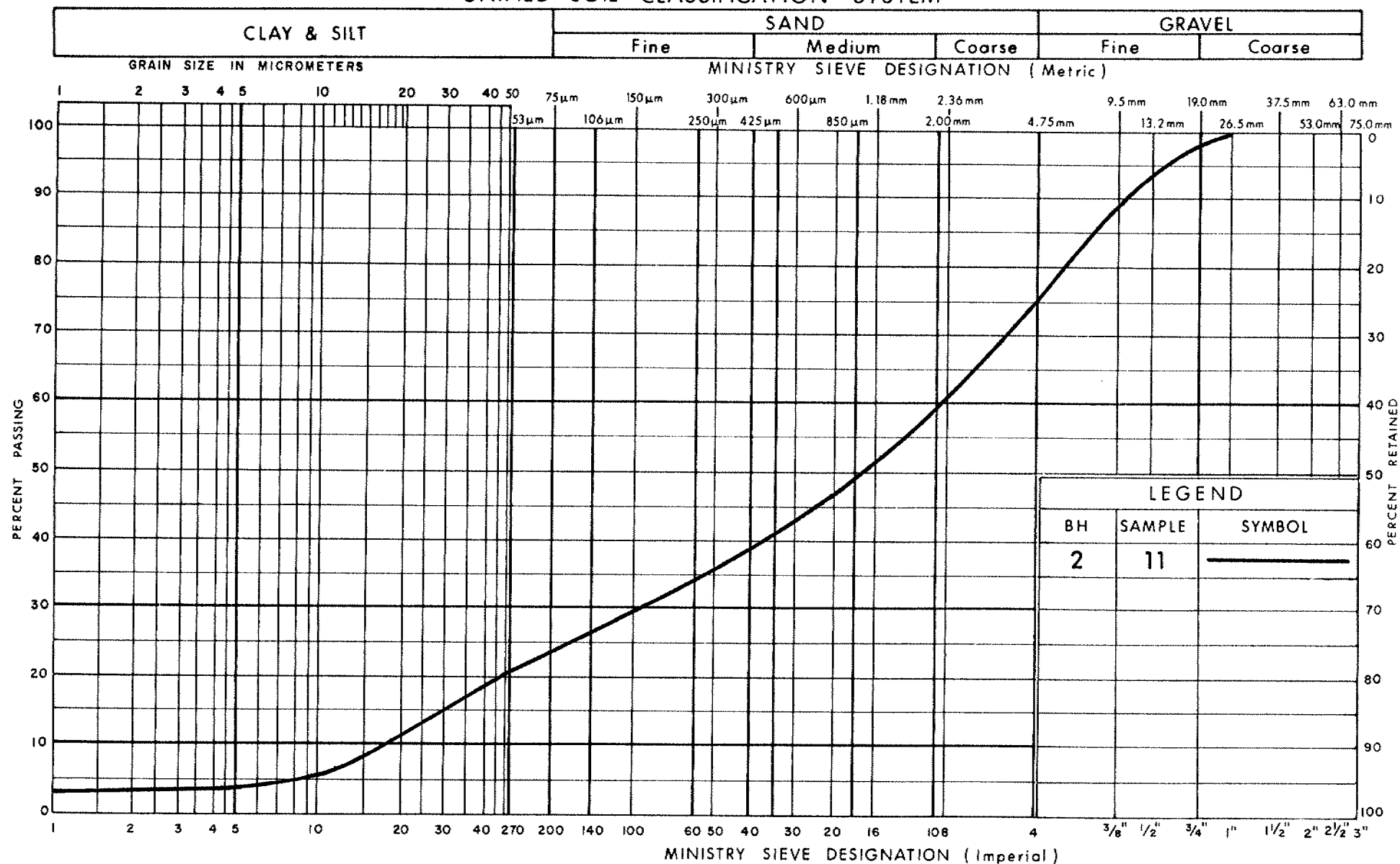
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Transportation

GRAIN SIZE DISTRIBUTION
SANDY SILT, TRACE OF CLAY

FIG No 4

W P 34-81-03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND, SOME GRAVEL

FIG No 5

W P 34-81-03

VOID RATIO - PRESSURE CURVES

47

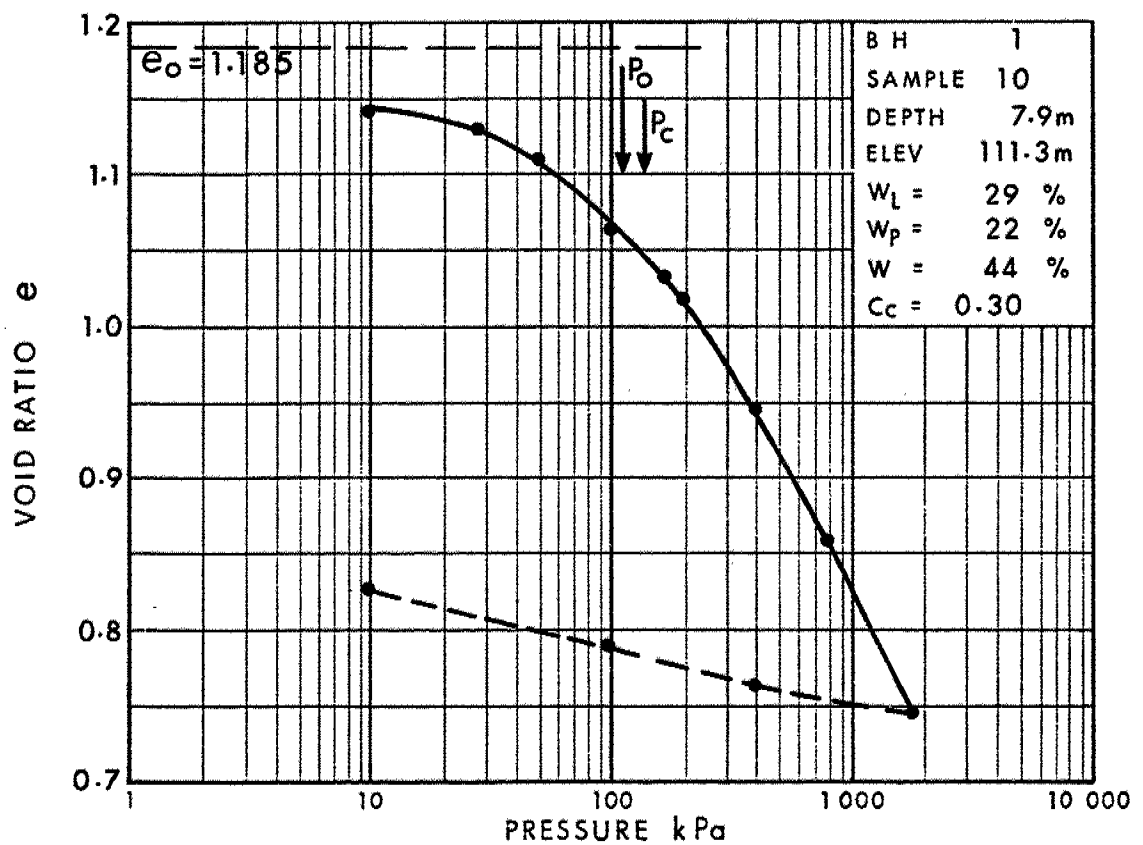
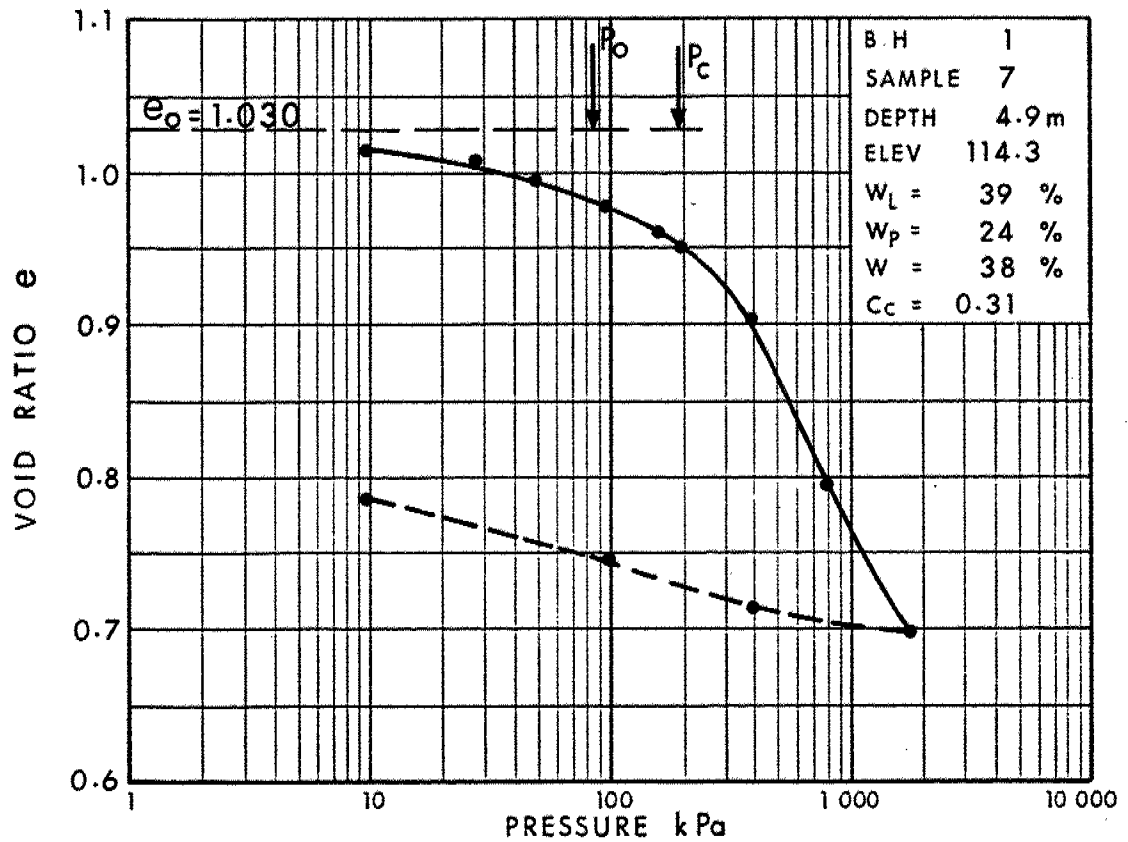


Fig 6

W P 34 - 81-03

VOID RATIO - PRESSURE CURVES

48

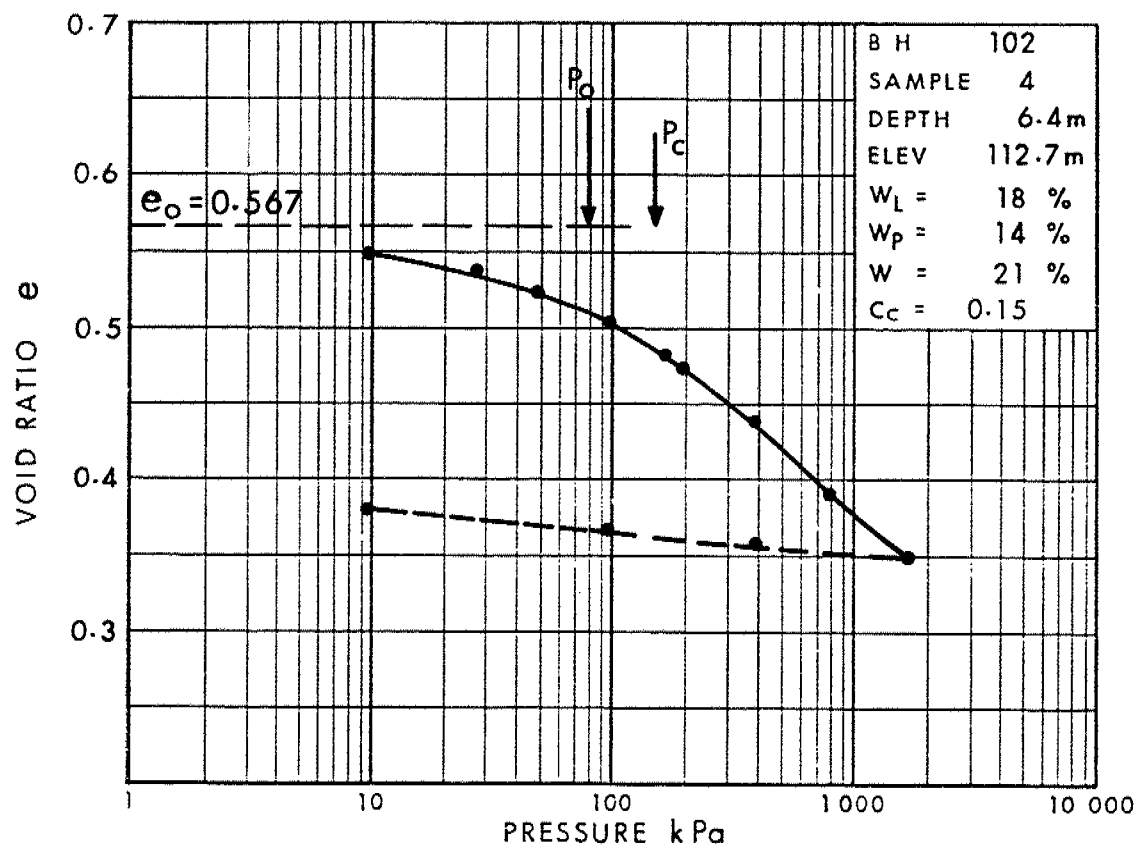
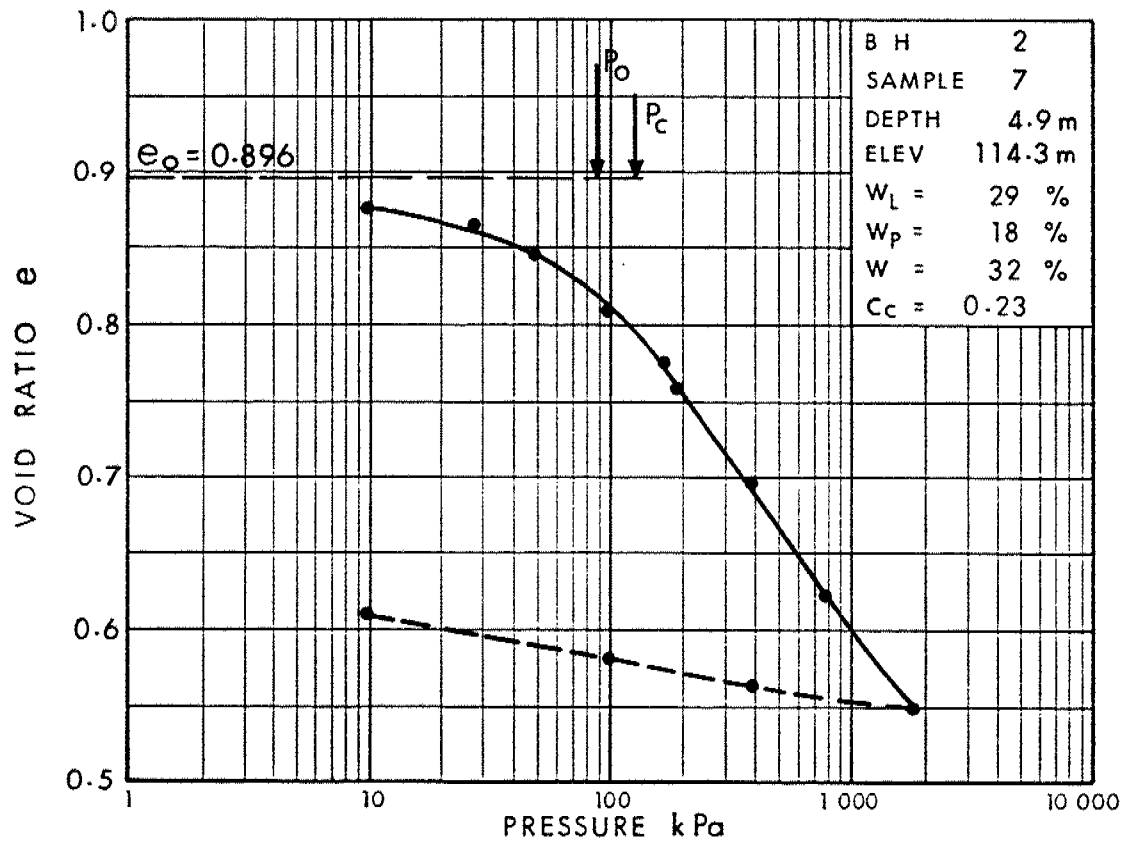
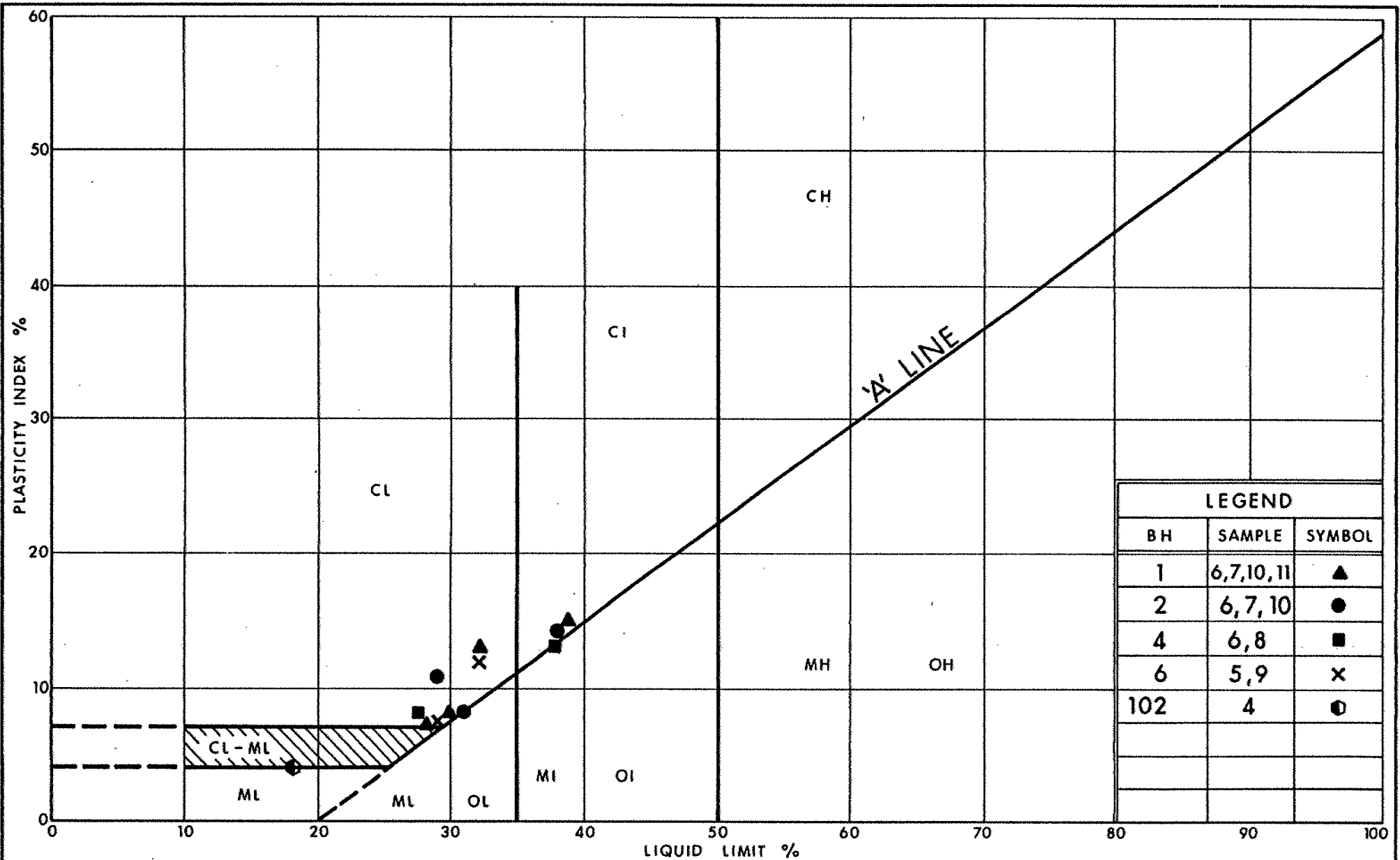


Fig 7

W P 34-81-03



Ministry of
Transportation

PLASTICITY CHART SILTY CLAY

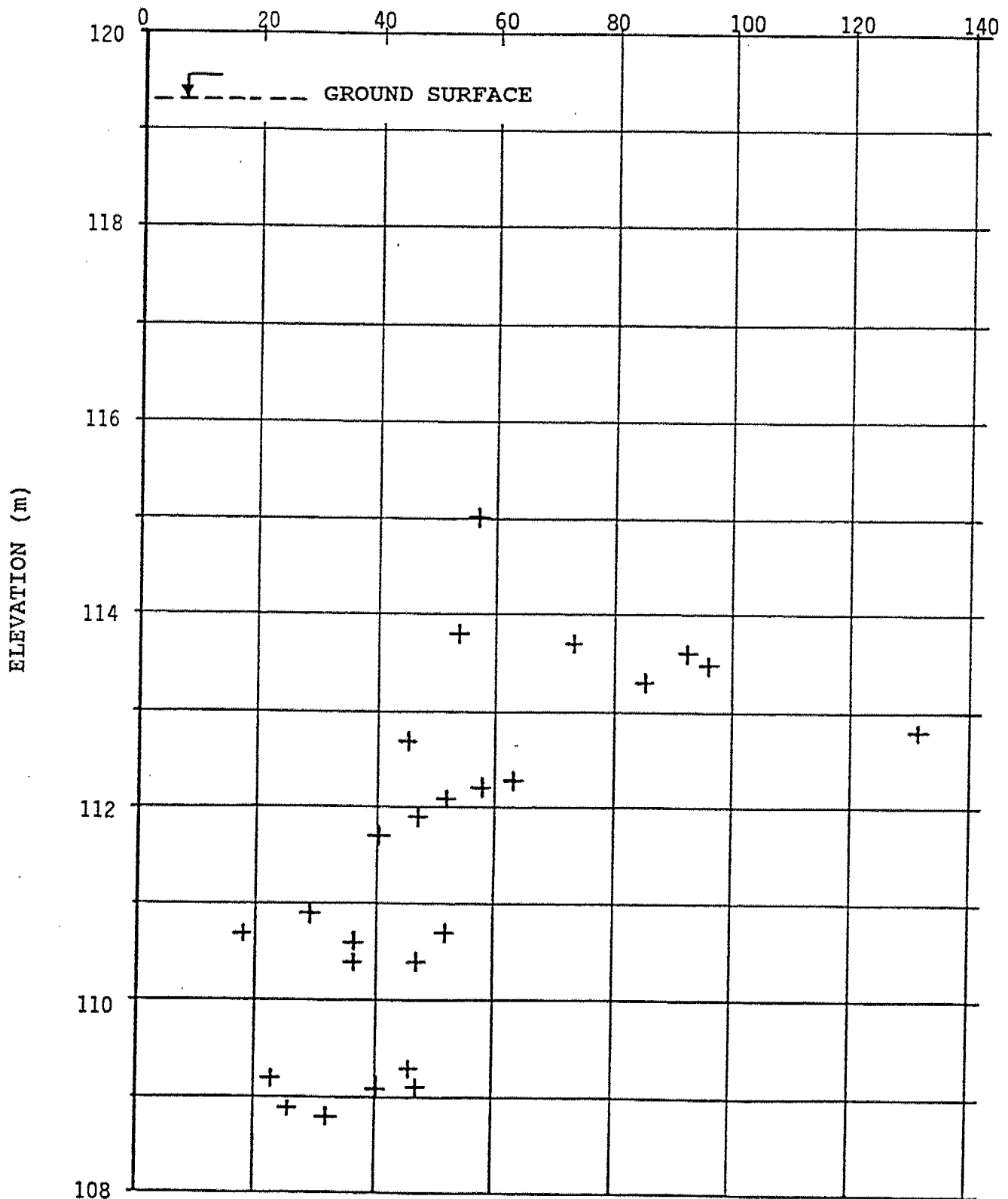
FIG No 8

W P 34-81-03

FIGURE NO. 9
WP 34-81-03

UNDRAINED IN-SITU SHEAR STRENGTH AS
MEASURED BY FIELD VANE TESTS (kPa)

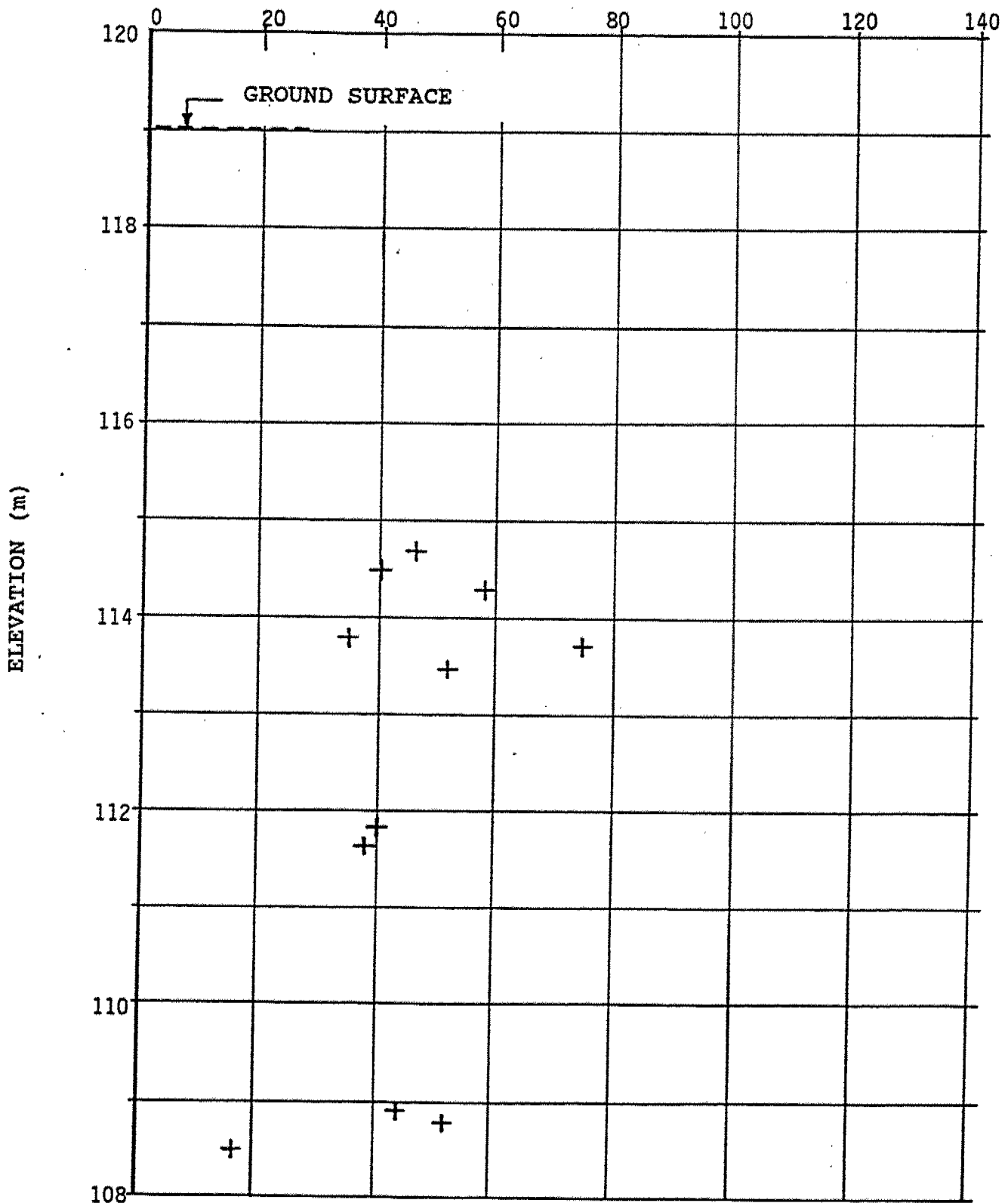
BOREHOLES 1, 101 & 4

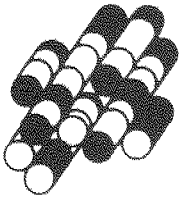


UNDRAINED IN-SITU SHEAR STRENGTH AS
MEASURED BY FIELD VANE TESTS (kPa)

FIGURE NO. 10
WP 34-81-03

BOREHOLES 2, 6 & 7





Terraprobe Limited

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FAX: 793-2655

CONT 93-31

FOUNDATION INVESTIGATION
PROPOSED CULVERT EXTENSION - MOODY CREEK
HIGHWAY 17 AND MCGEE ROAD
OTTAWA, ONTARIO
W.P. 34-81-01 SITE NO. 3-436
DISTRICT 9 EASTERN REGION

Prepared For: Ministry of Transportation Ontario
Foundation Design Section
1201 Wilson Ave.
Central Bldg. Rm. # 315
Downsview, Ontario
M3M 1J8

OUR FILE NO. 89362
May 1990

GEOCRES # 31F-119

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ABSTRACT

Terraprobe Limited was authorized by the Foundation Design Section of the Ministry of Transportation, to undertake a foundation investigation for a proposed culvert extension on Highway 17, near McGee Road in the City of Kanata, Ontario.

It is proposed to construct an embankment to carry the eastbound lanes of Highway 17 over the Moody Creek in this area. The proposed roadway would be constructed parallel to the existing Highway 17, and an extension to the existing box culvert would be required to carry the Moody Creek beneath the new road.

The field investigation for the project consisted of three sampled borings near the alignment of the proposed culvert extension. The borings were advanced to depths of about 3.5 to 6.6 m below existing grades.

Boreholes generally encountered a thin layer of topsoil or fill near the ground surface. Beneath the topsoil or fill, silty clay soils were encountered to the base of the borings. The clay was generally in a firm to stiff condition, and was overconsolidated.

It is considered that the native silty clay soils will provide a suitable foundation base for the box culvert on either spread footings or a slab. The native soils will also provide suitable foundation for the proposed 2 m high roadway embankment. The embankment is considered to be stable with conventional 2 to 1 (horiz. to vert.) side slopes.

The settlement of the embankment and box culvert are estimated to be on the order of 20 to 50 mm.

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1. INTRODUCTION

Terraprobe Limited was authorized by the Foundation Design Section of the Ministry of Transportation Ontario (MTO), to undertake a foundation investigation for a proposed culvert extension located on Highway 17. The site is located east of McGee Road in the City of Kanata, Ontario. The details of the project were discussed with the Foundation Design Section of the MTO, during December 1989, in order to define the appropriate scope of work for the geotechnical investigation. The details of the project were presented in our proposal letter of December 19, 1989.

The purpose of the investigation was to determine the subsurface conditions at the site, and to provide geotechnical engineering recommendations for the design and construction of an extension to an existing concrete box culvert. Comments regarding the design and construction of the proposed road embankment for the Highway 17 east-bound lane at this location, were also required.

A field investigation for the project was conducted on December 20 and 21, 1989, when three boreholes were advanced at the locations shown on Drawing No. W.P. 34-81-01. Details of the field investigation program are provided in Appendix A of this report.

2. SITE AND GEOLOGY

The site is located on Highway 17, east of McGee Road in the City of Kanata, Ontario. There is an existing concrete box culvert at the site through which the Moody Creek flows in a northerly direction beneath existing Highway 17. At this location, Highway 17 is a two lane paved road with gravel shoulders. The culvert passes through an earth embankment which has a total height of approximately 2 m in this area. We understand the existing culvert is approximately 6 m wide, 37 m long, and 1.5 m in deep.

In the vicinity of the site, the Moody Creek channel is approximately 3 to 4 m wide. The depth of the creek could not be measured at the time of our investigation, due to the creek being frozen. However, based on the information we have received on the culvert dimensions, it was estimated that there was flow in the channel to a depth of about 0.5 to 1 m.

The site is situated in a geologic area consisting of a clay plain. In the vicinity of the site, the overburden materials are characterized by relatively thick and extensive deposits of clayey soils. The ground surface in the vicinity of the site is quite flat and at an elevation of approximately 117 to 118 m (Geodetic). Areas surrounding the site are covered with isolated bush and open field. Based on the review of local Ministry of Environment water well records, the depth the bedrock in the area may be on the order of 20 to 30 m.

Existing geologic mapping indicates that the bedrock materials underlying the site consist predominantly of limestone of the Trenton and Black River groups.

It is proposed to construct two additional traffic lanes on Highway 17 to carry eastbound traffic. The additional lanes would be constructed parallel to the existing embankment and at a distance of about 30 m south west of the existing Highway 17. This would require a 28 m long westerly extension of the existing box culvert, as shown on the accompanying Drawing W.P. 34-81-01. The extended culvert alignment would be slightly skewed from the existing culvert, to permit crossing of the road embankment at right angle. It is also proposed to re-align the creek channel in this area, in order to eliminate the meander and provide a straight entrance section to the culvert.

3. SUBSURFACE CONDITIONS

Details of the subsurface conditions encountered at the site are summarized below and also presented on the accompanying borehole logs and sections on Drawing no. W.P. 34-81-01.

A summary of the results of laboratory and field tests are presented on the Borehole Logs and on Figures 1 to 4 inclusive.

It should be noted that the subsurface conditions are confirmed at the borehole locations only, and may vary at other locations. The boundaries between the various strata shown on the borehole logs and sections, are based on non continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise claim of geologic change.

In summary, the three borings generally encountered a thin layer of topsoil near the ground surface. Fill materials were noted to a depth of about 1.5 m in the vicinity of the toe of the existing embankment (Borehole 1). Beneath the topsoil and fill, native silty clay soils were noted, extending to the base of the borings at 3.5 to 6.6 m. The groundwater level was generally within about 2.3 m of the ground surface.

3.1 Topsoil

Topsoil was encountered at the ground surface at Boreholes 2 and 3 and was approximately 150 to 200 mm in thickness. The topsoil consisted of dark brown silty material with traces of organic matter including roots. The topsoil was frozen at the time of investigation.

3.2 Fill

Fill soils were encountered at the ground surface of Borehole 1, extending to a depth of approximately 1.5 m. The fill consisted of dark brown sandy silt with some organic matter including roots and topsoil. The fill was frozen to a depth of approximately 0.6 m.

The water content of a sample of the fill was approximately 52 percent. The standard penetration resistance of the material was 6 to 7 blows per 300 mm, indicating a relatively loose state.

Borehole 1 was drilled near the toe of the existing roadway embankment. This suggests that the fill material encountered is likely associated with the construction of the embankment.

3.3 Silty Clay

Native silty clay soils were encountered beneath the topsoil and fill material in each of the boreholes, and extended to the base of the holes at 3.5 to 6.6 m below existing grades. These stratum ranged in composition from silty clay to clayey silt, with a trace of sand. Occasional fine embedded gravel was noted in some of the samples. Two selected samples of this stratum were subjected to grain size analysis, the results of which are presented on Figure 1.

The moisture content of the clay ranged from about 25 to 42 percent, with an average of about 35 percent. The consistency of the clay was determined on the basis of field vane tests, unconfined compression testing, and standard penetration resistances. Measured field vane undrained shear strengths of the clay were generally greater than 150 kPa, except near the base of Boreholes 1 and 2 (depth of approximately 6 m), where undrained shear strengths of 58 and 124 kPa were measured. The silty clay is considered to have a firm to stiff consistency. The remoulded undrained shear strength of the clay was considerably less, with sensitivities ranging from about 4 to 16. This clay would be classified as extrasensitive, typical of marine clays.

The six samples taken with thin walled samplers were tested in our laboratory for their Atterberg Limits, bulk unit weight, unconfined compressive strength, laboratory penetrometer shear strength. The following table presents the results of that testing:

Sample	Atterberg Limits			Bulk Unit Weight (kN/cu.m)	Unconfined Shear Strength (kPa)	Laboratory Penetrometer Shear (kPa)
	w _L	w _p	w			
BH1 Sa3	49	23	42	17.9	52	50 - 75
BH1 Sa5	43	23	38	18.1	37	50 - 75
BH1 Sa6	36	19	35	18.8	41	75
BH2 Sa3	49	22	41	18.0	57	50 - 75
BH2 Sa4	42	24	37	18.6	83	75 - 100
BH2 Sa5	40	21	40	18.4	31	75

It is noted that the shear strengths determined by unconfined compressive testing and laboratory penetrometer testing, were much lower than those determined in the field using a shear vane. It is considered that this is the result of slight disturbance of the sensitive silty clay soils, during the preparation for these tests.

The results of the Atterberg Limit tests are plotted on the accompanying plasticity charts shown on Figure 2. The results of the tests consistently plot above the 'A' line, indicating a clay of intermediate plasticity.

One dimensional consolidation tests were conducted on two selected samples. The results of the testing are summarized on the accompanying Figures 3 and 4. In summary, the following data was obtained from the tests:

Sample	Depth (m)	Cr	Cc		OCR
BH1 Sa5	1.5	0.025	0.300	290 kPa	6
BH2 Sa3	0.8	0.030	0.410	335 kPa	14

The results of the testing indicate the material is generally overconsolidated by about 6 to 14 times, near the ground surface.

3.4 Groundwater

Minor seepage was noted into each of the borings during drilling. Standpipes were installed in the borings, and the water levels were measured on December 22, 1989 (1 day following completion of drilling). The following water level depths were noted:

Borehole 1	-	1.0 m
Borehole 2	-	0.9 m
Borehole 3	-	1.3 m

Due to the expected low permeability of the native clayey soils, it is likely that the groundwater levels had not stabilized when the measurements were taken.

4 DISCUSSION AND RECOMMENDATIONS

The following discussion and recommendations are based on the factual data obtained from the borehole investigation and from laboratory testing, and are presented for the guidance of the design engineer only. Contractors bidding on, or conducting work associated with this project, should review the factual information to assess their affect on proposed construction methods and scheduling. It is noted that recommendations are based on the data obtained from the boreholes, and that subsurface conditions may vary considerably between the borehole locations, particularly with respect to the depth of fill materials.

The investigation and recommendations, are directed towards a 28 m westerly extension of the existing 37 m long concrete box culvert, and construction of the associated roadway (Hwy 17) embankment. It is our understanding that there are no existing structures or utilities in the immediate vicinity of the proposed construction area which would be influenced or require support during construction of the project.

4.1 Embankment Design

The native silty clay materials encountered in the investigation will provide a suitable foundation for the proposed 2 m high earth embankment. Stability of the embankment against shear failure of the foundations was assessed. The typical cross section used in the analysis is presented on Figure 5. In summary, a variety of potential failure surfaces were analyzed using a simplified Bishop's method of slope stability analysis in order to calculate factors of safety. The analysis was conducted using both short term (undrained) and long term (drained) soil strength parameters.

Due to the relatively low embankment height (2 m) and the firm to stiff subsoil conditions, relatively high factors of safety are calculated for both the drained and undrained analysis. The minimum factors of safety calculated are summarized below:

Undrained Analysis - 7.7

Drained Analysis - 2.8

The results of the analysis suggests that the proposed road embankments can be constructed with 2 to 1 side slopes, while maintaining a high degree of safety against shear failure.

Terraprobe

The amount of settlement of the silty clay foundation beneath the embankment, was estimated using the soil properties obtained from the consolidation tests. It is noted that the additional vertical stress imposed by the 2 m high embankment (approximately 40 to 50 kPa) is considerably less than the pre-consolidation pressure of the underlying silty clay. The maximum settlement calculated beneath the centre line of the embankment is on the order of 20 to 30 mm. Therefore it is possible to construct a higher embankment if needed. The following soil properties were used in these calculations:

Initial Void Ratio	= 1.16
Pre-consolidation Pressure	= 300 kPa
Compression Index	= 0.350
Recompression Index	= 0.028

The foundation area beneath the proposed embankment should be prepared by removing all vegetation, topsoil, and loose or deleterious fill materials from beneath the embankment area. The embankment base should be proof rolled and any local soft or loose areas should be subexcavated and replaced with suitably compacted fill.

It is assumed that the embankment fill will consist of clean mineral soil, which is placed and compacted in thin lifts to at least 95 percent of the Standard Proctor Maximum Dry Density.

The embankment side slope should be provided with surface erosion protection. The protection may consist of either a thick vegetative mat, or a prefabricated block and geotextile system for areas which are not suitable for vegetation (ie. continually shaded).

4.2 Culvert Foundations

It is our understanding that the proposed extension will be constructed in a fashion similar to the existing box culvert beneath Highway 17.

The native silty clay soils encountered in the borings are considered suitable for support of the box culvert, either on a base slab (i.e. slab forming the base or bottom of the box) or on spread footings. Based on an average undrained shear strength of approximately 150 kPa

in the shallow soil zone, the factored capacity at Ultimate Limit States (Q_f) would be about 550 kPa. However, the maximum bearing pressure on the silty clay strata will generally be governed by settlement considerations.

There are two possible settlement effects to consider; settlement due to embankment loads, and settlement due to box culvert loads. A 2 m high embankment would have a bearing pressure of about 40 to 50 kPa on the underlying silty clay soils. If the box culvert is constructed on a slab foundation, the foundation pressure below the slab will likely be less than the surrounding embankment pressure on the subgrade. In this case the capacity at Serviceability Limit States Type II (Q_s) is not relevant, since the box culvert will be placed within an embankment of approximately 2 m height and the settlement of the box culvert will be governed by settlement of the surrounding embankment subgrade (estimated as about 20 to 30 mm).

If the box culvert is constructed with strip footings, then it is possible that the foundation pressures might exceed the embankment pressure, and the proposed culvert may experience additional settlement to that caused by the embankment. Based on the 6 m span, about 1 m of earth cover, and traffic considerations, the estimated foundation loads for a strip footing are about 90 kN per m length or about 90 kPa for a 1 m wide footing. It is estimated that 90 kPa strip footing pressure for the culvert foundations would result in additional settlement of about 20 mm. If this amount of additional settlement is not acceptable, consideration can be given to increasing the footing size, or to pre-loading the site.

Additional considerations for the designers are that the new embankment fill and new culvert may settle differentially to the existing culvert. Allowances should be made at the connection between the existing and new culverts, to permit this differential movement without damage to the structures.

The soil cover required to provide frost protection in the Ottawa area is approximately 1.8 m. It is our understanding that the box culvert will be constructed as a rigid structure and that frost cover need not be provided to the foundation.

The foundation base beneath the culvert should be prepared by removing any existing topsoil or fill materials down to the native silty clay. The silty clay materials exposed at the base of the excavation will be susceptible to loss of strength both as the result of disturbance by traffic on the base of the excavation, and seepage or rainfall. Trafficability conditions on the silty clay can be improved by placing a mat of graded granular material, such as OPSS Granular 'A', or a 'mud mat' of lean concrete. It is considered that excavation of silty clay materials will likely not be required, provided that the above procedures are followed. However should the silty clay soils become overly wet and soft, either naturally or due to construction disturbances, the soft soils should be subexcavated and replaced with fill materials compacted to a minimum of 95 percent SPMDD.

Temporary diversion, construction of a coffer dam, or simply constructing a large sump pit and pumping the flow, will be required to divert the flow of the Moody Creek and permit construction in the dry. Also, pumping from prepared sumps at the base of the footing excavation may be required in order to remove groundwater which seeps upward through the excavation base.

The foundation excavations should be carefully undertaken to protect against undermining of the existing culvert foundations.

4.3 Channel Realignment and Erosion Protection

It is our understanding that the channel of the Moody Creek immediately upstream of the proposed culvert will be realigned as shown on the accompanying Drawings W.P. 34-81-01. The native silty clay materials encountered in the investigation are cohesive in nature, and therefore not readily subject to erosion. Based on the plasticity and nature of the silty clay, it is estimated that the competent velocity (velocity at which erosion of the material begins) for the flowing creek waters, is approximately 2 m per second. Erosion control works may be required if flow velocity in the creek regularly exceeds this value.

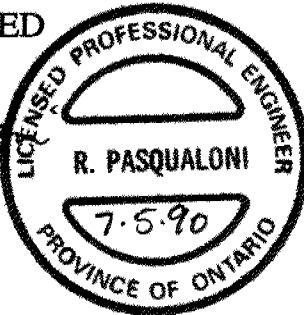
It is noted that alluvial materials maybe encountered along the creek alignment during reconstruction. The composition of these materials may vary from that noted in the boreholes. Inspection should be conducted during the construction of the channel, in order to determine the requirements for safe side slopes and possible erosion control works along the channel

alignment. A preliminary design slope inclination of 3 to 1 (H:V) can be used for the new channel alignment, but steeper inclinations can be utilized with lining of the channel.

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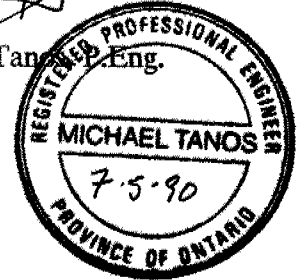
Renato Pasqualoni

Renato Pasqualoni, P.Eng.



Michael Tanos

Michael Tanos, P.Eng.



APPENDIX A
SUMMARY OF FIELD PROCEDURES
PROPOSED BOX CULVERT EXTENSION
HIGHWAY 17 AND McGEE ROAD

APPENDIX A

FIELD PROCEDURES

The field investigation for the project was conducted on December 20 and 21, 1989 when three boreholes were advanced to depths of 3.5 to 6.6 m below existing grades at the locations shown on the accompanying Drawing W.P. 34-81-01. The drilling was conducted using machinery supplied and operated by Longyear Canada Limited of Concord, Ontario. The drilling operations were directed and supervised by Mr. Renato Pasqualoni, P.Eng. of Terraprobe Limited.

The boreholes were put down in the vicinity of the proposed culvert extension. The borings were advanced with a bombardier mounted CME 55 power auger, using hollow stem augers. Split spoon samples of the overburden materials were obtained in conjunction with thin wall samples and shear vane testing as detailed on the accompanying borehole logs. Dynamic cone tests were also carried out at the borehole locations. All samples obtained in the investigation were sealed into containers or Shelby tubes and transported to our laboratory for detailed examination and laboratory testing.

Standpipes were sealed into each of the boreholes on completion, in order to permit monitoring of groundwater levels. The standpipes comprised of 12 mm diameter CPCV tubing which was saw slotted near the base and fitted with a sand fill and bentonite seal.

The locations of the borings were determined by measuring relative to the existing box culvert. The elevations of the borings were surveyed relative to a local benchmark, which was the top of the south east corner of the existing concrete culvert which has been measured relative to Geodetic datum.

APPENDIX B
ABBREVIATIONS
BOREHOLE LOGS
FIGURES 1 to 6
PRELIMINARY PLAN AND SECTION

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 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
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	a	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						

RECORD OF BOREHOLE No 1

METRIC

W P 34-81-01 LOCATION Co-ordinates N 5 016 974 E 342 657 ORIGINATED BY RP
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RP
 DATUM Geodetic DATE December 20, 1989 CHECKED BY KJ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
117.3	Ground Surface													
0.0	Sandy Silt, some organics (Fill)		1	SS	7		117							
	Loose Dark Brown		2	SS	6		116							
115.8														
1.5	Silty Clay trace sand and gravel, occasional cobble.		3	TW	PH		115							
	Soft to Firm		4	SS	10		114							
	Grey		5	TW	PH		113							
			6	TW	PH		112							
111.1			7	SS	55/6		111							
6.2	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 2

METRIC

W P 34-81-01 LOCATION Co-ordinates N 5 016 966 E 342 635 ORIGINATED BY RP
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RP
DATUM Geodetic DATE December 21, 1989 CHECKED BY KJ

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							WATER CONTENT (%)			
								20 40 60 80 100										
117.3	Ground Surface																	
0.0	Topsoil						117											
0.2	Silty Clay		1	SS	6		Seal											
	trace sand and gravel occasional cobble.		2	SS	5		Water Level Dec. 22/89											
	Firm to Stiff		3	TW	PH		116						18.1	0 8 44 48				
	Grey						115 Dec. 21/89											
			4	TW	PH		114						18.6					
							113											
			5	TW	PH		112						18.4					
							111											
110.7	End of Borehole		6	SS	13		Standpipe											
6.6							110											

OFFICE REPORT ON SOIL EXPLORATION



METRIC

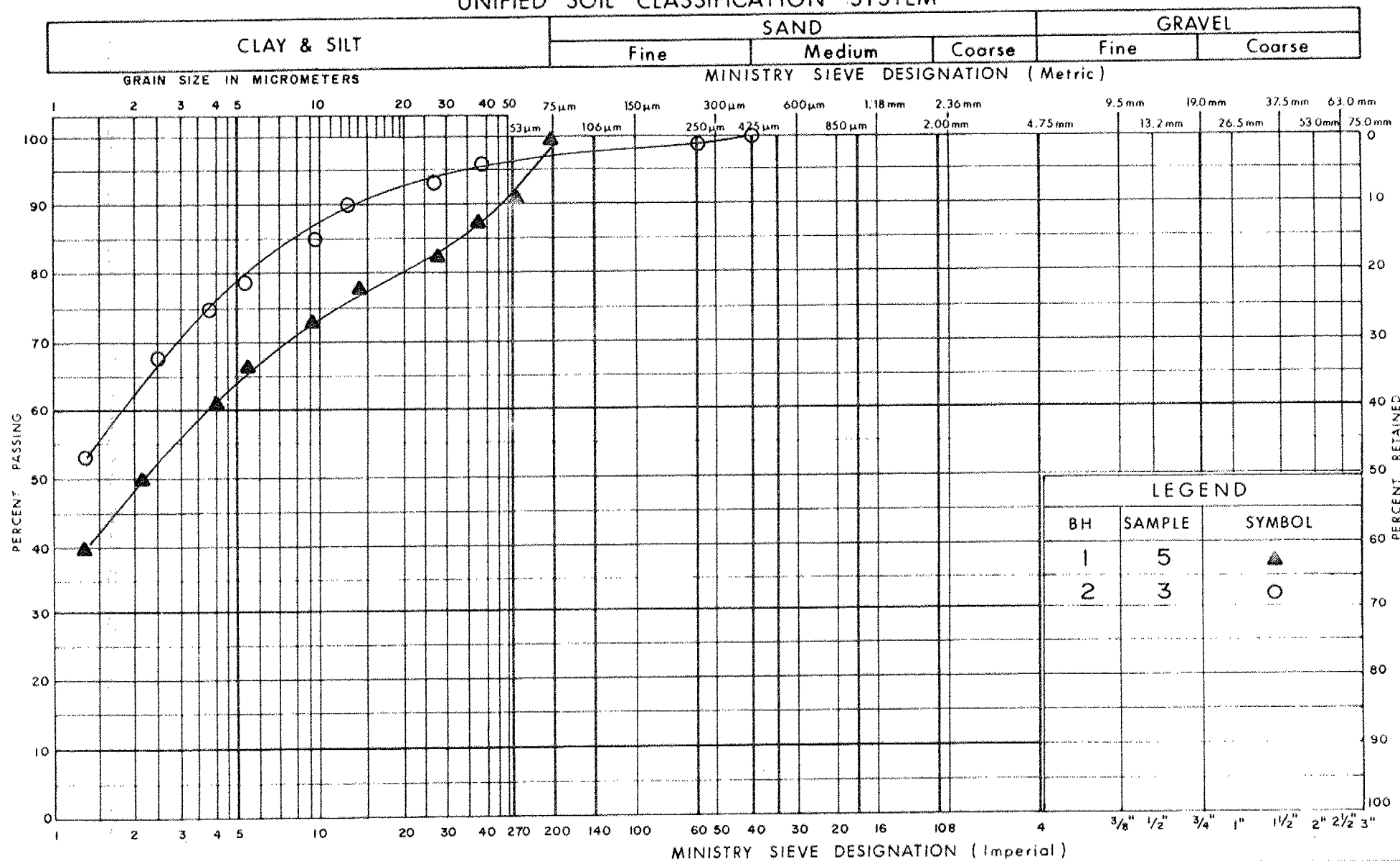
W P 34-81-01 LOCATION Co-ordinates N 5 016 958 E 342 631 ORIGINATED BY RP
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RP
DATUM Geodetic DATE December 21, 1989 CHECKED BY KJ

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							WATER CONTENT (%)			
								SHEAR STRENGTH kPa										
								○ UNCONFINED	+ FIELD VANE									
								● QUICK TRIAXIAL	x LAB VANE									
								20 40 60 80 100										
117.1	Ground Surface																	
0.0	Topsoil						117											
0.2	Silty Clay trace sand and gravel.		1	SS	8		Seal											
			2	SS	9													
	Stiff Grey						116 Water Level Dec. 22/89											
			3	SS	8		115											
			4	SS	9		114											
113.6							Standpipe											
3.5	End of Borehole																	
							113											

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵; Numbers refer to Sensitivity

UNIFIED SOIL CLASSIFICATION SYSTEM

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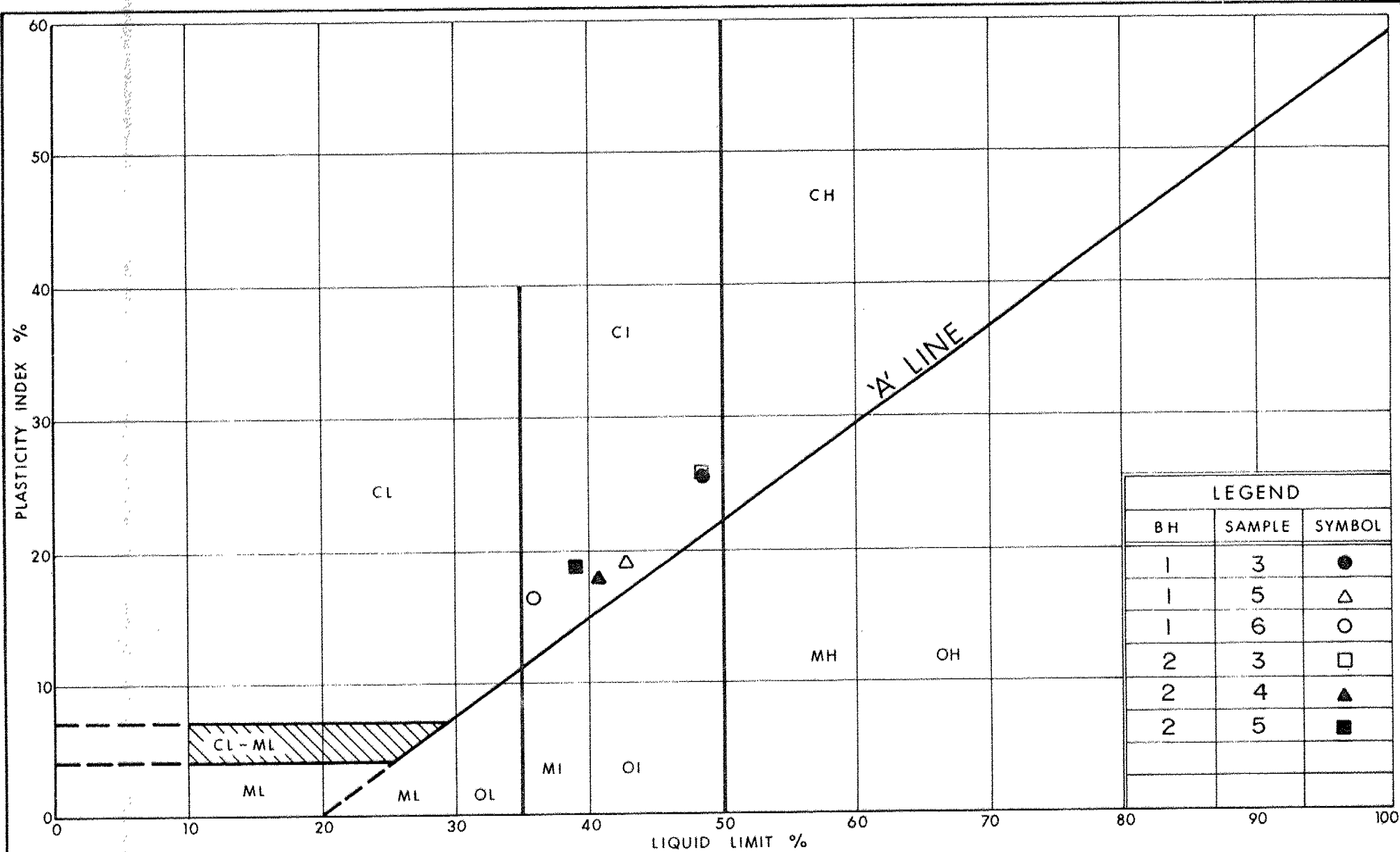
Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY (cl)

FIG No 1

W P 34 - 81 - 01



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PLASTICITY CHART
SILTY CLAY TRACE SAND (CI)

FIG No 2

W P 34-81-01

VOID RATIO - PRESSURE CURVES

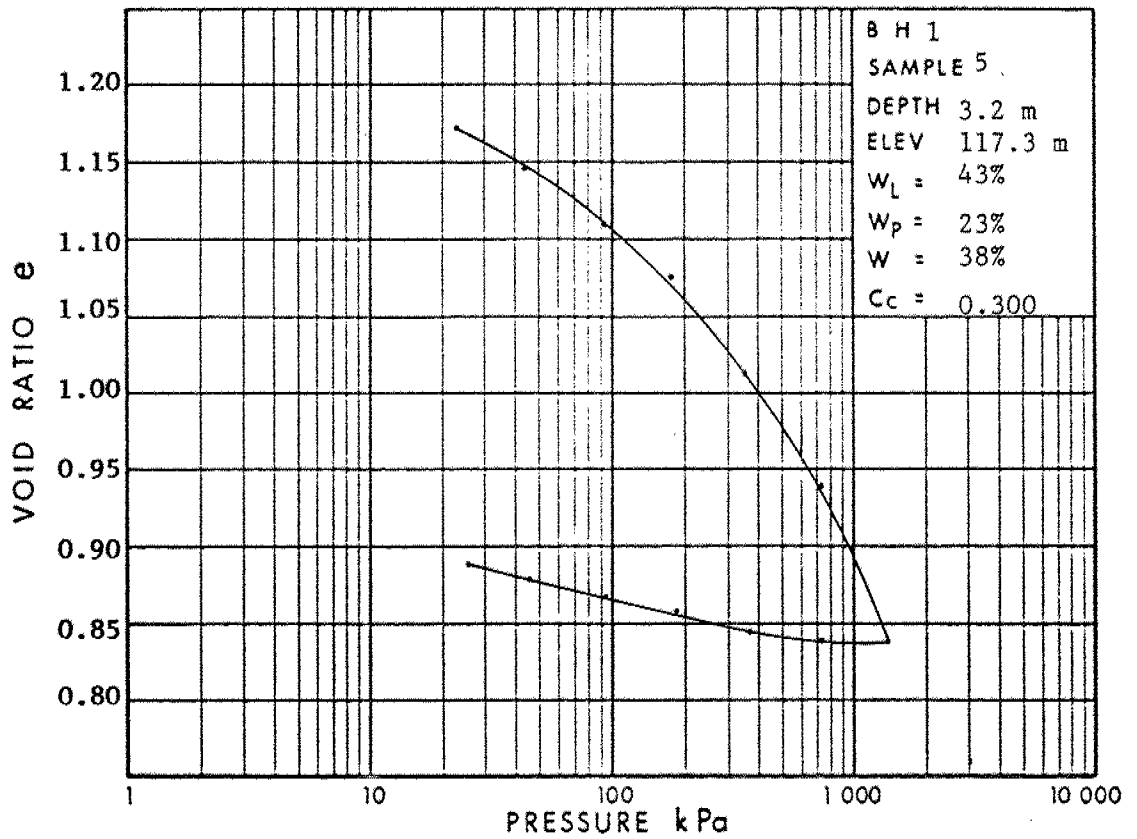


FIGURE 3

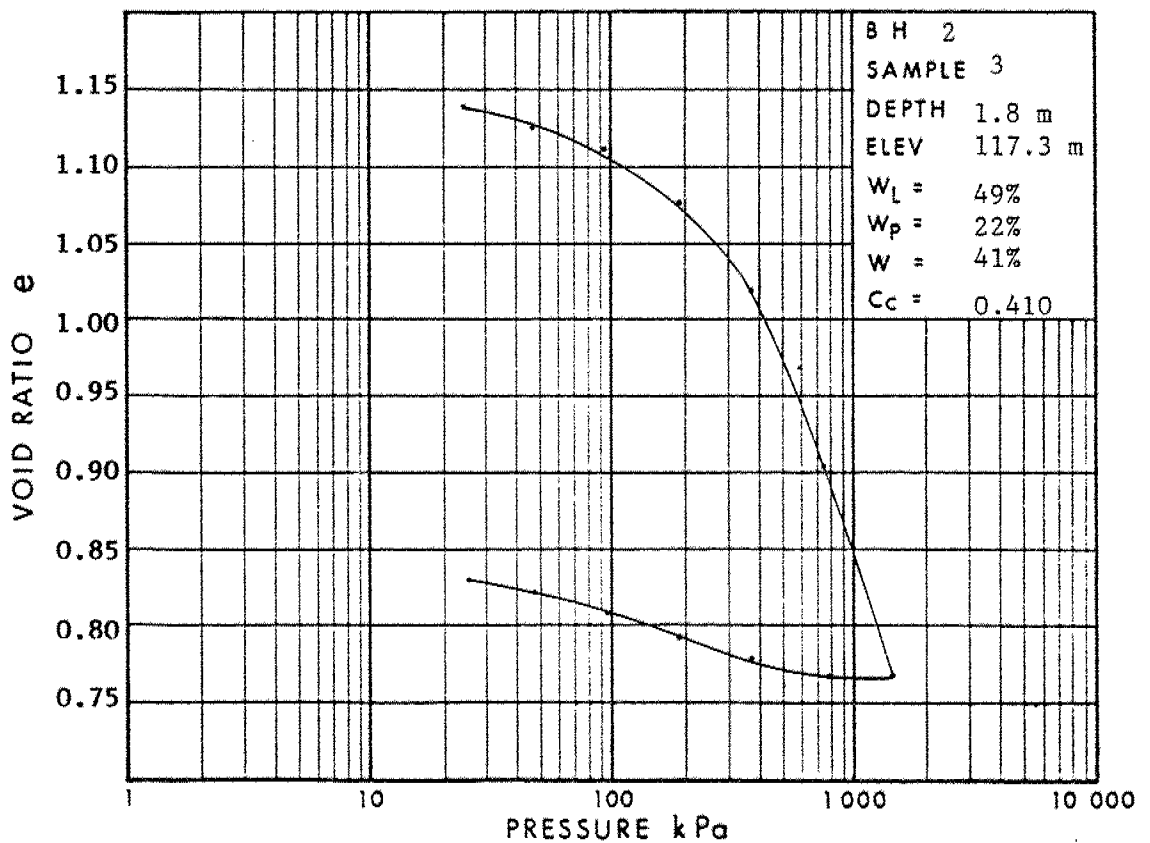


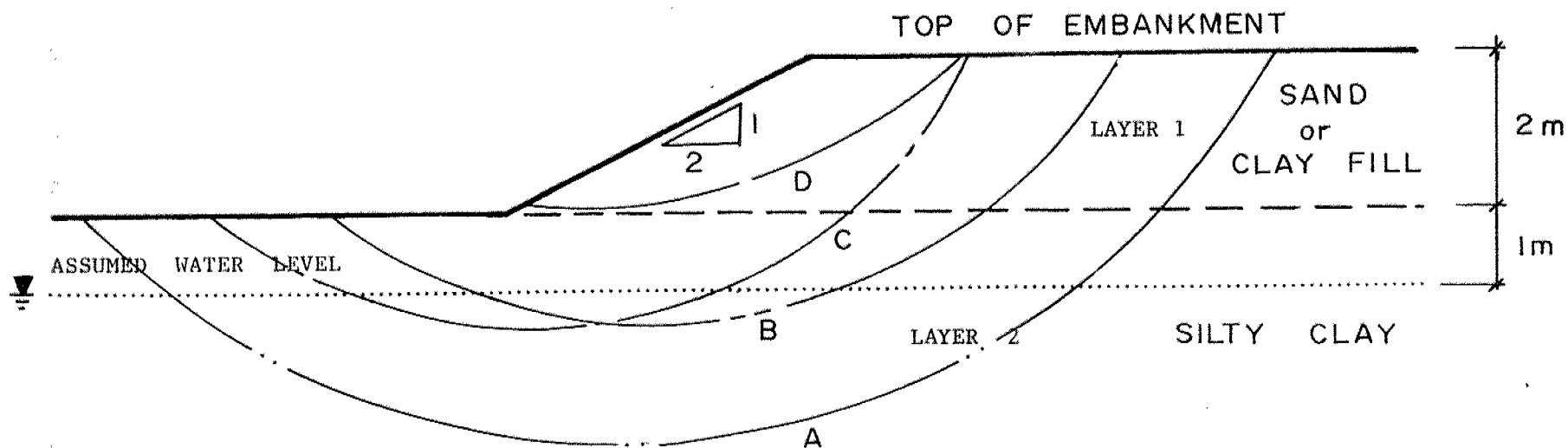
FIGURE 4

RESULTS OF FAILURE ANALYSIS

Surface	Analysis	Fill Type	Factor of Safety (simplified Bishop)
A	Undrained	SAND	10.2
	Undrained	CLAY	11.0
	Drained	SAND	4.4
	Drained	CLAY	4.1
B	Undrained	SAND	7.6
	Undrained	CLAY	7.7
	Drained	SAND	3.2
	Drained	CLAY	2.8
C	Undrained	SAND	10.6
	Undrained	CLAY	11.5
	Drained	SAND	3.1
	Drained	CLAY	2.9
D	Drained	SAND	1.8
	Drained	CLAY	1.5

ASSUMED SOIL PROPERTIES

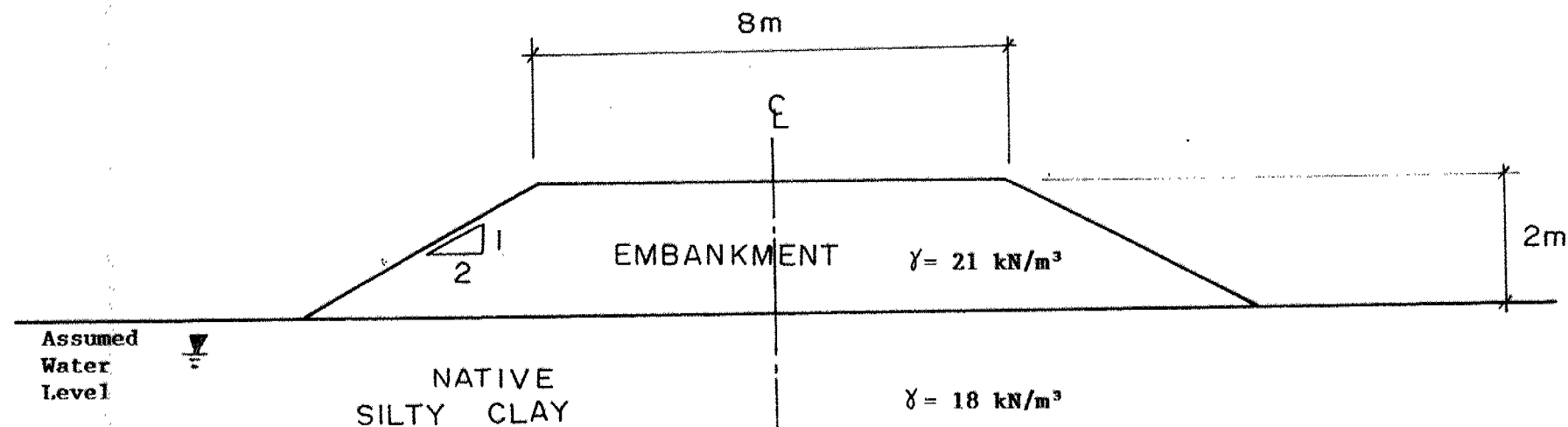
Soil	$\gamma'(\text{kN/m}^3)$	ϕ'	$C'(\text{kPa})$	$C_u(\text{kPa})$
Native Clayey Silt (drained case)	18	25°	10	-
Native Clayey Silt (undrained case)	18	0	-	150 kPa
Sand Fill	20	30°	0	-
Clay Fill	18	25°	0	-

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SLOPE STABILITY ANALYSIS

FIG No 5

W P 34-81-01



Properties
of Native :

$$C_R = 0.028$$

$$e_o = 1.16$$

$$\sigma'_p = 300 \text{ kPa}$$

NOTES: 1) Approximate settlement of native at centreline of embankment is estimated at 20 to 50 mm.

2) It is anticipated that 90 percent of the settlement will occur within 2 years of construction.



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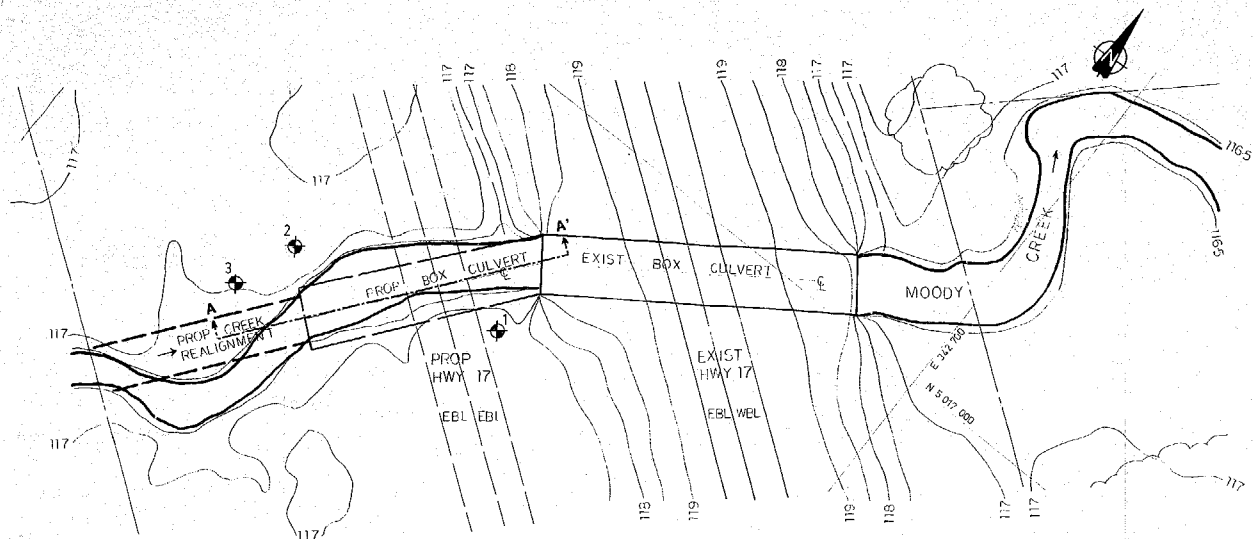
Ontario

EMBANKMENT SETTLEMENT

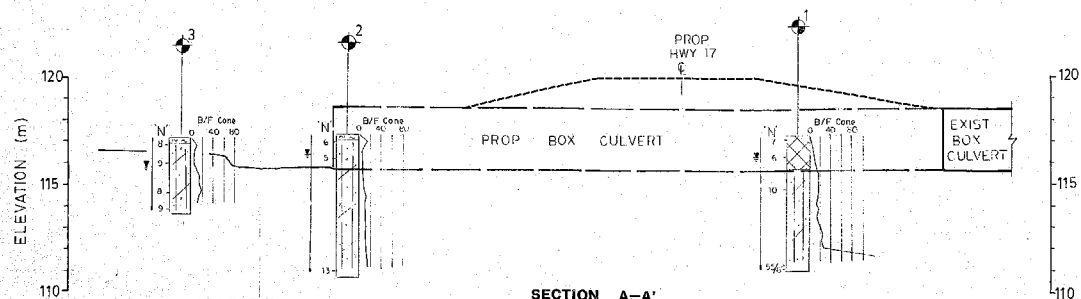
FIG No 6

W P 34-81-01

OVERSIZE DRAWING



PLAN
scale 1:250



LEGEND

- TOPSOIL
- FILL
- SILTY CLAY
- WATER LEVEL
- STANDPIPE

DECEMBER 22, 1989

SECTION A-A'
scale 1:100

- STANDARD PENETRATION TEST
- BOREHOLE & CONE TEST

Geocres # 31F-119

TERRAPROBE LIMITED

PRELIMINARY PLAN AND SECTION

PROPOSED BOX CULVERT
EXTENSION

HWY #17 AT MOORE ROAD (Moody Creek)

SITE NO. 3-436

WP 34-81-01