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DIST. 9 REGION

W.P. No. 11-81-01 (B)

CONT. No. 93-62

W. O. No.

STR. SITE No.

HWY. No. 17

LOCATION (High Hills) Stability Evaluation
Nawan Rd. to Champlain Ave.

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

R-10

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 11-81-01 (B) DIST 9
HWY 17 STR SITE N/A

Embankment Design for Highway Widening

CONT 93-62

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FOUNDATION INVESTIGATION REPORT For
Embankment Design for Highway Widening
W.P. 11-81-01 (B), Site N/A
Hwy. 17, District 9, Ottawa

INTRODUCTION

This report summarizes the foundation investigation for the proposed widening of Hwy. 17 at 3 proposed fill areas between Naven Road and Champlain Street in Orleans.

SITE DESCRIPTION

The sites are located on the north side of Hwy. 17. Details of locations are indicated in the following table and are numbered from west to east.

Area	Survey Chainage (re: Hwy. 17 EBL centreline)
1	11+875 to 11+980
2	12+250 to 12+300
3	12+550 to 12+650

Approximate locations of the sites are illustrated in Figure 1.

The sites are located in the physiographic area of the Ottawa Valley Clay Plain (Chapman and Putnam, 1984). At these locations the ground surface slopes towards the Ottawa River (north) while the grade of Hwy. 17 is level.

INVESTIGATION PROCEDURES

The field work was carried out between 88 06 27 and 88 07 04 utilizing a continuous-flight auger machine equipped with 82 mm I.D. hollow stem augers. Boreholes from a previous investigation (WO 86-11007 from 87 01 08 to 87 02 17) were also referred to.

The investigation, including the previous boreholes, consisted of 6 sampled boreholes accompanied by dynamic cone penetration tests. At Areas #1 and #3, boreholes were advanced through the north shoulder of Hwy. 17. The remainder of the boreholes were advanced near the north toe of slope. The boreholes were advanced for depths ranging from 6.7 m to 38.4 m. At the toe of slope borehole at Area #3, a cone test was driven beyond the augered borehole depth in order to probe the extend of the overburden.

Survey details of the borehole locations were provided by the Eastern Region Surveys and Plans Section.

A total of 43 samples were collected consisting of 34 split spoon samples, 1 auger sample, and 8 shelby tube samples. The split spoon samples provided Standard Penetration Test values for assessment of the in situ state of compaction of the non-cohesive materials, and for an indication of shear strength of the cohesive materials. The split spoon and auger samples provided material for identification purposes. The shelby tube samples provided relatively undisturbed samples for detailed laboratory evaluation of representative zones of the cohesive overburden. Groundwater elevation measurements were attempted at each borehole, although at some locations stabilized levels were difficult to achieve because of the high plasticity of the overburden.

The laboratory testing consisted of:

- 15 grain size analyses
- 28 natural water content determinations
- 17 Atterberg Limit tests
- 6 unit weight tests
- 6 undrained unconfined compression tests

In addition a total of 44 in-situ vane shear tests were conducted.

Previous investigations in the immediate area for WO 73-11053 and WO 86-11007 were also referred to.

SUBSURFACE CONDITIONS

General

The Record of Boreholes Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as follows:

Area Reference	
<u>Number</u>	<u>Borehole</u>
1	#1, #2
2	#3, #4
3	#2-1, #2-3

The highway embankments at these sites are 7 m to 11.4 m high. Typically the upper 1.5 m of the fill is granular roadbed material, while the remainder is composed of clay of intermediate to high plasticity.

The embankments are underlain by extensive deposits of sensitive marine clays. The thickness of the clay is indicated for various areas:

<u>Area</u>	<u>Thickness</u>
#1	11.5 m
#2	6.5 m
#3	over 25 m

At some locations the clay is overlain by up to 1 m of organic material.

Beneath the clay, and immediately above the bedrock a thin layer of sand was encountered at Area #1 and #2.

Detailed descriptions of the various materials encountered are provided below:

Granular Base Course Fill (Sand, some Silt, trace clay)

This non-cohesive fill material is the roadbed material. Its thickness is approximately 2.4 m at Area #1 and 1.5 m at Area #3. The extent of this

material was not determined at Area #2.

Based on the results of Standard Penetration Tests, the material is compact.

Main Embankment Fill (Clay (CI-CH), with Silt, trace sand, trace gravel)

This cohesive material is the main highway embankment fill. Its thickness is variable depending on local topography. Based on available profile data, the maximum thickness at each site is estimated as follows:

Area 1	9 m
Area 2	7 m
Area 3	8 m

Reference is made to the foundation investigation Design Report for WO 86-11007 from which the following typical values for material properties are based.

- moisture content (w)	32%
- liquid limit (w_L)	55%
- plastic limit (w_p)	22%
- undrained shear strength	75 kPa
- unit weight (γ)	18.7 kN/m ³

A typical grain size distribution is indicated below:

Gravel	0-1%
Sand	5-13%
Silt	29-37%
Clay	50-63%

Based on the Atterberg Limits, the material is generally clay of high plasticity, although it does contain some clays of intermediate plasticity.

Based on the results of unconfined compression tests, field vanes and Standard Penetration Tests, the consistency of this material is generally stiff.

Clay (Clay (CH), with Silt, trace Sand)

This cohesive material is the native surficial material. (At some locations the upper 1± m contains organics). It also underlies the existing highway embankments. Its thickness is in the order of 11.5 m at Area 1, approximately 6.5 m at Area 2 and over 25 m at Area 3.

Typical properties of the material, as determined by field and laboratory tests, are summarized as follows:

	<u>Range</u>
- moisture content (w)	40-55%
- liquid limit (w_L)	45-70%
- plastic limit (w_p)	25-30%
- undrained shear strength (C_u)	40-100 kPa
- unit weight (γ)	15.7-17.0 kN/m ³

A typical grain size distribution is indicated below:

Gravel	0%
Sand	0-13%
Silt	23-41%
Clay	35-67%

Based on the Atterberg Limits, the material is clay of high plasticity.

Based on the results of field vanes, the consistency of this material is firm to stiff.

Sand

This non-cohesive material was encountered immediately above the bedrock in a thin layer less than 1 m thick.

Bedrock

No core sampling of the bedrock was conducted. Bedrock in this area is limestone of the Bobcaygeon Formation.

Groundwater

At the time of the subsurface investigations, groundwater was encountered at the natural ground surface.

Artesian groundwater conditions were encountered at both borehole locations at Area #1 where pressures are estimated to extend to 5 m above the ground surface. This condition was encountered in the thin layer of non-cohesive material immediately above the bedrock surface. Artesian groundwater is expected to exist immediately above the bedrock at all three sites.

At BH #1, the artesian condition was plugged by driving a 3.4 m long H casing over the cone penetration test hole, and a 1.8 m long H casing over the borehole. The tops of both casings were left 0.3 m above the ground surface. The casings were backfilled with bentonite and cement.

At BH #2, the artesian condition was plugged by driving a 3 m H casing over the cone penetration test hole, leaving 0.3 m of stick-up. This casing was backfilled with bentonite and cement.

The site was checked on a number of occasions and the artesian conditions were effectively plugged.

DISCUSSION AND RECOMMENDATIONS

As requested by the Eastern Region Geotechnical Section, the Foundation Design Section has carried out an investigation to determine the appropriate embankment design for three high fill areas along Hwy. 17 between Champlain Avenue and Naven Road. These fills are associated with the proposed widening of Hwy. 17 consisting of the addition of 2 lanes and a median to the north of the existing lanes.

The locations of these areas and the proposed fill heights follow:

Area	Survey Chainage (re: Hwy. 17 EBL centreline)	Maximum Fill Height
1	11+875 to 11+980	9 m
2	12+250 to 12+300	7 m
3	12+550 to 12+650	8 m

It has been assumed that the widening of the embankments will be constructed of similar clay materials to those in the existing embankments.

Stability Considerations

Detailed stability analyses, in terms of total and effective stresses have been carried out for 3 typical sections with embankment heights of 6, 9 and 12 m respectively. These analyses were conducted with the aid of Bishop's simplified slope stability program assuming conditions typical of the general area.

Reference is made to the Foundation Investigation Reports for WO 73-11053 and WO 86-11007 for more rigorous assessments of the material properties as they relate to stability.

Details of the assumptions and results of the stability analyses are provided in the following figures.

Embankment Height	Stability Analysis	
	Total Stress	Effective Stress
6	Figure 2A	Figure 2B
9	Figure 3A	Figure 3B
12	Figure 4A	Figure 4B

Based on these analyses surface treatment of the slopes is required to ensure surficial stability of embankments less than 6 m in height, while surface treatment and berms are required to ensure both surficial and deep-seated stability of embankments over 6 m in height.

The surficial treatment and embankment geometry requirements are illustrated in Figure 5. Basically the embankments should be constructed with 2H:1V slopes and the slopes should be covered with 1 m thick blanket of rock fill or free-draining granular material. Where embankments are over 6 m high, berms are required. Berm widths are indicated in Figure 6.

If granular material is used for the blanket, vegetation should be established on the slope as soon as possible after construction.

Settlement Considerations

Settlement analyses were based on a correlation of material properties with those for previous project WO 73-11053 for which more vigorous calculations were carried out. Assuming that typical values for e_0 and Δe are in the order of 1.5 and 0.15 respectively, the settlements are estimated to be in the order of 6% of the fill height. (under the new fills)

Since it is proposed to divide the new highway widening from the existing lanes with a median, differential settlements between these portions is not expected to present a problem. However, preloading the widened portion for a period of 1 year before paving is recommended.

Construction Considerations

Historically the fills for Hwy. 17 in this area have been constructed with the

more desicated crust portions of the native overburden. Obviously this is not a preferred fill material due to its high plasticity and poor drainage characteristics. However, it has performed adequately in the past, except for surficial instability and settlement problems, and due to its availability it may have economic advantages over imported fill. Compaction control will be important and ideally moisture contents for material such as this, with plasticity indices over 7%, should be restricted to 3% above optimum as defined by standard Proctor criteria. The new fills should be benched into the existing.

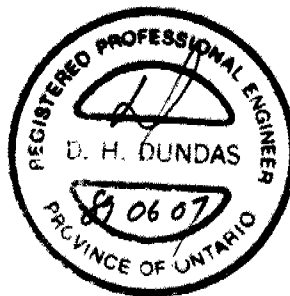
The upper 1 m of natural overburden under the plan limits of the proposed fill is extremely soft and often organic in nature. This material should be subexcavated and fills placed below the water table and within 1 m above the natural ground surface should consist of rock fill or free-draining granular in order to facilitate drainage. The contractor should be advised of the plugged artesian wells at Area #1 and instructed to avoid disturbance of these plugs during construction. Hand-digging with 3 m of the plugged well is advisable.

MISCELLANEOUS

The field work for this project was supervised by Mr. J. Fellenius, Engineering Student.

The equipment was owned and operated by Johnston Drilling Company Ltd.

The report was written by Mr. D. Dundas, Sr. Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer.



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APPENDIX

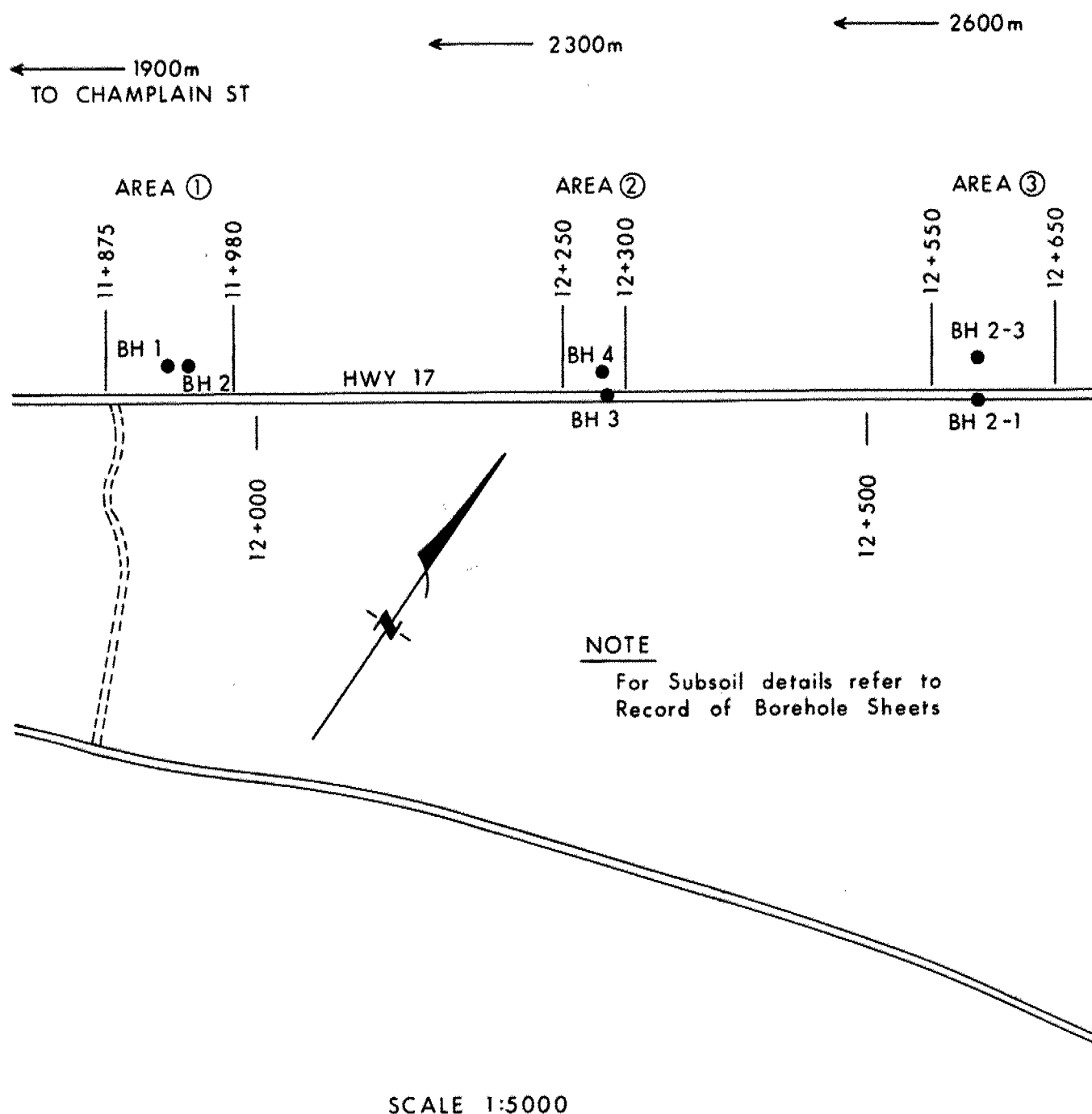


Fig 1
Geocres No 31G5-158
WP 11-81-01 (B)

6m EMBANKMENT
DEEP-SEATED STABILITY
TOTAL STRESS

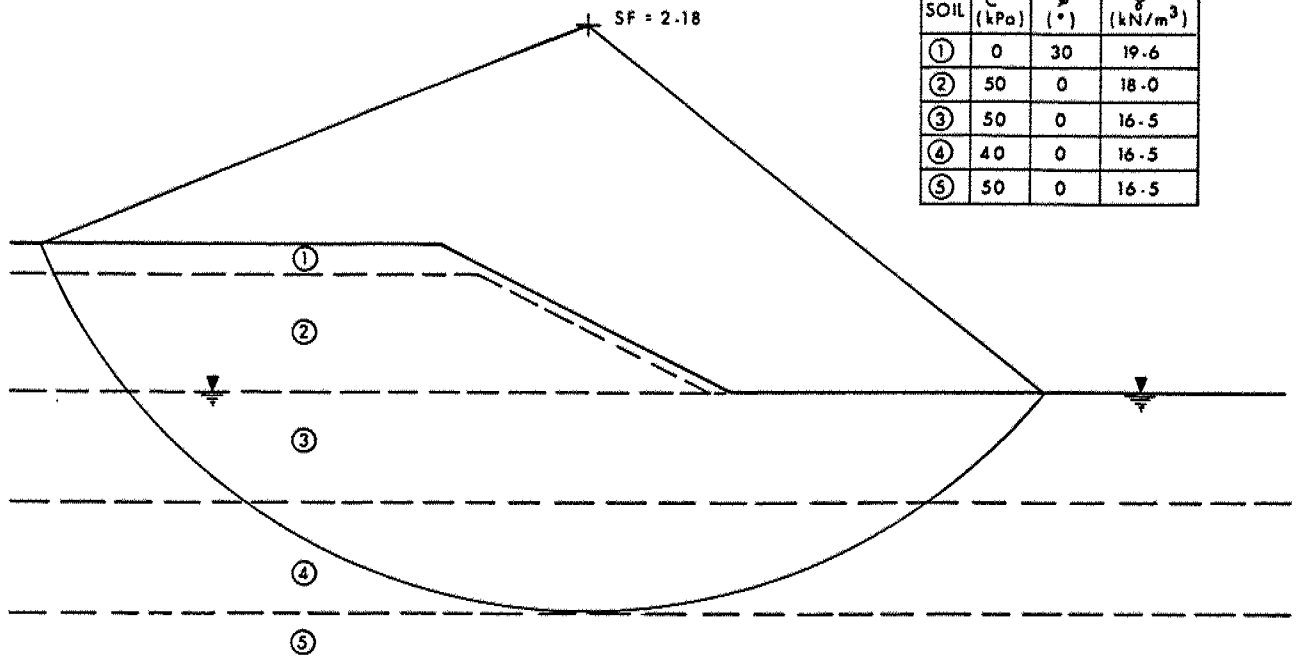


Fig 2A

6m EMBANKMENT
SURFICIAL STABILITY
EFFECTIVE STRESS

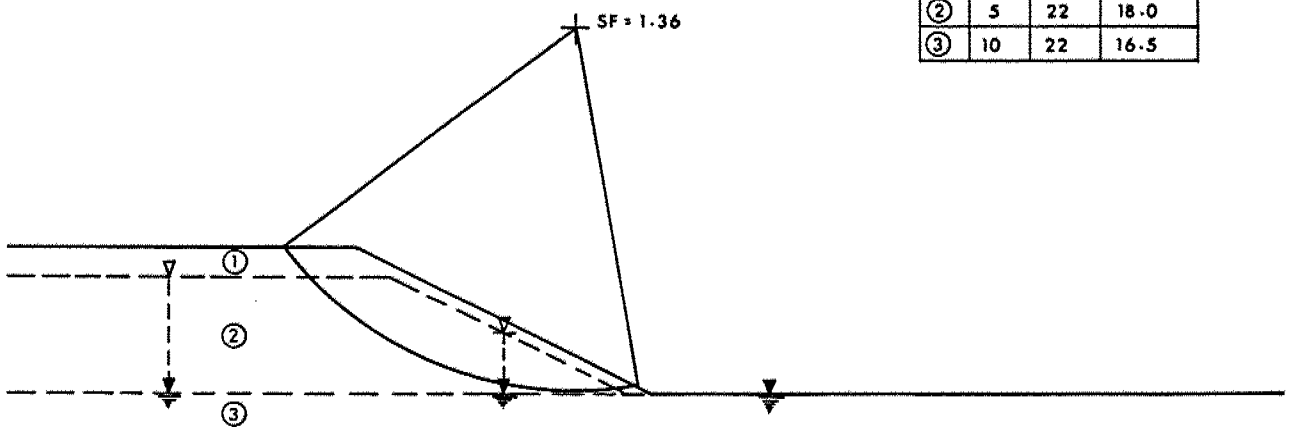


Fig 2B

9m EMBANKMENT
DEEP-SEATED STABILITY
TOTAL STRESS

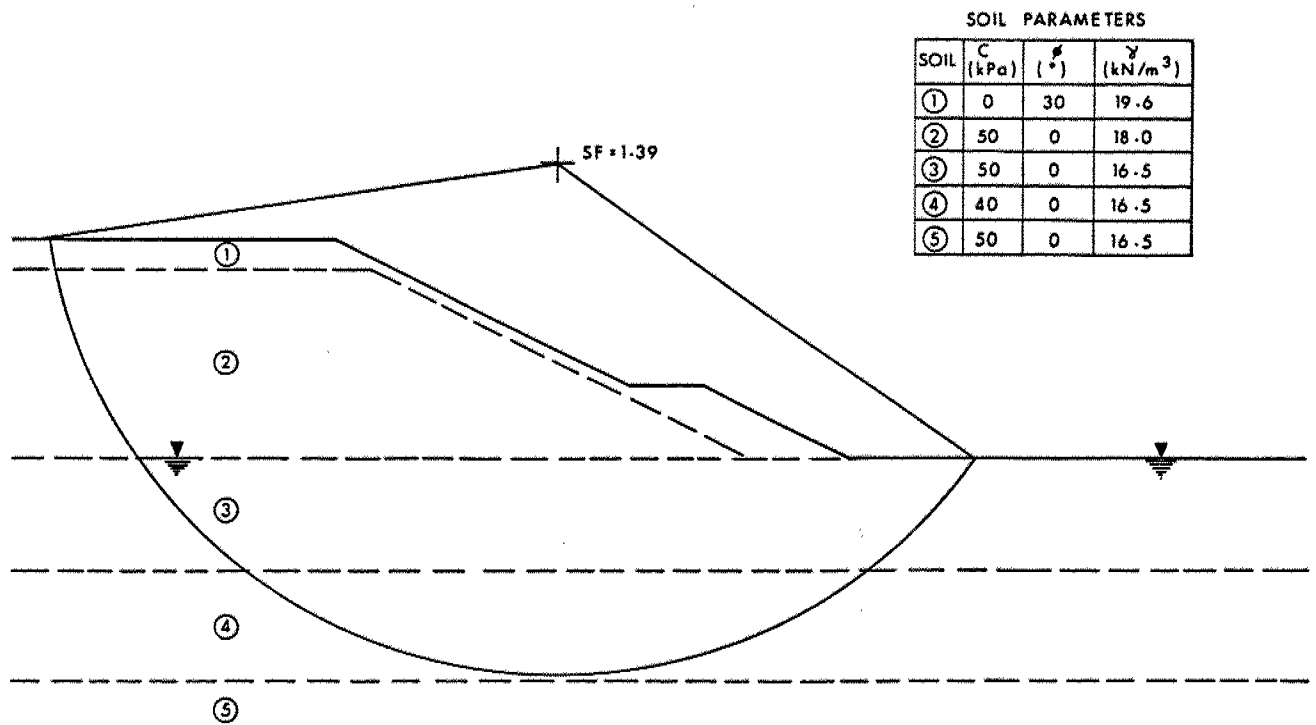


Fig 3A

9m EMBANKMENT
SURFICIAL STABILITY
EFFECTIVE STRESS

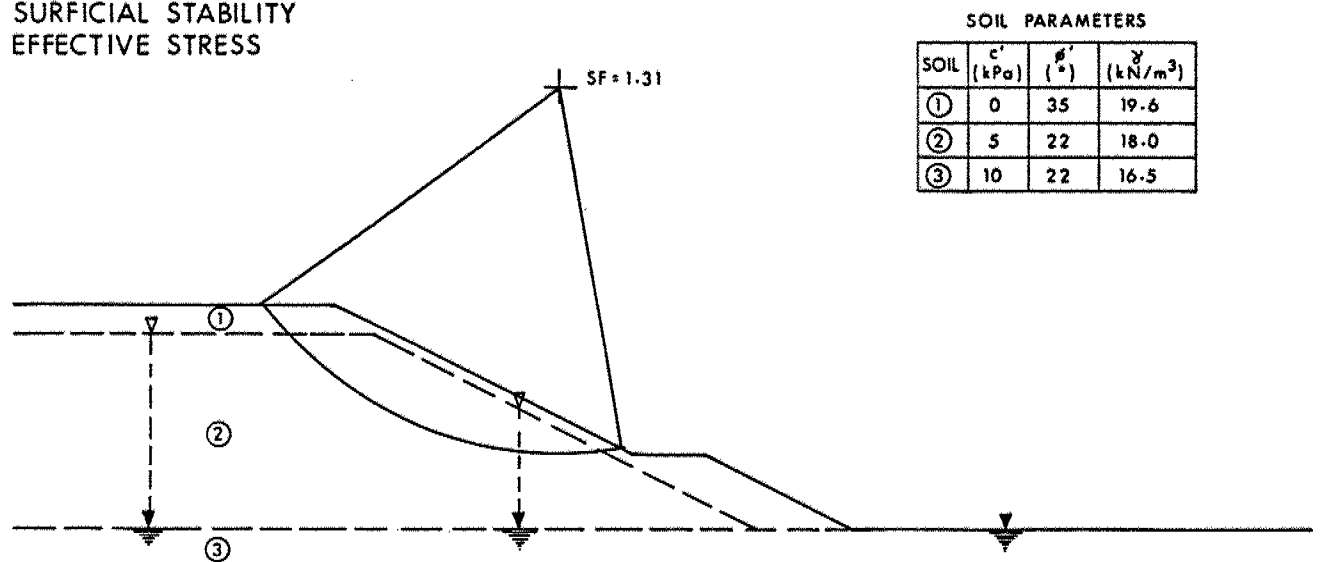
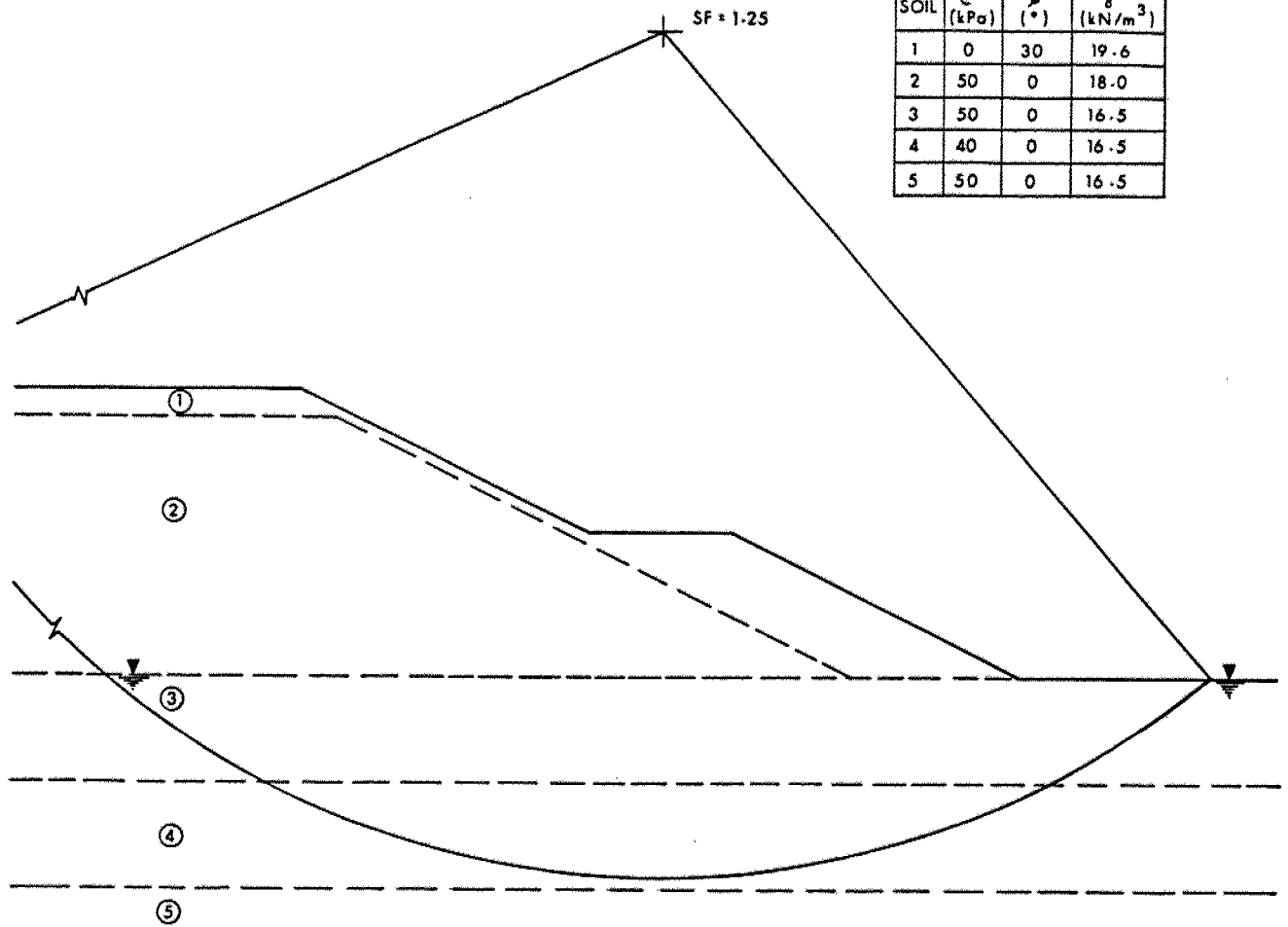


Fig 3B

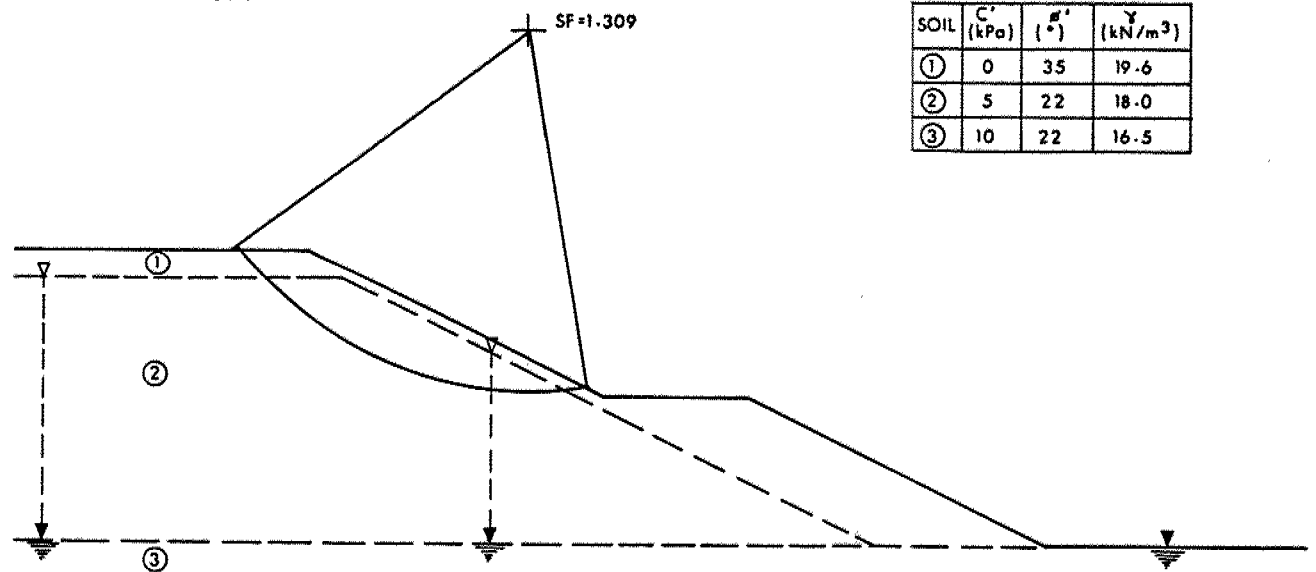
12m EMBANKMENT
DEEP-SEATED STABILITY
TOTAL STRESS



SOIL PARAMETERS			
SOIL	C (kPa)	ϕ (°)	γ (kN/m ³)
1	0	30	19.6
2	50	0	18.0
3	50	0	16.5
4	40	0	16.5
5	50	0	16.5

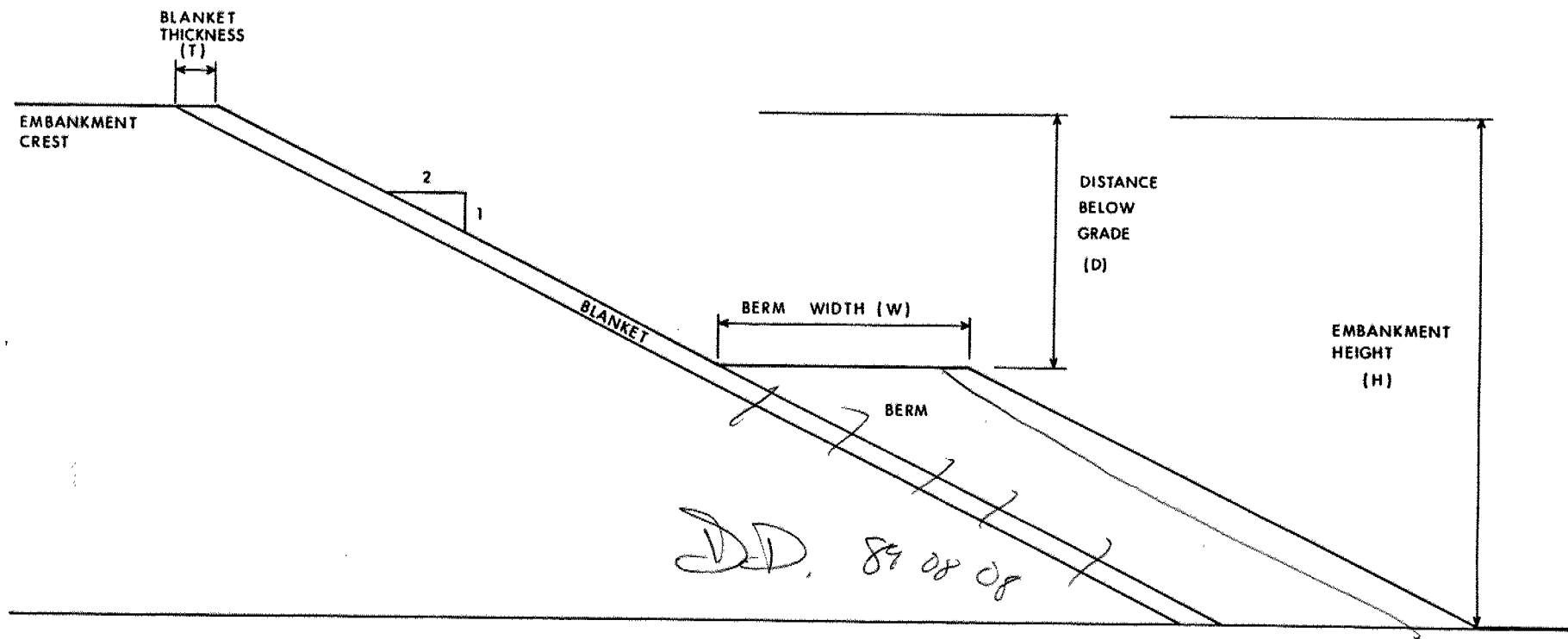
Fig 4A

12m EMBANKMENT
SURFICIAL STABILITY
EFFECTIVE STRESS



SOIL PARAMETERS			
SOIL	C' (kPa)	ϕ' (°)	γ (kN/m ³)
①	0	35	19.6
②	5	22	18.0
③	10	22	16.5

Fig 4B



RECOMMENDED EMBANKMENT GEOMETRY

Fig 5

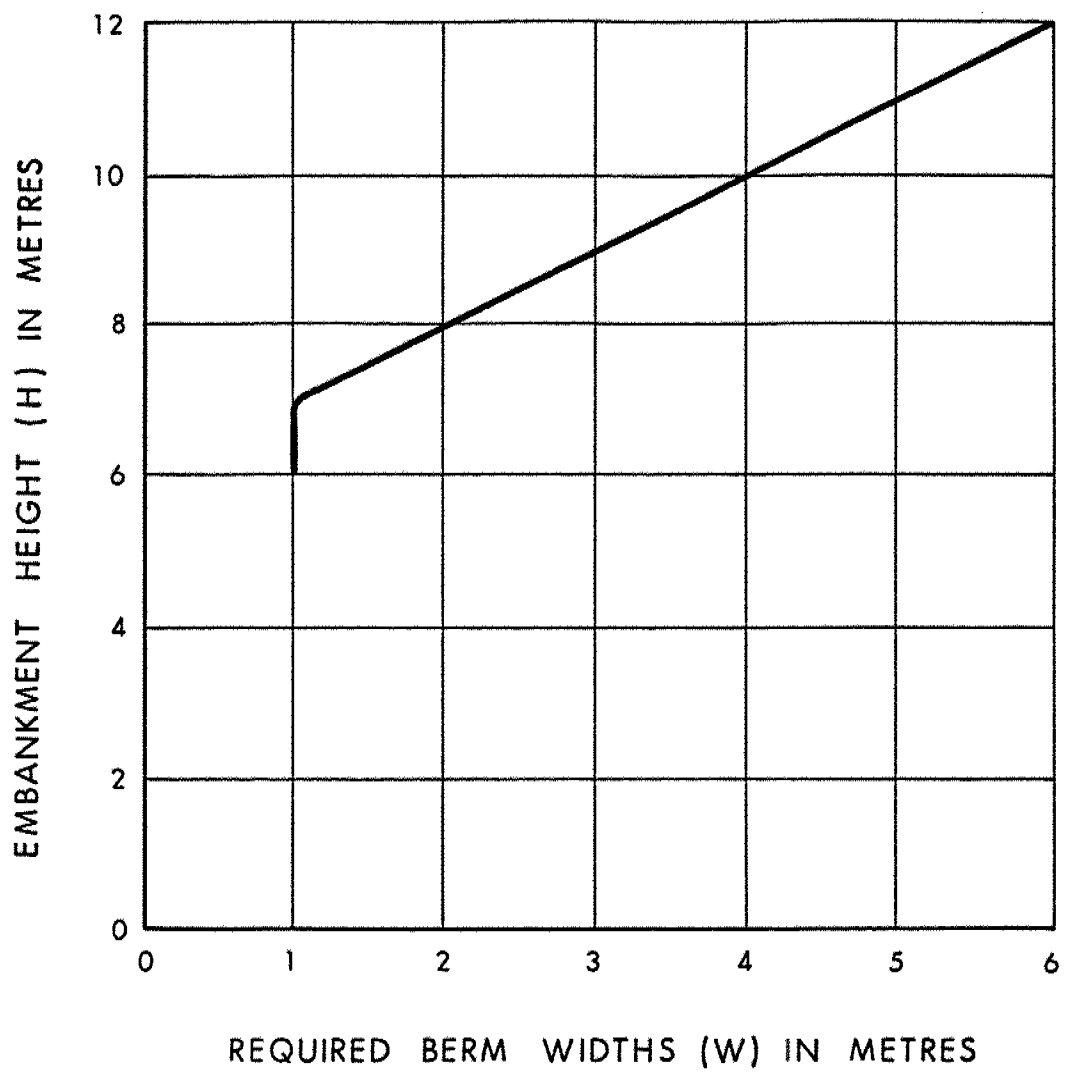


FIG 6

WP 11-81-01(B)

NOTE: This figure indicates minimum berm widths. It may not be practical to construct berms less than 2 m wide.

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
WS	WASH SAMPLE	OS	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

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 = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

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

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^2	SEEPAGE FORCE
γ'	kn/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1 (Area 1) METRIC

W P 11-81-01 (B) LOCATION Sta. 11+929.5; o/s 28.0 m Lt. of Hwy 17 EBL ORIGINATED BY JBF
 DIST 9 HWY 17 BOREHOLE TYPE Cone Test, Hollow Stem Augers COMPILED BY JBF
 DATUM Geodetic DATE 88 06 29-30 CHECKED BY DD

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	NUMBER	TYPE			VALUES	20 40 60 80 100					
48.4	Ground Surface											
0.0	Clay (CH) With Silt Trace Sand Very Soft to Stiff (Marine)											
		1	SS	3								0 0 34 66
		2	SS	1								
		3	TW	P.H.							16.5	
		4	TW	P.H.							16.2	0 0 38 62
		5	SS	2								
		6	SS	5								
37.3		7	SS	4								
36.8	End of Borehole *											
11.6	End of Cone Test											
	*Probable Sand											

RECORD OF BOREHOLE No 2 (Area 1) METRIC

W P 11-81-01 (B) LOCATION Sta. 11+943.1; o/s 29.5 m Lt. of Hwy 17 EBL ∇ ORIGINATED BY JBF
 DIST 9 HWY 17 BOREHOLE TYPE Cone Test, Hollow-Stem Augers COMPILED BY JBF
 DATUM Geodetic DATE 88 06 27-28 CHECKED BY DD

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					
48.1	Ground Surface													
0.0	Some Sand		1	AS	-	Artesian Pressure to Estimated Elev 53m	48							0 13 52 35
	Clay (CH)		2	SS	3		46	5*	5*					0 0 23 77
	With Silt													
	Trace Sand		3	SS	3		44		19					
	Very Soft to Stiff (Marine)		4	SS	3				10					0 0 36 64
			5	SS	1		42	11*						
			6	SS	2		40	15*	10*					
			7	SS	2		38	19*	15*					
37.0			8	SS	5			18*	10*					
36.6	Probable Sand													
11.5	End of Borehole													

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

RECORD OF BOREHOLE No 3 (Area 2) METRIC

W P 11-81-01 (B) LOCATION Sta. 12+286.5; 5.4 m Lt. of Hwy 17 EBL ∇ ORIGINATED BY JBF
 DIST 9 HWY 17 BOREHOLE TYPE Hollow-Stem Augers COMPILED BY JBF
 DATUM Geodetic DATE 88 07 04 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT ∇					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
57.7 0.0	Ground Surface																
	Probable Sand																
	Probable Clay																
	(Fill)																
50.1 7.6	Clay (CH) With Silt Trace Sand Very Soft to Stiff (Marine)																
			1	TW	P	H											
45.1 12.6	End of Borehole Probable Sand		2	TW	P	H											

RECORD OF BOREHOLE No 4 (Area 2) METRIC

W P 11-81-01 (B) LOCATION Sta. 12+282.0; 22.7 m Lt. of Hwy 17 EBL E ORIGINATED BY JBF
 DIST 9 HWY 17 BOREHOLE TYPE Cone Test, Hollow-Stem Augers COMPILED BY JBF
 DATUM Geodetic DATE 88 06 29 - 88 06 30 CHECKED BY DD


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
50.5	Ground Surface													
0.0	Clay (CH) With Silt Trace Sand Very Soft to Stiff (Marine)		1	SS	8		50							0 0 33 67
			2	TW	P H		48						17.0	0 0 41 59
			3	TW	P H		46							
43.8	Probable Sand		4	SS	10		44							0 0 33 67
6.7	End of Borehole Auger Refusal On Probable Bedrock							60/13cm						

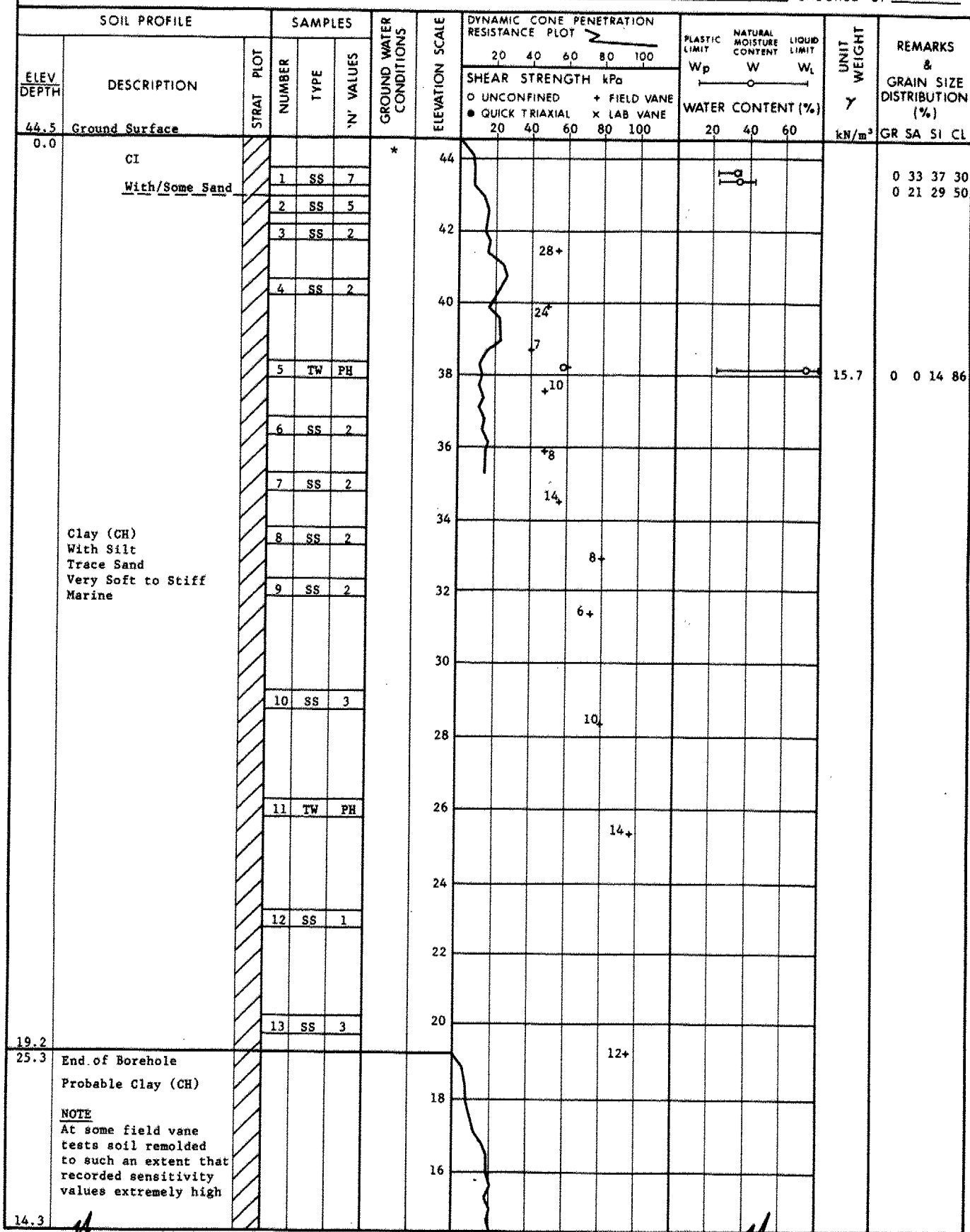
RECORD OF BOREHOLE No 2-1 (Area 3) METRIC

W P 11-81-01(B)/WO 86-11007 LOCATION Sta. 12 + 588.4; o/s 4.7 m Rt. of Hwy. 17 ORIGINATED BY DL & DD
 DIST 9 HWY 17 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY DL
 DATUM Geodetic DATE 87 01 08 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT 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		
								SHEAR STRENGTH kPa						
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	WATER CONTENT (%) 20 40 60				
56.7	Ground Surface													
0.0	Sand					**	56	Augered						
55.2	Some Silt, Trace Clay Compact, Fill		1	SS	12									
1.5	Clay With Silt Trace Sand Firm to Very Stiff (Fill)		2	SS	10									1 13 36 50
			3	SS	9									
			4	TW	PH									0 5 37 58
			5	SS	6									
			6	SS	8									0 8 29 63
			7	SS	13									
			8	SS	13									
			9	SS	9									0 72 13 15
44.8	Occ. Sand Pockets													
11.9	End of Borehole													
	*Shear Strength greater than 112 kPa													
	**Stabilized groundwater elevation not established													

RECORD OF BOREHOLE No 2-3 (Area 3) METRIC

W P 11-81-01(8)/WO 86-11007 LOCATION Sta. 12 + 588.4; O/S 34.0 m Lt. of Hwy 17  ORIGINATED BY DL
DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY DL
DATUM Geodetic DATE 87 02 17 CHECKED BY DD



OFFICE REPORT ON SOIL EXPLORATION

Continued
*Stabilized groundwater
elevation not established

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 2-3 (Area 3) METRIC

W P 11-81-01(B)/WO 86-11007 LOCATION Sta. 12 + 588.4; O/S 34.0 m Lt. of Hwy. 17 E ORIGINATED BY DL
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY DL
 DATUM Geodetic DATE 87 02 17 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
14.3	Continued										
30.2	Probable Clay (CH)										
6.1											
38.4	End of Cone Test										