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CONT. No. 92-71

W. O. No.

STR. SITE No.

HWY. No. 69

LOCATION Proposed Embankment
From Muskegon Rd. at Port Severn

No of PAGES - Worthy 6.3 km

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 212-89-00

DIST 11

HWY 69

STR SITE -

Proposed Embankments
Highway 69, from Muskoka Road at
Port Severn, Northerly 6.3 km

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FOUNDATION INVESTIGATION REPORT

For

Proposed Embankments

Highway 69, from Muskoka Road at

Port Severn, Northerly 6.3 km

W.P. 212-89-00

District 11, Huntsville

INTRODUCTION

A foundation investigation was carried out at the above-captioned site, between 91 07 23 and 91 08 01, for proposed highway embankments to be constructed at the following locations:

Proposed Southbound Lane

Station to Station

13+100 to 13+320 (Site 1)

13+500 to 13+780 (Site 1a)

14+580 to 14+720 (Site 2)

During this investigation, 10 boreholes, 3 vane test holes and 11 auger probes or dynamic cone penetration tests were carried out to depths of 1.7 to 13.3 m where the presumed bedrock surface was encountered.

This report contains the factual information obtained from the boreholes and other vane, cone, or probe tests, which were related to the proposed embankments at the three sites.

SITE DESCRIPTION

The proposed embankments at Sites 1, 1A and 2 will be located along Highway 69, between 0.4 and 2 km north of Lone Pine Road, within Baxter Township, Regional Municipality of Muskoka.

All three of the sites represent low swampy areas between rocky outcrops. Such topography is typical of the surrounding area as well.

Site 1, which is, by far, the largest of the three sites, is surficially covered by grasses and cattails. The water table is at or close to the ground surface and minor standing water (ie. less than 0.3 m) is found at several locations.

Site 1A, essentially consists of three separate swampy areas. The swamp furthest to the south (ie. Swamp 'A'), which lies between Stations 13+510 and 13+550, has significant standing water. Where the water is shallower, cattails and some grasses can be found. Similar conditions are found at Swamp 'C', which lies between Stations 13+715 and 13+775. Swamp 'B', (between Stations 13+635 and 13+695), is grassed and relatively dry to the southeast but it has minor standing water and cattails to the northwest where it curves to the northeast around a rock knoll to join Swamp 'C'.

Site 2, is heavily treed and no standing water can be found. However, the water table is at or close to the ground surface in this area as well.

PROCEDURES

The fieldwork, for Sites 1, 1A and 2, was carried out by this office between 91 07 23 and 91 08 01. A total of 10 boreholes, 3 vane tests and 11 auger probes or dynamic cone penetration tests were advanced to the presumed bedrock surface (ie. depths of 1.5 to 13.3 m) by two different methods.

In dry areas, or in areas with minor standing water (ie. less than 0.2 m), the boreholes were advanced by means of continuous flight hollow (or solid) stem augers driven by a track-mounted drilling rig equipped with standard soil sampling equipment. However, in areas of significant standing water, the boreholes were advanced by casing and wash boring using a hand-operated tripod-mounted drilling apparatus placed on top of a small raft. Probing for bedrock were carried out by augering to practical refusal or by conducting dynamic cone penetration tests.

The locations of the boreholes and other test holes or probe holes were staked out in the field by representatives from this office and then their approximate elevations, determined with respect to the existing embankment by using a hand level.

The approximate locations of the boreholes, probings and vane shear tests are shown on Drawing No. 2128900-A to 2128900C.

The soil samples, which were obtained in the field, were examined in the laboratory by visual and tactile methods. Moisture content, unit weight, Atterberg Limits, grain size distribution and consolidation tests were conducted on select soil samples. The results of this laboratory testing are included on the borehole log sheets (Table 1, 1A and 2) and on Figures 1 to 6.

SUBSURFACE CONDITIONS

The subsoils, encountered at the boreholes, generally consist of a layer of peat or other organic soils, from 0.6 to 4.9 m thick, which is, in turn, underlain by an extensive deposit of silty clay to clay. At some locations, the clay deposit is underlain by layers of silty sand to sand and gravel. The presumed bedrock surface was found to be at depths of 1.5 to 13.3 m, at the locations investigated. The groundwater table was at or above the existing ground surface.

Detailed descriptions of the soil and groundwater conditions which were encountered at the various borehole or probe locations are shown on Tables 1, 1A and 2 given at the back of this report. The following paragraphs are intended to augment these data.

Peat

All of the boreholes or probe tests contacted dark brown to black, fibrous peat and/or organic silts at the ground surface. These organic soils were found to reach depths ranging from 1.3 to 2.0 m at Site 1 and 0.6 to 2.4 m at Swamps 'A' and 'B' of Site 1A. However, the thickness of these organic soils is significantly greater at Swamp 'C' of Site 1A and Site 2 (up to 4.9 m in this investigation). The moisture contents of these organic soils were found to range from 92 to 581 percent (average of 320 percent).

Silty Clay to Clay

The peat and other organic soils, are immediately underlain by an extensive deposit of silty clay to clay which reaches depths of 5.0 to 13.3 m at Site 1, 1.5 to 5.8 m at Swamps 'A' and 'B' of Site 1A, 4.9 to 8.5 m at Swamp 'C' of Site 1A and up to 9.6 m at Site 2.

Several (20) Atterberg limits tests, carried out on samples obtained from this clay deposit resulted in liquid limits and plasticity indices ranging from 34 to 68 percent (average of 48 percent) and 18 to 41 (average of 26 percent), respectively. These results, which have been plotted on Figures 1 to 3, indicate that these soils may be classified as CI to CH or silty clay to clay. The moisture contents, of several samples tested from this deposit, ranged from 38 to 95 percent (average of 70 percent). The moisture content was found to be higher than the liquid limit, in all 20 of the Atterberg limits tests which were carried out.

A grain size distribution test was carried out on a sample of clay obtained close to the bottom of this deposit. The results of this test, which are shown on Figure 4, indicate a soil with about 32 percent clay-sized particles, 22 percent silt, 44 percent sand and 2 percent gravel.

Six unit weight tests, carried out on samples of soil obtained from this deposit, ranged from 14.6 to 16.3 (average of 15.6) kN/m³.

At Site 1 and Swamps 'A' and 'B' of Site 1A, vane tests carried out within the silty clay to clay deposit, indicate that shear strengths are generally less than 10 kPa, at depths less than about 3.5 m. However, at Site 2, vane tests indicate that shear strengths are generally less than 10 kPa to somewhat greater depths (ie. about 5.5 m). It should be noted that the clay was found to be even softer at Swamp 'C' of Site 1A, where all shear strength test results were found to be less than 10 kPa.

Consolidation tests were conducted on three representative samples obtained from this deposit. The results, shown on Figures 5 and 6, indicate that the clays are lightly preconsolidated with compression indices (C_c) of 0.88 to 1.78.

Silty Sand to Sand and Gravel

At some locations, layers of silty sand to sand and gravel, from 0.7 to 2.7 m thick, were found to be sandwiched between the silty clay to clay layer and the assumed bedrock surface. Such material was found at BH's 1-4B and vane and probe tests 1-7V (and possibly 1-3P) at Site 1, BH's 1A-1B and 1A-3B at Site 1A and BH 2-4B (and possibly probe test 2-5P) at Site 2.

A moisture content of 11.5 percent was measured in a sample obtained from one of these layers.

Penetration resistances ('N' values), which ranged from 7 to more than 100 blows/0.3 m, indicated that these cohesionless soils were generally loose, but often become dense to very dense, immediately above the assumed bedrock surface.

Bedrock

All boreholes or probings reached, what was assumed to be, the bedrock surface at depths ranging from 1.5 to 13.3 m. As in previous investigations, bedrock was found to be highly variable at all three sites. It should be noted, however, that the bedrock surface was found to be the deepest at points furthest away from the rock knolls which surround the swamps creating bowl-like depressions in which the various soil types were deposited.

GROUNDWATER CONDITIONS

At most locations, the groundwater table was found to be at or slightly below the existing ground surface. However, at Swamps 'A' and 'C' of Site 1A, the groundwater table was found to be up to 0.9 m above the existing ground surface.

In any case, the groundwater table is always subject to seasonal fluctuations and is likely to rise significantly during the spring freshet and during and immediately following any periods of prolonged heavy rainfall.

DISCUSSION AND RECOMMENDATIONS

General

The existing Highway 69, which extends through the area of investigation, consists of a relatively narrow single lane road running in a generally north/south direction. The highway is comprised of a series of embankments or cuts, with a general increase in elevation towards the north.

It is proposed to use the existing highway for the northbound lanes and to construct a parallel embankment, to the west, which will be used to carry the new southbound lanes. Most of the new embankments will be from 2.5 to 3.0 m above the existing ground (or water) surface. However, at Swamps 'B' and 'C', of Site 1A, the proposed embankments will be constructed to heights of 3.0 to 4.3 m above the existing ground (or water) surface.

Design Considerations

Since the soil conditions and proposed embankment heights vary from site-to-site, the general recommendations for each site will be treated separately.

Site 1 - Station 13+100 to 13+320

The soil conditions, at Site 1, generally consist of 1.3 to 2.0 m of peat, which is, in turn, underlain by very soft to soft silty clay to clay, to depths of 5.0 to 13.3 m. In this area, it is proposed to construct the embankment to a height of about 2.5 to 3 m above the existing ground surface.

Since the shear strength within the upper portion of the clay layer is quite low, it is recommended that, not only should all of the organics be removed, but also the underlying very soft clay to a depth of about 3.5 m (ie. to an elevation of 176.5 m). On each side of the embankment, the subexcavation of the clay should extend from a point vertically below the toe of the berm, with the excavation backslope being carried out as steeply as possible. (see Figure 7, attached).

On the east side of the proposed embankment, the backslope of the excavation will be well within 10 m of the toe of the existing embankment. Therefore, in order to maintain the stability of the existing embankment, it is recommended that the excavation should be carried out in strips perpendicular to the existing embankment. The base width of these strips should be no greater than one metre and the side slopes should be constructed as steeply as possible.

The slopes of the embankment should be constructed at 2H:1V. In addition, in order to increase the stability of the embankment, a 4 m wide, mid-height berm (from the finished ground surface to the top of the embankment), should also be constructed.

A total settlement of about 1.2 m is expected to occur due to consolidation of the rather extensive deposit of clay (ie. up to 7.0 m) that will remain. It is expected that about 90 percent of this consolidation, would extend over a period of 1 year following the completion of construction.

Therefore, to reduce the post construction settlements of the proposed highway, it is recommended that the embankment be overbuilt by about 1.0 m between Station 13+130 and 13+300. This surcharge should be tapered to zero thickness where bedrock is encountered in the excavation (ie. approximately at Stations 13+110 and 13+330). The settlement of the embankments should be allowed to take place over a period of six to twelve months. After that time, the embankment may be bladed off and the slopes flattened to their final grades.

Site 1A - Swamp 'A' - Station 13+510 to 13+550
- Swamp 'B' - Station 13+635 to 13+695

The soil conditions at Swamps 'A' and 'B' of Site 1A consist of up to 0.9 m of standing water underlain by 0.3 to 1.5 m of peat. The peat is, in turn, underlain by generally very soft to soft clay which reaches depths of up to 5.8 m. At one of the boreholes (1A-3B), a gravelly sand layer was found above the assumed bedrock surface.

At Swamps 'A' and 'B', the height of the proposed embankment ranges from about 2.5 to 3.5 m above the surface of the peat. Once again, in view of the generally weak nature of the underlying clay and the height of the proposed embankments, at both these sites, it is recommended that all of the peat and the underlying silty clay to clay be removed to an elevation of about 177.5 m or to a depth of about 2.5 to 3.2 m beneath the existing ground surface.

The recommendations for the excavation of the subsoils and the construction of the embankments, which have been given for Site 1, will also apply here.

In this case, however, the settlements of the proposed embankments over Swamps 'A' and 'B' would be about 0.25 m with about 90 percent of this consolidation settlement taking place over a period of about 3.0 months.

Overbuilding of these embankments would not be necessary. However, it is recommended that the embankments be left for at least 6 months, before placement of asphalt surfacing.

Site 1A - Swamp 'C' - Station 13+715 to 13+775

The soil conditions, at Swamp 'C' of Site 1A, consist of 0.3 to 0.5 m of standing water, which is, in turn, underlain by up to 3.0 to 4.7 m of peat. Very soft (shear strengths of 3 to 9 kPa) silty clay to clay underlies the peat to depths of up to 8.5 m. The proposed embankment is likely to be about 4.0 m above the surface of the peat. We also understand that a culvert is to be constructed beneath the embankment.

If the embankment is constructed from above the existing ground surface, then the maximum height should be kept below 1.5 m, even with the use of a lightweight fill material with an unit weight of about 15 kN/m³. It is considered that partial excavation and removal of the peat and silty clay soils would not permit construction of embankments to the heights proposed.

In view of the weak nature of the foundation soils present at this location, it is considered that the construction of a 4 m high embankment would require excavation and removal of the peat and the underlying silty clay down to the bedrock surface. However, such an excavation would undermine the existing highway embankment. Thus this option is not considered viable at this location.

The construction of a 4 m high embankment without the excavation and removal of the existing natural foundation soils may be carried out with the use of geogrids. A typical section of such an embankment is shown on Figure 8. The design using the geogrid is being carried out at present. Details regarding the proposed construction methodology and the type of geogrids required etc. would be discussed in a separate memo. Comments on the construction of the proposed culvert across the new embankment would also be discussed in this memo.

Alternatively, consideration may be given to the construction of a timber trestle across this swamp. If this option is favoured, this office should be contacted for detailed recommendations regarding pile lengths, pile capacities etc.

Site 2 - Station 14+580 to 14+720

The soil conditions, at Site 2, consist of 0.2 to 5.0 m of peat, which is, in turn, underlain by up to 6 m of very soft to soft silty clay. The height of the proposed embankment, will be about 2.5 to 3 m above the existing ground surface, at this location.

Based on vane shear tests, carried out at the site, it appears that the upper part of the silty clay to clay deposit is too weak to support the embankment. Therefore, it is recommended that all of the peat and the underlying silty clay to clay be removed to a depth of at least 5.5 m (or to an elevation of about 175.5 m). The depth of removal should be slightly greater (ie. 6.0 m) at the centre of the site (ie. Station 14+620 to 14+670) where the thickness of peat increases significantly.

The recommendations for the excavation of the subsoils, as well as the construction and overbuilding of the embankment, which were given in the section for Site 1, will also apply here.

The proposed embankment would result in a total settlement of about 1.1 m, due to the rather extensive deposit of clay that would remain (ie. up to 5.5 m). It is expected that about 90 percent of the consolidation of the clay would take place over period of about 8 months. Therefore, to reduce post-construction settlements, it is recommended that the embankment be overbuilt by about 1.0 m between approximately Stations 14+625 and 14+680. This surcharge should be tapered to zero thickness where bedrock is contacted in the excavation (ie. approximately Stations 14+615 and 14+690. The settlement of the embankment should be allowed to take place over a period of six months. At that time, the embankment may be bladed off and the slopes flattened to their final grades.

Construction Considerations

Materials, used to construct the embankments, should consist of well-graded rock fill or any suitable, well-graded lightweight granular material.

Within the excavated area, the fill should be end-dumped until it is at least 0.3 m above the water surface. At that point, compaction of the rockfill should be attempted. In any case, the construction of the embankments should be in accordance with current MTO standards and practice.

Alternatives

At some locations, it may be possible to reduce the recommended berm width by either reducing the height of the embankment or by using slag or other lightweight fill in the construction of the embankment.

At some locations, it may also be possible to construct a very small embankment directly on the peat mat (possibly with the aid of a geogrid). Excavation of the existing peat and soft clay would, therefore, not be required.

MISCELLANEOUS

The field investigation was conducted by J. Blair, Project Foundation Engineer and P. Thase, Student Engineer, using equipment owned and operated by Master Soil Investigation Limited.

The project was carried out by J. Blair, under the general supervision of B. Iyer, Senior Foundation Engineer.

This report was written by J. Blair reviewed by B. Iyer and approved by M. Devata, Chief Foundation Engineer.

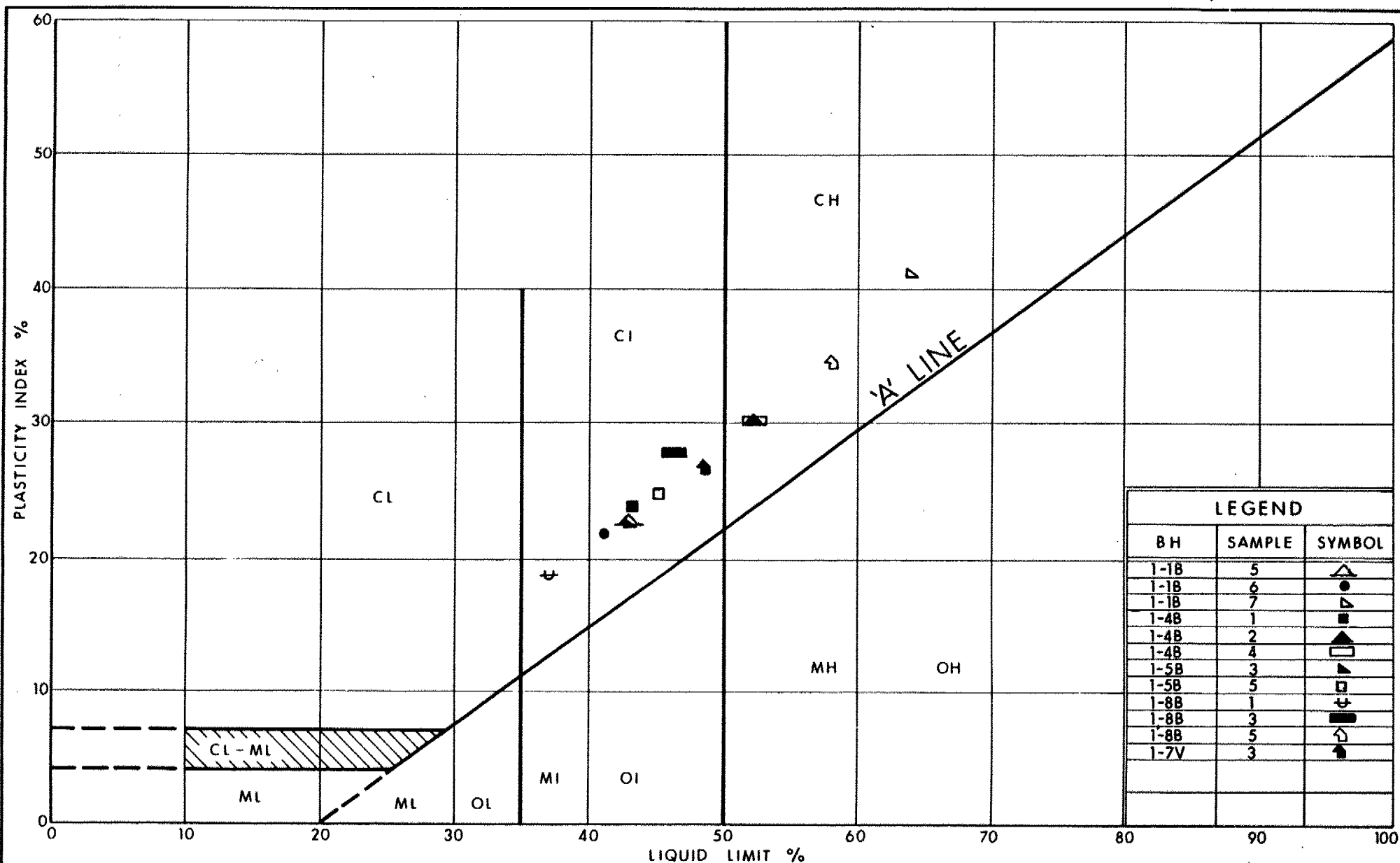
John A. Blair

J. Blair, P.Eng.
Project Foundation Engineer



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

APPENDIX



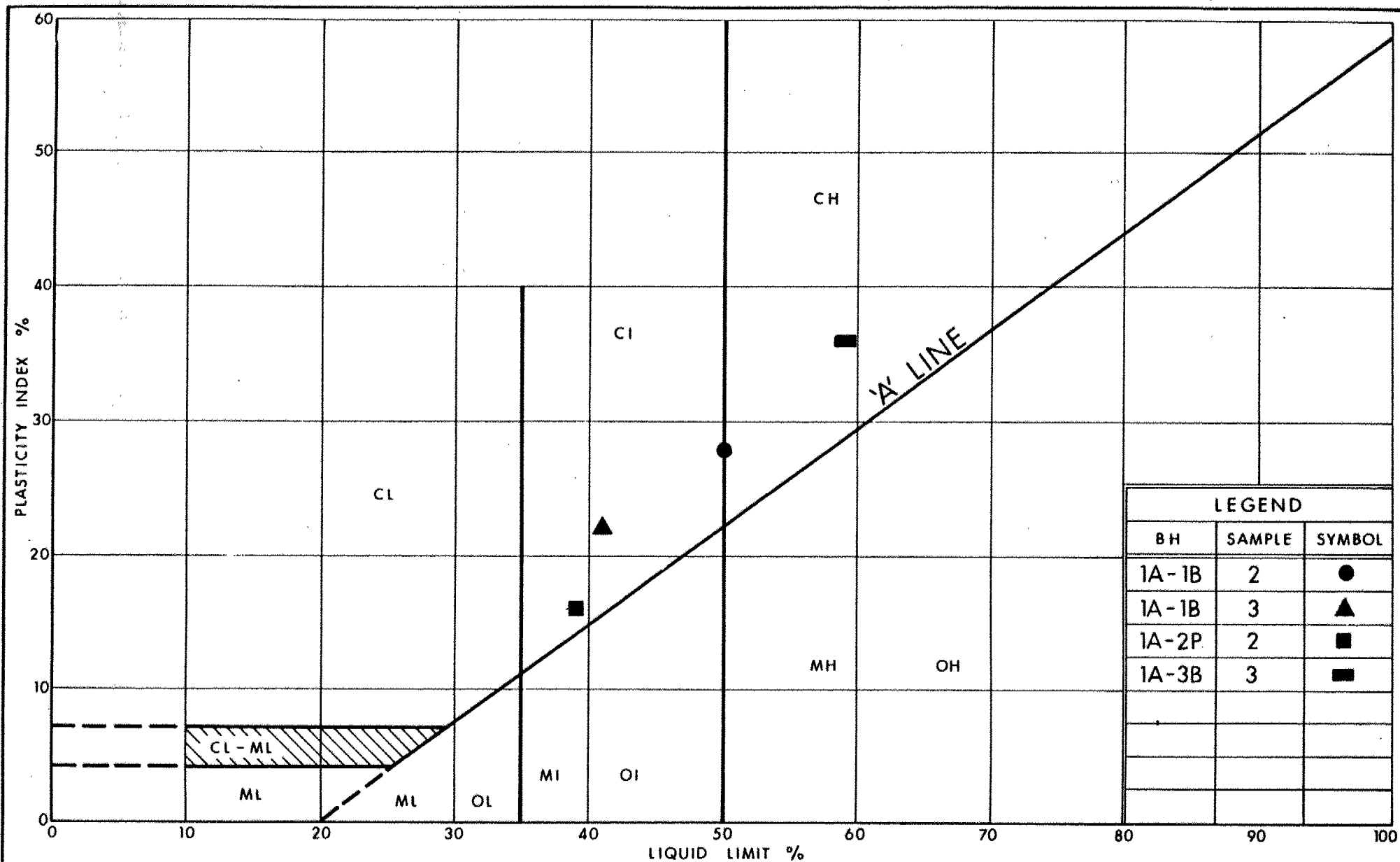
Ontario

Ministry of
Transportation

PLASTICITY CHART
SILTY CLAY TO CLAY
(SAMPLES FROM SITE-1)

FIG No 1

W P 212-89-00



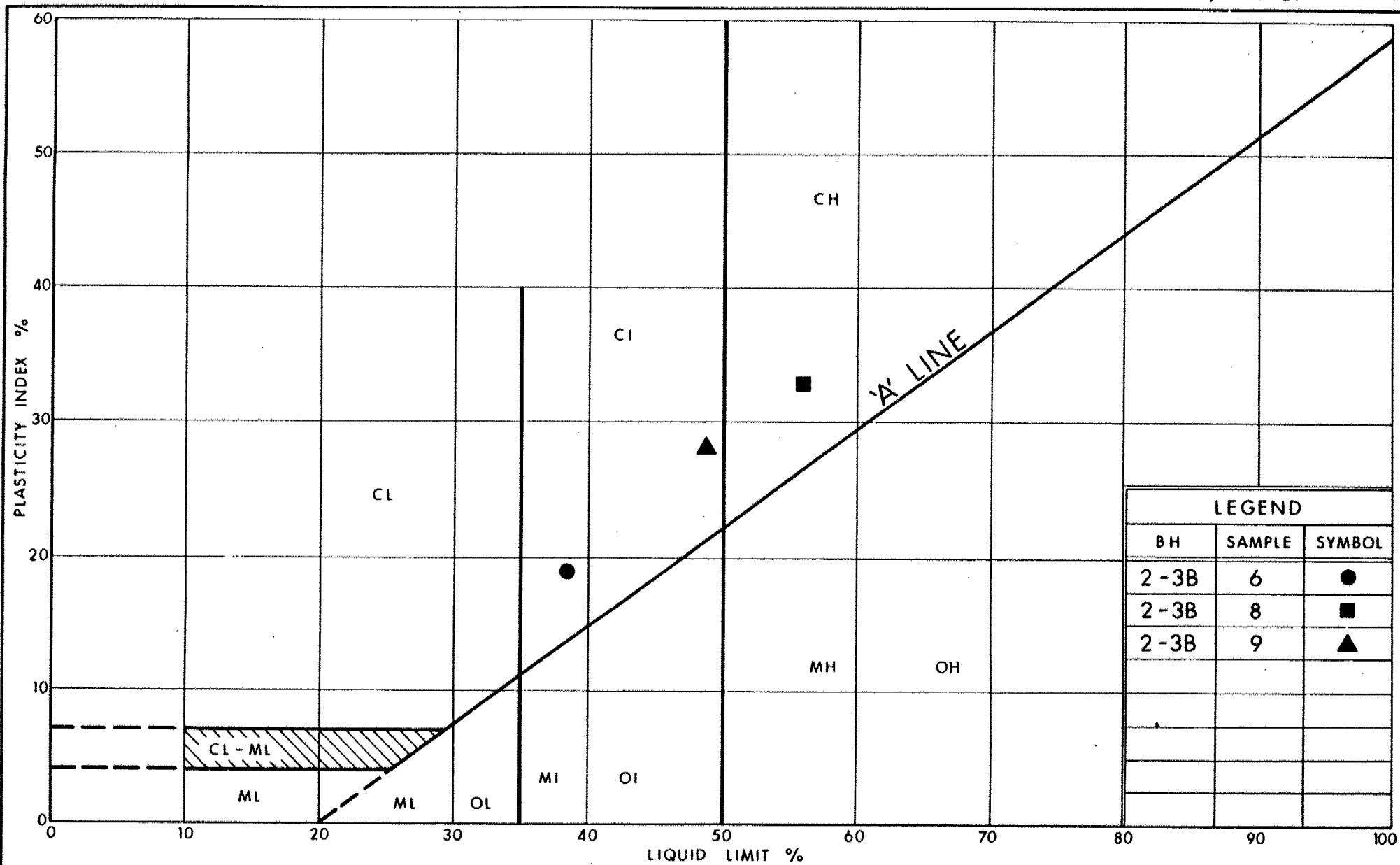
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Ministry of
Transportation

PLASTICITY CHART
SILTY CLAY TO CLAY
(SAMPLES FROM SITE -2)

FIG No 2

W P 212-89-00



Ontario

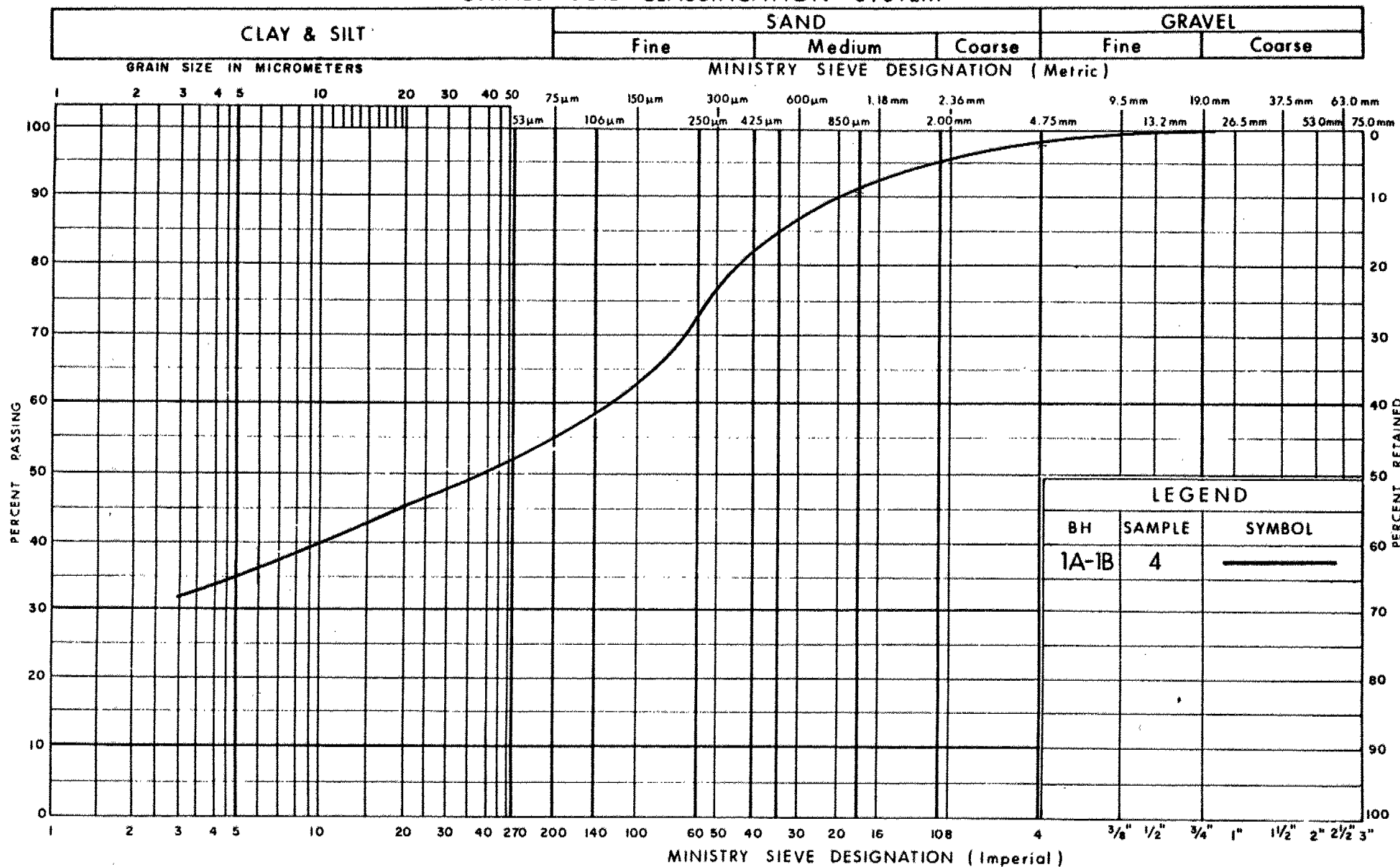
Ministry of
Transportation

PLASTICITY CHART
SILTY CLAY TO CLAY
(SAMPLES FROM SITE -3)

FIG No 3

W P 212-89-00

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY

FIG No 4

W P 212-89-00

VOID RATIO - PRESSURE CURVES

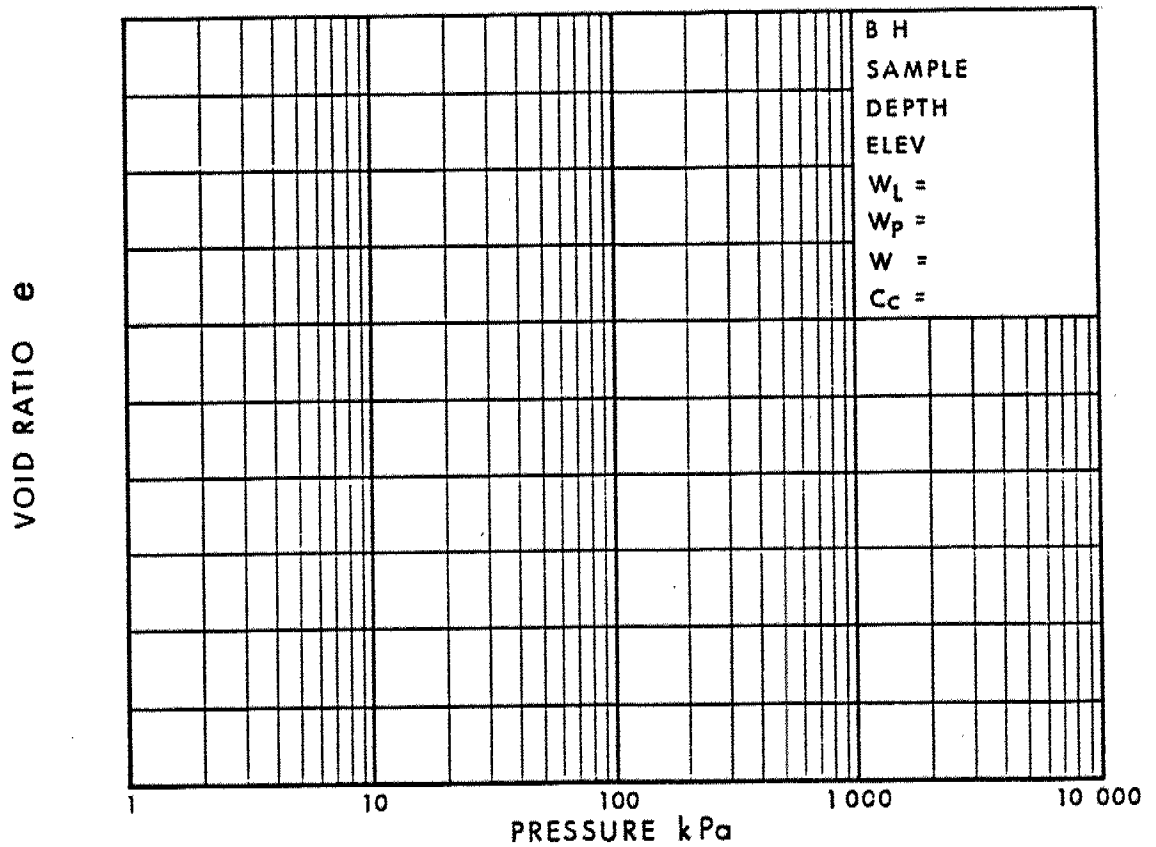
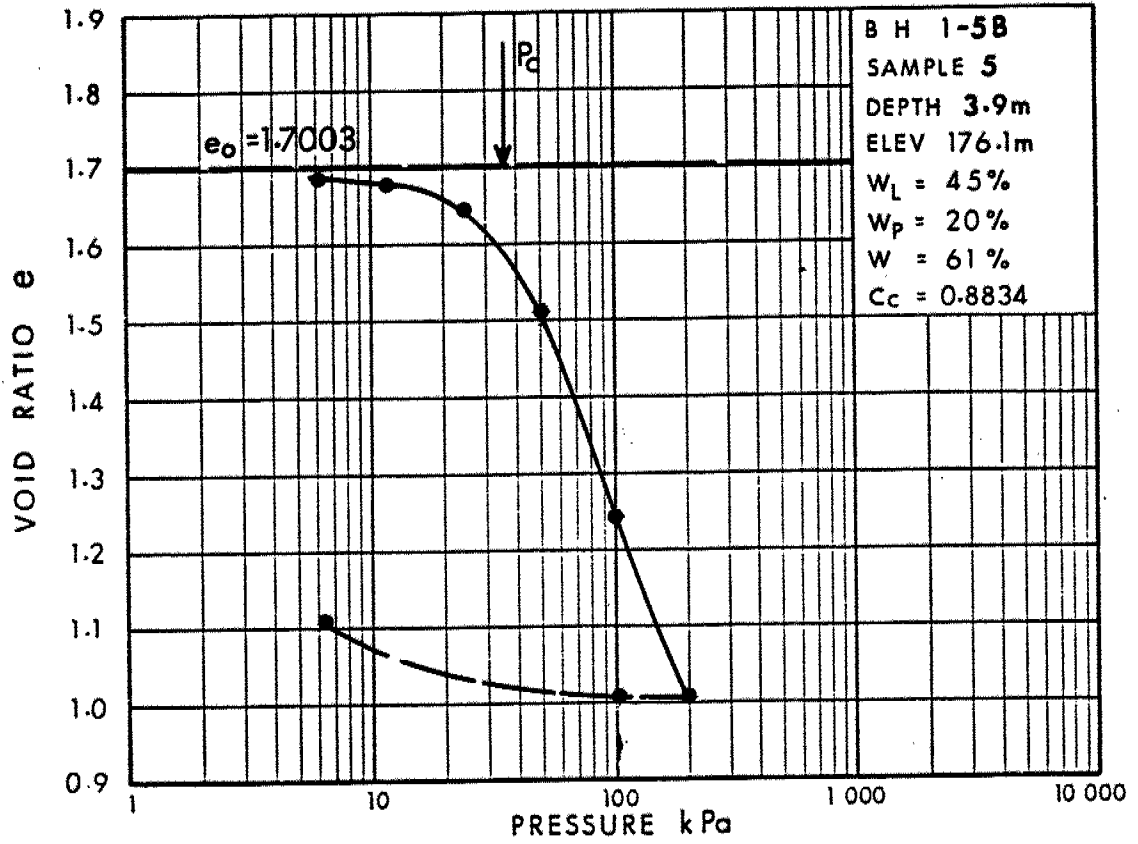


Fig 5

W P 212-89-00

VOID RATIO - PRESSURE CURVES

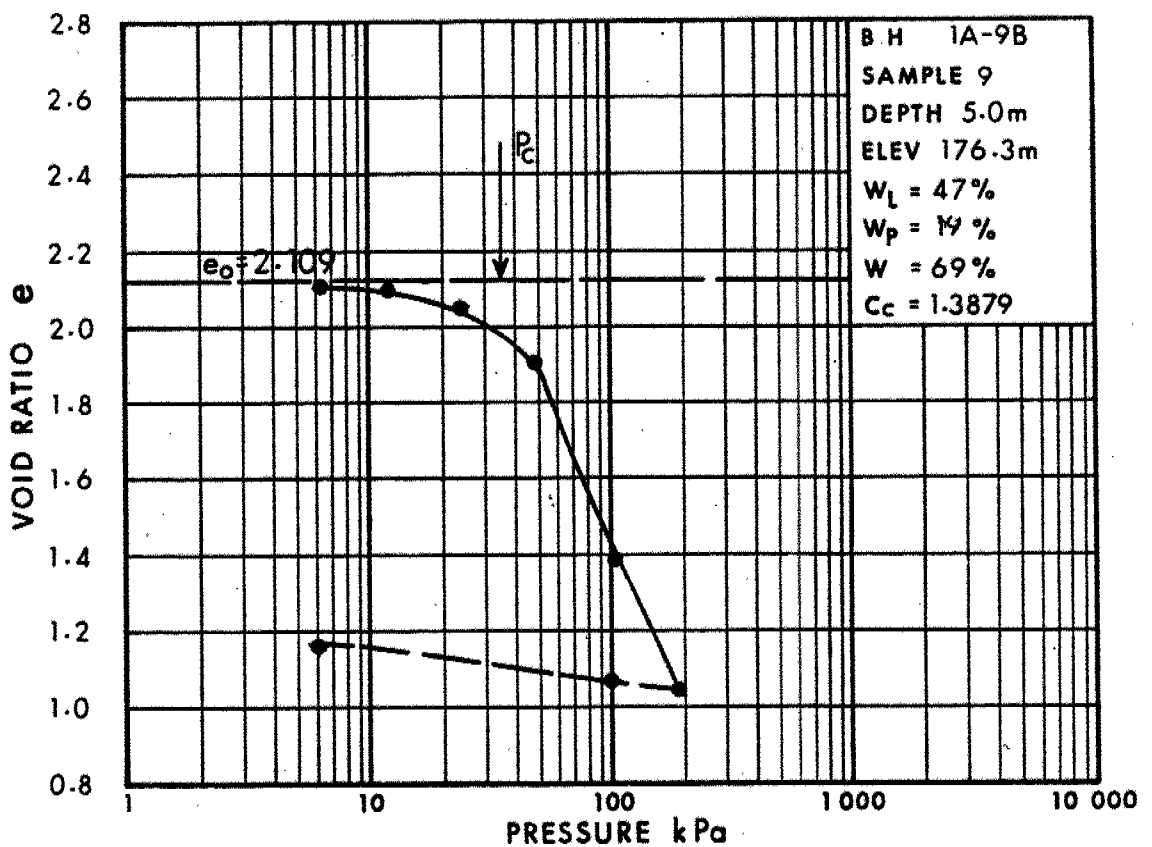
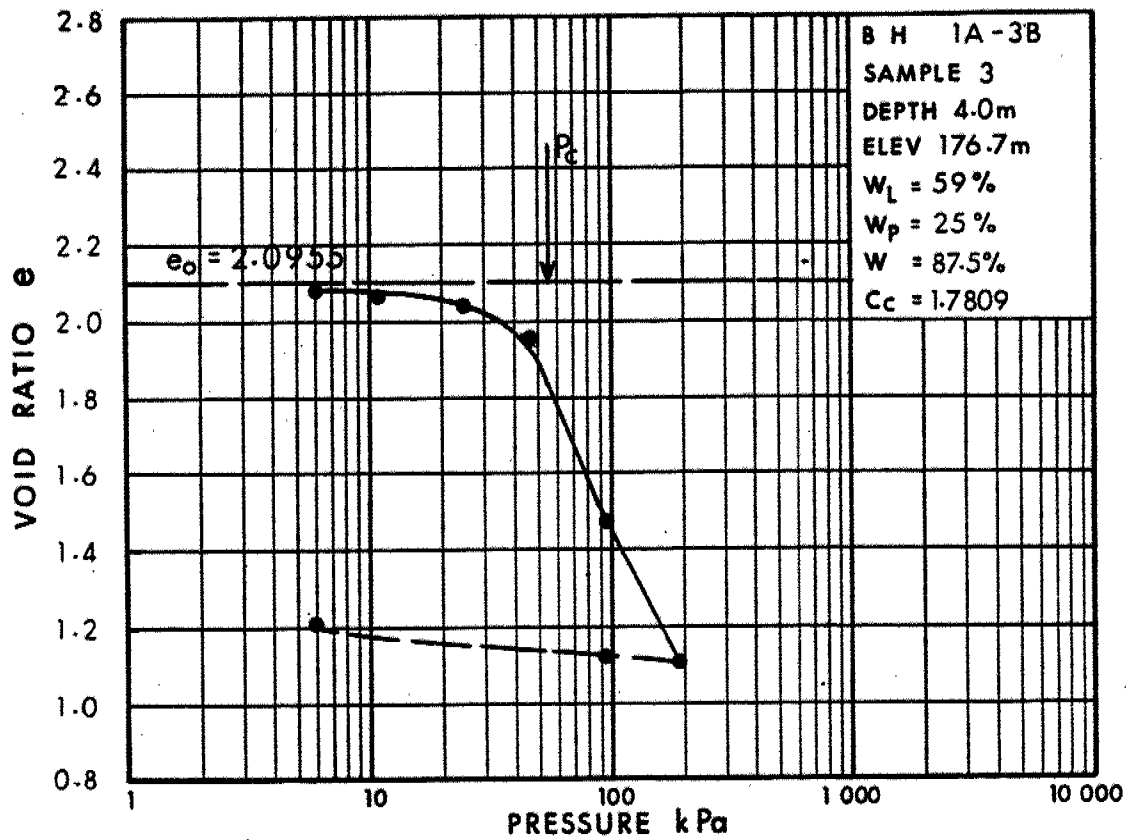
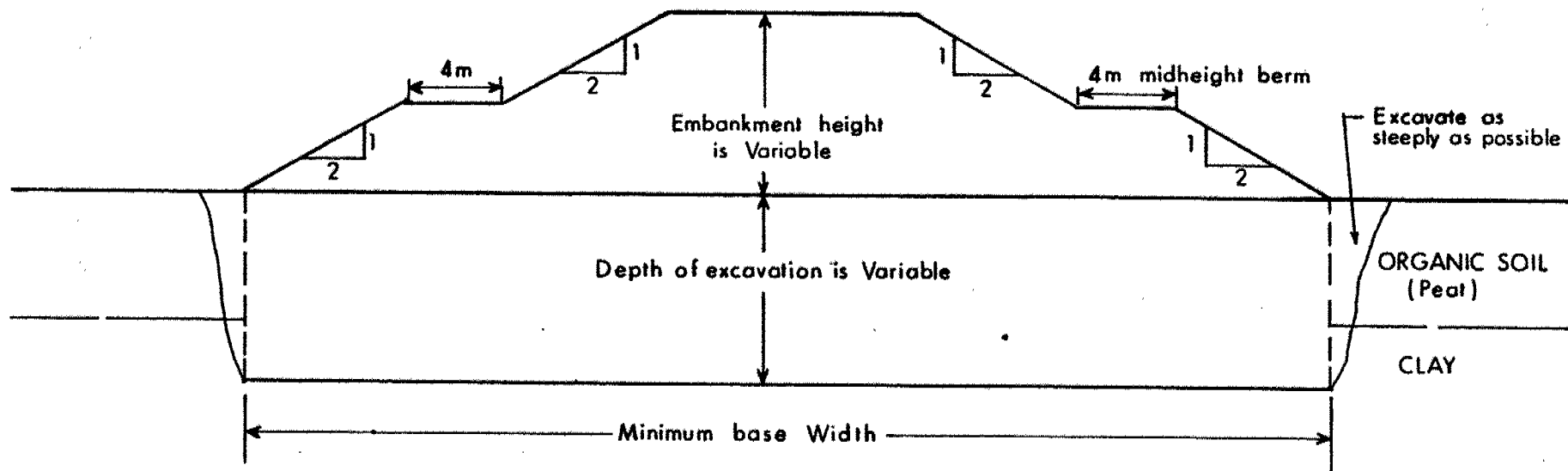
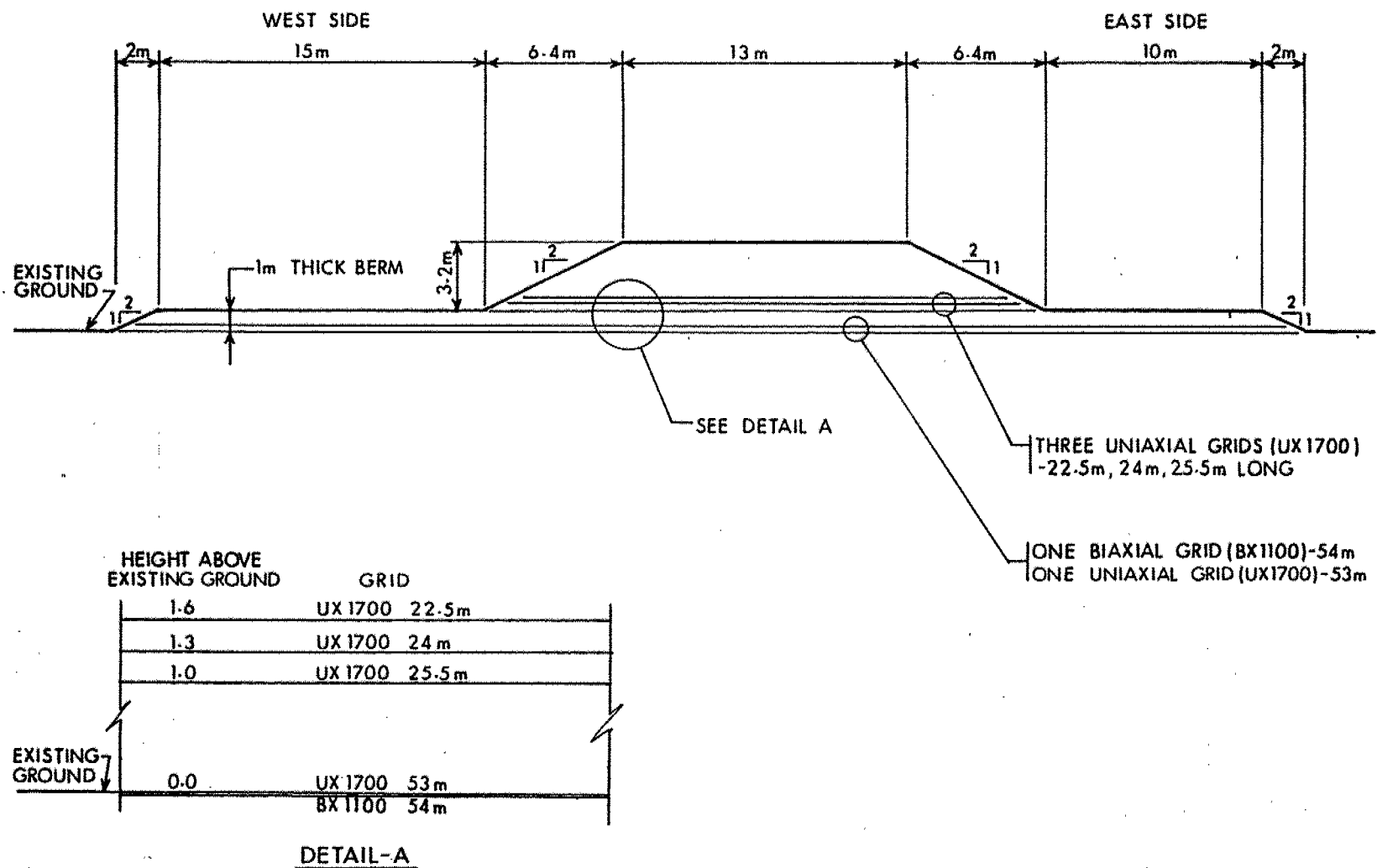


Fig 6

W P 212-89-00



EXCAVATION LIMITS FOR HWY 69 EMBANKMENTS
NTS



TYPICAL EMBANKMENT SECTION USING GEOGRIDS
SITE-1A SWAMP 'C'

FIG-8
WP 212-89-00

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

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

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						

Table 1

Borehole Logs - Site 1

Borehole No.	Depth		Elevation		Soil Description	Approximate Groundwater Table
	From	To	From	To		Elevation (m)
1-1B	0	2.0	180.2	178.2	Peat - Brown, Very Soft	180.0
	2.0	10.1	178.2	170.1	Silty Clay, trace Sand, Very Soft to Soft (C=6 to 23 kPa)	
	10.1	11.6	170.1	168.6	Silty Sand interbedded with Clayey Silt and Sand Layers, Grey, Loose	
	11.6		168.6		NFP - Possible Bedrock	
1-2P	0	13.3	180.0	166.7	Peat/Silty Clay to Clayey Silt	180.0
	13.3		166.7		NFP - Possible Bedrock	
1-3P	0	9.9	180.0	170.1	Peat/Silty Clay to Clayey Silt	180.0
	9.9	12.4	170.1	167.6	Possible Sand and Gravel	
	12.4		167.6		NFP - Possible Bedrock	
1-4B	0	1.7	180.1	178.4	Peat, Brown, Very Soft	180.0
	1.7	8.8	178.4	171.3	Silty Clay to Clay, Grey, Very Soft to Soft (C=5 to 19 kPa)	
	8.8	11.5	171.3	168.6	Medium Sand to Coarse Sand and Gravel, Grey, Dense	
	11.5		168.6		NFP - Possible Bedrock	
1-5B	0	1.5	180.0	178.5	Peat, Dark Brown, Very Soft	180.0
	1.5	7.6	178.5	172.5	Silty Clay, some Sand, Grey, Very Soft to Soft (C=8 to 25 kPa)	
	7.6		172.5		NFP - Possible Bedrock	

Table 1

Borehole Logs - Site 1 .../cont'd

Borehole No.	Depth		Elevation		Soil Description	Approximate Groundwater Table
	From	To	From	To		Elevation (m)
1-6V	0	1.4	180.1	178.7	Peat, Dark Brown, Very Soft	180.0
	1.4	9.1	178.7	171.0	Silty Clay, some Sand, Grey, Very Soft to Firm, (C=5 to 41 kPa)	
	9.1		171.0		NFP - Possible Bedrock	
1-7V	0	1.5	180.0	178.5	Peat, Dark Brown, Very Soft	180.0
	1.5	5.0	178.5	175.0	Silty Clay, Grey, Very Soft to Firm, (C=9 to 38 kPa)	
	5.0	7.6	175.0	172.4	Fine to Medium Sand, some Gravel, Loose, (N=7 to 8 blows/0.3 m)	
	7.6		172.4		NFP - Possible Bedrock	
1-8B	0	1.3	180.1	178.8	Peat, Dark Brown, Very Soft	180.0
	1.3	8.4	178.8	171.7	Silty Clay to Clay, some Sand, Grey, Very Soft to Soft (C=8 to 20 kPa)	
	8.4		171.7		NFP - Possible Bedrock	

Table 1A

Borehole Logs - Site 1A

Borehole No.	Depth		Elevation		Soil Description	Approximate Groundwater Table
	From	To	From	To		Elevation (m)
1A-1B	0	0.9	180.7	179.8	Water	180.7
	0.9	1.5	179.8	179.2	Peat, Dark Brown to Black, Very Soft	
	1.5	5.8	179.2	174.9	Silty Clay to Clay, some Sand, Grey, Soft to Firm, (C=11 to 37 kPa)	
	5.8	6.7	174.9	174.0	Silty Sand to Clayey Silt and Sand (Lower Part - Weathered Bedrock), Green, Loose to Very Dense, (N=9 blows/0.3 m to >100 blows/0.3 m)	
	6.7		174.0		NFP - Possible Bedrock	
1A-2P	0	0.6	180.7	180.1	Water	180.7
	0.6	0.9	180.1	179.8	Peat, Dark Brown to Black, Very Soft	
	0.9	5.8	179.8	174.9	Silty Clay to Clay, some Sand, Grey, Soft to Firm, (C=21 kPa)	
	5.8		174.9	169.1	NFP - Possible Bedrock	
1A-3B	0	0.8	180.7	179.9	Water	180.7
	0.8	1.4	179.9	179.3	Peat, Dark Brown to Black, Very Soft	
	1.4	4.5	179.3	176.2	Silty Clay to Clay, some Sand, Grey, Very Soft to Firm, (C=8 to 11 kPa)	
	4.5	5.2	176.2	175.5	Gravelly Sand, Grey, Dense (N=38 blows/0.3 m)	
	5.2		175.5		NFP - Possible Bedrock	

Table 1A

Borehole Logs - Site 1A .../cont'd

Borehole No.	Depth		Elevation		Soil Description	Approximate Groundwater Table
	From	To	From	To		Elevation (m)
1A-4P	0	0.9	180.7	179.8	Water	180.7
	0.9	2.4	179.8	178.3	Peat/Silty Clay to Clay	
	2.4		178.3		NFP - Possible Bedrock	
1A-5P	0	1.7	181.4	179.7	Peat/Silty Clay to Clay	181.0
	1.7		179.7		NFP - Possible Bedrock	
1A-6B	0	0.3	181.3	181.0	Water	181.3
	0.3	0.6	181.0	180.7	Peat, Black, Very Soft	
	0.6	1.5	180.7	179.8	Sandy Silt, some Clay, Grey, Very Loose (N=1 blow/0.3 m)	
	1.5	4.6	179.8	176.7	Silty Clay to Clay, some Sand, Grey, Very Soft to Soft, (C=10 to 23 kPa)	
	4.6		176.7		NFP - Possible Bedrock	
1A-7P	0	0.1	181.3	181.2	Water	181.3
	0.1	1.2	181.2	180.1	Peat, Black, Very Soft	
	1.2	4.7	180.1	176.6	Silty Clay to Clay, some Sand, Grey, Very Soft to Soft	
	4.7		176.6		NFP - Possible Bedrock	
1A-8V	0	0.5	181.3	180.8	Water	181.3
	0.5	3.0	180.8	178.3	Peat, Dark Brown to Black, Very Soft	
	3.0	8.5	178.3	172.8	Silty Clay to Clayey Silt, some Sand, Grey, Very Soft (C=2 to 8 kPa)	
	8.5		172.8		NFP - Possible Bedrock	

Table 1A

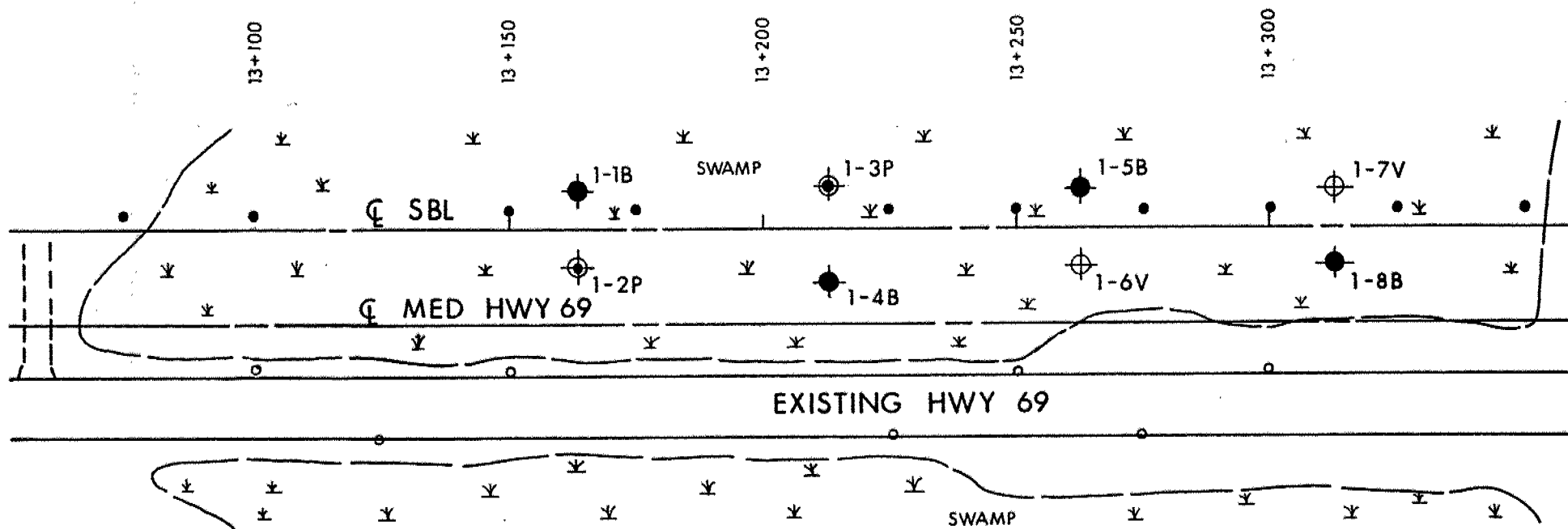
Borehole Logs - Site 1A .../cont'd

Borehole No.	Depth		Elevation		Soil Description	Approximate Groundwater Table Elevation (m)
	From	To	From	To		
1A-9B	0	0.4	181.3	180.9	Water	181.3
	0.4	3.0	180.9	178.3	Peat, Dark Brown, Very Soft	
	3.0	5.5	178.3	175.8	Silty Clay to Clayey Silt, some Sand, Grey, Very Soft, (C=3 to 9 kPa)	
	5.5				NFP - Possible Bedrock	
1A-10P	0	0.3	181.3	181.0	Water	181.3
	0.3	4.9	181.0	176.4	Peat/Silty Clay to Clayey Silt	
	4.9		176.4		NFP - Possible Bedrock	

Table 2

Borehole Logs - Site 2

Borehole No.	Depth		Elevation		Soil Description	Approximate Groundwater Table Elevation (m)
	From	To	From	To		
2-1P	0	1.2	181.0	179.8	Peat, Dark Brown, Very Soft	181.0
	1.2	1.7	179.8	179.3	Silty Clay, some Sand, Very Soft	
	1.7		179.3		NFP - Possible Bedrock	
2-2P	0	1.8	181.3	179.5	Peat, Dark Brown, Very Soft	181.0
	1.8	2.9	179.5	178.4	Organic Silt - Greenish Grey, Very Soft	
	2.9	8.2	178.4		Silty Clay to Clayey Silt, Grey, Very Soft to Soft	
	8.2				NFP - Possible Bedrock	
2-3B	0	3.9	181.2	177.3	Peat, Black to Brown, Very Soft	181.0
	3.9	9.6	177.3	171.6	Silty Clay to Clayey Silt, Grey, Very Soft to Soft (C=4 to 20 kPa)	
	9.6		171.6		NFP - Possible Bedrock	
2-4B	0	4.9	181.0	176.1	Peat, Black to Brown, Very Soft	181.0
	4.9	9.4	176.1	171.6	Silty Clay to Clayey Silt, Grey, Very Soft to Soft (C=6 to 19 kPa)	
	9.4		171.6		NFP - Possible Bedrock	
2-5P	0	0.8	181.0	180.2	Peat, Black, Very Soft	181.0
	0.8	2.4	180.2	178.6	Organic Silt - Brown, very Soft	
	2.4	4.1	178.6	176.9	Silty Clay to Clayey Silt, Grey, Very Soft to Soft	
	4.1	6.0	176.9	175.0	Sand	
	6.0		175.0		NFP - Possible Bedrock	
2-6P	0	0.4	181.0	180.6	Topsoil/Peat	181.0
	0.4	1.4	180.6	179.6	Silty Clay to Clayey Silt, Grey, Very Soft to Soft	
	1.4	1.5	179.6	179.5	Sand	
	1.5		179.5		NFP - Possible Bedrock	



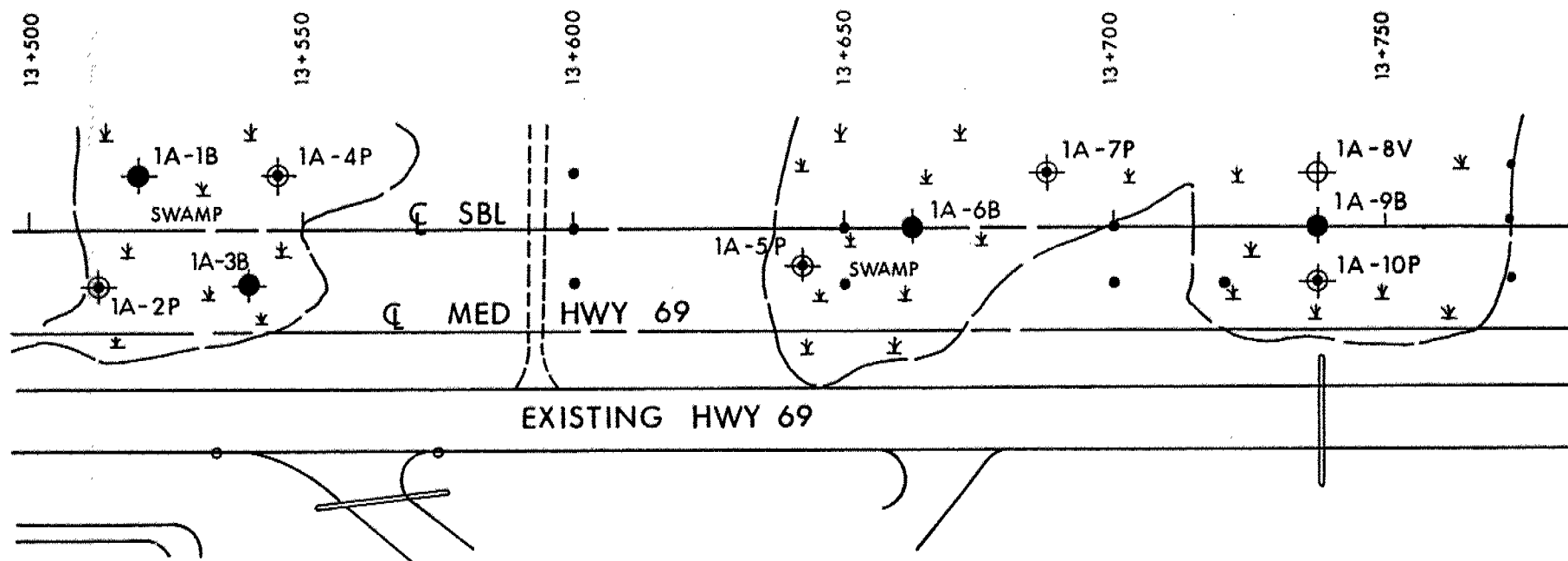
No	DEPTH TO BEDROCK
1-1B	2.3m
1-2P	13.2m
1-3P	12.4m
1-4B	11.5m
1-5B	7.6m
1-6V	9.2m
1-7V	7.6m
1-8B	8.3m

LEGEND

- BOREHOLE
- ⊕ PROBEHOLE
- ⊕ VANE
- TEST HOLE (SEE Profile No 69N11-6)
- TEST HOLE (SEE SHEET No 23 of Cont 89-71)

SITE -1
NTS






WP 212-89-00
Dwg No 2128900A



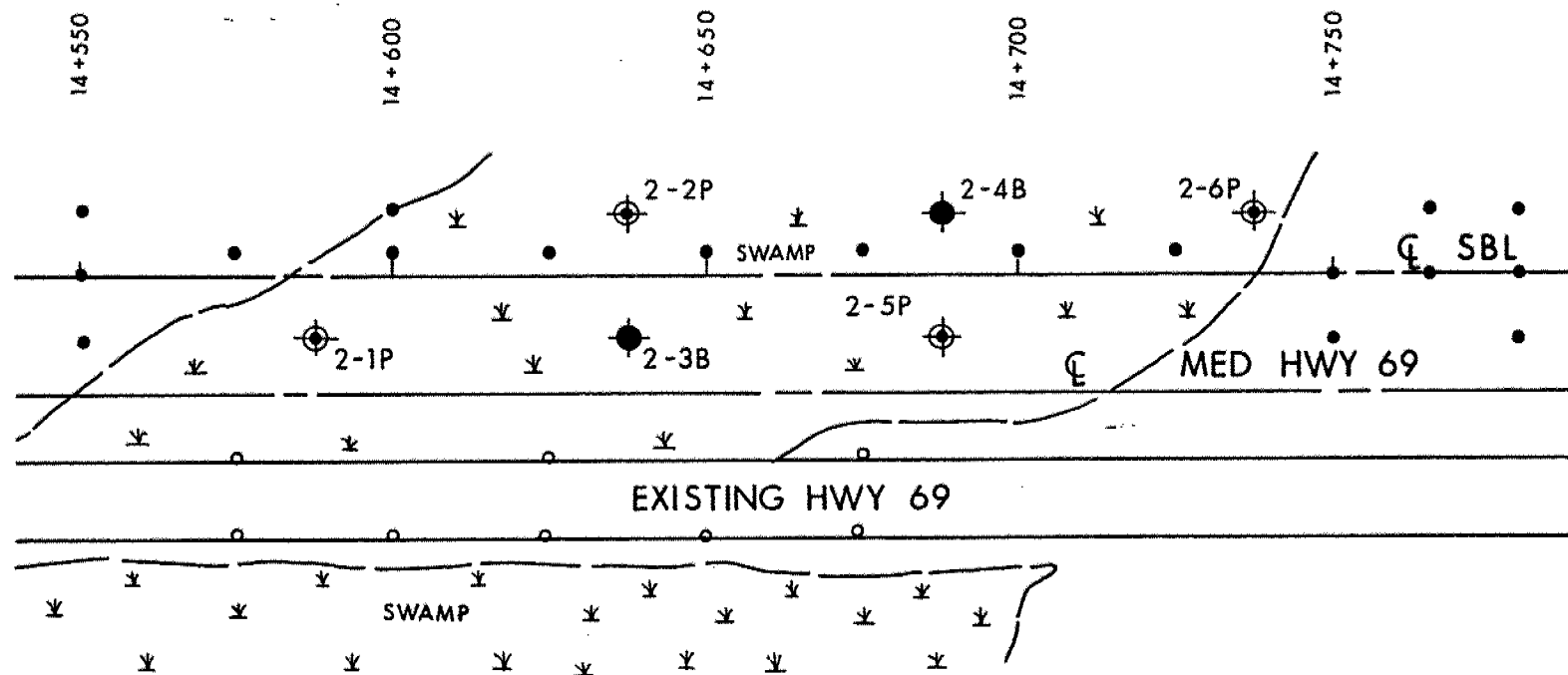
No	DEPTH TO BEDROCK
1A-1B	6.7m
1A-2P	5.8m
1A-3B	5.2m
1A-4P	2.5m
1A-5P	1.7m
1A-6B	4.6m
1A-7P	4.7m
1A-8V	8.5m
1A-9B	5.8m
1A-10P	4.8m

SITE -1A NTS

LEGEND

-  BOREHOLE
-  PROBEHOLE
-  VANE
-  TEST HOLE (See Profile No 69N11-6)
-  TEST HOLE (See Sheet No 23 of Cont 89-71)

WP 212-89-00
Dwg No 2128900B



No	DEPTH TO BEDROCK
2-1P	1.7 m
2-2P	8.2 m
2-3B	9.6 m
2-4B	9.4 m
2-5P	6.0 m
2-6P	1.5 m

LEGEND

- BOREHOLE
- ⊕ PROBEHOLE
- TEST HOLE (See Profile No 69N11-6)
- TEST HOLE (See Sheet No 23 of Cont 89-71)

SITE -2
NTS

WP 212-89-00
Dwg No 2128900C