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DIST. 1 REGION

W.P. No. 94-83-02

CONT. No. 92-02

W. O. No.

STR. SITE No. 14-140

HWY. No. 21

LOCATION Hwy 21 & Black Creek
(Bridge #2)

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 92-02



**Ministry of
Transportation**

Ontario

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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

2

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						

**FOUNDATION INVESTIGATION REPORT
FOR
CROSSING AT HIGHWAY 21 AND
BLACK CREEK NO. 2
DISTRICT 1 CHATHAM
W.P. 94-83-02 SITE 14-140**

INTRODUCTION

This report summarizes the results of a foundation investigation for the proposed crossing of Black Creek No. 2 at Highway 21. The investigation was carried out at the request of Foundation Design Section of the Ministry of Transportation of Ontario.

This report contains geotechnical information pertaining to structure foundations, approach embankments and related earthworks between Sta. 17 + 540 and Sta. 17 + 590.

SITE DESCRIPTION

The site is located at the present crossing of Black Creek No. 2 and Highway 21, in District 1, Chatham, Ontario. The existing crossing consist of a single span concrete bridge structure.

The floor of the creek bed is about 3.0 m below the road surface. At the time of the investigation, the depth of the water in the creek was about 0.5 m. The creek bed is about 2 to 7 meters wide, with a gentle slope rising out of the creek bed, at both the banks.

PROCEDURE

The field investigation was carried out between the period of August 20 and 22, 1990. The fieldwork consisted of drilling two boreholes accompanied with dynamic cone tests. The boreholes were advanced using a track mounted C.M.E. 55 equipped with hollow stem augers. The boreholes were further advanced in the bedrock, using BXT size core bits.

Disturbed samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specification of the Standard penetration Test (ASTM D 1587-8). In addition, field MTO type vane tests were attempted in the cohesive deposits.

As requested, one sample collected from the stream bed, at 0.2 to 0.5 m depth and adjacent to south west abutment, was analyzed for gradation.

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the overburden including:

Natural moisture content
Grain size distribution
Atterberg Limit
Unit Weight

The elevations of the boreholes were referenced to a local geodetic benchmark at Elevation 199.898 m. (cut cross on SW corner of a catch basin, 13.60 m RT at Sta. 17 + 714.3 m).

SITE GEOLOGY AND SUBSURFACE CONDITIONS

Physiographically, the site lies in the area known as St. Clair Clay Plain. The region is one of little relief with a deep deposit of clay. Most of the Lambton County is essentially till plains smoothed by shallow deposits of lacustrine clay which settled in the depressions while the knolls were being lowered by wave action.

The subsoil conditions essentially consist of 14.6 to 16.3 m of cohesive soil overlying shale bedrock. The subsurface material consist of 1.4 to 2.1 m of clayey silt fill, with trace/specs of organics, overlying 2.6 to 3.2 m of very stiff silty clay with sand seams. This deposit overlies very stiff silty clay of glacial till origin, about 10.0 m thick, and below this is a heterogeneous mixture of clay, silt, sand, gravel and shale layer overlying shale bedrock.

The boundaries of the different strata, together with the field and laboratory test results, appear on the Record of Borehole sheets appended to this report. Also refer to the sheets for the locations and elevations of the boreholes. Stratigraphical section of the subsurface conditions is shown on Drawing 948302-A.* Detailed description of the different strata is provided below.

Clayey Silt, trace of organics (Fill)

Cohesive material consisting of stiff clayey silt, with trace to specs of organics, extends to Elevation 195.4 m, i.e. to a depth of about 1.4 to 2.1 m. This fill appears to have been placed during the construction of the existing structure and embankments. The moisture content varies from 19 to 39 percent.

* Drawing No. 2 of the Contract Dwg's

Silty Clay, trace of sand and fine gravel, with sand seams

This strata was encountered in both the boreholes and its thickness range from 2.6 to 3.2 m. The upper 0.5 to 1.0 m of this deposit contains specs of organics. Sand seams were present within this cohesive deposit. Undrained shear strength values were in excess of 110 kpa, the maximum capacity of the field vane apparatus. The consistency of this deposit is very stiff. The moisture content varies from 18 to 23 percent and the liquid and plasticity index vary from 40 to 43 and 13 to 23, respectively. The unit weight varies from 20.1 to 21.2 kN/m³. Typical gradation curves and plasticity chart are given in Appendix as Figures 1 and 2.

Silty Clay (Glacial Till)

This predominant deposit was encountered in both the boreholes and it is about 10.0 m thick. Undrained shear strength of the soil, determined by in situ field vane tests, was measured to be in excess of 110 kpa. The consistency of this deposit is very stiff.

The results of four Atterberg Limit tests (Figure 3), performed on this material, are summarized as follows:

Property	Range	Average
Natural Moisture Content (%)	17 - 30	22.0
Liquid Limit (%)	34 - 40	37.0
Plastic Limit (%)	19 - 26	22.0
Plasticity Index (%)	13 - 17	15.0
Unit Weight (kN/cu.m)	21.2 - 20.4	20.8

From the plasticity chart, this deposit is classified as inorganic silty clay of intermediate to low plasticity.

Grain size distribution envelope is given in Figure 4.

Heterogeneous Mixture of Clay, Silt, Sand, Gravel and Shale (Glacial Till)

This deposit, about 0.6 to 1.0 m thick, overlies the shale bedrock. The 'N' value is 73 blows per 300 mm and the consistency of this material is described as hard. The moisture content of this layer was 9.0 percent.

Bedrock

Bedrock was core drilled at both borehole locations. The bedrock is identified as grey shale bedrock with medium spaced horizontal bedding. The bedrock, although relatively sound is classified as weak with respect to strength. Core recoveries and R.Q.D. ranged from 95 % to 100 %. The quality of the rock is defined as excellent.

The bedrock dips down from south east at Elevation 182.2 m, to north west at Elevation 181.4 m.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water levels in the open borehole, and in a piezometer installed in Borehole 1. In Borehole 2, the groundwater level, in the open hole, was at 4.0 m depth, Elevation 192.8 m, on completion of drilling. In Borehole 1, the hole was dry prior to coring bedrock. The water in the piezometer, after one day, was at 8.0 m depth, Elevation 189.6 m. The water in the creek was at Elevation 195.5 m. The long term groundwater level is expected to correspond with the creek level. It should be noted that the groundwater is subject to changes with the fluctuations in the creek levels.

Note: The preceding report is a copy of the factual information from the Foundation Report prepared by McClymont & Rak Engineers, Inc. (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

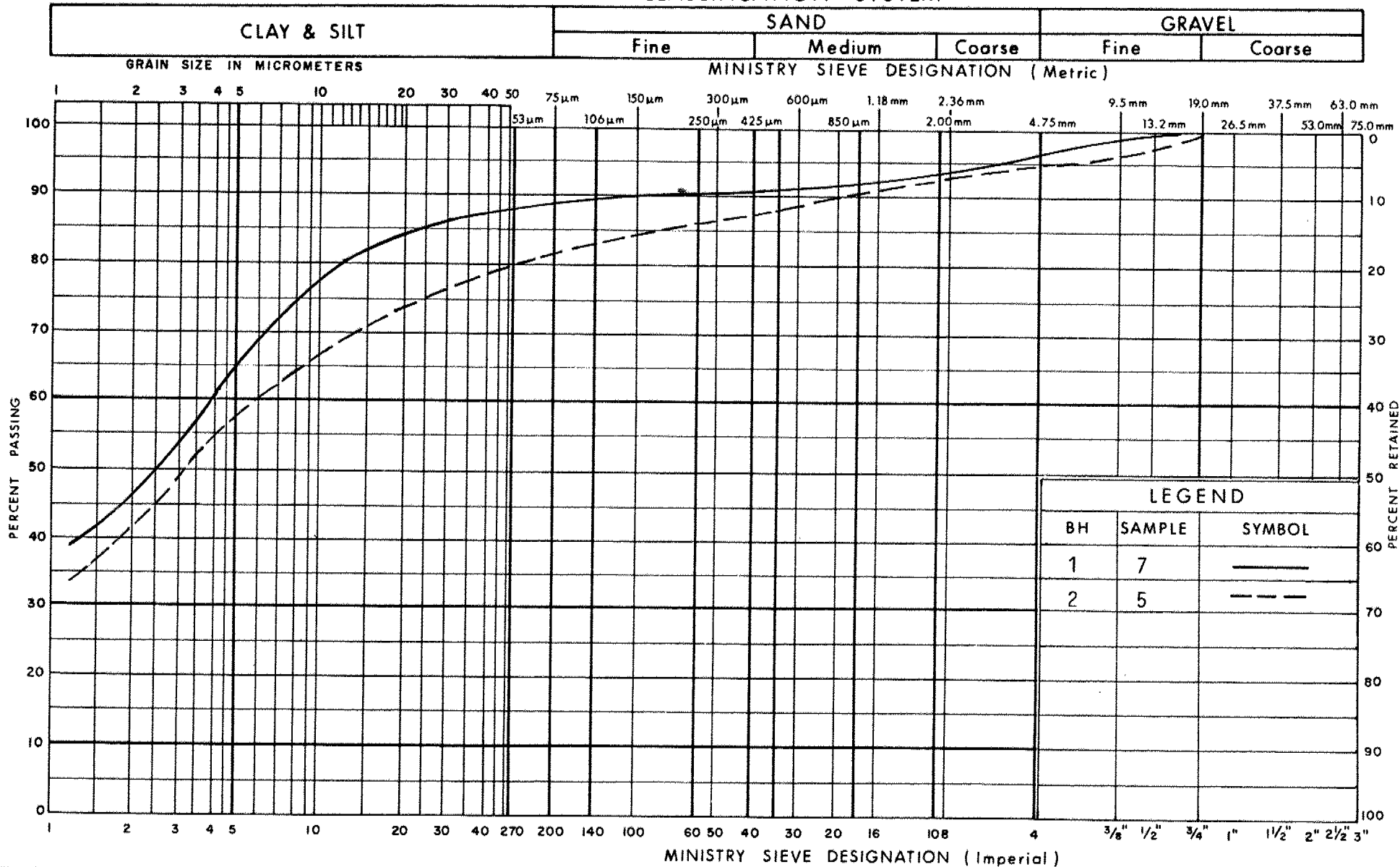


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Sr. Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

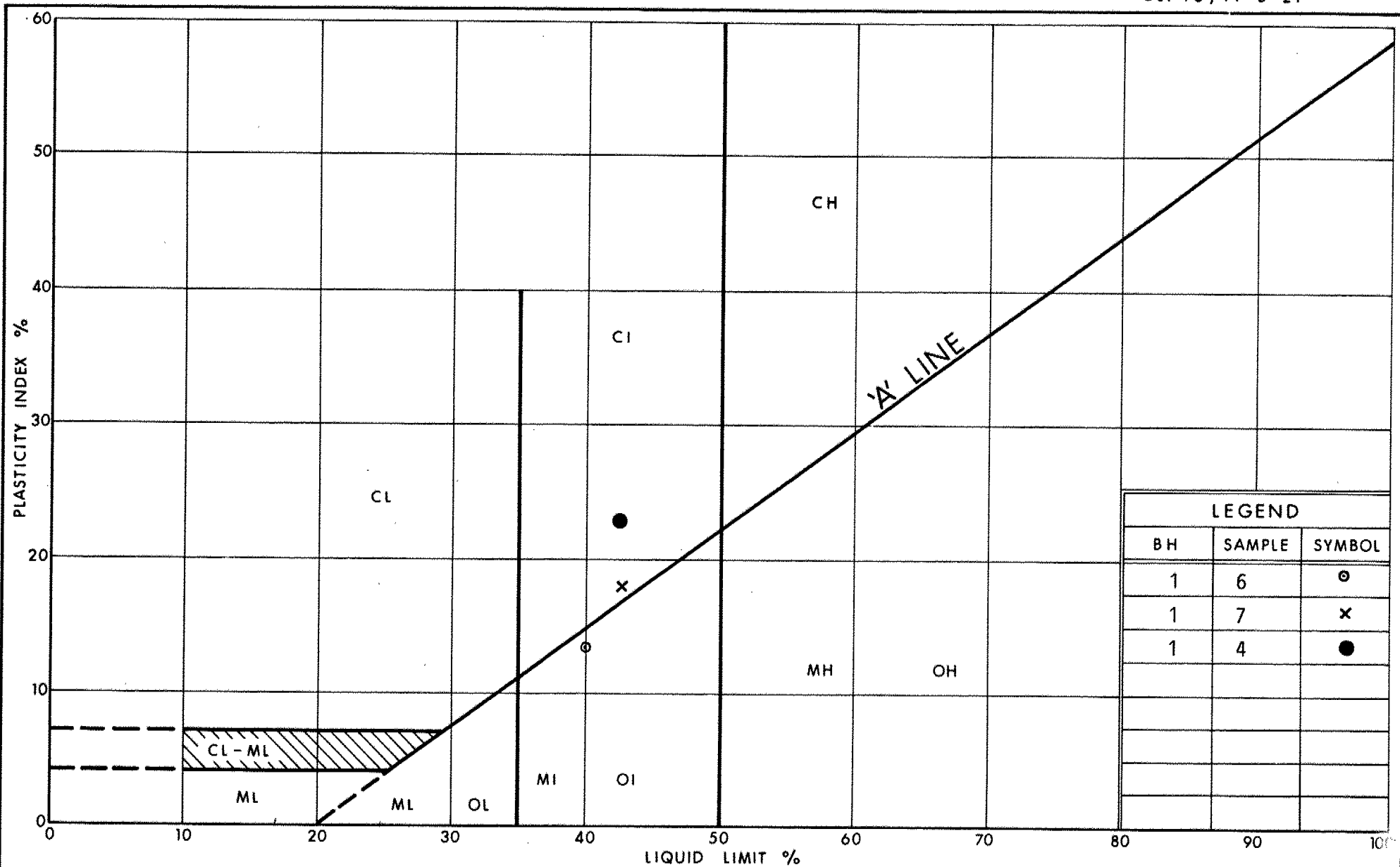

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GRAIN SIZE DISTRIBUTION

SILTY CLAY, TRACE OF SAND AND FINE GRAVEL

FIG No 1

W P 94-83-02

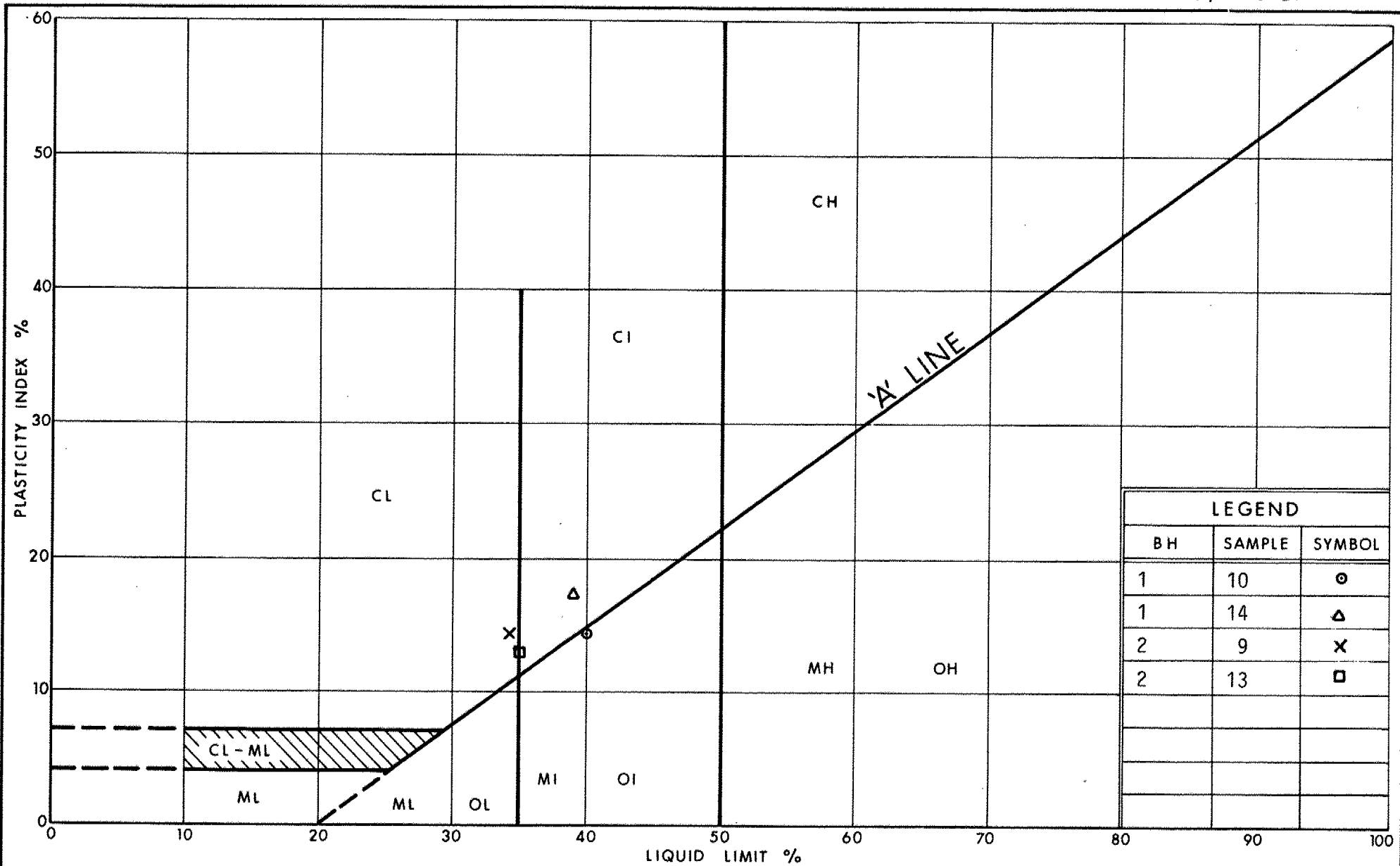


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PLASTICITY CHART SILTY CLAY

FIG No 2

W P 94-83-02



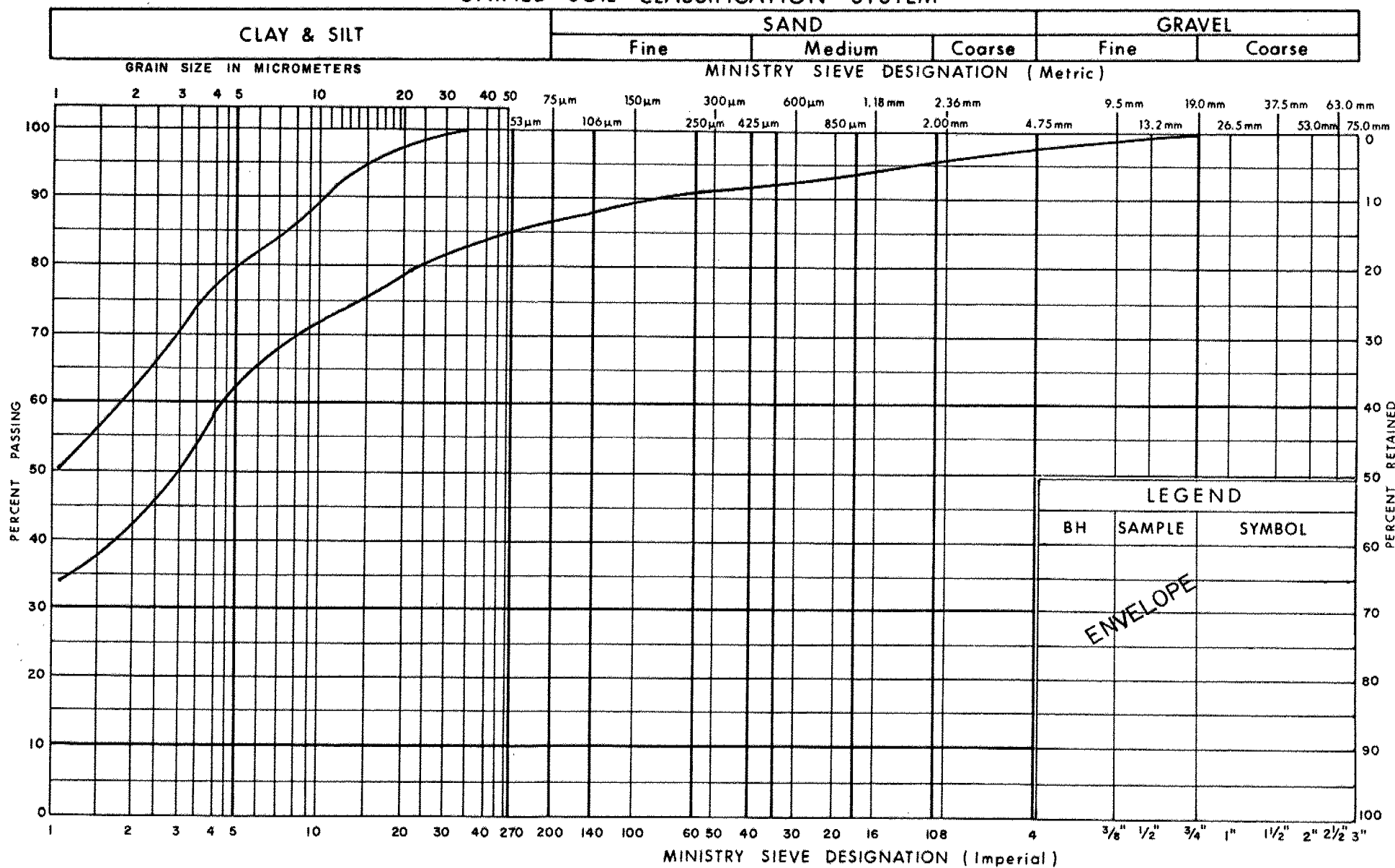
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PLASTICITY CHART SILTY CLAY (TILL)

FIG No 3

W P 94-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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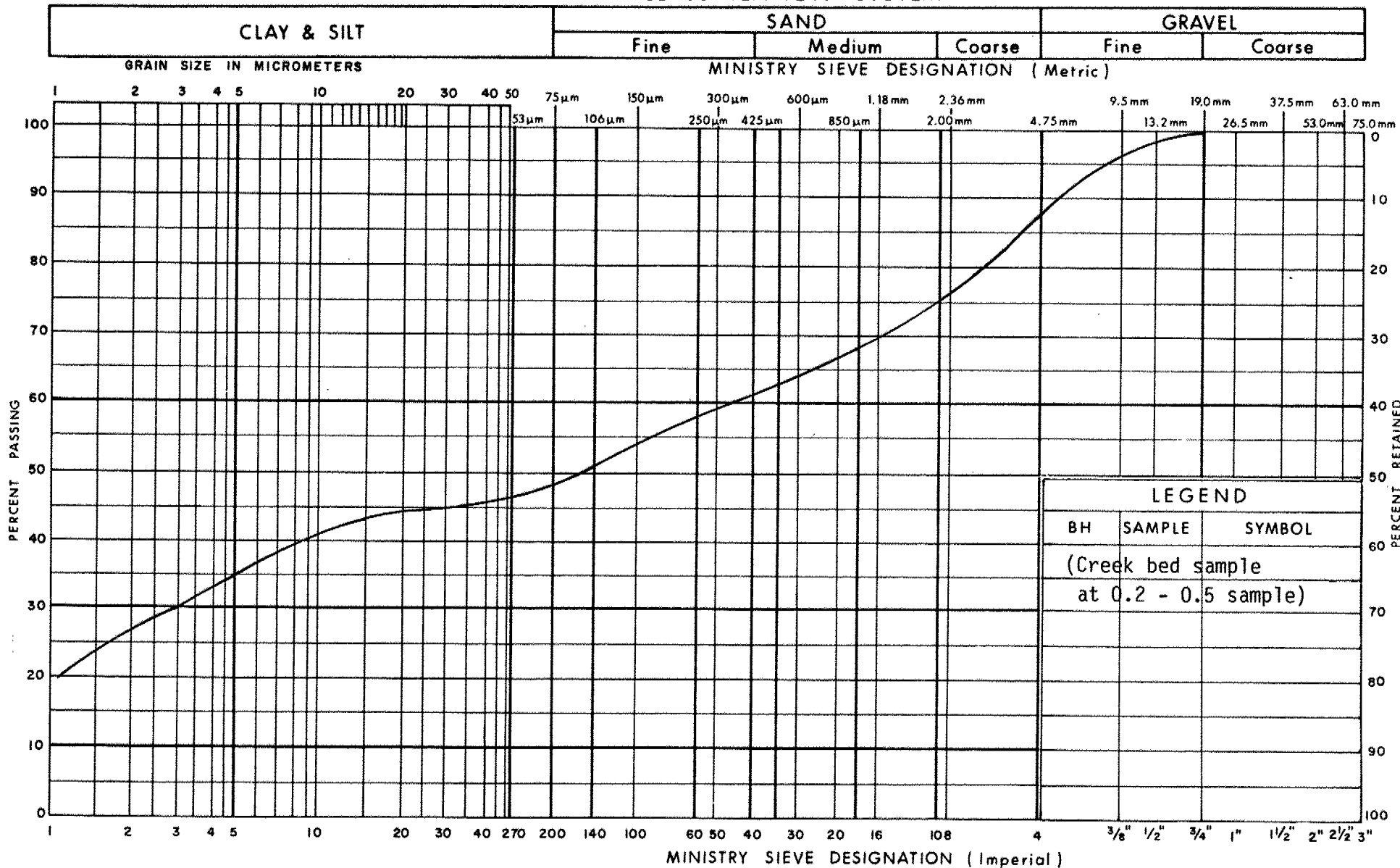
GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)

FIG No 4

W P 94-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
CLAYEY SAND WITH SOME SILT AND GRAVEL

FIG No 5

W P 94-83-02

RECORD OF BOREHOLE No 1

METRIC

W P 94-83-02 LOCATION Sta 17 + 571.5m, 10.2m Lt of E of Hwy 21 ORIGINATED BY MR
DIST 1 HWY 21 BOREHOLE TYPE Hollow stem auger, Rock core, Cone test COMPILED BY SB
DATUM Geodetic DATE Aug. 20th, 1990 CHECKED BY SB

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT		UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	W _p W _L	W _p W _L	W _L		
197.6	Ground surface											
0.0	Topsoil: 20 cm Clayey silt trace of organics, stiff (fill)		1	SS	6						20.6	
195.5			2	SS	15							
2.1			3	SS	16							
	Silty clay sand seams, grey, very stiff		4	SS	26							
			5	SS	23							
			6	SS	24							
192.3			7	SS	18							
5.3			8	SS	22							
	Silty clay grey, very stiff (glacial till)		9	SS	24							
			10	SS	23							
			11	SS	25							
			12	SS	32							
			13	SS	29							
	wet silt seam at 12.8m		14	SS	21							
182.4			15	SS	73							
181.4	Het. mix clay/gravel/ sand (till), hard		16	SS	50/cm							
16.2	SHALE BEDROCK grey, sound, fine, medium spaced bedding, excellent quality		17	BXT	REC 95%							RQD 95%
177.8			18	BXT	REC 100%							RQD 100%
19.8	End of Borehole											
	* W.L. not stabilized											

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 94-83-02 LOCATION Sta 17 + 553.7m, 13.0m Rt of E of Hwy 21 ORIGINATED BY MR
DIST 1 HWY 21 BOREHOLE TYPE Hollow stem auger, Rock core, Cone test COMPILED BY SB
DATUM Geodetic DATE Aug. 21st, 1990 CHECKED BY SB

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	Wp	W	WL	
196.8	Ground surface		1	SS	5		196									
0.0	Clayey silt trace of organics, stiff (fill)		2	SS	11		195.4									
1.4	Silty clay sand seams, very stiff		3	SS	17		194									
			4	SS	21											
192.8			5	SS	16											
4.0			6	SS	21											
	Silty clay grey, very stiff (glacial till)		7	SS	18		192									
			8	SS	18											
			9	SS	20		190									
			10	SS	20											
			11	SS	21		188									
			12	SS	24		186									
	wet silt seam at 11.0m		13	SS	18		184									
182.8			14	SS	23		182									
182.2	Wet mix clay/sand/shale (fill)/hard															
14.6	SHALE BEDROCK grey, sound, fine medium spaced bedding, excellent quality		15	RC BXT	REC 95%		180									
178.5			16	RC BXT	REC 100%											
18.3	End of Borehole * W.L. not stabilized															

+3, x5: Numbers refer to
Sensitivity

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

MC CLYMONT & RAK ENGINEERS, INC.

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C1179

SEPTEMBER 1990

FOUNDATION INVESTIGATION REPORT

CROSSING AT HIGHWAY 21 AND

BLACK CREEK NO. 2

DISTRICT 1 CHATHAM

W.P. 94-83-02 SITE 14-140

CONT 92-02

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DOWNSVIEW, ONTARIO
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MC CLYMONT & RAK ENGINEERS INC.
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GEOTECHNICAL CONSULTANTS

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Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water levels in the open borehole, and in a piezometer installed in Borehole 1. In Borehole 2, the groundwater level, in the open hole, was at 4.0 m depth, Elevation 192.8 m, on completion of drilling. In Borehole 1, the hole was dry prior to coring bedrock. The water in the piezometer, after one day, was at 8.0 m depth, Elevation 189.6 m. The water in the creek was at Elevation 195.5 m. The long term groundwater level is expected to correspond with the creek level. It should be noted that the groundwater is subject to changes with the fluctuations in the creek levels.

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DISCUSSIONS AND RECOMMENDATIONS

It is proposed to upgrade the existing road to the current MTO standards. This requires a replacement of the existing bridge structure. The proposed structure will be a single span, 8.5 to 9.0 m in length, concrete rigid frame or concrete beam structure. The proposed structure will be located at the same location as the existing one, having the same skew. It is proposed to raise the existing grade by about 0.48 m.

The proposed profile grade, in the vicinity of the crossing, will be at approximate Elevation 198.8 m. With an additional fill of 0.48 m, the approach fills will thus have a maximum height of 3.5 m, above the elevation of the creek bottom.

Based on the subsoil conditions, the foundation recommendations for the design of the concrete structure are as follows:

Structure Foundations

The proposed structure can be supported on conventional spread and strip foundations, founded in the very stiff silty clay with sand seams. For purposes of the O.H.B.D.C., the following design values are recommended at the anticipated founding elevations:

Bearing Capacity at S.L.S. Type II (kPa)	Factored Bearing Capacity at U.L.S. (kPa)	Recommended Footing Elevation (m)
200	350	Below 193.8

The footings must be protected against scour. The gradation of the stream-bed sample for scour calculation is given in Figure 5.

Settlement of the foundation subsoil as a result of applied footing pressure will be time dependent in nature. The magnitude of total and differential settlement is expected to be well within the tolerable limits of construction, i.e. 25 and 19 mm respectively, provided the subsoil is not disturbed by construction or related activities. It is recommended that the working slab be placed to protect the founding soil within four hours of exposure.

Resistance to sliding of the footings can be calculated assuming an adhesion value of 100 kpa to apply between the underside of the footings and the founding soil.

Frost Protection

The footings require a minimum of 1.2 m of soil cover for frost protection.

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Approach Fills

The existing grade will be raised by an additional 0.48 m. With the additional load, no stability or settlement problems are anticipated for the approaches to a maximum height of 4.5 m, above the elevation of the creek bottom. Any existing steep slopes can be dressed to 2H to 1V.

Lateral earth pressure

Free draining granular material, such as Granular 'A' or 'B', is recommended as appropriate backfill to the abutment walls, to prevent hydrostatic pressure build-up.

Lateral earth pressures should be computed in accordance with Section 6.6.1.2 of the O.H.B.D.C. The design parameters are as follows:

	Granular 'A'	Granular 'B'
Angle of Internal Friction (degrees)	35	30
Unit Weight (KN\cu.m.)	22.8	21.2

The earth pressure coefficient at rest (K_0) is to be used in design if the structure is rigid and unyielding. An active condition (K_a) may be assumed to apply for a yielding structure.

Dewatering

No major excavation problems are anticipated for footing excavations due to the relatively low permeability of the cohesive foundation soils. However, if localized seepage or surface water do accumulate in excavations, it can be controlled by perimeter ditches and pumping from sumps.

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MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Rusu, Geologist. The equipment was owned and operated by Master Soils Investigations Limited.

The project was carried out under the supervision of S. Bandukwala, Project Engineer. The report was written by S. Bandukwala, and reviewed by L. Rak, Principal Engineer.

Submitted by

MCCLYMONT AND RAK ENGINEERS INC.

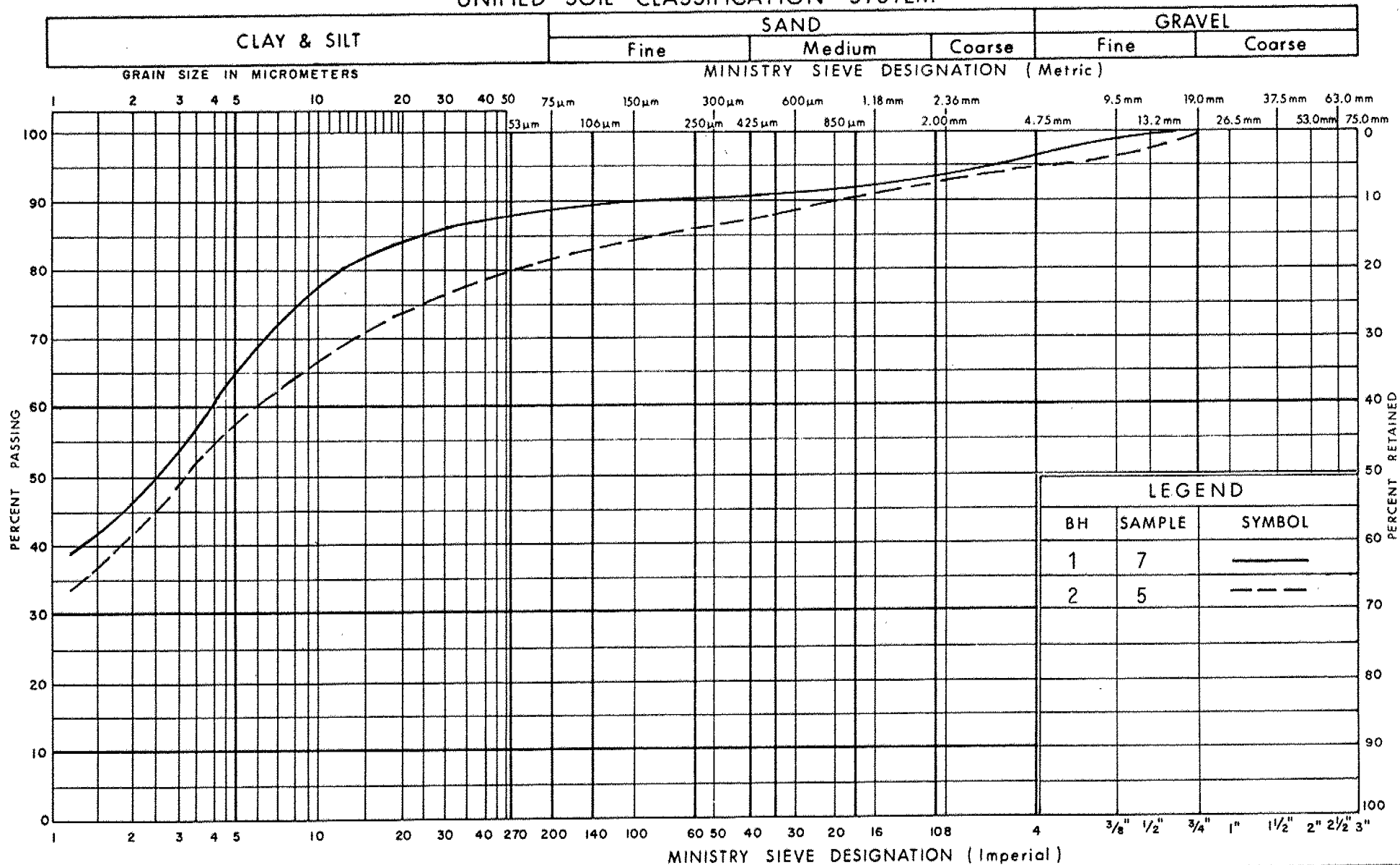


S. Bandukwala

S. Bandukwala, P.Eng.

L. J. Rak
L.J. Rak, P.Eng.

UNIFIED SOIL CLASSIFICATION SYSTEM

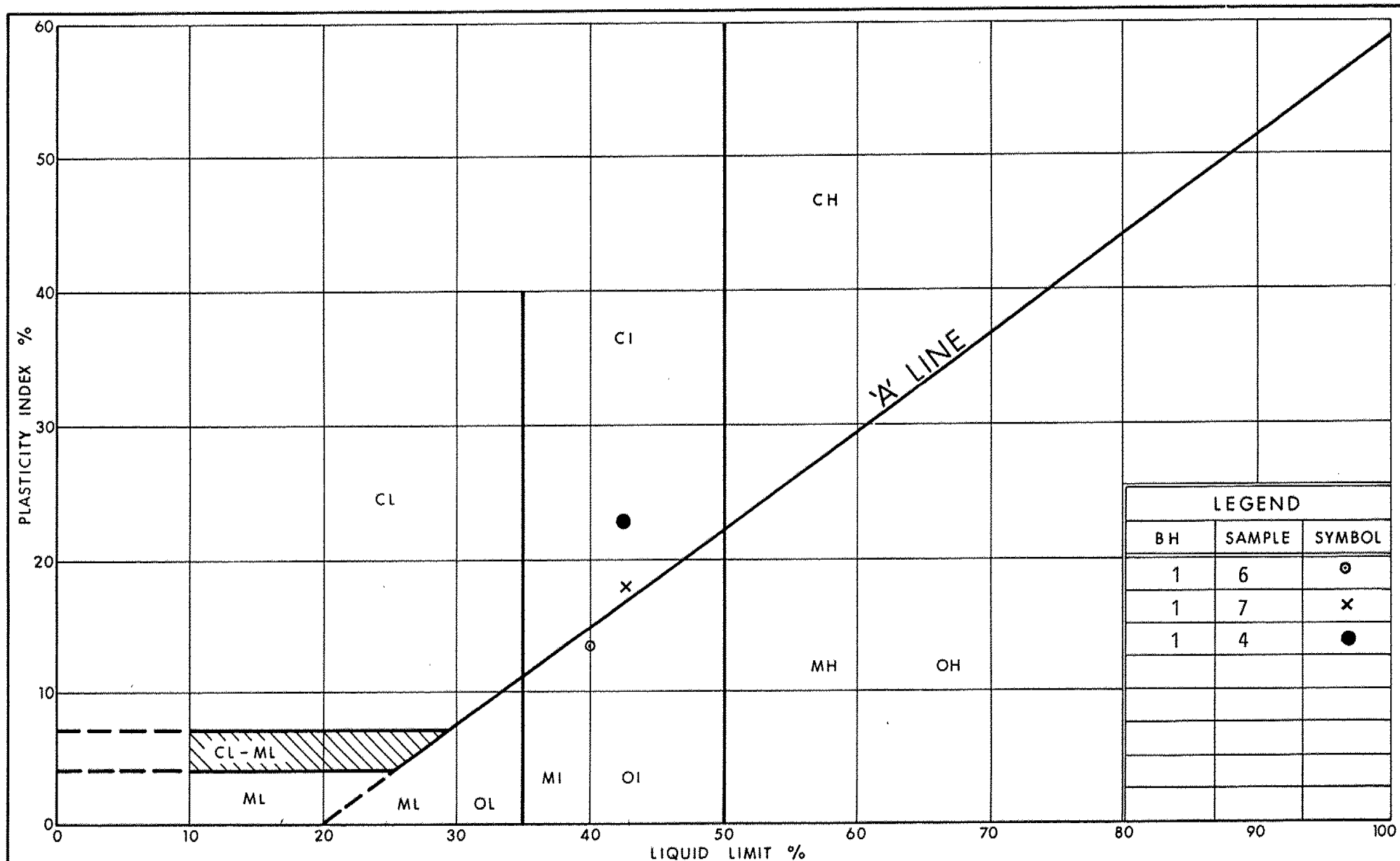


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GRAIN SIZE DISTRIBUTION
SILTY CLAY, TRACE OF SAND AND FINE GRAVEL

FIG No 1

W P 94-83-02



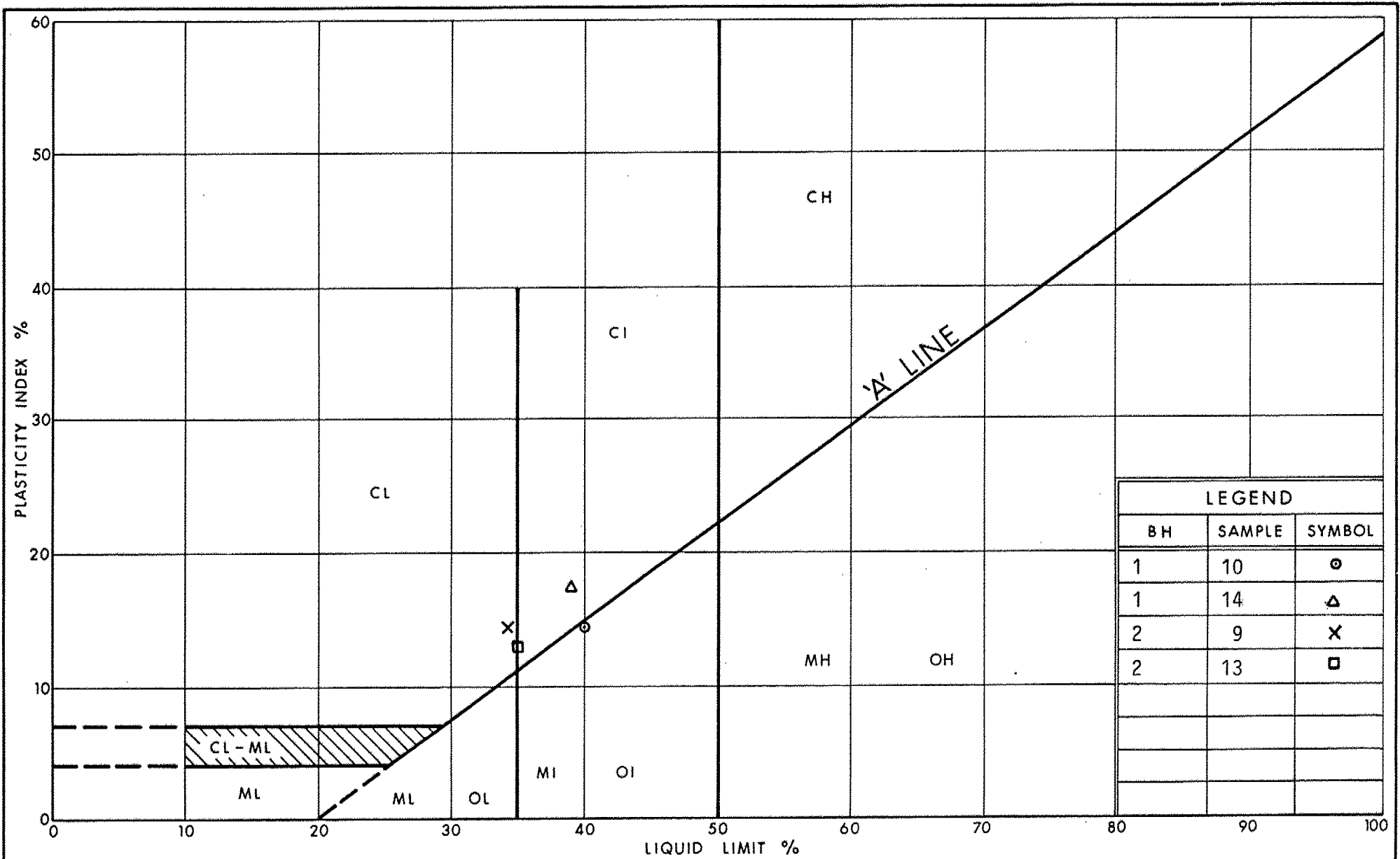
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PLASTICITY CHART SILTY CLAY

FIG No 2

W P 94-83-02



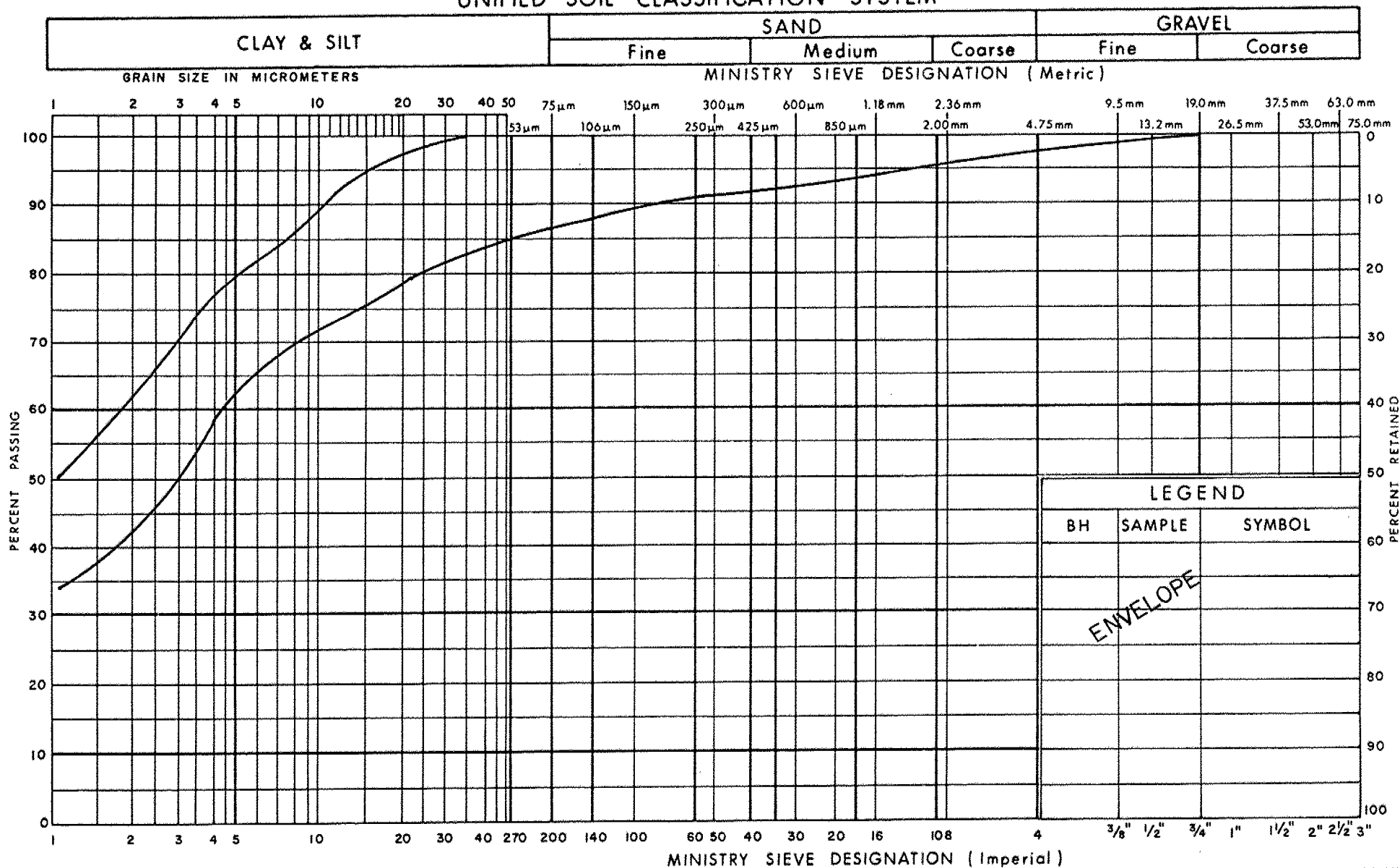
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PLASTICITY CHART SILTY CLAY (TILL)

FIG No 3

W P 94-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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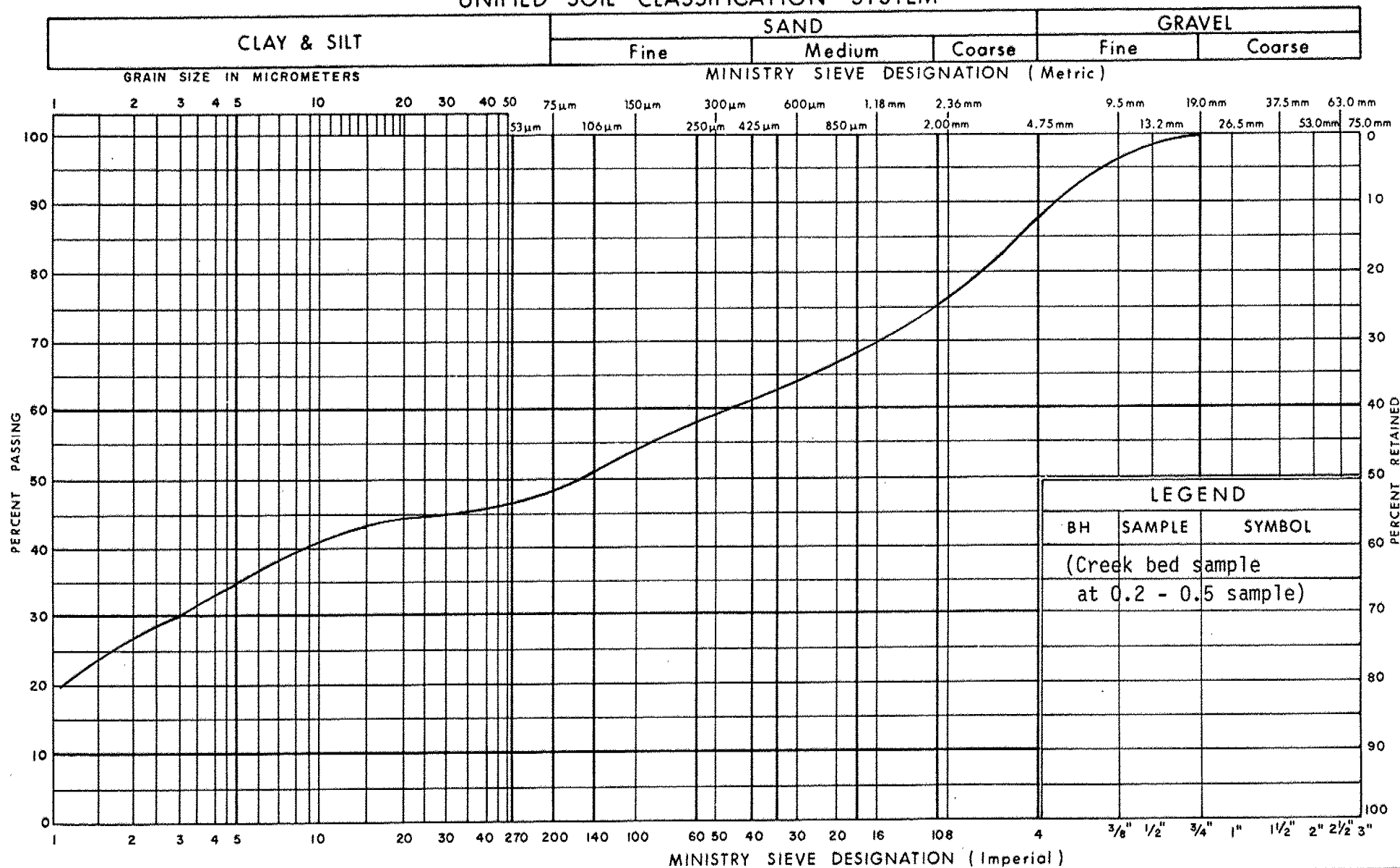
GRAIN SIZE DISTRIBUTION

SILTY CLAY (TILL)

FIG No 4

W P 94-83-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
CLAYEY SAND WITH SOME SILT AND GRAVEL

FIG No 5

W P 94-83-02

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

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

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						

RECORD OF BOREHOLE No 1

METRIC

W P 94-83-02 LOCATION Sta 17 + 571.5m, 10.2m Lt of E of Hwy 21 ORIGINATED BY MR
DIST 1 HWY 21 BOREHOLE TYPE Hollow stem auger, Rock core, Cone test COMPILED BY SB
DATUM Geodetic DATE Aug. 20th, 1990 CHECKED BY SB

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	W VALUES			20	40	60	80	100				
197.6	Ground surface															
0.0	Topsoil: 20 cm Clayey silt trace of organics, stiff (fill)		1	SS	6		197								20.6	
195.5			2	SS	15											
2.1			3	SS	16											
	Silty clay sand seams, grey, very stiff		4	SS	26		195								21.0	0 0 53 47
			5	SS	23											
			6	SS	24											
192.3			7	SS	18		193								21.0	3 8 43 46
5.3			8	SS	22											
			9	SS	24											
	Silty clay grey, very stiff (glacial till)		10	SS	23		191									
			11	SS	25		189									
			12	SS	32		187									
			13	SS	29		185									
	wet silt seam at 12.8m		14	SS	21		183									
182.4			15	SS	73		181									
15.2	Ret.mix clay/gravel/ sand (till), hard		16	SS	50/Gcm											
181.4			17	BXT	95%		179									
16.2	SHALE BEDROCK grey, sound, fine, medium spaced bedding, excellent quality		18	BXT	100%											
177.8																
19.8	End of Borehole															
	* W.L. not stabilized															

RECORD OF BOREHOLE No 2

METRIC

W P 94-83-02 LOCATION Sta 17 + 553.7m, 13.0m Rt of E of Hwy 21 ORIGINATED BY MR
DIST 1 HWY 21 BOREHOLE TYPE Hollow stem auger, Rock core, Cone test COMPILED BY SB
DATUM Geodetic DATE Aug. 21st, 1990 CHECKED BY SB

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			20 40 60 80 100	100					
196.8	Ground surface												
0.0	Clayey silt trace of organics, stiff (fill)		1	SS	5							20.1	
195.4			2	SS	11								
1.4	Silty clay sand seams, very stiff		3	SS	17								
			4	SS	21								
192.8			5	SS	16							21.2	5 14 39 42
4.0			6	SS	21								
	Silty clay grey, very stiff (glacial till)		7	SS	18							20.9	
			8	SS	18								
			9	SS	20								
			10	SS	20							20.9	2 9 46 43
			11	SS	21								
			12	SS	24							21.2	
			13	SS	18								
	wet silt seam at 11.0m		14	SS	23								
182.8			15	RC BXT	REC 95%								RQD 95%
182.2	Her mix clay/sand/shale (fill)/hard		16	RC BXT	REC 100%								RQD 100%
14.6	SHALE BEDROCK grey, sound, fine medium spaced bedding, excellent quality												
178.5													
18.3	End of Borehole												
	* W.L. not stabilized												

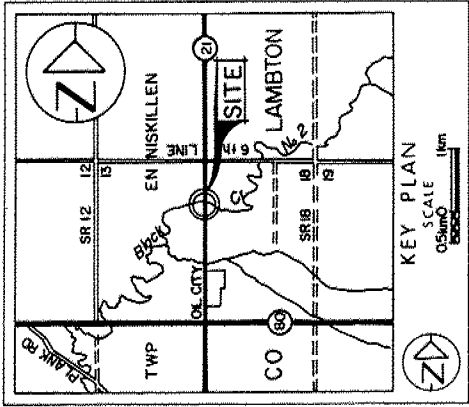
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DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 94-83-02

BLACK CREEK No2

BORE HOLE LOCATIONS & SOIL STRATA

MC CLYMONT & RAK ENGINEERS, INC.



- LEGEND
- Bore Hole
 - Dynamic Cone Penetration Test (Cone)
 - Bore Hole & Cone
 - N Blows/0.3m [Std Pen Test, 475 J/blow]
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - WL at time of investigation Aug 1990
 - PIEZOMETER

No	ELEVATION	STATION	OFFSET
1	197.6	17 + 571.5	10.2m LT
2	196.8	17 + 553.7	13.0m RT

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

NOTE: The complete foundation investigation and design report this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

DATE BY DESCRIPTION

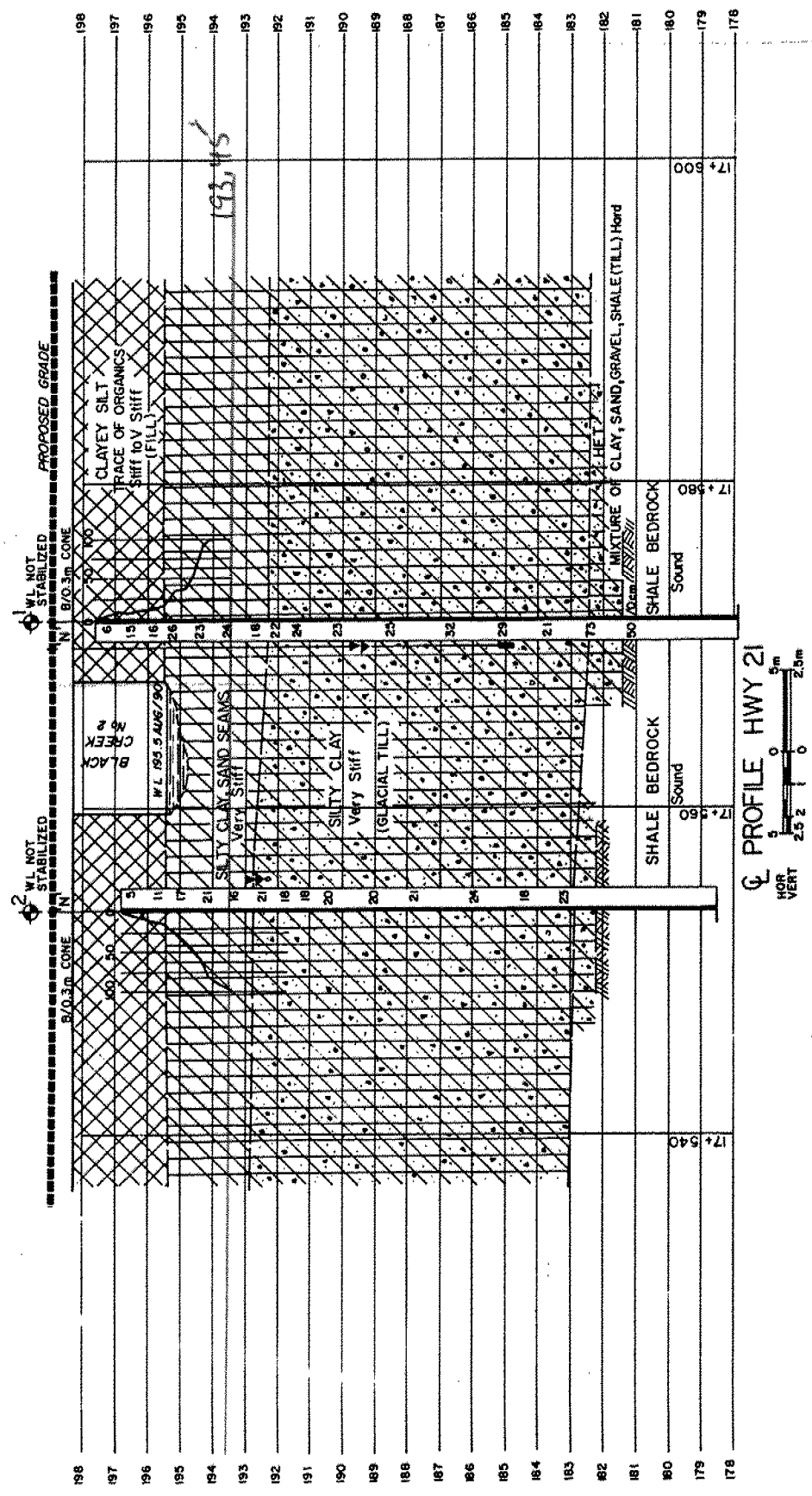
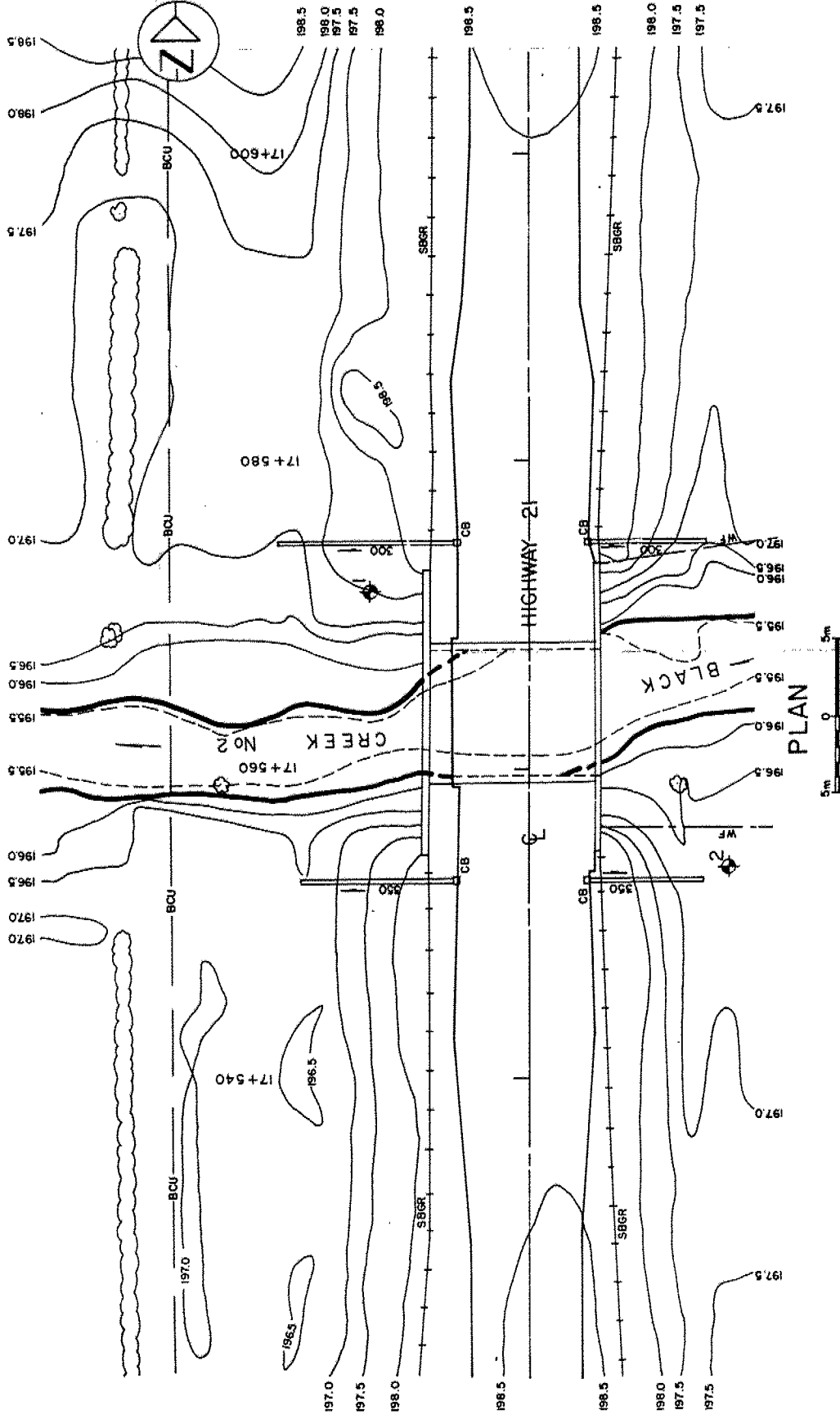
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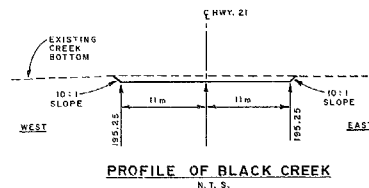
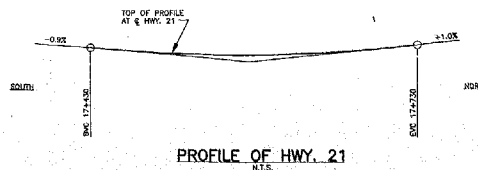
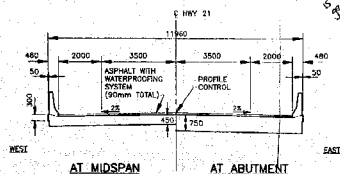
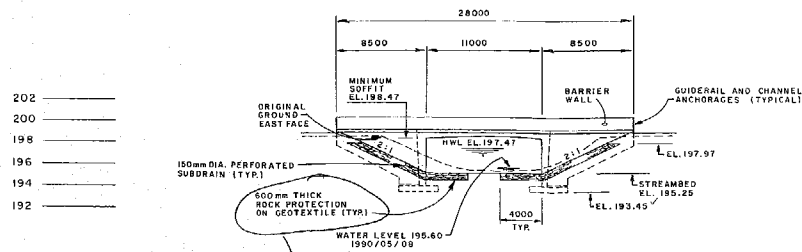
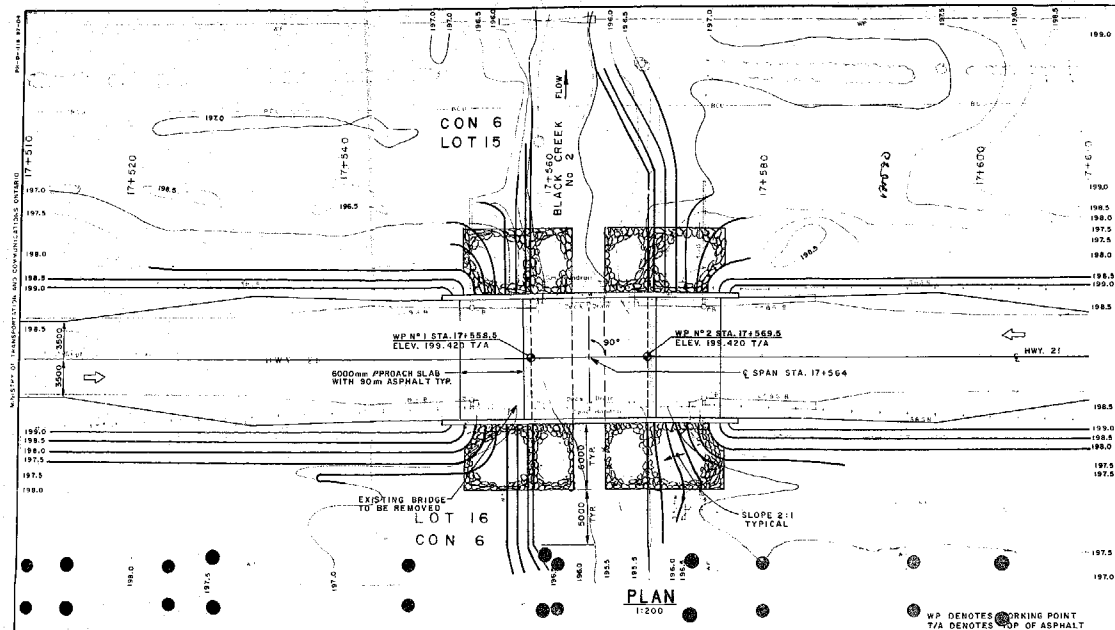
HWY No 21
SUBMID SB
DRAWN ER

CHECKED SB
DATE Sept 14, 1990
ER

SITE 14-140
DWG 948302-A

DIST 1





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

DIST No 1
CONT No 94-83-02
WP No ~~260-66-06~~

BLACK CREEK BRIDGE
HWY. 21
GENERAL ARRANGEMENT

**TODGHAM
& CASE
ASSOCIATES
INC.**

Consulting Civil Engineers
Chatham, Ontario

NOTES

- | | |
|---|------------------------------|
| 1. CLASS OF CONCRETE | 30 MPa |
| 2. CLEAR COVER TO REINFORCING STEEL | |
| FOOTINGS | 100±25 |
| ABUTMENTS AND WINGWALLS | |
| FRONT FACE | 80±20 |
| BACK FACE | 70±20 |
| DECK | |
| TOP | 70±20 |
| BOTTOM | 50±10 |
| REMAINDER | 70±20 UNLESS OTHERWISE NOTED |
| 3. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX "C" DENOTE COATED BARS. | |

CONSTRUCTION NOTES:

- a) FALSEWORK SUPPORTING WING WALLS TO REMAIN IN PLACE UNTIL CONCRETE IN DECK SLAB HAS REACHED 20 MPa COMPRESSIVE STRENGTH.
- b) NO BACKFILL BEHIND ABUTMENT SHALL BE PLACED UNTIL AFTER DECK SLAB HAS REACHED 20 MPa COMPRESSIVE STRENGTH.
- c) PLACE BACKFILL SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING HEIGHTS OF BACKFILL WITHIN 600mm DIFFERENTIAL BEHIND BOTH ABUTMENTS.
- d) FALSEWORK SUPPORTING THE DECK SHALL BE REMOVED UNTIL AFTER THE BACKFILL HAS BEEN PLACED BEHIND THE ABUTMENTS TO AT LEAST THE ELEVATION OF NATIVE BACKFILL.

LIST OF DRAWINGS

14-140/1 GENERAL ARRANGEMENT

- ① Why Bearing Capacity Reduction
- ② Coexistent to loose Rock
- ③ Temporary Overturn to facilitate excavation of Footings
- ④ Reels for Fullwork can be derived from Foundation report
- ⑤ Temporary Overturn to facilitate struts

REVISIONS									