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GEOCRES No. 4079-19

DIST. 32 REGION

W.P. No. 163-96-01

CONT. No.

W. O. No.

STR. SITE No. 13-38&C

HWY. No. 21

LOCATION Hwy 21 & Molly Creek Tributary

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP	163-96-01	DIST	32
HWY	21	STR SITE	14-388C

Molly Creek Tributary Culvert Replacement

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GEOCRES 40J9-19

DATE NOV 20 1996

FOUNDATION INVESTIGATION REPORT
For
Molly Creek Tributary Culvert Replacement
W.P. 163-96-01, Site 14-388C
Highway 21, District 32, Chatham

INTRODUCTION

This report contains the results of a foundation investigation carried out at the crossing of Highway 21 and Molly Creek Tributary. The fieldwork was carried out between 1996 07 23 and 25, and comprised of two sampled boreholes and Dynamic Cone Penetration Test adjacent to both of these holes.

Boreholes were advanced to a maximum depth of 13.9 m (El. 168.0) below the existing highway shoulder level using 82 mm I.D. continuous flight hollow stem auger and BW casing.

SITE DESCRIPTION

The site under investigation is located approximately 1.0 km north of Highway 78 at the crossing of Highway 21 and Molly Creek Tributary in the Township of Gore of Camden, County of Kent.

The topography of the site is generally undulating with cultivated farm lands. Physiographically, the area is located in the region known as the "St. Clair Clay Plain". Adjoining Lake St. Clair in Essex and Kent Counties and the St. Clair River in Lambton County are extensive clay plains covering several hundred square kilometres. Glacial Lake Whittlesey which deeply covered all of these lands and subsequent to this Lake Warren covered nearly the whole area. Most of Lambton and Kent Counties, therefore are essentially till plains smoothed by shallow deposits of lacustrine clay. Limestone underlies Essex County and the adjacent part of Kent, while the remainder of the region is underlain by a black shale. The site is located in an area where glacial process have deposited a mantle of clayey till over a shale bedrock.

SUBSURFACE CONDITIONS

The underlying subsoil at this site consists of 1.1 m to 2.1 m stiff to firm clayey silt fill. However, on the east side of the road, the upper 1.5 m consists of granular fill. This is underlain by 7.3 m to 9.0 m stiff to soft silty clay to clayey silt which overlies hard heterogeneous mixture of clayey silt, sand and gravel (glacial till). For classification purposes, the soils encountered at this site can be divided into three different zones.

a) Clayey Silt (Fill)
b) Silty Clay to Clayey Silt
c) Heterogeneous Mixture of Clayey Silt, Sand & Gravel (Glacial Till)

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. The location of the boreholes is shown on Drawing No. 1639601-A. A stratigraphical section is shown on Drawing No. 1639601-B. Description of the strata encountered are given below.

Clayey Silt (Fill)

This fill which was placed to raise the finished grade of Highway 21 was encountered in both boreholes and consists of stiff to firm clayey silt. However, the borehole located on the east side of the road indicates presence of granular fill down to about 1.5 m below the ground level. The thickness of this fill varies from 1.1 m to 2.1 m and extends to elevations 180.9 and 180.8. The Standard Penetration Test results were observed to vary between 5 blows/0.3 m and 18 blows/0.3 m .

Silty Clay to Clayey Silt

The fill is underlain by this silty clay to clayey silt. Thickness of this clayey deposit varies from 7.3 m to 9.0 m and extends to elevations 173.6 to 171.8. The natural moisture content of this deposit varies from 21.5% to 41.5% with an average value of 31.3%. The results of the Atterberg Limit Test are shown on Figure 1. In-situ vane shear strength in this deposit varies over a wide range from a minimum of 19 kPa to a maximum of 96 kPa indicating soft to stiff consistency. However, Standard Penetration Test values were observed to vary from 2 blows/0.3 m to 12 blows/0.3 m.

The bulk density from a undisturbed sample was observed to be in the order of 18.4 kN/m^3 and corresponding dry density being 13.1 kN/m^3. The results of the Consolidation Test carried out to determine the compressibility characteristics of this deposit are shown on Figures 2 and 3. Test results indicate that this deposit is slightly over consolidated with preconsolidation pressure of 133 kPa compared to an effective over burden pressure of 80 kPa.

The void ratio was observed to be in the order of 1.36 and corresponding compression index Cc being 0.54. Compression ratio Cc/(1 + eo) determined for this sample falls at 0.23.

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

The upper boundary of this glacial till deposit was encountered between elevations 173.6 and 171.8. Results of the Atterberg Limit Test are shown on Figure 4. Gradation Test results are shown on Figure 5 in an envelope form. These results indicate 4% to 9% gravel, 18% to 37% sand and 59% to 73% clayey silt. The Standard Penetration Test results indicate hard consistency (N values 81 blows/0.3 m to over 100 blows/0.3 m) The full extent of this deposit was not proven below elevation 168.0.

Groundwater Conditions

Groundwater was not encountered in both boreholes and the holes were dry upon completion. However, the water level in the tributary was observed at about elevation 179.2.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to replace the existing culvert at the crossing of Molly Creek Tributary and Highway 21 due to its state of deterioration. The new structure will be a closed concrete box culvert 5.0 m x 2.0 m in size with a profile grade elevation of 182.4. We understand that a local detour will be used for the traffic during construction, and the new structure will be constructed along the same horizontal and vertical alignment as the existing culvert.

The existing structure is a single cell, 4.88 m x 1.83 m open type culvert. The total length of the culvert is about 20.4 m with a profile grade elevation of 182.4. The information provided to us by the Structural Section, Southwestern Region indicate that the culvert was built in the early 1930's and supported on spread footings.

Transverse cracks varying in width from a minimum of 10 mm to a maximum of 20 mm were observed at three locations. These cracks which can be seen from inside of the culvert are wider near the invert than at the roof, and generally extend at an angle from the foundation to the full height of the culvert. Two of the cracks are located on the north wall, and are approximately 6.0 m apart. The first crack is located approximately 1.8 m from the west end of the culvert. The third crack is located on the south wall approximately 7.6 m from the west end.

The borehole data indicated that the compressible silty clay to clayey silt strata on the west side of the road is 1.7 m thicker than that on the east side. The difference in thickness often results in differential settlement. The differential settlement of the culvert may have contributed to the cracks described above.

Structure Foundation

The Consolidation Test results indicated that the silty clay to clayey silt strata is slightly over consolidated with preconsolidation pressure of 133 kPa compared to effective over burden pressure of 80 kPa. Considering the subsoil conditions and the type of replacement structure, it is recommended that the culvert be placed at an elevation of about 178.5, and designed assuming the following bearing pressures.

Factored Bearing Pressure at U.L.S.	=	100 kPa
Bearing Pressure at S.L.S.	=	80 kPa

The culvert invert should have a minimum of 1.2 m earth cover to protect against the frost penetration.

Lateral Earth Pressure

Earth pressure should be computed as per Section 6.7.4.5 of the O.H.B.D.C., and "at rest" condition may be assumed for the calculation of earth pressure on culvert. The Granular "A" or "B" backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	Granular 'A'	Granular 'B'
Angle of Internal Friction	$\phi = 35^0$	$\phi = 30^0$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

Approach Embankment

We understand that the finished grade of the replacement culvert will be identical to that of the existing (ie El. 182.4). No major instability problems are anticipated for the approach embankment constructed with 2H:1V side slope. The fill should consist of well compacted acceptable material. Any spongy or soft area observed within the base width of the embankment should be removed before placing the fill.

Other Considerations

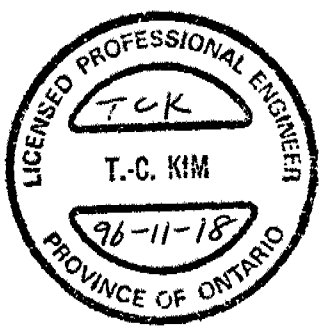
The backfill operations should be carried out simultaneously on both sides of the culvert. Compaction of the backfill should adhere to the Ministry Directive B-131.

The tributary may have to be diverted to facilitate the construction of the culvert. However, in view of the impervious nature of the subsurface conditions at this site, no major dewatering problems are anticipated. Any minor seepage or surface run-off into the excavation may be readily handled by pumping from the sump. Care shall be exercised during the construction to prevent any flow of water from the river into the excavation.

MISCELLANEOUS

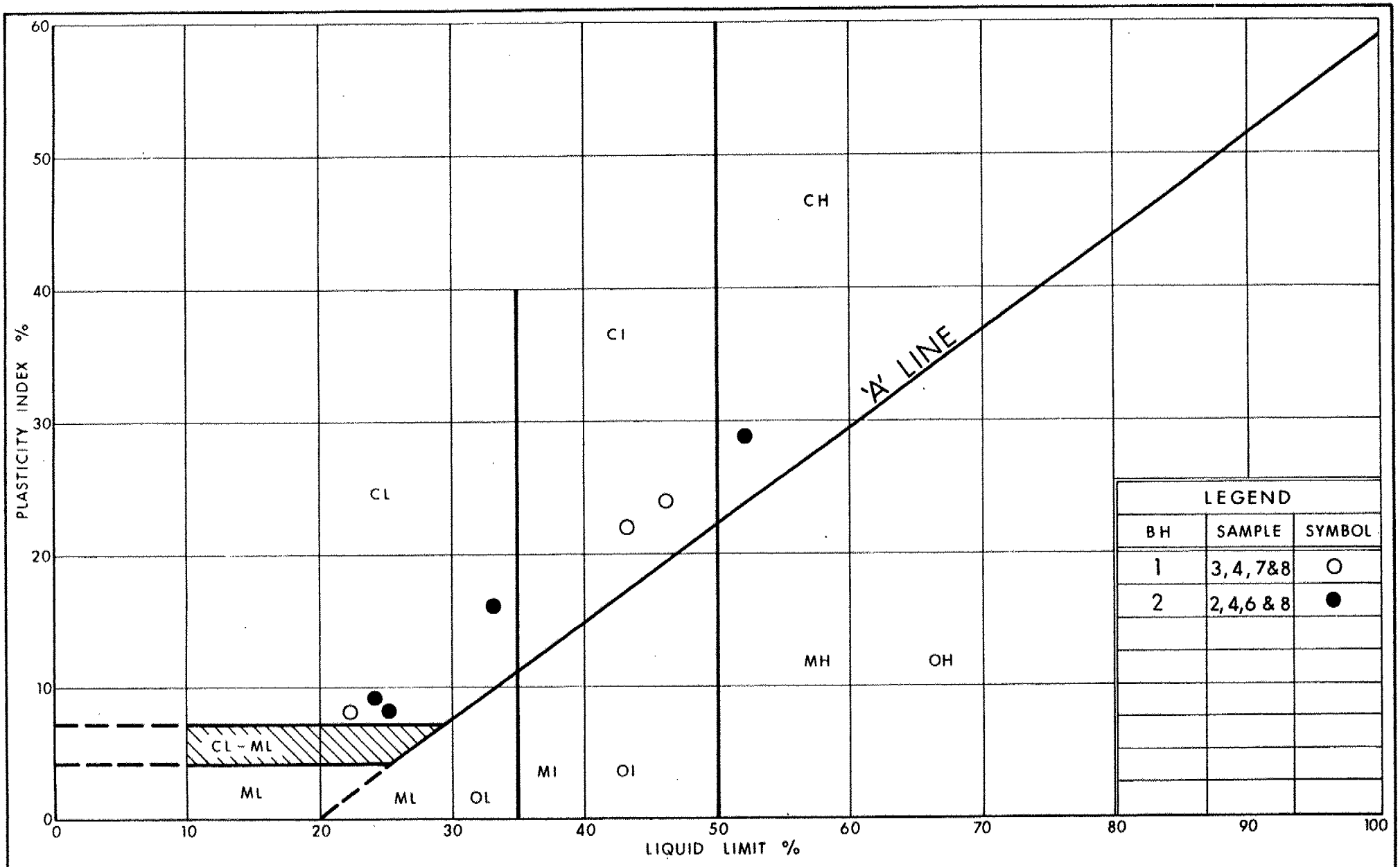
The fieldwork for this investigation was carried out under the supervision of M. Vasavithasan, Foundation Engineer and Lizette Viera, Engineering Student. The equipment used was owned and operated by London Soil Test Limited. This report was prepared by M. Vasavithasan, Foundation Engineer and reviewed by Tae C. Kim, Sr. Foundation Engineer.

M. Vasavithasan, P. Eng.
Foundation Engineer



Tae C. Kim, P. Eng.
Senior Foundation Engineer

APPENDIX



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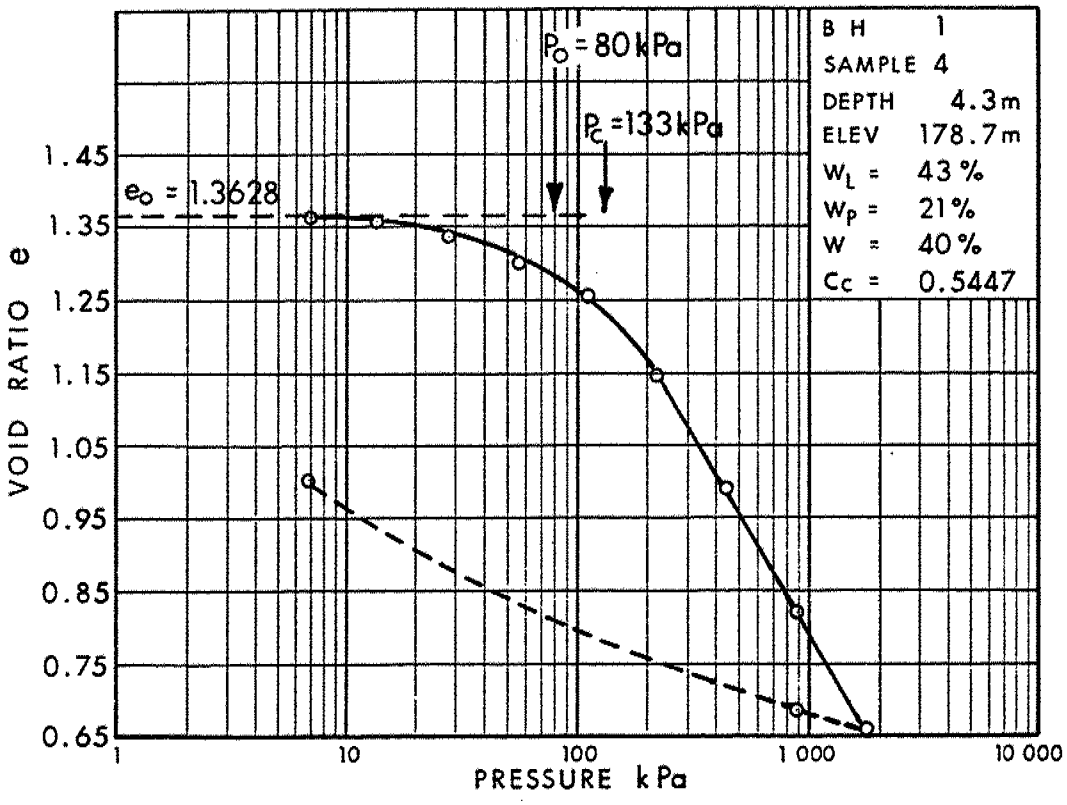
PLASTICITY CHART
SILTY CLAY TO CLAYEY SILT

FIG No 1
W P 163-96-01

VOID RATIO - PRESSURE CURVES



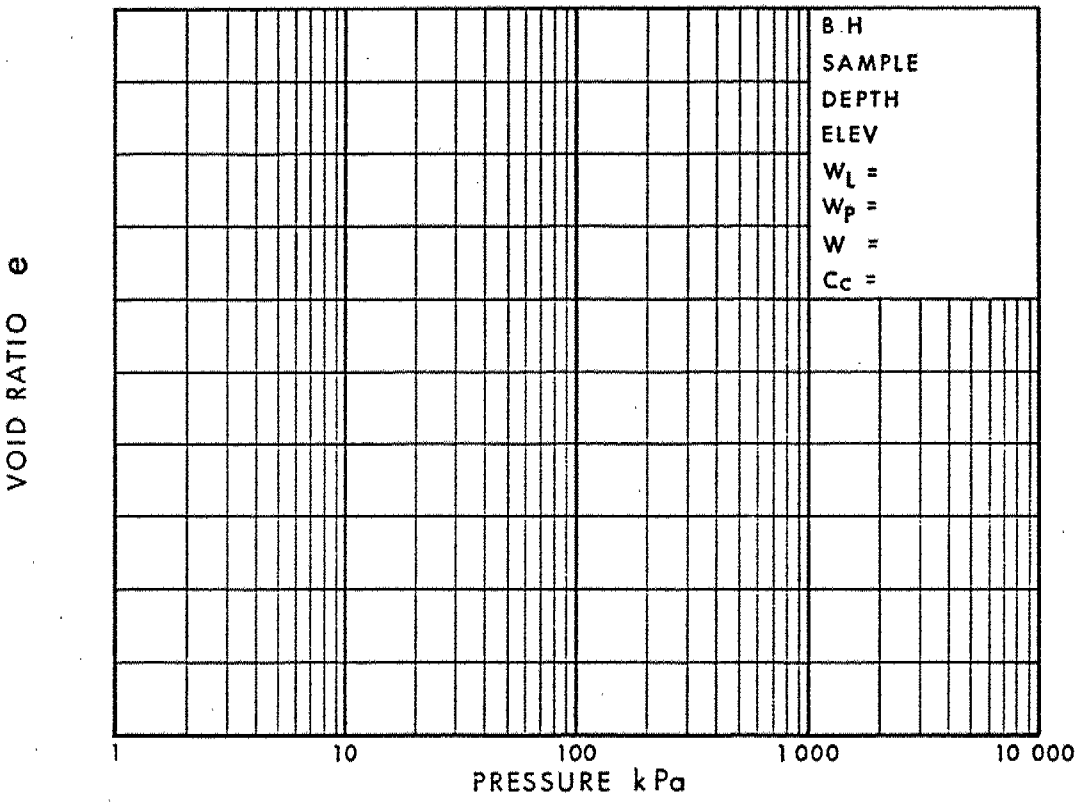


Fig 2 WP 163-96-01

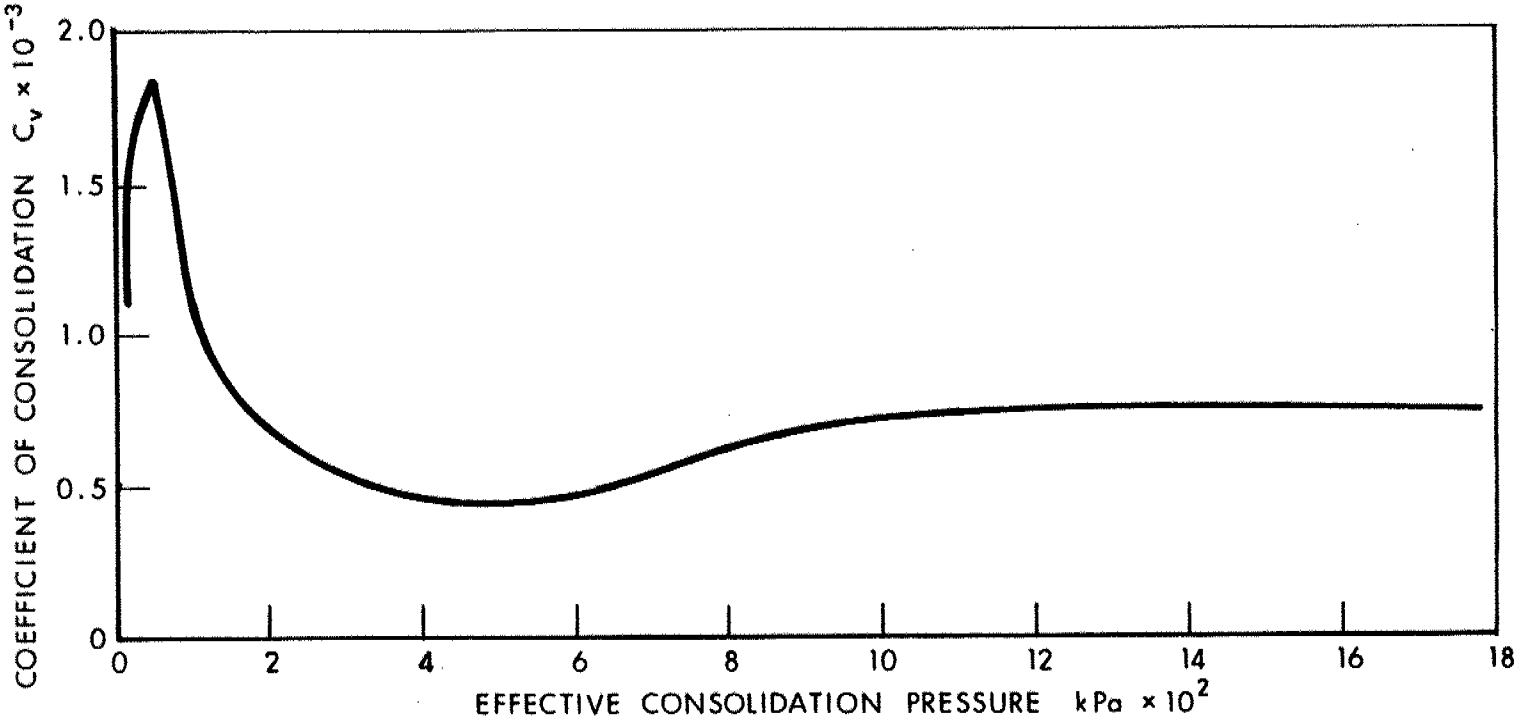
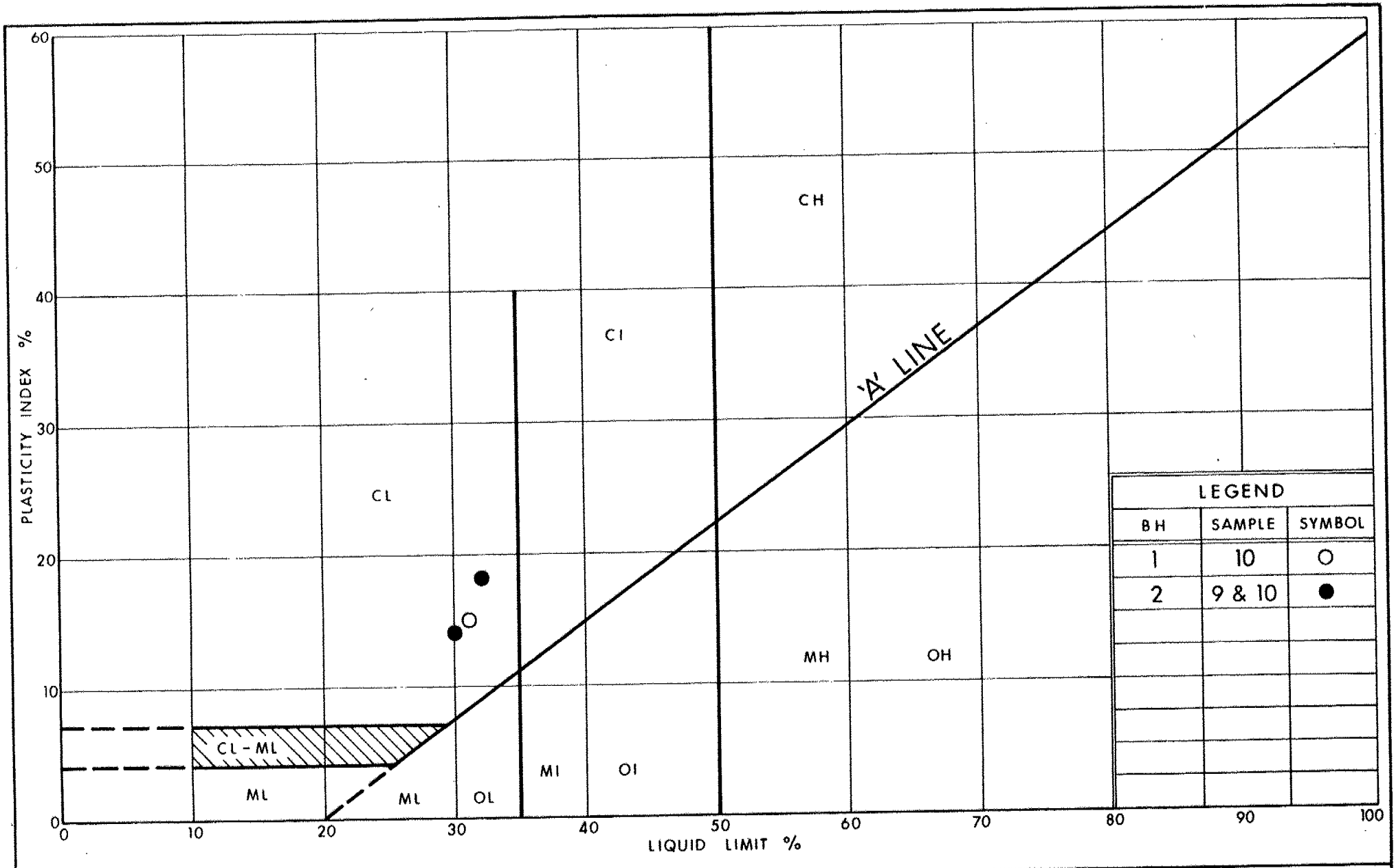


Figure No 3

WP 163 - 96 - 01



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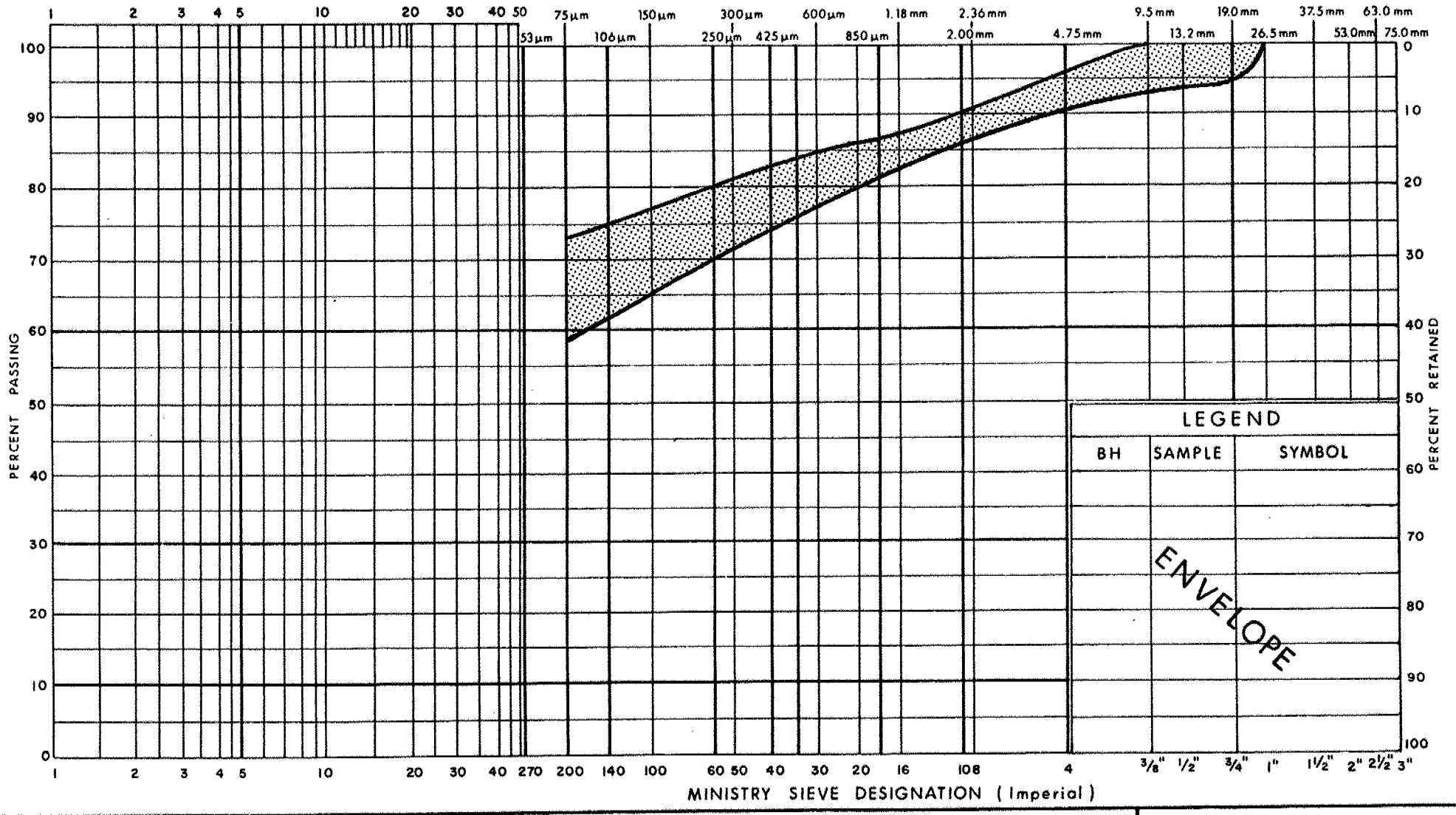
PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4
W P 163-96-01

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 5

W P 163-96-01

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. 163 - 96 - 01 LOCATION STA. 30 + 411.4; O/S 7.3 m RT ℄ HWY. 21 ORIGINATED BY M V&L V

DIST 32 HWY 21 BOREHOLE TYPE HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1996 07 24 & 25 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
183.0	Ground Surface						
0.0	Gravelly Sand, Some Silt					DRY *	
	Sandy Silt, Tr. Gravel		1	SS	18		182
	CLAYEY SILT, Occasional Organics, Firm (Fill)		2	SS	5		181
180.9							
2.1	Stiff		3	SS	9		180
			4	TW	PH		179
	SILTY CLAY TO CLAYEY SILT, Soft to Firm		5	SS	2		178
			6	SS	2		177
	Some Sand, Trace of Gravel		7	SS	3		176
173.6							175
9.4			8	SS	12		174
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Occasional Boulders, Hard (Glacial Till)		9	SS	174 /28cm		173
			10	SS	89		172
169.5							171
							170
13.5	End of Borehole						

* Borehole Dry on Completion

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ kN/m³

18.4

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Pc = 133 kPa
Cc = 0.54
e = 1.36

9 18 (73)

120/8cm

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 163 - 96 - 01 LOCATION STA. 30 + 439.4; O/S 7.3 m LT ℄ HWY. 21 ORIGINATED BY M V&L V

DIST 32 HWY 21 BOREHOLE TYPE HOLLOW STEM AUGER, BW CASING & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1996 07 23 & 24 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
181.9	Ground Surface						
0.0	Topsoil					DRY *	
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff (Fill)		1	SS	7		
180.8							
1.1	Stiff		2	SS	10		
			3	SS	8		
			4	SS	4		
	SILTY CLAY TO CLAYEY SILT, Soft to Firm		5	SS	2		
			6	SS	2		
	With Sand, Trace of Gravel		7	SS	12		
171.8			8	SS	11		
10.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Occasional Boulders, Hard (Glacial Till)		9	SS	119		
			10	SS	81		
168.0							
13.9	End of Borehole * Borehole Dry on Completion						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

	GR	SA	SI	CL
8	5	32		(63)
9	4	37		(59)
10	7	20		(73)

120/ 23cm

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

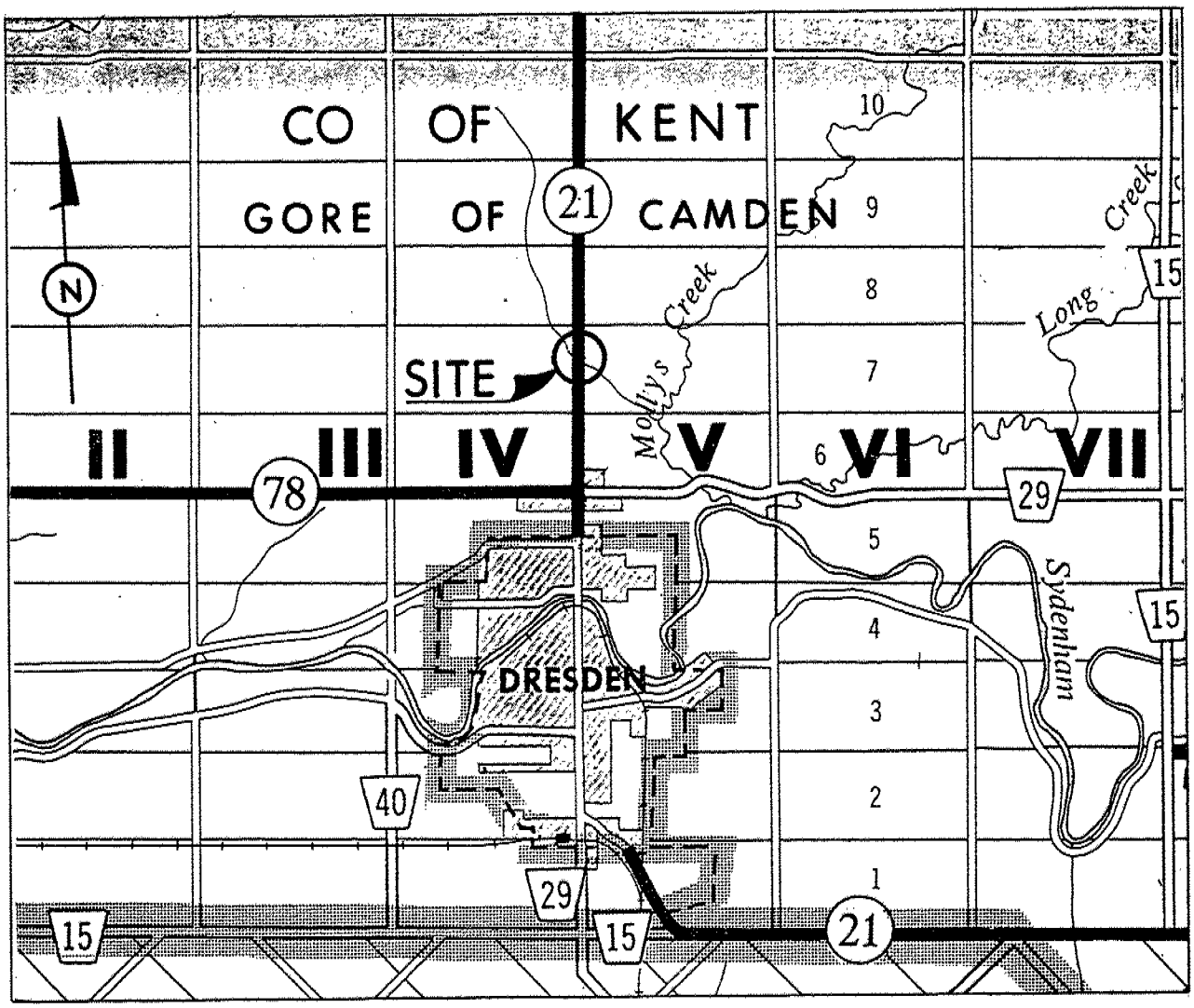
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_U	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_S	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $w_L - w_P$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL				k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL	e_{max}	1,%	VOID RATIO IN LOOSEST STATE			

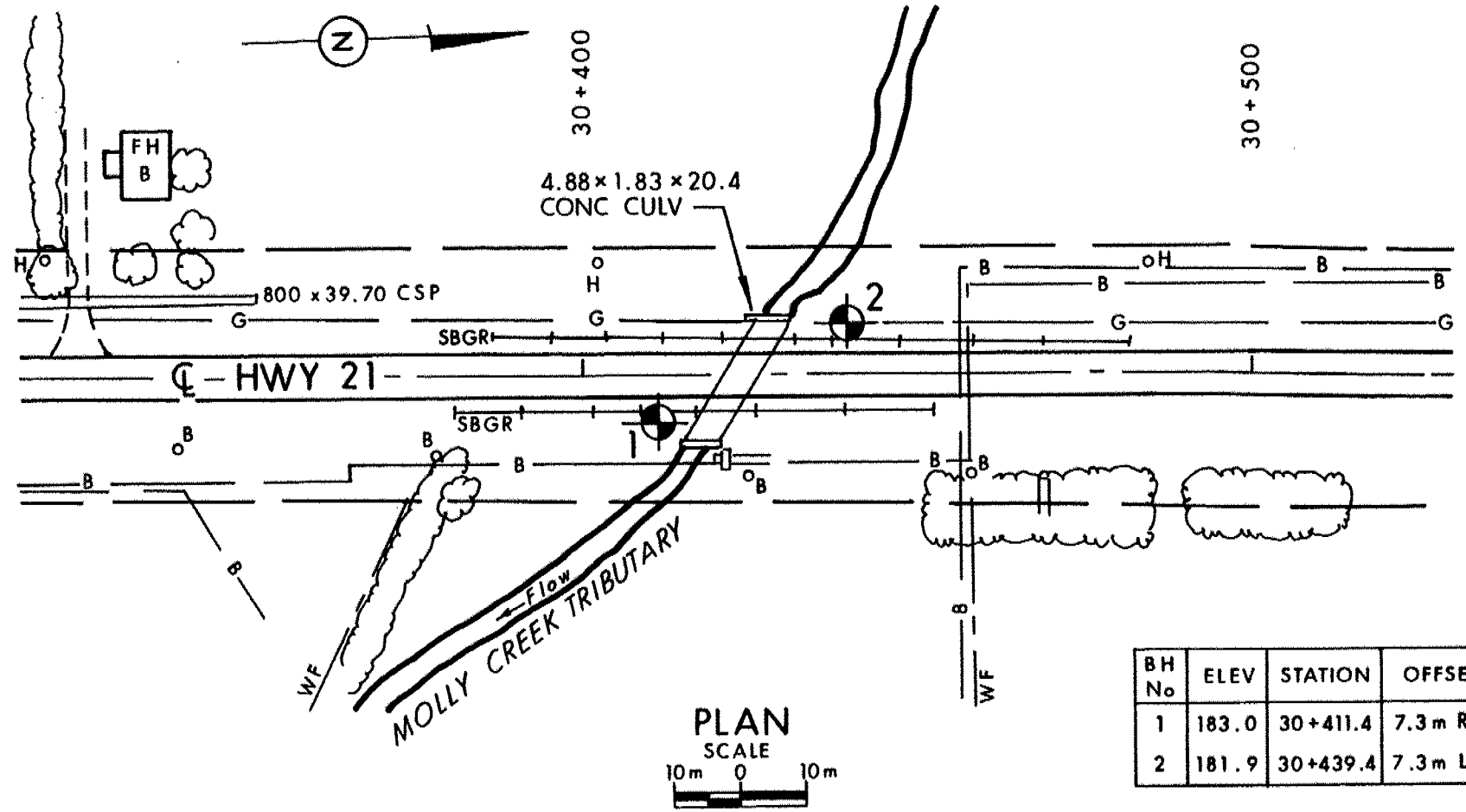


KEY PLAN

SCALE

1 km 0 1 km

WP 163-96-01



PLAN
SCALE
10m 0 10m

BH No	ELEV	STATION	OFFSET
1	183.0	30+411.4	7.3m RT
2	181.9	30+439.4	7.3m LT

LEGEND

BORE HOLE & CONE

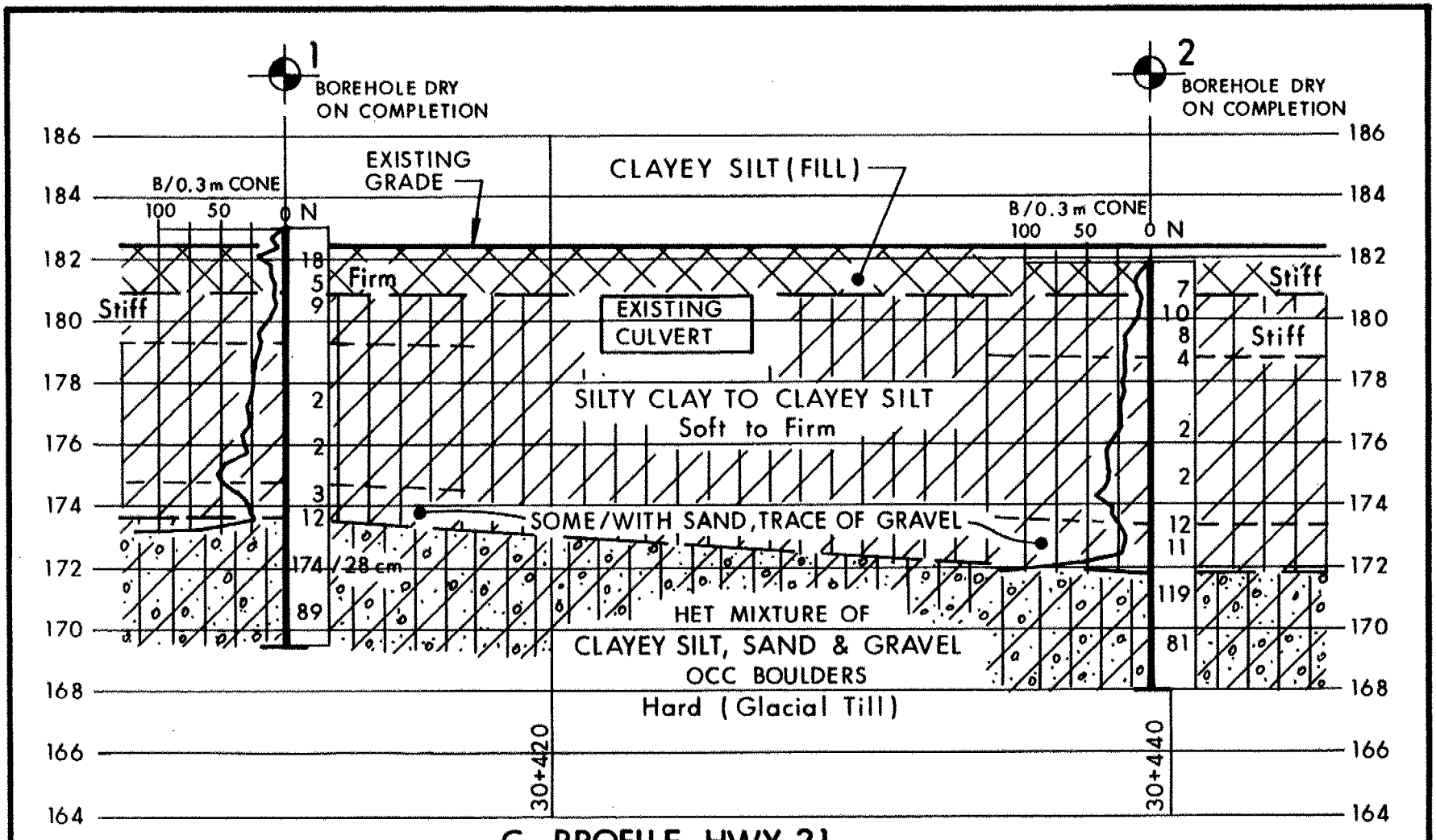
NOTE

FOR PROFILE REFER TO DWG 1639601-B

REF No ETR PLATE No's 101-21/32 & 33 Rev 84-02

MOLLY CREEK TRIBUTARY
CULVERT REPLACEMENT

HWY 21 DIST 32 SITE 13-388C
WP 163-96-01 DATE 1996 10 30
Geocres No 40J9-19 DWG 1639601-A



℄ PROFILE HWY 21

SCALE
2m 0 2m

LEGEND

BORE HOLE & CONE

NOTE

FOR PLAN REFER TO DWG 1639601-A

MOLLY CREEK TRIBUTARY
CULVERT REPLACEMENT

HWY 21 DIST 32 SITE 13-388C
WP 163-96-01 DATE 1996 10 30
Geocres No 40J9-19 DWG 1639601-B

MEMORANDUM

Ontario

To: A. Ho
Head, Structural Section
Southwestern Region

Date: September 19, 1996

From: Pavements & Foundations Section
Room 315, Central Building

Tel: 235-3731
Fax: 235-5240

Atten: John Schaefer, P. Eng.
Senior Structural Engineer

Re: Molly Creek Tributary Culvert Replacement
W.P. 163-96-01, Site 14-388C
Highway 21, District 32, Chatham

The fieldwork for this project was carried out between 1996 07 23 and 07 25. Since the fieldwork and laboratory tests have been completed, a preliminary recommendation is submitted to enable you to proceed with the design. The final report will be submitted at a later date when the 'E' plan becomes available. For your information, borehole log sheets are attached to this memorandum.

Fieldwork comprised of two sampled boreholes and Dynamic Cone Penetration Test adjacent to these holes. Boreholes were advanced to a maximum depth of 13.9 m (El. 168.0) below the existing highway shoulder level using 82 mm I.D. continuous flight hollow stem auger and BW casing.

The site under investigation is located approximately 1.0 km north of Highway 78 at the crossing of Highway 21 and Molly Creek Tributary in the Township of Gore of Camden, County of Kent.

The topography of the site is generally undulating with cultivated farm lands. Physiographically, the area is located in the region known as the "St. Clair Clay Plain". Adjoining Lake St. Clair in Essex and Kent Counties and the St. Clair River in Lambton County are extensive clay plains covering several hundred square kilometres. Glacial Lake Whittlesey which deeply covered all of these lands and subsequent to this Lake Warren covered nearly the whole area. Most of Lambton and Kent Counties, therefore are essentially till plains smoothed by shallow deposits of lacustrine clay. Limestone underlies Essex County and the adjacent part of Kent, while the remainder of the region is underlain by a black shale. The site is located in an area where glacial processes have deposited a mantle of clayey till over a shale bedrock.

The underlying subsoil at this site consists of 1.1 m to 2.1 m stiff to firm fill consists of clayey silt. However, on the east side of the road, the upper 1.5 m consist of granular fill. The fill is underlain by 7.3 m to 9.0 m stiff to soft silty clay to clayey silt which overlies hard heterogeneous mixture of clayey silt, sand and gravel (glacial till).

Groundwater was not encountered in boreholes. However, the water level in the tributary was observed at about elevation 179.2.

The existing structure is a single cell, 4.88 m x 1.83 m open type culvert. Total length of the culvert is about 20.4 m with a profile grade elevation of 184.2. The information provided to us by the Structural Section, Southwestern Region indicate that the culvert was built in the early 1930's and supported on spread footings.

Transverse cracks varying in width from a minimum of 10 mm to a maximum of 20 mm were observed at three locations. These cracks which can be seen from inside of the culvert are wider near the invert than at the roof, and generally extend at an angle from the foundation to the full height of the culvert. Two of the cracks are located on the north wall, and the cracks are approximately 6.0 m apart. The first crack is located approximately 1.8 m from the west end of the culvert. The third crack is located on the south wall approximately 7.6 m from the west end. The differential settlement of the culvert caused by the variation in thickness (1.7 m) of the compressible clayey strata have contributed to the cracks described above.

The approach embankment appear in good condition. However, the reinforcement of the roof has been exposed and corroded at several locations. In addition, voids have been created at the underside of the roof as well as on the walls due to the spalling of concrete.

Recommendations

It is proposed to replace the existing culvert at the crossing of Molly Creek Tributary and Highway 21 due to its state of deterioration. The new structure will be a closed concrete box culvert 5.0 m x 2.0 m in size with a profile grade elevation of 182.4. We understand that a local detour will be used for the traffic during construction and the new structure will be constructed along the same horizontal and vertical alignment as the existing culvert.

The consolidation test results indicate that the silty clay to clayey silt strata is slightly over consolidated with preconsolidation pressure of 133 kPa compared to effective over burden pressure of 80 kPa.

Considering the subsoil conditions, it is recommended that the culvert be placed at about elevation 178.5 and designed assuming the bearing pressures as follows:

Factored Bearing Pressure at U.L.S. = 100 kPa
Bearing Pressure at S.L.S. = 80 kPa

The culvert invert should have a minimum of 1.2 m earth cover to protect against the frost penetration.

Earth pressure should be computed as per Section 6.7.4.5 of the O.H.B.D.C., and "at rest" condition may be assumed for the calculation of earth pressure on culvert. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	Granular 'A'	Granular 'B'
Angle of Internal Friction	$\phi = 35^0$	$\phi = 30^0$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

We understand that the finished grade of the replacement culvert will be identical to that of the existing (ie. El. 184.2). No major instability problems are anticipated for the approach embankment constructed with 2H:1V side slope. The fill should consist of well compacted acceptable material. Any spongy or soft area observed within the base width of the embankment should be removed before placing the fill.

The backfill operations should be carried out simultaneously on both sides of the culvert. Compaction of the backfill should adhere to the Ministry Directive B-131.

The tributary may have to be diverted to facilltate the construction of the culvert. However, in view of the impervious nature of the subsurface conditions at this site, no major dewatering problems are anticipated at this site. Any minor seepage or surface run-off into the excavation may be readily handled by pumping from the sump. Care shall be exercised during the construction to prevent any flow of water from the river into the excavation.

We believe that this memorandum meets with your requirements. If you have any questions or need clarification, please contact this office.

Vasavithasan

M. Vasavithasan, P. Eng.
Foundation Engineer
for
Tae C. Kim, P. Eng.
Sr. Foundation Engineer

MV/mmj

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 163 - 96 - 01 LOCATION STA. 30 + 411.4; O/S 7.3 m RT ℄ HWY. 21 ORIGINATED BY M V&L V

DIST 32 HWY 21 BOREHOLE TYPE HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1996 07 24 & 25 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
183.0	Ground Surface						
0.0	Gravelly Sand, Some Silt					DRY *	
	Sandy Silt, Tr. Gravel		1	SS	18		182
	CLAYEY SILT, Occasional Organics, Firm (Fill)		2	SS	5		181
180.9							
2.1	Stiff		3	SS	9		180
			4	TW	PH		179
	SILTY CLAY TO CLAYEY SILT, Soft to Firm		5	SS	2		178
			6	SS	2		177
	Some Sand, Trace of Gravel		7	SS	3		176
173.6			8	SS	12		175
9.4	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Occasional Boulders, Hard (Glacial Till)		9	SS	174 /28cm		174
			10	SS	89		173
169.5							172
							171
							170
13.5	End of Borehole						

* Borehole Dry on Completion

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH kPa — ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) — 15 30 45

UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
18.4	Pc = 133 kPa Cc = 0.54 e = 1.36
	9 18 (73)

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 163 - 96 - 01 LOCATION STA. 30 + 439.4; O/S 7.3 m LT ℄ HWY. 21 ORIGINATED BY M V&L V

DIST 32 HWY 21 BOREHOLE TYPE HOLLOW STEM AUGER, BW CASING & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 1996 07 23 & 24 CHECKED BY T C K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.9	Ground Surface						
0.0	Topsoil					DRY *	
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff (Fill)		1	SS	7		
180.8							
1.1	Stiff		2	SS	10		
			3	SS	8		
			4	SS	4		
	SILTY CLAY TO CLAYEY SILT, Soft to Firm		5	SS	2		
			6	SS	2		
	With Sand, Trace of Gravel		7	SS	12		
			8	SS	11		5 32 (63)
171.8							
10.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Occasional Boulders, Hard (Glacial Till)		9	SS	119		4 37 (59)
			10	SS	81		7 20 (73)
168.0							
13.9	End of Borehole * Borehole Dry on Completion						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
• QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

ELEVATION SCALE: 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169

+3 at 178; +6 at 177; +5 at 176; +2 at 174; 120/23cm at 172

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%) 15 30 45

UNIT WEIGHT γ kN/m^3

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE