

REMARKS: \_\_\_\_\_



Ministry of  
Transportation and  
Communications

FILE No. \_\_\_\_\_ DATE \_\_\_\_\_

REMARKS \_\_\_\_\_

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# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 89-11



Ministry of  
Transportation and  
Communications



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Note: For purposes of the contract this report supersedes all other Foundation Reports prepared by or for the Ministry in connection with the above mentioned project.

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_a$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kn/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kn/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kn/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kn/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT  
For  
Highway 401, London  
W.P. 139-86-00, High Mast Lighting  
District 2, London

INTRODUCTION

This report contains the results of a foundation investigation conducted at the above mentioned site on 88 11 15, 88 11 16 and 88 12 28. The fieldwork consisted of a borehole together with a dynamic cone penetration test at each of the three proposed high mast lighting locations. The borings were advanced by a truck mounted auger machine equipped with hollow stem augers.

SITE DESCRIPTION

The high mast lights are located at the Highway 401 and Wellington Road Interchange. The site is relatively flat and consists of fill overlying silty clay. According to Chapman and Putnam (1984), the site lies on the north edge of the "Mount Elgin Ridges". It is composed largely of calcareous clay or silty clay.

SUBSURFACE CONDITIONS

General

At each of the high mast light locations, the subsoil consists of fill overlying clayey silt to silty clay. Underlying the clayey silt to silty clay, there is silty sand. The fill consists mostly of clayey silt, however, at BH #C-3-12 silty sand overlies the clayey silt.

The boundaries of the different deposits together with the field and laboratory test results are shown on the Record of Borehole sheets found in the Appendix of this report. Figure 1 shows the locations of the boreholes. A description of the strata encountered is provided below.

### Silty Sand (fill)

A 0.9 m layer of loose silty sand fill overlies the clayey silt fill in BH #C-3-12. This silty sand is partially composed of winter sand depositions.

### Clayey Silt, trace of Sand, Gravel and Organics (fill)

A 3.7 to 6.7 m thick layer of stiff to hard clayey silt fill overlies clayey silt to silty clay. This layer is dry with the moisture content near the plastic limit. The sand, gravel and organic content varies within this layer. In situ shear strengths vary from 84 kPa to greater than 115 kPa. The consistency ranges from firm to very stiff.

### Clayey Silt to Silty Clay

A 9.5 to 10.5 m thick layer of clayey silt to silty clay underlies the fill. This layer is stiff to hard. Occasional zones of plastic silt occur at the bottom of this layer. Silt content increases with depth. This layer was easier to penetrate or auger though below the water table.

### Silty Sand

Borehole #C-3-12 was terminated in very dense silty sand. The silty sand starts at El. 246.5 m.

### Groundwater

The groundwater elevations at the time of the investigation were:

BH #C-1-12	-	Borehole was dry
BH #C-2-12	El. 251.2	10.0 m below ground level
BH #C-3-12	El. 251.7	9.7 m below ground level

The groundwater level could vary with the season.



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Senior Foundation Engineer

*M. Devata*  
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Chief Foundation Engineer

## APPENDIX



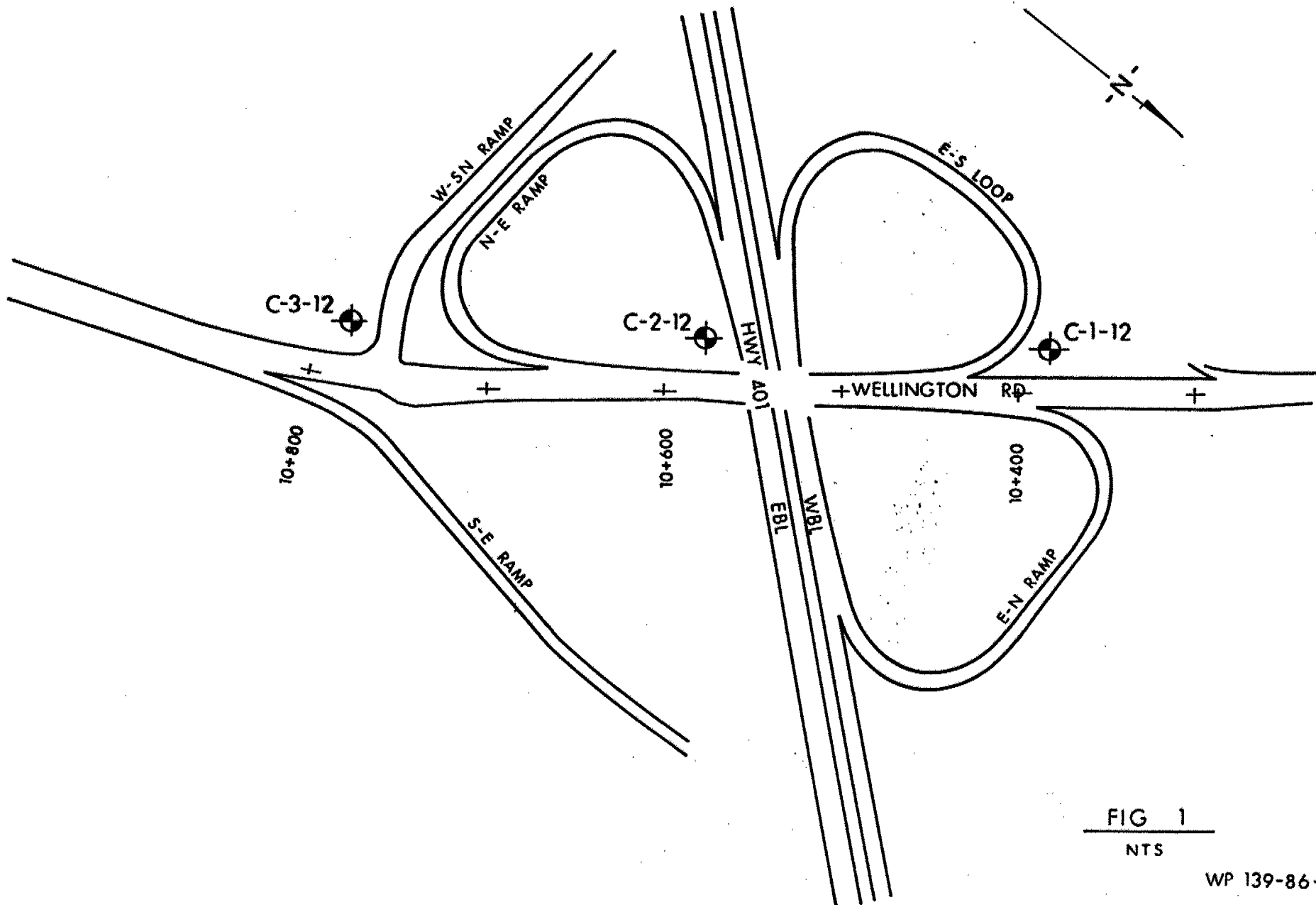


FIG 1  
NTS

WP 139-86-00

RECORD OF BOREHOLE No C-1-12

METRIC

W P 139-86-00 LOCATION Sta. 10+380; o/s 25.0m Right of Wellington Rd. ORIGINATED BY G.B.  
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY G.B.  
DATUM Geodetic DATE 88 11 15-16 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
263.7	Ground Surface											
0.0	Clayey Silt, Trace Sand, Gravel and Organics (Fill)		1	SS	13							0 24 54 23
			2	SS	9							0 9 56 35
			3	SS	4							0 14 49 37
			4	SS	6							1 4 63 32
			5	SS	7							0 0 64 36
	Stiff to Hard		6	SS	9							
			7	SS	28							
257.0			8	SS	48							
6.7	Clayey Silt to Silty Clay		9	SS	35							
			10	SS	26							
			11	SS	32							
			12	SS	25							
			13	SS	24							
			14	SS	18							
	Hard to Stiff		15	SS	8							
247.5												
16.2	End of Borehole											
	*Borehole Dry											

# RECORD OF BOREHOLE No C-2-12

METRIC

W P 139-86-00 LOCATION Sta. 10+576; o/s 29.0 m Right of Wellington Rd. ORIGINATED BY G.B.  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY SMH  
 DATUM Geodetic DATE 88 12 28 CHECKED BY SMH

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa 20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					W <sub>p</sub>	W	W <sub>L</sub>		
261.2	Ground Surface																
0.0	Clayey Silt, Trace Sand, Gravel and Organics (Fill)		1	SS	14		260									0 8 52 40	
			2	SS	10												
			3	SS	12												
257.5	Stiff to Hard		4	SS	26		258										
3.7	Clayey Silt to Silty Clay		5	SS	36												
			6	SS	23		256									0 5 60 35	
			7	SS	19												
			8	SS	19												
	Very Stiff to Stiff		9	SS	22		254										
			10	SS	20												
			11	SS	10		252									0 0 60 40	
			12	TV	FE											0 0 66 34	
			13	SS	12		250										
	Occ. Zones of Plastic Silt		14	SS	12		248										
247.0			15	SS	11											0 0 72 28	
14.2	End of Borehole																

+3, x5: Numbers refer to Sensitivity

20  
15  $\pm$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No C-3-12

METRIC

W P 139-86-00 LOCATION Sta. 10+780; e/s 28.0 m Right of Wellington Rd. ORIGINATED BY G.B.  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY G.B.  
 DATUM Geodetic DATE 88 11 15 CHECKED BY [Signature]

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40					
261.4	Ground Surface													
0.0	Silty Sand (Fill)													
260.5	Loose		1	SS	15									
0.9	Clayey Silt, Trace Sand, Gravel and Organics (Fill)		2	SS	30									
			3	SS	31									
			4	SS	27									
			5	SS	23									
256.8	Very Stiff to Hard		6	SS	15									
4.6	Clayey Silt to Silty Clay		7	TV	PH									
			8	SS	16									
			9	SS	17									
			10	SS	10									
			11	SS	10									
			12	SS	16									
			13	SS	10									
			14	SS	11									
246.8	Occ. Zones of Plastic Silt		15	SS	60/14cm									
14.6	Silty Sand													
245.9	Very Dense													
15.5	End of Borehole													

## FOUNDATION INVESTIGATION REPORT

For

Pond Mills Road Overpass Widening

Hwy. 401, 1.0 km West of Hwy. 126

W.P.139-86-02; Site No. 19-94-372

District 2, London

### INTRODUCTION

This report contains the results obtained from the foundation investigation carried out at the above-mentioned site for the proposed overpass widening. The fieldwork was conducted during the period from 86 11 11 to 86 12 08 utilizing a continuous flight auger machine equipped with 83 mm I.D. hollow stem augers, solid stem augers, and BX sized casings. A diamond drill equipped with BX and NX casings was also used at the approach embankments. The fieldwork consisted of eight sampled boreholes and two dynamic cone penetration tests. Two boreholes were advanced through the approach embankments and the remaining six were advanced in the vicinity of the footings for the overpass widenings.

### SITE DESCRIPTION

The site is located on Hwy. 401, 1.0 km West of Hwy. 126. It is proposed to widen the approaches and the existing structure crossing Pond Mills Road. The terrain in the immediate vicinity is flat. Land use is largely industrial and commercial. The site lies in the physiographic region of the Stratford Till Plain.

### SUBSURFACE CONDITIONS

#### General

The subsoil encountered at this location consisted largely of clayey silt. The two boreholes advanced at the approaches contained fill material that varied in depth from 5.2 m to 6.7 m, overlying a clayey silt deposit. The remaining six boreholes contained surficial deposits of clayey silt with traces of sand, gravel and organics that ranged in thickness from 3.5 m to 10.7 m. Below the layer of clayey silt, a deposit of silt was encountered

that varied in thickness from 3 m to 3.2 m. In BH's 3, 4 and 5, sandy silt to silty sand was found below the clayey silt and silt layers and extended for the full length of the borehole. In BH 2, which was advanced to the greatest depth, the silt deposit was underlain by 3.1 m of clayey silt followed by 4.7 m of silt, 4.4 m of silty sand and ending in a clayey silt deposit that extended for the remaining length of the borehole.

The boundaries of the different strata encountered at the boring locations together with the obtained field and laboratory test results are shown on the Record of Borehole sheets located in the Appendix of this report. A stratigraphical profile across the site is shown on Dwg. No. 2 of the contract documents.

#### SUBSURFACE CONDITIONS

##### Silty Clay (Fill Material)

The fill material encountered in BH's 4 and 102 was clayey silt containing traces of sand and gravel that extended to a depth of 5.2 m. The consistency varied from firm to very stiff. Laboratory tests performed on the fill material yielded the following physical properties:

		<u>RANGE %</u>
Natural Moisture Content	(w)	14.5 - 17.5
Liquid Limit	(w <sub>L</sub> )	22.0 - 30.0
Plastic Limit	(w <sub>p</sub> )	13.5 - 15.5

Figure 1 illustrates a typical grain size distribution envelope for this material.

##### Sand (Fill Material)

BH 101 contained non-cohesive fill material comprised of sand, some gravel and a trace of silt. Occasional cobbles were encountered throughout the 6.7 m thick deposit. The denseness of the fill ranged from loose to very dense, with 'N' values of 7 to 120 obtained from field testing. From laboratory testing, the natural moisture content obtained for the fill material ranged from 5.5% to 13.5%.

Refer to Figure 2 for a typical grain size distribution envelope for this material.

Clayey Silt, trace Sand, trace Gravel

A layer of clayey silt was encountered as the surficial deposit in BH's 1 through 5 and as the underlying deposit in BH 101 and BH 102. The material contained varying proportions of sand and gravel in each borehole. Organic material was present in BH's 1 and 4. The consistency is ranging from soft to hard.

Laboratory tests performed on the samples yielded the following physical properties:

		<u>RANGE %</u>
Natural Moisture Content	(w)	12.5 - 17.5
Liquid Limit	(w <sub>L</sub> )	17.0 - 37.0
Plastic Limit	(w <sub>p</sub> )	11.5 - 18.5

Refer to Figure 3 for a typical grain size distribution envelope for this material.

Silt

A thin stratum of silt was found below the clayey silt deposit in BH's 2, 4 and 3B. The silt layer contained occasional pockets of clayey silt and trace amounts of sand and gravel. The denseness of the material ranged from compact to very dense, with 'N' values varying from 24 to 84. The natural moisture content obtained from laboratory testing ranged from 11.5% to 19%.

Clayey Silt, trace Sand

In BH 2, a 3.1 m layer of clayey silt was encountered below the stratum of silt. The consistency is classified as hard.

### Silt

A stratum of silt was present below the thin layer of clayey silt and found only in BH 2. The silt contained a trace of sand. It is described as very dense, the 'N' value obtained being greater than 120 blows.

### Sandy Silt to Silty Sand

A deposit of sandy silt to silty sand was encountered in BH's 1 to 5 inclusive. The lower boundary of the non-cohesive deposit was not established in BH's 3B, 4 and 5 since the boring was terminated within the deposit. However, the extent of the deposit in the boreholes was found to be 9.3 m or greater. In BH 2, the stratum of sandy silt extended only 4.4 m. The silty sand to sandy silt contained a trace of clay. 'N' values ranged from 13 to 120, reflecting a material that is compact to very dense. The natural moisture content of the deposit ranged from 13.5% to 20.5%.

Refer to Figure 4 for a typical grain size distribution envelope of this material.

### Clayey Silt, some Sand, trace Gravel

Sampling in BH 2 extended to a depth of 40.1 m, terminating in a thick deposit of clayey silt. The consistency of the material can be described as hard.

Laboratory tests performed on the material yielded the following physical properties:

		<u>RANGE %</u>
Natural Moisture Content	(w)	12.5 - 15.5
Liquid Limit	(w <sub>L</sub> )	23.0 - 23.5
Plastic Limit	(w <sub>p</sub> )	12.5



GROUNDWATER CONDITIONS

The following groundwater levels were observed during the field investigation:

<u>Borehole</u>	<u>Elevations</u>
1	268.3
2	268.2
3	268.8
3A	268.8
3B	268.7
4	269.3
5	-
101	268.8
102	273.9

No artesian water conditions were encountered.



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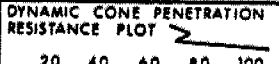
Chief Foundations Engineer

## APPENDIX

## RECORD OF BOREHOLE No 1

METRIC

W P 139-86-02 LOCATION Co-ords. N 4 755 438.0; E 411 554.3 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) COMPILED BY PP  
 DATUM Geodetic DATE 86 11 11 CHECKED BY Don

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
268.3	Ground Level															
0.0	Clayey Silt traces of sand traces of organics Very Stiff to Hard		1	SS	42	268										
			2	SS	45											
			3	SS	45											
			4	SS	29											
			5	SS	27											
264.0						266										
4.3	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

\*3, \*5: Numbers refer to  
Sensitivity

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

## RECORD OF BOREHOLE No 2

METRIC

W P 139-86-02 LOCATION Co-ords: N 4 755 427.4; E 411 549.2 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Washbore - BW Casing COMPILED BY PP  
 DATUM Geodetic DATE 86 11 11 - 86 11 13 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80	100
								SHEAR STRENGTH								WATER CONTENT (%)	
269.0	Ground Level														GR SA SI CL		
0.0																	
	Clayey Silt traces of sand traces of gravel  Very Stiff to Hard		1	SS	86		268										
			2	SS	27		266								0 7 (93)		
			3	SS	23		264										
			4	SS	20		262										
			5	SS	24		260										
			6	SS	17										0 5 (95)		
258.3																	
10.7	Silt traces of sand some clay  Dense		7	SS	31		258								0 5 80 15		
253.3							256										
13.7	Clayey Silt traces of sand  Hard		8	SS	35		254										
252.2							252										
16.8	Silt  trace/some sand trace clay  Very Dense		9	SS	60	13 cm	250										
247.5							248										
21.5	Sandy Silt traces of clay  Very Dense		10	SS	100	28 cm	246								0 13 76 11		
			11	SS	50		244										
243.1							242										
25.9	Clayey Silt		12	SS	84		240								2 20 (78)		

Continued

+3, x5: Numbers refer to  
Sensitivity20  
15 10 5 (%) STRAIN AT FAILURE  
10

Continued

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No 2 (Cont'd)

METRIC

W P 139-86-02 LOCATION Co-ords. N 4 755 427.4; E 411 549.2 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Washbore - BW Casing COMPILED BY PP  
 DATUM Geodetic DATE 86 11 11 - 86 11 13 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
238.8	Continued		13	SS	15											
	Some Sand traces of gravel															
			14	SS	74											
	Hard		15	SS	60											
228.9																
230																
40.1	End of Borehole		16	SS	30											4 16 (80)

OFFICE REPORT ON SOIL EXPLORATION

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  $\phi$  3 (%) STRAIN AT FAILURE  
10

## RECORD OF BOREHOLE No 3A

METRIC

W P 139-86-02 LOCATION Co-ords: N 4 755 507.3; E 411 554.8 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (S.S.) COMPILED BY DC  
 DATUM Geodetic DATE 86 12 03 CHECKED BY DT

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	Wp	W	Wl		
269.0	Ground Level												
0.0	Clayey Silt with sand traces of gravel  Soft to Hard		1	SS	5								7 38 (55)
			2	SS	3								
			3	SS	21								
265.5			4	SS	46								3 11 (86)
3.5	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No 3B

METRIC

W P 139-86-02

LOCATION Co-ords. N 4 755 513.1; E 411 554.2

ORIGINATED BY DC

DIST 2 HWY 401

BOREHOLE TYPE Cont. Flight Auger (S.S.)

COMPILED BY PP

DATUM Geodetic

DATE 86 12 04

CHECKED BY JT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
269.0	Ground Level																
0.0	Probably Clayey Silt																
265.3																	
3.7	Silt Occasional Clayey Silt Pockets traces of sand Very Dense		5	SS	68											0 3 83 14	
			6	SS	55												
262.0			7	SS	84											0 4 79 17	
7.0			8	SS	17											9 10 76 5	
	Sandy Silt traces of clay traces of gravel Compact to Very Dense		9	SS	31												
			10	SS	49											0 16 79 5	
			11	SS	100/28 cm												
250.4			12	SS	60/15 cm												
18.6	End of Borehole																

\*<sup>3</sup>, \*<sup>5</sup>: Numbers refer to  
Sensitivity

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

OFFICE REPORT UIN SOIL EXPLORATION

## RECORD OF BOREHOLE No 4

METRIC

W P 139-86-02 LOCATION Co-ords. N 4 755 516.7; E 411 569.3 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (S.S.) COMPILED BY DC  
 DATUM Geodetic DATE 86 12 05 CHECKED BY DT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH											
								20	40	60	80	100							
								○ UNCONFINED + FIELD VANE					WATER CONTENT (%)						
								● QUICK TRIAXIAL x LAB VANE											
269.5	Ground Level																		
0.0	Clayey Silt traces of organics traces of gravel some (Fill Material) sand Very Stiff to Hard		1	SS	15		268										4 21 (75)		
			2	SS	40														
			3	SS	30														
265.8			4	SS	25		266										1 11 (88)		
3.7	Silt traces of gravel traces of sand Occasional Clayey Silt Seams Compact to Very Dense		5	SS	45														
			6	SS	61		264										8 4 79 9		
			7	SS	24														
261.6			8	SS	30		262										0 2 (98)		
7.9	Sandy Silt to Silty Sand traces of clay  Compact to Very Dense		9	SS	13		260												
			10	SS	71		258												
			11	SS	49		256												
							254												
						252													
250.8			12	SS	59														
18.7	End of Borehole																		

+3, x5: Numbers refer to  
Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION



## RECORD OF BOREHOLE No 5

METRIC

W P 139-86-02 LOCATION Co-ords. N 4 755 445.9; E 411 573.6 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (S.S.) COMPILED BY PP  
 DATUM Geodetic DATE 86 12 08 CHECKED BY JS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub>	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
269.5	Ground Level											
0.0	Clayey Silt trace/some sand traces of gravel		1	SS	32							2 38 (60)
			2	SS	40							
			3	SS	41							
			4	SS	25							
			5	SS	54							
	Hard		6	SS	55							0 2 (98)
263.1	Sandy Silt to Silty Sand traces of clay  Compact to Dense		7	SS	19							
6.4			8	SS	50							
			9	SS	45							
253.8	End of Borehole											7 38 (55)
15.7	* Groundwater Level not observed											

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 101

METRIC

W P 139-86-02 LOCATION Co-ords: N 4 755 456.3; E 411 548.6 ORIGINATED BY DM  
 DIST 2 HWY 401 BOREHOLE TYPE Washbore - NX Casing COMPILED BY PP  
 DATUM Geodetic DATE 86 11 18 - 86 11 20 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
274.7	Ground Level																GR SA SI CL
0.0	Sand Some Gravel Occasional Cobbles traces of silt traces of clay  Loose to Very Dense  (Fill Material)		1	SS	28		274										19 67 10 4
			2	SS	11												
			3	SS	7		272										
			4	SS	7												
			5	SS	14												
			6	SS	60/7.5 cm		270										14 41 29 16
			7	SS	60/10 cm												
268.0			8	SS	45		268										13 73 10 4
6.7	Clayey Silt trace/with sand traces of gravel  Occasional Silt Seams and Layers  Hard		9	SS	44												1 30 (69)
			10	SS	67		266										
			11	SS	32												
			12	SS	60		264										0 5 (95)
			13	SS	46		262										
259.0			14	SS	46		260										
15.7	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION









+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity

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

## RECORD OF BOREHOLE No 102

METRIC

W P 139-86-02 LOCATION Co-ords: N 4 755 503.6; E 411 577.0 ORIGINATED BY DM  
 DIST 2 HWY 401 BOREHOLE TYPE Washbore - NX Casing COMPILED BY DM  
 DATUM Geodetic DATE 86 11 21 - 86 11 24 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	*N* VALUES			20	40	60	80	100					
274.5	Ground Level																GR SA SI CL
0.0	Clayey Silt some/with sand trace/some gravel  Firm to Very Stiff  (Fill Material)		1	SS	4		274										13 28 (59)
			2	SS	4		272										
			3	SS	10												
			4	SS	6												
			5	SS	24		270										
269.3			6	SS	22												3 35 (62)
5.2	Clayey Silt trace/some sand traces of gravel		7	SS	41												1 12 (87)
			8	SS	50		268										
			9	SS	43												
266.4	Hard		10	SS	25												6 16 (78)
8.1	End of Borehole																
	* Water Level was observed to be 0.6 m below ground level, one day after the removal of casings.																

OFFICE REPORT ON SOIL EXPLORATION

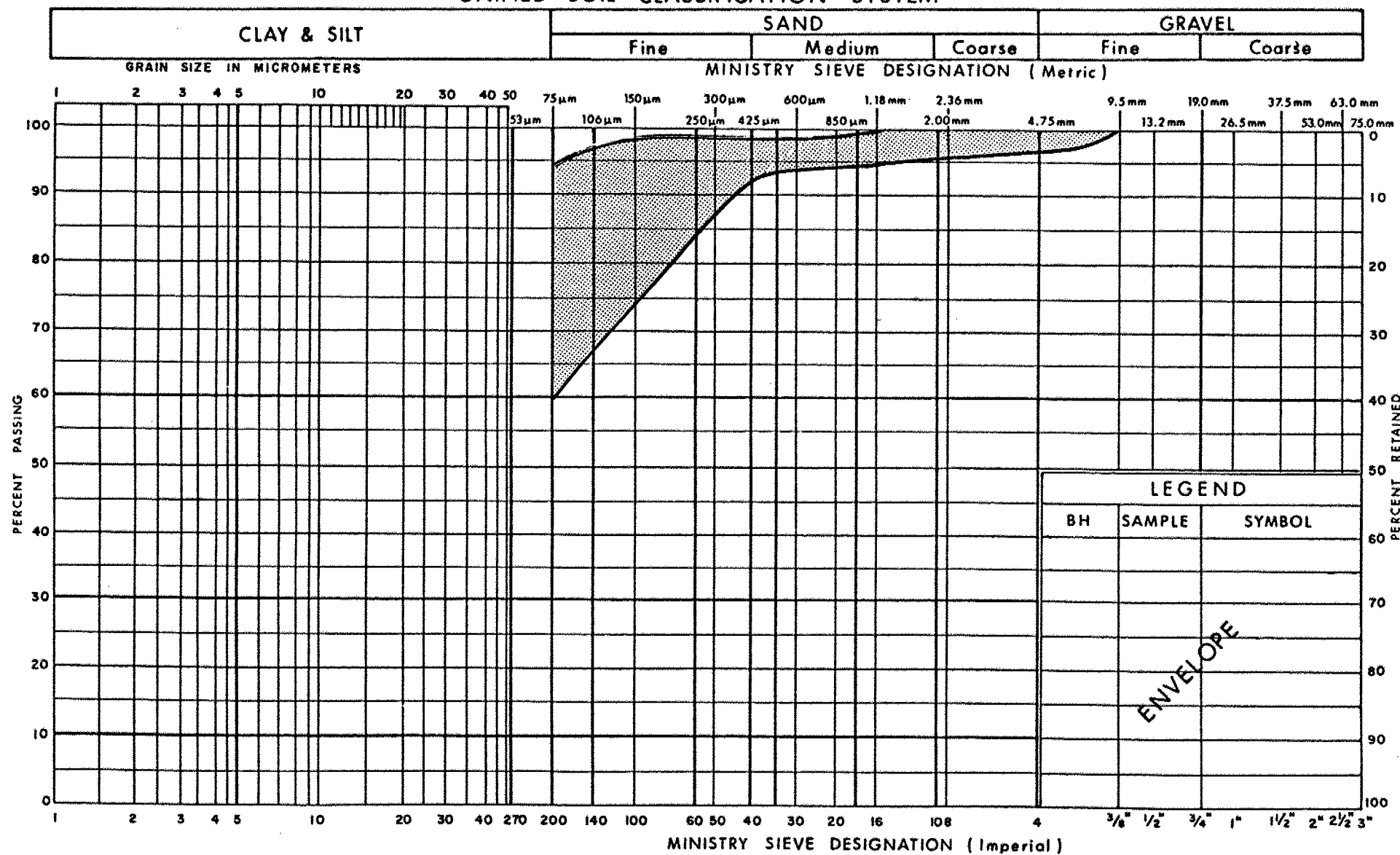
+3, x3: Numbers refer to  
Sensitivity

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



W P 139 -86 -02





**Ministry of  
Transportation and  
Communications**

## GRAIN SIZE DISTRIBUTION

CLAYEY SILT      TRACE / SOME SAND, TRACE GRAVEL

FIG No 3

W P 139 - 86 - 02



## FOUNDATION INVESTIGATION REPORT

For

CNR Overhead Widening

W.P. 139-86-03; Str. Site 19-94-371

Highway 401, District #2, LondonINTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed widening of the existing structure and approaches. The fieldwork consisted of the following.

Five sampled boreholes and dynamic cone penetration tests located adjacent to the bridge were advanced by hollow stem auger (8.3 cm I.D.) using a machine mounted on tracks. Another sampled borehole was made through the approach embankment advanced by NX casing using a diamond drill. These boreholes and cone tests were carried out from 86 11 17 to 86 12 02. Three additional sampled boreholes and cone tests were carried out on 89 02 28 and 89 03 01. The borings were advanced by hollow stem auger using a machine mounted on a truck through the approach embankments. Sampling was performed to a maximum depth of 37.2 m to an approximate elevation of 230.6 m and the cone tests to a maximum depth of 8.9 m to an approximate elevation 263.4 m.

SITE DESCRIPTION

The site is located south of London in the County of Middlesex, Township of Westminster just west of Ponds Mills Road at the crossing of Hwy. 401 and the CNR. The terrain in the immediate vicinity is flat with a raised highway. The physiographic region is the Stratford Till Plains (undrumlinized). The land use in the area is commercial.

SUBSURFACE CONDITIONSGeneral

The subsoil at the approach fills was found to consist mainly of two different types of fill. The top layer ranged from a gravelly sand some



silt to silty sand with trace of gravel (loose to very dense). The fill beneath this was generally a stiff to very stiff clayey silt.

The original ground consists of about 1.4 to 2 m of stiff to very stiff organic clay with some, to traces of sand followed by layers of dense to very dense silt to very stiff to hard clayey silt extending to the maximum depth tested, 37 m at El. 230. The layers are in random occurrence and range in thickness from about 3 to 16 m.

It should be noted that in areas where excavation for structure footings has been done and within the railway right-of-way the surficial organic clay deposit has been wholly or partially removed and replaced with non-cohesive fill material.

A brief description of the different soil types is given below.

#### Fill Material

Fill material consisting of gravelly sand some silt and silty sand, some gravel was encountered in the approach in BH #103 at the surface to a depth of 7.5 m, elevation 268.7 m and at BH's 6 and 7 from ground level to 1.8 m to 2.7 m below to elevation 265.6 m.

The natural moisture content of the material ranges from 14% under the structure to 7% in the approach fill. The grain size distribution for this material is shown in envelope form in Figure 1, in the appendix. The denseness of the fill material ranges from very loose to compact in boreholes 6 and 7 and from compact to very dense in borehole 103.

At boreholes 110, 111 and 112 the fill consisted of 3.7 to 7 m of dense to loose silty sand with to trace of gravel and occasional pockets of clayey silt. The grain size distribution was 0 to 31% gravel, 52 to 75% sand and 17 to 38% fines.

Beneath this fill at elevation 272.3 to 269.3 m to the original ground was clayey silt with to trace of sand, trace of gravel, of stiff to very stiff consistency. Within this fill was a metre thick layer of sandy silt to sand with clayey silt found in boreholes 110 and 112 respectively at 271 and 268 m.

The physical properties of the material as determined by laboratory tests are as follows:

	<u>Mean</u>
Natural Moisture Content (w)	17%
Liquid Limit ( $w_L$ )	29%
Plastic Limit ( $w_p$ )	16%

The grain size distribution was 0 to 6% gravel, 7 to 38% sand and 57 to 87% fines. The deposit plots as a CL on the plasticity chart.

A deposit of gravelly sand, some silt was also found in BH #103 beneath the clayey silt deposit at elevation 267.2 m. The natural moisture content was 9%. The grain size distribution was gravel 35%, sand 44% and fines 21%. The denseness of the deposit was very dense.

#### Organic Clay

Organic clay, trace to with sand, traces of wood fibres was found at the surface to an approximate elevation 266.2 at BH's 8 and 9, up to 2.1 m thick. At BH #7 a thin 0.5 m layer was encountered under the fill approximately 2 m below the existing ground surface. The natural moisture content of the material was approximately 32%. The liquid limit 54% and the plastic limit 28%. The grain size distribution for this material was sand 27%, silt and clay 73%. The consistency varied from stiff to very stiff.

#### Clayey Silt, with Sand

This material has occasional silt pockets at the bottom of the 5 to 6 m thick deposit encountered at ground level in BH #10 and beneath the organic

clay 1.4 to 2.3 m below the surface at BH's 7, 8, and 9. It is also in a 1.5 to 3 m thick deposit beneath the fill material at BH #6 and 103 located 2.7 to 7.5 m below the surface. In BH's 7 and 8 additional deposits (6 to 14 m+ thick) were found alternating with deposits of silt.

The physical properties of the material as determined by field and laboratory tests are summarized below:

	<u>Mean</u>
Natural Moisture Content (w)	18%
Liquid Limit ( $w_L$ )	29%
Plastic Limit ( $w_p$ )	14%

The consistency of the deposits ranged from firm to hard. The grain size distribution is shown in Figure 2 in the Appendix in envelope form and Figure 3 indicates that the deposit plots predominantly as a CL on the Plasticity chart.

### Silt

This material was found beneath the clayey silt deposits in boreholes 6, 7, 8, 9 and 10, in varying thickness from 3 to 16 m. Traces of sand, gravel and occasional clayey silt layers were found in some of the holes. The upper silt deposit was located 7.2 m below the surface at BH #7, 8 and 9 and 5.3 m below at BH #6 and 10. The lower deposit of silt was found at elevation 250.9, 17 m below the surface.

The physical properties of the material as determined by laboratory tests are as follows:

	<u>Mean</u>
Natural Moisture Content (w)	17%
Liquid Limit ( $w_L$ )	23%
Plastic Limit ( $w_p$ )	16%

The denseness of the deposit ranged from compact to very dense. The grain size distribution is shown in Figure 4 in the Appendix in envelope form.

Figure 5 indicates that the deposit plots as a (ML-CL) on the plasticity chart.

#### GROUNDWATER CONDITIONS

The following groundwater conditions were observed during the field investigations.

<u>Borehole</u>	<u>Elevation (m)</u>
6	267.9
7	267.7
8	Artesian conditions encountered at Elev. 230.6, head to 273.0 m.
9	267.6
10	267.9
103	268.1
110	269.1
111	267.8
120	Water level not established

The boreholes indicate the groundwater level to be in general about 0.3 m below the ground (original) level at Elev. 268 m. This level will most likely vary seasonally. Artesian water was encountered in BH #8 at Elev. 230 m with a head to Elev. 273 m (5.2 m above the ground level).



*Pamela Marks*

P. Marks, P.Eng.  
Foundation Engineer

*M. Devata*

M. Devata, P.Eng.  
Chief Foundation Engineer

## APPENDIX

# RECORD OF BOREHOLE No 6

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 377.8 E 411 370.6 ORIGINATED BY DC  
DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger COMPILED BY DM  
DATUM Geodetic DATE 86 11 17 CHECKED BY SK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
268.3	Ground Level												
0.0	Gravelly Sand some silt Very Loose to Compact (Fill Material)		1	SS	29		268		○				21 67 (12)
265.6			2	SS	5		266		○				30 55 (15)
2.7	Clayey Silt some sand trace of gravel Very Stiff to Hard		3	SS	3		264		○				6 31 (63)
262.7			4	SS	22		262						
5.6	Silt some gravel trace sand Dense to Very Dense		5	SS	22		260						
			6	SS	25		258						
			7	SS	43		256						
			8	SS	82								
			9	SS	86								
			10	SS	77								
			11	SS	49								
255.6			12	SS	55								
12.7	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 7

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 415.5 E 411 369.8 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (HS) COMPILED BY PM  
 DATUM Geodetic DATE 86 11 18 to 86 11 19 CHECKED BY DA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
268.0	Ground Level																
0.0	Silty Sand some gravel Very Loose to Compact (Fill Material)		1	SS	23												18 46 (36)
266.2			2	SS	6												
1.8	Organic Clay		3	SS	11		266										
2.3			4	SS	27												
	Cloyey Silt trace of sand		5	SS	24		264										
	occ. silt layers		6	SS	20												0 1 (99)
	Stiff to Very Stiff		7	SS	19		262										0 0 (100)
260.8																	
7.2	Silt		8	SS	47		260										
	Dense		9	SS	37												0 0 (100)
			10	SS	43		258										
256.7	Occ. Cloyey Silt Layers																
11.3			11	SS	35		256										
	Cloyey Silt		12	SS	33		254										0 0 (100)
	occ. silt layers		13	SS	32		252										
	Hard																
250.9							250										
17.1	Silt																
249.3	Dense		14	SS	33												
18.7																	

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 8

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 363.7 E 411 373.7 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (HS) & BX Casing COMPILED BY DM  
 DATUM Geodetic DATE 86 11 19 and 86 11 20 CHECKED BY DT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
267.8	Ground Level													
0.0	Organic Clay with sand Very Stiff		1	SS	17		To Elev. 273.0							0 27 (73)
266.4			2	SS	7		266							
1.4	Cloyey Silt trace of sand		3	SS	27									
			4	SS	34									0 12 (88)
	Firm to Hard		5	SS	28		264							
			6	SS	26									
	occasional silt layers		7	SS	24		262							0 0 (100)
260.6							260							
7.2	Silt Dense to Very Dense		8	SS	37									
			9	SS	64		258							
257.6														
10.2	Cloyey Silt trace of sand		10	SS	45		256							0 0 (100)
	Hard		11	SS	34		254							
			12	SS	36		252							0 1 (99)
250.9							250							
16.9	Silt		13	SS	100		248							
	Some Sand						246							0 17 (83)
	Very Dense		14	SS	45/7.5cm									
244.8							244							
23.0	Cloyey Silt		15	SS	44		242							
	trace of sand						240							
	trace of gravel													
	occasional silt pockets		16	SS	50									
							238							

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

Continued

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 8 Cont

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 363.7 E 411 373.7 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (HS) & BX Casing COMPILED BY PM  
 DATUM Geodetic DATE 86 11 19 and 86 11 20 CHECKED BY SA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
237.6	Continued		17	SS	90	15 cm										
30.2	Hard		18	SS	70											
230.6			19	SS	67											
37.2	End of Borehole					Artesian Encountered El. 230.6										

+3, x5 : Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 9

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 357.5 E 411 359.2 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Cont. Flight Auger (HS) COMPILED BY PM  
 DATUM Geodetic DATE 86 11 28 to 86 12 01 CHECKED BY DA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
268.3	Ground Level													
0.0	Organic Clay trace of sand traces of wood fibres Stiff		1	SS	15									
266.2			2	SS	13									
2.1	Cloey Silt traces of organics trace of sand trace of gravel Very Stiff		3	SS	18									
			4	SS	25									
			5	SS	30									
			6	SS	26									
	Occasional Silt Pockets		7	SS	20									
261.1			8	SS	21									
7.2	Silt  Occasional Cloey Silt Layers		9	SS	39									
			10	SS	29									
			11	SS	32									
	Compact to Very Dense		12	SS	38									
249.7			13	SS	52/15 cm									
18.6	End of Borehole													

+3, x<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 10

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 429.4 E 411 357.8 ORIGINATED BY DC  
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (HS) COMPILED BY DM  
 DATUM Geodetic DATE 86 12 01 and 86 12 02 CHECKED BY ST

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
269.0	Ground Level												
0.0	Clovey Silt trace/with sand traces of organics  Very Stiff to Hard		1	SS	20								0 30 (70)
			2	SS	35								
			3	SS	50								
			4	SS	46								
			5	SS	45								
	occasional silt pockets		6	SS	55								0 1 (99)
263.4			7	SS	49								
5.6			8	SS	46								
	Silt		9	SS	44								
	trace of sand		10	SS	61								0 0 (100)
	Compact to Very Dense		11	SS	101								0 3 (97)
			12	SS	38								
247.2			13	SS	22								
21.8	End of Borehole												

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 103

METRIC

W P 139-86-03 LOCATION Co-ords: N 4 755 384.9 E 411 378.2 ORIGINATED BY DM  
DIST 2 HWY 401 BOREHOLE TYPE Washbore - BX & NX Casings COMPILED BY DM  
DATUM Geodetic DATE 86 11 25 to 86 11 28 CHECKED BY *DM*

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
276.2	Ground Level															GR SA SI CL
0.0						276										
	Gravelly Sand		1	SS												
	some silt		2	SS												
	Compact		3	SS		274										
	to		4	SS												
	Very Dense															
	(Fill Material)		5	SS		272										
			6	SS												
			7	SS		270										
			8	SS												
268.7			9	SS												
7.5	Clayey Silt with/some sand trace of gravel		10	SS		268										
267.2	Very Stiff															
9.0	Gravelly Sand some															
266.6	Silt Very Dense		11	SS												
9.6	End of Borehole															

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

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

# RECORD OF BOREHOLE No 110

METRIC

W P 139-86-03 LOCATION Station: 25+441.6; Offset 14m Lt of C  
 Co-ords: N 4 755 418.0 E 411 379.6  
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.)  
 DATUM Geodetic DATE 89 02 28  
 ORIGINATED BY PD  
 COMPILED BY PM  
 CHECKED BY DT

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
276.4	Ground Level															
0.0	Shoulder Material		1	SS	36		276									
	Silty Sand		2	SS	18											
	Trace of Gravel		3	SS	29		274									
	occ. Pockets of Clayey Silt (Fill)		4	SS	18											
	Dense to Loose		5	SS	23		272									
270.9			6	SS	8											0 62 (38)
5.5	Clayey Silt With/Trace Sand Trace of Gravel (Fill)		7	SS	17		270									2 24 (74)
			8	SS	14											
			9	SS	20											
	Sandy Silt (ML)		10	SS	34		268									
			11	SS	9											5 38 (57)
266.2	Stiff to Hard		12	SS	55											6 7 48 39
10.2	End of Borehole															

# RECORD OF BOREHOLE No 111

METRIC

W P 139-86-03 LOCATION Station: 25+409.7, Offset 14m Lt of C  
 Co-ords: N 4 755 405.5; E 411 350.2  
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.)  
 DATUM Geodetic DATE 89 02 28  
 ORIGINATED BY PD  
 COMPILED BY PM  
 CHECKED BY JDT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
276.3	Ground Level													
0.0	Shoulder Material						276							
			1	SS	40									
	Silty Sand with Gravel (Fill)		2	SS	33		274							
			3	SS	47									
	Occ. Pockets of Clayey Silt		4	SS	34		272							
			5	SS	7									
	Dense to Loose		6	SS	10		270							
			7	SS	20									
269.3														
7.0	Clayey Silt with to Some Sand		8	SS	19		268							
	Trace of Gravel (Fill)		9	SS	8									
	Stiff/Very Stiff						266							
			10	SS	31									
265.2														
11.1	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 112

METRIC

W P 139-86-03 LOCATION Station: 25+400; Offset 14.25m Rt of C ORIGINATED BY PD  
 DIST 2 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM  
 DATUM Geodetic DATE 89 03 01 CHECKED BY JTA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%)	GR SA SI CL
								SHEAR STRENGTH kPa								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
276.0	Ground Level															
0.0	Shoulder Material															
	Silty Sand		1	SS	40											
	Trace of Gravel		2	SS	33											
	Occ. Pockets of Clayey Silt		3	SS	53											
	(Fill)		4	SS	42	*										
272.3	Dense to Very Dense															
3.7	Clayey Silt		5	SS	19											
	Some Sand		6	SS	21											
	Sand With Clayey Silt		7	SS	30											
	(Fill)		8	SS	25											
	Stiff to Very Stiff		9	SS	14											
267.2	Organic (Original Test)		10	SS	26											
8.8	End of Borehole															
	* Water Level not Established															

OFFICE REPORT ON SOIL EXPLORATION



GRAIN SIZE DISTRIBUTION  
GRAVELLY SAND SOME SILT (FILL MATERIAL)

W P 139-86-03

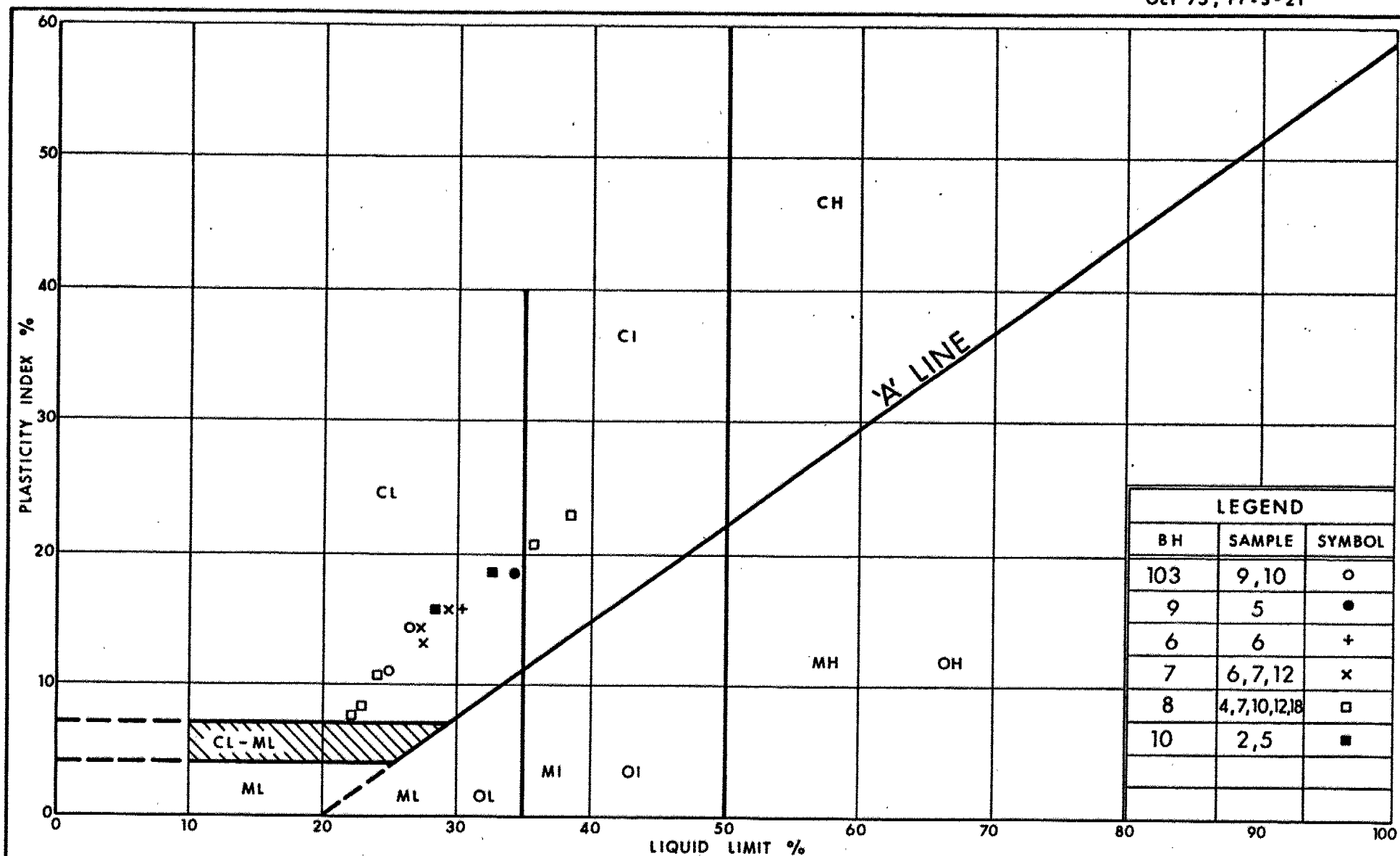




GRAIN SIZE DISTRIBUTION  
CLAYEY SILT , WITH SAND

FIG No 2

W P 139-86-03



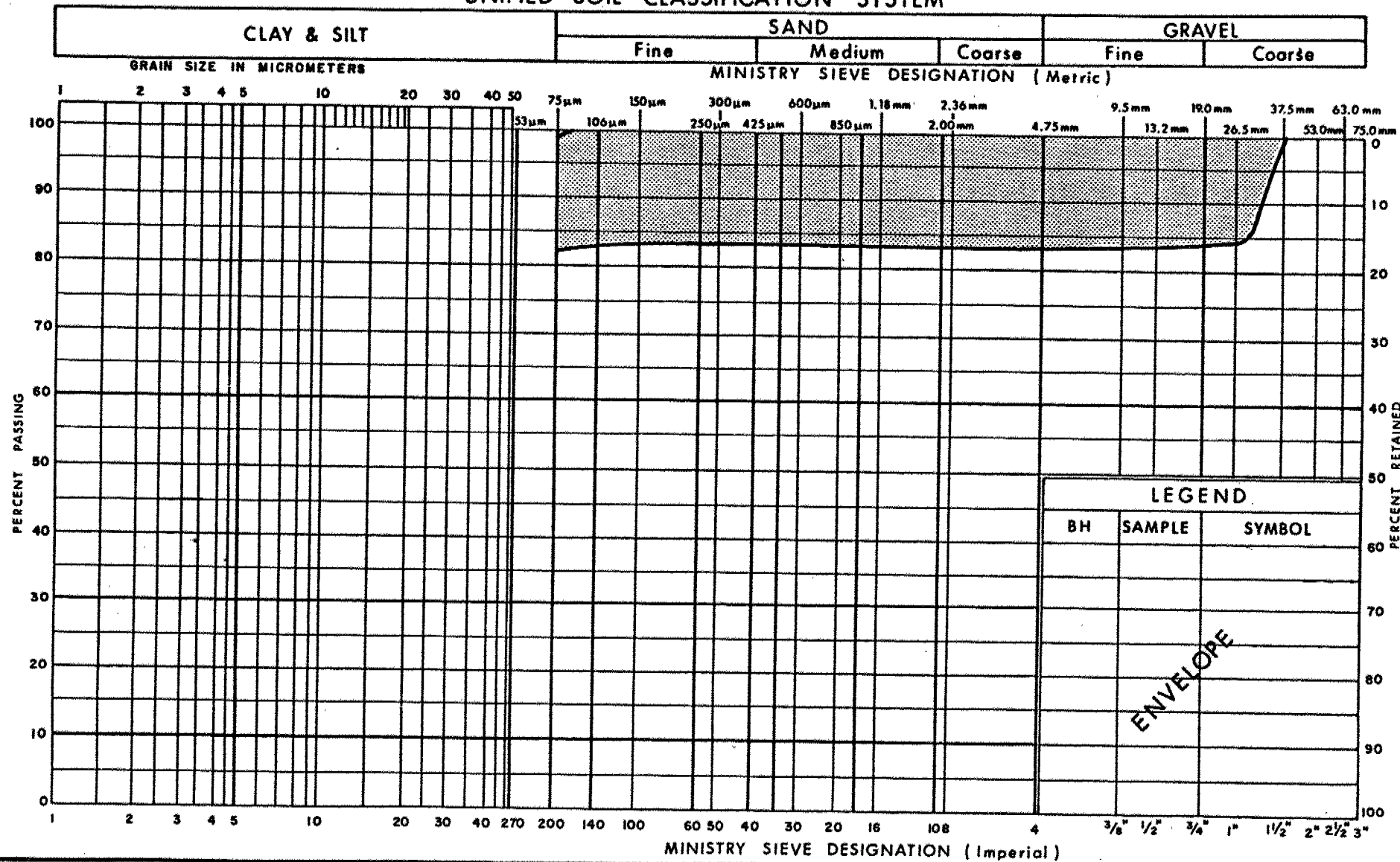
Ministry of  
Transportation and  
Communications  
Ontario

# PLASTICITY CHART CLAYEY SILT, WITH SAND

FIG No 3

W P 139 - 86 - 03

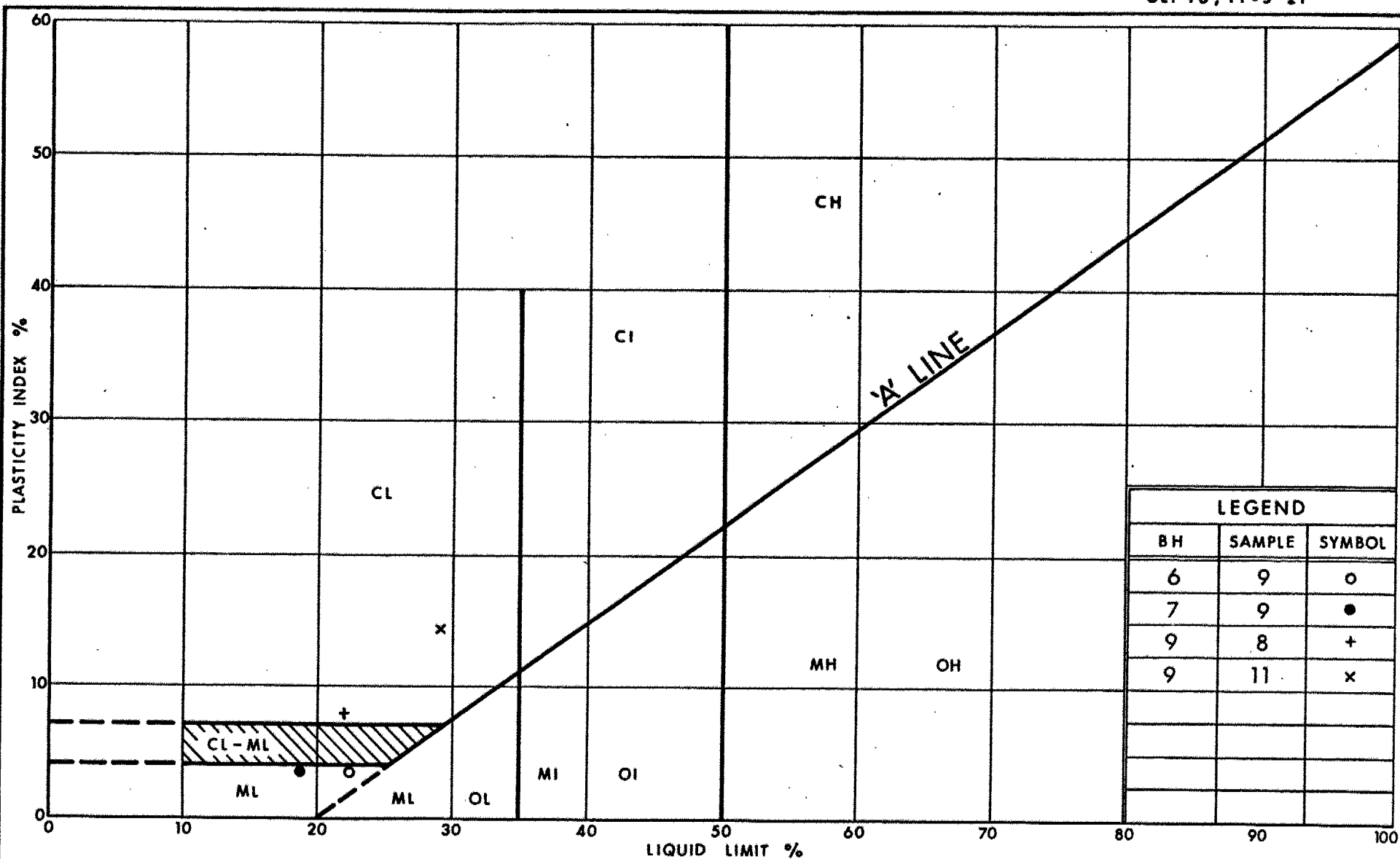
# UNIFIED SOIL CLASSIFICATION SYSTEM

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Communications

GRAIN SIZE DISTRIBUTION  
SILT, TO SOME SAND, GRAVEL

FIG No 4

W P 139 - 86 - 03



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Transportation and  
Communications

# PLASTICITY CHART SILT, TRACE OF SAND, OCCASIONAL CLAYEY SILT LAYERS

FIG No 5

W P 139-86-03

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 139-86-00 DIST 2  
HWY 401 STR SITE

High Mast Lighting

DISTRIBUTION

A. Ho (2)  
C.M. Bond  
A.E. Irving  
D.A. Waller (2)  
K. Bassi (2)  
D. Aspinwall  
T. Yakutchik  
G. Szekreny  
D. Fusee (Cover Only)  
M. Maclean (Cover Only)  
File ✓

## FOUNDATION INVESTIGATION REPORT

For  
WP 139-86-00, High Mast Lighting  
Highway 401, London  
District 2, London

### INTRODUCTION

This report contains the results of a foundation investigation conducted at the above mentioned site on 88 11 15, 88 11 16 and 88 12 28. The fieldwork consisted of a borehole together with a dynamic cone penetration test at each of the three proposed high mast lighting locations. The borings were advanced by a truck mounted auger machine equipped with hollow stem augers.

### SITE DESCRIPTION

The high mast lights are located at the Highway 401 and Wellington Road Interchange. The site is relatively flat and consists of fill overlying silty clay. According to Chapman and Putnam (1984), the site lies on the north edge of the "Mount Elgin Ridges". It is composed largely of calcareous clay or silty clay.

### SUBSURFACE CONDITIONS

#### General

At each of the high mast light locations, the subsoil consists of fill overlying clayey silt to silty clay. Underlying the clayey silt to silty clay, there is silty sand. The fill consists mostly of clayey silt, however, at BH # C-3-12 silty sand overlies the clayey silt.

The boundaries of the different deposits together with the field and laboratory test results are shown on the Record of Borehole sheets found in the Appendix of this report. Figure 1 shows the locations of the boreholes. A description of the strata encountered is provided below.

#### Silty Sand (fill)

A 0.9 m layer of loose silty sand fill overlies the clayey silt fill in BH # C-3-12. This silty sand is partially composed of winter sand depositions.

#### Clayey Silt, Trace Sand, Gravel and Organics (fill)

A 3.7 to 6.7 m thick layer of stiff to hard clayey fill overlies clayey silt to silty clay. This layer is dry with the moisture content near the plastic limit. The sand, gravel and organic content varies within this layer. In situ shear strengths vary from 84 kPa to greater than 115 kPa.

### Clayey Silt to Silty Clay

A 9.5 to 10.5 m thick layer of clayey silt to silty clay underlies the fill. This layer is stiff to hard with in situ shear strengths measured at 115 kPa or greater. Occasional zones of plastic silt occur at the bottom of this layer. Silt content increases with depth. This layer was easier to penetrate or auger through below the water table.

### Silty Sand

Borehole # C-3-12 was terminated in very dense silty sand. The silty sand starts at El 246.5 m.

### Groundwater

The groundwater elevations at the time of the investigation were:

BH # C-1-12	-	Borehole was dry
BH # C-2-12	El 251.2	10.0 m below ground level
BH # C-3-12	El 251.7	9.7 m below ground level

The groundwater level could vary with the season.

### DISCUSSION AND RECOMMENDATIONS

It is proposed to install 3 high mast lighting poles at the Highway 401 and Wellington Road interchange.

The high mast lighting foundation design follows the method as outlined in the following papers.

Broms, B.B. Lateral Resistance of Piles in Cohesive Soils  
Journal of the Soil Mechanics and Foundations Division,  
ASCE Vol. 90, No. SM2, Paper 3825, March 1964

Broms, B.B. Lateral Resistance of Piles in Cohesionless Soils  
Journal of the Soil Mechanics and Foundations Division,  
ASCE Vol. 90, No. SM3, Paper 3909, May 1964.

The following parameters are recommended for the cohesive subsoil encountered at the site:

Undrained Shear Strength (Cu)	0 - 5 m = 84 kPa
	5 - 10 m = 115 kPa
Bulk Unit Weight ( $\gamma$ )	= 21.4 kN/m <sup>3</sup>

It is assumed that the material within the zone of frost penetration does not provide any lateral resistance. At this site, the depth of frost penetration is 1.2 m.

### MISCELLANEOUS

The fieldwork for this investigation was carried out by Mr. G. Beauchesne, Engineering student and Mr. S. Holmes, Foundation Engineer. The equipment was owned and operated by London Soil Test Inc. The report was prepared by Mr. S. Holmes and reviewed by Mr. P. Payer, Senior Foundation Engineer.



*S. Holmes*  
S. Holmes, P. Eng.  
Foundation Engineer

*P. Payer*  
for M. Devata, P. Eng.  
Chief Foundation Engineer



## APPENDIX

## 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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	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
$C_\alpha$	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
$\sigma'_{VO}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_r$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$kg/m^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$kN/m^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$kg/m^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$kN/m^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$kg/m^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$kN/m^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$kg/m^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$m^3/s$	RATE OF DISCHARGE
$\gamma_d$	$kN/m^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	$kg/m^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$kN/m^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$kg/m^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$kN/m^3$	SEEPAGE FORCE
$\gamma'$	$kN/m^3$	UNIT WEIGHT OF SUBMERGED SOIL						

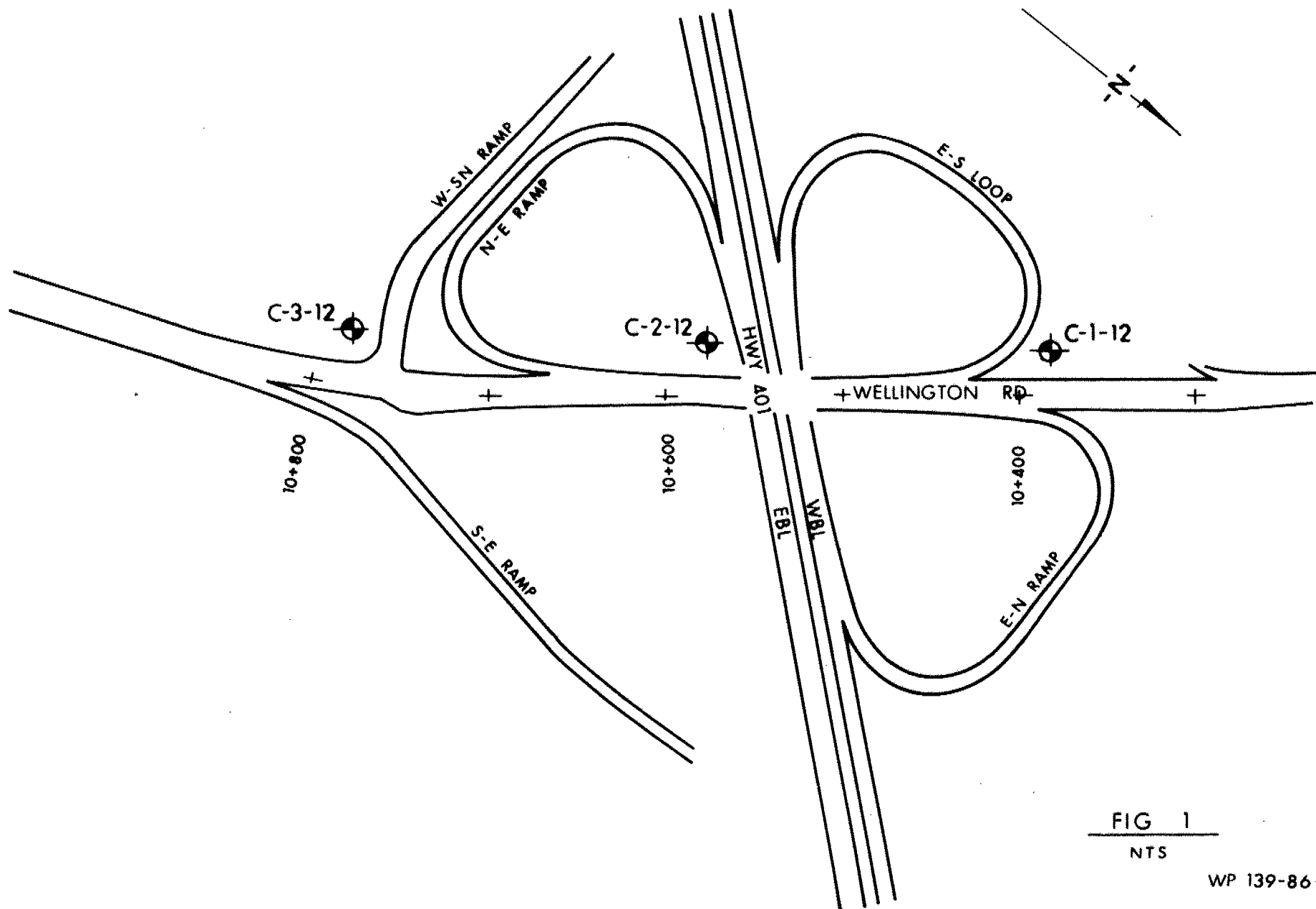


FIG 1  
NTS

# RECORD OF BOREHOLE No C-1-12

METRIC

W P 139-86-00 LOCATION Sta. 10+380; o/s 25.0m Right of Wellington Rd. ORIGINATED BY G.B.  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY G.B.  
 DATUM Geodetic DATE 88 11 15-16 CHECKED BY [Signature]

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
263.7	Ground Surface										
0.0	Clayey Silt, Trace Sand, Gravel and Organics (Fill)		1	SS	13						0 24 54 23
			2	SS	9						0 9 56 35
			3	SS	4						
			4	SS	6						
			5	SS	7						
	Stiff to Hard		6	SS	9						0 14 49 37
			7	SS	28						
257.0			8	SS	48						
6.7	Clayey Silt to Silty Clay		9	SS	35						1 4 63 32
			10	SS	26						
			11	SS	32						
			12	SS	25						
			13	SS	24						
			14	SS	18						
	Hard to Stiff		15	SS	8						0 0 64 36
247.5											
16.2	End of Borehole										
	*Borehole Dry										

# RECORD OF BOREHOLE No C-2-12

METRIC

W P 139-86-00 LOCATION Sta. 10+576; o/s 29.0 m Right of Wellington Rd. ORIGINATED BY G.B.  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY SMH  
 DATUM Geodetic DATE 88 12 28 CHECKED BY SP

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
261.2	Ground Surface														
0.0	Clayey Silt, Trace Sand, Gravel and Organics (Fill)		1	SS	14		260								
			2	SS	10										
			3	SS	12										
257.5	Stiff to Hard		4	SS	26		258								
3.7	Clayey Silt to Silty Clay		5	SS	36										
			6	SS	23		256								
			7	SS	19										
			8	SS	19										
			9	SS	22		254								
			10	SS	20										
	Very Stiff to Stiff		11	SS	10		252								
			12	TW	PH										
			13	SS	12		250								
			14	SS	12										
247.0	Occ. Zones of Plastic Silt		15	SS	11		248								
14.2	End of Borehole														

# RECORD OF BOREHOLE No C-3-12

METRIC

W P 139-86-00 LOCATION Sta. 10+780: o/s 28.0 m Right of Wellington Rd. ORIGINATED BY G.B.  
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY G.B.  
 DATUM Geodetic DATE 88 11 15 CHECKED BY SB

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
261.4	Ground Surface													
0.0	Silty Sand (Fill)													
260.5	Loose		1	SS	15		260							0 12 52 36
0.9	Clayey Silt, Trace Sand, Gravel and Organics (Fill)		2	SS	30									
			3	SS	31									
			4	SS	27		258							
256.8	Very Stiff to Hard		5	SS	23									
4.6	Clayey Silt to Silty Clay		6	SS	15		256						21.9	
			7	TW	PH									
			8	SS	16									
			9	SS	17		254							0 1 65 34
			10	SS	10									
			11	SS	10		252							
			12	SS	16		250							
	Very Stiff to Stiff		13	SS	10									0 0 70 30
			14	SS	11		248							0 0 80 20
246.8	Occ. Zones of Plastic Silt													
14.6	Silty Sand		15	SS	60/	14cm	246							
245.9	Very Dense													
15.5	End of Borehole													