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## **FOUNDATION DESIGN SECTION**

# **foundation investigation and design report**

**ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION**

WP 208-94-01 DIST 31  
HWY 86 STR SITE 33-291

Intersection of Highway 86 and  
Regional County Road 15

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**GEOCRE 40P10-29**

**DATE**

**MAY 15 1995**

## FOUNDATION INVESTIGATION REPORT

for

Intersection of Highway 86 and Regional County Road 15

WP 208-94-01, Site No. 33-291

Hwy. 86, District 31, London

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### Introduction

This report contains the results of a Foundation Investigation carried out at the above mentioned site between 94 06 13 to 94 06 17. It is proposed to widen an existing two span concrete post-tensioned bridge to accommodate additional traffic lanes.

Five sampled boreholes together with two cone penetration tests were advanced as part of this project by means of 82 mm ID Hollow Stem Augers. These boreholes extended down to depths of 13.7 m to 15.2 m below existing ground surface. A previous foundation investigation (WP 281-66-06) was completed at this site prior to the construction of the original Hwy 85/Regional County Rd. 15 structure between 71 10 20 and 71 10 25 resulting in five boreholes. This data is utilized and included within this report.

### Site Description and Geology

The site is located at the intersection of Hwy. 86 and Regional County Road 15 (King St. North) in the Township of Woolwich, Regional Municipality of Waterloo. The topography of this area is flat and gently undulating. Land use in the vicinity of the site is primarily agricultural farm land.

Physiographically, this site is located in the "Waterloo Hills", an area of variable landforms ranging from sandy till ridges to sandy outwash (Ref.: Chapman and Putnam, 1984).

### Investigation Procedures

Soil data and inherent properties were obtained by in situ and laboratory testing. The procedures employed are discussed below.

### Field

The field work for the investigation was carried out between 94 06 13 and 94 06 17 and consisted of a total of five sampled boreholes which were advanced to depths of 13.7 m to 15.2 m. In addition two cone penetration tests were conducted terminating at depths of approximately 5.5 metres. Two boreholes were advanced south of the bridge structure in consideration of the 6.0 m widening and three boreholes to the north at the east, pier and west abutment locations in consideration of the 5.26 m widening of the west bound lane.

The boreholes were advanced using conventional Hollow Stem Augers. One track mounted continuous flight auger drill was employed for the operation. In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 6 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the standard penetration test (ASTM D1586).

All subsoil samples were identified in the field and returned to the laboratory for further examination and applicable testing.

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled upon completion of the field work.

Survey information related to the location and elevation of boreholes were provided by the Southwest Region, Surveys and Plans Section.

### Laboratory Analysis

The following laboratory tests were carried out on select soil samples.

1. Atterberg Limit Test
2. Grain Size Distribution
3. Natural Moisture Contents

Laboratory test results are given in the following section of the report and are illustrated on Figures and Record of Borehole Logsheets in the Appendix.

### Subsurface Conditions

The subsoil conditions are generally consistent across the site with variations near the surface depending on the borehole location. A 0.8 m - 2.1 m sand and gravel deposit was encountered throughout the site with depths of 0.6 m - 0.8 m

classified as a fill. To the south the two boreholes located along the east bound lane expansion contained traces of clay and silt. The sand and gravel layer was not encountered at one location (BH 94-3). Underlying the above deposit in one borehole (BH 94-4) and encountered surficially in another (BH 94-3) was a 0.6 m thick organic topsoil. The three boreholes placed to the north along the west bound lane expansion in turn consisted of a silty sand to sandy silt, trace/some clay, some gravel. This layer has a thickness of 2.1 m to 2.3 m. The underlying material become more coarse with another layer of sand and gravel, some silt with a thickness of 0.8 m - 1.0 m.

Throughout the entire site underlying all the above is a clayey silt to silty clay, trace sand deposit which within contained a layer of silty sand to sandy silt, trace clay. The first deposit of silty clay to clayey silt had a thickness of 2.1 m - 7.7 m, the silty sand to sandy silt had a thickness of 0.3 m - 2.6 m, and the second deposit of silty clay to clayey silt had a thickness of 4.5 m - 6.9 m. Beyond the above layer was a more dense non-cohesive heterogeneous mixture of silt, sand and gravel, some clay (Glacial Till) which was encountered throughout the site and reached beyond the scope of this investigation.

In addition to the foundation investigation conducted for the current proposed widening, the logsheets are enclosed with this report for the original structural investigation. Five boreholes were placed at abutment and pier locations down to depths of 9.6 m to 11.1 m, together with three cone penetration tests. Stratigraphy encountered closely resembles those described as part of the current investigation, however with a greater extent of organic topsoil. Due to the shallower nature of this investigation the non-cohesive till was not encountered.

The soils encountered during the course of this investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the appendix of this report. Stratigraphical sections are shown on Drawing No. 2089401-A. This drawing also shows the locations and elevations of the borings. A detailed description of the strata encountered are given below.

#### Organic top soil

This deposit was only encountered in two boreholes, either surficially or directly beneath the existing fill. (BH 94-3, BH 94-4). Its thickness ranged from 0.6 m to 0.7 m. One split spoon sample within this layer was recovered having 10 blows/0.3 m. Its believed this layer was removed at most locations throughout the site.

Sand and gravel, some silt

Encountered surficially as part of the existing fill and found at greater depths primarily overlying the cohesive silty clay to clayey silt was a non-cohesive stratum of sand and gravel, some silt. The thickness at the surface ranged from 0.8 m - 2.1 m and at greater depths of approximately 2.9 m - 3.7 m with a thickness of 0.8 - 1.0 m.

Results of grain size distribution tests carried out on select samples indicate that the material contains a large percentage of gravels and sands (39 - 61 % and 15 % - 47 % respectively) with little silt and clay ( 4 % - 11 %). Figure 1 illustrates grain size distribution curves for this material, based on representative samples within this layer.

Standard penetration tests conducted in this layer ranged from 22 to 33 blows/0.3 m within the surficial deposit and from 35 to 50 blows/0.3 m within the second deposit encountered. This indicates a compact to dense state of denseness.

Silty sand to sandy silt

This stratum was encountered once beneath the sand/gravel and organic surficial deposits and a second time sandwiched within the cohesive clayey silt to silty clay. The thickness of the first layer was 2.1 m to 2.3 m, with the second layer having a thickness of 0.3 m to 2.6 m.

Results of grain size distribution tests carried out on select samples indicate 0 % gravel, 54 - 68 % sand, 28 - 90 % silt and 3 - 8 % clay. Figure 2 illustrates grain size distribution curves for this material in an envelope form.

Standard penetration tests conducted in this layer ranged from 14 to 51 blows/0.3 m indicating a loose to dense state of denseness.

Clayey silt to silty clay, some sand, some gravel

Encountered throughout the site this cohesive deposit contained sandwiched within, a layer of silty sand to sandy silt either as a seam or as a complete layer. The clayey silt to silty clay deposit ranged in thickness between 2.3 m to 7.9 m, either as one layer or as two separated by the silty sand to sandy silt deposit.

Results of the grain size distribution tests carried out on select samples

indicate that the material contains 0 % gravel, 1 - 6 % sand, 34 - 74 % silt and 26 - 66 % clay. Figure 3 illustrates grain size distribution curves for this material in an envelope form.

The results from the field and laboratory tests performed on this deposit are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural moisture content (w)	18 - 21.5 %	8
Liquid Limit (WL)	21 - 44 %	8
Plastic Limit (Wp)	15 - 20 %	8
Plastic Index (Ip)	6 - 24 %	8

The natural moisture contents are generally close to or slightly less than plastic limit. Figure 4 illustrates the plotted plasticity chart for this material, based on representative samples. It indicates that the material is of intermediate plasticity.

Standard penetration tests conducted in this layer gave 'N' values ranging from 24 - 86 Blows/0.3 m indicating a hard consistency.

Heterogeneous mixture of silt, sand, gravel, some clay (Glacial Till)

Underlying the cohesive layer above is a non-cohesive heterogenous mixture of silt, sand and gravel (Glacial Till) encountered throughout the site at depths of 11.6 - 12.2 m. The investigation was terminated in this stratum.

Results of grain size distribution tests carried out on select samples indicate that the material contains 3 - 8 % gravel, 28 - 33 % sand, 49 - 56 % silt and 13 - 14 % clay. Figure 5 illustrates grain size distribution curves for this material, based on representative samples within the layer in an envelope form.

The results from the field and laboratory tests performed on this deposit are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural moisture content (w)	8.5 - 10.5 %	2
Liquid Limit (WL)	15 - 16 %	2
Plastic Limit (Wp)	11 %	2
Plastic Index (Ip)	4 - 5 %	2

Figure 6 illustrates the plotted plasticity chart for this material, based on representative samples.

Standard penetration tests conducted in this layer gave 'N' values of > 120 blows/0.3 m indicating a very dense state of denseness.

Groundwater conditions

Observations of the groundwater levels was carried out by measuring the water levels in open boreholes during the course of the investigation. The groundwater level was found to be at an approximate elevation between 337.1 m and 338.5 m which corresponds to depths of 2.9 m and 1.6 m below the existing ground surface. It should be noted that the groundwater levels are subject to seasonal fluctuations.

## Discussion

### General

In order to facilitate the construction of an interchange at the above site the existing structure, a two-span concrete post tensioned bridge carrying Regional County Road 15 (King Street North) over Highway 86 will be widened in order to accommodate additional traffic lanes.

The existing bridge deck width is 12.44 m with the widening to the north and south to be 5.26 m and 6.0 m respectively.

The existing structure together with its approaches appears to be performing satisfactorily. It is understood from plans provided that the existing structure rests on perched abutments with steel 'H' piles driven in overburden and piers resting on shallow spread footings placed within the native soil. The existing grade is at an elevation of 346.0 m, resulting in fill heights of about 6 m to the west and 6.75 m to the east. The proposed structural widening is expected to be of a similar design.

To facilitate the design and construction of the proposed structure, the following foundation and geotechnical recommendations are given in the scope of this report.

1. Structure Foundation
2. Lateral Earth Pressure
3. Approach Fills
4. Construction Considerations

The structure widening and borehole locations are shown on Dwg. No. 2089401-A in the appendix.

### Structural Foundation

#### East and West Abutments

Based on a review of the above data, the structure may be supported on steel 'H' piles driven into the non-cohesive till and be perched within the embankment in a manner similar to the existing structure.

For the purpose of the O.H.B.D.C., the following design values are recommended:

Pile Type		HP 310x110	HP310x79
Factored Axial Capacity at U.L.S.		1600 kN	1150 kN
Axial Capacity at S.L.S.		1150 kN	900 kN
Pile Tip Elevations (m)	East Abutment	326.5 m (North) 328.0 m (South)	
	West Abutment	328.0. m	

The driving of piles shall be carefully monitored and controlled employing the Hiley Dynamic Pile Driving formula driven in accordance with MTO Standards SS103-10 or SS103-11 assuming an ultimate capacity as follows:

<u>Pile Type</u>	<u>Ultimate Capacity (kN)</u>
HP310x110	3450
HP310x79	2700

The pile tips should be reinforced with steel plates as per MTO Standards (DD-3301 latest revision).

The existing pile cap bottom elevation is about 341.1 m. Since the abutment footing may be perched within the embankment fill to facilitate pile driving, particle sizes in the fill immediately beneath the pile locations should not exceed 75 mm.

Pile caps should have a minimum of 1.2 m earth cover to protect against frost penetration.

### Piers

The piers for the widened portion should be founded on spread footings constructed within the hard clayey silt to silty clay to the south and within the compact to dense silty sand at the north side at or below the elevation of approximately 337.5 m which is similar to the existing pier. A minimum of 1.2 m of soil should be placed over the footing to serve as frost protection.

For the purpose of the O.H.D.D.C., the following values are recommended:

Factored Bearing Capacity at U.L.S.	550 kPa
Bearing Capacity at S.L.S.	350 kPa

Lateral Earth Pressures

Free draining material such as Granular 'A' or Granular 'B' is recommended as an appropriate backfill material to prevent hydrostatic pressure build-up on the abutment walls. Design parameters of the soil are given below for the purpose of the O.H.B.D.C..

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction	35°	30°
Unit Weight (kN/m <sup>3</sup> )	22.8	21.2
Coefficient of Active Earth Pressure (ka)	0.27	0.33
Coefficient of Earth Pressure at Rest (ko)	0.43	0.5

The earth pressure coefficient at rest is to be used when the design of abutment walls are rigid and unyielding.

Approach Fills

No stability problems are anticipated for the approach fills, provided they are built with 2H:1V side slopes. The fill may 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 benching for the approach fill shall be carried out in accordance with OPSD 208.01.

Construction Considerations

No major dewatering difficulties are anticipated for footing excavation in consideration of lower groundwater levels on the north side and the relatively low permeability of the clayey silt on the southside. However, localized seepage or surface water accumulating within the excavations should be controlled by perimeter ditches and pumping from corner sumps.

During construction, care must be taken to avoid undermining the existing foundation. If during excavation, the material at the footing level adjacent to

the existing foundation appears to soften and/or be disturbed, it should be carefully excavated and replaced with mass concrete.

A shoring scheme will be required during construction in order to protect the existing fills of the travelled portion of King Street. The excavation may be supported by soldier piles and timber lagging. Normal construction joints with dowels should be used to fasten together the footings.

Miscellaneous

The fieldwork for this investigation was carried out under the supervision of T. Kim, Sr. Foundation Engineer together with T. Cross, Trainee Engineer. The equipment was owned and operated by Dominion Soils Investigations Ltd, London.

The report was written by M. Michalek, Jr. Foundation Engineer and reviewed by T. Kim, Sr. Foundation Engineer.



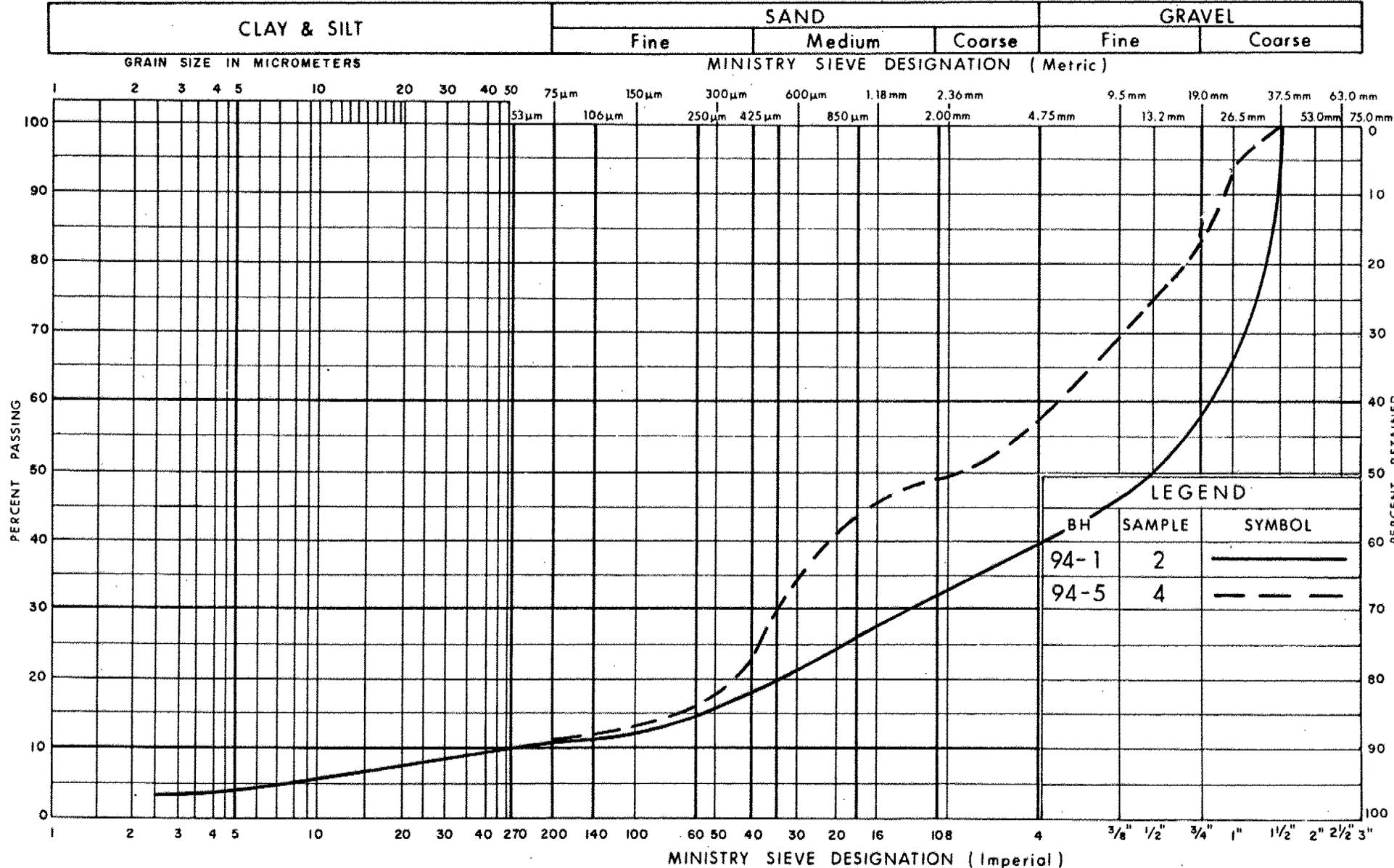
M. Michalek, P. Eng.  
Jr. Foundation Engineer



T. Kim, P. Eng.  
Sr. Foundation Engineer

## **APPENDIX**

UNIFIED SOIL CLASSIFICATION SYSTEM

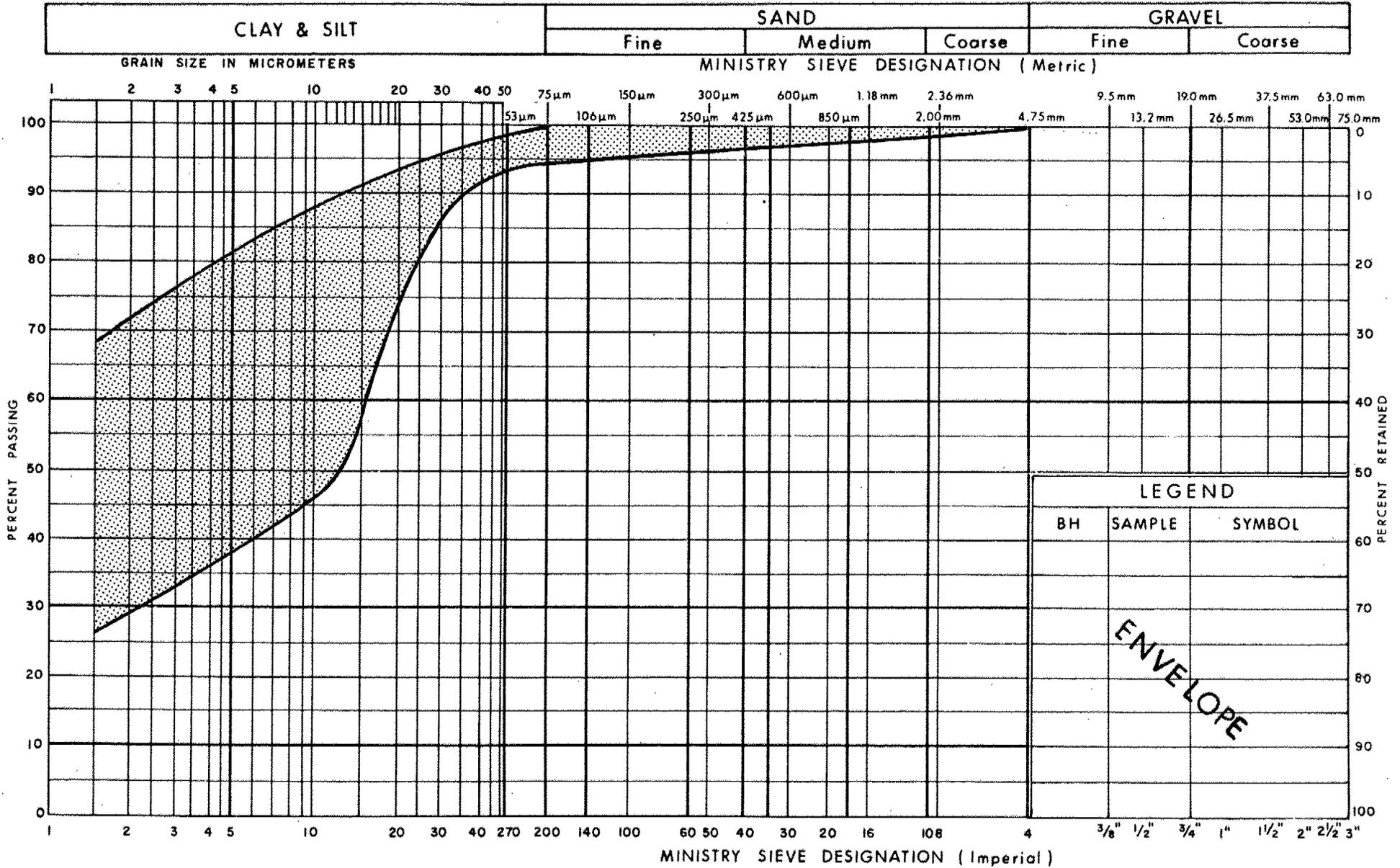


GRAIN SIZE DISTRIBUTION  
SAND & GRAVEL

FIG No 1  
W P 208-94-01

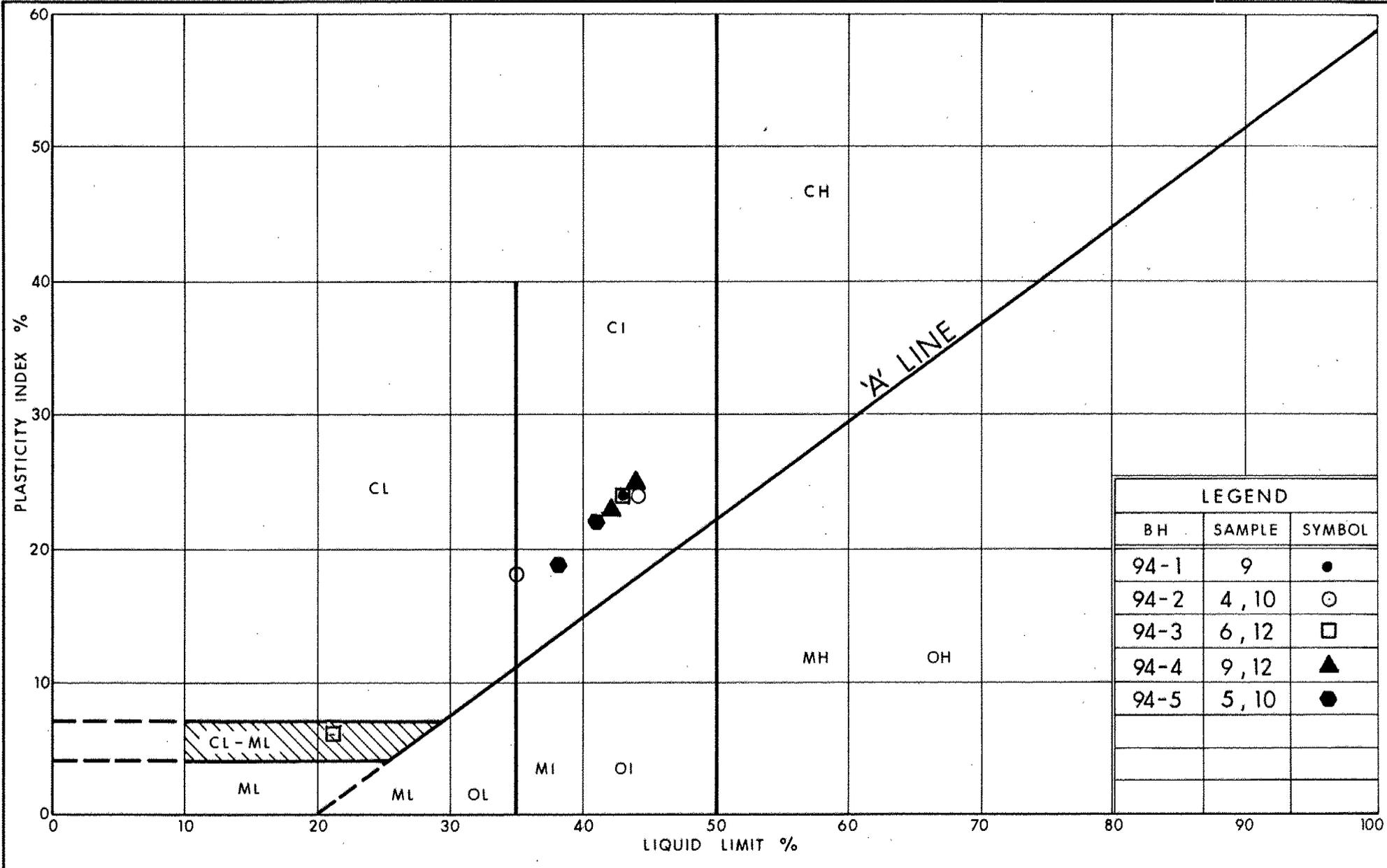


UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
CLAYEY SILT TO SILTY CLAY  
TRACE OF SAND

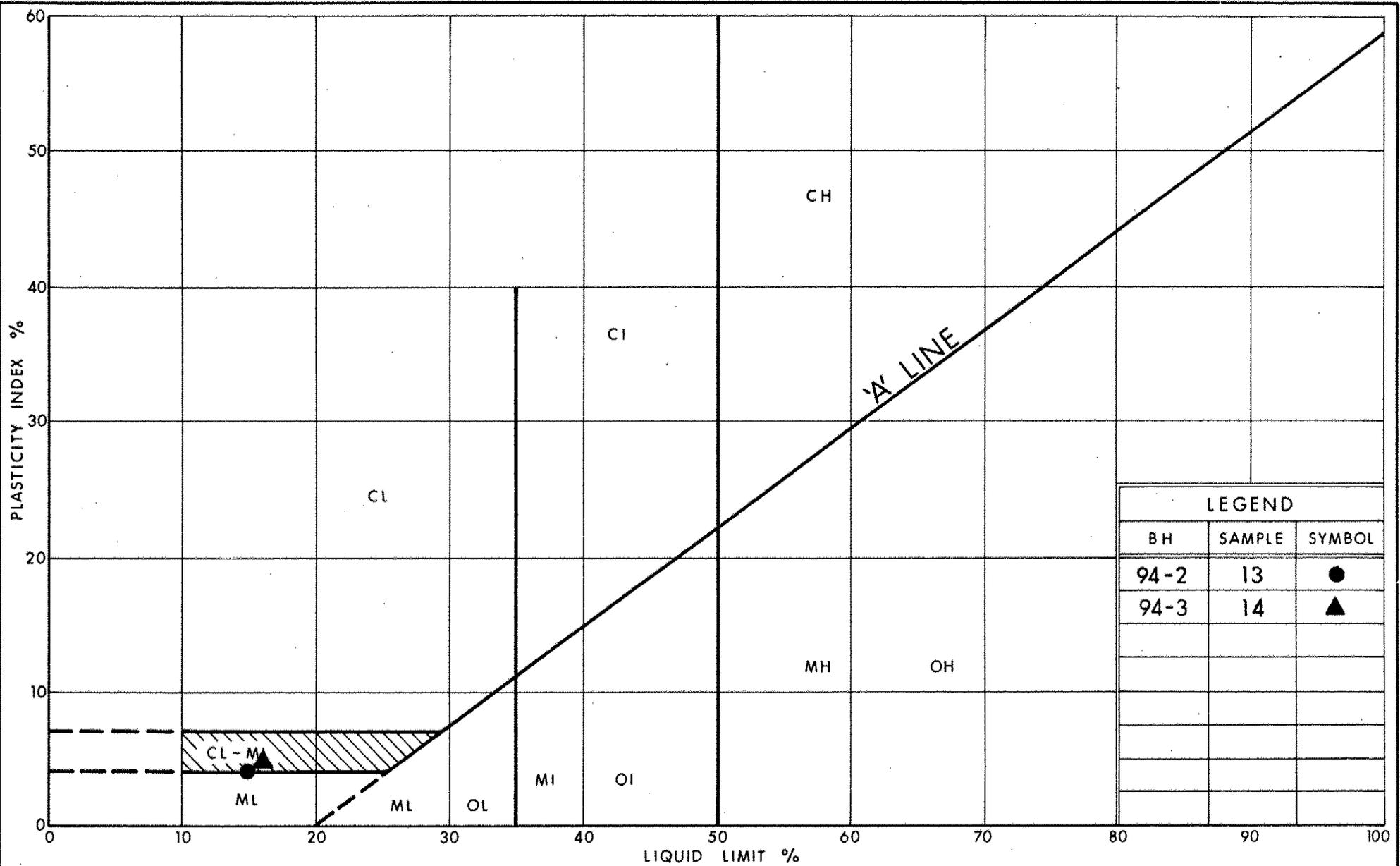
FIG No 3  
W P 208-94-01



PLASTICITY CHART  
CLAYEY SILT TO SILTY CLAY  
TRACE OF SAND

FIG No 4  
W P 208-94-01





**PLASTICITY CHART**  
**HET MIXTURE OF SILT, SAND & GRAVEL**  
**SOME CLAY ( Glacial Till )**

FIG No 6  
 W P 208-94-01

# RECORD OF BOREHOLE No 94-1 1 OF 1 METRIC

W.P. 208-94-01 LOCATION Co-ords. N 4819 373.3; E 220 183.4 ORIGINATED BY I.C.  
 DIST 31 HWY 86 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY V.B.  
 DATUM Geodetic DATE 1994 06 13 CHECKED BY I.C.K.

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	10
340.2	Ground Surface																	
0.0	Fill Sand and Gravel Trace Clay/Silt Dense	Brown X	1	SS	32													61 29 6 4
338.1			2	SS	33													
2.1	Clayey Silt to Silty Clay some sand/gravel Very stiff		3	SS	22													
			4	SS	26													
335.8			5	SS	24													
4.4	Silty Sand to Sandy Silt, some/trace Clay some gravel Compact to very dense		6	SS	25													
			7	SS	51													0 2 90 8
333.2			8	SS	46													
7.0	Clayey Silt to Silty Clay, trace sand Hard		9	SS	67													0 1 38 61
			10	SS	86													
328.0			11	SS	150	/28cm												
12.2	Het. mixture of silt, sand and gravel, some clay (Glacial Till) Very dense		12	SS	137	/15cm												
			13	SS	128	/15cm												
325.0																		

15.2 End of Borehole

+3, x<sup>5</sup>: Numbers refer to Sensitivity  
 20  
 15-5 (%) STRAIN AT FAILURE  
 10

# RECORD OF BOREHOLE No 94-2 1 OF 1 METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4819 378.0 E 220 165.6 ORIGINATED BY T.C.  
 DIST 31 HWY 86 BOREHOLE TYPE Hollow Stem Auger COMPILED BY V.B.  
 DATUM Geodetic DATE 1994 06 13 & 14 CHECKED BY T.C.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID 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			20	40	60	80	100	W <sub>P</sub>	W	W <sub>L</sub>			20	40	60	80	100	10	20	30	
340.1	Ground Surface																									
0.0	Fill	Brown																								
	Sand and Gravel trace clay/silt		1	SS	27																					
	Compact		2	SS	27																					
338.0																										
2.1	Clayey Silt to Silty Clay some sand/gravel		3	SS	36																					
	Hard		4	SS	35																					0 6 37 57
			5	SS	43																					
335.7																										
335.4	Silty Sand to Sandy Silt, Compact		6	SS	27																					
4.7																										
	Clayey Silt to Silty Clay, trace sand		7	SS	42																					
	Hard		8	SS	44																					
			9	SS	45																					
			10	SS	61																					
			11	SS	62																					
328.5																										
11.6	Het. mixture of silt, sand and gravel, some clay (Glacial Till)		12	SS	105	/15cm																				
	Very dense		13	SS	100	/15cm																				3 28 56 13
324.9			14	SS	136	/15cm																				

15.2 End of Borehole

+3, x<sup>5</sup> Numbers refer to Sensitivity 20 15-0-5 (%) STRAIN AT FAILURE 10

# RECORD OF BOREHOLE No 94-3 1 OF 1 METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4819 407.0; E 220 148.9 ORIGINATED BY I.C.  
 DIST 31 HWY 86 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY V.B.  
 DATUM Geodetic DATE 1994 06 14 & 15 CHECKED BY I.C.K.

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					
339.6	Ground Surface													
0.0	Organic topsoil	Dark Brown												
339.0														
0.6		Brown												
	Silty sand to Sandy Silt, some/trace clay some gravel Compact		1	SS	31									
			2	SS	16									
			3	SS	14									
336.7														0 54 43 3
2.9	Sand and Gravel some silt Dense		4	SS	35									
335.7														
3.9			5	SS	58									
			6	SS	43									0 0 74 26
			7	SS	50									
			8	SS	50									
	Clayey Silt to Silty Clay trace sand		9	SS	60									
	Hard		10	SS	41									
			11	SS	66									
			12	SS	67									0 1 38 61
328.0														
11.6			13	SS	110 /15cm									
	Het. mixture of silt, sand and gravel, some clay (Glacial Till)													
	Very dense		14	SS	99 /15cm									8 29 49 14
324.4			15	SS	106 /15cm									

15.2 End of Borehole

+3, x<sup>5</sup> Numbers refer to Sensitivity  
 20  
 15-5 (%) STRAIN AT FAILURE  
 10

# RECORD OF BOREHOLE No 94-4 1 OF 1 METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4819 396.4; E 220 187.0 ORIGINATED BY T.C.  
 DIST 31 HWY 86 BOREHOLE TYPE Hollow Stem Auger COMPILED BY V.B.  
 DATUM Geodetic DATE 1994 06 17 CHECKED BY T.C.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W		
340.0	Ground Surface															
0.0	Sand & gravel (Fill)	Brown														
339.2																
0.8	Organic topsoil	Dark Brown	1	SS	10											
338.6	Loose															
1.4		Brown	2	SS	20											
	Silty Sand to Sandy Silt trace/some clay some gravel		3	SS	29										0 68 28 4	
	Compact to Dense		4	SS	42											
336.3																
3.7	Sand and Gravel some silt		5	SS	50											
335.3	Dense to very dense															
4.7			6	SS	37											
	Sand		7	SS	28											
	Clayey Silt to Silty Clay trace sand Occ. sand layers		8	SS	28											
	Very stiff to hard		9	SS	30										0 4 34 62	
332.2																
7.8	Silty Sand to Sandy Silt trace clay		10	SS	33											
331.4	Dense															
8.6			11	SS	35											
	Clayey Silt to Silty Clay trace sand		12	SS	40											
	Hard															
			13	SS	58											
326.9																
13.1	Het. Mixture of Silt, Sand and Gravel, some clay (Glacial Till)		14	SS	117	/15cm									5 37 46 12	
	Very dense															
324.8			15	SS	86	/15cm										

15.2 End of Borehole

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

# RECORD OF BOREHOLE No 94-5 1 OF 1 METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4819 401.1 E 220 168.2 ORIGINATED BY I.C.  
 DIST 31 HWY 86 BOREHOLE TYPE Hollow Stem Auger COMPILED BY V.B.  
 DATUM Geodetic DATE 1994 06 16 CHECKED BY I.C.K.

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						10	20
339.9	Ground Surface	Brown																	
0.0	Sand and Gravel (Fill)	Brown																	
339.1																			
0.8	Silty Sand to Sandy Silt some/trace clay some gravel Compact to Dense	Brown	1	SS	38													0 59 36 5	
			2	SS	34														
			3	SS	25														
337.0																			
2.9	Sand and Gravel some silt		4	SS	49													42 47 11	
336.2	Dense																		
3.7			5	SS	37														
			6	SS	31														
	Silty Sand to Sandy silt trace clay Dense		7	SS	35														
			8	SS	52														
	Clayey Silt to Silty Clay, trace sand Very Stiff to Hard		9	SS	53														
			10	SS	55													0 1 33 66	
			11	SS	55														
328.3																			
11.6	Het. mixture of Silt, Sand and Gravel, some clay (Glacial Till) Very Dense		12	SS	150	/25cm												3 33 64	
326.2																			
13.7	End of Borehole																		

RECORD OF BOREHOLE No 1\*

1 OF 1

METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4 819 387.2; E 220 199.5 ORIGINATED BY P.K.  
 DIST 31 HWY 86 BOREHOLE TYPE Washboring, BX Casing COMPILED BY V.B.  
 DATUM Geodetic DATE 1971 10 20 & 21 CHECKED BY T.C.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			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			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
341.1	Ground Surface																
0.0	Organic topsoil Stiff	Brown															
339.6			1	SS	10												
1.5	Sandy silt to Silty Sand some/trace clay some gravel		2	SS	20											4 37 49 10	
	Very dense		3	SS	106												
336.8			4	SS	51											0 25 75	
4.3	Sand and Gravel some silt		5	SS	70											39 15 46	
335.6	Very dense		6	SS	100	/25cm										0 39 53 B	
5.5	Sandy Silt to Silty Sand, trace clay		7	SS	116												
333.2		Brown															
7.9	Clayey Silt to Silty Clay, trace sand	Grey	8	SS	49											0 6 78 16	
	Hard		9	SS	55												
330.0		Grey															
11.1	End of Borehole																

\* Formerly BH No 1  
of WP 281-66-08

RECORD OF BOREHOLE No 2\*

1 OF 1

METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4 819 378.7; E 220 187.7 ORIGINATED BY P.K.  
 DIST 31 HWY 86 BOREHOLE TYPE Washboring, BX Casing COMPILED BY V.B.  
 DATUM Geodetic DATE 1971 10 21 CHECKED BY T.C.K.

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	10
341.0	Ground Surface																	
0.0	Organic topsoil Firm	Brown																
339.6			1	SS	7													
1.4	Sandy Silt to Silty Sand some/trace clay some gravel Compact to Very Dense		2	SS	10													17 30 45 8
337.6			3	SS	54													8 64 28
3.4	Sand and Gravel some silt Dense		4	SS	47													41 35 21 3
336.1			5	SS	34													
4.9	Sandy Silt to Silty Sand trace clay Very dense		6	SS	74													0 37 63
333.7		Brown																
7.3	Clayey Silt to Silty Clay, trace sand Hard	Grey	7	SS	34													
331.4		Grey	8	SS	25													
9.6	End of Borehole  * Formerly BH No 2 of WP 281-66-06																	

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to Sensitivity  
 20  
 15-5 (%) STRAIN AT FAILURE  
 10

RECORD OF BOREHOLE No 3\*

1 OF 1

METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4 819 389.8; E 220 168.2 ORIGINATED BY P.K.  
 DIST 31 HWY 86 BOREHOLE TYPE Washboring, BX Casing COMPILED BY V.B.  
 DATUM Geodetic DATE 1971 10 21 & 22 CHECKED BY T.C.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
340.9	Ground Surface									
0.0	Organic topsoil Firm	Brown								
339.7			1	SS	8					
1.2	Sandy Silt to Silty Sand some/trace clay some gravel Compact to very dense		2	SS	14					
			3	SS	100	100cm				
335.5		Brown	4	SS	54					
4.4	Clayey Silt to silty Clay, some/trace sand Hard	Grey	5	SS	37					
			6	SS	34					1 27 42 30
			7	SS	38					
331.3		Grey	8	SS	50					
9.6	End of Borehole  * Formerly BH No 3 of WP 281-66-06									

\* 3, x 5: Numbers refer to Sensitivity  
 20  
 15-5 (%) STRAIN AT FAILURE  
 10

RECORD OF BOREHOLE No 4\*

1 OF 1

METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4 819 399.0; E 220 147.0 ORIGINATED BY P.K.  
 DIST 31 HWY 86 BOREHOLE TYPE Washboring, BX Casing COMPILED BY V.B.  
 DATUM Geodetic DATE 1971 10 22 & 25 CHECKED BY T.C.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			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			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
341.1	Ground Surface																
0.0	Organic Topsoil																
340.0																	
1.1	Sandy Silt to Silty Sand some/trace clay some gravel  Loose to compact		1	SS	11												
			2	SS	4												
			3	SS	25												
337.6	Sand and Gravel some silt																
3.5	Dense		4	SS	37												
336.8																	
4.3	Clayey Silt to Silty Clay, trace sand  Hard	Grey	5	SS	32												
				6	SS	45											
				7	SS	57											
				8	SS	60											
330.0		Grey	9	SS	60												
11.1	End of Borehole																
	* Formerly BH No 4 of WP 281-66-06																

RECORD OF BOREHOLE No 5\*

1 OF 1

METRIC

W.P. 208-94-01 LOCATION Co-ords: N 4 819 393.1; E 220 135.6 ORIGINATED BY P.K.  
 DIST 31 HWY 86 BOREHOLE TYPE Washboring, BX Casing COMPILED BY V.B.  
 DATUM Geodetic DATE 1971 10 25 CHECKED BY T.C.K.

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
341.1	Ground Surface															
0.0	Organic topsoil															
339.9																
1.2	Sandy Silt to Silty Sand some/trace clay some gravel		1	SS	3											
338.7	Loose		2	SS	10											
2.4	Sand and Gravel some silt Dense		3	SS	46											
336.8			4	SS	26											
4.3		Grey														
			5	SS	49											
			6	SS	51											
	Clayey Silt to Silty Clay, trace sand Hard		7	SS	79											
			8	SS	77											
330.0		Grey														
			9	SS	86											
11.1	End of Borehole															
	* Formerly BH No 5 of WP 281-66-05															

+3, x5: Numbers refer to Sensitivity  
 20  
 15-0.5 (%) STRAIN AT FAILURE  
 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/0.3 m)	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

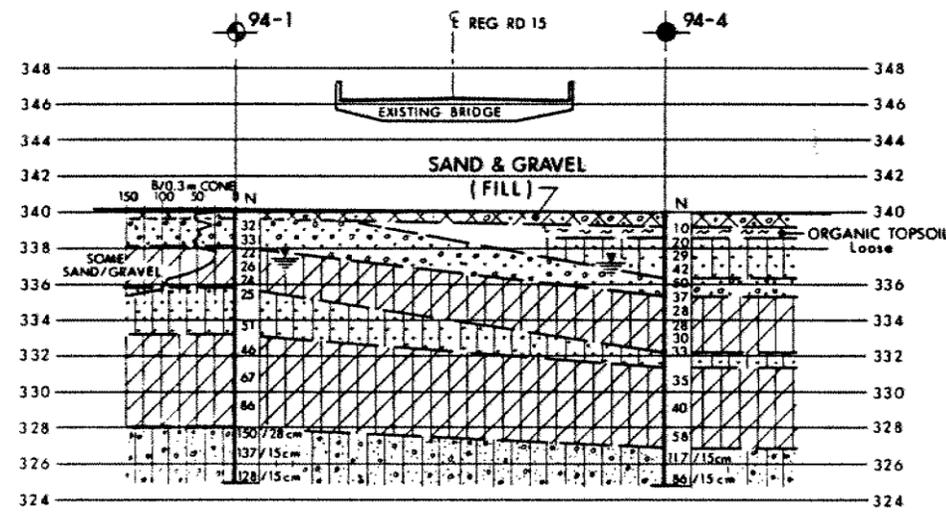
$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS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

### MECHANICAL PROPERTIES OF SOIL

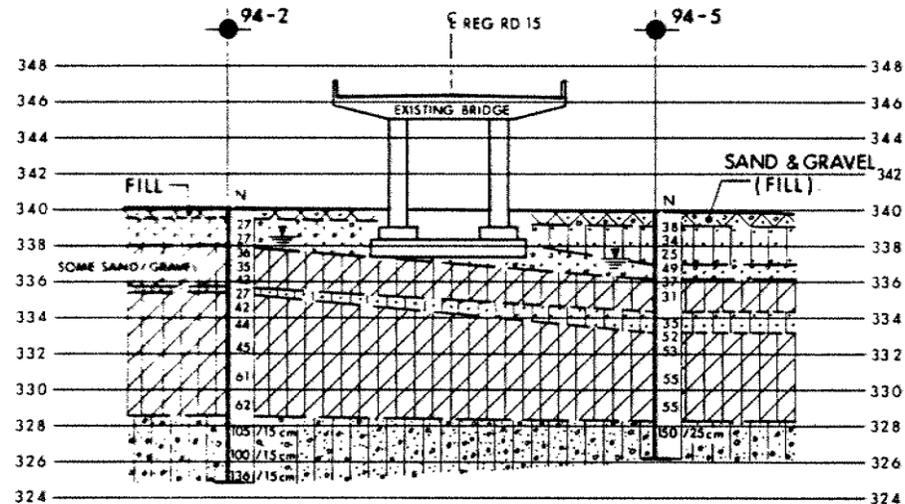
$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_{\alpha}$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$m^2/s$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	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

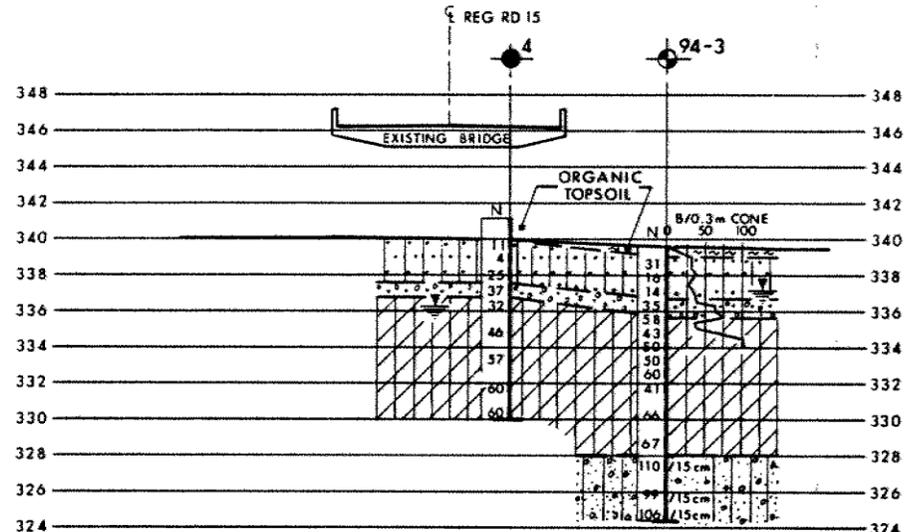
$\rho_s$	$kg/m^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$kn/m^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$kg/m^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN 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 = $\frac{w_L - w_p}{w - w_p}$	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						



A-A

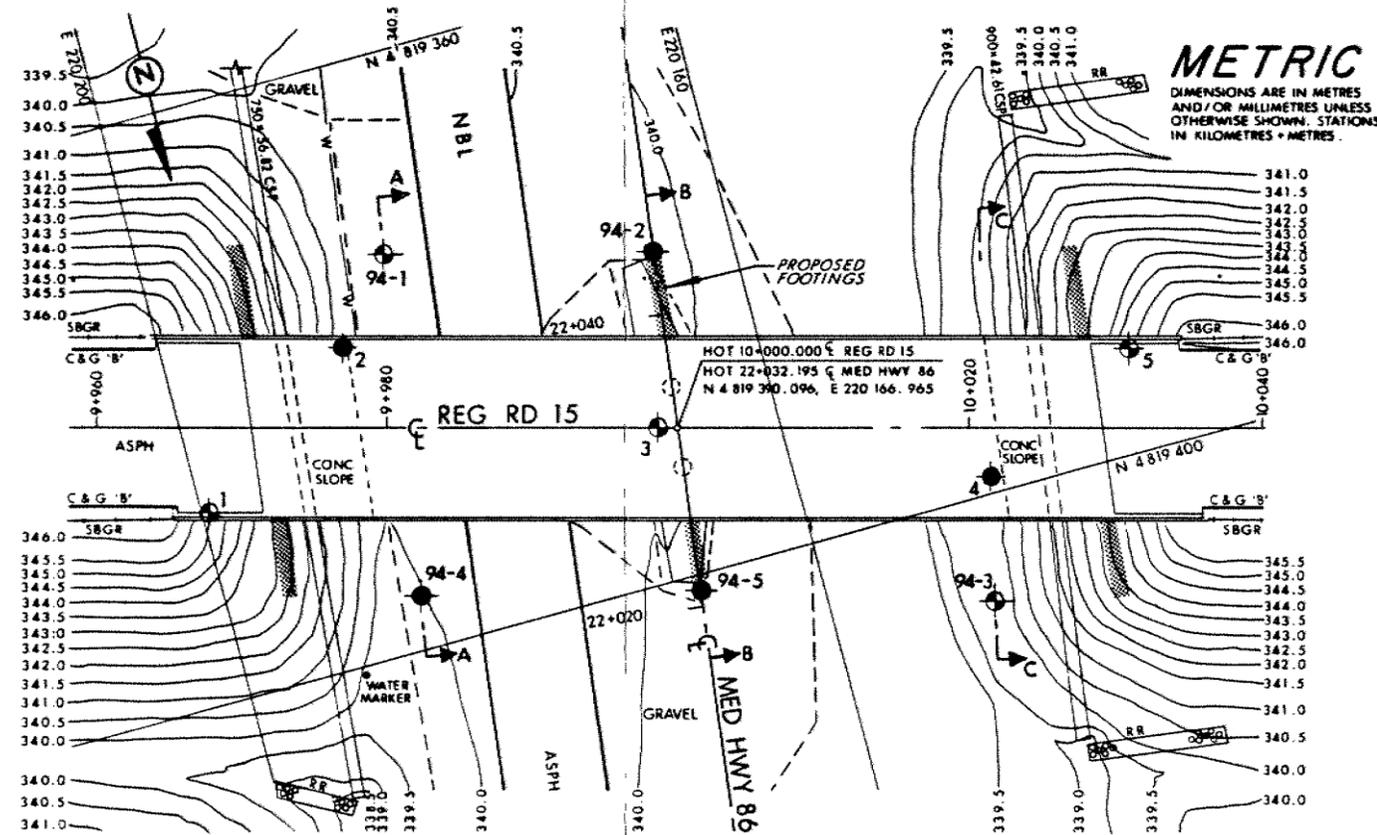


B-B



C-C SECTIONS

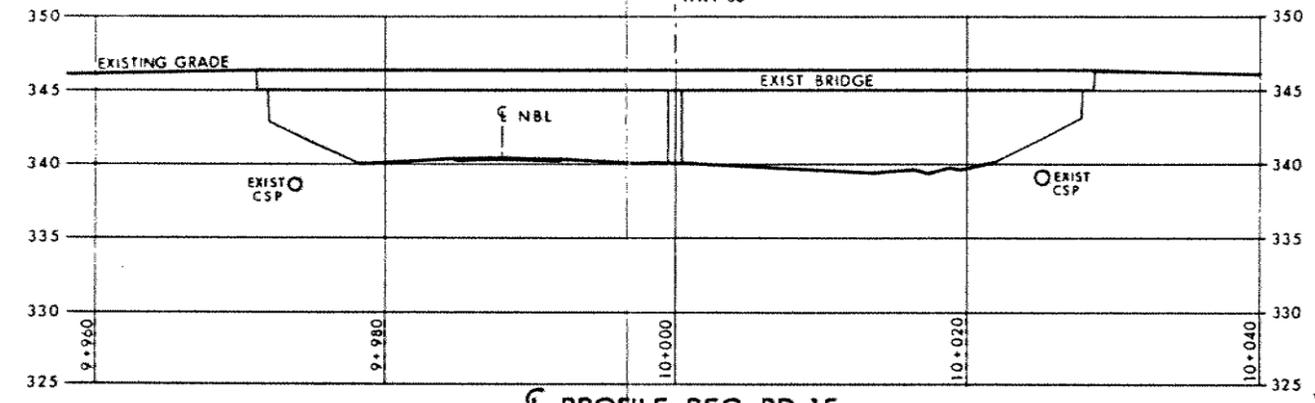
SCALE  
4m 0 4m



PLAN SCALE

5m 0 5m

**NOTE**  
For Subsoil information of B.H.'s 1, 2, 3 & 5 refer to Record of Borehole Sheets.



PROFILE REG RD 15

SCALE  
5m 0 5m

**SOIL STRATIGRAPHY LEGEND**

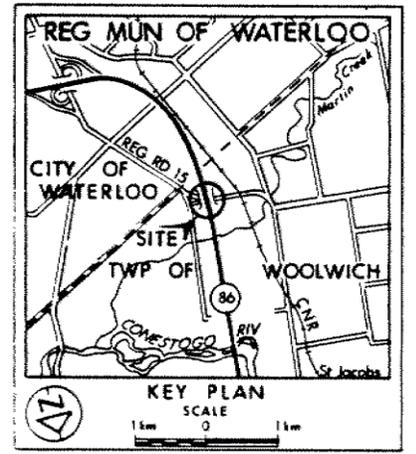
- SAND & GRAVEL  
TRACE CLAY, TRACE/SOME SILT  
Compact to Very Dense
- SILTY SAND TO SANDY SILT  
SOME / TRACE CLAY, SOME GRAVEL  
Loose to Very Dense

- CLAYEY SILT TO SILTY CLAY  
TRACE SAND  
Very Stiff to Hard
- HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL  
SOME CLAY, (Glacial Till)  
Very Dense

CONT No  
WP No 208-94-01

REGIONAL ROAD 15 SHEET

BORE HOLE LOCATIONS & SOIL STRATA



**LEGEND**

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 1994 06 and 1971 10

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
94-1	340.2	4819 373.3	220 183.4
94-2	340.1	4819 378.0	220 165.6
94-3	339.6	4819 407.0	220 148.9
94-4	340.0	4819 396.4	220 187.0
94-5	339.9	4819 401.1	220 168.2
1	341.1	4819 387.2	220 199.5
2	341.0	4819 378.7	220 187.7
3	340.9	4819 389.8	220 168.2
4	341.1	4819 399.0	220 147.0
5	341.1	4819 393.1	220 135.6

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

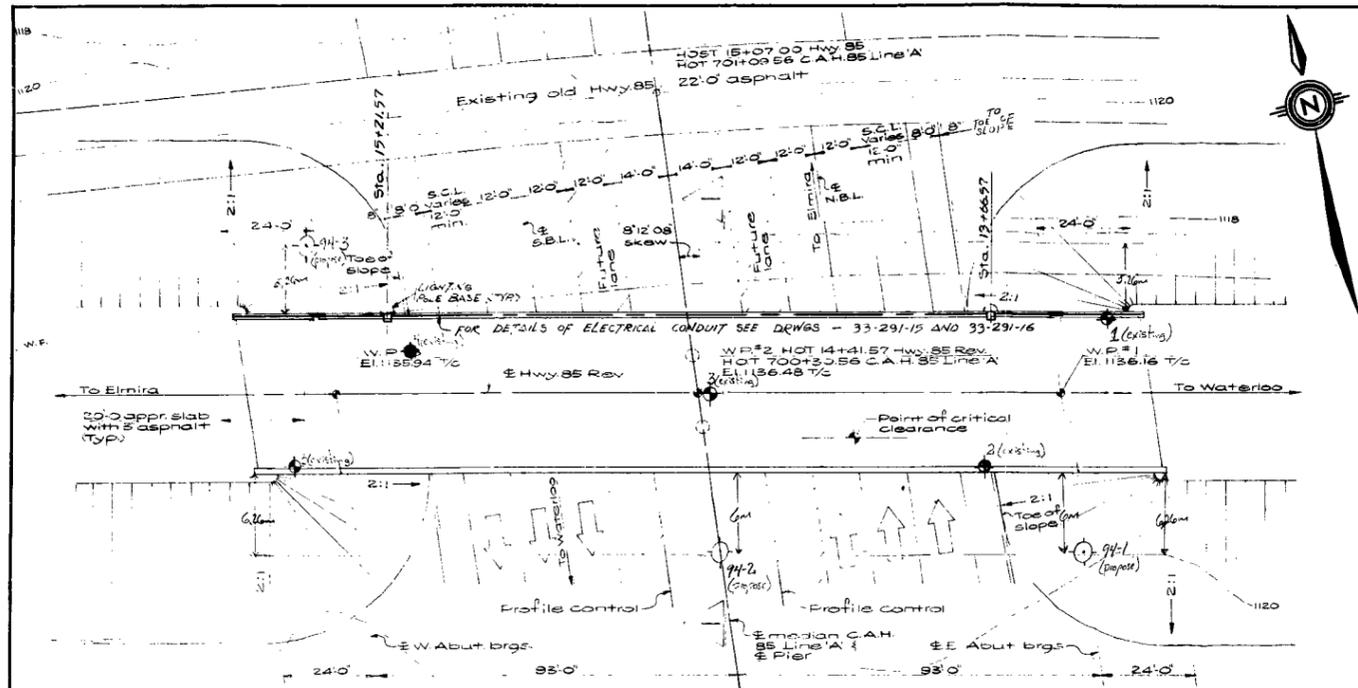
**NOTE:** The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.



REV	DATE	BY	DESCRIPTION

Geocres No 40P10-29

HWY No 86	DIST 31
SUBMPT TK CHECKED DATE 1995 03 01	SITE 33-291
DRAWN RS CHECKED APPROVED	DWG 2089401-A

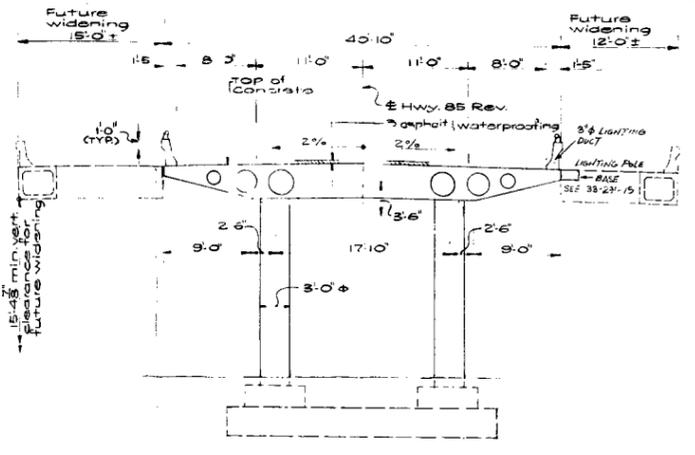


PLAN  
1"=20'-0"

Functions of 8' 12" OS Skew

Sin	0.1426673
Cos	0.98937707
Tan	0.1441418
Sec	1.0103550

W.P. = Working point  
T/C = Top of concrete



LIST OF DRAWINGS

- 1 GENERAL PLAN
- 2 BORE HOLE LOCATION AND SOIL STRATA
- 3 FOOTING LAYOUT AND ABUTMENT FOOTING DETAILS
- 4 ABUTMENTS
- 5 PIER COLS AND FOOTINGS
- 6 DECK DETAILS AND BEARINGS
- 7 DECK REINFORCING
- 8 LONGITUDINAL CABLE DETAILS
- 9 TRANSVERSE
- 10 CONCRETE BARRIER WALL
- 11 PARAPET RAILING
- 12 CONCRETE SLOPE PAVING
- 13 APPROACH SLABS
- 14 STANDARD DETAILS I
- 15 STANDARD DETAILS II
- 16 BRIDGE ELECTRICAL DETAILS

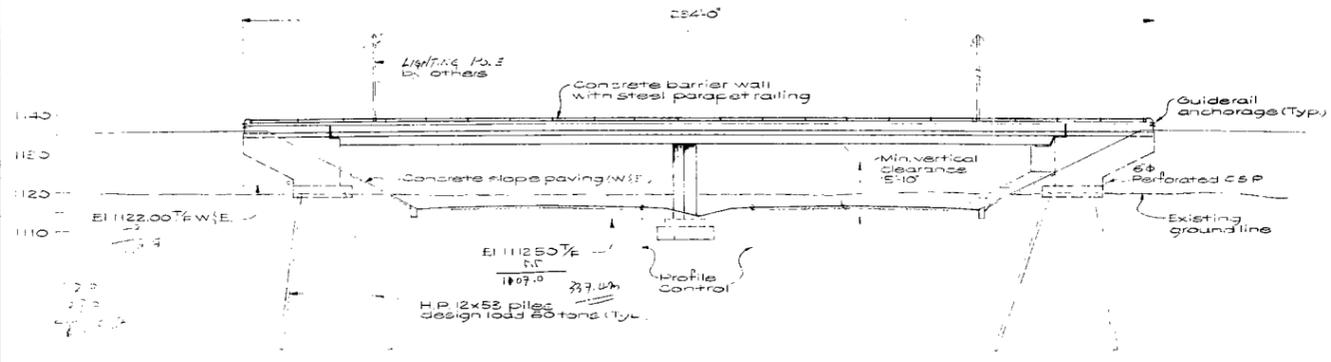
NOTES:

- CLASS OF CONCRETE:  
DECK, BARRIER WALLS, COLUMNS 5000 P.S.I.  
REMAINDER 3000 P.S.I.
- CLEAR COVER ON REINF. STEEL:  
FOOTINGS 3"  
ABUTMENTS 3"  
PIER COLUMNS AS NOTED  
DECK TOP 2"  
DECK BOTTOM 1 1/2"  
BARRIER WALLS 1 1/2"

CONSTRUCTION NOTES:

- THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BENCHING, SEALS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 1/8" INCH.
- NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BENCHING SEALS UNTIL AFTER THE DECK HAS BEEN STRESSED AND CURED.

B.M. 1120.79  
Cut cross on S.E. corner of 1st step of 22' BHE 36' ft. of 17+65



ELEVATION  
1"=2'-0"



PROFILE AT CROWN OF HWY. 85 REV.  
N.T.S.

PROFILE AT PROFILE CONTROL  
OF C.A.H 85 LINE 'A'  
N.T.S.

NO.	DATE	BY	DESCRIPTION

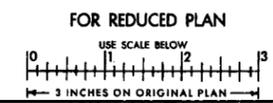
DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS  
ONTARIO

**OLD HWY. 85 UNDERPASS**  
At existing Highway 85 revision

KING'S HIGHWAY No. C.A.H. 85 DIST. No. 3  
CO. Waterloo  
TWP. Woolwich LOT 18 CON. Co. Trust

GENERAL PLAN 33-291-10-22

APPROVED	SITE No. 33-291	W.P. No. 281-66-06
DESIGN S.R.	CHECK J.L.R.	CONTRACT No. 74-60
DRAWING D.C.	CHECK W.D.S.	DRAWING No. 33-291-1
DATE JULY 1972	LOADING H-20-44	



(33-291) TWP 267-291-1-A B