

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M15-58 <sup>57</sup>

DIST. 6 REGION                     

W.P. No. 110-72-01

CONT. No. 86-36

W. O. No.                     

STR. SITE No.                     

HWY. No. 2

LOCATION Retaining Wall between  
STA. 11+030 & STA. 11+130

No of PAGES -                     

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 86 - 36



Ministry of  
Transportation and  
Communications

I N D E X

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3-20	FOUNDATION INVESTIGATION REPORTS FOR: W. P. 110-72-01 DISTRICT #7 FAREWELL CREEK CONCRETE CULVERT [STA. 10 + 982.200] SITE: 21-368  AND  RETAINING WALL [STA. 11 + 090 - 11 + 130] HIGHWAY #2 SITE: 21-RW

NOTE: FOR PURPOSES OF THE CONTRACT THESE REPORTS SUPERCEDE ALL OTHER FOUNDATION REPORTS PREPARED BY OR FOR THE MINISTRY IN CONNECTION WITH THE ABOVE-MENTIONED PROJECTS.

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	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
$C_\alpha$	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
$\sigma'_{v0}$	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
$S_f$	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

FAREWELL CREEK CONCRETE CULVERT  
[STA. 10 + 982]  
EXTENSION, 1 km EAST OF OSHAWA  
W. P. 110-72-01, SITE 21-368  
HIGHWAY #2, DISTRICT #7, PORT HOPE

---

INTRODUCTION

This report contains the results of the foundation investigation carried out at the above site. The field work was performed on 80 09 25 and 80 09 26 employing a track mounted, continuous flight, hollow stem auger. Three boreholes were augered to 5 m with the fourth going to 9 m. The boreholes were located as close as possible to the proposed location of the culvert extension footings.

SITE DESCRIPTION

Farewell Creek crosses Highway #2 approximately 1 km east of the Oshawa townline. The valley, cut through the southward sloping area, is approximately 350 metres in width by 11 metres in depth.

Land use in the area is mixed, and includes a motel site, residential housing, bush and open fields. Bell Telephone and Natural Gas Services run below the existing shoulders of Highway#2. A well, probably used for summer lawn watering, is located on the valley floor just north of the culvert extension.

Farewell Creek is 0.2 m to 0.5 m deep and 6 m wide at the Highway #2 crossing. The water surface elevation at the time of investigation was 113.5 m. To the north and the south of the site trees exist along the creek valley. A small swampy area is located just north of the proposed culvert extension.

## SUBSURFACE CONDITIONS

4

### Subsoil General

Farewell Creek has a bed of boulders, cobbles and gravel for a depth of 0.8 m. On either side of the creek there is a recent alluvial deposit consisting of a 0.3 metre layer of topsoil and from 0.6 to 0.9 metres of silty sand with a trace of organics. These superficial deposits overlie a hard homogeneous mixture of silty clay, sand and gravel of glacial origin. It extends to a depth of at least 9 metres, where the deepest borehole was terminated.

Reference should be made to Sheet #23 of the contract dwg's. which shows the borehole locations and an inferred subsoil stratigraphy. A more detailed description and location of the subsoils can be found on the Borehole Log Sheets in the Appendix.

### Heterogeneous Mixture of Silty Clay, Sand and Gravel

The predominant soil type at the site is a hard glacial till consisting of a heterogeneous mixture of silty clay, sand and gravel which extends from elevation 113 to below the maximum depth of the borings. It contains some silt inclusions but is generally cohesive in nature. This is indicated by the fact that the results of Atterberg Limit Tests [Figure 2] plot close to or in the CL - ML range. Grain size distribution curves [Figure 1] are typical of glacial till deposits with high fractions of sand and silt with some clay and gravel. Standard Penetration 'N' values range from 31 to above 100, with most values in excess of 50. This indicates a hard consistency. Moisture contents of samples tested are very low, ranging from 5 to 8 percent.

### Groundwater

Boreholes 2, 3 and 4 all indicate water levels which correspond to the creek water level of 113.5 m. Borehole #1 had an artesian head of approximately 0.3 m above the existing ground surface. The artesian pressure was met at elevation 108 m, six metres below ground level.



L. Politano, P. Eng.,  
Project Foundations Engineer

 FOR

M. Devata, P. Eng.,  
Chief Foundations Engineer  
(East)

APPENDIX

## METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity





## RECORD OF BOREHOLE No 2

METRIC

W P 110-72-01 LOCATION Sta. 10+982.5 14.2 m LT. ORIGINATED BY R.B.  
DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
DATUM Geodetic DATE 80-09-26 CHECKED BY

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					
113.5	Ground Level															
112.7	Boulders, Cobbles & Gravel															
0.8	Heterogeneous Mixture of Silty Clay, Sand & Gravel Random Silt Inclusions		1	SS	100/	23 cm	112									
			2	SS	74											
			3	SS	100/	36 cm	110									
108.7	Grey Hard (Glacial Till)		4	SS	100/	25 cm										
4.8	End of Borehole															

+3, x5 : Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 3

METRIC

W P 110-72-01 LOCATION Sta. 10+974.2 15.1 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY 72 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY \_\_\_\_\_

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					
114.2	Ground Level						114										
113.9	Top Soil																
0.3	Silty Sand, Trace																
113.0	Organics																
1.2	Heterogeneous		1	SS	31		112							0	10	15	
	Mixture of Silty Clay		2	SS	100/	28 cm											25 35 31 9
	Sand and Gravel		3	SS	35/	15 cm								0	10	15	
	Random Silt																
	Inclusions																
109.4	Grey Hard		4	SS	100/	23 cm	110										
	(Glacial Till)																
4.8	End of Borehole						108										

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

20  
15  
10  
5 (%) STRAIN AT FAILURE

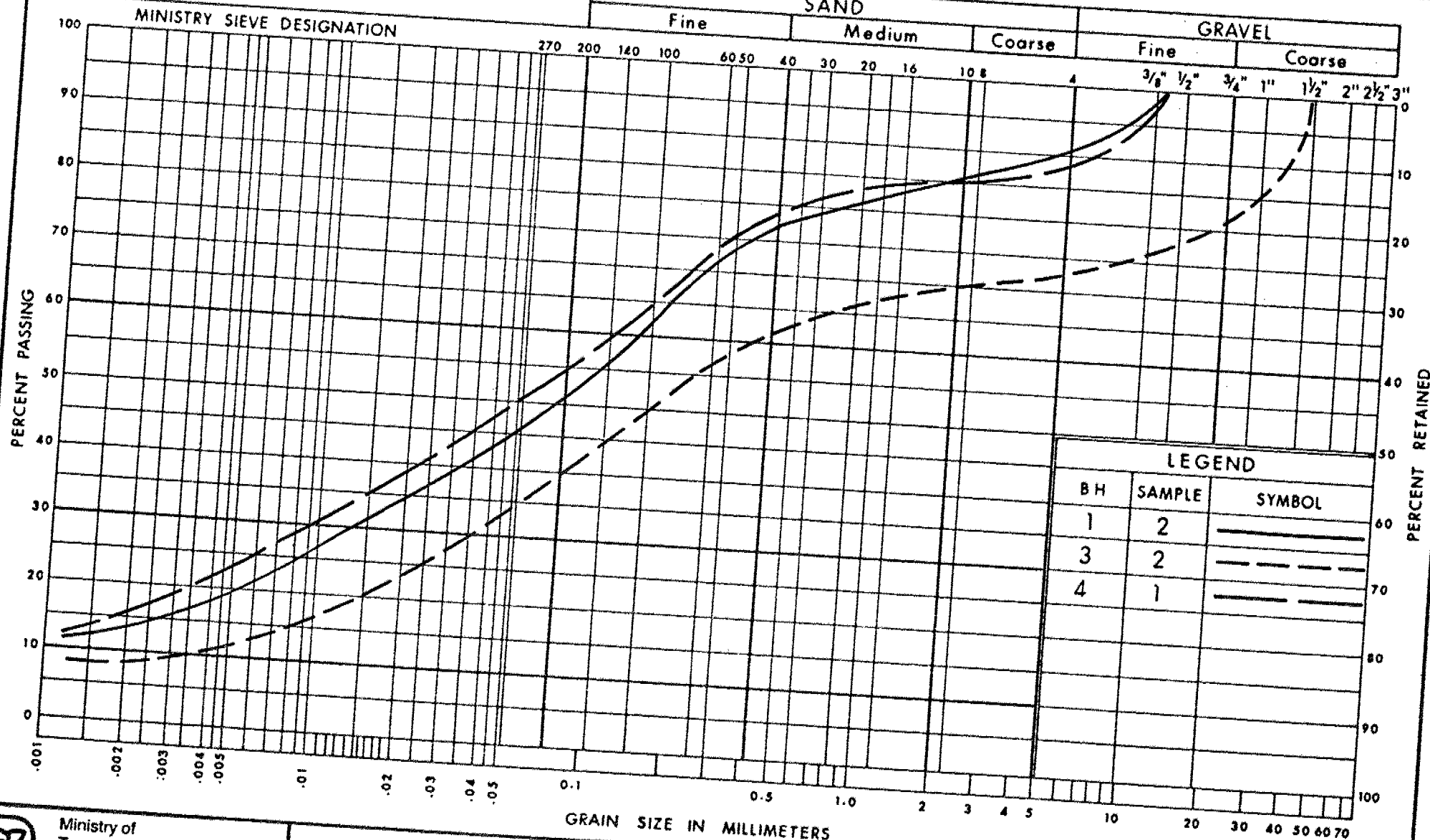
## METRIC

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT	LQUID LIMIT	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	W		
114.2	Ground Level												
113.9	Top Soil												
0.3	Silty Sand						114						
113.0	Trace Organics												
1.2	Heterogeneous Mixture of Silty Clay Sand and Gravel Random Silt Inclusions Grey Hard (Glacial Till)		1	SS	55		112						8 36 40 16
			2	SS	80								
			3	SS	100/	28 cm							
109.3	(Glacial Till)						110						
4.9	End of Borehole		4	SS	100/	31 cm							
							108						

OFFICE REPORT ON SOIL EXPLORATION

# UNIFIED SOIL CLASSIFICATION SYSTEM

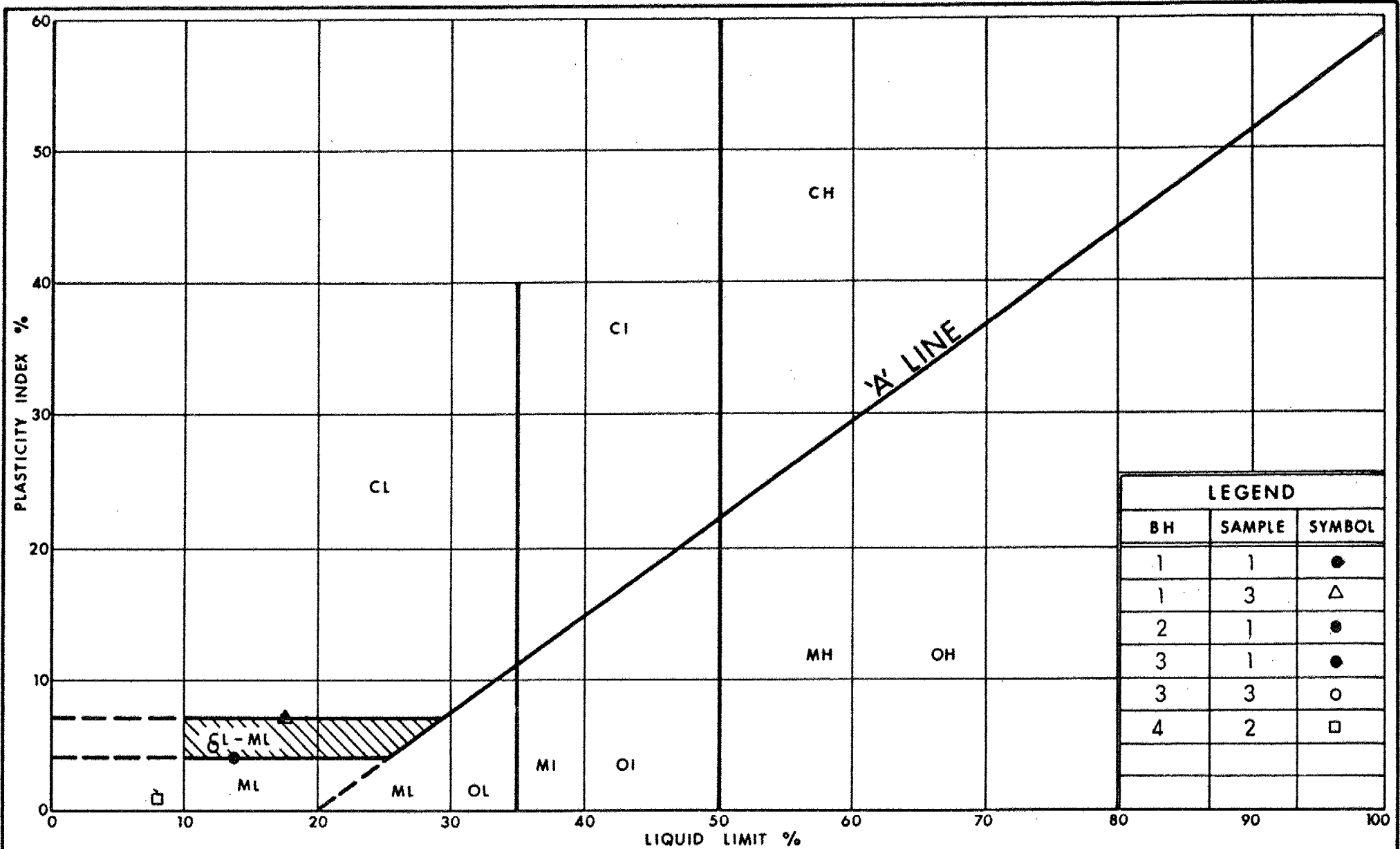
Oct 75, FF-S-22



Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No 1  
W P 110-72-01



Ontario

Ministry of  
Transportation and  
Communications

**PLASTICITY CHART**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No. 2

W P 110-72-01

=

## FOUNDATION INVESTIGATION REPORT

For

RETAINING WALL [STA. 11 + 090 - 11 + 130]  
W. P. 110-72-01, SITE 21-RW  
HIGHWAY #2, DISTRICT #7, PORT HOPE

---

Site Investigation Services Limited was retained by the Ministry of Transportation and Communications of Ontario to evaluate the soil conditions at the above-noted site.

The locations of 3 boreholes and a summary soil profile are provided on Sheet #25 of the contract dwg's. More detailed soil profile and field test data is presented on the Borehole Summary Sheets in the Appendix.

Borings were completed with a track-vehicle-mounted power drill equipped with hollow stem and continuous flight augers. Samples were obtained with a 50 mm diameter "split spoon" sampler driven in accordance with Standard Penetration Test procedures (63.5 kg hammer falling 760 mm) and with a 50 mm thin wall tube sampler.

Field work was completed on January 19 and 21, 1981. Elevations were related to site survey data provided by the MTC.

SUBSURFACE CONDITIONSGeneral

The retaining wall site is located near the top of the valley of the adjacent Farewell Creek on the south side of Highway #2. The existing highway is cut into the native soils in this area.

Native soils at the site consist of 2.13 to 2.44 metres of sandy silt underlain by 1.17 to 1.67 metres of layered silty clay.

These lacustrine soils are underlain by a heterogeneous mixture of gravel, sand, silt and clay that contains scattered cobbles. This lower material is classified as a glacial till. Both borings terminated in the till.

#### Topsoil

Topsoil at borehole locations is 205 mm thick. Similar depths are expected on native soils beyond the existing cut. The topsoil is a good quality silty loam.

#### Sandy Silt

The layered sandy silt soils are classified as compact on the basis of standard penetration resistances of 12 to 22 blows per 305 mm. A particle size analysis on a representative sample is shown on Figure 1 in the Appendix. There are occasional clay seams in the lower metre of these deposits.

#### Silty Clay

The layered silty clay soils generally are classified as stiff on the basis of penetration resistances of 3 to 4 blows per 305 mm and vane shear strengths of 75 to 82 kPa. These clayey soils are slightly softer near the contact with the underlying till soils. Figure 2 shows the results of Atterberg Limits testing carried out on 2 samples of this material.

#### Sandy Silt (Till)

The stony sandy silt is part of the extensive basal till deposits common to the area. Most of these till textured soils contain some clay size particles and scattered cobbles. Occasional boulders may also be encountered. A typical grain-size distribution of this material is shown on Figure 3 in the Appendix.

The till-textured soils are classified as very dense on the basis of standard penetration resistances of 50 to more than 100 blows per 305 mm. In 3 of the 5 tested locations the till was extremely dense and the sampler could not be driven the full 305 mm standard test depth.

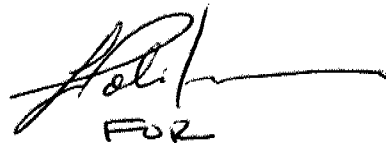
Groundwater

The lower part of the sandy silt was very wet at the time of drilling but no free water was noted. The groundwater level was between elevation 123.0 and 123.4 metres on January 19, 1981. This is roughly 2.4 to 2.7 metres below the ground surface at the boreholes and is close to the existing Highway #2 road grade in the borehole area. There is a slight westward slope toward the creek.

Seasonal water table fluctuations of at least one-metre should be expected as should seasonal saturation of the contact area between the sandy silt and the underlying silty clay.



L. Politano, P. Eng.,  
Project Foundations Engineer



M. Devata, P. Eng.,  
Chief Foundations Engineer  
(East)



APPENDIX

RECORD OF BOREHOLE No 1 & 1A

METRIC

W P 110-72-01 LOCATION Sta. 11+098.2 o/s 15 m RT 9 Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm diameter. COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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			20	40	60	80	100					
125.61	Ground Level															
0.0	Topsoil															
205 mm	Sandy silt					125										
	Trace of clay															
	Wet below 1 m															
	Compact. Light brown to dense		1	SS	22	124										0 44 44 12
123.17	Silty clay		1A	TW	PH	123										
2.44	Wet		2	SS	3	122										
	Stiff to firm Grey		3	SS	4											
121.5	Gravelly		4	SS	70	121										
4.11	Sandy silt, some clay and cobbles					120										
	(Glacial Till)															
	Very Dense Dark Grey		5	SS	50/125 mm	119										
						118										
117.81	End of Borehole		6	SS	50/100 mm											
7.80																
	Note Borehole 1A drilled 1 meter east of Borehole No.1 to obtain thin wall sample and vane tests.															

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 110-72-01 LOCATION Sta. 11+118.6 o/s 16 m RT 9 Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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	IN' VALUES			20	40	60	80	100				
125.78	Ground Level															
0.00	Topsoil															
205 mm	Sandy silt						125									
	Compact Light brown						124									
123.65			1	SS	12											
2.13	Silty clay						123									
	Wet															
	Stiff to firm Grey															
122.48			2	SS	3		122									
3.30	Gravelly sandy silt, trace to some clay.															
	(Glacial Till)						121									
	Very Dense Dark Grey		3	SS	50											
119.53			4	SS	50/125 mm		120									
6.25	End of Borehole						119									

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

OFFICE REPORT ON SOIL EXPLORATION

## UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY &amp; SILT

SAND

GRAVEL

Fine

Medium

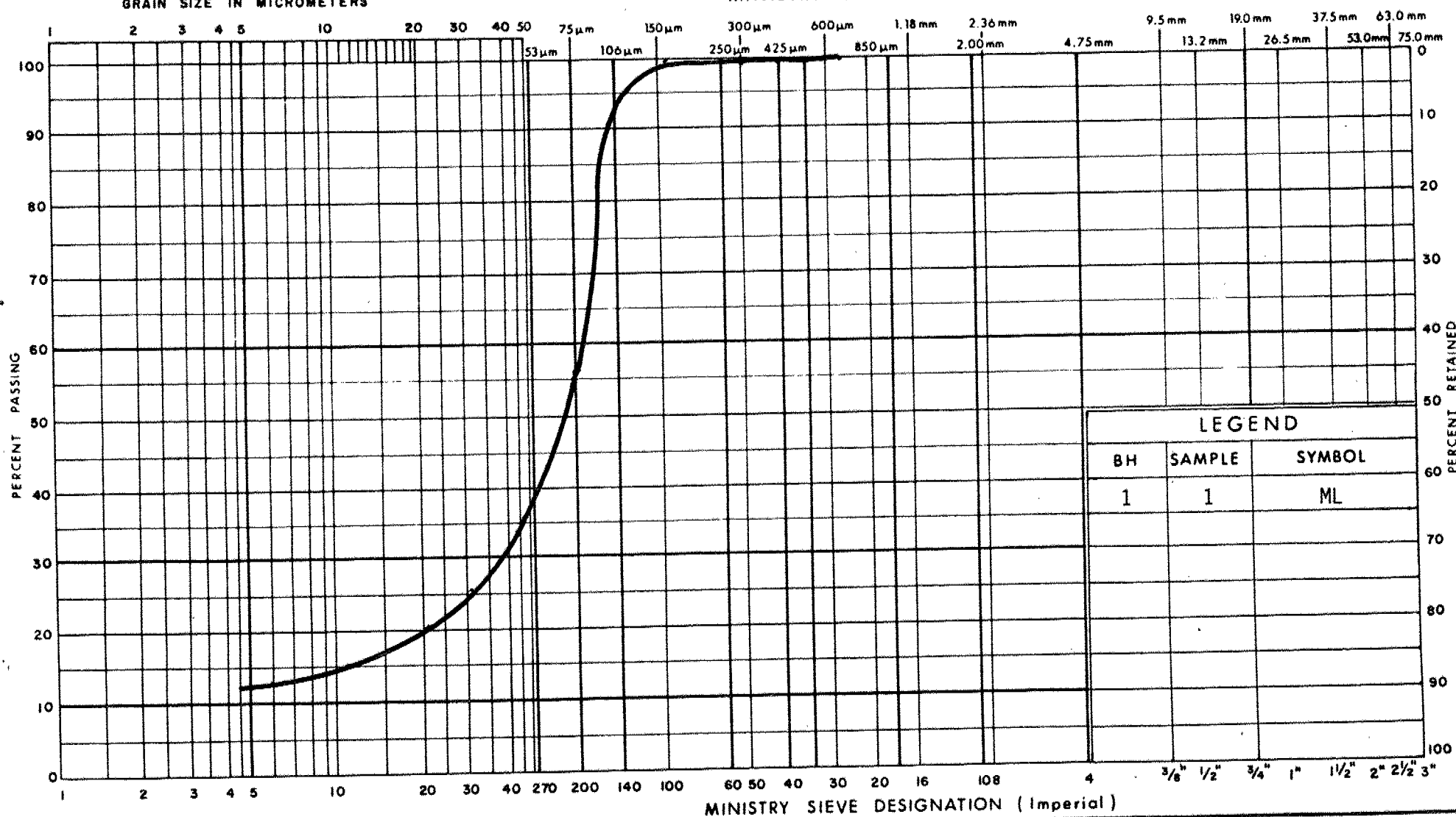
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



## LEGEND

BH	SAMPLE	SYMBOL
1	1	ML

GRAIN SIZE DISTRIBUTION

SANDY SILT

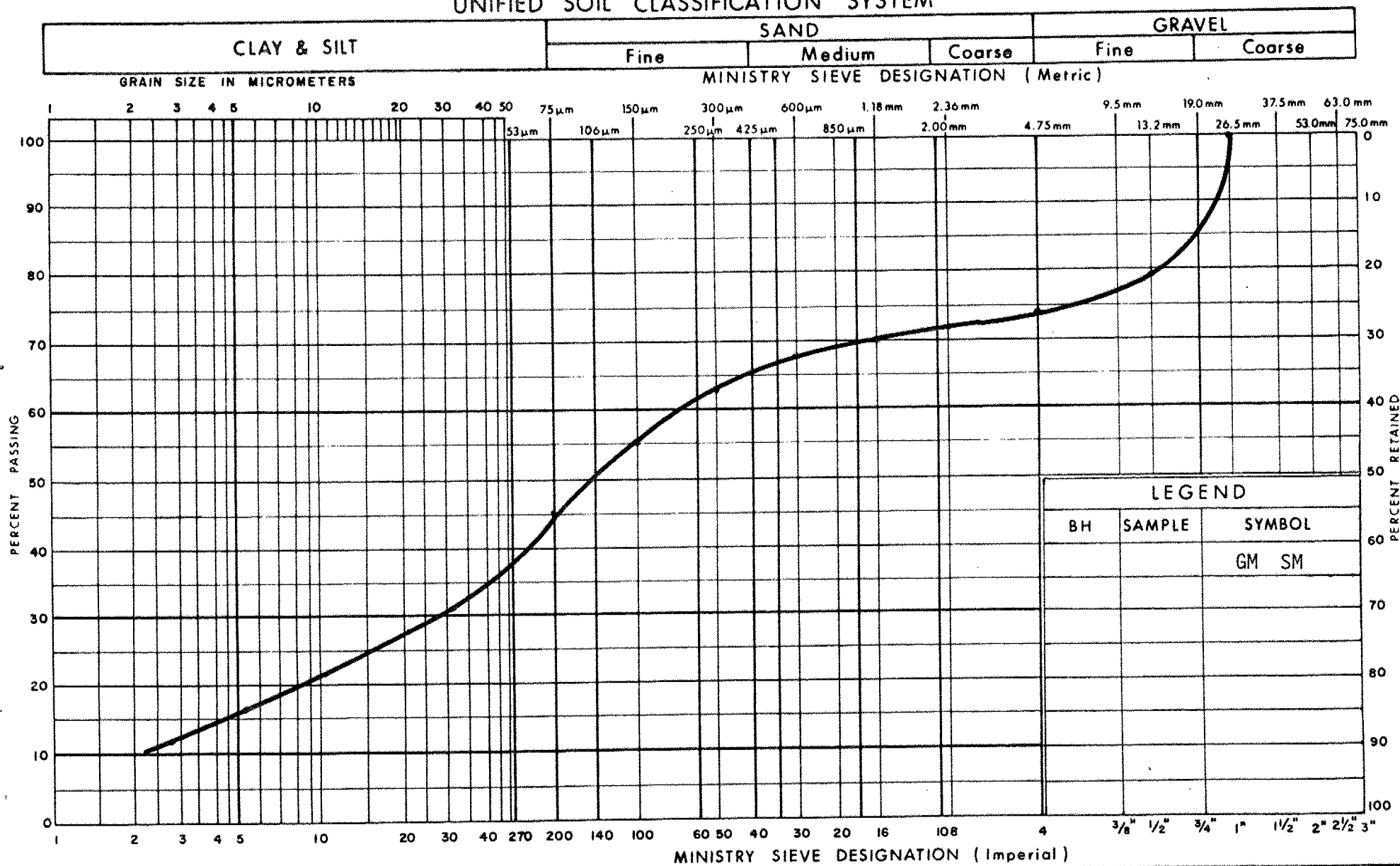
FIG No 1

W P 110-72-01



Ministry of  
Transportation and  
Communications

## UNIFIED SOIL CLASSIFICATION SYSTEM



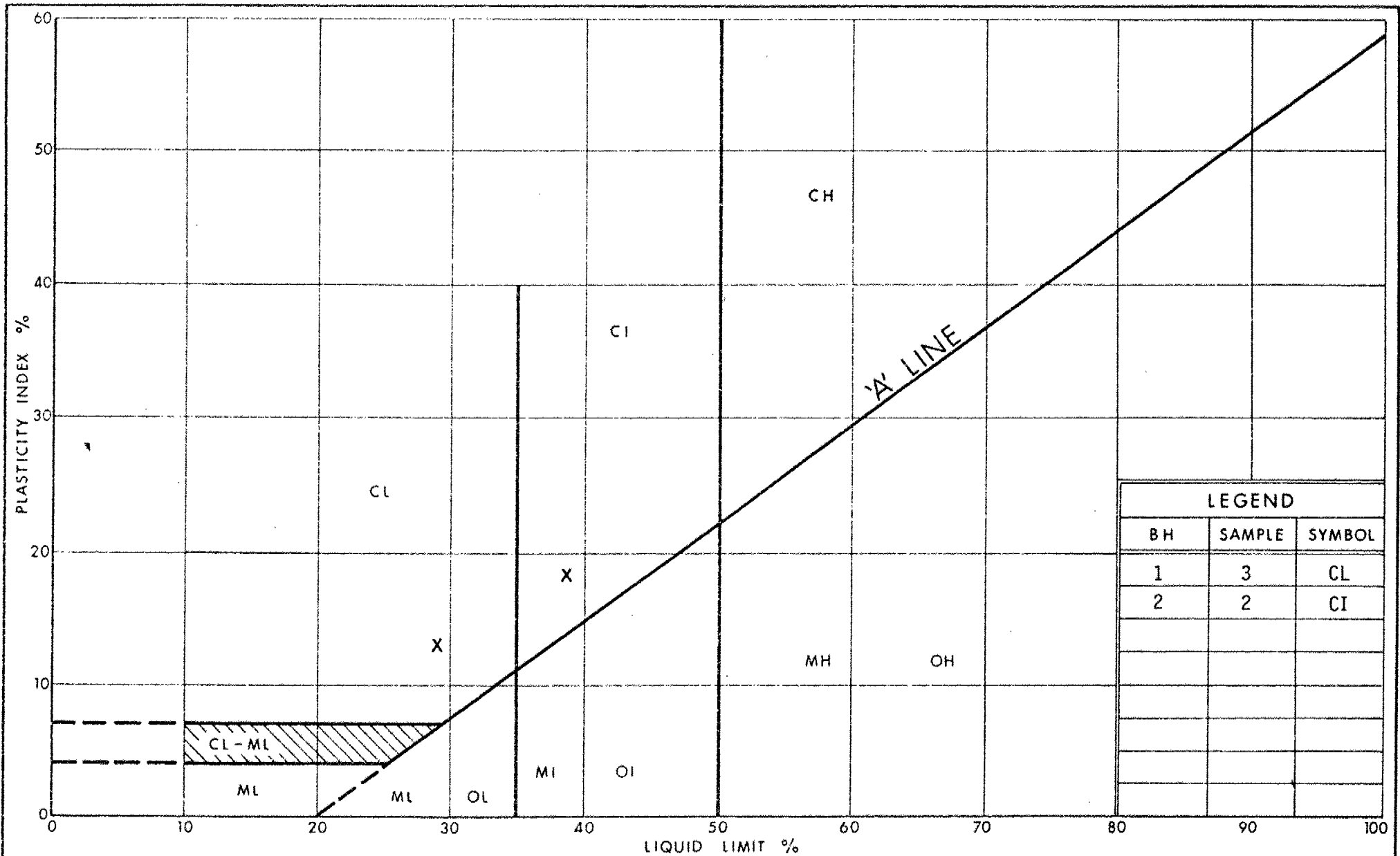
Ontario

**Ministry of  
Transportation and  
Communications**

GRAIN SIZE DISTRIBUTION  
GRAVELLY SANDY SILT (TILL)

FIG No 2

W P 110-72-01



Ontario

 Ministry of  
Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY

FIG No 3

W P 110-72 - 01

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS  
Soil Mechanics Section  
1201 Wilson Avenue  
DOWNSVIEW, Ontario  
M3M 1J8

CONT 86-36  
GEOCRETS No  
30M15-58

REPORT ON SOIL CONDITIONS  
RETAINING WALL  
EAST OF OSHAWA  
ON HWY. NO. 2  
(WP NO. 110-72-01)

DISTRIBUTION

12 copies - M.T.C.  
1 copy - S.I.S.L.

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ATTERBERG LIMITS TEST	FIGURE 6
EXPLANATION OF TERMS USED IN REPORT	APPENDIX



## 1.0 INTRODUCTION

An evaluation of soil conditions has been completed at a proposed retaining wall on the south side of Highway No. 2 just east of the City of Oshawa, Ontario. The retaining wall limits are between stations 11+090 and 11+130. The study was undertaken to assess requirements for retaining wall foundations, backfill and excavations. The retaining wall is part of the work related to widening the highway to four lanes (WP 110-72-01).

This report summarizes soil profile and test data and discusses considerations for design and construction. The study and report were authorized by Mr. M. Devata, P. Eng. of the Ministry of Transportation and Communications.

## 2.0 FIELD WORK

The locations of 3 boreholes and a summary soil profile are provided on Drawing No. 1107201-A. More detailed soil profile and field test data is presented on the attached borehole summary forms.

Borings were completed with a track-vehicle-mounted power drill equipped with hollow stem and continuous flight augers. Samples were obtained with a 50 mm diameter "split spoon" sampler driven in accordance with standard penetration test procedures (63.5 kg hammer falling 760 mm) and with a 50 mm thin wall tube sampler.

Field work was completed on January 19 and 21, 1981. Elevations were related to site survey data provided by the M.T.C.

### 3.0 SOIL CONDITIONS

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#### 3.1 General

The retaining wall site is located near the top of the valley of the adjacent Farewell Creek on the south side of Highway No. 2. The Highway is cut into the native soils in this area and the cut will be deepened as part of the highway reconstruction.

Native soils at the site consist of 2.13 to 2.44 meters of sandy silt underlain by 1.17 to 1.67 meters of layered silty clay. These lacustrine soils are underlain by a heterogeneous mixture of gravel, sand, silt and clay that contains scattered cobbles. This lower material is classified as a glacial till. Both borings terminated in the till.

#### 3.2 Topsoil

Topsoil at borehole locations is 205 mm thick. Similar depths are expected on native soils beyond the existing cut. The topsoil is a good quality silty loam.

#### 3.3 Sandy Silt

The layered sandy silt soils are classified as compact on the basis of standard penetration resistances of 12 to 22 blows per 305 mm. A particle size analysis on a representative sample is shown on Figure 4. There are occasional clay seams in the lower meter of these deposits.

#### 3.4 Silty Clay

The layered silty clay soils generally are classified as stiff on the basis of penetration resistances of 3 to 4 blows per 305 mm and vane shear strengths of 75 to 82 kPa. These clayey soils are slightly softer near the contact with the underlying till soils.

### 3.0 SOIL CONDITIONS (cont.)

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#### 3.5 Sandy Silt (Till)

The stony sandy silt is part of the extensive basal till deposits common to the area. Most of these till textured soils contain some clay size particles and scattered cobbles. Occasional boulders may also be encountered.

The till-textured soils are classified as very dense on the basis of standard penetration resistances of 50 to more than 100 blows per 305 mm. In 3 of the 5 tested locations the till was extremely dense and the sampler could not be driven the full 305 mm standard test depth.

#### 3.6 Groundwater

The lower part of the sandy silt was very wet at the time of drilling but no free water was noted. The groundwater level was between elevation 123.0 and 123.4 meters on January 19, 1981. This is roughly 2.4 to 2.7 meters below the ground surface at the boreholes and is close to the existing Highway No. 2 road grade in the borehole area. There is a slight westward slope toward the creek.

Seasonal water table fluctuations of at least one meter should be expected as should seasonal saturation of the contact area between the sandy silt and the underlying silty clay.

### 4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

---

#### 4.1 General

We understand that the required retaining wall will be about 40 meters long and will extend a maximum of 3.7 meters above the proposed new road grade. Backfill behind the wall will extend horizontally from the top of the wall.

Site conditions are good and no significant problems are anticipated in design or construction of the wall.

Recommendations in this report are compatible with the Ontario Highway Bridge Design Code, 1979.

#### 4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

---

##### 4.2 Footings

The base of the retaining wall will be within very dense stony sandy silt (till) soils. Under "serviceability limit state" conditions an allowable stress of 500 kPa would produce settlements of less than 20 mm for footings wider than 1.3 meters. The "ultimate limit state" of stress is in excess of 2000 kPa.

All footings should be provided with at least 1.2 meters of soil cover for frost protection or be protected to an equivalent condition with insulation.

All loose, wet and disturbed soil should be hand excavated from below footing areas just prior to concrete placement.

##### 4.3 Backfill and Earth Pressures

Backfill should consist of clean pit run sand and gravel (MTC granular 'B') compacted in 300 mm maximum lifts to 95 percent of standard proctor density (ASTM D 698 standard). The granular fill limits should extend at least to the 60 degree line described on Figure 6.9.6.1 of the Code.

Provided that the backfill is fully drained, as subsequently discussed, the following lateral earth stress conditions can be assumed for design purposes.

Condition	at "serviceability limit state"	at "ultimate limit state"
active state	6.5 kPa/m	8 kPa/m
passive state	56.0 kPa/m	46 kPa/m

These values are stresses per meter of depths and the total cumulative pressures can be assumed to act at the lower 1/3 point of the wall.

#### 4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

---

##### 4.3 Backfill and Earth Pressures (cont.)

The "serviceability limit state" stresses should prevail with wall deflections of a few millimeters provided that the backfill is compacted with hand operated compactors. Use of heavy self propelled rollers could increase stresses substantially through a wedging effect.

##### 4.4 Drainage

The retaining wall backfill should be fully drained with at least one perforated pipe drain placed behind the wall at footing grade. The drains should extend through or beyond the wall to ensure positive gravity drainage.

To ensure against clogging by fines the drain should be surrounded with a positive filter system consisting of one of the following.

- (a) A minimum of 150 mm of clear washed stone next to the perforated pipe and 150 mm of coarse sand around the clear stone.
- (b) A minimum of 150 mm of clear stone next to the perforated pipe and the clear stone completely surrounded by suitable filter fabric.

Acceptable particle size limits for the sand and clear stone are as follows.

<u>Sieve Size</u>	<u>Clear Stone</u>	<u>Coarse Sand</u>
25 mm	100	
19 mm	90 - 100	
12.5 mm		
9.5 mm	20 - 55	100
4.75 mm	0 - 10	95 - 100
2.36 mm	0 - 5	80 - 100
1.18 mm		50 - 85
600 um		25 - 60
300 um		10 - 30
150 um		2 - 10

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

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4.5 Excavations

During dry seasonal periods open excavations should be straightforward with little or no sloughing expected where slopes of 1:1 are excavated above the initial near vertical cut permitted by current provincial construction safety requirements. If seasonally wet conditions prevail at the time of construction some minor short term sloughing may occur near the contact between the silty clay and overlying sandy silt. All soils are fine grained and seepage inflow rates should be small.

Open cut procedures will require an excavation that extends within 1 or 2 meters of an existing house. If temporary easements cannot be arranged to permit open excavation procedures it will be necessary to provide some form of shoring to protect workmen. Penetrating the very dense till with soldier piles may require pre-augering. Otherwise we do not anticipate any major problems in installing most varieties of temporary shoring.

4.6 Construction Inspection

The continuity of soil conditions between borings should be confirmed by a soils engineer when the soils are exposed during construction. We should be contacted to review our recommendations should any significant differences be observed.

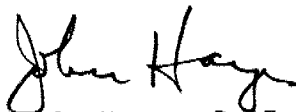
Submitted by:

SITE INVESTIGATION SERVICES LIMITED



R. Marttila, P. Eng.

Reviewed by:



J. A. Hayes, P. Eng.

RM/lp



# RECORD OF BOREHOLE No 1 & 1A

METRIC

W P 110-72-01 LOCATION Sta. 11+098.2 o/s 15 m RT-9 Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm diameter. COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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					
125.61	Ground Level															
0.0	Topsoil															
205 mm	Sandy silt					125										
	Trace of clay															
	Wet below 1 m															
	Compact Light brown to dense		1	SS	22	124										0 44 44 12
123.17																
2.44	Silty clay		1A	TW	PH	123										
	Wet															
	Stiff to firm Grey		2	SS	3	122										
121.5			3	SS	4											
4.11	Gravelly Sandy silt, some clay and cobbles					121										
	(Glacial Till)		4	SS	70											
	Very Dense Dark Grey					120										
			5	SS	50/125 mm	119										
117.81			6	SS	50/100 mm	118										
7.80	End of Borehole															
	Note Borehole 1A drilled 1 meter east of Borehole No.1 to obtain thin wall sample and vane tests.															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

FIGURE 2



# RECORD OF BOREHOLE No 2

METRIC

W P 110-72-01 LOCATION Sta. 11+118.6 o/s 16 m RT Q Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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					
125.78	Ground Level															
0.00	Topsoil															
205 mm	Sandy silt															
	Compact Light brown															
123.65			1	SS	12											
2.13	Silty clay															
	Wet															
122.48	Stiff to firm Grey															
3.30	Gravelly sandy silt, trace to some clay.		2	SS	3											
	(Glacial Till)															
	Very Dense Dark Grey		3	SS	50											
119.53			4	SS	50/125 mm											
6.25	End of Borehole															

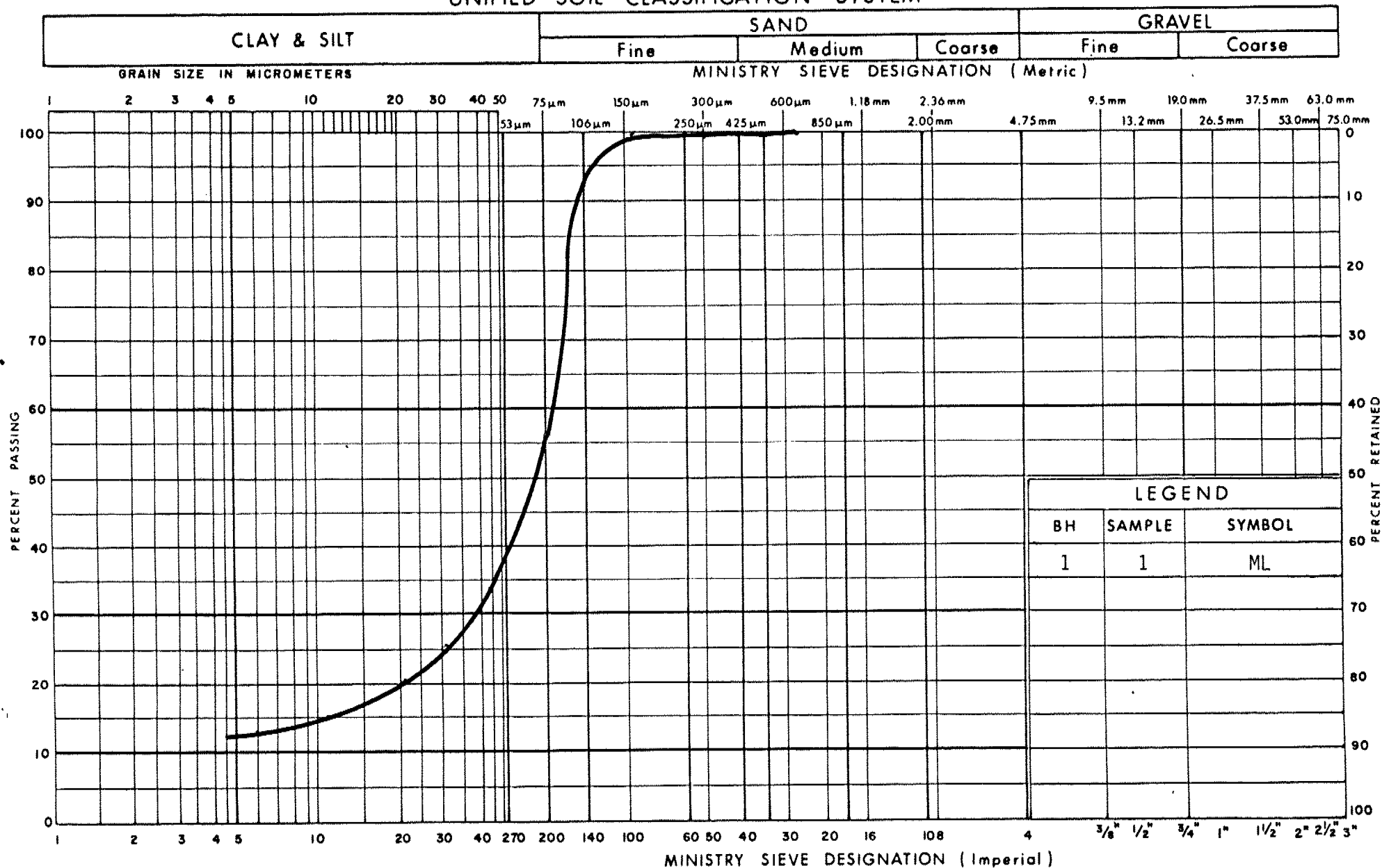
+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

FIGURE 3



## UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION  
SANDY SILT

FIG No 4

W P 110-72-01

## UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY &amp; SILT

SAND

GRAVEL

Fine

Medium

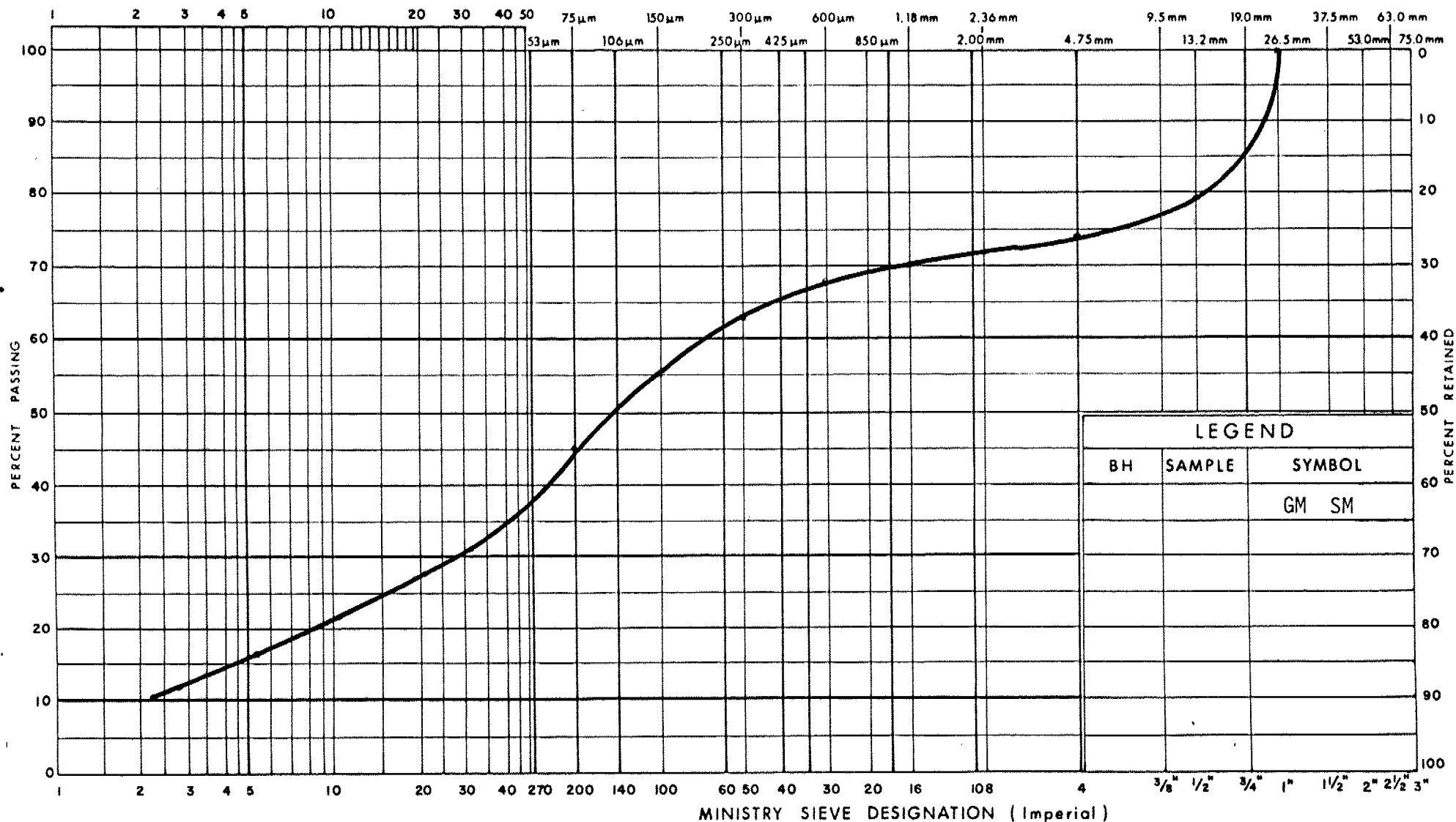
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



## LEGEND

BH	SAMPLE	SYMBOL
		GM SM

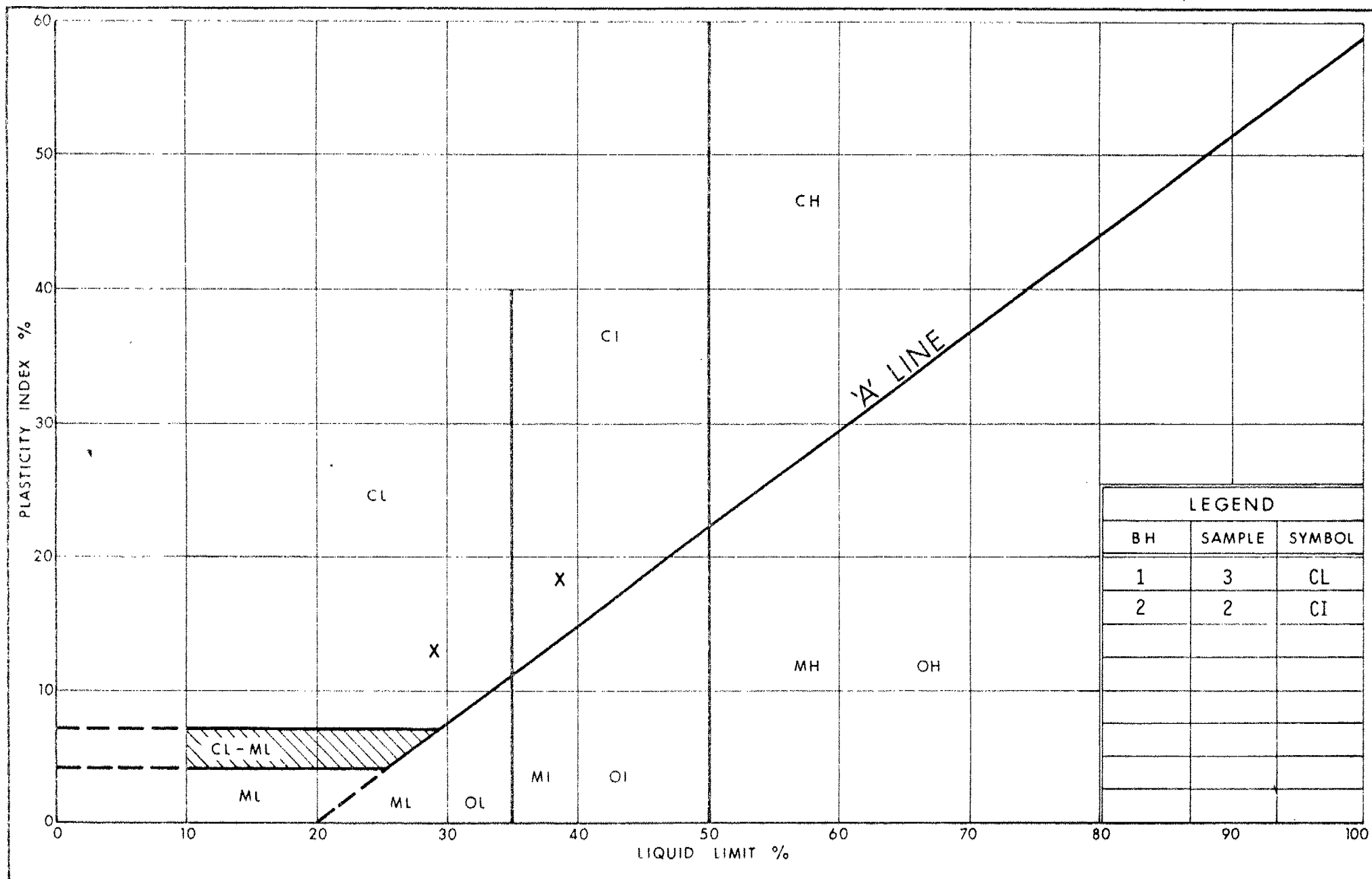


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GRAIN SIZE DISTRIBUTION  
GRAVELLY SANDY SILT (TILL)

FIG No 5

W P 110-72-01



Ontario

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Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY

FIG No 6

W P 110-72 - 01

# EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	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

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	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

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

*a copy of the  
original*

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 110-72-01

DIST #7

HWY #2

STR SITE 21-268

Farewell Creek Concrete Culvert

DISTRIBUTION

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R.D. Gunter

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D.E. Thrasher (2)

C. Grebski

B.J. Giroux

R. Hore

R. Fitzgibbon )

J. Anderson ) Cover only

T.J. Kovich )

Files

# FOUNDATION INVESTIGATION REPORT

For

Farewell Creek Concrete Culvert  
Extension, 1 km East of Oshawa  
W.P. 110-72-01, Site 21-268  
Highway 2, District 7, Port Hope

---

## INTRODUCTION

This report contains the results of the foundation investigation carried out at the above site. The field work was performed on 80 09 25 and 80 09 26 employing a track mounted, continuous flight, hollow stem auger. Three boreholes were augered to 5 m with the fourth going to 9 m. The boreholes were located as close as possible to the proposed location of the culvert extension footings.

## SITE DESCRIPTION

Farewell Creek crosses Highway #2 approximately 1 km east of the Oshawa townline. The valley, cut through the southward sloping area, is approximately 350 metres in width by 11 metres in depth.

Landuse in the area is mixed, and includes a motel site, residential housing, bush and open fields. Bell telephone and natural gas services run below the existing shoulders of Highway #2. A well, probably used for summer lawn watering, is located on the valley floor just north of the culvert extension.

Farewell Creek is 0.2 m to 0.5 m deep and 6 m wide at the Highway #2 crossing. The water surface elevation at the time of investigation was 113.5 m. To the north and the south of the site trees exist along the creek valley. A small swampy area is located just north of the proposed culvert extension.

## SUBSURFACE CONDITIONS

### Subsoil General

Farewell Creek has a bed of boulders, cobbles and gravel for a depth of 0.8 m. On either side of the creek there is a recent

alluvial deposit consisting of a 0.3 metre layer of topsoil and from 0.6 to 0.9 metres of silty sand with a trace of organics. These superficial deposits overlie a hard homogeneous mixture of silty clay, sand and gravel of glacial origin. It extends to a depth of at least 9 metres, where the deepest borehole was terminated.

Reference should be made to Drawing #1107201-A in the Appendix which shows the borehole locations and an inferred subsoil stratigraphy. A more detailed description and location of the subsoils can be found on the borehole log sheets in the Appendix.

#### Heterogeneous Mixture of Silty Clay, Sand and Gravel

The predominant soil type at the site is a hard glacial till consisting of a heterogeneous mixture of silty clay, sand and gravel which extends from elevation 113 to below the maximum depth of the borings. It contains some silt inclusions but is generally cohesive in nature. This is indicated by the fact that the results of Atterberg Limit Tests (Figure 2) plot close to or in the CL-ML range. Grain size distribution curves (Figure 1) are typical of glacial till deposits with high fractions of sand and silt with some clay and gravel. Standard Penetration 'N' values range from 31 to above 100, with most values in excess of 50. This indicates a hard consistency. Moisture contents of samples tested are very low, ranging from 5 to 8 percent.

#### Groundwater

Boreholes 2, 3 and 4 all indicate water levels which correspond to the creek water level of 113.5 m. Borehole 1 had an artesian head of approximately 0.3 m above the existing ground surface. The artesian pressure was met at elevation 108 m, six metres below ground level.

## DISCUSSION AND RECOMMENDATIONS

The existing structure at Farewell Creek is a (6.10 x 3.66 x 17.70 metres) open type concrete culvert. This structure is founded on the glacial till subsoil. The culvert will be extended by 15.5 metres to the north and south to give an overall length of 48.70 metres.

### RECOMMENDATIONS

It is recommended that the culvert extension be supported on spread footings founded between elevations 112.5 and 111 metres. Design loads of up to 300 kPa can be supported by the glacial till subsoil. Resistance to lateral forces can be calculated using an adhesion value of 96 kPa between the base of the footing and the underlying subsoil. Lateral earth pressures can be calculated using a coefficient of earth pressure at rest of 0.5 and a unit weight of granular backfill of 21 kN/m<sup>3</sup>.

Settlements of the foundation will be less than 2 centimetres. Placement of the footings should be done as soon after excavation as possible, thereby lessening the time likely to weaken the concrete-soil interface.

### Groundwater Conditions & Dewatering

An artesian condition was met in borehole one at elevation 108 metres (6 metres below the surface) in a 0.1 metre layer. The artesian condition is not of concern if the base of the footing excavation is above elevation 111.

An earth dyke will be required to keep the footing excavations relatively dry for the placement of concrete. This method of dewatering will have to be cleared for environmental suitability. If this method is unsatisfactory, piping of the water may be considered. Driving sheet piles to cut-off the water flow would be difficult due to the hard nature of the glacial till and the overlying boulders.

Footing excavation dewatering problems are not anticipated due to the relatively impervious nature of the subsoil. Sumps can be used to pump out any seepage or surface water. Drainage of surface



water from the existing and proposed embankments must be provided for during and after construction.


#### Embankments


Existing embankments are in excess of 1.5 to 1.0 at this location. Finished slopes of 2.0 to 1.0 and construction slopes of 1.0 to 1.0 will be sufficient to prevent slope failure.

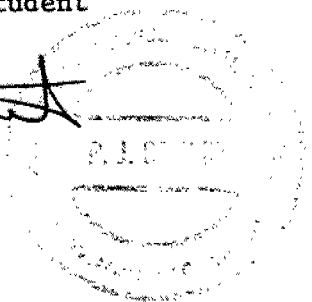
Benching Standard SS-414 should be followed to lessen the likelihood of slippage between the old and new fills. Removal of the upper 0.6 metres of soil in the area of embankment widening will reduce the settlement of the embankment widening and insure good performance.

#### MISCELLANEOUS

The base of the spread footings should have at least 1.2 metres of cover to provide frost protection. Scour protection will be required over the subsoil after the covering boulders have been removed. The boring equipment used during the field work was provided by Atcost Soil Drilling Inc.

  
Richard Burgess  
U. of W. Co-operative Student

  
Peter Stuart, P. Eng.  
Foundations Engineer



## APPENDIX

# RECORD OF BOREHOLE No 1

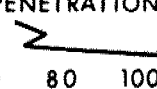


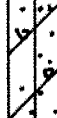
W P 110-72-01 LOCATION Sta. 10+986.2 10.2 m LT. ORIGINATED BY R.B.  
 DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/25 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)				
114.2	Ground Level															
113.7	Top Soil															
0.3	Silty Sand Trace Organics															
113.1																
0.9	Sand, Gravel and Cobbles															
112.7																
1.5																
	Heterogeneous Mixture of Silty Clay, Sand and Gravel		1	SS	80											
	Random Silt Inclusions		2	SS	92											
	Grey Hard (Glacial Till)		3	SS	51											
			4	SS	44											
105.1																
9.1	End of Borehole															
	Note: - Borehole 1 m from Creek - Some Artesian Conditions at Elevation 108.1 m.															

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

# RECORD OF BOREHOLE No 2

W P 110-72-01 LOCATION Sta. 10+982.5 14.2 m LT. ORIGINATED BY R.B.  
 DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80-09-26 CHECKED BY \_\_\_\_\_

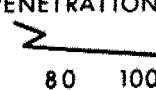

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 						PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH											WATER CONTENT (%)		
								○ UNCONFINED			+ FIELD VANE								● QUICK TRIAXIAL		
113.5	Ground Level							20	40	60	80	100									
112.7	Boulders, Cobbles & Gravel																				
0.8	Heterogeneous Mixture of Silty Clay, Sand & Gravel Random Silt Inclusions		1	SS	100/	23 cm	112							0	10	15					
			2	SS	74																
			3	SS	100/	36 cm	110														
108.7	Grey Hard (Glacial Till)		4	SS	100/	25 cm															
4.8	End of Borehole																				

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

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

# RECORD OF BOREHOLE No 3

W P 110-72-01 LOCATION Sta. 10+974.2 15.1 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY 72 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY \_\_\_\_\_

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										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								● QUICK TRIAXIAL		x LAB VANE
114.2	Ground Level																			
113.9	Top Soil						114													
0.3	Silty Sand, Trace																			
113.0	Organics																			
1.2	Heterogeneous Mixture of Silty Clay Sand and Gravel Random Silt Inclusions		1	SS	31		112						○							
			2	SS	100/	28 cm														
			3	SS	35/	15 cm							○				25 35 31 9			
109.4	Grey Hard (Glacial Till)		4	SS	100/	23 cm	110													
4.8	End of Borehole																			
							108													

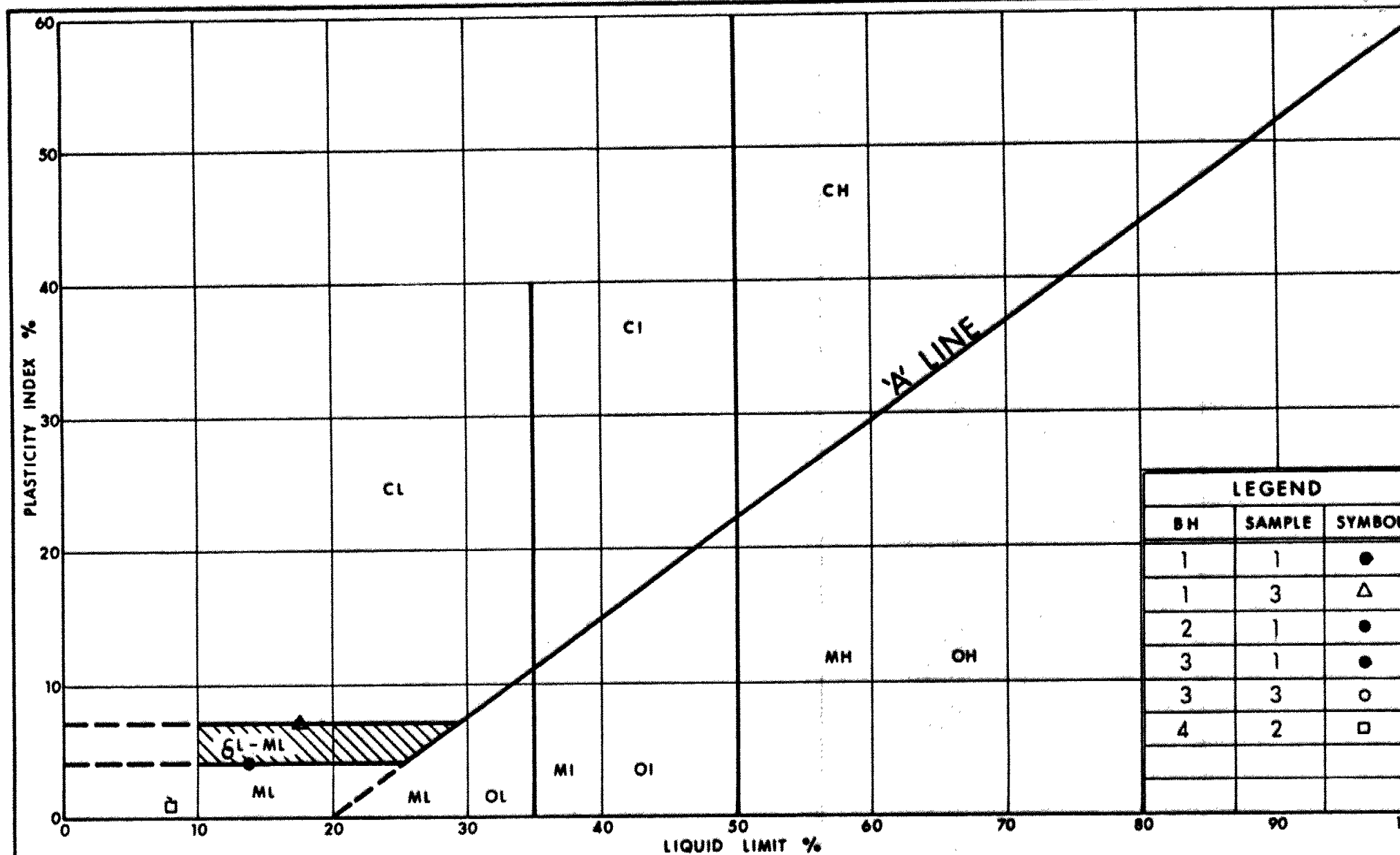
+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
 Sensitivity

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

# RECORD OF BOREHOLE No 4

W P 110-72-01 LOCATION Sta. 10+988.0 14.3 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY \_\_\_\_\_

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					
114.2	Ground Level																
113.9	Top Soil						114										
0.3	Silty Sand																
113.0	Trace Organics																
1.2	Heterogeneous Mixture of Silty Clay Sand and Gravel Random Silt Inclusions Grey Hard (Glacial Till)		1	SS	55		112							o			8 36 40 16
			2	SS	80									o	I		
			3	SS	100/	28 cm	110										
109.3			4	SS	100/	31 cm											
4.9	End of Borehole						108										

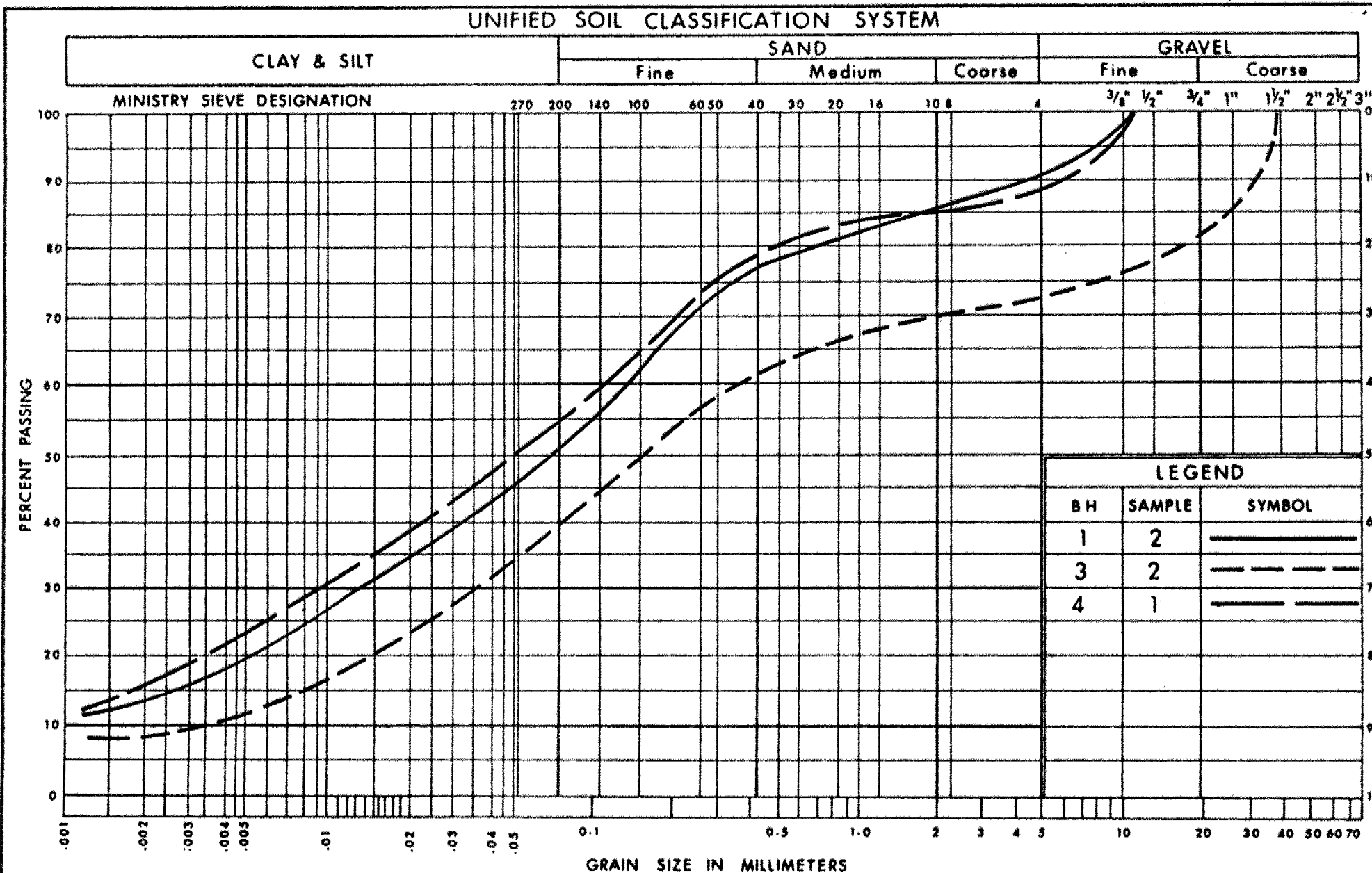


Ministry of  
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Communications

**PLASTICITY CHART**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No. 2

W P 110-72-01



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Communications

**GRAIN SIZE DISTRIBUTION**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No 1

W P 110-72-01



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 = $\frac{w_L - w_p}{w - w_p}$	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						

**METRIC**

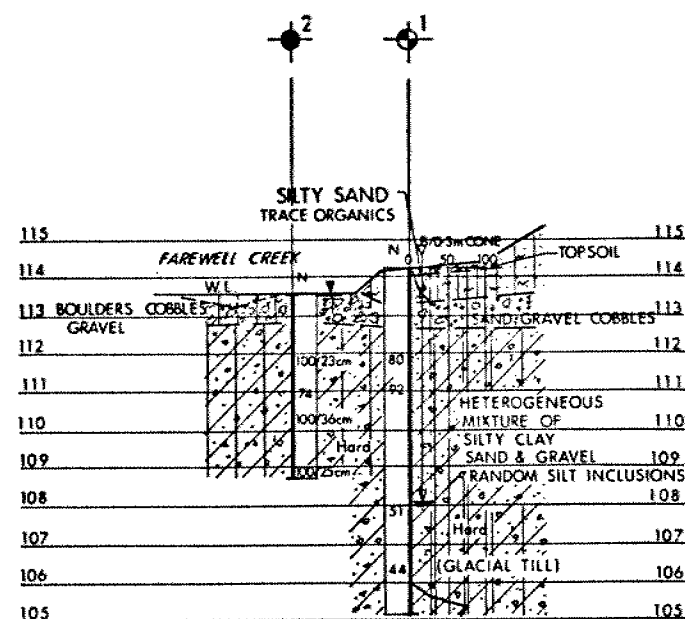
NOTE: DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No  
WP No 110-72-01

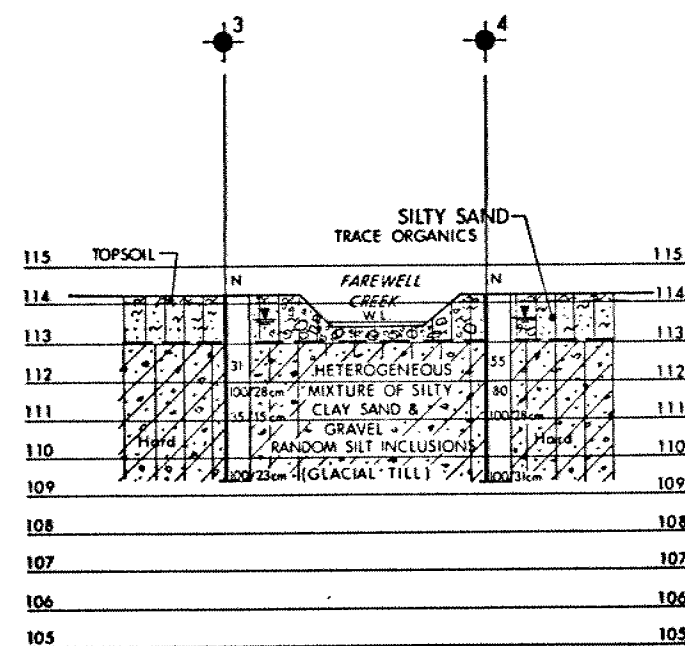
FAREWELL CREEK CULVERT  
EXTENSION

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

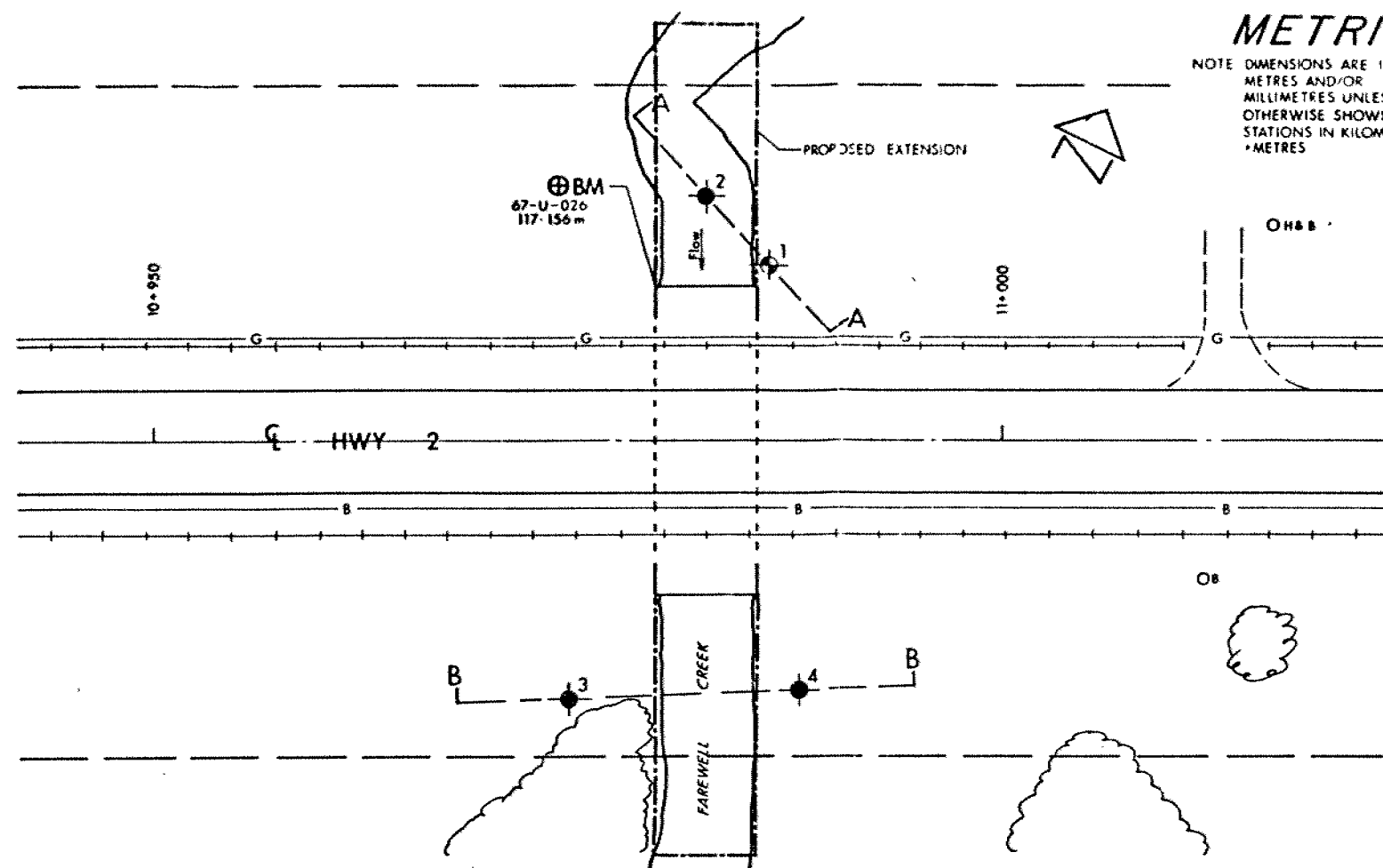


A - A



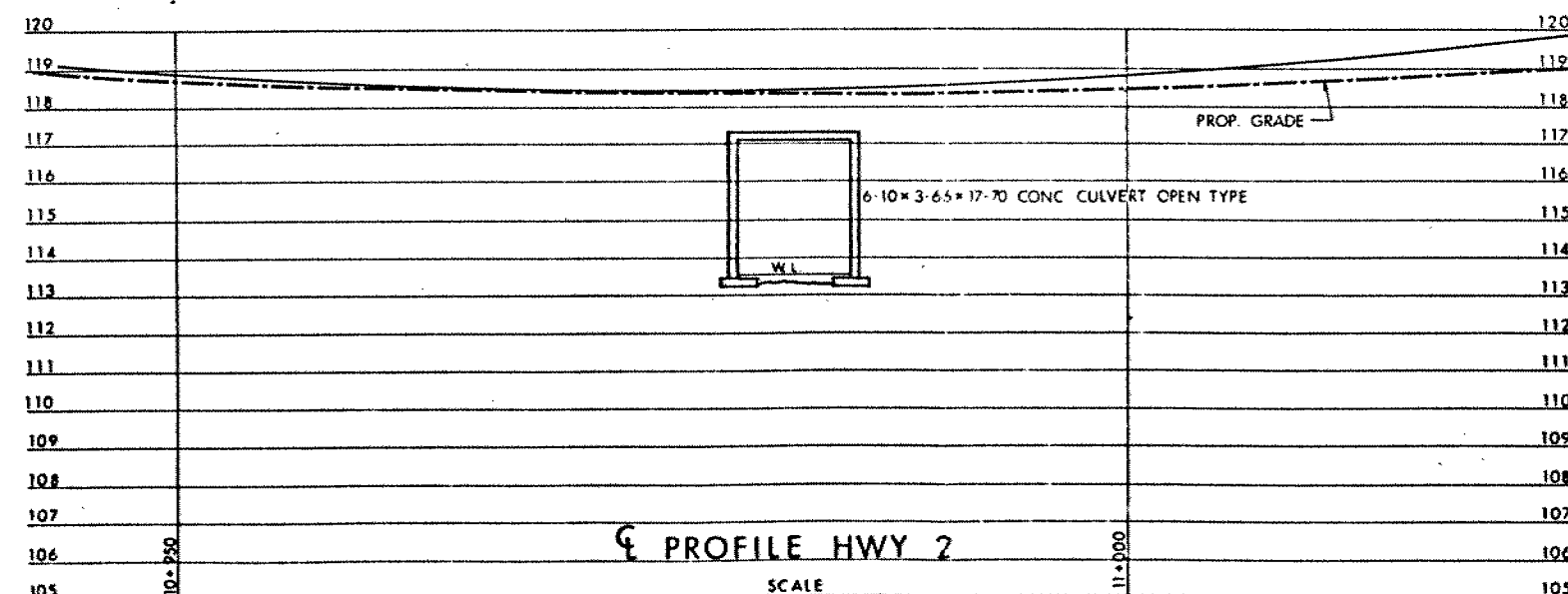
B - B

SECTIONS  
SCALE  
0 2.5 5 m



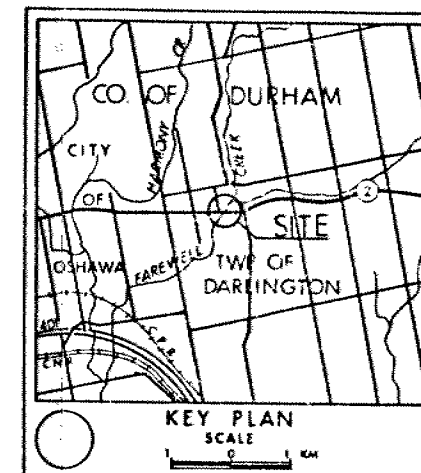
PLAN

SCALE  
0 5 m



PROFILE HWY 2

SCALE  
0 2.5 5 m



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 80 09 26
- Head
- ARTESIAN CONDITION
- Encountered

No	ELEVATION	STATION	OFFSET
1	114.2	10+986.2	10.2 LT
2	113.5	10+982.5	14.2 LT
3	114.2	10+974.2	15.1 RT
4	114.2	10+988.0	14.3 RT

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 30M15-57

HWY No	2	DIST	7
SUBMD P	5	CHECKED	DATE 80 12 02
DRAWN	NO	CHECKED	DATE 80 12 02

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M15-58 <sup>57</sup>

DIST. 6 REGION                     

W.P. No. 110-72-01

CONT. No. 86-36

W. O. No.                     

STR. SITE No.                     

HWY. No. 2

LOCATION Retaining Wall between  
STA. 11+030 & STA. 11+130

No of PAGES -                     

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:                       
                      
                      
                    

G.I.-30 SEPT. 1976

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 86 - 36



Ministry of  
Transportation and  
Communications

I N D E X

<u>PAGE NO.</u>	<u>DESCRIPTION</u>
1	INDEX
2	ABBREVIATIONS AND SYMBOLS
3-20	FOUNDATION INVESTIGATION REPORTS FOR: W. P. 110-72-01 DISTRICT #7 FAREWELL CREEK CONCRETE CULVERT [STA. 10 + 982.200] SITE: 21-368  AND  RETAINING WALL [STA. 11 + 090 - 11 + 130] HIGHWAY #2 SITE: 21-RW

NOTE: FOR PURPOSES OF THE CONTRACT THESE REPORTS SUPERCEDE ALL OTHER FOUNDATION REPORTS PREPARED BY OR FOR THE MINISTRY IN CONNECTION WITH THE ABOVE-MENTIONED PROJECTS.

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	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
$C_\alpha$	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
$\sigma'_{v0}$	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
$S_f$	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

FAREWELL CREEK CONCRETE CULVERT  
[STA. 10 + 982]  
EXTENSION, 1 km EAST OF OSHAWA  
W. P. 110-72-01, SITE 21-368  
HIGHWAY #2, DISTRICT #7, PORT HOPE

---

INTRODUCTION

This report contains the results of the foundation investigation carried out at the above site. The field work was performed on 80 09 25 and 80 09 26 employing a track mounted, continuous flight, hollow stem auger. Three boreholes were augered to 5 m with the fourth going to 9 m. The boreholes were located as close as possible to the proposed location of the culvert extension footings.

SITE DESCRIPTION

Farewell Creek crosses Highway #2 approximately 1 km east of the Oshawa townline. The valley, cut through the southward sloping area, is approximately 350 metres in width by 11 metres in depth.

Land use in the area is mixed, and includes a motel site, residential housing, bush and open fields. Bell Telephone and Natural Gas Services run below the existing shoulders of Highway#2. A well, probably used for summer lawn watering, is located on the valley floor just north of the culvert extension.

Farewell Creek is 0.2 m to 0.5 m deep and 6 m wide at the Highway #2 crossing. The water surface elevation at the time of investigation was 113.5 m. To the north and the south of the site trees exist along the creek valley. A small swampy area is located just north of the proposed culvert extension.

## SUBSURFACE CONDITIONS

4

### Subsoil General

Farewell Creek has a bed of boulders, cobbles and gravel for a depth of 0.8 m. On either side of the creek there is a recent alluvial deposit consisting of a 0.3 metre layer of topsoil and from 0.6 to 0.9 metres of silty sand with a trace of organics. These superficial deposits overlie a hard homogeneous mixture of silty clay, sand and gravel of glacial origin. It extends to a depth of at least 9 metres, where the deepest borehole was terminated.

Reference should be made to Sheet #23 of the contract dwg's. which shows the borehole locations and an inferred subsoil stratigraphy. A more detailed description and location of the subsoils can be found on the Borehole Log Sheets in the Appendix.

### Heterogeneous Mixture of Silty Clay, Sand and Gravel

The predominant soil type at the site is a hard glacial till consisting of a heterogeneous mixture of silty clay, sand and gravel which extends from elevation 113 to below the maximum depth of the borings. It contains some silt inclusions but is generally cohesive in nature. This is indicated by the fact that the results of Atterberg Limit Tests [Figure 2] plot close to or in the CL - ML range. Grain size distribution curves [Figure 1] are typical of glacial till deposits with high fractions of sand and silt with some clay and gravel. Standard Penetration 'N' values range from 31 to above 100, with most values in excess of 50. This indicates a hard consistency. Moisture contents of samples tested are very low, ranging from 5 to 8 percent.

### Groundwater

Boreholes 2, 3 and 4 all indicate water levels which correspond to the creek water level of 113.5 m. Borehole #1 had an artesian head of approximately 0.3 m above the existing ground surface. The artesian pressure was met at elevation 108 m, six metres below ground level.



L. Politano, P. Eng.,  
Project Foundations Engineer

 FOR

M. Devata, P. Eng.,  
Chief Foundations Engineer  
(East)



APPENDIX

## METRIC

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

OFFICE REPORT ON SOIL EXPLORATION



## RECORD OF BOREHOLE No 2

METRIC

W P 110-72-01 LOCATION Sta. 10+982.5 14.2 m LT. ORIGINATED BY R.B.  
DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
DATUM Geodetic DATE 80-09-26 CHECKED BY

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							
113.5	Ground Level														
112.7	Boulders, Cobbles & Gravel														
0.8	Heterogeneous Mixture of Silty Clay, Sand & Gravel Random Silt Inclusions  Grey Hard (Glacial Till)		1	SS	100/	23 cm	112								
			2	SS	74										
			3	SS	100/	36 cm	110								
			4	SS	100/	25 cm									
108.7	End of Borehole														
4.8															

# RECORD OF BOREHOLE No 3

METRIC

W P 110-72-01 LOCATION Sta. 10+974.2 15.1 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY 72 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY \_\_\_\_\_

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					
114.2	Ground Level						114										
113.9	Top Soil																
0.3	Silty Sand, Trace																
113.0	Organics																
1.2	Heterogeneous		1	SS	31		112							0	10	15	
	Mixture of Silty Clay		2	SS	100/	28 cm											25 35 31 9
	Sand and Gravel		3	SS	35/	15 cm								0	10	15	
	Random Silt																
	Inclusions																
109.4	Grey Hard		4	SS	100/	23 cm	110										
	(Glacial Till)																
4.8	End of Borehole						108										

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

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 4

METRIC

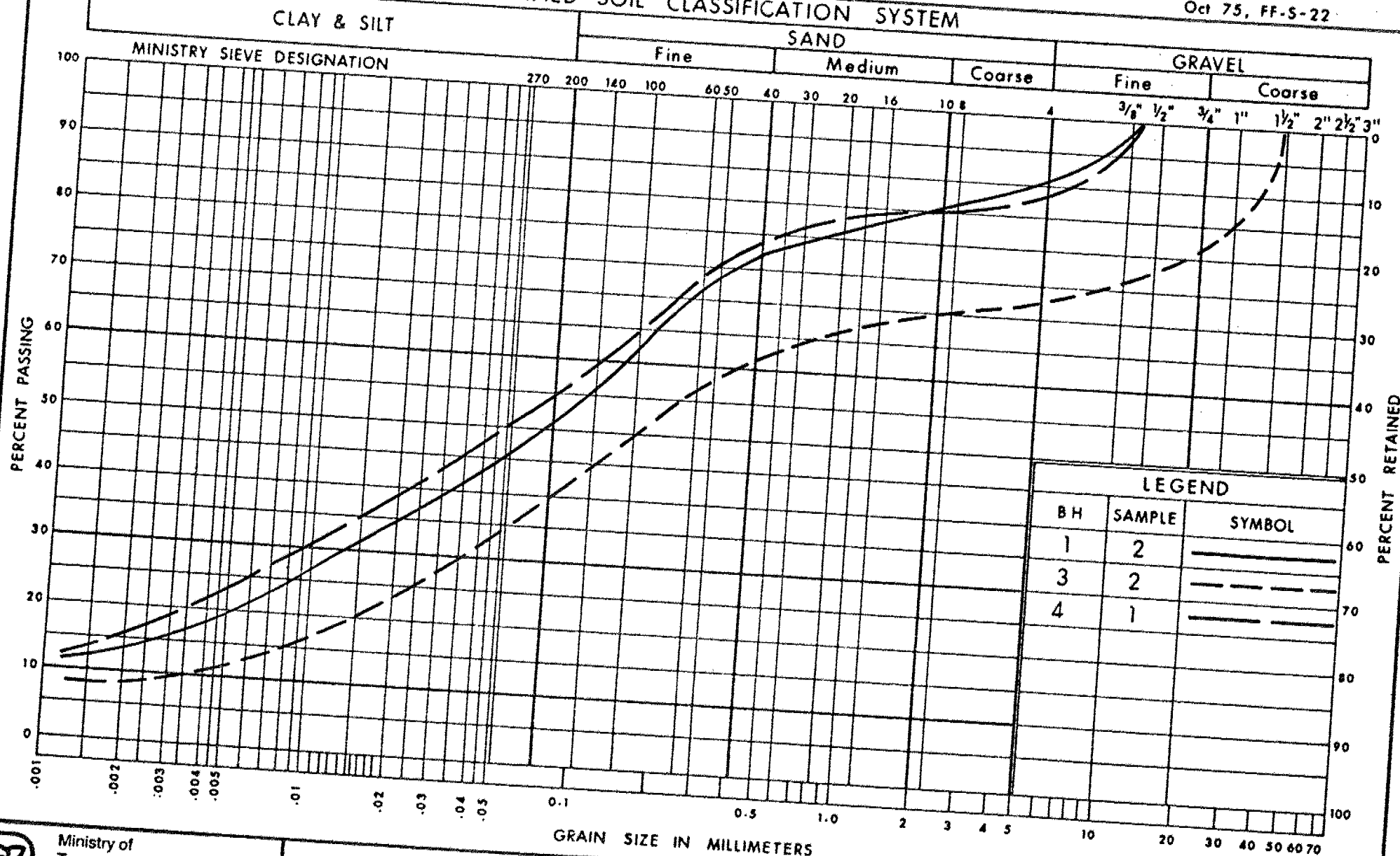
W P 110-72-01 LOCATION Sta. 10+988.0 14.3 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY

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					
114.2	Ground Level																
113.9	Top Soil																
0.3	Silty Sand																
113.0	Trace Organics																
1.2	Heterogeneous Mixture of Silty Clay Sand and Gravel		1	SS	55									o			8 36 40 16
	Random Silt Inclusions		2	SS	80									o	I		
	Grey Hard		3	SS	100/	28 cm											
109.3	(Glacial Till)		4	SS	100/	31 cm											
4.9	End of Borehole																
							108										

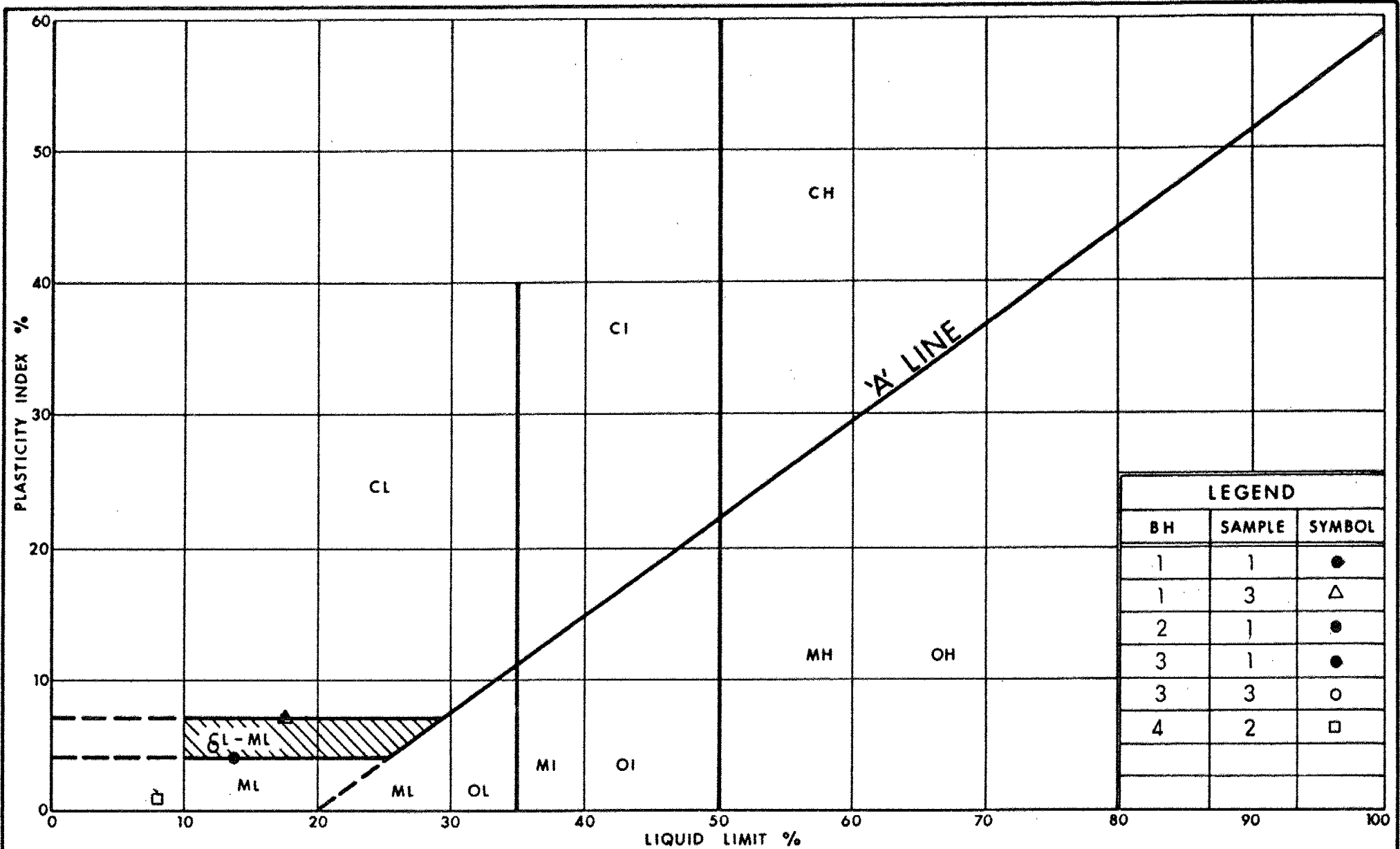
+3, x5: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

# UNIFIED SOIL CLASSIFICATION SYSTEM

Oct 75, FF-S-22



LEGEND		
BH	SAMPLE	SYMBOL
1	2	—————
3	2	- - - - -
4	1	—————



Ontario

Ministry of  
Transportation and  
Communications

**PLASTICITY CHART**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No. 2

W P 110-72-01

=

## FOUNDATION INVESTIGATION REPORT

For

RETAINING WALL [STA. 11 + 090 - 11 + 130]  
W. P. 110-72-01, SITE 21-RW  
HIGHWAY #2, DISTRICT #7, PORT HOPE

---

Site Investigation Services Limited was retained by the Ministry of Transportation and Communications of Ontario to evaluate the soil conditions at the above-noted site.

The locations of 3 boreholes and a summary soil profile are provided on Sheet #25 of the contract dwg's. More detailed soil profile and field test data is presented on the Borehole Summary Sheets in the Appendix.

Borings were completed with a track-vehicle-mounted power drill equipped with hollow stem and continuous flight augers. Samples were obtained with a 50 mm diameter "split spoon" sampler driven in accordance with Standard Penetration Test procedures (63.5 kg hammer falling 760 mm) and with a 50 mm thin wall tube sampler.

Field work was completed on January 19 and 21, 1981. Elevations were related to site survey data provided by the MTC.

SUBSURFACE CONDITIONSGeneral

The retaining wall site is located near the top of the valley of the adjacent Farewell Creek on the south side of Highway #2. The existing highway is cut into the native soils in this area.

Native soils at the site consist of 2.13 to 2.44 metres of sandy silt underlain by 1.17 to 1.67 metres of layered silty clay.



These lacustrine soils are underlain by a heterogeneous mixture of gravel, sand, silt and clay that contains scattered cobbles. This lower material is classified as a glacial till. Both borings terminated in the till.

#### Topsoil

Topsoil at borehole locations is 205 mm thick. Similar depths are expected on native soils beyond the existing cut. The topsoil is a good quality silty loam.

#### Sandy Silt

The layered sandy silt soils are classified as compact on the basis of standard penetration resistances of 12 to 22 blows per 305 mm. A particle size analysis on a representative sample is shown on Figure 1 in the Appendix. There are occasional clay seams in the lower metre of these deposits.

#### Silty Clay

The layered silty clay soils generally are classified as stiff on the basis of penetration resistances of 3 to 4 blows per 305 mm and vane shear strengths of 75 to 82 kPa. These clayey soils are slightly softer near the contact with the underlying till soils. Figure 2 shows the results of Atterberg Limits testing carried out on 2 samples of this material.

#### Sandy Silt (Till)

The stony sandy silt is part of the extensive basal till deposits common to the area. Most of these till textured soils contain some clay size particles and scattered cobbles. Occasional boulders may also be encountered. A typical grain-size distribution of this material is shown on Figure 3 in the Appendix.

The till-textured soils are classified as very dense on the basis of standard penetration resistances of 50 to more than 100 blows per 305 mm. In 3 of the 5 tested locations the till was extremely dense and the sampler could not be driven the full 305 mm standard test depth.

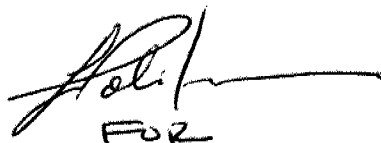
Groundwater

The lower part of the sandy silt was very wet at the time of drilling but no free water was noted. The groundwater level was between elevation 123.0 and 123.4 metres on January 19, 1981. This is roughly 2.4 to 2.7 metres below the ground surface at the boreholes and is close to the existing Highway #2 road grade in the borehole area. There is a slight westward slope toward the creek.

Seasonal water table fluctuations of at least one-metre should be expected as should seasonal saturation of the contact area between the sandy silt and the underlying silty clay.



L. Politano, P. Eng.,  
Project Foundations Engineer



M. Devata, P. Eng.,  
Chief Foundations Engineer  
(East)

APPENDIX

# RECORD OF BOREHOLE No 1 & 1A

METRIC

W P 110-72-01 LOCATION Sta. 11+098.2 o/s 15 m RT 9 Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm diameter. COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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			20	40	60	80	100					
125.61	Ground Level															
0.0	Topsoil															
205 mm	Sandy silt					125										
	Trace of clay															
	Wet below 1 m															
	Compact. Light brown to dense		1	SS	22	124										0 44 44 12
123.17	Silty clay		1A	TW	PH	123										
2.44	Wet		2	SS	3	122										
	Stiff to firm Grey		3	SS	4											
121.5	Gravelly		4	SS	70	121										
4.11	Sandy silt, some clay and cobbles															
	(Glacial Till)															
	Very Dense Dark Grey		5	SS	50/125 mm	120										
						119										
						118										
117.81	End of Borehole		6	SS	50/100 mm											
7.80																
	Note Borehole 1A drilled 1 meter east of Borehole No.1 to obtain thin wall sample and vane tests.															

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 110-72-01 LOCATION Sta. 11+118.6 o/s 16 m RT 9 Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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	IN' VALUES			20	40	60	80	100				
125.78	Ground Level															
0.00	Topsoil															
205 mm	Sandy silt						125									
	Compact Light brown		1	SS	12		124									
123.65																
2.13	Silty clay						123									
	Wet															
	Stiff to firm Grey		2	SS	3		122									
122.48																
3.30	Gravelly sandy silt, trace to some clay.						121									
	(Glacial Till)		3	SS	50		120									
	Very Dense Dark Grey															
119.53			4	SS	50/125 mm		119									
6.25	End of Borehole															

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

OFFICE REPORT ON SOIL EXPLORATION

## UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY &amp; SILT

SAND

GRAVEL

Fine

Medium

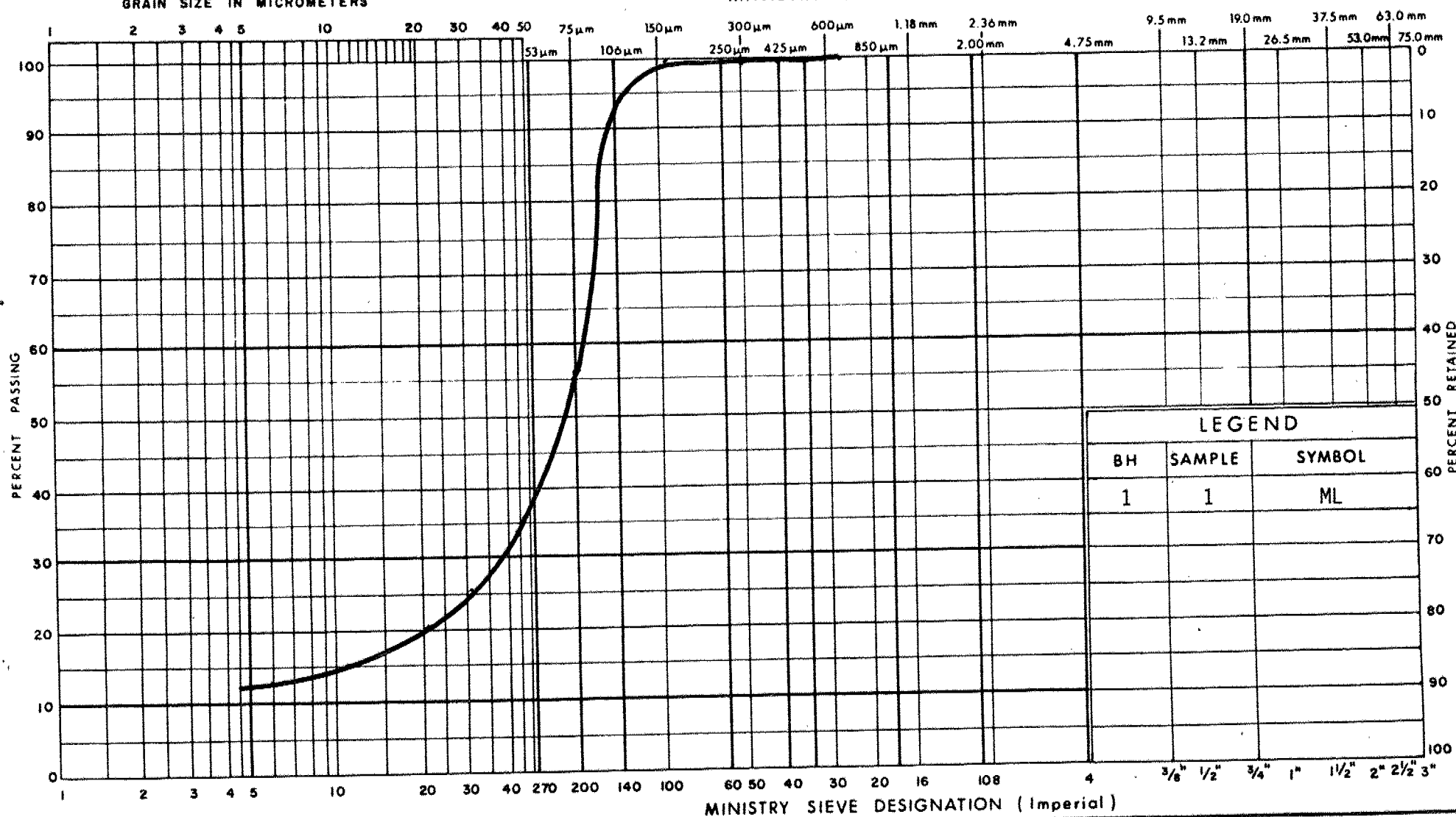
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



## LEGEND

BH	SAMPLE	SYMBOL
1	1	ML

GRAIN SIZE DISTRIBUTION  
SANDY SILT

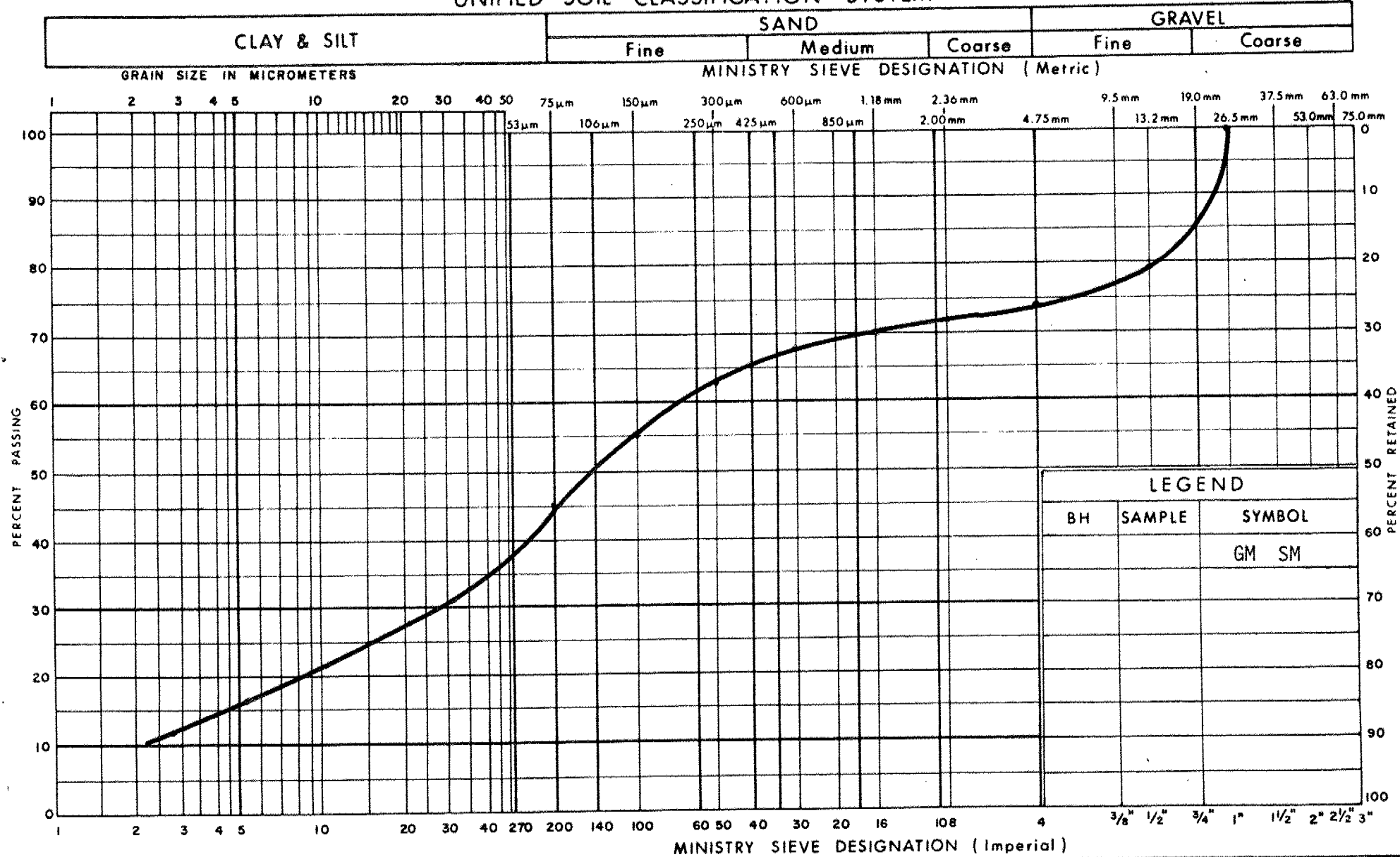
FIG No 1

W P 110-72-01



Ministry of  
Transportation and  
Communications

## UNIFIED SOIL CLASSIFICATION SYSTEM

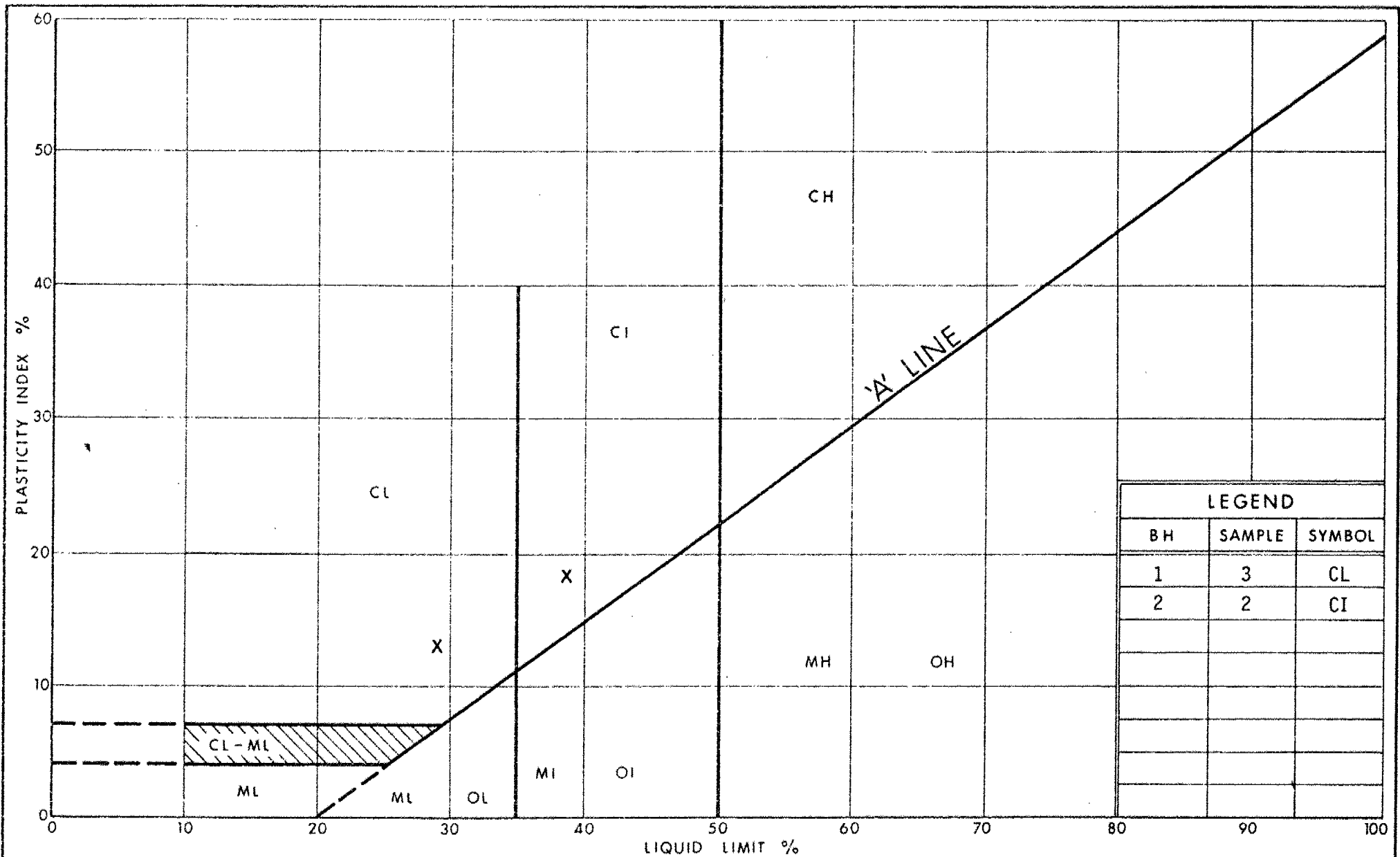


Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
**GRAVELLY SANDY SILT (TILL)**

FIG No 2

W P 110-72-01



Ontario

 Ministry of  
Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY

FIG No 3

W P 110-72 - 01



MINISTRY OF TRANSPORTATION AND COMMUNICATIONS  
Soil Mechanics Section  
1201 Wilson Avenue  
DOWNSVIEW, Ontario  
M3M 1J8

CONT 86-36  
GEOCRE'S NO  
30M15-58

REPORT ON SOIL CONDITIONS  
RETAINING WALL  
EAST OF OSHAWA  
ON HWY. NO. 2  
(WP NO. 110-72-01)

DISTRIBUTION

12 copies - M.T.C.  
1 copy - S.I.S.L.

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BOREHOLE LOGS	FIGURES 2 & 3
SIEVE AND HYDROMETER ANALYSIS	FIGURES 4 & 5
ATTERBERG LIMITS TEST	FIGURE 6
EXPLANATION OF TERMS USED IN REPORT	APPENDIX

## 1.0 INTRODUCTION

An evaluation of soil conditions has been completed at a proposed retaining wall on the south side of Highway No. 2 just east of the City of Oshawa, Ontario. The retaining wall limits are between stations 11+090 and 11+130. The study was undertaken to assess requirements for retaining wall foundations, backfill and excavations. The retaining wall is part of the work related to widening the highway to four lanes (WP 110-72-01).

This report summarizes soil profile and test data and discusses considerations for design and construction. The study and report were authorized by Mr. M. Devata, P. Eng. of the Ministry of Transportation and Communications.

## 2.0 FIELD WORK

The locations of 3 boreholes and a summary soil profile are provided on Drawing No. 1107201-A. More detailed soil profile and field test data is presented on the attached borehole summary forms.

Borings were completed with a track-vehicle-mounted power drill equipped with hollow stem and continuous flight augers. Samples were obtained with a 50 mm diameter "split spoon" sampler driven in accordance with standard penetration test procedures (63.5 kg hammer falling 760 mm) and with a 50 mm thin wall tube sampler.

Field work was completed on January 19 and 21, 1981. Elevations were related to site survey data provided by the M.T.C.

### 3.0 SOIL CONDITIONS

---

#### 3.1 General

The retaining wall site is located near the top of the valley of the adjacent Farewell Creek on the south side of Highway No. 2. The Highway is cut into the native soils in this area and the cut will be deepened as part of the highway reconstruction.

Native soils at the site consist of 2.13 to 2.44 meters of sandy silt underlain by 1.17 to 1.67 meters of layered silty clay. These lacustrine soils are underlain by a heterogeneous mixture of gravel, sand, silt and clay that contains scattered cobbles. This lower material is classified as a glacial till. Both borings terminated in the till.

#### 3.2 Topsoil

Topsoil at borehole locations is 205 mm thick. Similar depths are expected on native soils beyond the existing cut. The topsoil is a good quality silty loam.

#### 3.3 Sandy Silt

The layered sandy silt soils are classified as compact on the basis of standard penetration resistances of 12 to 22 blows per 305 mm. A particle size analysis on a representative sample is shown on Figure 4. There are occasional clay seams in the lower meter of these deposits.

#### 3.4 Silty Clay

The layered silty clay soils generally are classified as stiff on the basis of penetration resistances of 3 to 4 blows per 305 mm and vane shear strengths of 75 to 82 kPa. These clayey soils are slightly softer near the contact with the underlying till soils.

### 3.0 SOIL CONDITIONS (cont.)

---

#### 3.5 Sandy Silt (Till)

The stony sandy silt is part of the extensive basal till deposits common to the area. Most of these till textured soils contain some clay size particles and scattered cobbles. Occasional boulders may also be encountered.

The till-textured soils are classified as very dense on the basis of standard penetration resistances of 50 to more than 100 blows per 305 mm. In 3 of the 5 tested locations the till was extremely dense and the sampler could not be driven the full 305 mm standard test depth.

#### 3.6 Groundwater

The lower part of the sandy silt was very wet at the time of drilling but no free water was noted. The groundwater level was between elevation 123.0 and 123.4 meters on January 19, 1981. This is roughly 2.4 to 2.7 meters below the ground surface at the boreholes and is close to the existing Highway No. 2 road grade in the borehole area. There is a slight westward slope toward the creek.

Seasonal water table fluctuations of at least one meter should be expected as should seasonal saturation of the contact area between the sandy silt and the underlying silty clay.

### 4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

---

#### 4.1 General

We understand that the required retaining wall will be about 40 meters long and will extend a maximum of 3.7 meters above the proposed new road grade. Backfill behind the wall will extend horizontally from the top of the wall.

Site conditions are good and no significant problems are anticipated in design or construction of the wall.

Recommendations in this report are compatible with the Ontario Highway Bridge Design Code, 1979.

#### 4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

---

##### 4.2 Footings

The base of the retaining wall will be within very dense stony sandy silt (till) soils. Under "serviceability limit state" conditions an allowable stress of 500 kPa would produce settlements of less than 20 mm for footings wider than 1.3 meters. The "ultimate limit state" of stress is in excess of 2000 kPa.

All footings should be provided with at least 1.2 meters of soil cover for frost protection or be protected to an equivalent condition with insulation.

All loose, wet and disturbed soil should be hand excavated from below footing areas just prior to concrete placement.

##### 4.3 Backfill and Earth Pressures

Backfill should consist of clean pit run sand and gravel (MTC granular 'B') compacted in 300 mm maximum lifts to 95 percent of standard proctor density (ASTM D 698 standard). The granular fill limits should extend at least to the 60 degree line described on Figure 6.9.6.1 of the Code.

Provided that the backfill is fully drained, as subsequently discussed, the following lateral earth stress conditions can be assumed for design purposes.

Condition	at "serviceability limit state"	at "ultimate limit state"
active state	6.5 kPa/m	8 kPa/m
passive state	56.0 kPa/m	46 kPa/m

These values are stresses per meter of depths and the total cumulative pressures can be assumed to act at the lower 1/3 point of the wall.

#### 4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

---

##### 4.3 Backfill and Earth Pressures (cont.)

The "serviceability limit state" stresses should prevail with wall deflections of a few millimeters provided that the backfill is compacted with hand operated compactors. Use of heavy self propelled rollers could increase stresses substantially through a wedging effect.

##### 4.4 Drainage

The retaining wall backfill should be fully drained with at least one perforated pipe drain placed behind the wall at footing grade. The drains should extend through or beyond the wall to ensure positive gravity drainage.

To ensure against clogging by fines the drain should be surrounded with a positive filter system consisting of one of the following.

- (a) A minimum of 150 mm of clear washed stone next to the perforated pipe and 150 mm of coarse sand around the clear stone.
- (b) A minimum of 150 mm of clear stone next to the perforated pipe and the clear stone completely surrounded by suitable filter fabric.

Acceptable particle size limits for the sand and clear stone are as follows.

<u>Sieve Size</u>	<u>Clear Stone</u>	<u>Coarse Sand</u>
25 mm	100	
19 mm	90 - 100	
12.5 mm		
9.5 mm	20 - 55	100
4.75 mm	0 - 10	95 - 100
2.36 mm	0 - 5	80 - 100
1.18 mm		50 - 85
600 um		25 - 60
300 um		10 - 30
150 um		2 - 10

4.0 DESIGN AND CONSTRUCTION CONSIDERATIONS (cont.)

---

4.5 Excavations

During dry seasonal periods open excavations should be straightforward with little or no sloughing expected where slopes of 1:1 are excavated above the initial near vertical cut permitted by current provincial construction safety requirements. If seasonally wet conditions prevail at the time of construction some minor short term sloughing may occur near the contact between the silty clay and overlying sandy silt. All soils are fine grained and seepage inflow rates should be small.

Open cut procedures will require an excavation that extends within 1 or 2 meters of an existing house. If temporary easements cannot be arranged to permit open excavation procedures it will be necessary to provide some form of shoring to protect workmen. Penetrating the very dense till with soldier piles may require pre-augering. Otherwise we do not anticipate any major problems in installing most varieties of temporary shoring.

4.6 Construction Inspection

The continuity of soil conditions between borings should be confirmed by a soils engineer when the soils are exposed during construction. We should be contacted to review our recommendations should any significant differences be observed.

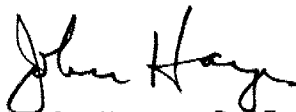
Submitted by:

SITE INVESTIGATION SERVICES LIMITED



R. Marttila, P. Eng.

Reviewed by:



J. A. Hayes, P. Eng.

RM/lp





# RECORD OF BOREHOLE No 1 & 1A

METRIC

W P 110-72-01 LOCATION Sta. 11+098.2 o/s 15 m RT-9 Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm diameter. COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

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					
125.61	Ground Level															
0.0	Topsoil															
205 mm	Sandy silt					125										
	Trace of clay															
	Wet below 1 m															
	Compact Light brown to dense		1	SS	22	124										0 44 44 12
123.17																
2.44	Silty clay		1A	TW	PH	123										
	Wet															
	Stiff to firm Grey		2	SS	3	122										
121.5			3	SS	4											
4.11	Gravelly Sandy silt, some clay and cobbles					121										
	(Glacial Till)		4	SS	70											
	Very Dense Dark Grey					120										
			5	SS	50/125 mm	119										
117.81			6	SS	50/100 mm	118										
7.80	End of Borehole															
	Note Borehole 1A drilled 1 meter east of Borehole No.1 to obtain thin wall sample and vane tests.															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

FIGURE 2



# RECORD OF BOREHOLE No 2

METRIC

W P 110-72-01 LOCATION Sta. 11+118.6 o/s 16 m RT Q Hwy. 2 ORIGINATED BY DWN  
DIST 6 HWY 2 BOREHOLE TYPE Hollow Stem Auger, 82.5 mm COMPILED BY PS  
DATUM Geodetic (MTC Survey) DATE January 19, 1981 CHECKED BY REM

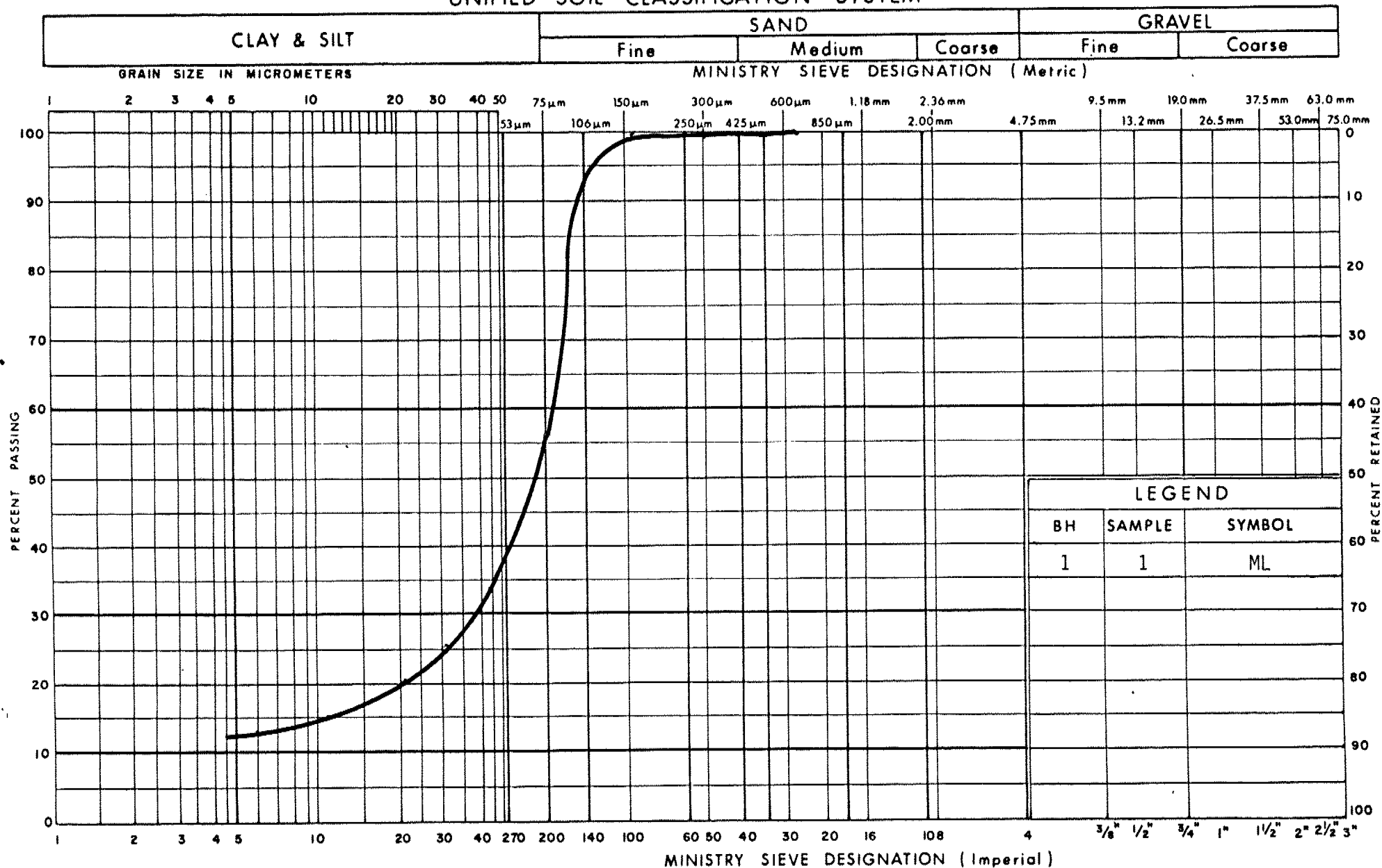
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
125.78	Ground Level															
0.00	Topsoil															
205 mm	Sandy silt															
	Compact Light brown		1	SS	12											
123.65																
2.13	Silty clay															
	Wet															
	Stiff to firm Grey															
122.48			2	SS	3											
3.30	Gravelly sandy silt, trace to some clay.															
	(Glacial Till)															
	Very Dense Dark Grey		3	SS	50											
119.53			4	SS	50/125 mm											
6.25	End of Borehole															

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

20  
15  
10  
5 (%) STRAIN AT FAILURE

FIGURE 3

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SANDY SILT

FIG No 4

W P 110-72-01

## UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY &amp; SILT

SAND

GRAVEL

Fine

Medium

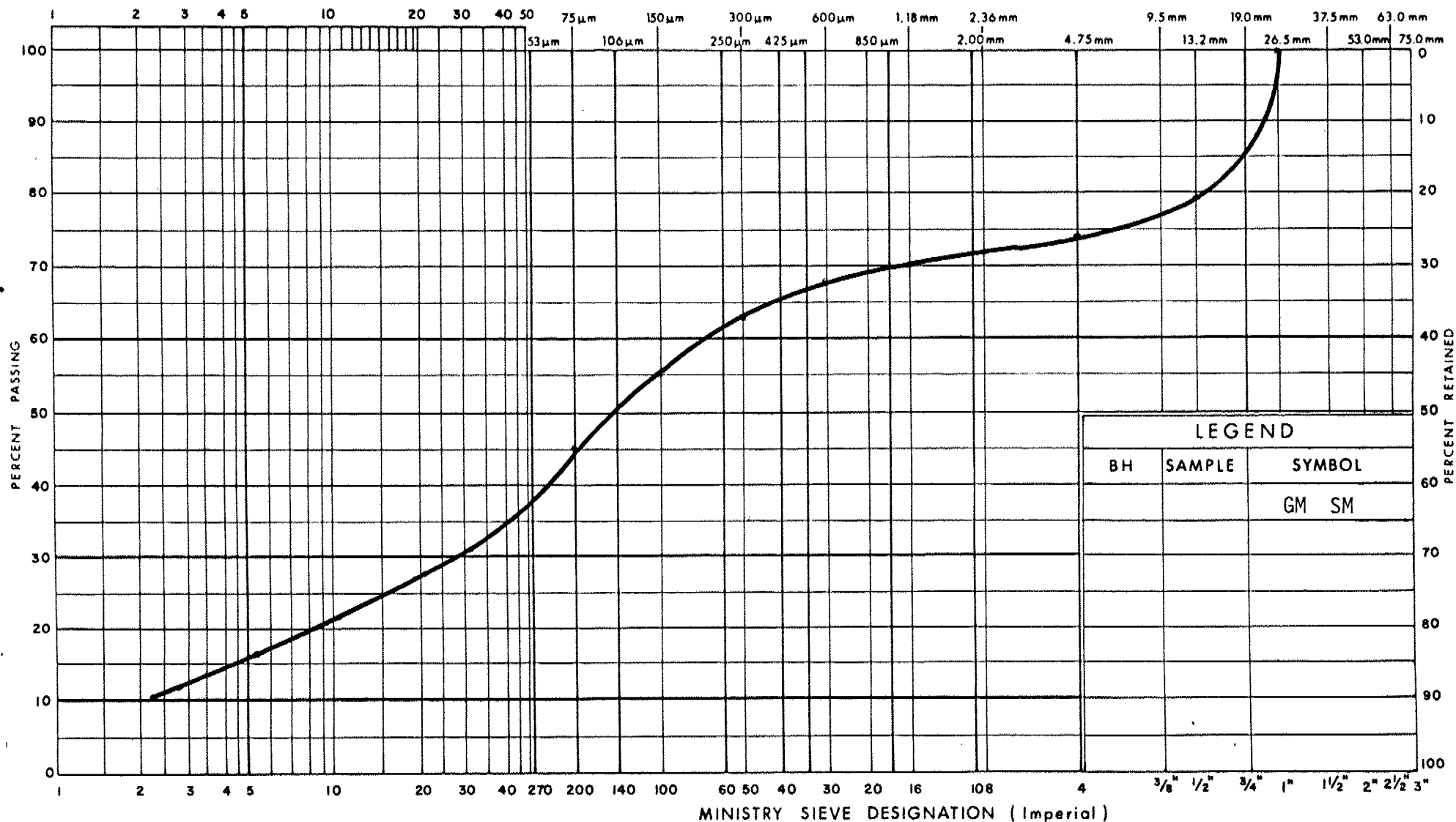
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



## LEGEND

BH

SAMPLE

SYMBOL

GM SM

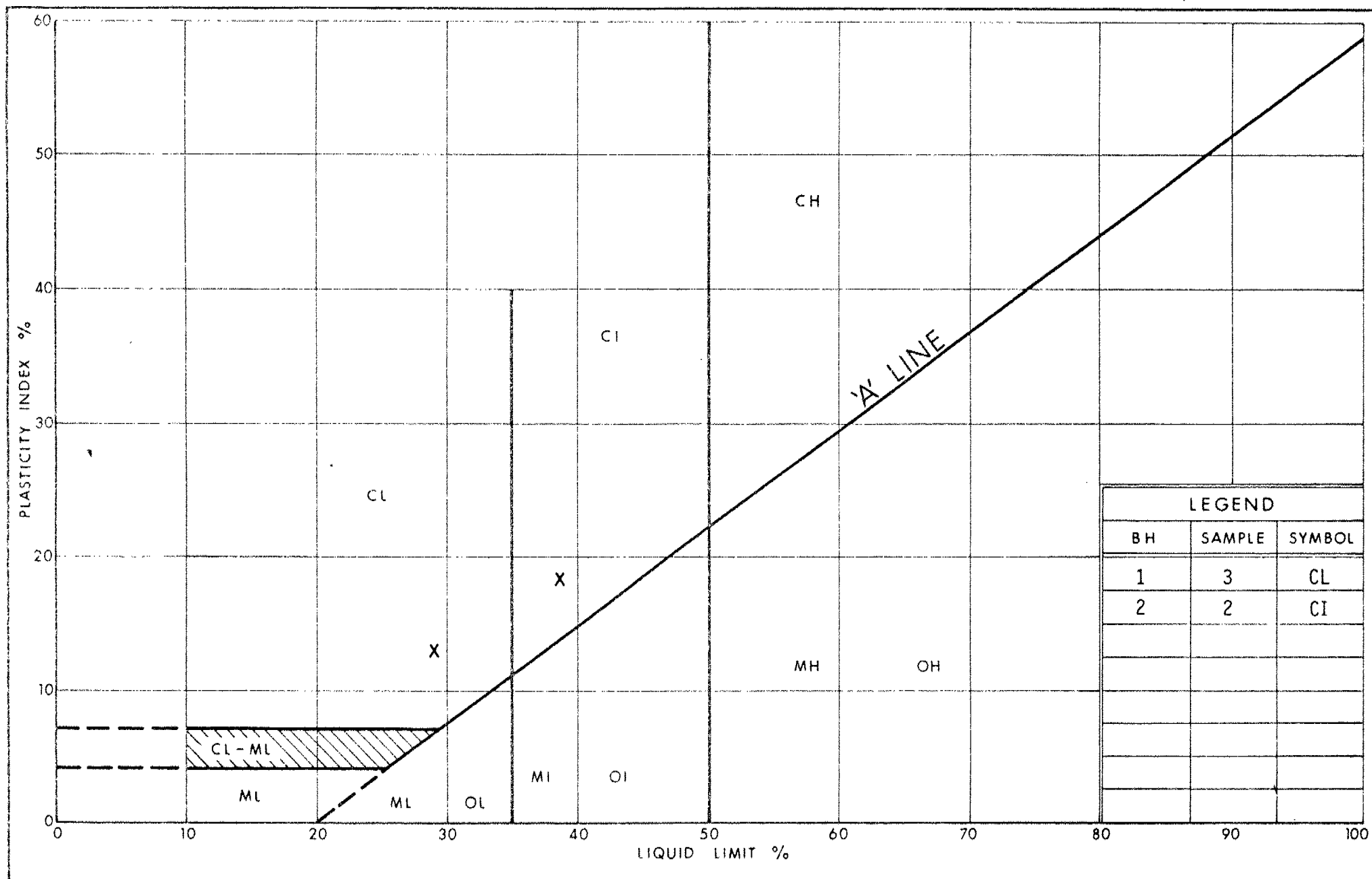


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GRAIN SIZE DISTRIBUTION  
GRAVELLY SANDY SILT (TILL)

FIG No 5

W P 110-72-01



Ontario

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# PLASTICITY CHART SILTY CLAY

FIG No 6

W P 110-72 - 01

# EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	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 = $\frac{c_u}{\tau_r}$

### 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

### PHYSICAL PROPERTIES OF SOIL

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

*a copy of the  
original*

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 110-72-01

DIST #7

HWY #2

STR SITE 21-268

Farewell Creek Concrete Culvert

DISTRIBUTION

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# FOUNDATION INVESTIGATION REPORT

For

Farewell Creek Concrete Culvert  
Extension, 1 km East of Oshawa  
W.P. 110-72-01, Site 21-268  
Highway 2, District 7, Port Hope

---

## INTRODUCTION

This report contains the results of the foundation investigation carried out at the above site. The field work was performed on 80 09 25 and 80 09 26 employing a track mounted, continuous flight, hollow stem auger. Three boreholes were augered to 5 m with the fourth going to 9 m. The boreholes were located as close as possible to the proposed location of the culvert extension footings.

## SITE DESCRIPTION

Farewell Creek crosses Highway #2 approximately 1 km east of the Oshawa townline. The valley, cut through the southward sloping area, is approximately 350 metres in width by 11 metres in depth.

Landuse in the area is mixed, and includes a motel site, residential housing, bush and open fields. Bell telephone and natural gas services run below the existing shoulders of Highway #2. A well, probably used for summer lawn watering, is located on the valley floor just north of the culvert extension.

Farewell Creek is 0.2 m to 0.5 m deep and 6 m wide at the Highway #2 crossing. The water surface elevation at the time of investigation was 113.5 m. To the north and the south of the site trees exist along the creek valley. A small swampy area is located just north of the proposed culvert extension.

## SUBSURFACE CONDITIONS

### Subsoil General

Farewell Creek has a bed of boulders, cobbles and gravel for a depth of 0.8 m. On either side of the creek there is a recent



alluvial deposit consisting of a 0.3 metre layer of topsoil and from 0.6 to 0.9 metres of silty sand with a trace of organics. These superficial deposits overlie a hard homogeneous mixture of silty clay, sand and gravel of glacial origin. It extends to a depth of at least 9 metres, where the deepest borehole was terminated.

Reference should be made to Drawing #1107201-A in the Appendix which shows the borehole locations and an inferred subsoil stratigraphy. A more detailed description and location of the subsoils can be found on the borehole log sheets in the Appendix.

#### Heterogeneous Mixture of Silty Clay, Sand and Gravel

The predominant soil type at the site is a hard glacial till consisting of a heterogeneous mixture of silty clay, sand and gravel which extends from elevation 113 to below the maximum depth of the borings. It contains some silt inclusions but is generally cohesive in nature. This is indicated by the fact that the results of Atterberg Limit Tests (Figure 2) plot close to or in the CL-ML range. Grain size distribution curves (Figure 1) are typical of glacial till deposits with high fractions of sand and silt with some clay and gravel. Standard Penetration 'N' values range from 31 to above 100, with most values in excess of 50. This indicates a hard consistency. Moisture contents of samples tested are very low, ranging from 5 to 8 percent.

#### Groundwater

Boreholes 2, 3 and 4 all indicate water levels which correspond to the creek water level of 113.5 m. Borehole 1 had an artesian head of approximately 0.3 m above the existing ground surface. The artesian pressure was met at elevation 108 m, six metres below ground level.

## DISCUSSION AND RECOMMENDATIONS

The existing structure at Farewell Creek is a (6.10 x 3.66 x 17.70 metres) open type concrete culvert. This structure is founded on the glacial till subsoil. The culvert will be extended by 15.5 metres to the north and south to give an overall length of 48.70 metres.

### RECOMMENDATIONS

It is recommended that the culvert extension be supported on spread footings founded between elevations 112.5 and 111 metres. Design loads of up to 300 kPa can be supported by the glacial till subsoil. Resistance to lateral forces can be calculated using an adhesion value of 96 kPa between the base of the footing and the underlying subsoil. Lateral earth pressures can be calculated using a coefficient of earth pressure at rest of 0.5 and a unit weight of granular backfill of 21 kN/m<sup>3</sup>.

Settlements of the foundation will be less than 2 centimetres. Placement of the footings should be done as soon after excavation as possible, thereby lessening the time likely to weaken the concrete-soil interface.

### Groundwater Conditions & Dewatering

An artesian condition was met in borehole one at elevation 108 metres (6 metres below the surface) in a 0.1 metre layer. The artesian condition is not of concern if the base of the footing excavation is above elevation 111.

An earth dyke will be required to keep the footing excavations relatively dry for the placement of concrete. This method of dewatering will have to be cleared for environmental suitability. If this method is unsatisfactory, piping of the water may be considered. Driving sheet piles to cut-off the water flow would be difficult due to the hard nature of the glacial till and the overlying boulders.

Footing excavation dewatering problems are not anticipated due to the relatively impervious nature of the subsoil. Sumps can be used to pump out any seepage or surface water. Drainage of surface

water from the existing and proposed embankments must be provided for during and after construction.


#### Embankments


Existing embankments are in excess of 1.5 to 1.0 at this location. Finished slopes of 2.0 to 1.0 and construction slopes of 1.0 to 1.0 will be sufficient to prevent slope failure.

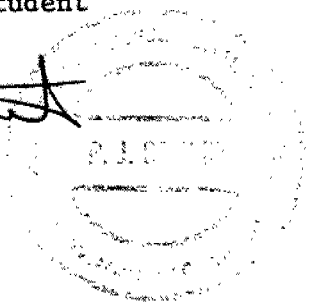
Benching Standard SS-414 should be followed to lessen the likelihood of slippage between the old and new fills. Removal of the upper 0.6 metres of soil in the area of embankment widening will reduce the settlement of the embankment widening and insure good performance.

#### MISCELLANEOUS

The base of the spread footings should have at least 1.2 metres of cover to provide frost protection. Scour protection will be required over the subsoil after the covering boulders have been removed. The boring equipment used during the field work was provided by Atcost Soil Drilling Inc.

  
Richard Burgess  
U. of W. Co-operative Student

  
Peter Stuart, P. Eng.  
Foundations Engineer



## APPENDIX

# RECORD OF BOREHOLE No 1

W P 110-72-01 LOCATION Sta. 10+986.2 10.2 m LT. ORIGINATED BY R.B.  
 DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/25 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)				
114.2	Ground Level															
113.7	Top Soil															
0.3	Silty Sand Trace Organics															
113.1																
0.9	Sand, Gravel and Cobbles															
112.7																
1.5																
	Heterogeneous Mixture of Silty Clay, Sand and Gravel		1	SS	80											
	Random Silt Inclusions		2	SS	92											
	Grey Hard (Glacial Till)		3	SS	51											
			4	SS	44											
105.1																
9.1	End of Borehole															
	Note: - Borehole 1 m from Creek - Some Artesian Conditions at Elevation 108.1 m.															

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

## 2

DATUM Geodetic DATE 80-09-26 CHECKED BY \_\_\_\_\_


[illegible]

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

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 3

W P 110-72-01 LOCATION Sta. 10+974.2 15.1 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY 72 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY \_\_\_\_\_

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									
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE									
114.2	Ground Level													5	10	15	
113.9	Top Soil	2					114										
0.3	Silty Sand, Trace	2.2															
113.0	Organics	2.2															
1.2	Heterogeneous Mixture of Silty Clay Sand and Gravel Random Silt Inclusions	3	1	SS	31		112							○	10		25 35 31 9
		2	SS	100/	28 cm												
		3	SS	35/	15 cm									○	10		
109.4	Grey Hard (Glacial Till)	3	4	SS	100/	23 cm	110										
4.8	End of Borehole						108										

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

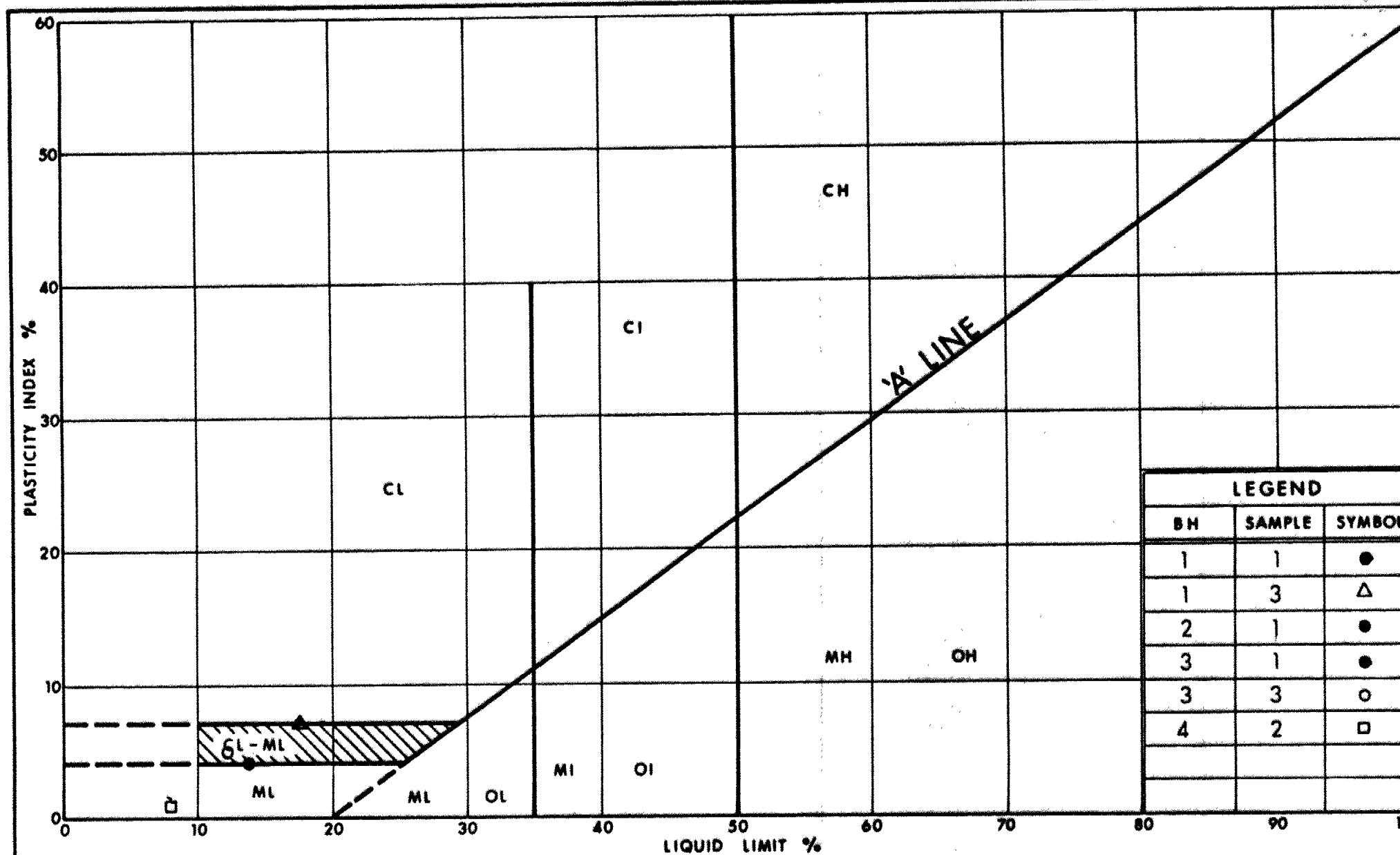
20  
 15 5 (%) STRAIN AT FAILURE  
 10

# RECORD OF BOREHOLE No 4

W P 110-72-01 LOCATION Sta. 10+988.0 14.3 m RT. ORIGINATED BY R.B.  
 DIST 6 HWY #2 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.B.  
 DATUM Geodetic DATE 80/09/26 CHECKED BY \_\_\_\_\_

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					
114.2	Ground Level																
113.9	Top Soil						114										
0.3	Silty Sand																
113.0	Trace Organics																
1.2	Heterogeneous Mixture of Silty Clay Sand and Gravel Random Silt Inclusions Grey Hard (Glacial Till)		1	SS	55		112							o			8 36 40 16
			2	SS	80									o	I		
			3	SS	100/	28 cm	110										
109.3			4	SS	100/	31 cm											
4.9	End of Borehole						108										



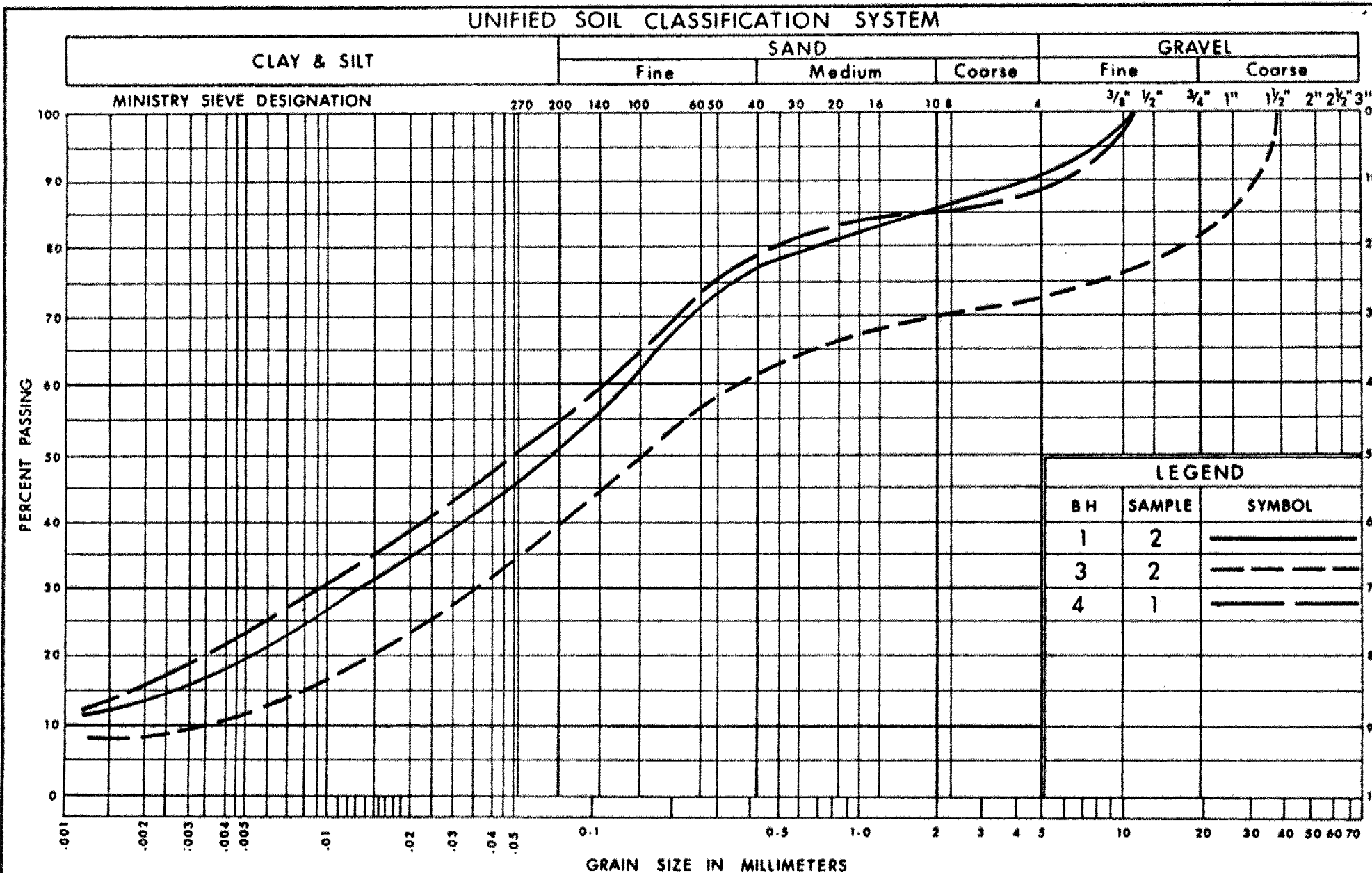


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**PLASTICITY CHART**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No. 2

W P 110-72-01



Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
HET. MIX OF SILTY CLAY SAND & GRAVEL RANDOM SILT  
INCLUSIONS. (GLACIAL TILL)

FIG No 1

W P 110-72-01

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 = $\frac{w_L - w_p}{w - w_p}$	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						

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, OTTAWA

METRIC

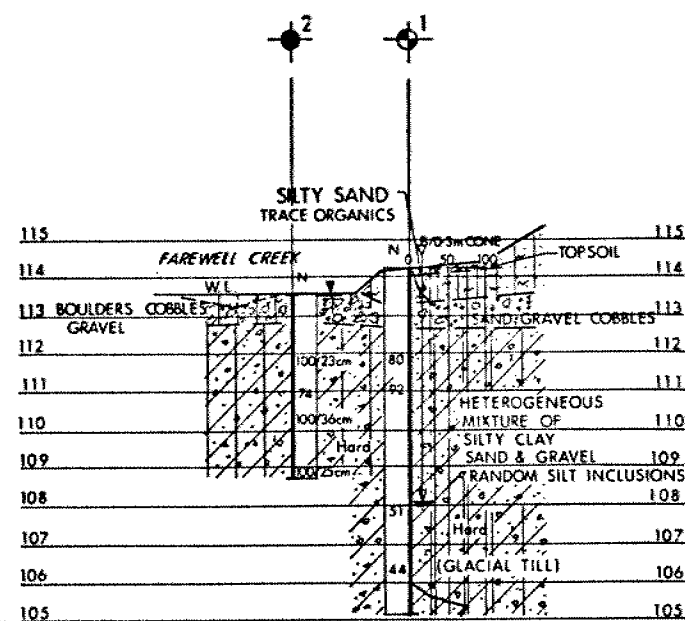
NOTE: DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No  
WP No 110-72-01

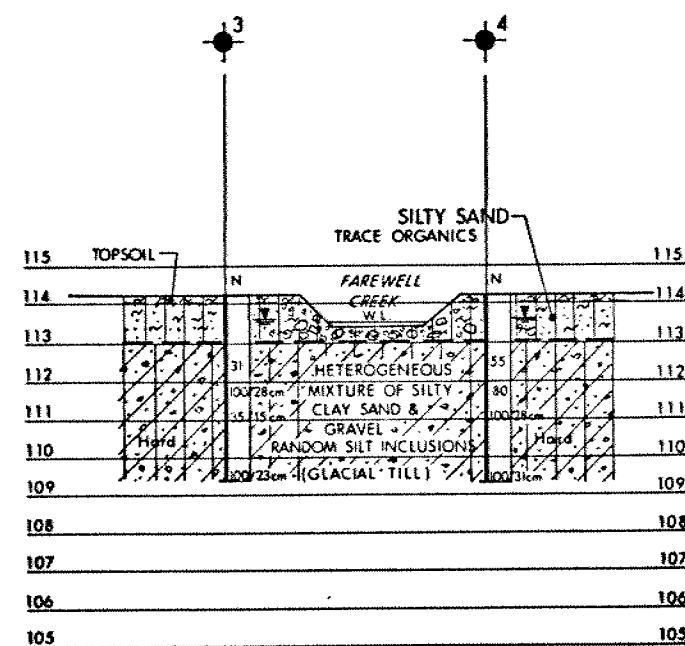
FAREWELL CREEK CULVERT  
EXTENSION

BORE HOLE LOCATIONS & SOIL STRATA

SHEET

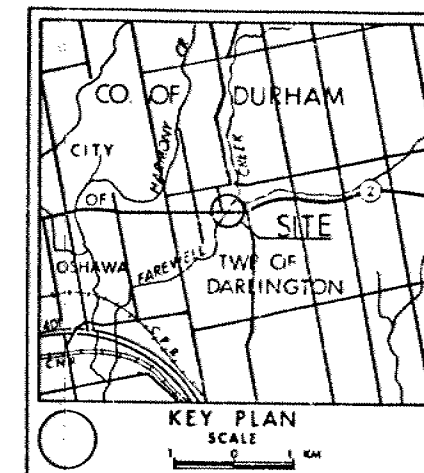
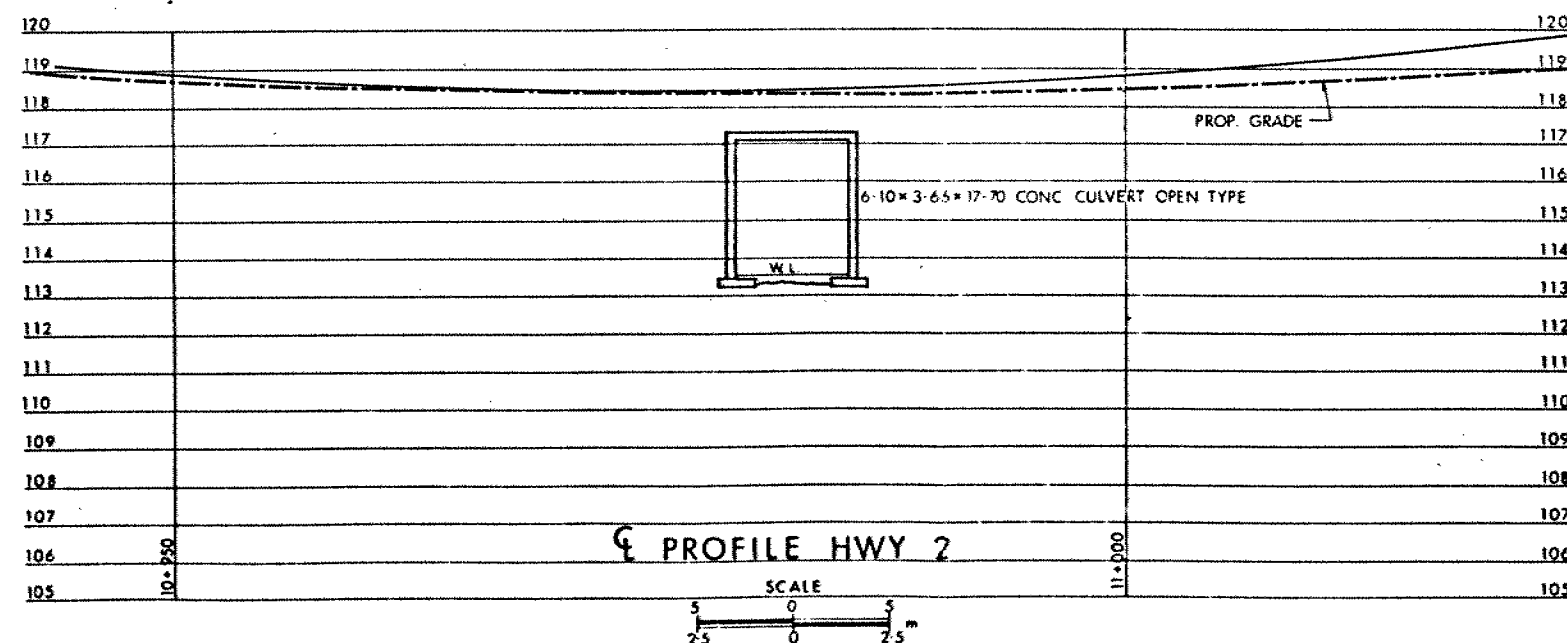
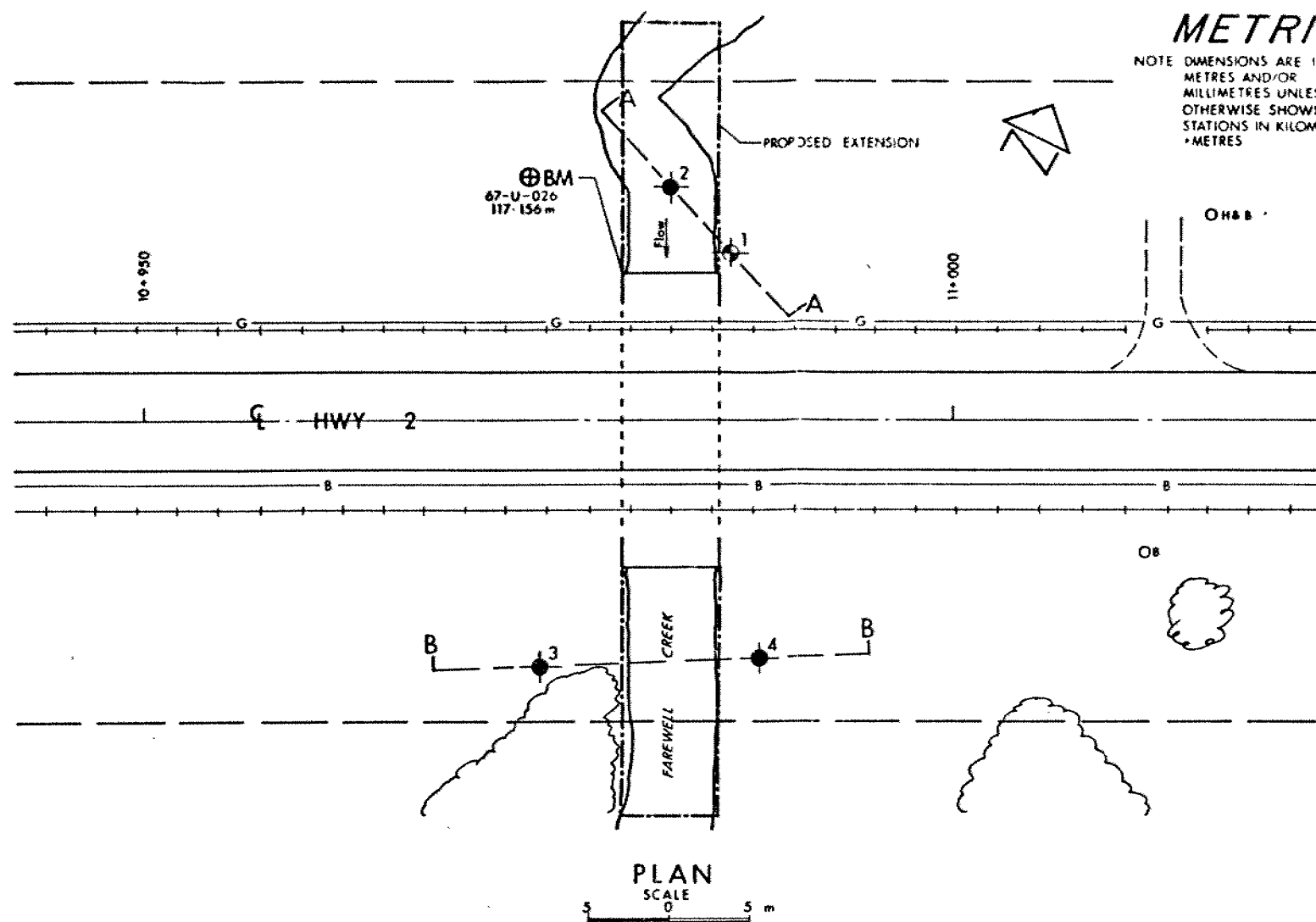


A - A



B - B

SECTIONS  
SCALE  
2.5 0 2.5 m



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 80 09 26
- Head
- ARTESIAN CONDITION
- Encountered

No	ELEVATION	STATION	OFFSET
1	114.2	10+986.2	10.2 LT
2	113.5	10+982.5	14.2 LT.
3	114.2	10+974.2	15.1 RT.
4	114.2	10+988.0	14.3 RT.

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 30M15-57

HWY No	2	DIST	7
SUBMD P	5	CHECKED	DATE 80 12 02
DRAWN	NO. 1	CHECKED	DATE 80 12 02

SEND  
TO

MR. M. DEVATA  
SENIOR FDN. ENGINEER  
PAV'T. & FDN. DESIGN SECTION

FROM

H. K. JAGASIA

BRANCH

STRUCTURAL SECTION

DATE

81.07.02

SUBJECT

RETAINING WALL, W.P. 110-72-01, HWY. 2  
OSHAWA TO BOWMANVILLE, DIST 6.

As discussed with you on 1981-06-29  
the above wall has been extended  
10 meters to the west to avoid the  
property purchase.


Would you please provide us with  
your recommendations by 1981-07-10, or  
earlier if possible.

I am attaching one dwg. which indicates  
the revised data.

REPLY

CC. B. SHAW

R. FITZGIBBON.

- As discussed with H. Jagasia on 81-07-02,  
in view of the competent uniform soils conditions  
no additional fieldwork is warranted for the  
extra 10 metres of retaining wall length. 

REPLY FROM

REPLY DATE

# memorandum



To: Mr. M. Devata,  
Senior Foundation Engineer,  
Pavement and Foundation  
Design Section,  
Central Building, Downsview.

Date: 1981-08-19

Central Region

RE: Hwy. 2, Oshawa to Bowmanville,  
W.P. 110-72-01,  
District 7, Port Hope

*> Mylar sent  
directly.*

Attached please find for your review and comments, one print  
each of the following drawings:

Farewell Creek Culvert

Drawing #1 Left Extension  
Drawing #2 Right Extension

50.7 m Retaining Wall

Drawing #1 General Arrangement  
Drawing #3 Details

It is recommended in the Foundation Investigation Report that  
the Farewell Creek Culvert extensions be supported on the footings  
founded between elevations 112.5 and 111.0 m. We discussed it  
further, and was agreed that it could be modified. This is  
indicated on the attached drawings.

Would you please provide us with one mylar each of your Bore Hole  
Locations and Soil Strata drawing for the above structures.

HKJ:rb  
Attach.

*H. Jagasia*

H.K. Jagasia,  
Senior Structural Engineer,  
for:  
G.C.E. Burkhardt,  
Head, Structural Section.

c.c. Mr. B. Shaw



# memorandum



To: G.C.E. Burkhardt,  
Head Structural Section,  
Central Region

Date: 81 03 12

From: Pavement and Foundation Design Section

Re: Foundation Investigation Report,  
Retaining Wall between Sta 11+030 and Sta 11+130  
Hwy #2, East of Oshawa,  
W.P. 110-72-01, Dist. #6 (Toronto)

The foundation investigation and design program for the above mentioned site has now been completed by Site Investigation Services Ltd., geotechnical consulting engineers.

Attached, please find the final report and drawing which this section has reviewed for technical content and format.

Our comments regarding structure foundations are as follows:

The bearing capacity at serviceability limit state should be 500 kPa which would produce settlements of less than 20 mm for footings wider than 1.3 meters. The bearing capacity at ultimate limit state should be 1000 kPa. For computations of earth pressure the values suggested in the code under section 6.6.1.1 should be used.

We believe the comments contained in this memo and data in the accompanying foundation, is adequate for your requirements.

Should you require additional information, please feel free to contact us.

  
M. Devata,  
Senior Foundations Engineer

MD:bcs





DIST No 6  
CONT No  
WP No 110-72-01

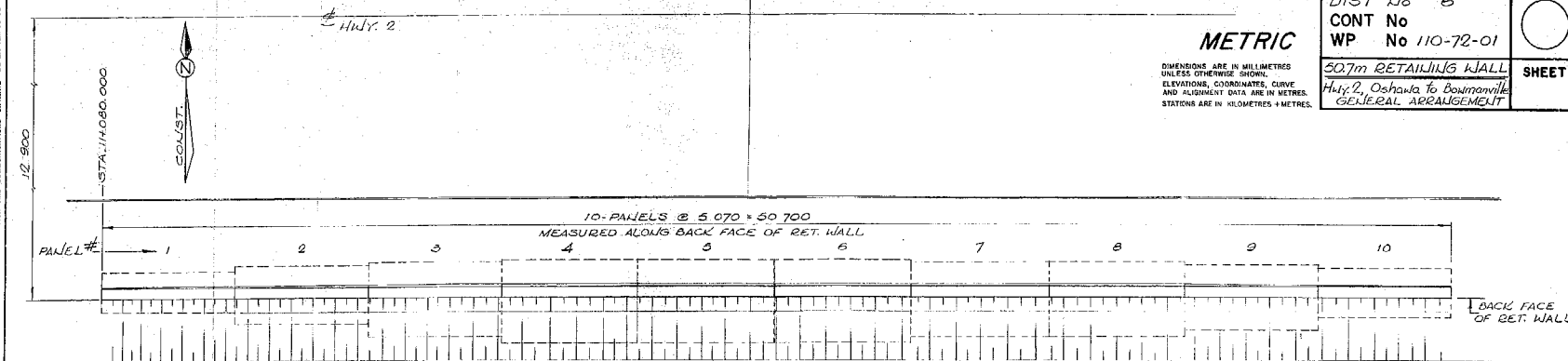


# METRIC

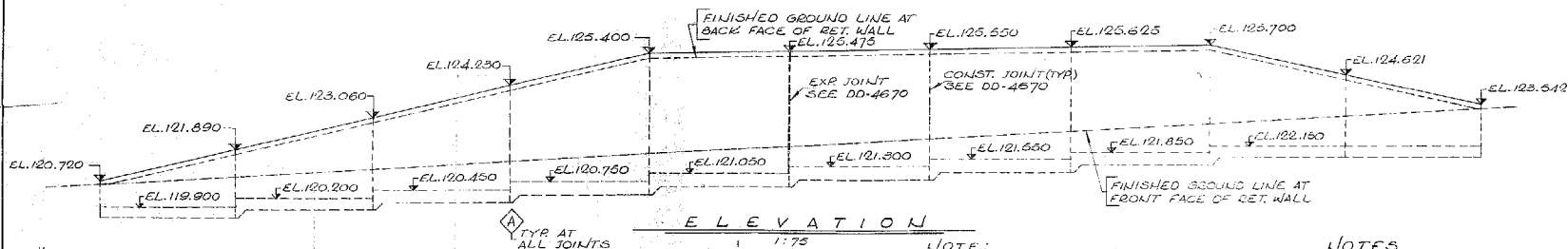
DIMENSIONS ARE IN MILLIMETRES  
UNLESS OTHERWISE SHOWN.  
ELEVATIONS, COORDINATES, CURVE  
AND ALIGNMENT DATA ARE IN METRES.  
STATIONS ARE IN KILOMETRES + METRES.

507m RETAINING WALL  
Hwy 2, Oshawa to Bowmanville  
GENERAL ARRANGEMENT

SHEET



PLAN  
1:75



## NOTES:

FOR FINISHED GROUND LINE ELEVATIONS  
AT FRONT AND BACK FACES OF RET. WALL,  
SEE GRADING DRAWINGS.

## NOTES

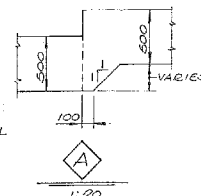
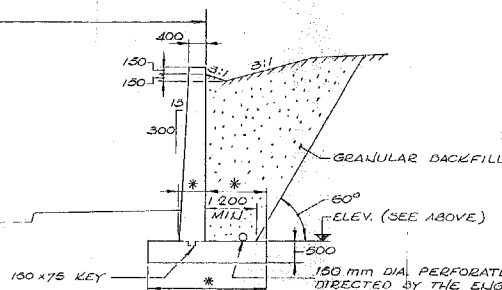
- CLASS OF CONCRETE ----- 20 MPa
- REINFORCING STEEL GRADE -- 400
- CLEAR COVER TO REINK. STEEL -- 75mm

## LIST OF DRAWINGS.

- GENERAL ARRANGEMENT
- BORE HOLE LOCATION & SOIL STRATA
- DETAILS

## CONCRETE QUANTITIES

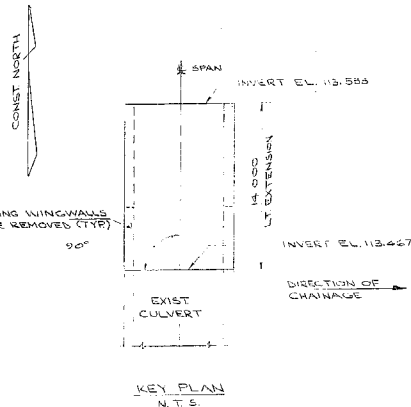
FOOTING ----- 66 m<sup>3</sup>  
RETAINING WALL ----- 79 m<sup>3</sup>



\* VARIES (SEE DWG. #3)

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE BY	DESCRIPTION
1	3/21/01	LOADING & 22 DATE 3/21/01
2	3/21/01	CHECKER 7 SITE NS 21-RN 108



NOTE:  
EXISTING WINGWALLS  
TO BE REMOVED (TYP)

KEY PLAN  
N.T.S.

## LIST OF DRAWINGS

- 1 CULVERT AT STA.10+982.200 (LT. EXT.)  
2 CULVERT AT STA.10+982.200 (RT. EXT.)  
3 BORE HOLE LOCATION & SOIL STRATA

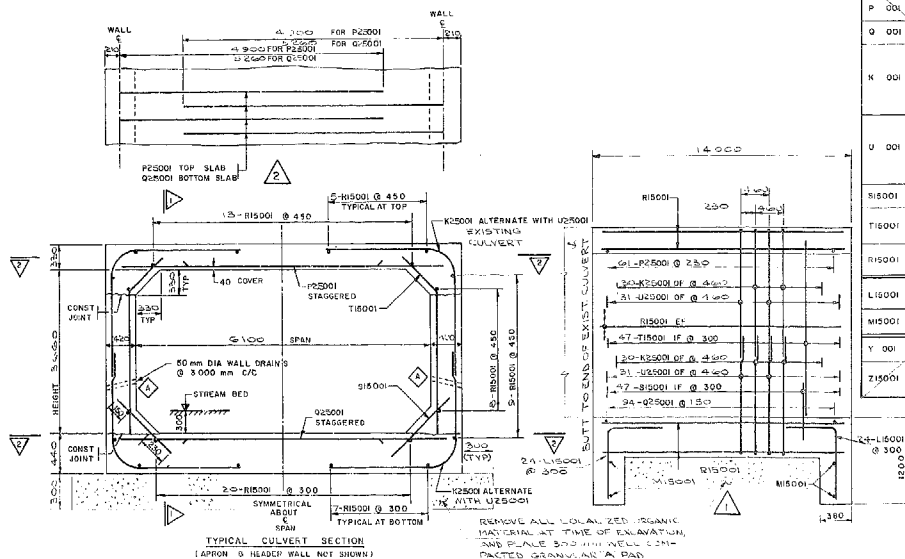
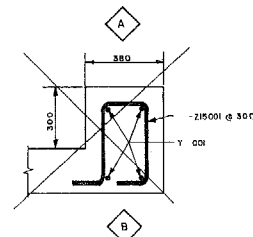
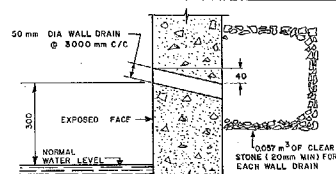
*METRIC*

DIMENSIONS ARE IN MILLIMETRES  
UNLESS OTHERWISE SHOWN.  
ELEVATIONS, COORDINATES, CURVE  
AND ALIGNMENT DATA ARE IN METRES.  
STATIONS ARE IN KILOMETRES + METRES

CONT No  
WP No 110-72-01






CULVERT LT. EXTN.  
STATION 10+982.200

**SHEET**



## STD RIGID FRAME BOX CULVERT

AT STATION 10+482.200 EX 1  
SPAN 100 HEIGHT 30.60 LENGTH 100 FILL HEIGHT 12.00

* VERTICAL DIMENSIONS				REMARKS	
MARK	No REQ'D	C/C	LENGTH	DETAILS	REMARKS
P 001				STRAIGHT	BOTTOM OF TOP SLAB STAGGERED
Q 001				STRAIGHT	TOP OF BOTTOM SLAB STAGGERED
K 001					K BARS ALTERNATE WITH U BARS
U 001					
R15001		300		STRAIGHT	INSIDE FACE OF WALLS 1' AT BOTTOM HUNCH
T15001		300			INSIDE FACE OF WALLS
R15001	SEE REMARKS			STRAIGHT LINES PER LINE	LONGITUDINAL STEEL (LAP 500) 3' 4.50 IN TOP SLAB AND WALLS 3' 0.00 IN BOTTOM SLAB
L15001		300	1700		APRON
M15001		480		STRAIGHT	APRON
Y 001		---		STRAIGHT	HEADER WALL
Z15001		300			HEADER WALL

GENERAL NOTES

- CLASS OF CONCRETE 20 MPa
- COVER TO REINFORCING STEEL 75 mm EXCEPT AS NOTED
- ALL EXPOSED CORNERS TO BE CHAMFERED 20 mm
- ALL EXPOSED SURFACES TO BE FINISHED WITH A FINISH WITHIN THE DEPTH OF THE EXCAVATION AND CHARACTER OF THE FOUNDATION MATERIAL HAVE BEEN APPROVED BY THE ENGINEER
- ALL PLACES AT BOTH SIDES OF CULVERT SIMULTANEOUSLY
- CULVERT AND RETAINING WALLS (WHERE APPLICABLE) SHALL BE BUILT TO THE SAME STANDARD WITH THE FORMWORK
- REINFORCING STEEL SHALL BE HARD GRADE
- STEEL FOR EACH CULVERT INCLUDING RETAINING WALLS WHERE REQUIRED SHALL BE BUNDLED SEPARATELY AND MARKED WITH STATION NUMBER
- WALL GAIN OPENINGS TO BE FORMED USING NON-METALLIC MATERIAL
- VERTICAL LOCATION OF WALL DRAWS SHALL BE DETERMINED IN CONSULTATION WITH THE ENGINEER
- IF DENOTES INSIDE FACE
- IF DENOTES OUTSIDE FACE
- IF DENOTES EACH FACE

QUANTITIES			
ITEM	WALLS & SLABS	RETAINING WALL	TOTAL
MASS OF REINF STL tonnes	SEE REINF.	STEEL S	SCHEDULE
VOL OF CONCRETE cubic metres	125		125

REG. MUN. OF DURHAM  
TOWN OF NEWCASTLE  
LOT 33 CON 2  
HWY 2 DIST 7 PORT HOP

REVISIONS					
DATE	BY	DESCRIPTION			
DESIGN STD	CHECK W K J	LOADING			DATE: 11-1-88
REVISION 1	CHECK D B	RTR No. 51-35-8			DATE: 11-1-88

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

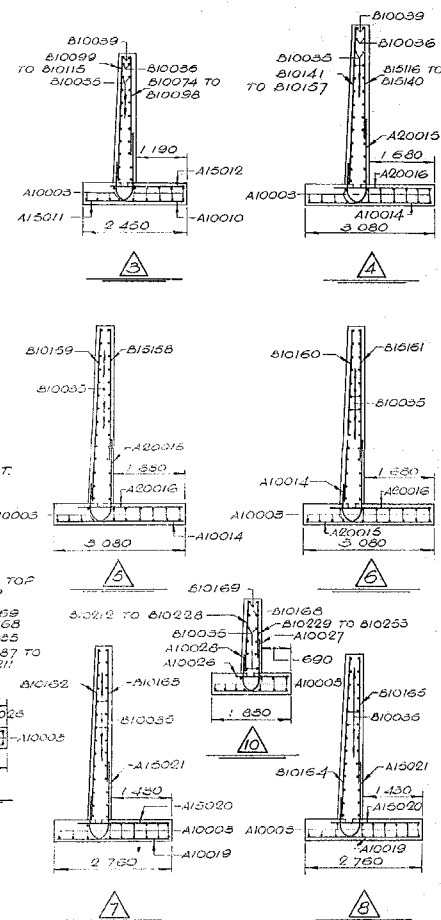
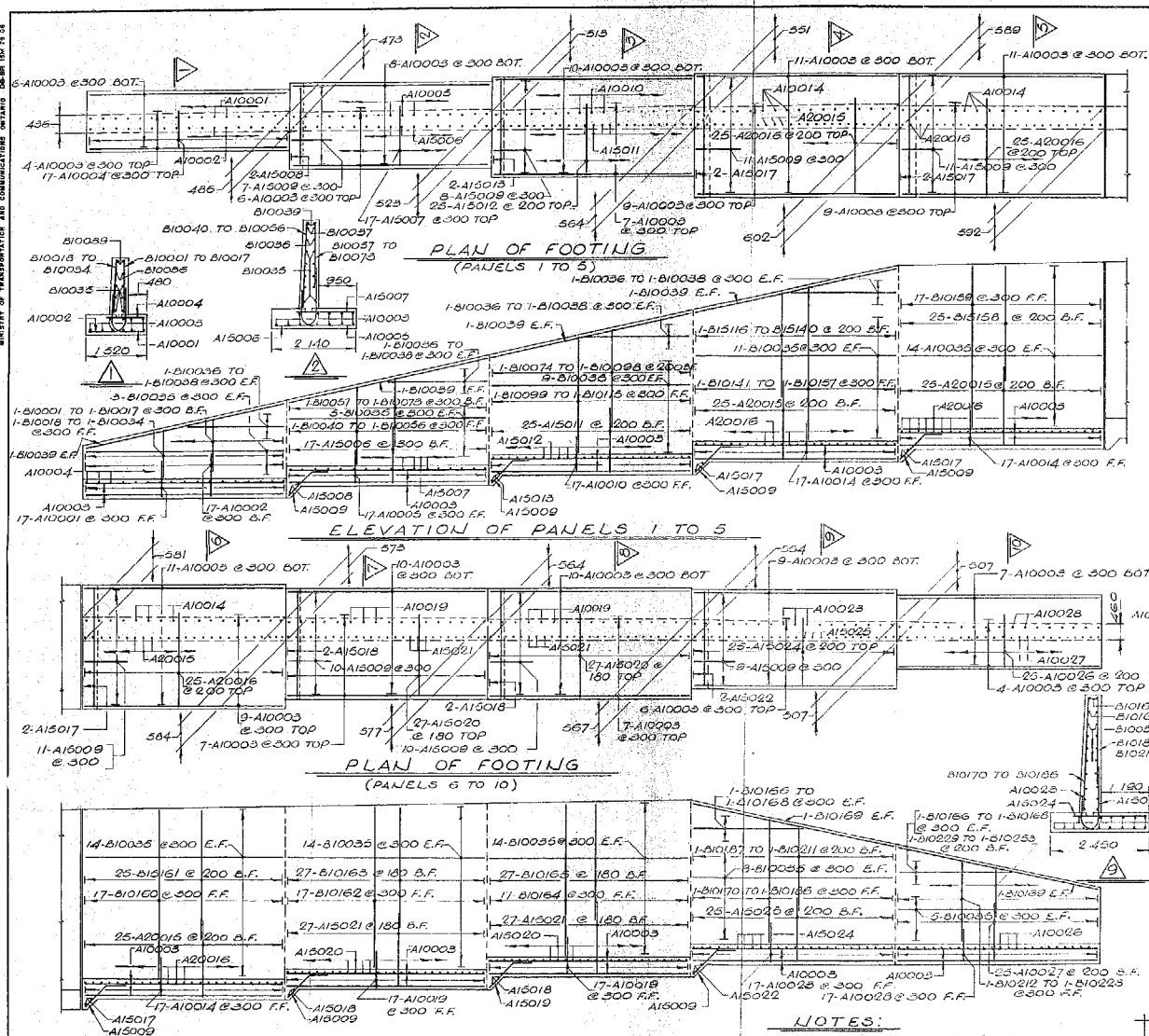
**METRIC**

CONT No  
WP No 110-72-01

50.7m RETAINING WALL  
Hwy. 2, Oshawa to Bowmanville  
DETAILS

**SHEET**

DIMENSIONS ARE IN MILLIMETRES  
UNLESS OTHERWISE SHOWN.  
ELEVATIONS, COORDINATES, CURVE  
AND ALIGNMENT DATA ARE IN METRES.  
STATIONS ARE IN KILOMETRES + METRES



NOTES:

F.F. DENOTES FRONT FACE  
B.F. DENOTES BACK FACE  
E.F. DENOTES EACH FACE

SCALE 1:50

the value of  $\lambda$  is used as a measure of  $\rho(\mathbf{X})$ .  $\rho(\mathbf{X})$  is

DRAWING NOT TO BE SCALED  
100 = 1" ON ORIGINAL DRAWING

REVISIONS			
	DATE	BY	DESCRIPTION
	DESIGN <i>STD</i>	CHECK <i>HKJ</i>	LOADING <i>0.5 DC-29</i> DATE <i>Aug 16</i>
	DRAWING <i>AS</i>	CHECK <i>HKJ</i>	SIZE <i>NO 21-2W</i> DWG <i>3</i>