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DIST. 4 REGION                     

W.P. No. 289-93-01

CONT. No. 95-39

W. O. No.                     

STR. SITE No. 18-146

HWY. No. 20

LOCATION  Hwy 20 & 20 Mi Creek  
 Bridge Replacement

No of PAGES -                     

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

# **FOUNDATION INVESTIGATION REPORT**

**CONTRACT NO. 95-39**



**Ontario**

**Ministry of  
Transportation**

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

# EXPLANATION OF TERMS USED IN REPORT

2

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 300mm OF UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 762mm. 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: N

**DYNAMIC CONE PENETRATION TEST:** DYNAMIC PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 1" SIZE OR L. ROCKS. 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	F.H. F.W. ADVANCED HYDRAULICALLY
C.S. CHUNK SAMPLE	F.M. F.W. ADVANCED MANUALLY
T.W. THINWALL OPEN	F.S. FOIL SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$U$		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
$\mu$		COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$		COMPRESSION INDEX
$C_s$		SWELLING INDEX
$C_\alpha$		RATE OF SECONDARY CONSOLIDATION
$C_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$		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
$S_t$		SENSITIVITY = $\frac{c_u}{c'_u}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$e$	1.0	VOID RATIO	$e_{min}$	1.0	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$n$	1.0	POROSITY	$I_D$		DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$w$	1.0	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	$C_u$		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 = $\frac{w_L - w_p}{I_p}$	$v$	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$LI$		LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$i$		HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$CI$		CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1.0	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**  
**Hwy. 20/20 Mile Creek Bridge Replacement**  
**W.P. 289-93-01, Site 18-146**  
**District 4, Burlington**

**INTRODUCTION**

This report summarizes the results of a foundation investigation conducted in conjunction with the proposed bridge replacement at the Hwy. 20 - Twenty Mile Creek crossing. The new structure will replace the existing structure along the same Hwy. 20 alignment. To facilitate the bridge replacement, two standard wide bailey bridges, one in each direction, will be constructed 20 m south of the centreline of the existing structure.

**SITE DESCRIPTION AND GEOLOGY**

The site is located at the existing Hwy. 20 - Twenty Mile Creek crossing approximately 0.5 km east of Regional Road 69 near St. Anns in the Township of West Lincoln, Regional Municipality of Niagara. The existing concrete structure, which has undergone some recent concrete rehabilitation is a two(2) span structure that supports concrete railings on both sides, a concrete sidewalk on the north side and two 3.75 m asphaltic roadways.

The Twenty Mile Creek is approximately 25 metres in width and 1 to 2 metres in depth at the site location. At the time of the investigation, the water level was less than 0.5 metre in depth. Bedrock is exposed at the bed of the creek.

The land surrounding the site is generally flat and consists of agricultural farmland or forest. Tall grass exists adjacent to the creek adjacent to the structure and tall deciduous trees are present at the creek banks further upstream and downstream of the structure. Farm houses are also present within the general vicinity of the site.

Approach embankments to the bridge and drainage ditches provide some surface relief at the site. The approach embankments are up to approximately 4 metres in height with 2H:1V slopes and the drainage ditches comprise the highway drainage scheme to the Twenty Mile Creek.

Physiographically, the site is located within the geological domain known as the Haldimand Clay Plain lying between the Niagara Escarpment and Lake Erie. The Haldimand Clay Plain is the product of glacial Lake Warren that existed subsequent to the Wisconsinian glacier that covered the area approximately 12,000 years ago. The overburden, which is generally less than a metre or so at the site location consists primarily of a deposit consisting of an unsorted, unstratified mixture of clayey silt, sand and gravel of glacial till origin. The overburden is underlain by dolostone bedrock of the Lockport Formation.

The clay plain also contains many wet sloughs which is an indication of poor drainage. In general, drainage is controlled by modest ridges formed by moraines deposited under water. Drainage occurs in an eastward direction in several parallel streams including Twenty Mile Creek, Forty Mile Creek and the Welland River.

## **INVESTIGATION PROCEDURE**

### **General**

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

### **Field Investigation**

The fieldwork for this project was conducted on 93 08 23 and 93 08 24 and consisted of a total of eight(8) sampled boreholes. The boreholes were advanced to depths ranging from 1.3 m to 6.1 m using conventional track mounted Central Mining Equipment (CME) 55 drilling units. Solid stem augering techniques were used to penetrate the overburden at the site.

Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT - ASTM D1586). The samples were generally retrieved at 0.76 m intervals.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Bedrock at the site was cored for depths ranging from 1.5 m to 3.2 m using conventional rock coring techniques. A NXL core barrel within NW Casing was used in the coring process.

Rock core samples were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Central Region Surveys and Plans.



### Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation, and natural moisture contents of soil were determined by conducting the appropriate laboratory tests on representative samples. Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

## SUBSURFACE CONDITIONS

### General

The subsurface conditions at the site are generally uniform and consists of some fill material comprised of an irregular mixture of silty clay, sand and gravel of thickness

ranging up to 4.6 metres underlain by dolostone bedrock. The fill material was placed for the construction of the approach embankments to the structure. Beyond the fill material, a native heterogeneous mixture of clayey silt, sand and gravel of glacial till origin exists surficially and is underlain by bedrock. The thickness of this natural deposit ranges from 1.3 m to 1.5 m.

A plan of the site illustrating the locations and elevations of the individual boreholes and the proposed replacement structure and bailey bridge is shown on Dwg. 2899301-A\* in the Appendix. Stratigraphical sections along the proposed replacement structure and the bailey bridge detour are also shown. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical sections and also on the individual Record of Borehole sheets in the Appendix. A detailed description of the subsurface conditions are given below.

#### SOIL/ ROCK DESCRIPTIONS

##### *Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)*

An irregular mixture of silty clay, sand and gravel comprises the fill material used in the construction of the approach embankments to the existing structure. The thickness of the fill material ranges up to 4.6 m. The fill material is generally brown or grey in colour.

Figure 1 in the Appendix illustrates grain size distribution curves of the fill material

\* Dwg. No 2, ( Sheet 29-1 ) of the Contract Drawings.

produced by mechanical sieve and hydrometer analysis. As the curves exhibit, traces of gravel and some sand is mixed with clay and silt fractions. The clay and silt fractions comprise greater than 90% of the material, and in accordance with the MTO soil classification system, the material is categorized according to its behaviour. To determine the behaviour of the material, Atterberg Limit tests were carried out on material less than  $425\ \mu\text{m}$  and the results are plotted on Figure 2. As Figure 2 illustrates, liquid limits ( $w_L\%$ ) range between 40% and 45% and the plasticity index is 20%. The test results reveal that the fine grained material has an intermediate plasticity and hence can be categorized as silty clay (CI). Natural moisture contents are within the liquid limit and plastic limit of the soil.

The consistency of the soil was determined by interpretation of the 'N' values derived from the Standard Penetration test. Based on 'N' values ranging from 4 blows/ 0.3 m to 16 blows/ 0.3 m the soil can be described as having a consistency of firm to very stiff.

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

Beyond the fill material, a native unsorted, unstratified deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel occurs surficially and is underlain directly by bedrock. This deposit of glacial till origin is brown in colour and of thickness of 1.3 m to 1.5 metres. Although not encountered during the investigation, boulders and cobbles are characteristic components of glacial till deposits and hence can exist. Figure 3 in the Appendix illustrates a typical grain size distribution curve of the deposit. As the

curve illustrates, grain sizes are predominantly fine grained and less than 75 micrometres.

In accordance with the MTO soil classification system, soil with more than 50% finer than 75 micrometres is categorized by its behaviour. The results of Atterberg Limit tests carried out to define the behaviour of the fine grain portion of the deposit (material less than 425 micrometres) are illustrated in Figure 4 in the Appendix. The test results reveal that the fine grained portion is of low plasticity and hence can be classified as a clayey silt. This clayey silt material essentially binds the coarse grained sand and gravel sizes into a soil matrix.

The consistency of the deposit is based on the interpretation of 'N' values derived from the Standard Penetration test. Based on 'N' values ranging from 6 blows/ 0.3 m to 22 blows/ 0.28 m, the deposit can be considered as having a firm to very stiff consistency.

### Bedrock

Bedrock at the site consists of dolostone of the Lockport Formation. The bedrock surface is flat and uniform across the site ranging in elevation from 176.9 m to 177.5 m. Bedrock is overlain by overburden as described above but is also visually exposed within the creek bed.

In general, the bituminous dolostone is medium light to dark grey in colour and contains extremely close to very close spaced fractures and very thin horizontal beds. The rock

is primarily fine grained and also contains random vugs up to 5 cm in diameter. The rock is moderately weathered up to approximately 0.7 m below the bedrock surface at some locations but otherwise the bedrock is generally unweathered. The rock strength ranges from weak to medium strong depending on the extent of weathering. Detailed rock core descriptions are included in the Appendix to the report.

An assessment of the quality and strength of the rock was carried out by measuring core recovery and Rock Quality Designations (RQD's) in the field and conducting physical index property tests. RQD's were generally low ranging from 0% to 56% indicating a very poor to poor quality rock. The very poor quality is indicative of the extent of the weathering of the surficial rock. Although, the rock competence improves with depth, the rock quality is still generally poor.

#### GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes. Groundwater levels ranged from 0 m to 4.5 m below the ground surface (Elevation 177.8 m to 177.3 m) and generally existed at the bedrock surface.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and N. Mullen, Student Engineer utilizing equipment owned and operated by Malone's Soil Samples. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

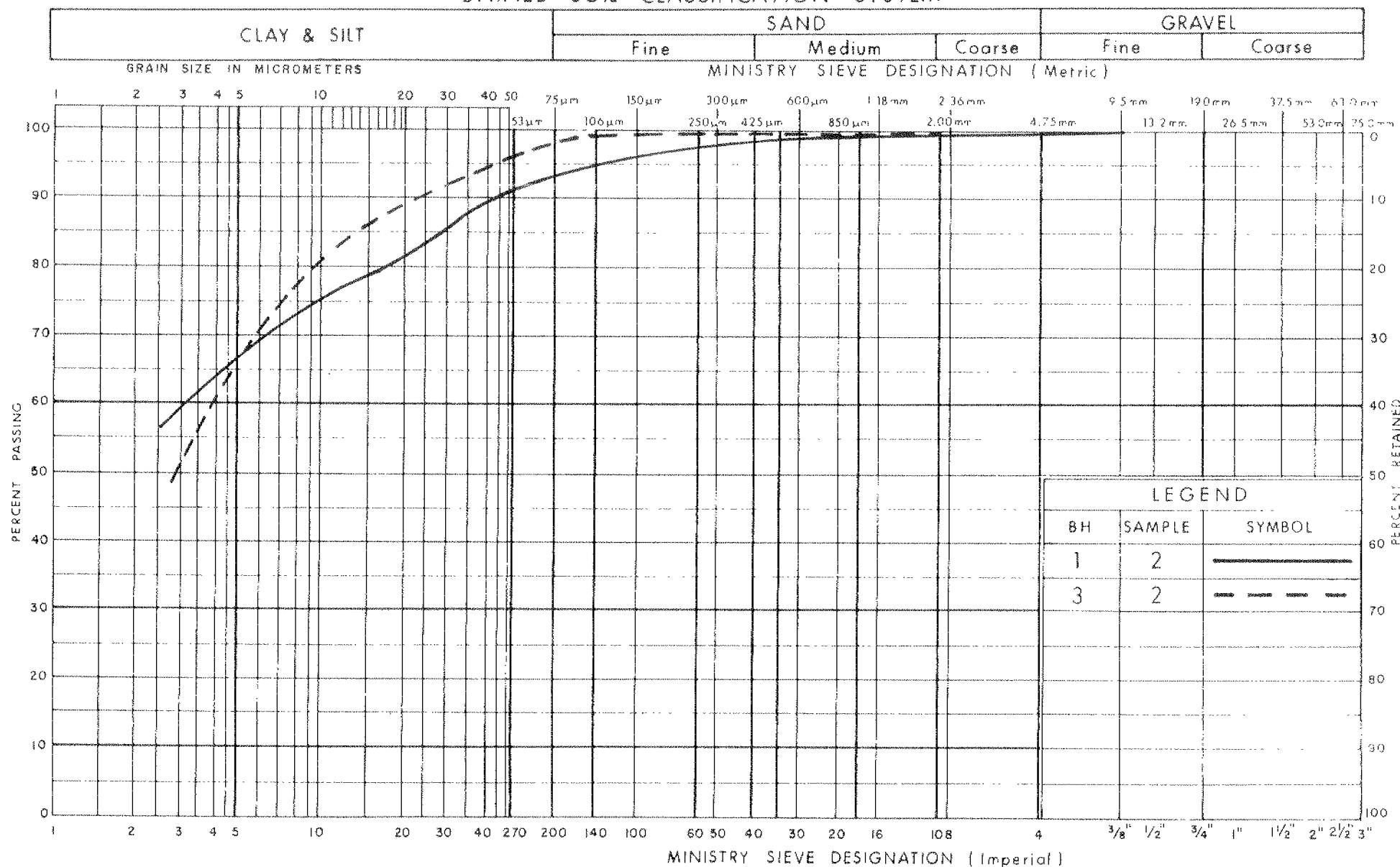
The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



*D. Dundas*  
D. Dundas, P. Eng.  
Senior Foundation Engineer

## APPENDIX

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

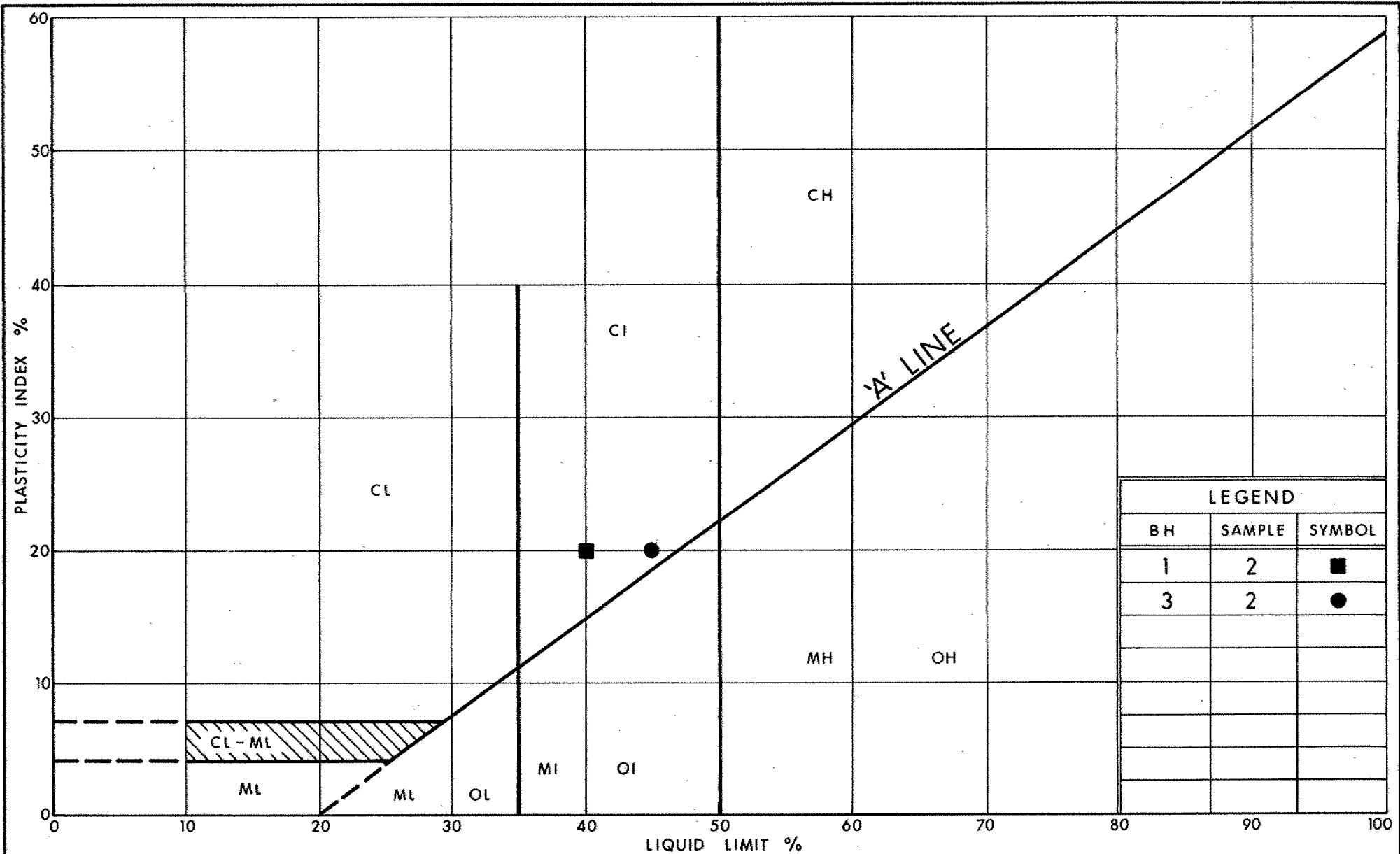
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Transportation

GRAIN SIZE DISTRIBUTION  
IRREGULAR MIXTURE OF  
SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)

FIG No 1

W P 289-93-01





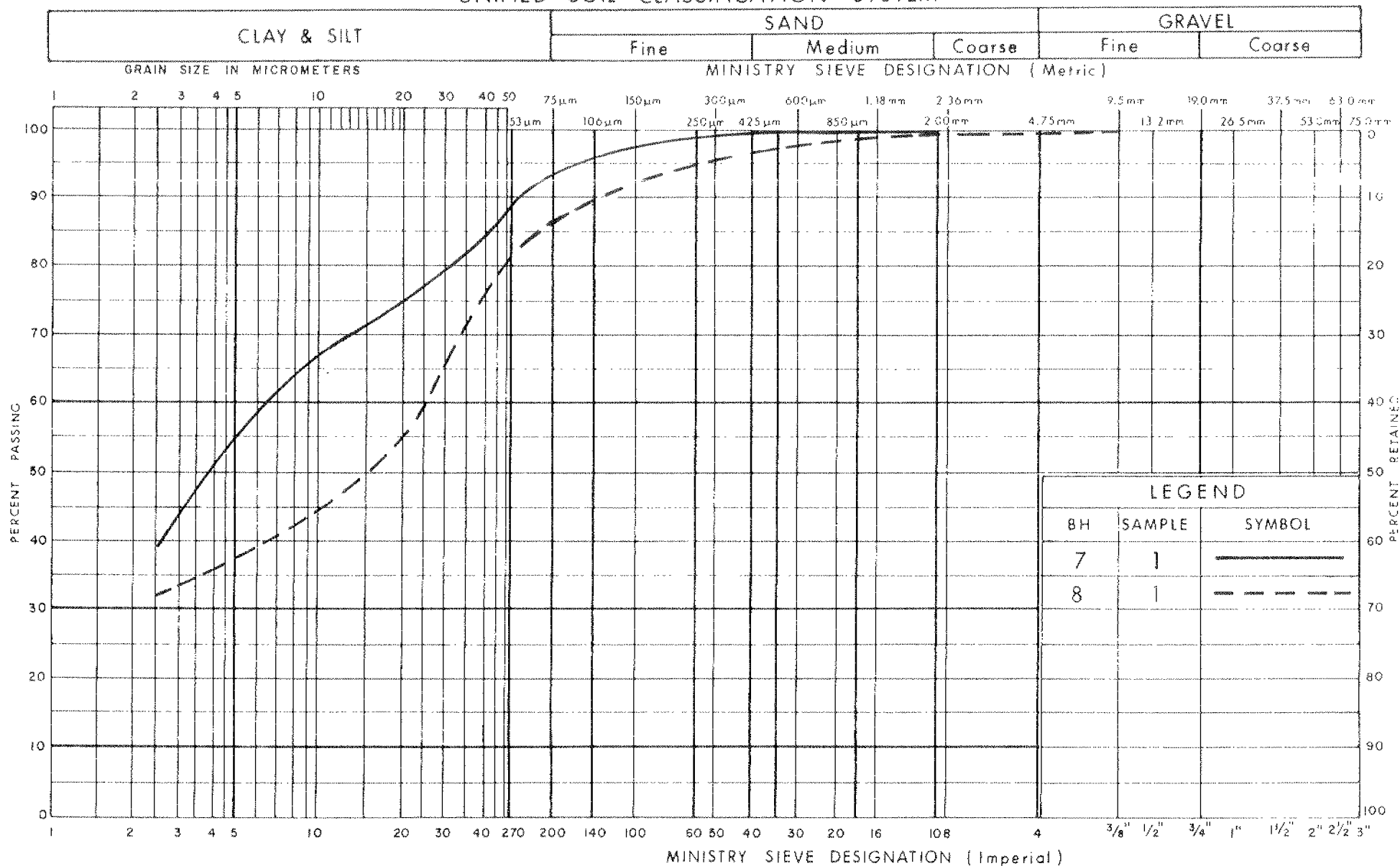
Ministry of  
Transportation  
Ontario

PLASTICITY CHART  
IRREGULAR MIXTURE OF  
SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)

FIG No 2

W P 289-93-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

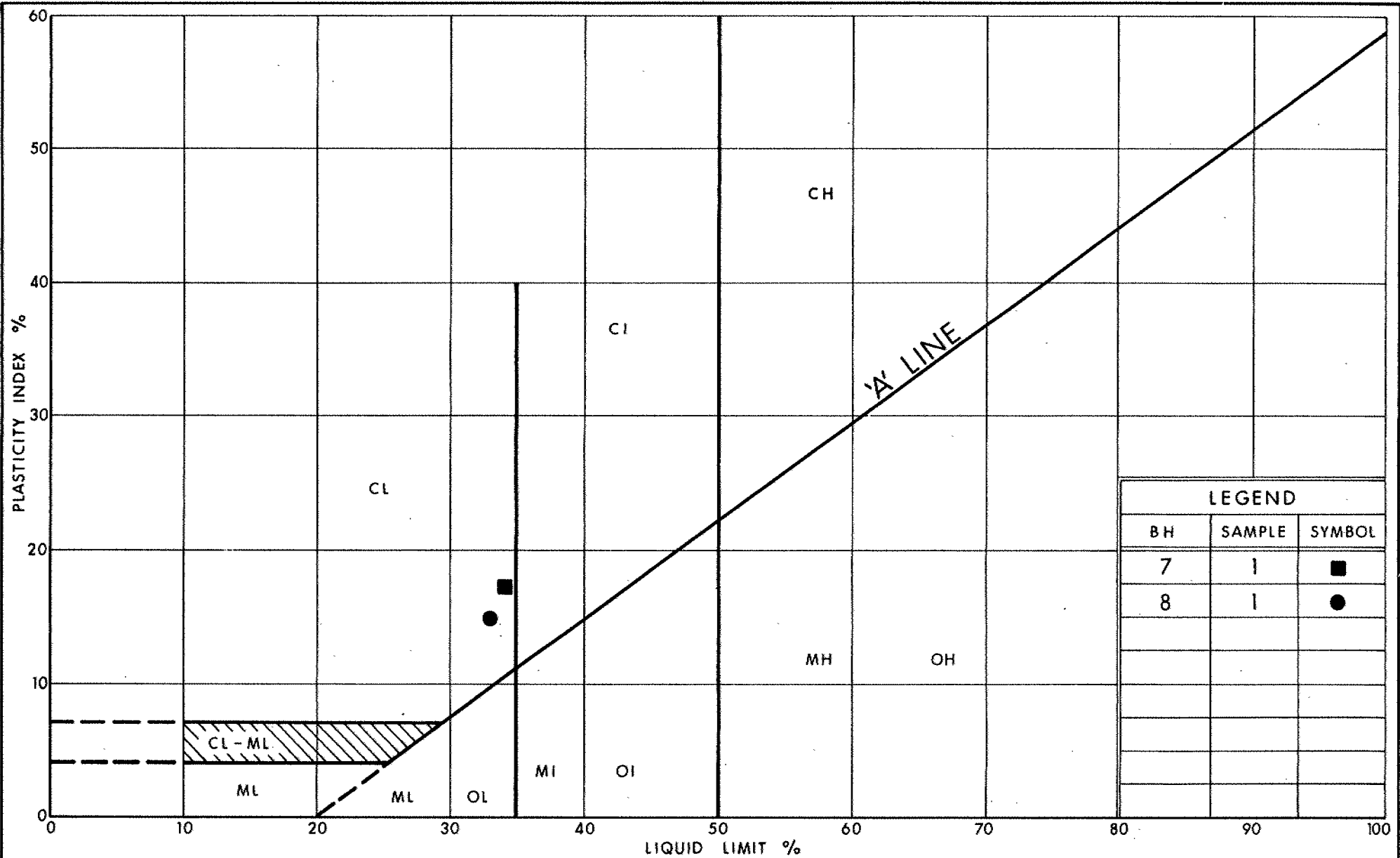
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Transportation

# GRAIN SIZE DISTRIBUTION

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

FIG No 3

W P 289-93-01



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Transportation  
Ontario

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

FIG No 4

W P 289 - 93 - 01

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+713.5 o/s 4.5m Lt. C/L Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
DATUM Geodetic DATE 93 08 23 CHECKED BY TS/E2

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					
181.8	Ground Surface															
0.0	Irregular Mixture of Silty Clay, Sand and Gravel  (Fill Material) Firm to Stiff		1	SS	9	180										
	Brown Grey		2	SS	4	178										0 7 40 53
177.2																
4.6	Weathered Dolostone Bedrock Unweathered Medium Grey		3	RC	REC 100%	176										ROD - OK
175.7	Weak to Medium Strong															
6.1	End of Borehole = 93 08 23															

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+730.0, o/s 6.0m Lt C/L Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
DATUM Geodetic DATE 93 08 23 CHECKED BY TS/PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
177.7	Ground Surface															
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)															
177.2	Brown, Firm															
0.5	Weathered ----- Unweathered		1	RC	REC											RQD = 0%
	Dolostone Bedrock				100%											
	Medium Grey		2	RC	REC	176										RQD = 42%
	Weak to Medium Strong				100%											
174.2	End of Borehole															
3.5	* 93 08 23															

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+747.0, o/s 5.0m Lt C/I Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
DATUM Geodetic DATE 93 08 23 CHECKED BY TS/PE

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					
181.7	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material) Brown, Firm to Very Stiff		1	SS	16	*	180										0 1 62 37
			2	SS	6												
177.5							178										
4.2	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		3	RC	REC 100%												RQD = 0%
176.0																	
5.7	End of Borehole v 93 08 23 (GWL not established)																

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+742.0, a/s 7.5m Rt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.1	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)																
178.9	Brown, Firm																
1.2	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		1	RC	REC 92%		176										RQD = 0%
			2	RC	REC 100%												RQD = 26%
173.7							174										
4.4	End of Borehole + 93 08 24																

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+719.0, g/s 7.5m Rt. C/L Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXI Core COMPILED BY NM  
DATUM Geodetic DATE 93 08 23 CHECKED BY TS/P

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					
177.8	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)																
177.2	Brown, Firm																
0.6	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		1	RC	REC 100%		176										ROD - 0%
			2	RC	REC 100%												ROD - 0%
174.1																	
3.7	End of Borehole * 93 08 23																



RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+720.0, o/s 15.0m Rt C/L Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger COMPILED BY NM  
DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.4	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)					DRY *	178										
177.1	Brown, Firm		1	SS	7												
1.3	End of Borehole Refusal (Probable Bedrock) • 93 08 24																

# RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Stc 28+714.0, a/s 22.0m Rt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 24 CHECKED BY TS/E

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					
178.5	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, firm		1	SS	6		178										0 5 5 35
177.0																	
1.5	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		2	RC	REC 100%		176										RQD = 91%
			3	RC	REC 98%												RQD = 51%
173.9							174										
4.6	End of Borehole + 93 08 24																

# RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+750.0, o/s 24.0m Rt C/L Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
178.6	Ground Surface															
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, Very Stiff		1	SS	22	178										0 13 52 35
177.1																
1.5	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		2	RC	REC 97%	176										RQD = 8%
			3	RC	REC 62%											RQD = 20%
174.0																
4.6	End of Borehole = 93 08 24 (GWL not established)															

# ROCK CORE DESCRIPTION WP 289-93-01

Page 1 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	3	4.57-6.10	100	0	4.57-6.10	DOLOSTONE (bituminous, with shaly partings, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 4.57-5.31 m); fractures extremely close to close spaced, flat to near vertical, undulating to planar, smooth to rough.
2	1	0.46-1.98	100	0	0.46-3.51	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 0.46-0.91 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	2	1.98-3.51	100	42		
3	3	4.19-5.72	100	0	4.19-5.72	DOLOSTONE (bituminous, with shaly partings, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
4	1	1.19-2.74	92	0	1.19-4.42	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 2 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 1.19-1.32 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	2	2.74-4.42	100	26		

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%  
Logged by: DAW, Soils and Aggregates Section

# **ROCK CORE DESCRIPTION** **WP 289-93-01**

Page 2 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
5	1	0.61-2.13	100	8	0.61-3.66	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 0.61-0.71 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	2	2.13-3.66	100	40		
7	2	1.52-3.05	100	9	1.52-4.57	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	3	3.05-4.57	96	56		
8	2	1.52-3.05	97	8	1.52-4.57	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium-light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	3	3.05-4.57	62	20		

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%  
Logged by: DAW, Soils and Aggregates Section



# FOUNDATION DESIGN SECTION

## foundation investigation and design report

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

*CONT 95-39*

WP 289-93-01

DIST 4

HWY 20

STR SITE 18-146

Hwy.20/20 Mile Creek Bridge Replacement

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# **FOUNDATION INVESTIGATION REPORT**

## **FOR**

### **Hwy. 20/20 Mile Creek Bridge Replacement**

**W.P. 289-93-01, Site 18-146**

**District 4, Burlington**

#### **INTRODUCTION**

This report summarizes the results of a foundation investigation conducted in conjunction with the proposed bridge replacement at the Hwy. 20 - Twenty Mile Creek crossing. The new structure will replace the existing structure along the same Hwy. 20 alignment. To facilitate the bridge replacement, two standard wide bailey bridges, one in each direction, will be constructed 20 m south of the centreline of the existing structure.

#### **SITE DESCRIPTION AND GEOLOGY**

The site is located at the existing Hwy. 20 - Twenty Mile Creek crossing approximately 0.5 km east of Regional Road 69 near St. Anns in the Township of West Lincoln, Regional Municipality of Niagara. The existing concrete structure, which has undergone some recent concrete rehabilitation is a two(2) span structure that supports concrete railings on both sides, a concrete sidewalk on the north side and two 3.75 m asphaltic roadways.



The Twenty Mile Creek is approximately 25 metres in width and 1 to 2 metres in depth at the site location. At the time of the investigation, the water level was less than 0.5 metre in depth. Bedrock is exposed at the bed of the creek.

The land surrounding the site is generally flat and consists of agricultural farmland or forest. Tall grass exists adjacent to the creek adjacent to the structure and tall deciduous trees are present at the creek banks further upstream and downstream of the structure. Farm houses are also present within the general vicinity of the site.

Approach embankments to the bridge and drainage ditches provide some surface relief at the site. The approach embankments are up to approximately 4 metres in height with 2H:1V slopes and the drainage ditches comprise the highway drainage scheme to the Twenty Mile Creek.

Physiographically, the site is located within the geological domain known as the Haldimand Clay Plain lying between the Niagara Escarpment and Lake Erie. The Haldimand Clay Plain is the product of glacial Lake Warren that existed subsequent to the Wisconsinian glacier that covered the area approximately 12,000 years ago. The overburden, which is generally less than a metre or so at the site location consists primarily of a deposit consisting of an unsorted, unstratified mixture of clayey silt, sand and gravel of glacial till origin. The overburden is underlain by dolostone bedrock of the Lockport Formation.

The clay plain also contains many wet sloughs which is an indication of poor drainage. In general, drainage is controlled by modest ridges formed by moraines deposited under water. Drainage occurs in an eastward direction in several parallel streams including Twenty Mile Creek, Forty Mile Creek and the Welland River.

## **INVESTIGATION PROCEDURE**

### **General**

Soil and rock data and inherent properties were obtained by conducting both an in situ field investigation and laboratory analyses. Details of the field investigation and laboratory testing program are discussed below.

### **Field Investigation**

The fieldwork for this project was conducted on 93 08 23 and 93 08 24 and consisted of a total of eight(8) sampled boreholes. The boreholes were advanced to depths ranging from 1.3 m to 6.1 m using conventional track mounted Central Mining Equipment (CME) 55 drilling units. Solid stem augering techniques were used to penetrate the overburden at the site.

Disturbed subsoil samples were retrieved in the overburden using a 50 mm diameter split spoon sampler driven in accordance with the Standard Penetration Test (SPT - ASTM D1586). The samples were generally retrieved at 0.76 m intervals.

All subsoil samples were identified in the field and then properly sealed in plastic containers to preserve natural moisture contents in the soil. The samples were then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests were conducted as described in the next section below.

Bedrock at the site was cored for depths ranging from 1.5 m to 3.2 m using conventional rock coring techniques. A NXL core barrel within NW Casing was used in the coring process.

Rock core samples were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and rock core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Central Region Surveys and Plans.

### Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation, and natural moisture contents of soil were determined by conducting the appropriate laboratory tests on representative samples. Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist. The core logging included descriptions of colour, grain size, bedding, jointing and strength.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

## **SUBSURFACE CONDITIONS**

### General

The subsurface conditions at the site are generally uniform and consists of some fill material comprised of an irregular mixture of silty clay, sand and gravel of thickness

ranging up to 4.6 metres underlain by dolostone bedrock. The fill material was placed for the construction of the approach embankments to the structure. Beyond the fill material, a native heterogeneous mixture of clayey silt, sand and gravel of glacial till origin exists surficially and is underlain by bedrock. The thickness of this natural deposit ranges from 1.3 m to 1.5 m.

A plan of the site illustrating the locations and elevations of the individual boreholes and the proposed replacement structure and bailey bridge is shown on Dwg. 2899301-A in the Appendix. Stratigraphical sections along the proposed replacement structure and the bailey bridge detour are also shown. The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical sections and also on the individual Record of Borehole sheets in the Appendix. A detailed description of the subsurface conditions are given below.

### SOIL/ ROCK DESCRIPTIONS

#### *Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)*

An irregular mixture of silty clay, sand and gravel comprises the fill material used in the construction of the approach embankments to the existing structure. The thickness of the fill material ranges up to 4.6 m. The fill material is generally brown or grey in colour.

Figure 1 in the Appendix illustrates grain size distribution curves of the fill material

produced by mechanical sieve and hydrometer analysis. As the curves exhibit, traces of gravel and some sand is mixed with clay and silt fractions. The clay and silt fractions comprise greater than 90% of the material, and in accordance with the MTO soil classification system, the material is categorized according to its behaviour. To determine the behaviour of the material, Atterberg Limit tests were carried out on material less than  $425\ \mu\text{m}$  and the results are plotted on Figure 2. As Figure 2 illustrates, liquid limits ( $w_L\%$ ) range between 40% and 45% and the plasticity index is 20%. The test results reveal that the fine grained material has an intermediate plasticity and hence can be categorized as silty clay (CI). Natural moisture contents are within the liquid limit and plastic limit of the soil.

The consistency of the soil was determined by interpretation of the 'N' values derived from the Standard Penetration test. Based on 'N' values ranging from 4 blows/ 0.3 m to 16 blows/ 0.3 m the soil can be described as having a consistency of firm to very stiff.

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

Beyond the fill material, a native unsorted, unstratified deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel occurs surficially and is underlain directly by bedrock. This deposit of glacial till origin is brown in colour and of thickness of 1.3 m to 1.5 metres. Although not encountered during the investigation, boulders and cobbles are characteristic components of glacial till deposits and hence can exist. Figure 3 in the Appendix illustrates a typical grain size distribution curve of the deposit. As the

curve illustrates, grain sizes are predominantly fine grained and less than 75 micrometres.

In accordance with the MTO soil classification system, soil with more than 50% finer than 75 micrometres is categorized by its behaviour. The results of Atterberg Limit tests carried out to define the behaviour of the fine grain portion of the deposit (material less than 425 micrometres) are illustrated in Figure 4 in the Appendix. The test results reveal that the fine grained portion is of low plasticity and hence can be classified as a clayey silt. This clayey silt material essentially binds the coarse grained sand and gravel sizes into a soil matrix.

The consistency of the deposit is based on the interpretation of 'N' values derived from the Standard Penetration test. Based on 'N' values ranging from 6 blows/ 0.3 m to 22 blows/ 0.28 m, the deposit can be considered as having a firm to very stiff consistency.

### **Bedrock**

Bedrock at the site consists of dolostone of the Lockport Formation. The bedrock surface is flat and uniform across the site ranging in elevation from 176.9 m to 177.5 m. Bedrock is overlain by overburden as described above but is also visually exposed within the creek bed.

In general, the bituminous dolostone is medium light to dark grey in colour and contains extremely close to very close spaced fractures and very thin horizontal beds. The rock

is primarily fine grained and also contains random vugs up to 5 cm in diameter. The rock is moderately weathered up to approximately 0.7 m below the bedrock surface at some locations but otherwise the bedrock is generally unweathered. The rock strength ranges from weak to medium strong depending on the extent of weathering. Detailed rock core descriptions are included in the Appendix to the report.

An assessment of the quality and strength of the rock was carried out by measuring core recovery and Rock Quality Designations (RQD's) in the field and conducting physical index property tests. RQD's were generally low ranging from 0% to 56% indicating a very poor to poor quality rock. The very poor quality is indicative of the extent of the weathering of the surficial rock. Although, the rock competence improves with depth, the rock quality is still generally poor.

### GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes. Groundwater levels ranged from 0 m to 4.5 m below the ground surface (Elevation 177.8 m to 177.3 m) and generally existed at the bedrock surface.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.



**DISCUSSION AND RECOMMENDATIONS**

It is proposed to replace the existing reinforced concrete structure at the Hwy. 20/ Twenty Mile Creek crossing with a new structure. The existing structure consists of a 2 lane, 2 span T-beam bridge, approximately 11.5 m wide and 30.5 m long. The new structure is to be located along the same alignment as the existing structure with a minimum bridge span of 30 metres and a maximum bridge span of 36 metres. At the time of the foundation request, the span geometry and structure type had not been finalized. It is known, however, that the new structure will consist of two 3.75 m lanes. The recommendations provided in this report, however, are sufficient to cover any foundation scheme within the maximum bridge span limits identified and illustrated on Dwg. 2899301-A.

To facilitate the demolition and removal of the existing structure and construction of the replacement structure, a temporary detour has been planned to divert the Hwy. 20 traffic. The temporary detour is to be located twenty(20) metres south of the existing structure as shown on Dwg. 2899301-A. Two standard-wide bailey bridges, one in each direction will span the creek upstream of the replacement structure.

The existing profile grade at the structure location is approximately 182 m and it is expected that the new profile grade is to be similar. It is expected that the profile grade at the bailey bridge location will also be similar.

Recommendations regarding the design and construction of the proposed replacement structure foundations and the temporary bailey bridge foundations are included in this report. Related earth/rock works are also included in this report. Specific recommendations include:

- 1) Structure Foundations
- 2) Backfill to Structure
- 3) Approach Embankments
- 4) Construction Considerations

1) Structure Foundations

General

The existing structure is supported on spread footings founded on bedrock. In view of the presence of the bedrock at or near the ground surface, conventional spread footings can be used to support the replacement bridge foundations and also the temporary bailey bridge footings. Detailed recommendations regarding the various spread footing options are given below. The most economical and technically feasible alternative that satisfies all design, construction, environmental and any other requirements shall be chosen.

Replacement Bridge

Spread Footings on Bedrock

All structure foundations can be founded directly on the sound, unweathered dolostone bedrock at or below the elevations given in Table 1 below. Foundation bearing capacities are also given in Table 1.

<b>Table 1 - Spread Footings on Bedrock</b>			
<b>Structure</b>	<b>Founding Elevation (m)</b>	<b>Factored Capacity at U.L.S. (kPa)</b>	<b>Bearing Capacity at S.L.S. Type II (kPa)</b>
West Abutment	177.2	1500	N/A
Pier	177.3	1500	N/A
East Abutment	176.9	1500	N/A

As indicated in Table 1 above, only the factored capacity at U.L.S. governs the design because of the unyielding nature of the bedrock. Stresses required to induce detrimental settlements at the Serviceability Limit State would exceed the factored capacity of U.L.S.

The capacities tabulated in Table 1 pertain to vertical normal loads only. Reductions of bearing capacities to account for inclined loadings shall conform to factors provided in Section 6-7.3.3.5 of the O.H.B.D.C.

The sliding resistance of the spread footings founded on the bedrock surface can be computed by employed an unfactored angle of friction of 30° between the concrete footing and the bedrock surface. Should additional horizontal resistance to sliding be

required, shear keys or dowels can be incorporated. An unconfined compressive strength of 100 MPa and a bond stress of 100 kPa (between cement grout and bedrock) at U.L.S. are relevant shear key/ dowel design parameters within the dolostone bedrock. The lateral resistance of shallow foundations shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C.

It is prudent that the footing base be protected against weathering during construction. To preserve the integrity of the bedrock surface during construction, it is recommended that a 100 mm thick lean mix concrete coating be placed on the footing bedrock surface within four(4) hours of exposure. Any previously weathered or loosened rock shall be removed prior to the placement of the concrete coating.

The construction procedure of the footings within and adjacent to Twenty Mile Creek including the dewatering method will be discussed later in this report under the subheading "Construction Considerations".

### Temporary Bailey Bridge

#### General

The temporary bailey bridge can be supported on a steel/timber crib founded on bedrock, a Granular 'A' pad or a rockfill pad as discussed below. The most economical and technically feasible alternative shall be selected. At the bailey bridge foundation locations, up to approximately 1.5 metres of the native heterogeneous mixture of clayey

silt, sand and gravel overlies the bedrock. It is recommended that this overburden be excavated and the temporary foundation be founded directly on the bedrock surface at Elevation 177.0 m.

The temporary bailey bridge foundation must be coordinated to avoid damage or interference with the Bell underground cable at the site. Any additional loading on the line must be considered.

*Option 1 - Crib Directly on Bedrock*

The temporary bailey bridge can be supported on a steel/timber crib founded on the bedrock surface at Elevation 177.0 m. All previous recommendations pertaining to the design of spread footings on the bedrock surface for the replacement structure are equally applicable for the crib design.

*Option 2 - Compacted Granular 'A' Pad*

The Bailey Bridge foundations can be founded on a compacted Granular 'A' pad bearing on the dolostone bedrock surface. The granular pad shall be constructed according to the geometry shown in Figure 5 in the Appendix. As illustrated, the Granular 'A' pad shall be constructed to a minimum 1 m edge distance from the top of the footing to the crest of the pad and with 1H:1V slopes. The granular pad shall have a minimum thickness of 1.5 m and the footings must have a minimum 1.2 m earth cover. For purposes of the O.H.B.D.C., the Granular 'A' pad as described above will provide the following bearing

O.H.B.D.C., the Granular 'A' pad as described above will provide the following bearing capacities.

<u>Table 2 - Perched Abutment on Granular 'A' Pad</u>	
Factored Capacity at U.L.S.	900 kPa
Bearing Capacity at S.L.S. Type II	350 kPa

Settlement of the foundation granular pad as a result of the applied footing pressure will be elastic in nature and consequently is expected to take place during or immediately following the construction period. The magnitude of this settlement is anticipated to be within 25 mm, provided the granular material is not loosened by construction or related activities.

The Granular 'A' material must be placed and compacted to achieve 100% of the Proctor maximum dry density as outlined in OPSS 501.08.02 (Method A). Quality control in the form of material inspection and field density measurements shall be conducted. The base for the Granular 'A' pad shall be free of any fill material.

Reduction for inclination of loading on the shallow foundation shall be carried out in accordance with Section 6.7.3.3.5 of the O.H.B.D.C.

accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of  $35^\circ$  can be used between concrete footing and the Granular 'A' material.

To preserve the slopes from scouring caused by the flowing waters of Twenty Mile Creek, it is recommended that the slopes adjacent to the creek be protected using a 300 mm rip rap cover up to approximately 0.5 metre above the high water level. The rip rap shall be clean, hard material as specified in 1004.05.06.

#### Option 3 - Rockfill Pad

Alternatively, the proposed abutment structure foundations can also be founded on a rockfill pad consisting of a heterogeneous mixture of boulders, cobbles and gravel. The rockfill can be placed employing conventional methods which usually involves end dumping and spreading the material using standard dozer equipment. The rockfill pad shall be placed on the bedrock surface and constructed with 1.5H:1V slopes. It is recommended that the material size be limited to 300 mm within 1.2 m of the proposed footing pad elevation. A minimum edge distance of 1 m shall be incorporated from the top of the footing to the crest of the pad similar to the granular 'A' pad. All footings must be protected against frost penetration and consequently a 1.2 m earth cover or equivalent rock fill cover (rock fill protection = 0.5 times earth protection) is required.

For purposes of the O.H.B.D.C., the bearing capacities tabulated in Table 3 below can be used in the design of foundations supported on rockfill embankments.

<u>Table 3 - Perched Abutment on Rockfill Pad</u>	
Factored Capacity at U.L.S.	900 kPa
Bearing Capacity at S.L.S. Type II	250 kPa

Immediate settlement of the rockfill pad foundation as a result of the applied footing pressure can be expected during the construction period. The magnitude of this settlement is anticipated to be within 25 mm.

Long term settlements within the rockfill pad as a result of particle breakage induced by contact forces and also as a result of particle reorientation caused by sustained loading can also be expected. Based on instrumented data, it is estimated that settlements in the order of 1% times the rockfill pad height can occur. Unlike the Granular 'A' pad, however, these settlements will not be instantaneous in nature but rather time dependent. Routine maintenance may therefore be required to account for these displacements. Reduction for the inclination of loading on the shallow foundation shall be carried out in accordance with Section 6.7.3.3.5 of the O.H.B.D.C.



The computation of the sliding resistance of the foundation shall be computed in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. An unfactored friction angle of  $30^\circ$  can be used between the concrete footing and the rockfill material.

## 2) Backfill to Structure

### Material

It is recommended that Granular 'A' or Granular 'B' material be placed within a wedge behind the abutments bounded by a plane rising at  $60^\circ$  to the horizontal as shown in Figure 6.9.6.1 of the O.H.B.D.C. The application of granular material combined with weep holes in the abutment walls or pipe subdrains to drain any accumulation of water in the backfill will prevent hydrostatic pressure build-up.

Design parameters of the soil are given in Table 4 below. Computations of lateral earth pressure shall be in accordance with Section 6-6.1.2 of the O.H.B.D.C.

Table 4 - Backfill Properties		
	Granular 'A'	Granular 'B'
Angle of Internal Friction ( $\phi^\circ$ ) (factored)	$35^\circ$	$30^\circ$
Unit Weight ( $\text{kN/m}^3$ ), $\gamma$	22.8	21.2
*Coefficient of Active Earth Pressure ( $K_a$ )		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.41
*Coefficient of Earth Pressure at Rest ( $K_o$ )		
- S.L.S.	0.43	0.50
- U.L.S.	0.50	0.58

\*These earth pressure coefficients apply to horizontal backfill surfaces only.

The appropriate consideration shall be given to account for sloping backfill.

The coefficient of earth pressure at rest shall be applied for rigid and unyielding walls.

### Backfilling and Compaction

The backfill shall be placed in 300 mm lifts in accordance with OPSS 902 series and compacted to achieve the target maximum dry density as outlined in OPSS 501 series.

Heavy vibratory equipment should be avoided in the backfill construction adjacent to the structure. It is therefore recommended that hand compaction equipment be employed in backfilling behind the abutment within a lateral distance equal to the current height of fill above the wall footing, in order to minimize deflection or possible damage of the wall.

### 3) Approach Embankments

#### General

It is understood that the profile grade along Hwy. 20 will be at the same elevation or slightly higher than the existing grade. Therefore only shallow additional thicknesses of fill material, if any, will be placed on the existing fill material. Should widening of the existing embankment be planned, up to approximately 4 metres of fill material will be required.

It is anticipated that the profile grade of the detour will be similar to the existing profile grade. Consequently up to 4 metres of fill material will also be required for the detour embankment construction. The design of embankments such as those proposed at the site must satisfy two major criteria.

- 1) Stability
- 2) Settlement

These criteria are discussed below. In addition, embankment material and construction, which are prudent to the safe and reliable performances of embankments are also discussed.

#### Stability

##### Global

There are no deep seated global stability problems anticipated at the site for the proposed permanent or temporary embankment slopes constructed at 2H:1V in both the transverse and longitudinal directions.

##### Internal

To preserve the internal stability of the proposed embankments and to avoid surficial slope failures, the following guidelines shall be followed.

1. Earth fills up to eight(8) metres in height shall be constructed at 2H:1V slopes or flatter.
2. Embankment slopes adjacent to the Twenty Mile Creek shall be protected against scouring and erosive water forces. A revetment system consisting of a 0.3 metre thick rip rap or gabion stone material as outlined in OPSS 1004.05.06 is recommended. A 0.3 m Granular 'A' filter material between the rock protection and the base embankment material is also recommended. The revetment system should be placed up to 0.5 m above the high water level.
3. In the construction of new fills that must be integrated into existing fills, it is essential that the construction be done in accordance with OPSD 208.01. This drawing describes a procedure of "keying" the new fills into the existing embankment to prevent plane translational instabilities.

### Settlement

Settlements induced as a result of the placement of the embankment fill material are expected to be small in magnitude and less than 25 mm. These settlements are expected to be primarily the result of settlements caused by internal stress created by the self weight of the fill material. Settlements within a granular fill embankment should occur almost instantaneously and hence should occur during or immediately following

construction. Settlement of cohesive fill embankments will be more time dependent and anticipated to be realized within a three(3) month time period following placement.

Settlements within the existing fill material or native subsoil are expected to be minimal and are anticipated to be elastic in nature. Hence, these settlements should be realized during the construction period.

#### Embankment Construction

Any softened or organic material within the plan limits shall be subexcavated prior to the construction of the embankment proper. Embankment fills shall then be placed and compacted as specified in OPSS 206.07.07 and OPSS 501 series.

As mentioned earlier, embankment construction of the new fills shall be integrated in the existing fills in accordance with OPSD 208.01.

#### 4) Construction Considerations

##### Dewatering

A temporary dewatering scheme will be required for any removal of the existing foundation and the foundation excavation and construction of the replacement structure adjacent to the Twenty Mile Creek. The creek level will determine the type of dewatering scheme that is the most feasible. One dewatering method is to divert the creek to one

side using an impervious earth dyke and corrugated steel pipe culverts. If the water levels is to high, an impervious earth dam may have to be constructed upstream of the bridge to enable foundation construction in the dry. Once the creek is diverted or a dam constructed, no further difficulties are anticipated in excavating any soil or rock in view of the relatively impervious nature of the material. Any minor groundwater seepage or surface water can be readily discharged using conventional sump pump techniques.

Another dewatering method involves a "box excavation scheme" which involves the excavation and then subsequent displacement of a prefabricated enclosure until the bedrock surface is encountered. Once the prefabricated enclosure is positioned on the bedrock surface and sealed effectively at the bedrock surface to prevent water inflow, conventional sump pumping techniques can be used to discharge any additional water.

In the bailey bridge foundation excavation and construction, a dewatering scheme may or may not be required depending on the creek level and the proximity of the proposed foundations to the creek. The foundations appear to be sufficiently distant from the creek such that any excavation can be carried out without inflow from the creek. Therefore, only conventional sump pumping dewatering would be required to discharge any localized seepage and surface runoff. However, the creek level/ foundation location would have to be reviewed before finalizing a dewatering scheme.

### Environmental Considerations

In stream and shoreline construction can increase sediment depositions to a waterbody. Special environmental construction precautions such as silt fencing shall be used to mitigate damage to the environment.

### Temporary Slopes

Temporary excavation slopes within the fill material or native material shall not be steeper than 1.5H:1V.

### MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and N. Mullen, Student Engineer, utilizing equipment owned and operated by Malone's Soil Samples. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by M. Devata, Chief Foundation Engineer.



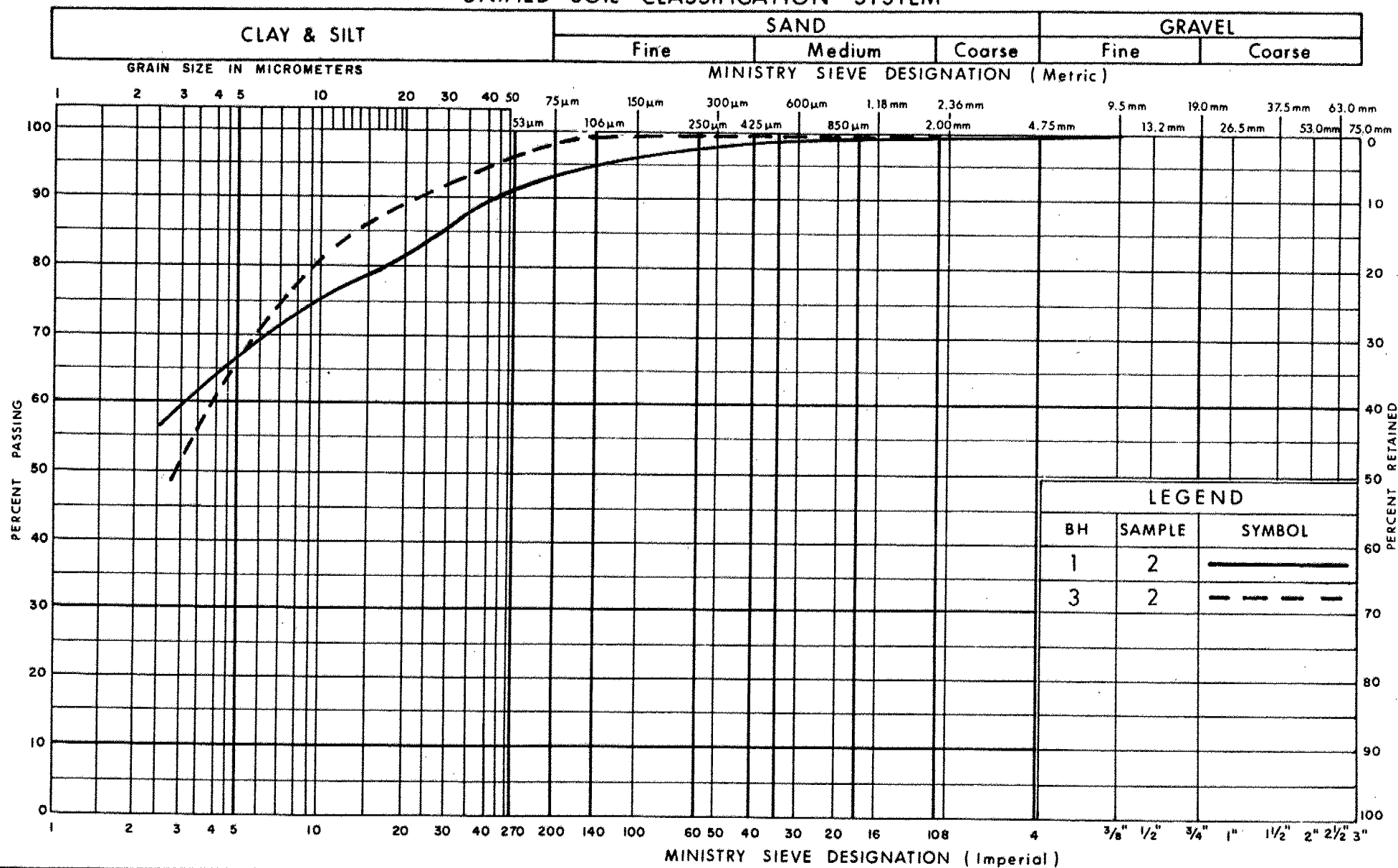
  
T. Sangiuliano, P.Eng.  
Foundation Engineer

  
M. Devata, P.Eng.  
Chief Foundation Engineer

## APPENDIX



## UNIFIED SOIL CLASSIFICATION SYSTEM

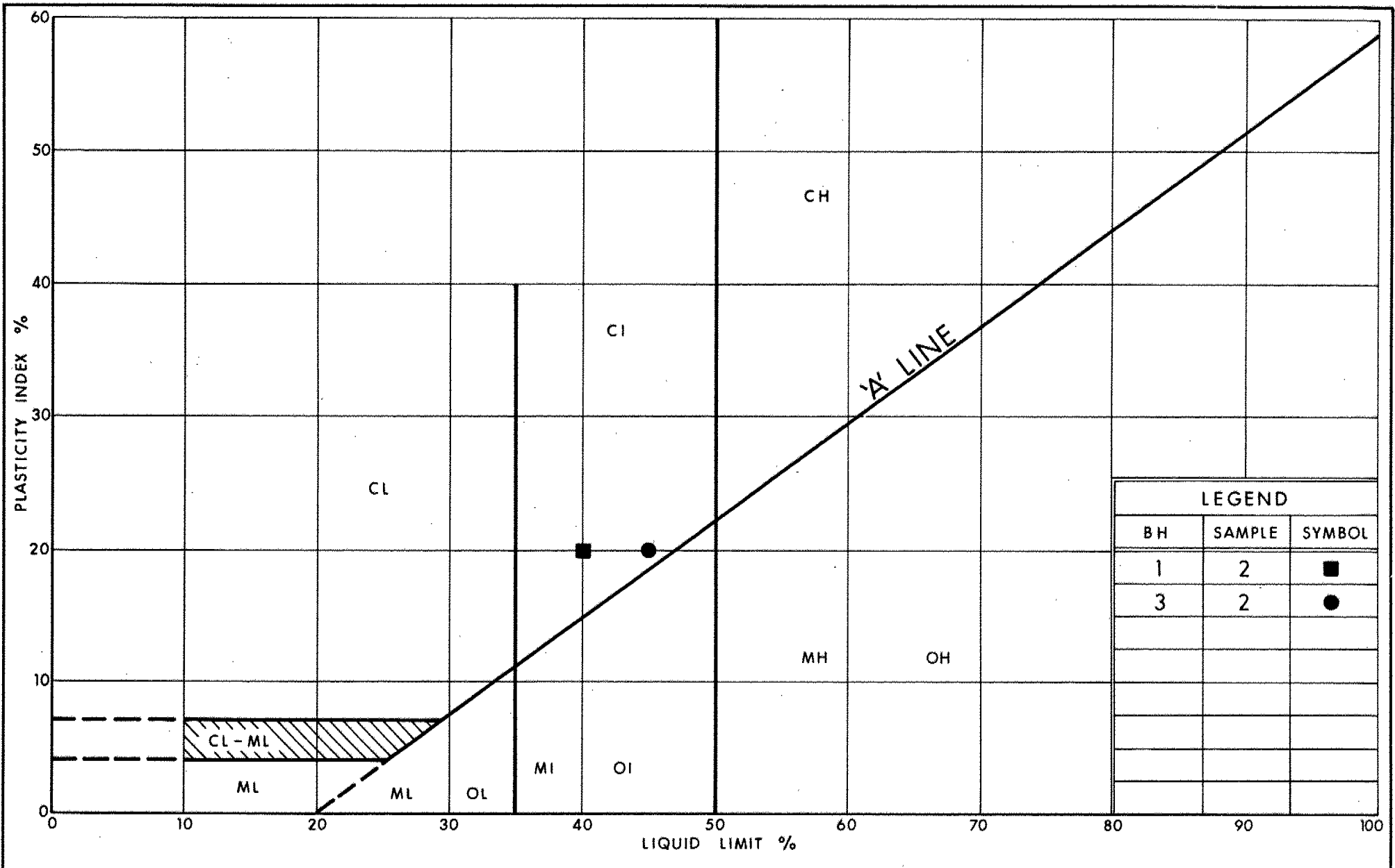


Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
IRREGULAR MIXTURE OF  
**SILTY CLAY, SAND & GRAVEL ( FILL MATERIAL )**

FIG No 1

W P 289-93-01



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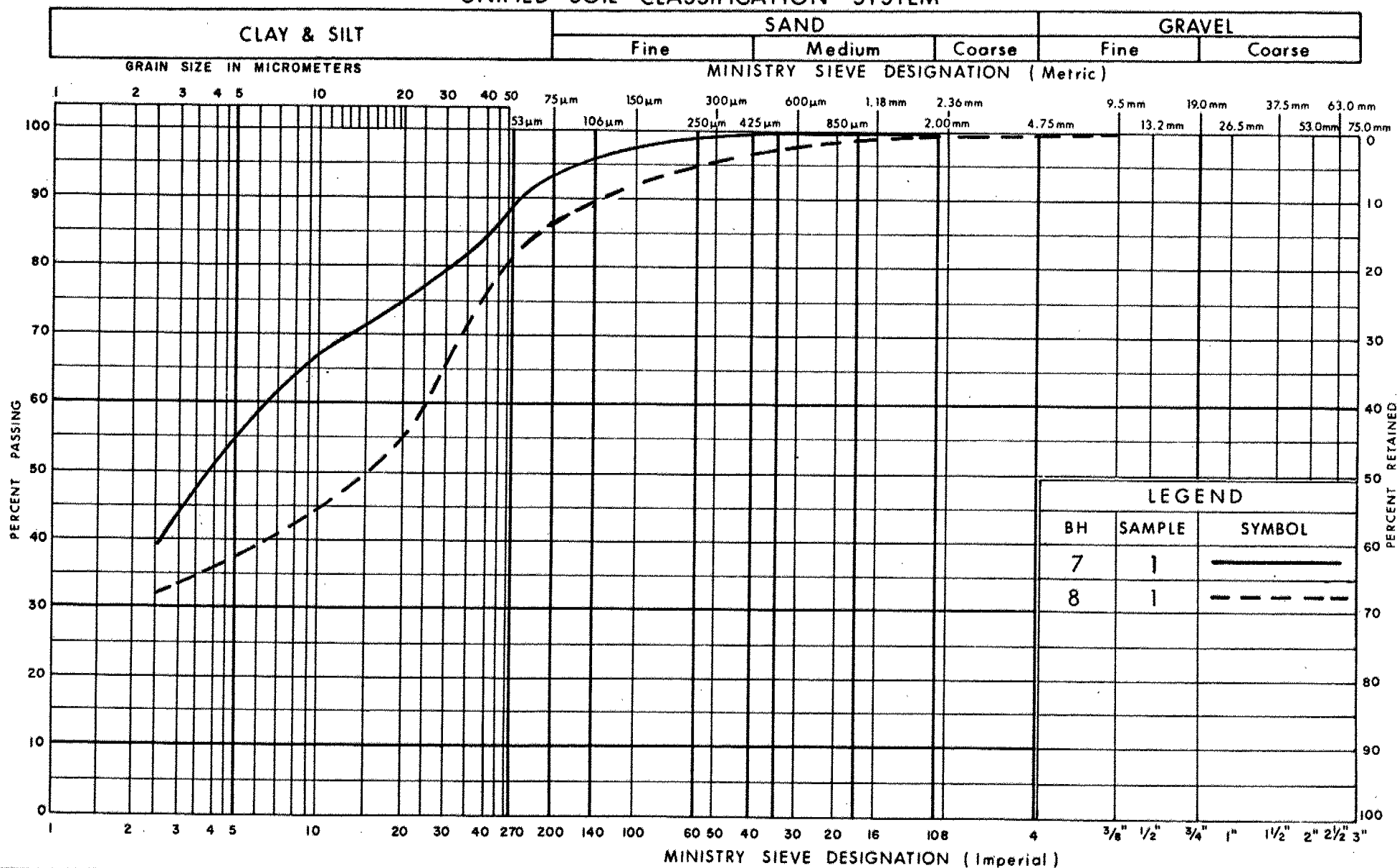
Ontario

PLASTICITY CHART  
IRREGULAR MIXTURE OF  
SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)

FIG No 2

W P 289-93-01

## UNIFIED SOIL CLASSIFICATION SYSTEM

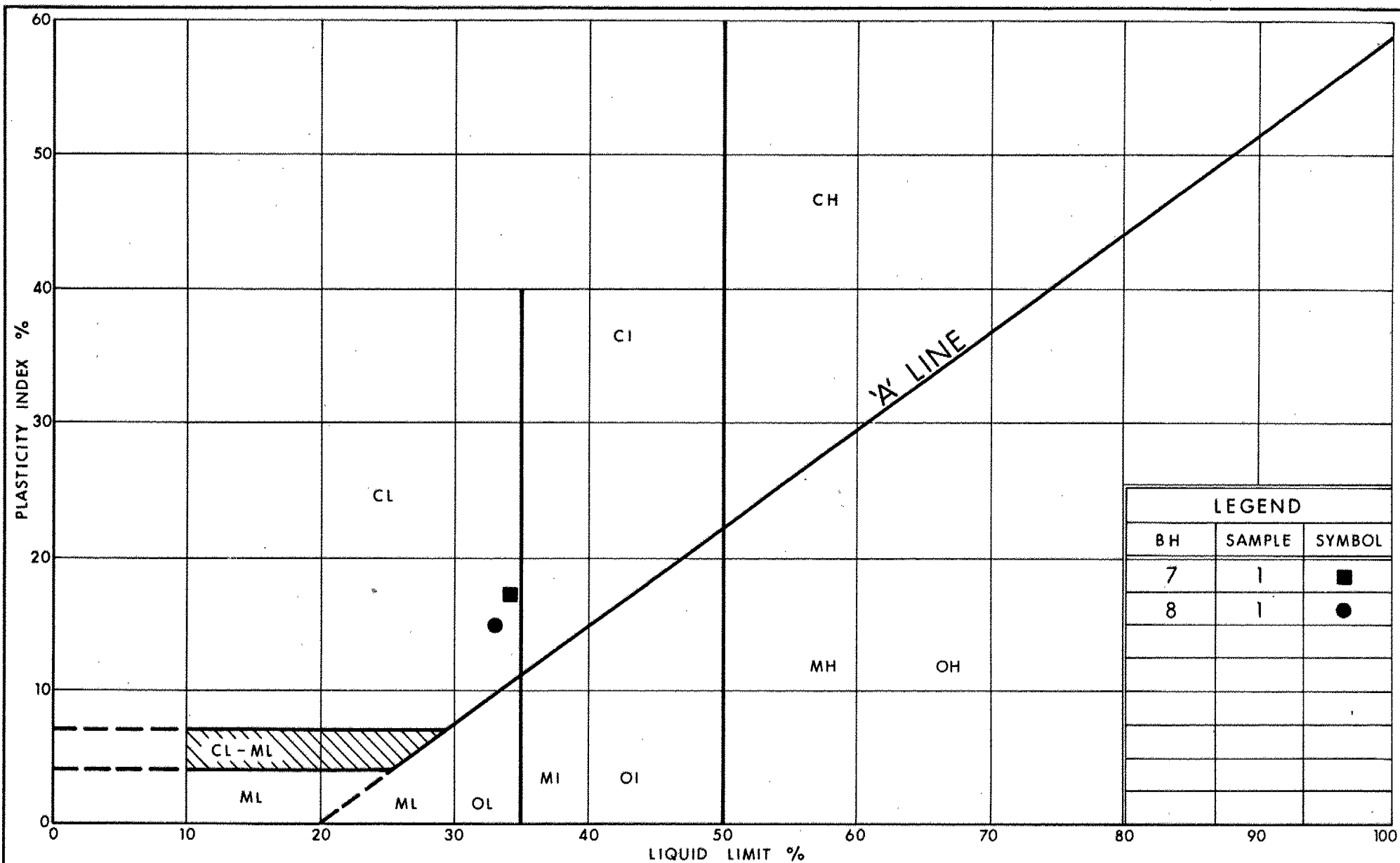


Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
 HETEROGENEOUS MIXTURE OF  
 CLAYEY SILT, SAND & GRAVEL ( Glacial Till )

FIG No 3

W P 289-93-01

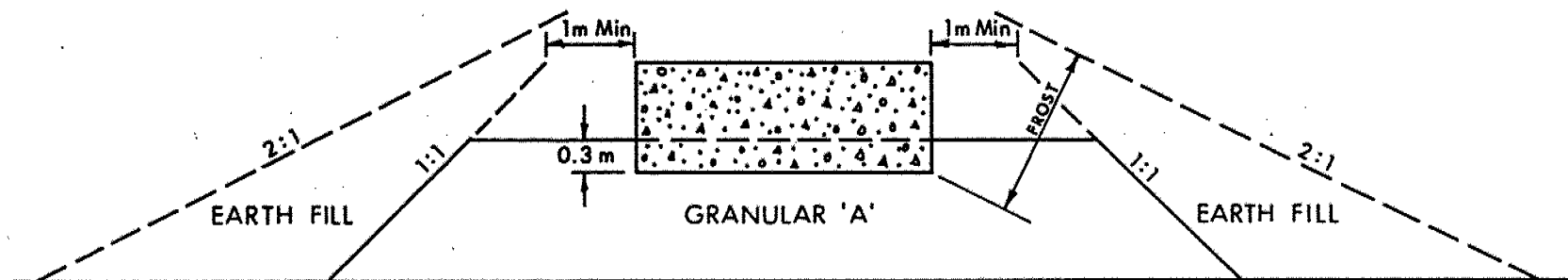


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Ontario

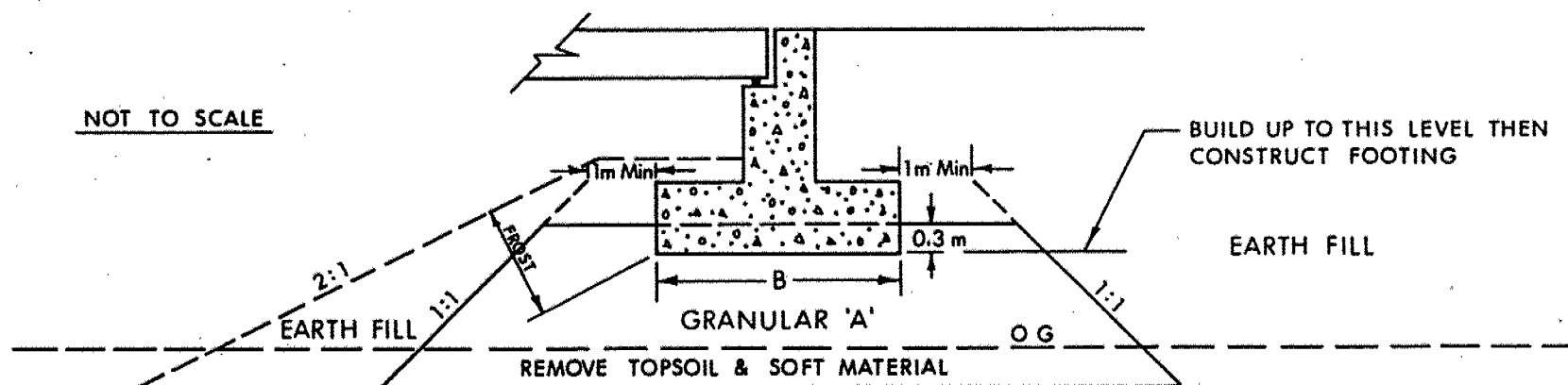
PLASTICITY CHART  
HETEROGENEOUS MIXTURE OF  
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4

W P 289-93-01



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



Ontario

Ministry of  
Transportation

ABUTMENT ON COMPACTED FILL  
SHOWING GRANULAR 'A' CORE

FIG No 5

W P 289-93-01

## 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

$m_v$	$kPa^{-1}$	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 = $\frac{c_u}{\tau_r}$

### 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

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

# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+713.5 o/s 4.5m Lt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 23 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
181.8	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel  (Fill Material) Firm to Stiff  Brown ----- Grey		1	SS	9		180										0 7 40 53
			2	SS	4		178										
177.2	Weathered Dolostone Bedrock Unweathered Medium Grey Weak to Medium Strong		3	RC	REC 100%		176										ROD = 0%
4.6																	
175.7	End of Borehole • 93 08 23																
6.1																	

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+730.0, o/s 6.0m Lt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 23 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
177.7	Ground Surface																
0.0	Irregular Mixture of Silty Clay Sand and Gravel (Fill Material) Brown, Firm																
177.2																	
0.5	Weathered Unweathered		1	RC	REC 100%		176										RQD = 0%
	Dolostone Bedrock Medium Grey Weak to Medium Strong		2	RC	REC 100%												RQD = 42%
174.2																	
3.5	End of Borehole + 93 08 23																



# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+747.0, o/s 5.0m Lt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 23 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
181.7	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel  (Fill Material)  Brown, Firm to Very Stiff		1	SS	16		180										0 1 62 37
			2	SS	6		178										
177.5	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		3	RC	REC 100%												RQD = 0%
4.2																	
176.0	End of Borehole																
5.7	* 93 08 23 (GWL not established)																

# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+742.0, o/s 7.5m Rt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.1	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)																
176.9	Brown, Firm																
1.2																	
	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		1	RC	REC 92%		176										RQD = 0%
			2	RC	REC 100%		174										RQD = 28%
173.7																	
4.4	End of Borehole  * 93 08 24																

# RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+719.0, a/s 7.5m Rt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 23 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
177.8	Ground Surface																
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material)																
177.2	Brown, Firm																
0.6	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		1	RC	REC 100%		176										RQD = 0%
			2	RC	REC 100%												RQD = 0%
174.1																	
3.7	End of Borehole * 93 08 23																

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+720.0, o/s 15.0m Rt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger COMPILED BY NM  
 DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.4	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)					DRY *	178										
177.1	Brown, Firm		1	SS	7												
1.3	End of Borehole Refusal (Probable Bedrock) * 93 08 24																

# RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+714.0, o/s 22.0m Rt C/L Hwy 20 ORIGINATED BY NM  
 DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
 DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
178.5	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, Firm		1	SS	6											0 6 59 35	
177.0																	
1.5	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		2	RC	REC 100%											RQD = 9%	
			3	RC	REC 96%											RQD = 56%	
173.9																	
4.6	End of Borehole • 93 08 24																

# RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 289-93-01 LOCATION Sta. 28+750.0, o/s 24.0m Rt C/L Hwy 20 ORIGINATED BY NM  
DIST 4 HWY 20 BOREHOLE TYPE SS Auger, NW Casing, and NXL Core COMPILED BY NM  
DATUM Geodetic DATE 93 08 24 CHECKED BY TS/PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.8	Ground Surface																
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, Very Stiff		1	SS	22	*	178										0 13 52 35
177.1																	
1.5	Dolostone Bedrock Medium Grey, Unweathered Weak to Medium Strong		2	RC	REC 97%		176										RQD = 8%
			3	RC	REC 82%												RQD = 20%
174.0																	
4.6	End of Borehole • 93 08 24 (GWL not established)																

# ROCK CORE DESCRIPTION

## WP 289-93-01

Page 1 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	3	4.57-6.10	100	0	4.57-6.10	DOLOSTONE (bituminous, with shaly partings, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 4.57-5.31 m); fractures extremely close to close spaced, flat to near vertical, undulating to planar, smooth to rough.
2	1	0.46-1.98	100	0	0.46-3.51	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 0.46-0.91 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	2	1.98-3.51	100	42		
3	3	4.19-5.72	100	0	4.19-5.72	DOLOSTONE (bituminous, with shaly partings, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
4	1	1.19-2.74	92	0	1.19-4.42	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 2 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 1.19-1.32 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	2	2.74-4.42	100	26		

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

*Note: Depths are approximated where core recovery is less than 100%*  
Logged by: DAW, Soils and Aggregates Section

# **ROCK CORE DESCRIPTION** **WP 289-93-01**

Page 2 of 2

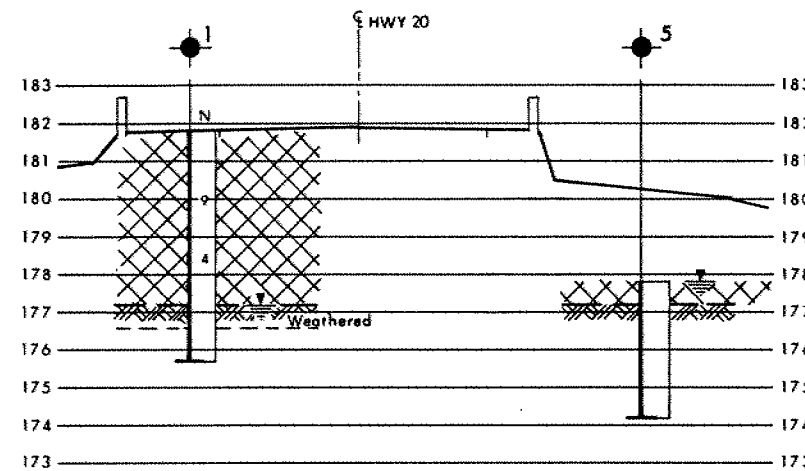
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
5	1	0.61-2.13	100	8	0.61-3.66	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered (moderately weathered, 0.61-0.71 m); fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	2	2.13-3.66	100	40		
7	2	1.52-3.05	100	9	1.52-4.57	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	3	3.05-4.57	96	56		
8	2	1.52-3.05	97	8	1.52-4.57	DOLOSTONE (bituminous, with shaly partings, stylolites, corals, and vugs up to 5 cm in diameter commonly containing calcite crystals), medium dark grey to medium-light grey; fine to medium grained; weak to medium strong; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, undulating to planar, smooth to rough.
	3	3.05-4.57	62	20		

\*CR = CORE RECOVERY

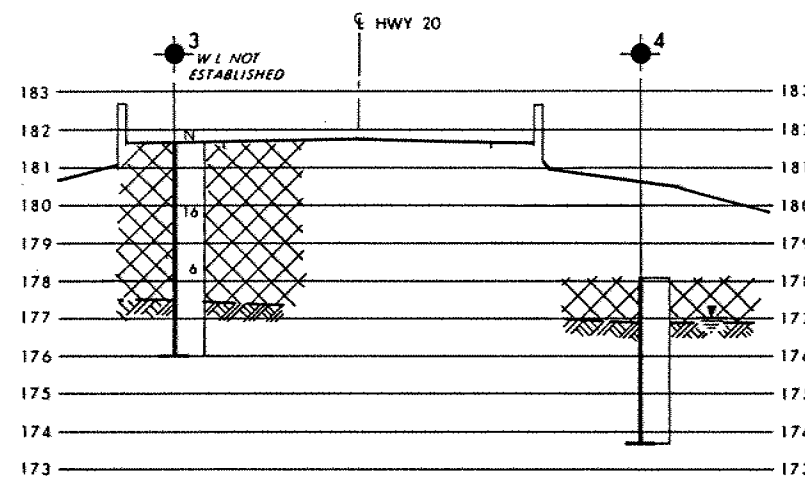
\*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%  
Logged by: DAW, Soils and Aggregates Section





SECTION A-A



SECTION B-B

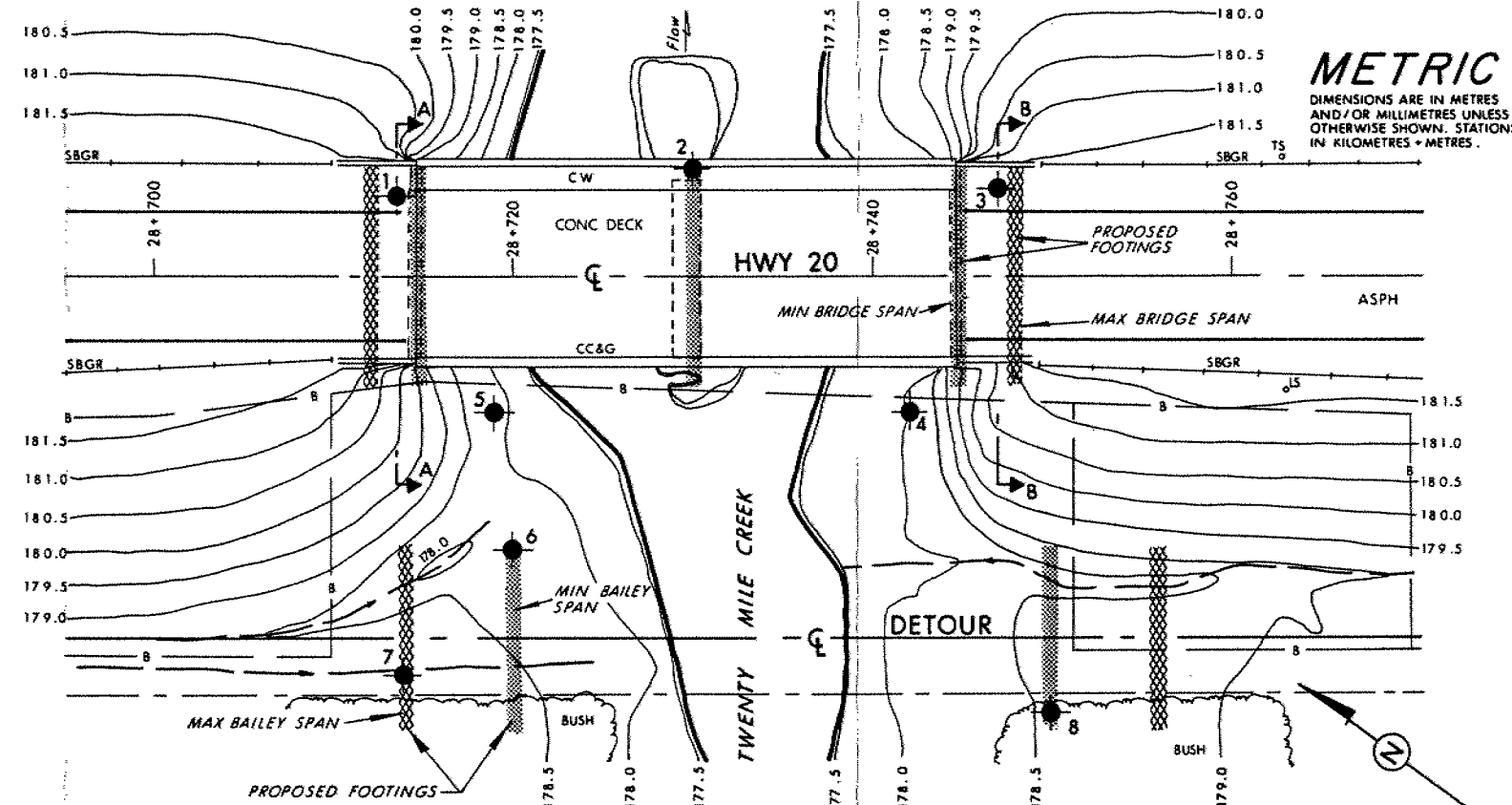
SECTIONS SCALE  
2m 1 0 2m

### SOIL STRATIGRAPHY LEGEND

IRREGULAR MIXTURE OF SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)  
Firm to Very Stiff

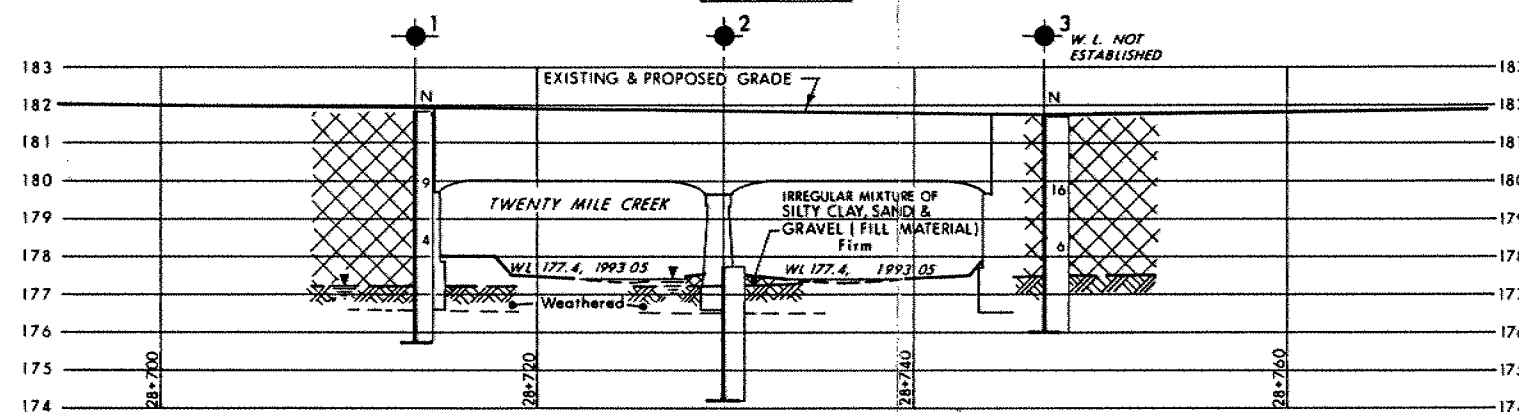
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)  
Firm to Very Stiff

DOLOSTONE BEDROCK  
Unweathered

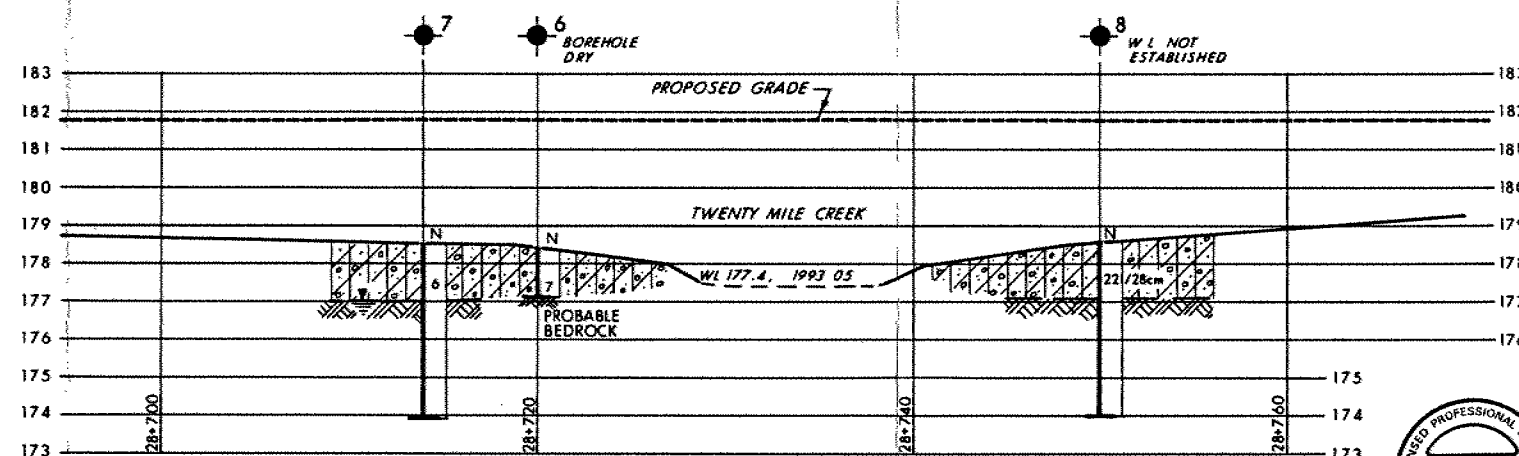


PLAN

SCALE  
4m 2 0 4m



PROFILE HWY 20



PROFILE DETOUR

PROFILES SCALES  
4m 2 0 4m HOR  
2m 1 0 2m VERT

**METRIC**

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

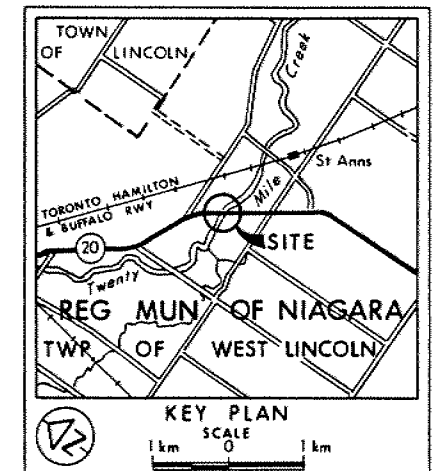
CONT No  
WP No 289-93-01

TWENTY MILE CREEK

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



### LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Srd Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1993 08

No	ELEVATION	STATION	OFFSET (HWY 20)
1	181.8	28+713.5	4.5mLT
2	177.7	28+730.0	6.0mLT
3	181.7	28+747.0	5.0mLT
4	178.1	28+742.0	7.5mRT
5	177.8	28+719.0	7.5mRT
6	178.4	28+720.0	15.0mRT
7	178.5	28+714.0	22.0mRT
8	178.6	28+750.0	24.0mRT

### NOTE

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

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

REV.	DATE	BY	DESCRIPTION
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Geocres No 30M4-73

HWY No 20	DIST 4
SUBNO TS	CHECKED TS DATE 1994 01 21 SITE 18-146
DRAWN RS	CHECKED RS APPROVED DWG 2899301-A



Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs



Site looking west.



North side looking west.

Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs



North side looking west.



North fascia, west span & abutment.

Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs



North fascia & pier.



Site looking east.

Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs



North side looking east.



South side looking east.

Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs



South side looking east.



South fascia looking east.

Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs



South fascia & pier.



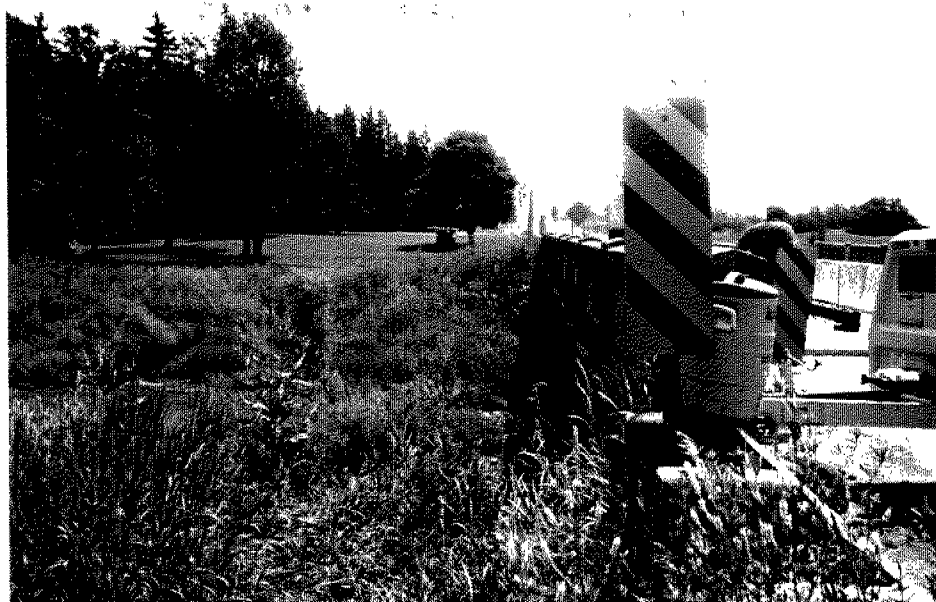
South fascia & east abutment.



Site 18-146 - 20 Mile Creek Bridge at Hwy. 20  
Site Photographs

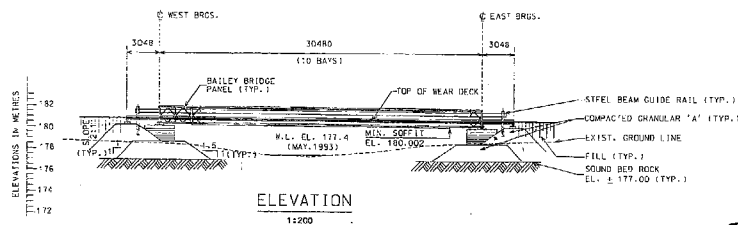
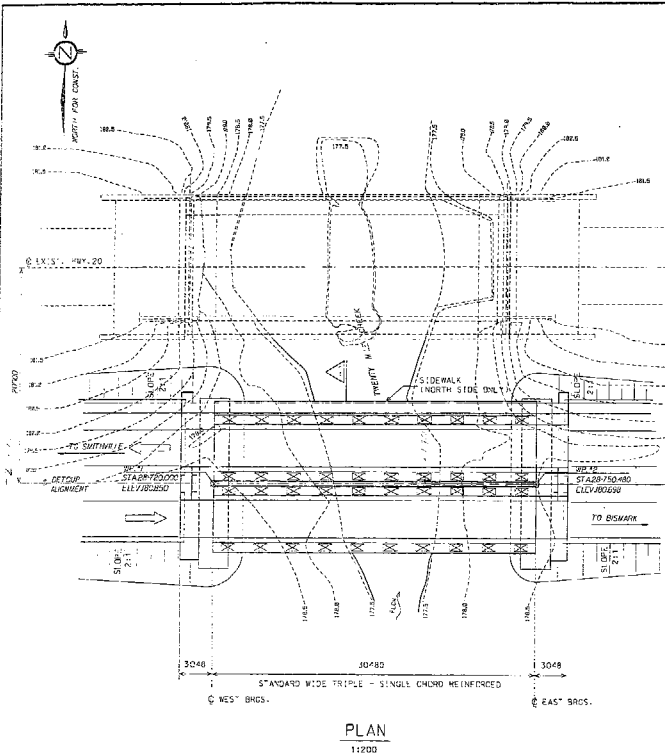


West abutment looking north.



North fascia looking east.





BM 182.742  
GEODETIC DATUM  
N & W 1/4 of 0.4 Oak  
15.4 x 28 + 596.0

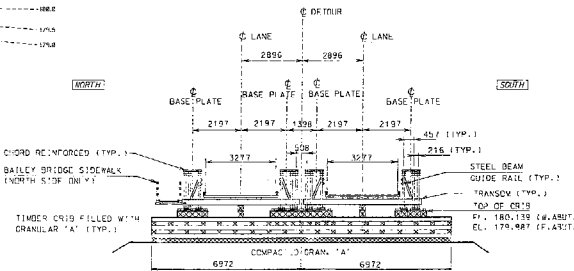
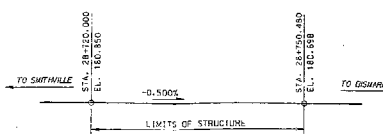


DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

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

DIST. 4  
CONT No 95-35  
WP No 289-93-00/01/02  
20 MILE CREEK BRIDGE REPLACEMENT  
HWY. 20  
BAILEY BRIDGE  
GENERAL ARRANGEMENT

**SHEET**  
25



## NOTES

### ERECTION AND LAUNCHING

- (1) THE CONTRACTOR SHALL NOT ASSEMBLE/LAUNCH OR DELAUNCH THE BAILEY UNTIL THE LAYOUT AND ELEVATIONS OF THE LAUNCHING AND CONSTRUCTION ROLLERS HAVE BEEN APPROVED BY THE CONTRACT ADMINISTRATOR. DOUBLE ROLLERS SHALL BE USED AT ALL LOCATIONS.
- (2) THE TOPS OF THE ROLLERS SHALL BE AT THE SAME ELEVATION UNLESS SPECIFIED OTHERWISE ON THE DRAWING AND LEVELLED ACROSS IN PAIRS AT RIGHT ANGLES TO THE CENTRE LINE OF STRUCTURE.
- (3) THE LAUNCHING NOSE SHALL CONSIST OF 6 BAYS OF SINGLE-HOLE SKELETON.
- (4) THE LAUNCHING LINKS SHALL BE INSERTED 3 BAYS FROM TIP OF NOSE.
- (5) ALL TINS-SOLTS AND THREADED PARTS SHALL BE FREE OF DIRT AND BE LUBRICATED AT THE TIME OF INSTALLATION.
- (6) TRANSOM CLAMP TIGHTENING BARS SHALL BE WIRED TO THE PANEL VERTICALS. WAY BRACKS SHALL BE FULLY TIGHTENED TO GAUGE BLOCKS AND ALL LOCK NUTS SECURED.
- (7) ALL PANEL PINS ON STRUCTURE SHALL BE KEPT.
- (8) WEAR DECK SHALL BE INSTALLED AFTER LAUNCHING.

### ADDITIONAL NOTES FOR CHORD REINFORCED BRIDGES

- (1) BRACING FRAME BOLTS SHALL BE INSTALLED IN THE REINFORCING CHORDS PRIOR TO THE CHORDS BEING INSTALLED ON THE PANELS.
- (2) TAPERED CHORDS SHALL BE USED FOR LAUNCHING AND DELAUNCHING. AFTER LAUNCHING, ENTIRE BAILEY BRIDGE SHALL BE JACKED AS ONE UNIT TO FACILITATE REMOVAL OF ROLLERS. ALL JACKING SHALL BE DONE SIMULTANEOUSLY AND DIFFERENCES IN ELEVATIONS OF BAILEY BRIDGE AT ADJACENT JACK POINTS SHALL NOT EXCEED 50mm.

### MAINTENANCE

- (1) THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE MAINTENANCE OF THE STRUCTURE AND APPROACHES, INCLUDING THE FOLLOWING: CHECK THAT ALL BRACING BOLTS, CHORD BOLTS, TRANSOM CLAMP ARE AND REMAIN FULLY TIGHTENED.
- (2) KEEP BASE PLATES AND CRIBS PERIODICALLY AND CORRECT ANY UNEVEN SETTLEMENT TO THE SATISFACTION OF THE ENGINEER. PACKING UNDER TRANSOM AND RAMPS MUST BE KEPT TIGHT.
- (3) NOTIFY THE ENGINEER IMMEDIATELY OF ANY DAMAGES.

### QUANTITIES

W.P.	STATION	ELEVATION
1	28120.000	180.850
2	28150.480	180.698

TOTAL = 103.5 TONNES

### NOTE

TOTAL UNFACTORED JACKING LOAD FOR ONE BAILEY BRIDGE AT ABUTMENT (EXCLUDING TIMBER DECK) IS 200KN.

### LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. ABUTMENTS
3. MISCELLANEOUS DETAILS & BILL OF MATERIALS
4. QUANTITIES - STRUCTURE

### APPLICABLE STANDARD DRAWINGS

- DD-5001 BAILEY BRIDGE (CHECKING FOR STD & STD WIDE BRIDGES)
- DD-5002 BAILEY BRIDGE SIDEWALKS
- DD-5003 STEEL BEAM GUIDE RAIL FOR BAILEY BRIDGE

REVISIONS	DESCRIPTION
1	DESIGN JK CHK NG CODE CHORD ST LOAD EL - 1/1 DATE REV - 1/1
2	DRAWN RR CHK JK SITE 18-148 STRUCT - 1/1 DATE REV - 1/1