

REMARKS: _____

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 96-59



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

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT

3

For

Rideau River Bridge, SBL

W.P. 370-89-01, Site No. 3-364

Highway 416, District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted for the proposed Rideau River Bridge for the Hwy. 416 southbound lanes. The investigation was carried out at the request of Eastern Region Structural Section. The report applies to a proposed five span bridge structure to support Highway 416 southbound and its approaches between Station 16+355 and 16+800, Highway 416 chainage.

Preliminary recommendations were provided by this office on May 18, 1990 based on previous investigations for the existing bridge at this site.

The foundation investigation for this project was delayed by several months to meet the requirements of Rideau Canal and other authorities.

SITE DESCRIPTION

The site is located about 7 km north of Highway 43 in Kemptville at the Highway 416 crossing over the Rideau River.

The nearest similar structure is a bridge structure which carries Highway 416 over the Rideau River. The existing bridge is presently used for both north and southbound traffic.

The actual site for the proposed bridge is on the south side of the existing bridge. The new bridge will be similar to the existing bridge in length and span geometry.

The river channel is about 280 m wide. The ground surface at the east bank is about 5 m higher than on the west bank. This is due to an already in place approach fill on the east bank which is about 7 m thick and has side slopes of approximately 2H:1V. The existing east approach fill

approximately extends from Station 16+350 to Station 16+475, Highway 416 chainage.

Physiographically the site is located in the Winchester Clay Plain. In this area although the clay plains are dominant, the landscape has some complexity. In many places the underlying till protrudes and there are a number of low drumlins. There are also areas of shallow soil over bedrock (Reference: Chapman and Putnam, The Physiography of Southern Ontario; 3rd Edition, 1984).

INVESTIGATION PROCEDURES

The field investigation for this project was conducted in two sessions. The first time was between July 16 and July 27, 1990 and the second time was between September 5 and September 13, 1990. A total of eleven boreholes (BH 1 through BH 11) were advanced for this investigation. Seven boreholes were accompanied by dynamic cone penetration tests. The boreholes on the ground were advanced using a track mounted auger machine equipped with 83 mm ID hollow stem augers. The boreholes on the river were advanced using washboring techniques with a conventional diamond drill rig adapted for soil sampling purposes. A raft was utilized for the execution of those boreholes located on the river. In non-cohesive soil, samples were recovered by means of 50 mm OD split spoon sampler driven into the soil according to the specification of the Standard Penetration Test (ASTM 1586). Samples were retrieved at intervals ranging from 0.75 m to 1.5 m. In cohesive soil undisturbed samples were also obtained at strategic locations by pushing 54 mm ID shelby tubes. Frequent field vane shear tests were carried out within the cohesive layer in order to determine the undrained and remoulded shear strength of the materials.

During the subsurface investigation selected soil samples were obtained from the river bed and provided to McCormick Rankin & Associates Ltd. for environmental assessment.

The boreholes were staked out by McCormick Rankin & Associates Ltd., the designer for the project. Locations and elevations were also provided by McCormick Rankin & Associates Ltd.

The laboratory testing for representative samples consisted of;

- Grain Size Analyses
- Natural Moisture Content Determinations
- Atterberg Limit Determinations
- Consolidation Test, and
- Unit Weight determinations

The results of the laboratory testing are plotted on the Record of Borehole Sheets (Appendix).

SUBSURFACE CONDITIONS

The record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 3708900-A.*

The predominant soil deposit at this site is a glacial till which consists of silty sand to sandy silt material. The glacial till is at the surface at the west bank of the river (El. 86 m to 88 m) and dips to the east as 6.5H:1V to El. 66± m near Station 16+515 m (Highway 416 SB chainage, south of the existing bridge) from where it rises at 12.5H:1V to the east. On the east of the west bank and east of Station of 16+700 the glacial till is overlain by a weak deposit of 6 m to 15 m thick sensitive clay. Within the river channel the silty clay stratum was overlain by approximately 1 m to 3 m thick muck. On the east bank of the river the silty clay was covered with approximately 3 m to 8 m of thick fill material, which was placed for the construction of the east approach.

Following are the detailed descriptions of the soil strata encountered.

* Dwg. No 2, (Sheet 46) of the Contract Drawings.

Fill Material

A non-cohesive fill material was encountered in boreholes located on the east shore of the river (BH 7 to BH 11). It was anticipated that due to the presence of the underlying thick layer of sensitive clay, consolidation settlement would take place when the approach fill was placed and therefore, it was decided to place the approach fill long before the construction of the new bridge took place. The fill was placed in 1974.

The top elevation of the fill, at the embankment surface, ranged from 89.6 m to 91.5 m. The thickness of the fill ranged from 3.5 m to 7.7 m.

The fill consisted of silty sand to sandy silt material with some gravel and trace of clay.

The Standard Penetration test 'N' value ranged from 4 to 103 blows/0.3 m which suggest that the fill is in a loose to a very dense state. However, the material was rarely loose. Generally the compactness ranged from dense to very dense.

Silty Clay

This cohesive material was encountered in all boreholes located on the east side of the navigational channel (between Pier 1 and Pier 2. This stratum was underlying the east approach fill outside the river channel or 1.1 to 3.1 m thick organic muck at the river bed.

The top elevation of this stratum was lowest in the centre of the river and rose towards the east. The top elevation ranged from 78.3 m to 86.1 m. The thickness of this layer ranged from 5.9 m to 15.2 m increasing from west to east. The thickest layer was encountered close to the east bank of the river (BH 6). Typical properties of the material, based on laboratory and field testings, are as follows:

	<u>Range</u>	<u>Average</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	24-69%	50%	25
Liquid Limit (w _p)	28-52%	40%	25
Plastic Limit (w _L)	17-24%	20%	25
Unit Weight (kN/m ³)	16.1-17.3	16.9%	9
Undrained Shear Strength (kPa) (Field Vane)	12-87	40	52

Undisturbed and remoulded field vane tests provided sensitivity values which were as high as 21. The sensitivity ranged from 2 to 21 averaging about 9. The silty clay is grey in colour and is a marine deposit. Locally this clay is known as Leda clay. Based on the undrained shear strength the consistency of the layer ranged from very soft to stiff. However, generally the material was firm.

Figure 1 illustrates a typical plasticity envelope for this material.

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

Consolidation tests were carried out on selected samples. The results are as follows:

	<u>Range</u>	<u>Average</u>
Initial Void Ratio (e ₀)	0.9159 to 1.5486	1.28
Preconsolidation (P _c), kPa	98 to 215	142
Compression Index (C _c)	0.112 to 0.741	0.43

The results of the consolidation tests are shown on Figure 3 through 7.

The moisture contents of the samples were found to be above liquid limits particularly at lower elevations.

Silty Sand to Sandy Silt (Glacial Till)

This non-cohesive material was encountered in all boreholes. This layer forms the surficial layer at the west bank and underlies the marine silty clay or the organic muck at the other locations. This deposit contains gravel and occasional cobbles and boulders.

The top elevations of this stratum ranges from 66.4 m to 88.1 m. The glacial till dips towards the east at 6.5H:1V and after reaching El. 66.4 m near Station 16+515 (Highway 416 SB chainage, south of the existing bridge) rises at a slope of 12.5H:1V towards the east. Boreholes penetrated 0.9 to 11.9 m in this material. Since all boreholes were terminated in this layer its thickness is undetermined.

Standard Penetration tests conducted in this layer achieved 'N' values ranging from 6 to 192 blows/0.3 m penetration. This suggests that the material is in a loose to a very dense state. However, generally the material is in a dense to a very dense state. Occasional low 'N' values were due to unbalanced hydrostatic pressure.

Grain size analyses were carried out on 15 samples. Figure 8 presents the grain size distribution envelope for this material.

Organic Muck

A black muck was observed overlying the river bed. The muck varied in thickness from 1.1 m to 3.1 m at the borehole locations. The top elevation of muck varied from 80.1 to 84.7 m.

Drilling rods and casing penetrated through the stratum by their own weight which suggested that the deposit has a very soft consistency. No shear strength can be attributed to this stratum.

Groundwater Conditions

The groundwater was measured in open boreholes where possible. Where groundwater was stabilized it was found to be approximately matching with the water level in the river (El. 85.6 m). Groundwater levels are shown on the individual borehole logs (Appendix).

It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore change as the water level in the river changes.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of Ken Ahmad.

The equipment used was owned and operated by Johnston Drilling Co. Ltd.

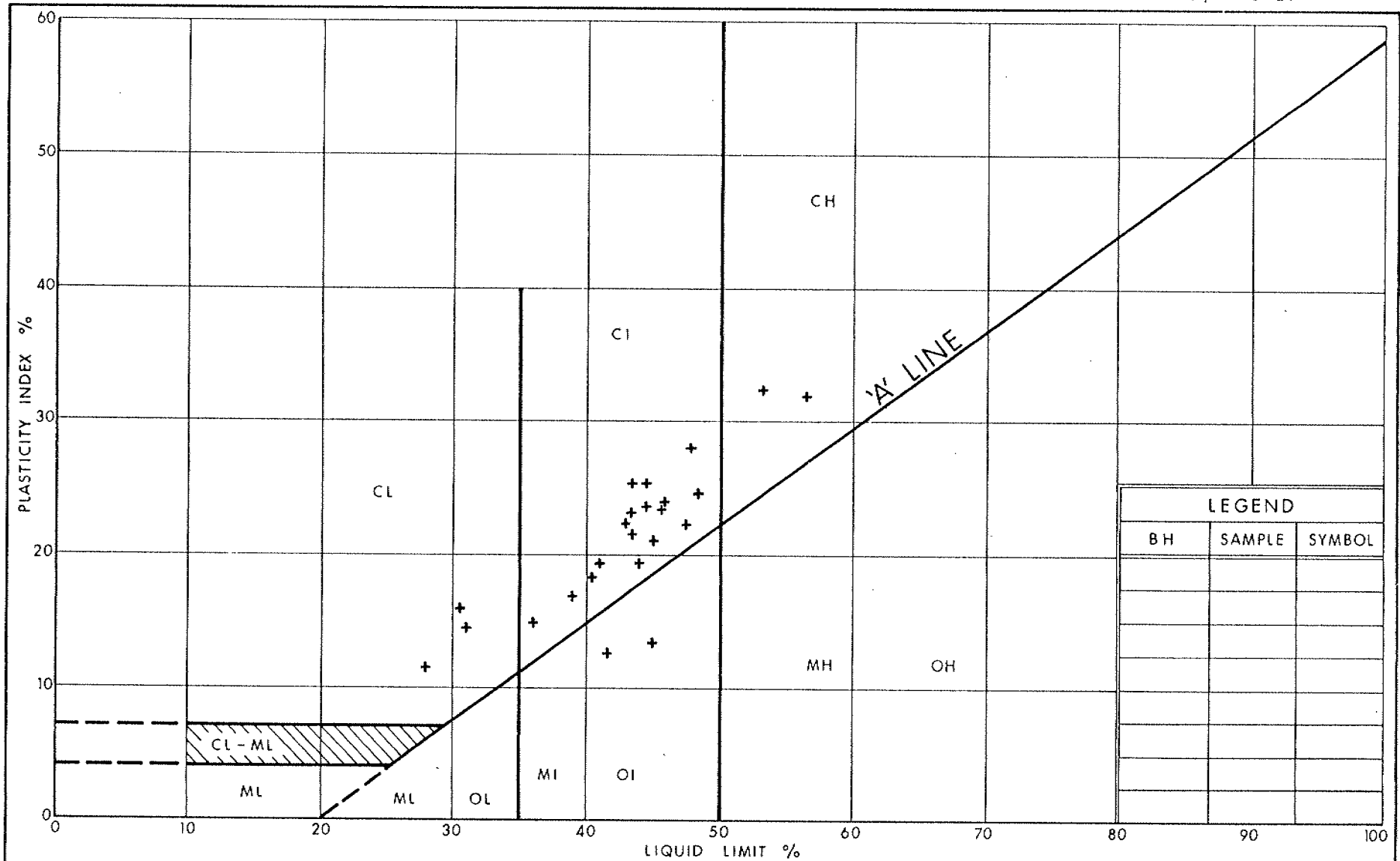
The report was written by Ken Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Engineer and approved by M. Devata, Chief Foundation Engineer.



D. Dundas

D. Dundas, P. Eng.
Senior Foundation Engineer

APPENDIX



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PLASTICITY CHART SILTY CLAY

FIG No 1

W P 370-89-01

2



GRAIN SIZE DISTRIBUTION
SILTY CLAY

W P 370-89-01

6

VOID RATIO - PRESSURE CURVES

14

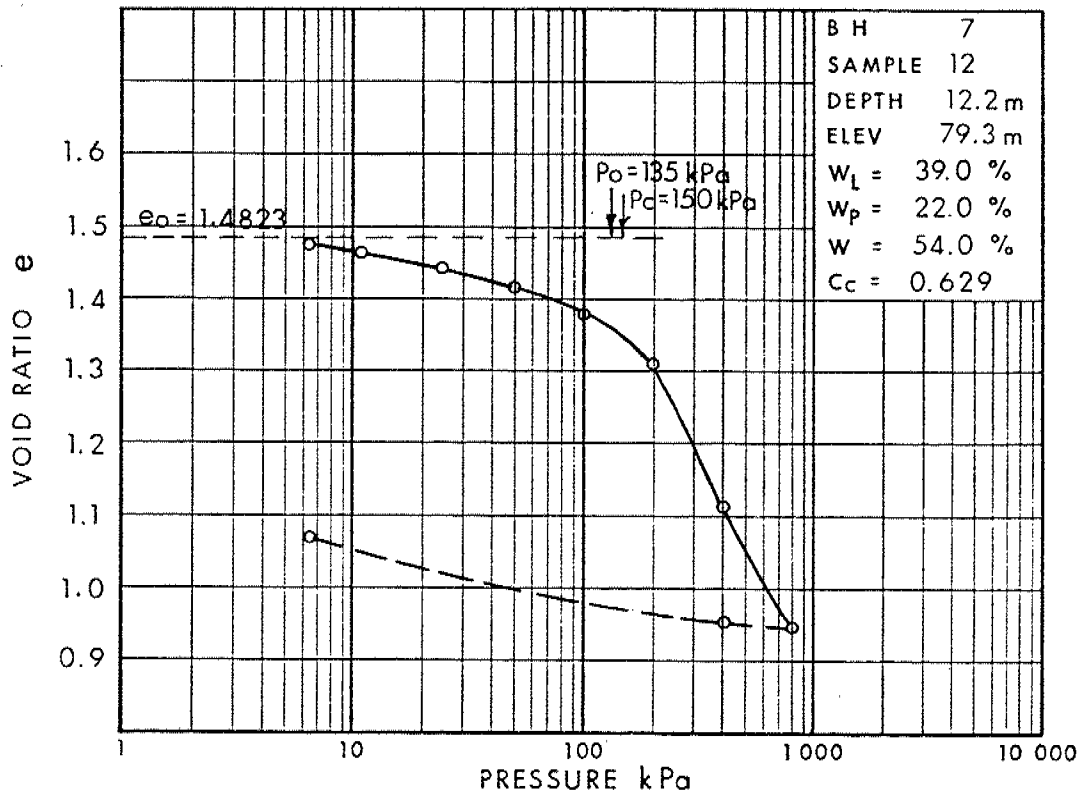
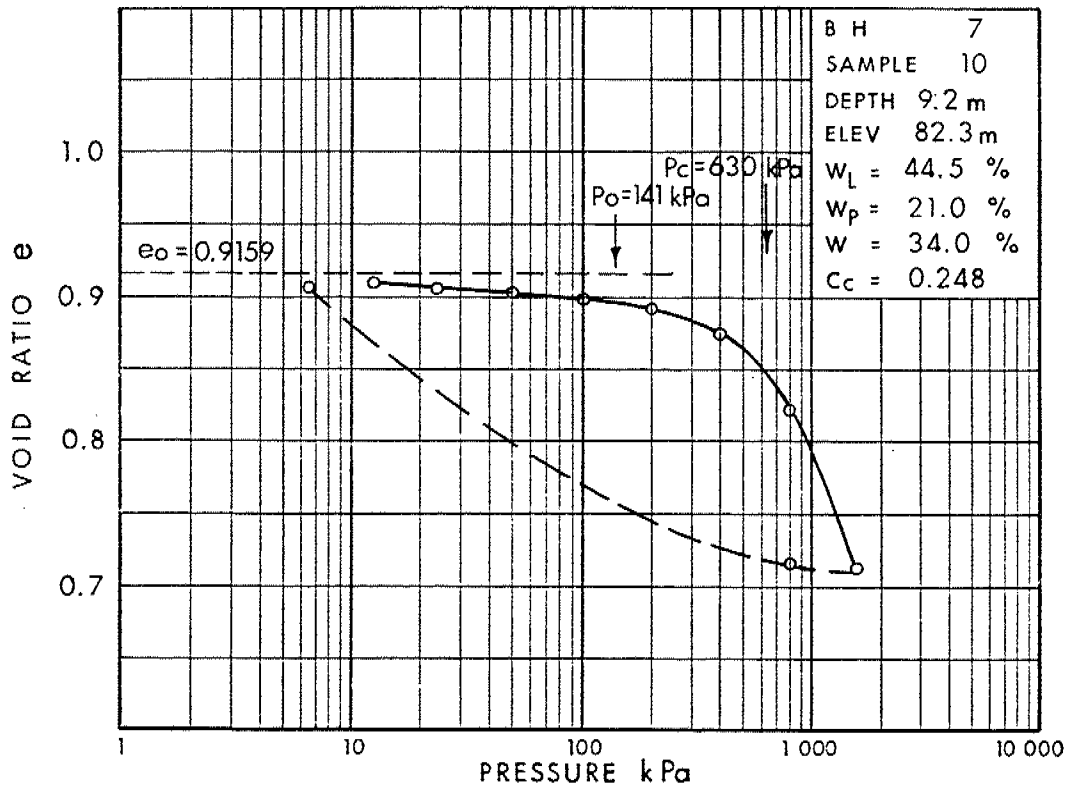


Fig 3

W P 370-89-01

VOID RATIO - PRESSURE CURVES

15

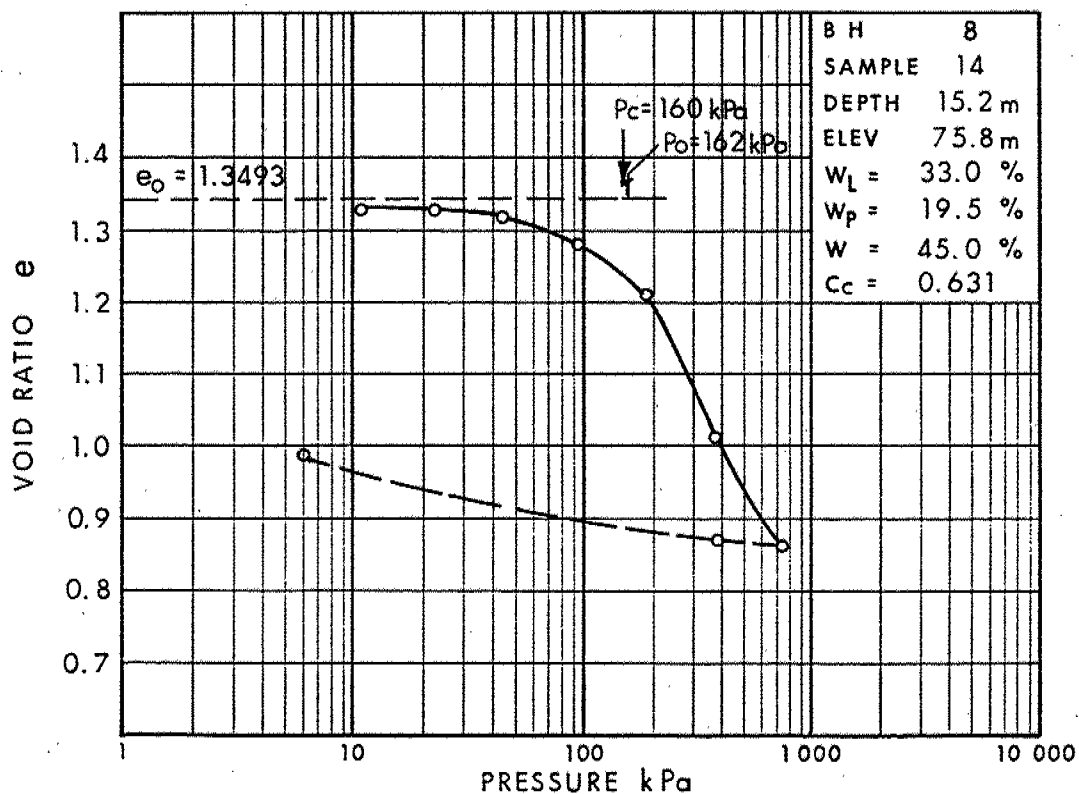
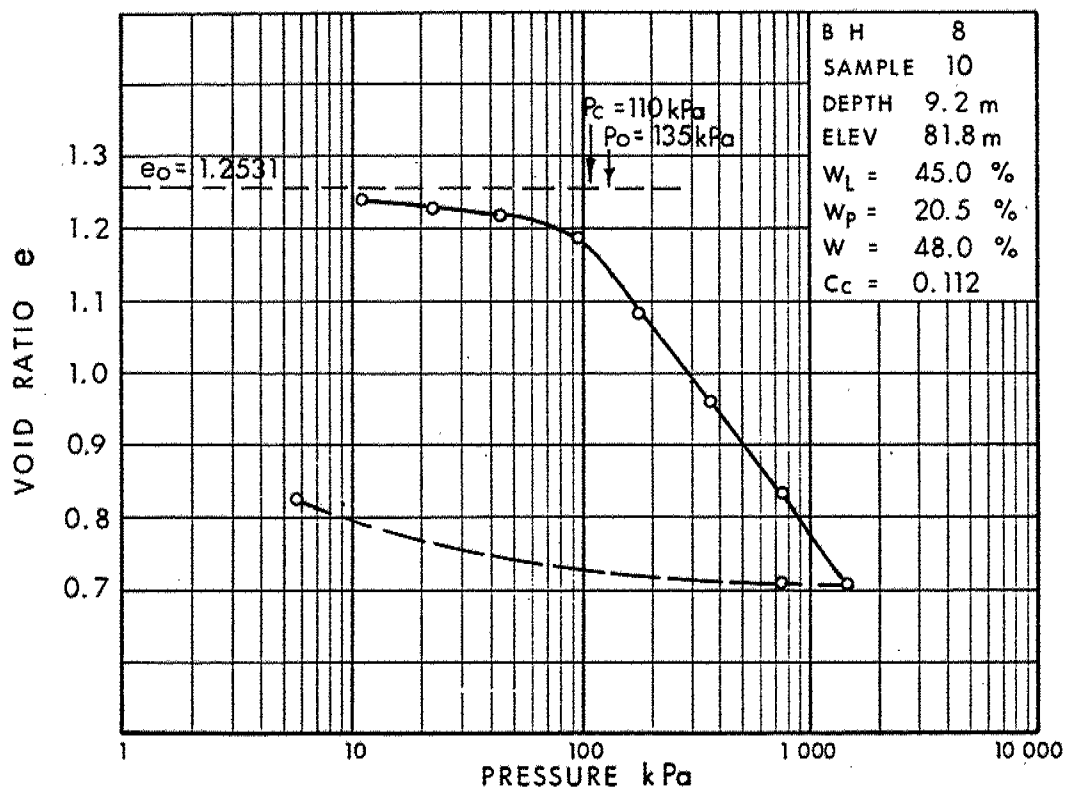


Fig 4

W P 370-89-01

VOID RATIO - PRESSURE CURVES

16

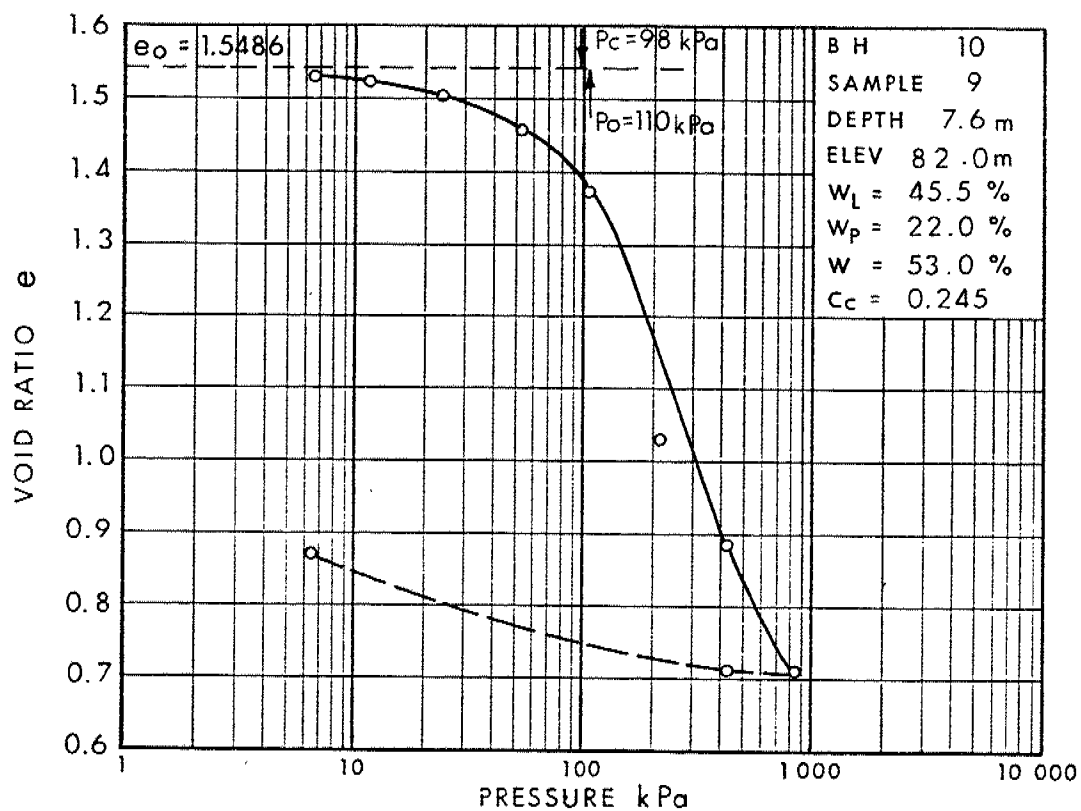
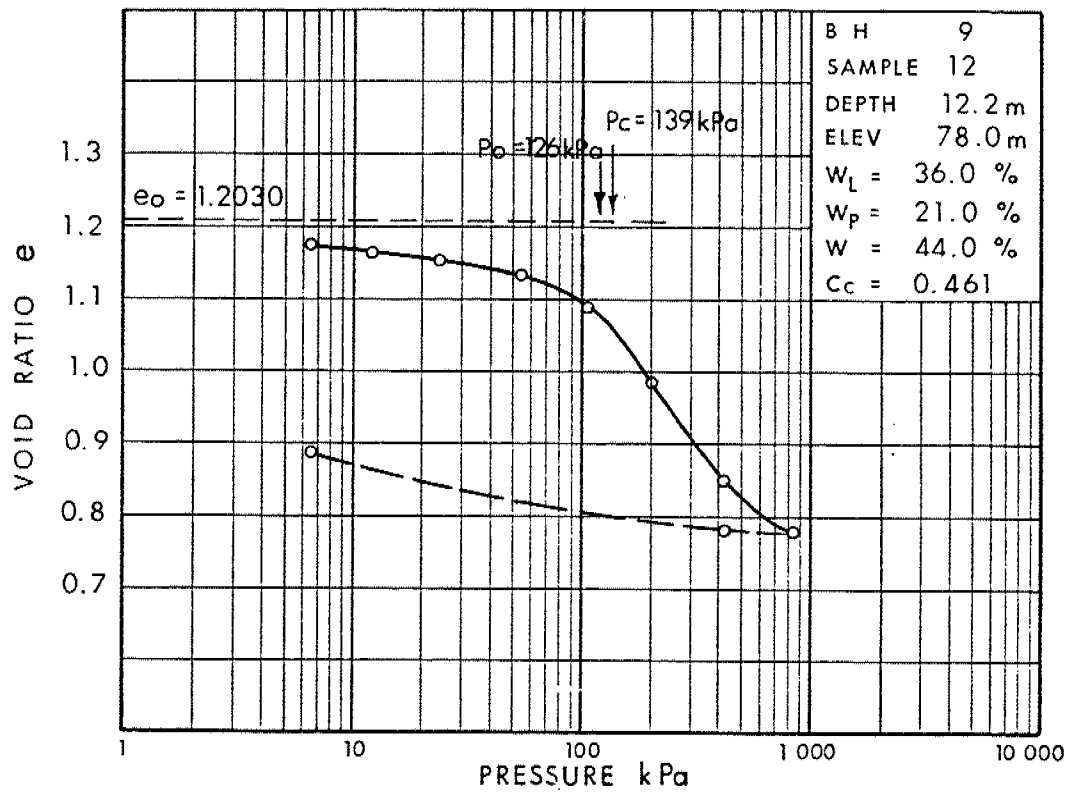


Fig 5

W P 370-89-01

VOID RATIO - PRESSURE CURVES

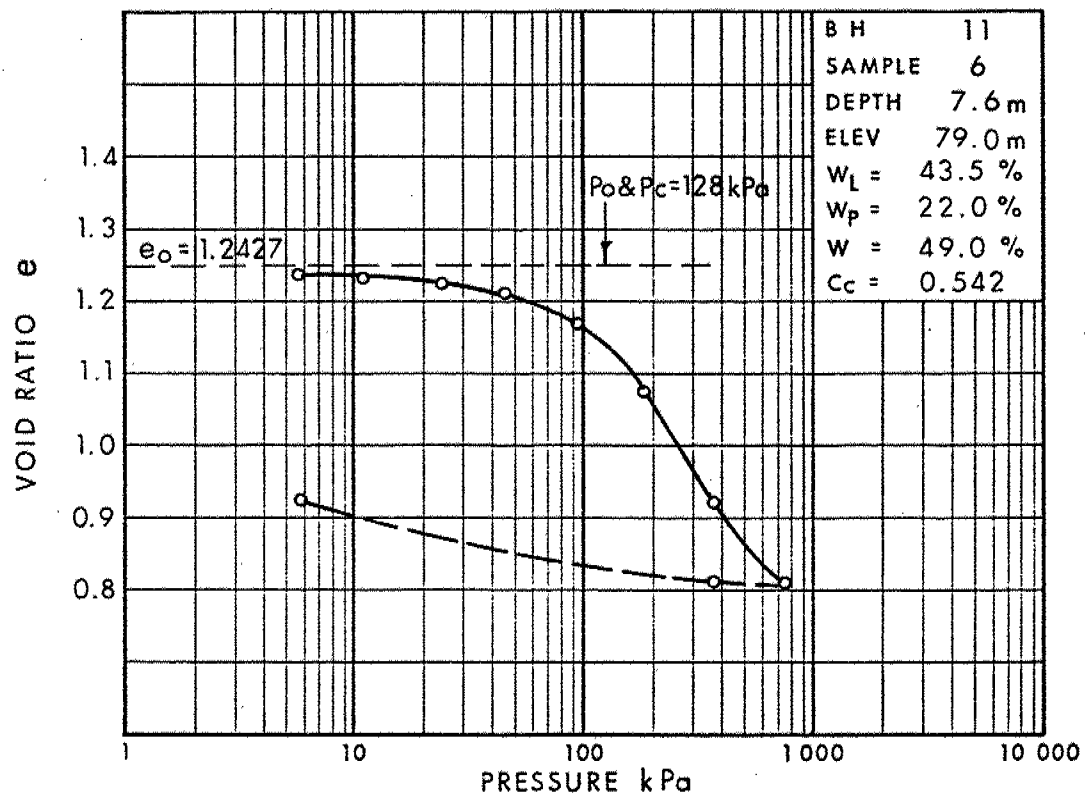
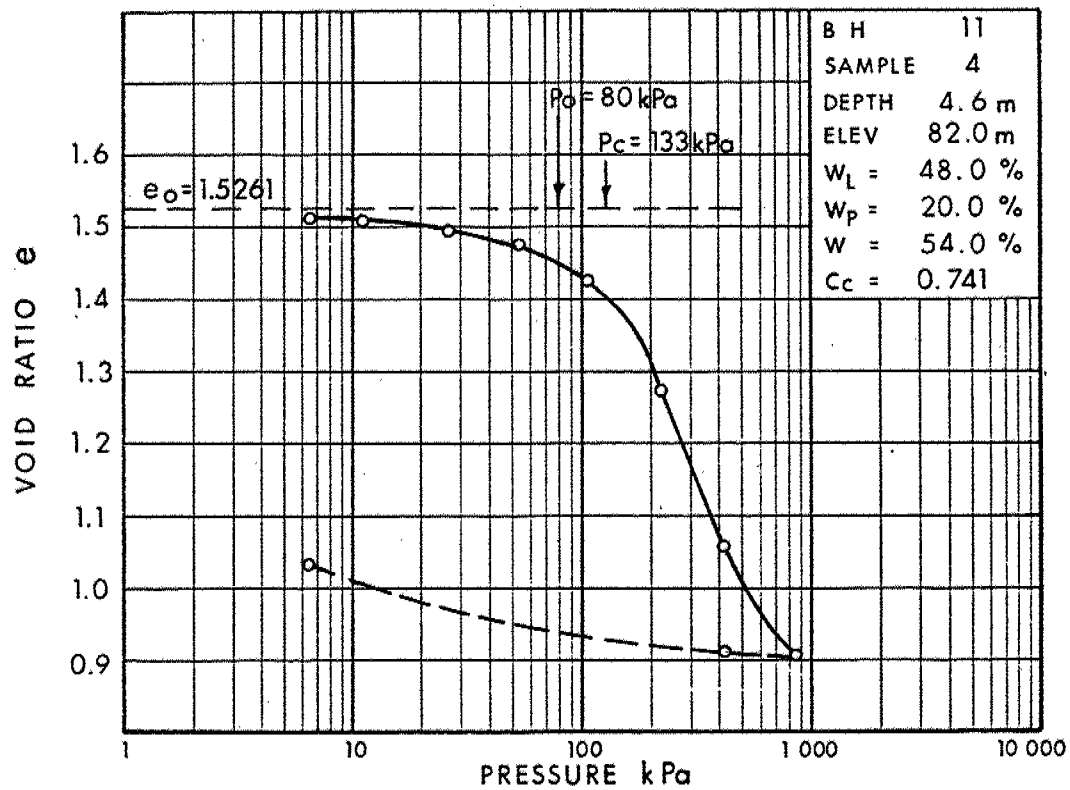


Fig 6

W P 370-89-01



GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT (Glacial Till)
WITH GRAVEL, TRACE CLAY, OCC COBBLES AND BOULDERS

W P 370-89-01

19

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 370-89-01 LOCATION N 4 993 824.2; E 372 462.5 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 90-07-22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.1	Ground Surface																
0.0			1	SS	53	/3cm	86										22 37 30 11
			2	SS	50												
			3	SS	89												
			4	SS	40												
			5	SS	34												
			6	SS	21												
			7	SS	20												
			8	SS	26												
			9	SS	86												
			10	SS	70												
77.4							78										34 26 30 10
10.7	End of Borehole																
	* W.L. not established																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 815.3; E 372 486.6 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90-07-16 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20						40
86.2	Ground Surface													
0.0	Silty Sand to Sandy Silt With Gravel, Trace Clay Occ. Cobbles and Boulders Compact To Very Dense Brown To Grey (Glacial Till)	STRAT PLOT 1 2 3 4 5 6 7 8	1	SS	29	/3cm								
			2	SS	52									
			3	SS	60									
			4	SS	11									
			5	SS	84									
			6	SS	35									
			7	SS	27									
			8	SS	109									
78.7														
7.5	End of Borehole													
	* W.L. not established													

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 787.0; E 372 543.0 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90-09-05, 06 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
85.6	River Surface															
0.0																
	Water															
80.1	River Bottom															
5.5	Organic Clayey Silt															
79.0	Black, Very Soft (Muck)															
6.6	Silty Sand to Sandy Silt Frequent Gravel & Boulder Zone Dense To Very Dense		1	SS	50											
	Grey		2	SS	67											
	(Probable Glacial Till)		3	SS	102	/15cm										
	Silty Sand to Sandy Silt with Gravel		4	SS	192	/23cm										
	Occ. Cobbles and Boulders Very Dense, Grey		5	SS	172	/26cm										
	(Glacial Till)		6	SS	100	/5cm										
67.1																
18.5	End of Borehole															

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 770.0; E 372 602.0 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90-09-07.10 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
85.6	River Surface													
0.0	River Water													
80.2	River Bottom													
5.4	Organic Clayey Silt Black, Very Soft (Muck)													
78.3														
7.3	Silty Clay Soft To Very Stiff Grey (Marine Deposit)		1	SS	*									
			2	SS	*									
			3	SS	24									
72.4														
13.2	Silty Sand to Sandy Silt With Gravel, Trace Clay Occ. Cobbles and Boulders Very Dense (Glacial Till)		4	SS	78									
			5	SS	72									
			6	SS	121	/26cm								
			7	SS	103	/15cm								
			8	SS	124	/15cm								
64.2														
21.4	End of Borehole • Split Spoon sank with its own weight													

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 741.5; E 372 655.5 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90-09-11,12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
85.6	River Surface													
0.0	River Water													
84.2	River Bottom													
1.4	Organic Clayey Silt Very Soft, Black (Muck)		1	SS	**									
81.2														
4.4	Silty Clay Soft to Firm, Gray (Marine Deposit)		2	SS	14									
			3	TW	PM									
			4	SS	1									
			5	TW	PM									
			6	SS	*									
			7	SS	*									
70.7														
14.9	Silty Sand to Sandy Silt with Gravel, trace of clay Occ. Cobbles and Boulders Dense to Very Dense, Grey (Glacial Till)		8	SS	43									45 27 (28)
			9	SS	56									
			10	SS	109									9 15 71 5
			11	SS	120	/5cm								
64.2														
21.4	End of Borehole • split spoon sunk with its own weight													

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 724.5; E 372 714.5 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90-07-12,13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.6	River Surface																
0.0	River Water																
84.7	River Bottom																
0.9	Organic Clayey Silt Very Soft, Dark Brown (Muck)																
81.6			1	SS	*												
4.0			2	SS	8												
			3	SS	6												
			4	SS	1												
	Silty Clay Soft to Firm Grey (Marine Deposit)		5	SS	*												
			6	SS	*												
			7	SS	*												
			8	SS	*												
			9	SS	*												
			10	SS	*												
	Silty Clay with Sand and Gravel		11	SS	10												
66.4			12	SS	151	/26cm											
19.2	Possible Silty Sand to Sandy Silt with Gravel Occ. Cobbles and Boulders Very Dense (Glacial Till)		13	SS	140	/13cm											
64.1																	
21.5	End of Borehole Possible Bedrock * split spoon sunk with its own weight																

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 370-89-08 LOCATION N 4 993 697.5; E 372 771.5 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90 07 17, 18, 19 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
91.5	Ground Surface													
0.0	Silty Sand to Sand with Gravel Compact to Very Dense (Fill)		1	SS	24	/3cm /28cm /10cm ▼	91						16.7	32 36 (32)
			2	SS	50									7 73 (20)
			3	SS	38		89							
			4	SS	77									
			5	SS	60		87							
			6	SS	46									
			7	SS	22									
			8	SS	21		85							27 38 (35)
84.5	Silty Clay Soft to Stiff Grey (Marine Deposit)		9	SS	5		83						16.7	0 3 55 42
7.0			10	TW	PM									
			11	SS	4		81							
			12	TW	PM									
			13	SS	*		79							
			14	TW	PM		77							
			15	SS	*		75							0 0 20 80
			16	TW	PM		73							
72.2	Silty Sand to Sandy Silt some Gravel, trace of Clay Occ. Cobbles and Boulders Dense to Very Dense (Glacial Till)		17	SS	36		71						16.7	30 31 31 8
19.3			18	SS	52									
			19	SS	56		69							
			20	SS	63									
			21	SS	119		67							
			22	SS	116		65							16 31 41 12
			23	SS	124									
63.9														
27.6	End of Borehole * split spoon sank with its own weight													

RECORD OF BOREHOLE No 8

1 OF 1 METRIC

W.P. 01 370-89-00 LOCATION N 4 993 683.4; E 372 806.8 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90-07-24 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
91.0	Ground Surface													
0.0	Silty Sand to Sandy Silt with Gravel Loose to Very Dense Brown (Fill)		1	SS	44		90						17.3	24 32 35 9
			2	SS	27									
			3	SS	35									
			4	SS	35									
			5	SS	98									
			6	SS	38									
			7	SS	13									
			8	SS	5									
83.9	Silty Clay trace of Sand Soft to Stiff Grey (Marine Deposit)		9	SS	5		84						17.2	0 2 55 43
7.1			10	TW	PM		82							
			11	SS	*		80							
			12	TW	PH		78							
			13	SS	*		76							
			14	TW	PM		74							
			15	SS	*		72							
			16	SS	*		70							
			17	SS	*									
20.8			18	SS	102									
69.2	NOTE 1 - Description													20 32 38 10
21.8	End of Borehole													
	NOTE 1 Silty Sand to Sandy Silt some Gravel, trace of Clay Occ. Cobbles and Boulders Very Dense (Glacial Till) * split spoon sank with its own weight													

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 669.6; E 372 840.1 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 90 07 25 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
90.2	Ground Surface													
0.0	Silty Sand to Sandy Silt some Gravel, trace of Clay occasional wood chips Dense to Very Dense (Fill)		1	SS	86	/15cm	90							
			2	SS	89		88							
			3	SS	41									
			4	SS	57									
			5	SS	39		86							31 48 (21)
85.0	loose		6	SS	4									
5.2	Brown Grey		7	SS	3		84							
			8	SS	3									
			9	SS	*		82							0 0 48 52
	Silty Clay Firm to Stiff		10	TW	PM		80							
			11	SS	*									
	(Marine Deposit)		12	TW	PM		78							
			13	SS	*		76							
			14	SS	*									
			15	SS	*		74							
72.5			16	SS	10	**	72							0 0 50 50
17.7	Silty Sand to Sandy Silt, some Gravel Occ. Cobbles and Boulders Very Dense (Glacial Till)		17	SS	100	/1cm								
70.7														
19.5	End of Borehole * split spoon sank with its own weight ** 'N' value is not representative													

RECORD OF BOREHOLE No 10

1 OF 1 METRIC

W.P. 370-89-00 LOCATION N 4 993 657.1; E 372 870.5 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90 07 26 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
89.6	Ground Surface													
0.0	Silty Sand to Sandy Silt some Gravel, trace of Clay (Fill)		1	SS	64	/15cm	89						16.1	38 30 (32)
			2	SS	103									
			3	SS	101		87							
86.1			4	SS	32									
3.5	Silty Clay to Clay Firm to Stiff		5	SS	6	▼	85						17.0	0 2 43 55
			6	SS	4									
			7	SS	2		83							
			8	SS	*									
			9	TW	PM		81							
			10	SS	*									
			11	TW	PM		79							
			12	SS	*									
			13	TW	PM		77							
			14	SS	*		75							
73.4	Silty Sand to Sandy Silt some Gravel Occ. Cobbles and Boulders Very Dense (Glacial Till)		15	SS	6	**	73						19 31 40 10	
16.2			16	SS	84									
70.9							71							
18.7	End of Borehole													
	• split spoon sank with its own weight													
	** 'N' value is not representative													

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 370-89-01 LOCATION N 4 993 643.2; E 372 852.8 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90 07 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
86.6	Ground Surface													
0.0	Silty Sand to Sand (Fill)		1	SS	6		86						18.5	
			2	TW	PH									
83.6	Silty Clay Soft to Firm Grey		3	SS	1		84							
3.0			4	TW	PM		82						16.5	0 0 38 62
			5	SS	*		80							
			6	TW	PM		78						16.9	
			7	SS	1		76							
			8	TW	PM		74						17.3	0 1 29 70
			9	SS	2									
73.8														
12.8	NOTE - Description													
72.9														
13.7	End of Borehole													
70.8														
15.8	End of Cone Test													
	NOTE Possible Silty Sand to Sandy Silt, with Gravel Occ. Cobbles and Boulders (Glacial Till) * split spoon sank with its own weight													



Golder Associates Ltd.

CONSULTING ENGINEERS

REPORT ON

FOUNDATION INVESTIGATION
PROPOSED COUNTY ROAD 19 UNDERPASS
HIGHWAY 416
W.P. 373-89-04, SITE 16-320
DISTRICT 9 (OTTAWA) EASTERN REGION

Submitted to:

McCormick Rankin
1148 Hunt Club Road
Ottawa, Ontario
K1V 0Y3

Distribution:

2 copies - McCormick Rankin
12 copies - Ministry of Transportation Ontario
2 copies - Golder Associates Ltd.

July 1991

901-2064B-2

1. INTRODUCTION

Golder Associates Ltd. has been retained by McCormick Rankin, consultants to the Ministry of Transportation Ontario (MTO), to carry out a subsurface investigation at the site of a proposed underpass for County Road 19 at Highway 416 (see key plan on Drawing 3738904-A)*. The purpose of this investigation was to determine the subsurface conditions at the site of the proposed underpass and approach embankments between Stations 39+800 and 40+200 along County Road 19.

2. SITE DESCRIPTION AND GEOLOGY

The site is located along Highway 16 some 160 metres to the southeast of the Rideau River. The topography across the site is relatively flat, although the existing County Road 19 and Highway 16 are raised relative to the adjacent existing ground surface. The area across the underpass and approach embankment site presently consists of cleared land, except for a treed section east of County Road 19 and south of Highway 16. Drainage ditches are present along both sides of County Road 19; several corrugated steel pipe drains cross the highway in the proposed bridge and embankment area.

A previous preliminary subsurface investigation was carried out by MTO along County Road 19 at Highway 16. The results of that work are provided in MTO report entitled "Preliminary Foundation Investigation Report for Proposed Underpass at the Crossing of Highway #416 and Relocated County Road #19, County of Grenville - Township of South Gower, District No. 8 (Kingston) W.O. 70-11078, W.P. 6-66", dated 1970. The subsurface conditions in this area were shown to consist of thin surficial deposits of sand, followed by a thin layer of clayey silt, followed by a thick deposit of firm to stiff, sensitive, grey silty clay. The silty clay was indicated to be underlain by glacial till extending to about 23 metres below ground surface, followed by very dense silt. Dolomitic limestone bedrock was previously encountered at about 25 to 26 metres below ground surface.

* Sheet No 120-1 of the Contract Drawings.

3. PROCEDURE

The field work for this investigation was carried out between May 2 and November 8, 1990. During this time, five (5) boreholes, numbered 1-1 to 1-5 inclusive, were advanced in the area of the proposed bridge, and seven (7) boreholes, numbered 1-6 to 1-12 inclusive, were put down within about 150 metres of the proposed bridge abutments for embankment design purposes. The boreholes were put down using a track mounted hollow stem auger drill rig. Two of the boreholes put down in the area of the bridge abutments and the borehole put down at the centre pier were advanced to bedrock and the bedrock was core drilled using BXL size diamond drilling equipment. The other two boreholes advanced in the abutment areas were taken to practical auger refusal. The boreholes advanced for embankment design purposes were terminated in glacial till at depths ranging from 11.3 to 14.3 metres below ground surface. Standard penetration and in-situ vane shear strength tests were carried out in the boreholes and samples of the soils encountered were recovered using drive open sampling equipment. In addition, relatively undisturbed 73 millimetre diameter Shelby tube samples of the silty clay were recovered for oedometer consolidation testing. Standpipes were sealed into most of the boreholes to determine the groundwater levels at the site. One groundwater sample was obtained from borehole 1-4 and was sent to a laboratory for basic chemical testing relating to corrosion of buried steel and concrete. The field work was supervised throughout by a member of our engineering staff.

Samples of the soil and bedrock encountered in the boreholes were taken to our laboratory for examination and classification testing. Samples of the soil were tested for moisture content, liquid and plastic limit, and grain size distribution. Oedometer consolidation tests were carried out on three samples of the sensitive, grey silty clay.

Logs of the soil, bedrock, and groundwater conditions encountered in boreholes 1-1 to 1-12, inclusive are provided on the Record of Borehole sheets following the text of this report. The locations of the boreholes are given on the Borehole Location and Soil

Strata, Drawing 3738904-A.* The subsurface profile together with the proposed bridge and approach embankment grades are provided on Drawings 3738904-A* and 3738904-B.* The results of the laboratory and field testing are provided on Figures 1 to 10, inclusive and on the Record of Borehole sheets. The results of the chemical analysis on the groundwater sample are shown on the Report of Analyses No. A1-0472 provided in Appendix A.

The borehole locations and elevations were determined by McCormick Rankin. The elevations are referenced to Geodetic datum.

4. SUBSURFACE CONDITIONS

4.1 General

As previously indicated, the detailed soil, bedrock and groundwater conditions determined from the boreholes are given on the Record of Borehole sheets following the text of this report.

The borehole logs indicate the approximate subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of boring, the frequency of sampling, the method of sampling and the uniformity of the subsurface conditions. Subsurface conditions between the boreholes may vary significantly from conditions encountered at the boreholes.

Groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These conditions may vary seasonally or as a consequence of construction activities.

*** Sheet Nos. 120-1 and 120-2 of the Contract Drawings.**

The soil and bedrock descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil and bedrock involves judgement and Golder Associates Ltd. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

In general, the site was found to be underlain by surficial deposits of roadway sand and gravel fill, followed by thin deposits of sandy silt, silty sand and sand, followed by thick deposits of sensitive, grey silty clay. Beneath the silty clay, sandy silt containing clay, gravel, cobbles and boulders (glacial till) was encountered. In the area of the proposed underpass, deposits of silt containing sand, gravel, cobbles and boulders and deposits of sand were encountered beneath the glacial till and above dolomitic limestone bedrock. For the most part, the groundwater levels were found to be at about 0.7 to 1.9 metres below existing ground surface (elevation 86.0 to 87.2 metres).

The following sections present descriptions of the soil, bedrock, and groundwater conditions encountered in the boreholes.

4.2 Topsoil, Fill

Surficial deposits consisting of roadway fill were encountered at all of the borehole locations. The fill is composed of sand and gravel containing a trace to some silt, and some cobbles. The fill was found to have a thickness of about 0.3 to 1.8 metres and extends to between elevation 85.8 and 87.3 metres. Standard penetration tests carried out in the sand and gravel fill at boreholes 1-1 and 1-4 gave N values of 10 and 14 blows per 0.3 metres, which reflect a compact relative density.

Borehole 1-8 encountered a 0.9 metre thick deposit of sandy silt (non cohesive) topsoil beneath the surficial fill. A standard penetration test in the topsoil at this location gave an N value of 10 blows per 0.3 metres, which reflects a compact relative density.

4.3 Sandy Silt, Silty Sand, Sand

Deposits composed of sandy silt, silty sand, and/or sand were encountered beneath the surficial fill and/or topsoil at the borehole locations. These deposits were found to have a thickness of about 0.8 to 2.2 metres and to extend to depths of 2.1 to 4.0 metres below ground surface (elevation 84.5 to 85.9 metres). Grain size distribution curves for samples of the silty sand and sandy silt are provided on Figures 3 and 4, respectively. Standard penetration testing carried out within these deposits gave N values of 5 to 13 blows per 0.3 metres, which reflect a loose to compact relative density. The moisture content of these deposits ranges from 21 to 32 percent.

4.4 Sensitive Silty Clay

The surficial fill/topsoil and sandy deposits are underlain by a thick deposit of sensitive, grey silty clay. The silty clay was found to have a thickness of 7.6 to 10.0 metres and to extend to depths of 9.8 to 13.0 metres below ground surface (elevation 75.5 to 77.5 metres). With the exception of boreholes 1-5 and 1-6, the grey silty clay was found to be mottled with black organic material. Atterberg limit tests carried out on samples of the silty clay gave liquid limit values ranging from 28 to 49 percent and plasticity indices of 11 to 23, which indicate a clay of low to intermediate plasticity. The Atterberg limit test results are summarized on the Plasticity Chart, Figures 1 and 2. The moisture content of the grey silty clay ranges from about 30 to 62 percent, which is near or above the measured liquid limit.

In situ vane testing carried out in the silty clay generally gave shear strengths of about 20 to 30 kilopascals between elevation 85.0 and 80.5 metres, and about 24 to 60 kilopascals below elevation 80.5 metres. The wide range in vane shear test results could be due to the presence of sandy silt seams in this deposit. A summary of the vane shear strength information is provided on Figure 10. Based on the remoulded vane shear

strengths, the sensitivity of the silty clay was found to range from about 1 to 31; the lower sensitivity values may be due to the presence of sandy silt seams in the silty clay.

Three oedometer consolidation tests were carried out on relatively undisturbed Shelby tube samples of the silty clay. The results of the consolidation tests are provided on the Void Ratio - Pressure Curves, Figures 7 to 9, inclusive. This testing shows that the apparent past preconsolidation pressure for the samples ranges from about 110 to 135 kilopascals, which is about 45 to 75 kilopascals in excess of the existing overburden pressure at the respective sample depths and locations.

4.5 Sandy Silt with Clay, Gravel, Cobbles and Boulders

A deposit of sandy silt containing clay, gravel, cobbles and boulders (glacial till) was encountered beneath the silty clay at all of the borehole locations. Where the deposit was fully penetrated with the sampling equipment (boreholes 1-1, 1-2, 1-4), the glacial till was found to have a thickness of about 11.1 to 12.8 metres and to extend to depths of about 21.8 to 22.9 metres below ground surface (elevation 64.4 to 65.6 metres). Auger refusal was encountered at boreholes 1-3 and 1-5 at depths of 14.0 to 20.5 metres (elevation 66.8 to 74.2 metres) within this deposit.

The glacial till is slightly cohesive and consists of a heterogeneous mixture of all grain sizes but may be generally described as a sandy silt containing clay, gravel, cobbles, and boulders. The results of grain size distribution tests carried out on samples of the glacial till are given on Figure 5. It should be noted that the gradation tests were carried out on 38 millimetre I.D. split barrel samples and so do not reflect the presence of cobbles and boulders which exist within the glacial till.

Standard penetration tests carried out within the glacial till at the proposed bridge location gave N values of 4 to over 100 blows per 0.3 metres, which reflect a variable,

loose to very dense relative density. The average penetration resistance N value obtained in this deposit is 21 blows per 0.3 metres.

In two out of the three boreholes taken to bedrock, it was necessary to use diamond drilling techniques in the glacial till due to the presence of cobbles and boulders.

The moisture content of the glacial till is between 5 and 12 percent.

4.6 Silt, Sand

Deposits of silt and sand were encountered beneath the glacial till deposits and above bedrock at boreholes 1-1, 1-2 and 1-4. These deposits have a thickness of between about 2.5 and 3.9 metres. At borehole 1-1, the deposit consists of sand with trace amounts of gravel and silt, whereas at boreholes 1-2 and 1-4, the deposit is composed of silt with gravel, sand, and occasional silty clay seams. Grain size distribution curves for samples of the silt encountered at boreholes 1-2 and 1-4 are provided on Figure 6. It should be noted that the grain size analyses were carried out on standard split barrel samples of the material and so do not reflect the presence of cobbles and boulders which exist within this deposit.

Standard penetration testing carried out within the silt gave N values of 67 to over 100 blows per 0.3 metres which reflect a very dense relative density. For the sand deposit at borehole 1-1, the split spoon sank under the weight of the rods, possibly due to some disturbance of the deposit during sampling due to an upward groundwater seepage into the open auger.

Diamond drilling techniques were required to penetrate the cobbles and boulders encountered in the silt at borehole 1-4.

4.7 Bedrock

The three cored boreholes at the abutment and pier locations encountered dolomitic limestone bedrock at depths of 25.1 to 26.4 metres below ground surface (elevation 61.7 to 61.9 metres).

The bedrock consists of fresh, thinly to thickly bedded, dolomitic limestone with occasional shaly limestone layers, typical of the Oxford formation.

A measure of the quality of the bedrock recovered from the boreholes is shown on the Record of Borehole sheets as the percent core recovery (REC) and Rock Quality Designation (RQD). Except for the upper, fractured bedrock zone at borehole 1-4, the core loss was low, resulting in core recovery values of 98 to 100 percent. The RQD values range from 45 to 91 percent, which reflect a poor to excellent quality bedrock.

4.8 Groundwater

Groundwater levels were obtained from standpipes sealed in the completed boreholes. On November 14, 1990, the groundwater levels in the silty clay were found to range from 0.7 to 2.1 metres below existing grade (elevation 86.0 to 87.2 metres). Multiple standpipe installations in the silty clay indicate a slight downward hydraulic gradient in this deposit. The water levels in the glacial till at borehole 1-3 and in the underlying silt at borehole 1-2 deposit were found to be at 5.2 and 1.2 metres below ground surface, respectively. It should be noted that the open hole water level in borehole 1-3 was found to be at 0.9 metres below ground surface and, therefore, the observed water level in the standpipe of 5.2 metres below ground surface may be anomalous.

The groundwater levels are expected to be higher during wet periods of the year such as the early spring.

The results of the chemical analyses on the groundwater sample from this site are as follows:

pH	- 7.70
Conductivity	- 1920 umhos per centimetre
Soluble Sulphate (SO ₄)	- 40 milligrams per litre (mg/L)
Soluble Chloride (Cl)	- 386 milligrams per litre (mg/L)

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), and signed and sealed by A.F. Chevrier, P. Eng. and R.A. Montgomery, P. Eng. The project was carried out under the technical supervision of McCormick Rankin, the supervising consultant for this project.

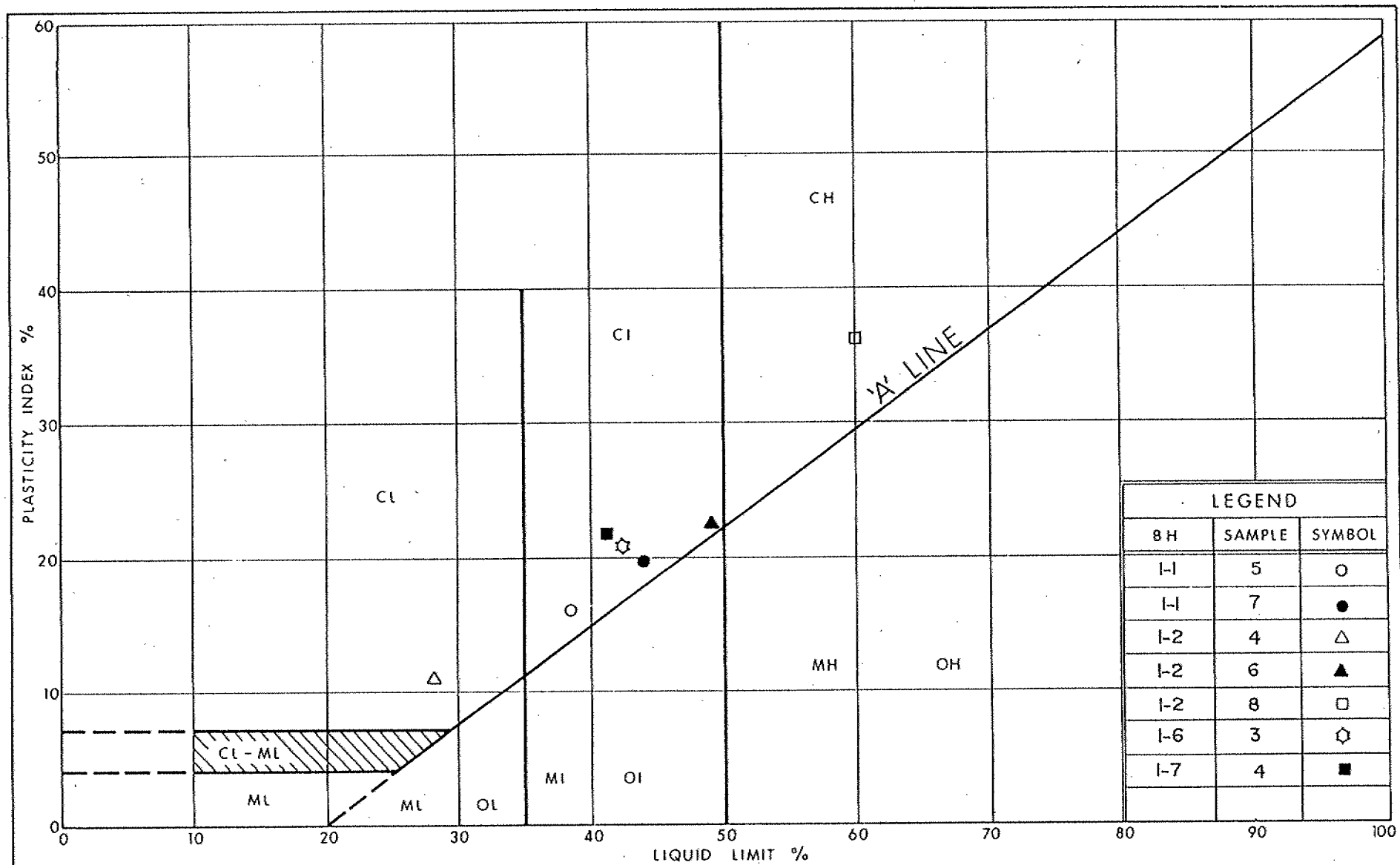


A handwritten signature in black ink, appearing to read 'D. Dundas'.

D. Dundas, P. Eng.

Sr. Foundation Engineer

APPENDIX

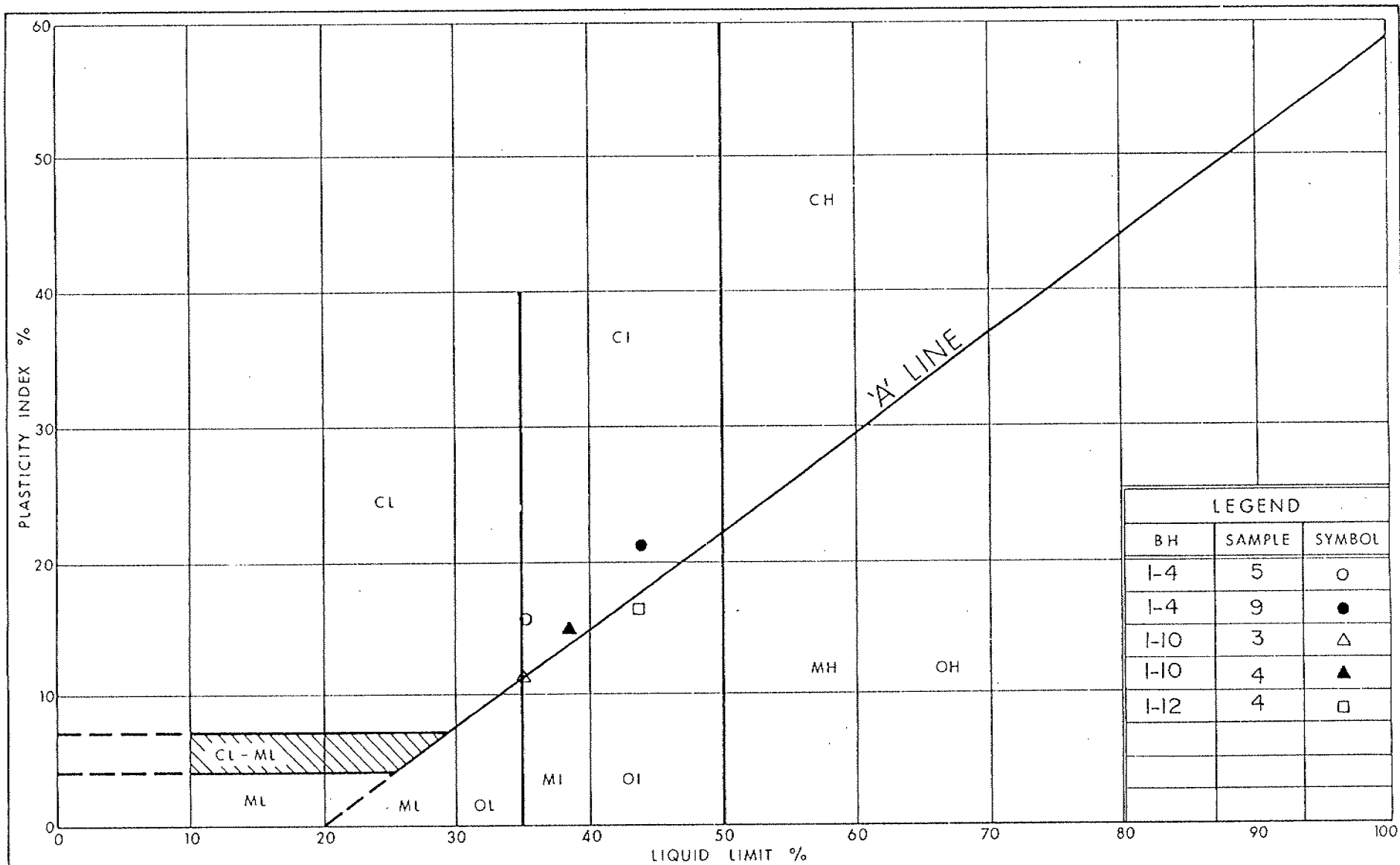


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PLASTICITY CHART SILTY CLAY

FIG No 1

W P 373-89-04



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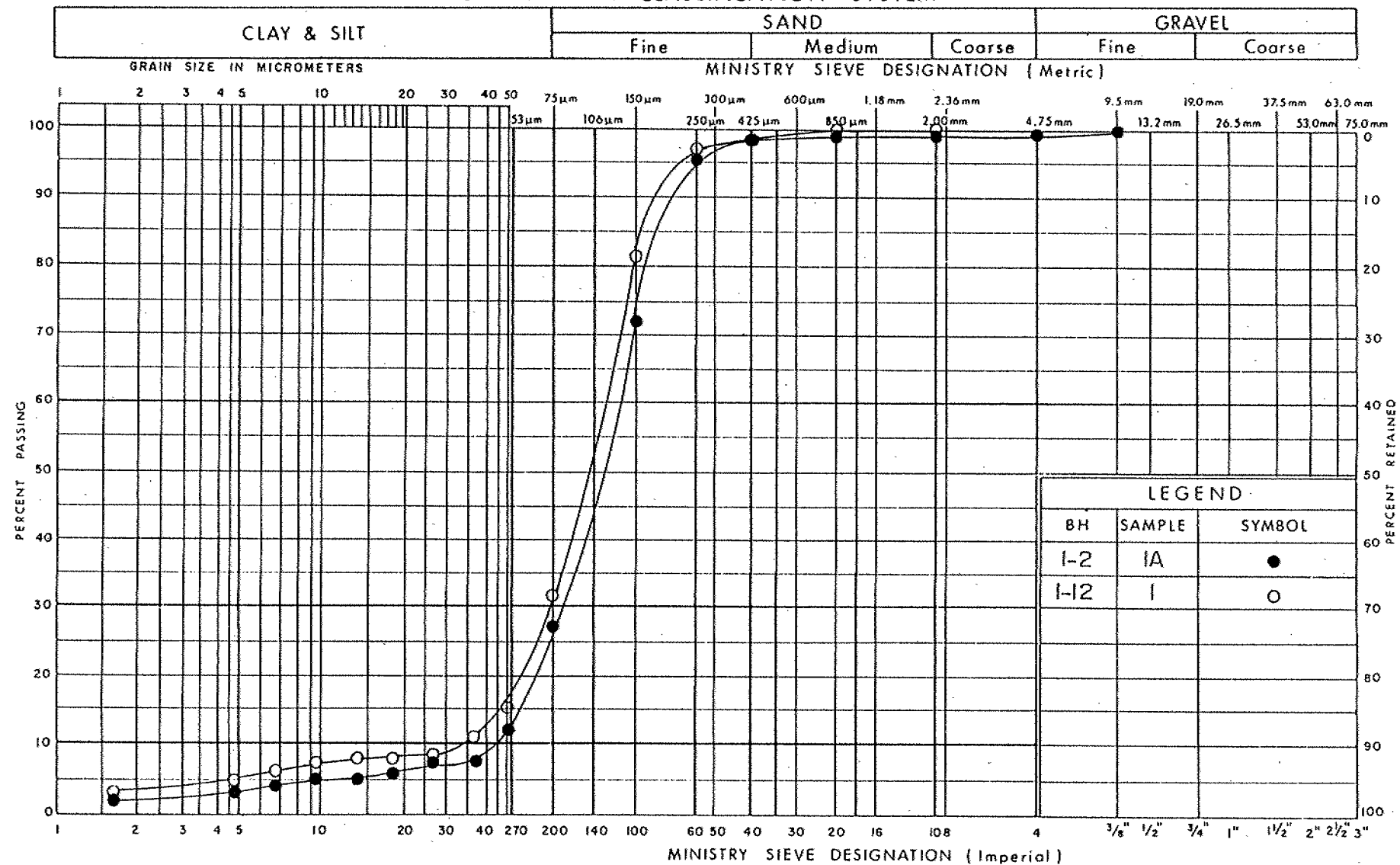
Ontario

PLASTICITY CHART SILTY CLAY

FIG No 2

W P 373-89-04

UNIFIED SOIL CLASSIFICATION SYSTEM



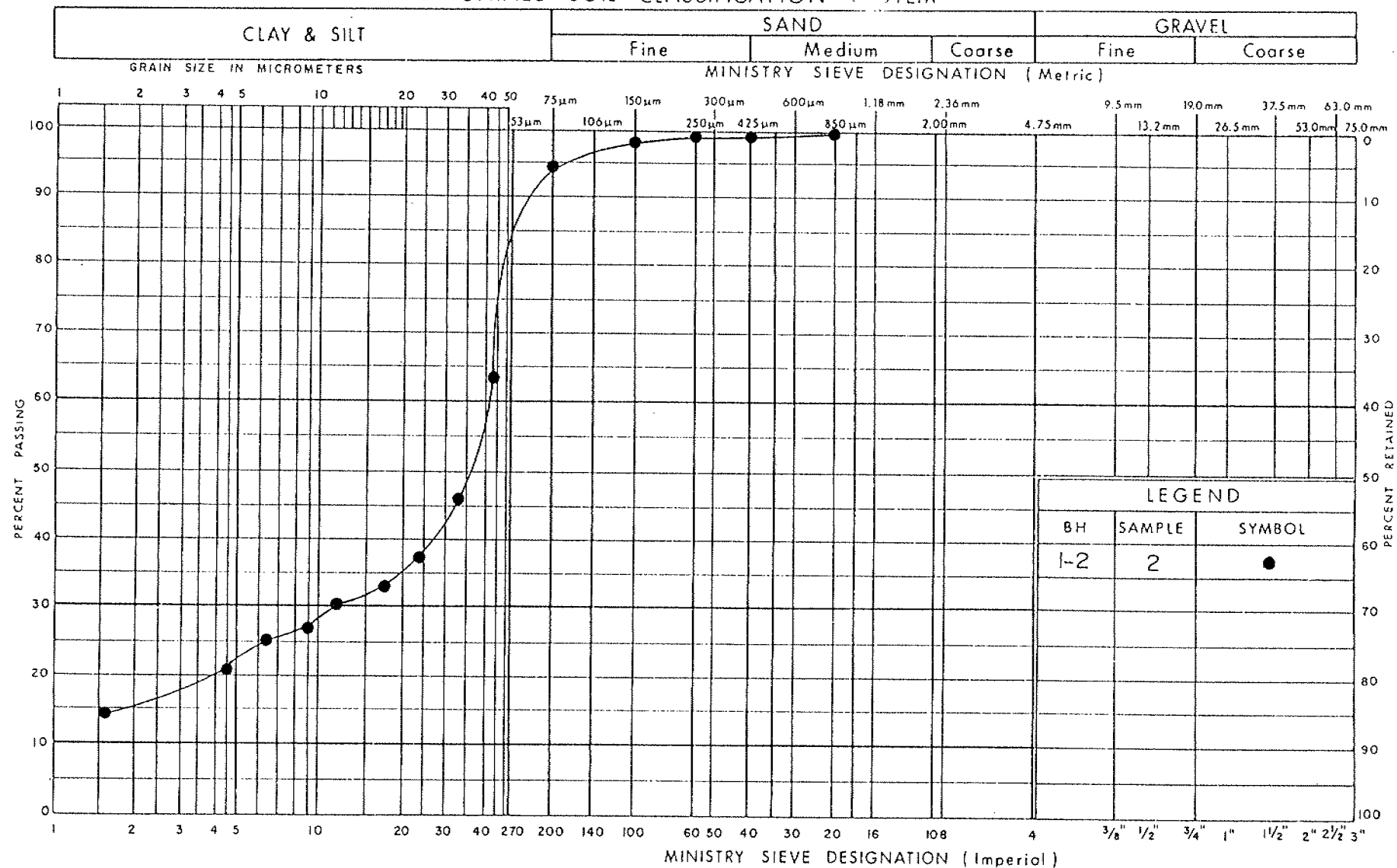
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND

FIG No 3

W P 373-89-04

UNIFIED SOIL CLASSIFICATION SYSTEM

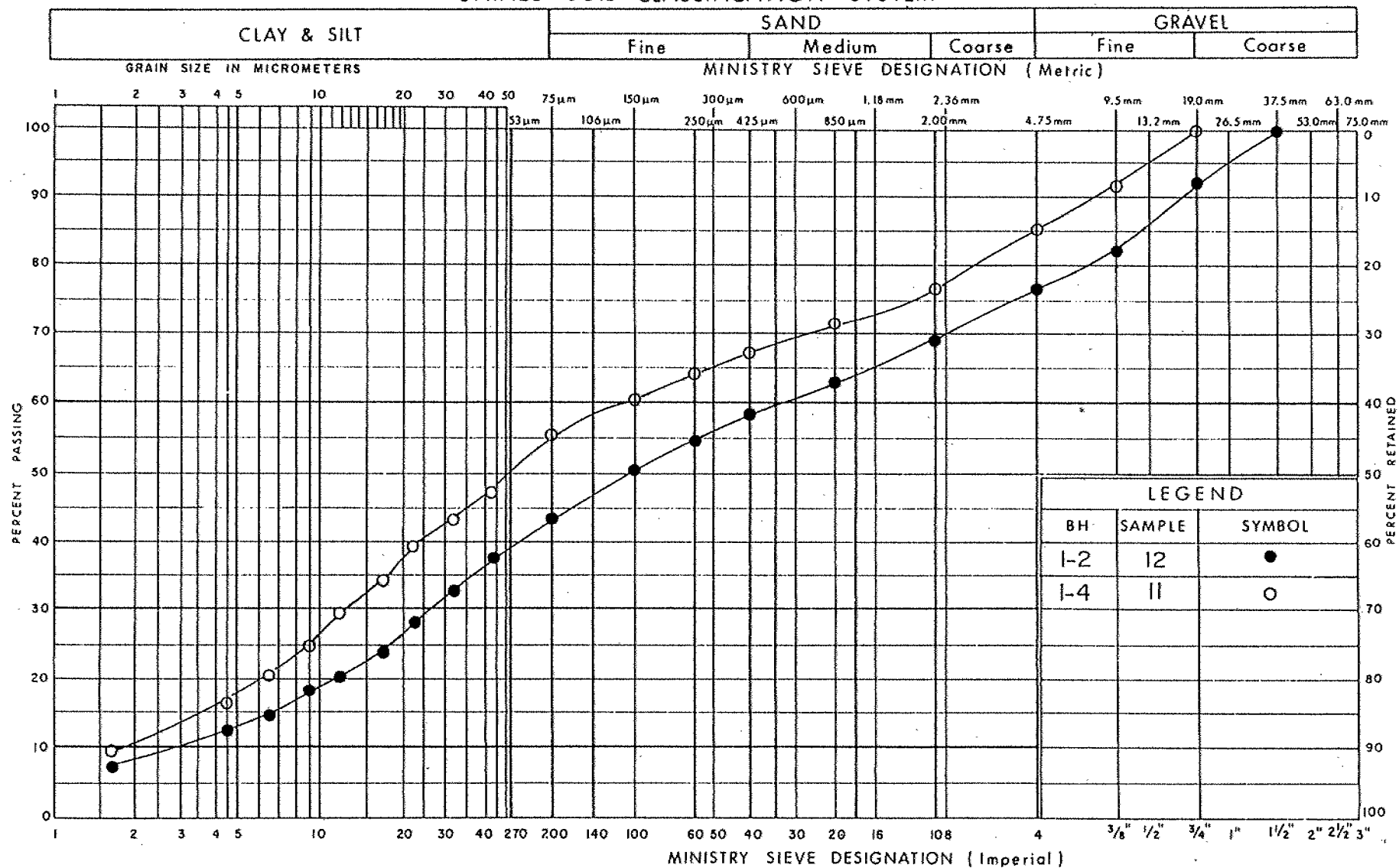

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 GRAIN SIZE DISTRIBUTION
SANDY SILT

FIG No 4

W P 373-89-04

UNIFIED SOIL CLASSIFICATION SYSTEM



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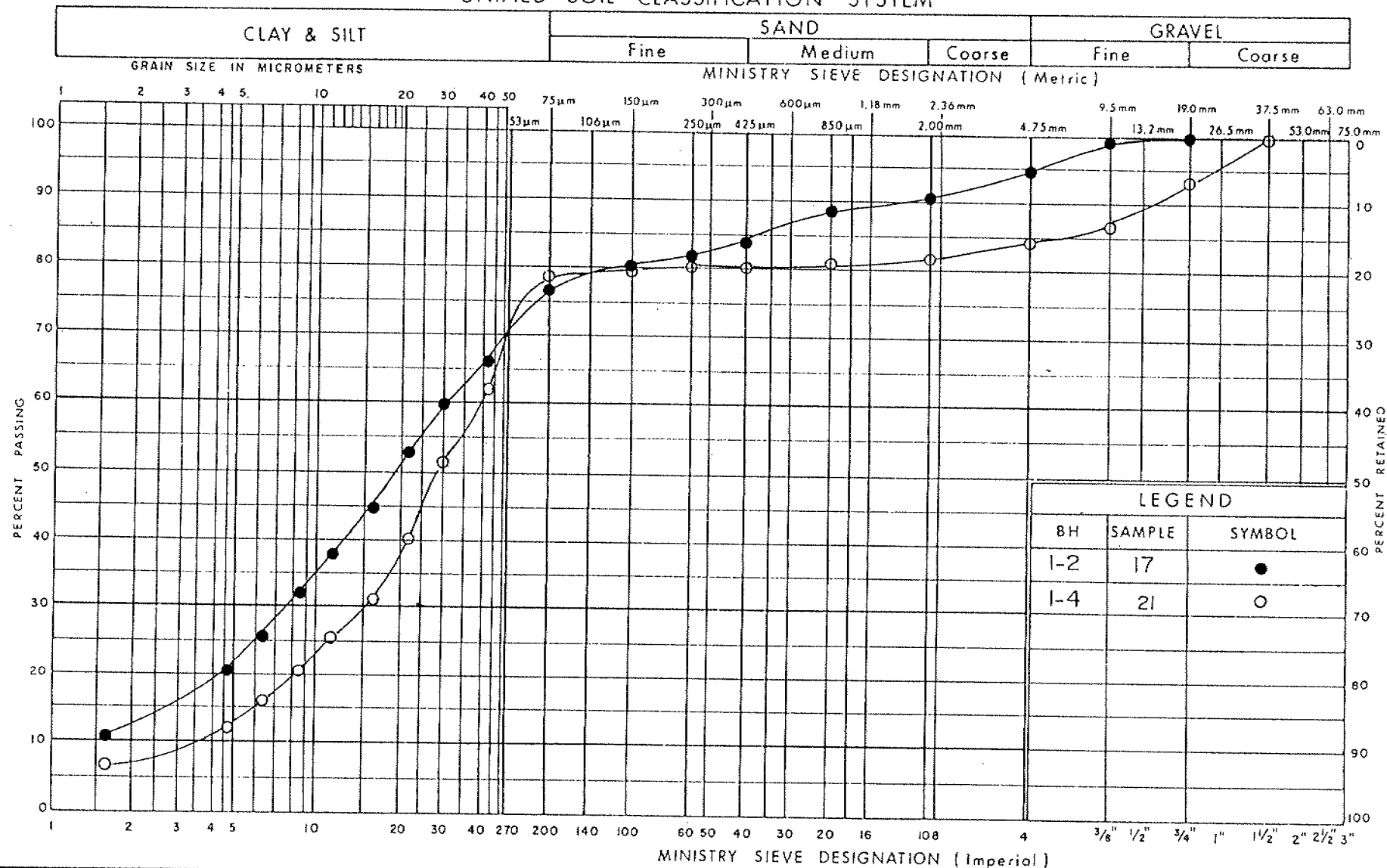
GRAIN SIZE DISTRIBUTION

SANDY SILT, trace clay
(GLACIAL TILL)

FIG No 5

W P 373-89-04

UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

GRAIN SIZE DISTRIBUTION

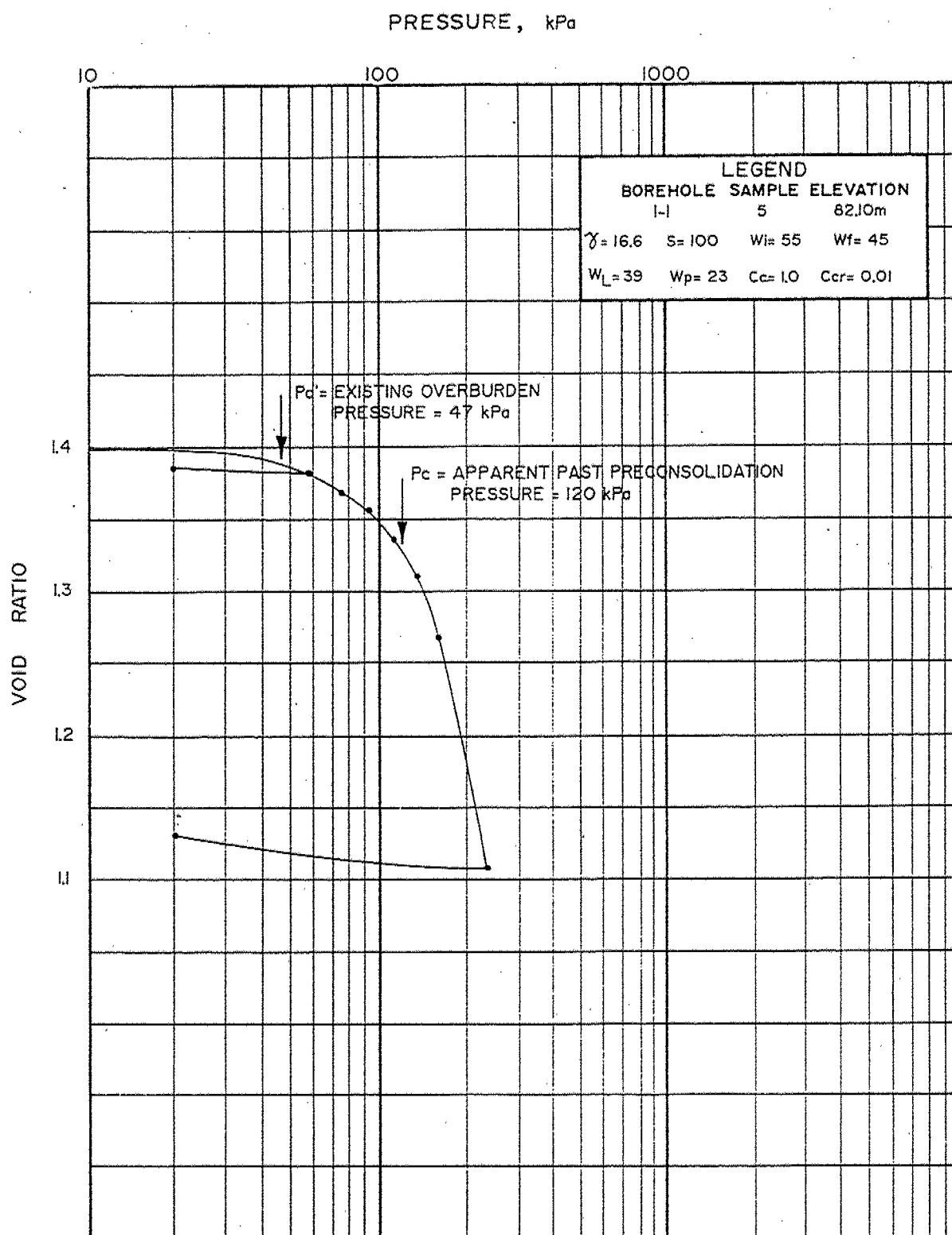
SILT, trace to some
sand and gravel

FIG No 6

W P 373-89-04

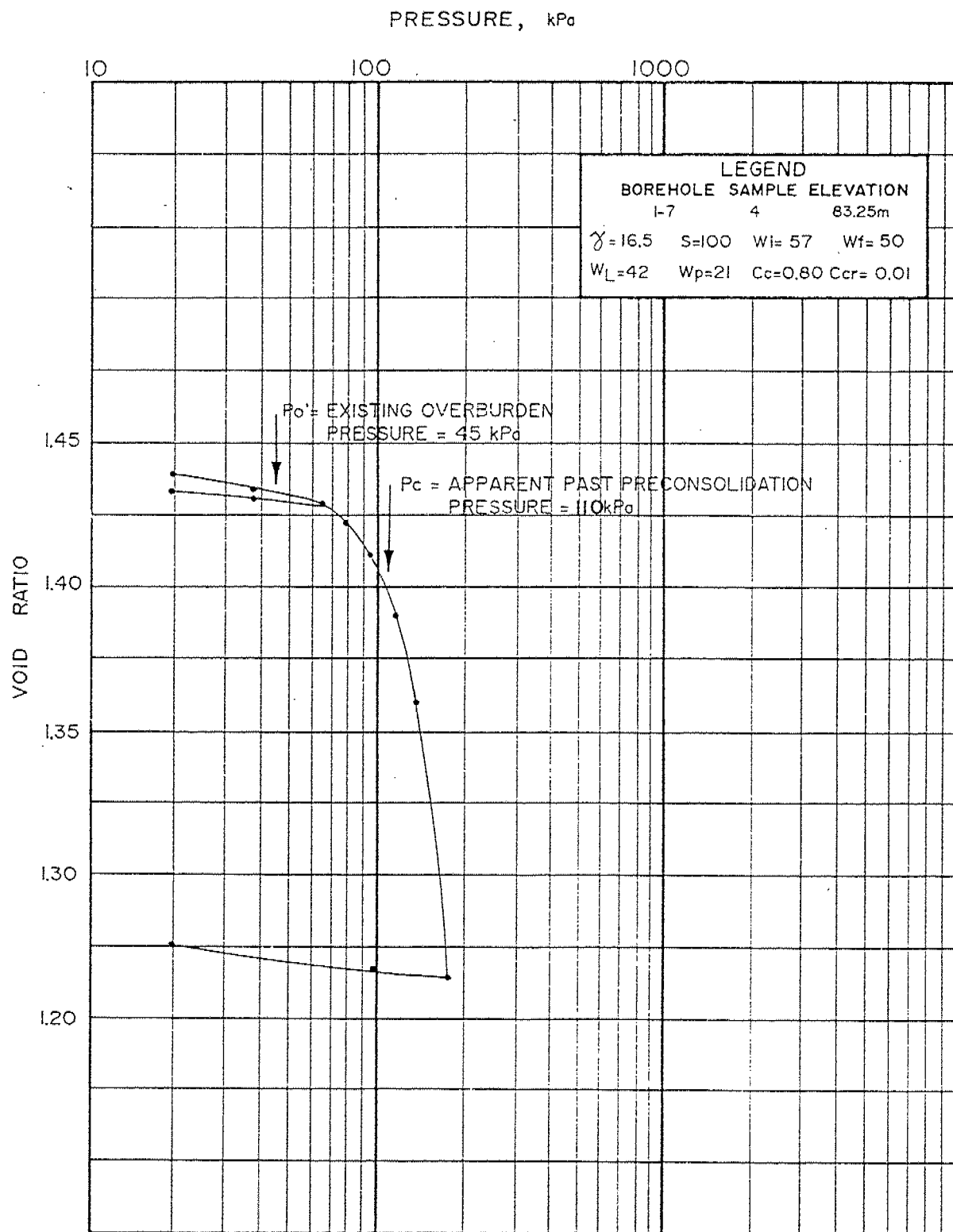
VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 7
WP 373-89-04



VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

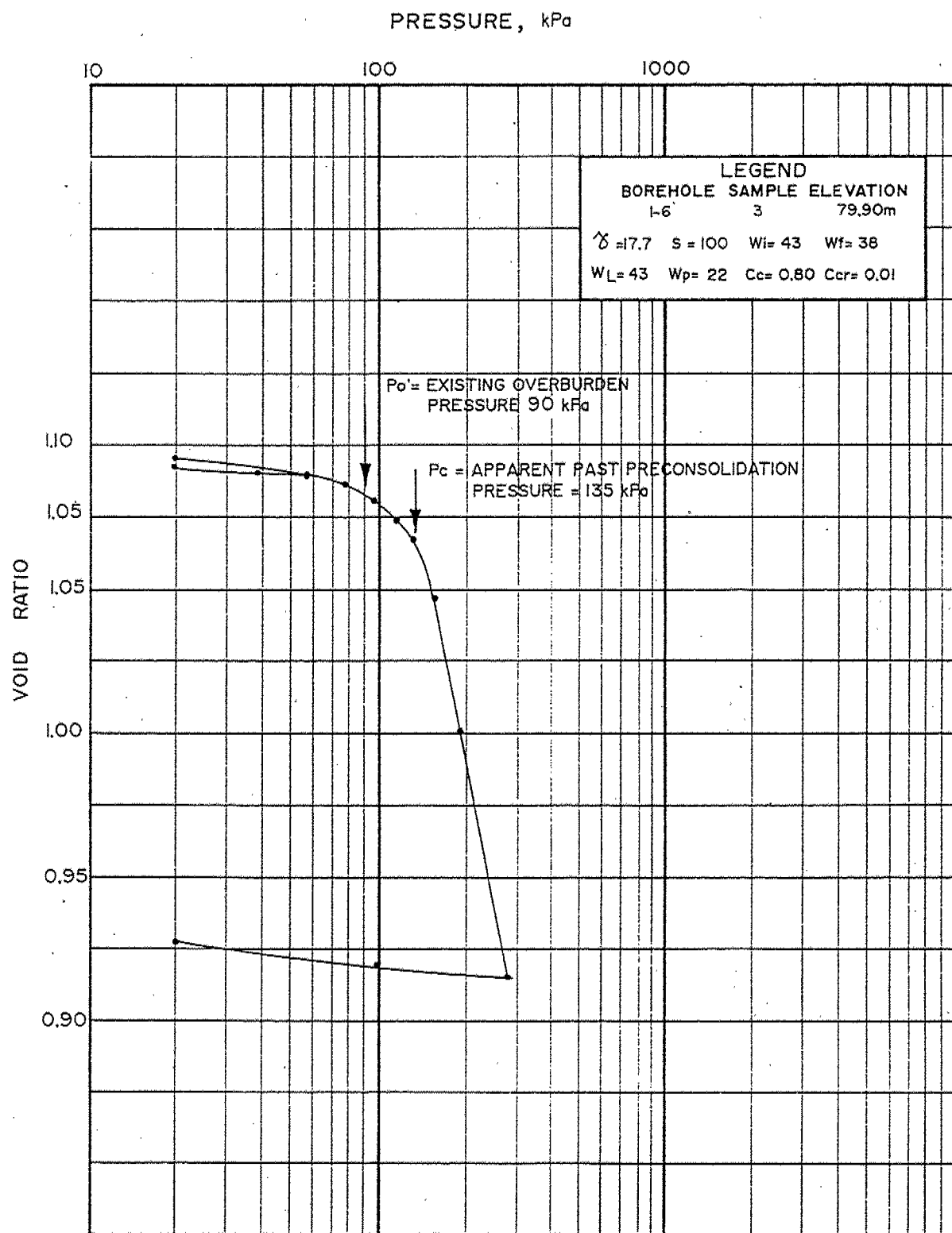
FIGURE 8
WP 373-89-04



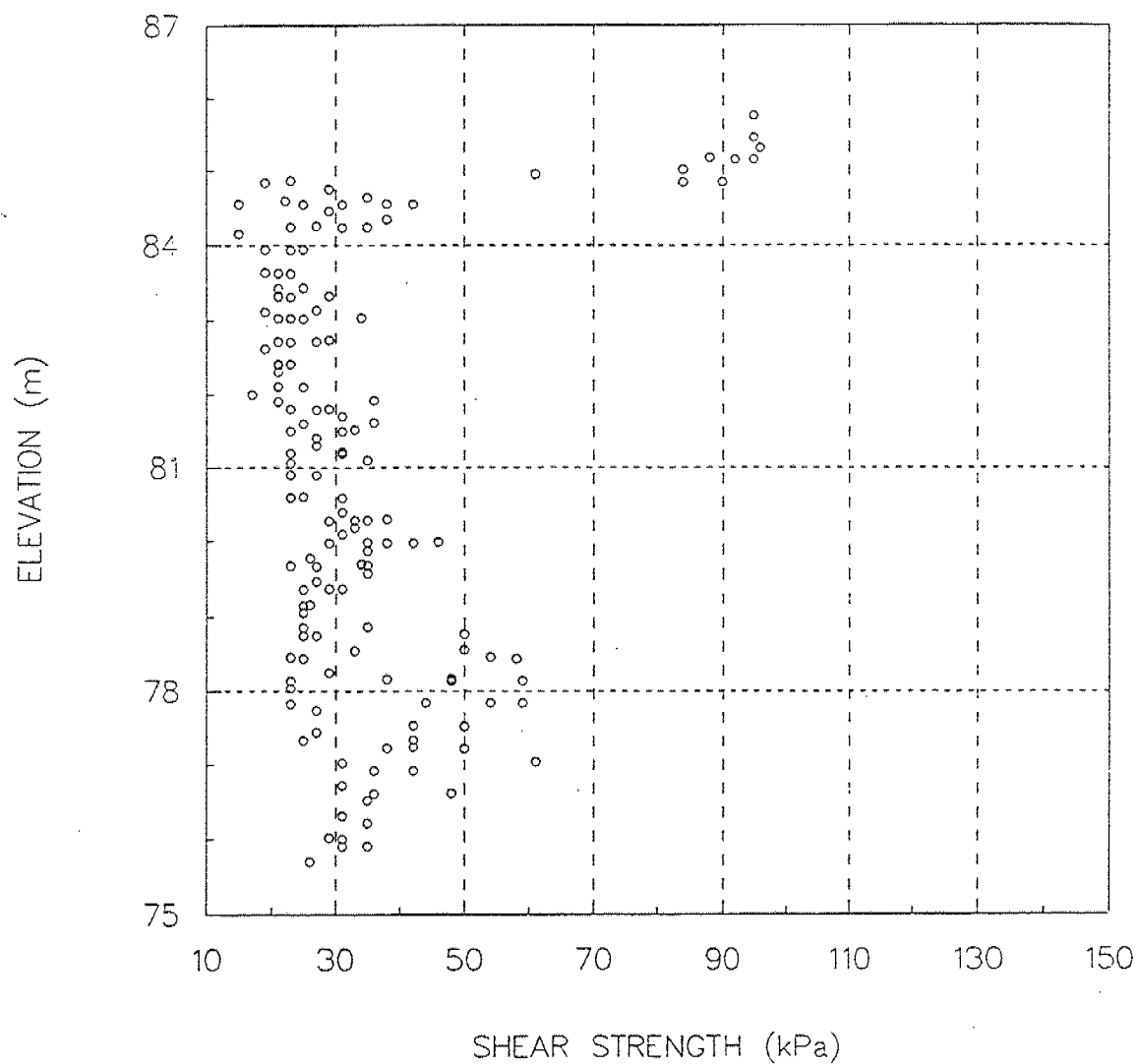
Golder Associates

VOID RATIO - PRESSURE CURVES CONSOLIDATION TEST

FIGURE 9
WP 373-89-04



Golder Associates

SUMMARY OF VANE SHEAR
STRENGTH vs. ELEVATIONFIGURE 10
WP 373-89-04Date JAN 10, 1991
Project 90I-2064B

Golder Associates

Drawn JC
Chkd. AC

METRIC

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		SHEAR STRENGTH kPa						
							○ UNCONFINED • QUICK TRIAXIAL	+ FIELD VANE × LAB VANE					
87.0	Ground Surface					20	40	60	80	100			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					W _p	W	W _L		
								SHEAR STRENGTH kPa									
87.0	Ground Surface																
0.0	Fill, sand and gravel, trace to some silt																
85.8	Compact Brown		1	SS	14												
1.2	Sandy silt, some silty clay layers		2	SS	7												
84.8	Loose Grey																
2.2	Silty clay, some sandy silt seams, trace black organic mottling		3	SS	2												
			4	SS	1												
			5	TP	PH												
			6	SS	PM												
			7	TP	PH												
			8	SS	PM												
			9	SS	18												
77.2	Firm to stiff Grey																
9.8	Sandy silt and gravel, trace clay, occasional cobble and boulder (glacial till)																
	Loose to compact Grey		10	SS	7												
			11	SS	10												
Continued																	

OFFICE REQUI UN SUR EXPLORATION.

+3, x5; Numbers refer to Sensitivity

METRIC

ORIGINATED BY DM

COMPILED BY AFO

CHECKED BY AFO

3, x⁵: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 1-2

METRIC

W.P. 373-89-04 LOCATION Co-ords N 4 993 548; E 373 025 ORIGINATED BY DM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY AFC
DATUM Geodetic DATE October 23 to 25, 1990 CHECKED BY AFC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
87.4	Ground Surface															
0.0	Fill, sand and gravel															
87.1	some silt Brown															
0.3	Silty sand															
	Loose Brown		1	SS	5											
86.2																
1.2	Sandy silt, some silty clay layers		2	SS	8											
85.3	Loose Grey															
2.1			3	SS	PM											
			4	SS	PM											
	Silty clay, some sandy silt seams, trace black organic mottling															
			5	TP	PH											
	Soft to stiff Grey		6	SS	PM											
			7	SS	WH*											
			8	SS	WH*											
76.7																
10.7	Sandy silt some gravel to sandy silt and gravel, trace clay, some sand seams, some cobbles and boulders (glacial till)		9	SS	13											
			10	SS	4											
	Loose to very dense Grey		11	SS	4											
	Continued															
	*Sank under weight of hammer															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 1-2

METRIC

W P 373-82-04 LOCATION Co-ords N 4 993 548; E 373 025 ORIGINATED BY DM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY AFC
DATUM Geodetic DATE October 23 to 25, 1990 CHECKED BY AFC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL												
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100																					
								SHEAR STRENGTH kPa																					
								O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE																					
								20 40 60 80 100					WATER CONTENT (%)																
													20 40 60																
Continued																													
	Sandy silt some gravel to sandy silt and gravel, trace clay, some sand seams, some cobbles and boulders (glacial till)		12	SS	7	Bentonite	72										23 33 36 8												
			13	SS	33		70																						
			14	SS	19		68																						
			15	SS	75		66																						
65.6			16	RC BXL	Rec= 70%		64																						
21.8			17	SS	71		62																						
	Silt, trace gravel, trace to some sand, occasional silty clay seam		18	SS	67	Standpipe	60										5 18 65 12												
			19	SS	100		58																						
			20	RC BXL	Rec= 100% RQD= 48%		56																						
61.7	Dolomitic limestone bedrock, fresh, medium to thickly bedded, occasional shaley limestone layer, occasional near vertical planar smooth joint		21	RC BXL	Rec= 100% RQD= 83%	Cave material	54																						
25.7							52																						
58.4							50																						
27.0	End of hole						48																						

*³, x⁵: Numbers refer to
Sensitivity

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15 ϕ 5 (%) STRAIN AT FAILURE
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OFFICE REPORT ON SOIL EXPLORATION

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W_p	NATURAL MOISTURE CONTENT	LQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		W	W_L		
								SHEAR STRENGTH: kP_o		WATER CONTENT (%)			
87.3	Ground Surface						O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE						
							20 40 60 80 100		20 40 60				

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 1-3

METRIC

W P 373-89-01 LOCATION Co-ords N 4 993 553; E 373 015 ORIGINATED BY DM
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC
 DATUM Geodetic DATE October 31, 1990 CHECKED BY AFC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	VALUES			20	40	60	80	100	W _p	W	W _L		
	Continued															
	Sandy silt and gravel, trace clay, occasional cobble and boulder (glacial till)	4	SS	17												
	Loose to compact															
66.8																
20.5	Auger refusal End of hole															
	*Sank under weight of hammer															

SOIL PROFILE

RECORD OF BOREHOLE No 1-4

METRIC

W P 373-89-04 LOCATION Co-ords N 4 993 623; E 373 055 ORIGINATED BY DM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY AFC
DATUM Geodetic DATE October 26 to 29, 1990 CHECKED BY AFC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.2	Ground Surface																
0.0	Fill, sand and gravel, some silt																
86.7	Compact Brown		1	SS	10												
1.5	Sand, some silt becoming silty sand		2	SS	10												
85.9	Compact Brown																
2.3	Silty clay, some silty sand seams		3	SS	10												
85.3	Stiff Grey																
2.9			4	SS	PM												
			5	TP	PH												
			6	TP	PH												
	Silty clay, some sandy silt seams, trace black organic mottling																
			7	SS	WH*												
			8	SS	WH*												
			9	SS	WH*												
	Soft to stiff Grey																
			10	SS	PM												
76.6																	
11.6																	
	Sandy silt, some gravel trace clay, some cobbles and boulders (glacial till)		11	SS	50 for 0.08 m												
			12	RC BXL	Rec- 100%												
	Loose to very dense Grey		13	SS	8												
	Continued																

*3, x5: Numbers refer to
Sensitivity

20
15 x 5 (%) STRAIN AT FAILURE
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15 30 45 10

RECORD OF BOREHOLE No I-4

METRIC

W P 373-89-04 LOCATION Co-ords N 4 993 623; E 373 055 ORIGINATED BY DM
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core COMPILED BY AFC
 DATUM Geodetic DATE October 26 to 29, 1990 CHECKED BY AFC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA Si CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
								O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE												
Continued																				
	Sandy silt, some gravel, trace clay, some cobbles and boulders (glacial till)		14	SS	8															
	Loose to dense		15	SS	8															
	Grey		16	SS	29															
	Very dense		17	RC BXL	Rec= 65%															
	Grey		18	SS	31															
	Dolomitic limestone bedrock, fresh, medium to thickly bedded, occasional shaley limestone layer, fractured core at 26.9 metres		19	SS	44															
65.3																				
22.9	Silt, trace sand, some gravel, occasional silty clay seam, some cobbles and boulders		20	RC BXL	Rec= 85%															
	Very dense		21	SS	76															
	Grey		22	RC BXL	Rec= 30%															
	Very dense		23	SS	94 for 0.18 m															
	Grey		24	RC BXL	Rec= 18%															
61.8																				
26.4	Dolomitic limestone bedrock, fresh, medium to thickly bedded, occasional shaley limestone layer, fractured core at 26.9 metres		25	SS	75 for 0.08 m															
	Grey		26	RC BXL	Rec= 90% RQD=83%															
	Dolomitic limestone bedrock, fresh, medium to thickly bedded, occasional shaley limestone layer, fractured core at 26.9 metres		27	RC BXL	Rec= 98% RQD=91%															
58.4																				
29.8	End of hole																			

*3, x5: Numbers refer to
Sensitivity

20
15
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5 (% STRAIN AT FAILURE

VERTICAL ALTERNATE SOIL EXPLORATION

*Sank under weight of hammer
 **Rec = Recovery
 RQD = Rock Quality Designation

RECORD OF BOREHOLE No 1-5

METRIC

W P 373-89-04 LOCATION Co-ords N 4 993 631; E 373 042 ORIGINATED BY DM
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC
 DATUM Geodetic DATE October 30, 1990 CHECKED BY AFC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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					
88.2	Ground Surface																
0.0	Fill, sand and gravel, some silt and cobbles						88										
87.2	Brown																
1.0	Sandy silt																
86.1	Brown						86										
2.1	Silty clay																
85.1	Stiff Grey																
3.1	Silty clay, some sandy silt seams		1	SS	PM												
			2	TP	PH		84										
	Soft to stiff Grey						82										
							80										
			3	SS	WH*		78										
77.5	Sandy silt some gravel, trace clay, occasional cobble and boulder (glacial till)																
10.7																	
	Dense. Grey		4	SS	34		76										
74.2																	
14.0	Auger refusal End of hole						74										
	*Water level not established **Sank under weight of hammer																

OFFICE REPORT ON SOIL EXPLORATION

METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ (KN/m^3)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100			
88.5	Ground Surface						○ UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 20 40 60			
0.0	Fill, sand						20 40 60 80 100	20 40 60		GR SA SI	

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 1-7

METRIC

W P 173-B9-04 LOCATION Co-ords N 4 993 525; E 373 005 ORIGINATED BY DM
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC
DATUM Geodetic DATE November 1, 1990 CHECKED BY AFC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
87.6	Ground Surface													
0.0	Fill, sand and gravel, some silt and cobbles													
86.8	Brown													
0.8	Silty sand, some silty clay layers		1	SS	14									
			2	SS	8									
85.3	Brown													
2.3	Silty clay, some sandy silt seams, trace black organic mottling		3	SS	1									
			4	TP	PM									
			5	TP	WR*									
			6	TP	PH									
			7	TP	PH									
			8	SS	8									
77.1	Sandy silt, some gravel, trace clay (glacial till)													
76.3	Loose													
11.3	End of Hole													
	*Sank under weight of rods													

*3, *5: Numbers refer to
Sensitivity

20
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5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

METRIC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE							"N" VALUES
88.5	Ground Surface						SHEAR STRENGTH k_p ○ UNCONFINED × FIELD VANE • QUICK TRIAXIAL + LAB VANE 20 40 60 80 100				

SOIL PROFILE						SAMPLES	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	Liquid Limit W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	"N" VALUES	GROUN WATER CONDITIONS	ELEVATION SCALE	Shear Strength kPo ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%)				
88.5	Ground Surface	X						20 40 60 80 100	20 40 60				GR SA SI CL
0.0	Fill, sand and gravel, some silt and cobbles	X					88						
97.3	Brown Topsoil, sandy silt, trace organic material	X											
86.4	Dark grey Silty clay with silty sand and sandy silt layers	X	1	SS	10			Water level in standpipe at elev. 86.7 metres on Nov. 14, 1990 ○					
85.4	Stiff Grey brown	X	2	SS	5		Native backfill			O			
3.1		X	3	SS	2			+ S=5 + S=6		O			
	Silty clay, some sandy silt seams, trace black organic mottling	X	4	SS	WH*			+ S=8 + S=8		O			
		X					Bentonite	+ S=11					
		X	5	TP	WR**		Sand Standpipe	+ S=8		O			
		X					Bentonite	+ S=4 + S=18					
	Soft to firm Grey	X					80	+ S=22					
		X	6	SS	WH*			+ S=7 + S=6		O			
		X					78	+ S=9 + S=9 + S=7					
75.5		X					76	+ S=9 + S=7					
13.0	Sandy silt, some gravel, trace clay (glacial till)	X											
74.2	Loose Grey	X	7	SS	9								
14.3	End of Hole *Sank under weight of hammer **Sank under weight of rods	X					74						

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+3, x5: Numbers refer to Sensitivity

METRIC

URFILE KEXUKI UN SOIL EXPLORATION

* 3, x 5: Numbers refer to Sensitivity

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+3, x5: Numbers refer to Sensitivity

METRIC

[illegible]

* 3, x⁵: Numbers refer to Sensitivity

RECORD OF BOREHOLE No I-12

METRIC

W P 373-B9-04 LOCATION Co-ords N 4 993 430: E 372 970 ORIGINATED BY DM
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AFC
 DATUM Geodetic DATE November 8, 1990 CHECKED BY AFC

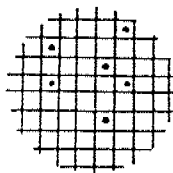
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION [%] GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										WATER CONTENT [%]		
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										20 40 60		
88.8	Ground Surface																			
0.0	Fill, sand and gravel, some silt and cobbles																			
87.0	Brown																			
1.8	Silty sand		1	SS	12															
86.7	Brown																			
2.1	Sandy silt with silty clay layers		2	SS	9															
85.7	Loose																			
3.1			3	SS	1															
	Silty clay, some sandy silt seams trace black organic mottling																			

July 1991

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901-2064B-2

APPENDIX A

CHEMICAL ANALYSIS OF GROUNDWATER SAMPLE



REPORT OF ANALYSES

CLIENT: Golder Assoc.

LAB REPORT NO: A1-0472

DATE: March 22, 1991

Attention: A.Chevrier

PROJECT: 901-2064B

PARAMETER	UNITS	Sample	Sample	Sample	Sample	Sample
Fe	mg/L					
Mn	mg/L					
Hardness	mg/L CaCO ₃					
Alkalinity	mg/L CaCO ₃					
pH		7.77				
Conductivity	umhos/cm	1920				
F	mg/L					
Na	mg/L					
N-NO ₃	mg/L					
N-NO ₂	mg/L					
N-NH ₃	mg/L					
SO ₄	mg/L	40				
Cl	mg/L	386				
Phenols	mg/L					
Turbidity	NTU					
Colour	Pt/Co Units					
Ca	mg/L					
Mg	mg/L					
Tann./Lig.	mg/L					
Total N	mg/L					
K	mg/L					

ANALYST: 

FOUNDATION INVESTIGATION REPORT

for

Regional Road 13 Underpass

W.P. 371-89-02, District 9, Ottawa

Highway 416, Str. Site 3-574

1.0 INTRODUCTION

Strata Engineering Corporation has been retained by M.M. Dillon Consulting Engineers to conduct a geotechnical study for a proposed interchange at future Highway 416 and Regional Road 13. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full foundation report.

This report, which follows a letter report dated 1991 01 03, is submitted in compliance with these terms of reference.

2.0 SITE AND GEOLOGY

The site is located in Rideau Township approximately 45 km south of Ottawa along Highway 16. The site location is shown on the key plan in Drawing No. 3718902-A*.

The topography is gently undulating. South of the site the land is used as pasture. To the north there is a small poorly drained area. Limestone boulders are present at the surface.

This site lies within the physiographic region known as the North Gower Drumlin Field. The drumlins are oriented more or less north-south. In some areas, these glacial deposits are draped with marine clays.

Bedrock in this area has been mapped as magnesium limestone to dolostone of the Oxford Formation, Lower Ordovician age.

3.0 FIELD AND LABORATORY WORK

The field work took place between 1990 10 03 and 10. Eight boreholes were drilled, of which five were placed near proposed structure footing locations and three were placed at approach fill and high ramp locations. The borehole locations are shown on Drawing No. 3718902-A*.

The boreholes for the structure were drilled as close as possible to the footing locations staked out by M.M. Dillon personnel who also provided the borehole elevations, which are referenced

* Sheet No 138 of the Contract Drawings.

to Geodetic datum.

Drilling was conducted with two CME 55 bombardier mounted drill rigs. Hollow stem augers as well as wash boring using N sized casing were used to advance the boreholes. All boreholes, with the exception of Borehole 6, were accompanied by dynamic cone penetration tests.

The overburden was sampled by means of the Standard Penetration Test. Bedrock was cored at all five structure borehole locations.

Water levels were noted in the uncased boreholes after the last soil sample was taken. Perforated standpipes with bentonite seals were installed in Boreholes 2, 3, 5 and 6. All other boreholes were backfilled with native soil cuttings. The water levels in the standpipes were monitored over a period of time.

Recovered soil samples were transported to our Don Mills laboratory where they were visually examined and classified. Index properties such as field moisture content and grain size analyses were performed. The results are shown on the Office Record of Boreholes and on Figure 1, 2 in the Appendix. All rock cores were examined for recovery and their RQD's noted.

4.0 SUBSURFACE CONDITIONS

4.1 General

The soil conditions comprise mostly non-cohesive glacial till overburden consisting of sandy silt overlying gravelly sand above bedrock.

4.2 Sandy Silt (Glacial Till)

Sandy silt with trace to some gravel (glacial till) was found in Boreholes 1 and 7 from surface to depths of approximately 2 m. The moisture content ranged from 12 to 18 per cent. Grain size curves of this deposit are shown on Figure 1. N values of 15 to 42 blows/0.3 m indicate this deposit to be compact to dense.

4.3 Gravelly Sand to Sandy Gravel (Glacial Till)

Below the sandy silt (glacial till) in Boreholes 1 and 7 and from surface down in the other boreholes there is a deposit of gravelly sand to sandy gravel (glacial till) with random cobbles and boulders. This deposit lies immediately above the bedrock. The thickness of this deposit varies between 1.8 m and 4.1 m. The moisture content ranged from 10 to 20 per cent with the average being 12 per cent. The grain size distribution for this deposit is shown in envelope form on Figure 2 in the Appendix.

N values ranged from 11 to 137 blow/0.3 m with most values being about 30 blows/0.3 m, with

lower values being recorded due to localized compact zones. Generally the deposit is dense.

4.4 Limestone Bedrock

Bedrock was cored in the five structure boreholes. The upper 1.5 m to 3 m of the rock was found to be fractured, with low core recoveries (as low as 50%) and RQD values of less than 40%. Below this fractured or weathered zone, core recoveries increased to over 90% and the RQD's improved to between 74% and 89%.

5.0 GROUNDWATER CONDITIONS

Groundwater observations are summarized below:

Borehole	W.L. Depth (m)	W.L. Elev.(m)	Date
1	0.5	86.6	1991 10 10
2	1.0	86.3	1991 10 26
3	1.1	86.5	1991 10 26
4	2.1	86.5	1991 10 05
5	1.7	86.5	1991 10 16
6	1.2	87.0	1991 10 10
7	4.1	85.5*	1991 10 03

* Not stabilized

7.0 CLOSURE

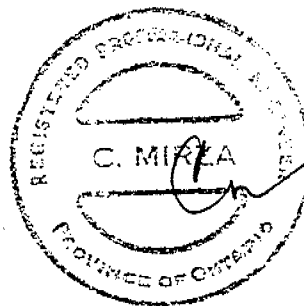
The field work for this investigation was carried out by A. C. Abel. The drilling equipment was rented from F.E. Johnston and Marathon Drilling companies, Ottawa.

Respectfully submitted:
STRATA ENGINEERING CORP.

ACA/rl

A. C. Abel, M. Sc.
Project Engineer

ACA/rl



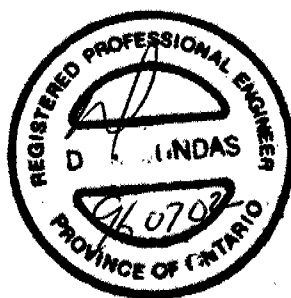
[Signature]
C. Mirza, P. Eng.
Senior Principal

Report Distribution:
M.M. Dillon
Strata File E-90-036C

15 copies
1 copy

Computer File: E90036C.REP

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Strata Engineering Corp. (consulting geotechnical engineers for this project), and signed and sealed by C. Mirza, P. Eng. and A.C. Abel, M.Sc. The project was carried out under the technical supervision of M.M. Dillon, the supervising consultant for this project.



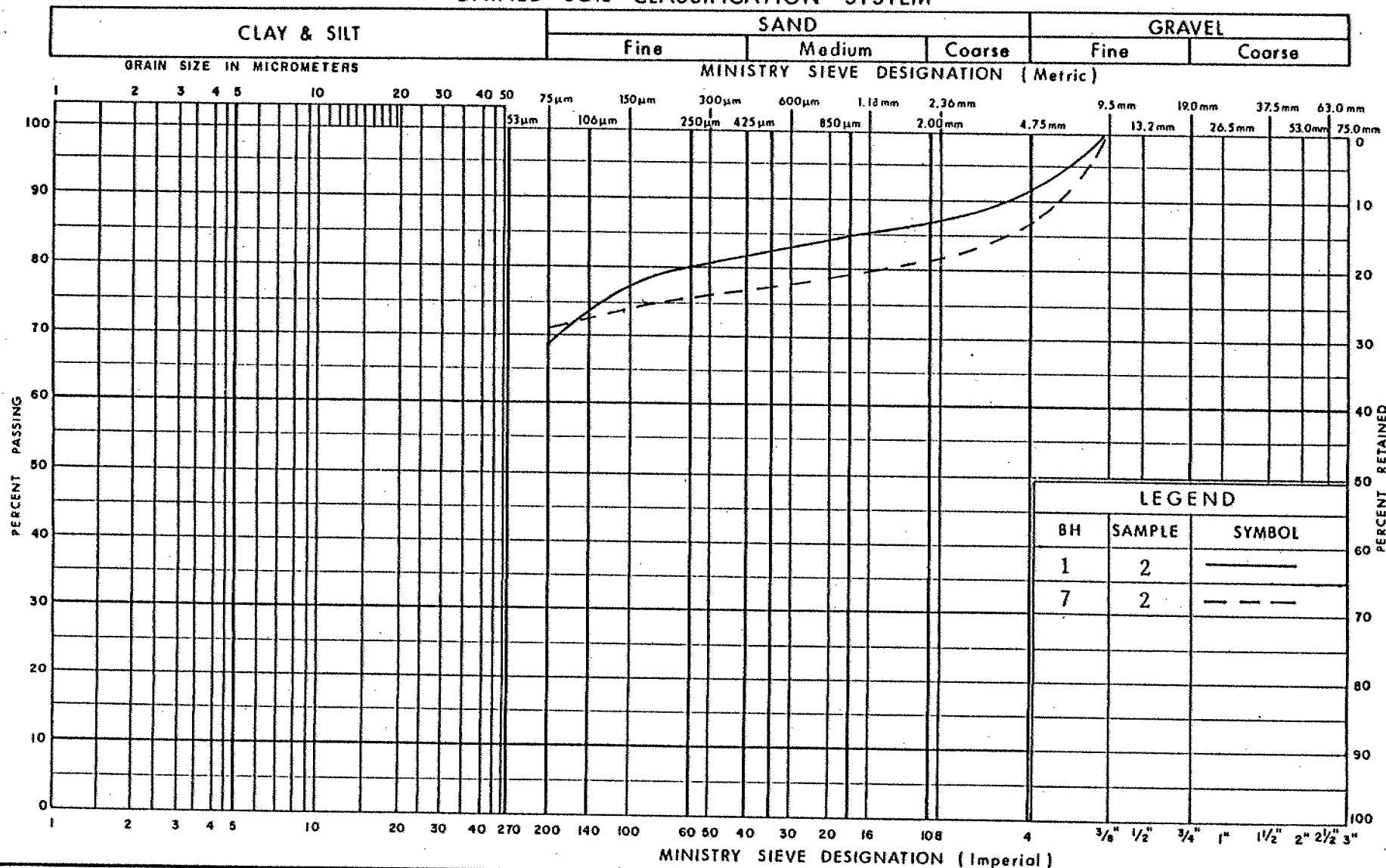
A handwritten signature in black ink, appearing to read "D. Dundas".

D. Dundas, P. Eng.

Sr. Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION

Sandy Silt some to trace Gravel
(Glacial Till)

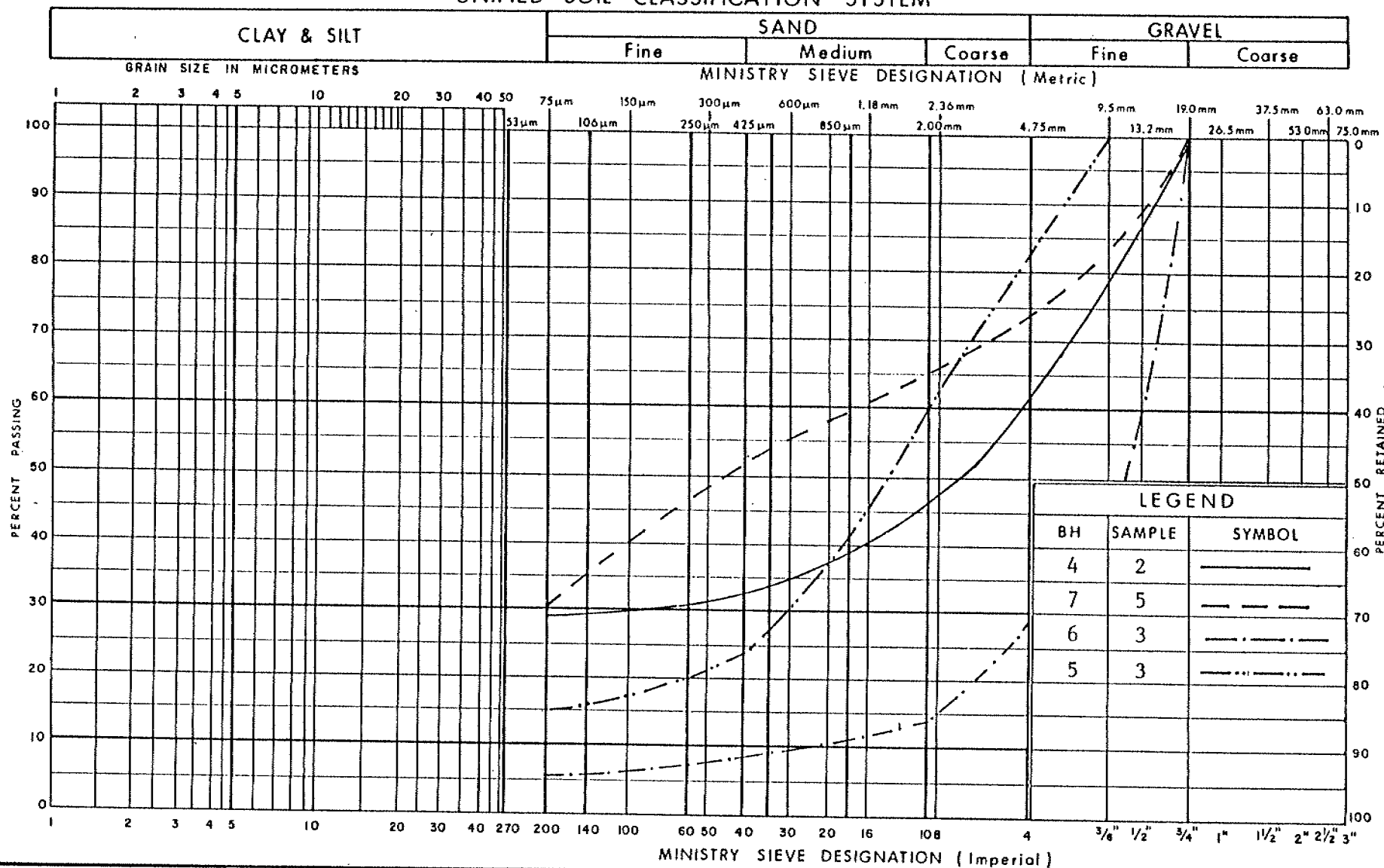
FIG No 1

W P 371-89-02

Regional Rd. 13

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UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sandy Gravel
with to trace Silt (Glacial Till)

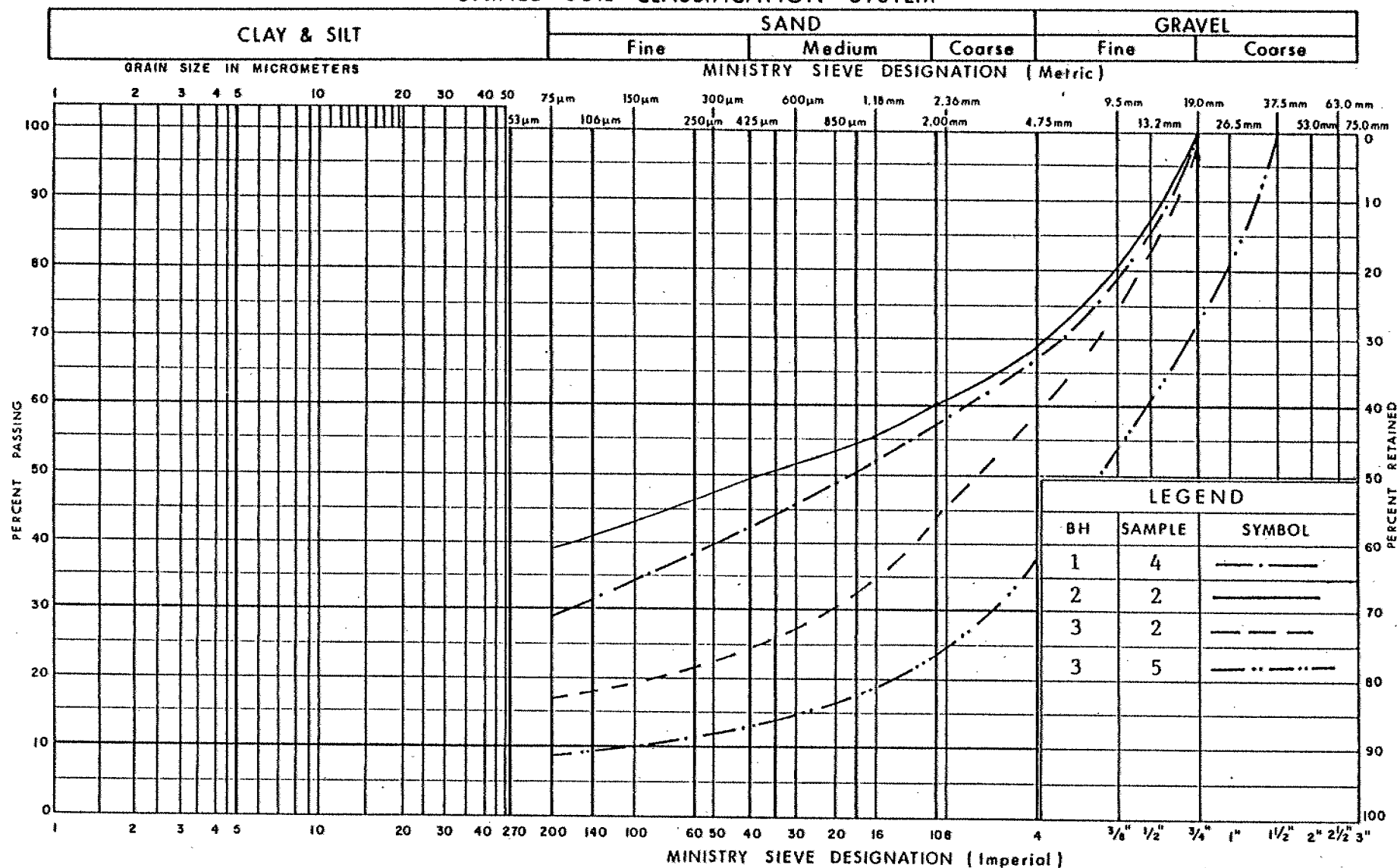
FIG No 2A

W P 371-89-02

Regional Rd. 13

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UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sandy Gravel
With to trace Silt (Glacial Till)

FIG No 2B

W P 371-89-02

Regional Rd. 13

RECORD OF BOREHOLE No1										METRIC			
W P 371-89-02			LOCATION N: 4 994 962 ; E: 371 550				ORIGINATED BY A.A.						
DIST 9 HWY 416			BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test				COMPILED BY A.K.						
DATUM Geodetic			DATE 1990 10 10				CHECKED BY C.M.						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
87.1	Ground Surface												
0.0	Sandy Silt trace Gravel (Glacial Till)		1	SS	15		87.0						W.L. on 1990 10 10
	Compact occ. Cobbles and Boulders Brown		2	SS	23		86.0						9 23 (68)
85.1	Gravelly Sand to Sandy Gravel with Silt (Glacial Till)		3	SS	28		85.0						
2.0	occ cobbles & Boulders Compact to Very Dense Brown		4	SS	84		84.0						33 38 (29)
83.2			5	SS	100	7.5cm							
3.9	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No2

METRIC

W P 371-89-02 LOCATION N: 4 994 930.0; E: 371 492.8 ORIGINATED BY A. A.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
 DATUM Geodetic DATE 1990 10 09 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
87.3	Ground Surface														GR SA SI CL
0.0	Gravelly Sand to Sandy Gravel with Silt (Glacial Till)														
	Compact to Very Dense		1	SS	11										
85.5	occ. Cobbles & Boulders Brown		2	SS	70/2	cm									W.L. on 1990 10 26
1.8	Limestone Bedrock Poor Quality - - Fractured		3	PX RC	Rec 89%										32 31 (37)
	Excellent Quality		4	BX RC	Rec 98%										RQD = 38%
83.9	Sound														RQD = 89%
3.4	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 371-89-02

LOCATION N: 4 994 908.6; E: 371 461.0

ORIGINATED BY A.A.

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test

COMPILED BY A. K.

DATUM Geodetic

DATE 1990 10 09

CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
87.6	Ground Surface										
0.0	Gravelly Sand to Sandy Gravel some Silt (Glacial Till) Occ. Cobbles & Boulders Dense Brown		1	SS	47		87.0				W. L. on 1990 10 26 42 42 (16) 64 29 (7) RQD = 13% RQD = 9% RQD = 36%
			2	SS	39		86.0				
			3	BX	Boulder		85.0				
			4	SS	30		84.0				
83.8			5	SS	50		83.0				
3.8	Limestone Bedrock Fractured Very Poor to Poor Quality		6	BX RC	Rec 57%		82.0				
			7	BX RC	Rec 88%		81.0				
			8	EX RC	Rec 98%						
80.7											
6.9	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 371-89-02 LOCATION N: 4 994 895 ; E: 371 425.2 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 05 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION [%] GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
88.6	Ground Surface												
0.0	Gravelly Sand to Sandy Gravel with Silt (Glacial Till)		1	SS	98								
	occ. Cobbles & Boulders		2	SS	96/23cm								
	Very Dense to Dense												
	Brown		3	SS	40								
84.6													
4.0	Limestone Bedrock Fractured Poor Quality		4	BX RC	Rec 88%								RQD = 13%
			5	BX RC	Rec 90%								RQD = 31%
	Sound		6	FX RC	Rec 90%								RQD = 75%
	Good Quality		7	EX RC	Rec 90%								RQD = 80%
81.6													
7.0	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No5

METRIC

W P 371-89-02 LOCATION N: 4 994 954.4; E: 371 485.0 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 10 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20	40					
87.7	Ground Surface													GR SA SI CL
0.0	Gravelly Sand to Sandy Gravel some Silt (Glacial Till)		1	SS	25									
	occ. Cobbles & Boulders		2	SS	32									W.L. on 1990 10 16
	Compact to Very Dense		3	SS	12									18 67 (15)
84.4	Brown		4	SS	50									
3.3	Limestone Bedrock		5	BX RC	Rec 50%									RQD = 16%
	Fractured		6	BX RC	Rec 55%									RQD = 18%
	Poor Quality		7	BX RC	Rec 81%									RQD = 36%
	Sound		8	BX RC	Rec 96%									RQD = 90%
	Excellent Quality													
79.8														
7.9	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No6

METRIC

W P 371-89-02 LOCATION N: 4 994 914.8; E: 371 415.4 ORIGINATED BY A.A.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, wash Casing COMPILED BY A.K.
 DATUM Geodetic DATE 1990 10 04 CHECKED BY G.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
88.2	Ground Surface														
0.0	Gravelly Sand to Sandy Gravel trace Silt (Glacial Till) Occ. Cobbles & Boulders		1	SS	43										
	Compact		2	SS	25										
	Brown.		3	BX	Boulder										
			4	SS	20										
			5	BX	Boulder										
84.1															
4.1	Limestone Bedrock		6	BX	Rec										
	Poor Quality			RC	96%										
	-----		7	BX	Rec										
				RC	91%										
	Excellent Quality		8	BX	Rec										
				RC	100%										
81.2															
7.0	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No7

METRIC

W P 371-89-02 LOCATION N: 4 994 895 ; E: 371 370 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 03 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
89.7	Ground Surface																GR SA SI CL
0.0	Sandy Silt some Gravel (Glacial Till)		1	SS	42		89.0							o			14 15 (71)
	Dense		2	SS	31		88.0							o			
17.5	Brown		3	SS	37		87.0							o			
2.2	Gravelly Sand to Sandy Gravel with Silt (Glacial Till) Compact to Very Dense		4	SS	25		86.0							o			
	Brown Occ. Cobbles & Boulders						85.0										W. L. on 1990 10 03
84.6			5	SS	137									o			28 41 (31)
0.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

FOUNDATION INVESTIGATION REPORT
for
Cranberry Creek Structure

W.P. 371-89-04, District 9, Ottawa

Highway 416, Str. Site 3-355

1.0 INTRODUCTION

Strata Engineering Corporation has been retained by M. M. Dillon Limited to carry out a foundation investigation for the crossing of the proposed southbound lanes of Highway 416 across Cranberry Creek. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full geotechnical report.

2.0 SITE AND GEOLOGY

The site is located in Rideau Township, approximately 40 km south of Ottawa and about 30 m west of the existing Highway 16 crossing of Cranberry Creek, as shown on the key plan, Drawing 3718904-A.*

The land use to the north of the creek is agricultural. The area south of the creek is flat and poorly drained. An extensive swamp occupies the future southbound lanes of Highway 416 in this area, extending 200 m south of the creek and located on the west side of the existing highway. The land rises gently to the north of the creek.

At the proposed crossing location, Cranberry Creek is approximately 8 m wide and 1.5 m deep. Flows are nominal. However, the Ministry of Natural Resources indicates the creek bed downstream from the existing structure may be a fish habitat.

Air photo examinations show the likely presence of buried channels from former courses the creek may have occupied, and these may be infilled with deep deposits of organic soils.

The general area lies within the North Gower Drumlin Field physiographic region. The drumlins have a north to south orientation. This area was inundated by the Champlain Sea during the most recent glaciation. A covering of marine soils, consisting of sensitive silts and clays, is present over the till plain and drumlins. The clay thickness is greater between buried drumlins.

Bedrock in this area comprises of magnesian limestone to dolostone of the Oxford Group of Lower Ordovician age.

* Sheet No 156 of the Contract Drawings.

3.0 FIELD AND LABORATORY WORK

It was originally proposed to drill six boreholes for this investigation (four at the proposed abutment locations and two for the approach fills). The presence of compressible peat of variable thickness, however, required additional probe holes to be placed at the south approach and south abutment locations of the proposed structure.

The drilling of the initial six boreholes was conducted in two phases due to soft terrain conditions and the necessity for winter freeze-up to occur to allow access to drilling machinery. The first phase was drilled from 1990 10 01 to 03. Four boreholes (Boreholes 2, 4, 5 and 6) were advanced in this phase, three at the proposed abutment locations and one in the vicinity of the north approach fill.

The second phase was drilled from 1991 02 13 to 18. One borehole was placed at the south approach fill location and one dynamic cone penetration test only was performed at the southwest corner of the proposed south abutment. A sampled borehole was not possible at this location due to lack of adequate winter freeze-up, very soft ground conditions, and up to 0.5 m depth of water below the ice cover.

M. M. Dillon personnel placed stakes at the edges of the proposed abutments, and the ground elevations, referenced to Geodetic datum, were supplied by them. Probe hole locations were determined by Strata personnel by chaining from known land marks in the area. The borehole and probe hole locations are shown on Drawing 3718904-A*.

Drilling of boreholes 1 to 6 inclusive was performed with a Bombardier mounted drill rig. Hollow stem augers were used to advance these boreholes. When drilling and sampling through non-cohesive strata, boiling under unbalanced hydrostatic conditions was prevented by maintaining a head of water at all times within the hollow stem augers. Boreholes 7 to 20 and A to E were drilled and sampled with hand augers and a piston type peat sampler.

Boreholes 1 to 6 were sampled at 0.75 m intervals of depth in the upper 6 m and at 1.5 m intervals thereafter, using the Standard Penetration Resistance test in non-cohesive strata and thin wall Shelby tubes in cohesive strata. In situ undrained shear strengths of cohesive soils were measured by means of an MTO "A" vane. Remoulded shear strengths were also measured to assess the sensitivity of cohesive strata. All sampled boreholes were accompanied by a dynamic cone penetration test.

After the last sample was taken in each augered borehole, the groundwater level was measured. Sealed perforated standpipes were installed in Boreholes 2 and 5 to monitor water levels over a period of time. The site was restored to its original condition by backfilling the open holes with native soil cuttings.

Recovered samples were transported to our Don Mills Laboratory where they were visually examined and classified. Tests for index properties such as moisture content, Atterberg limits and grain size analyses were conducted on representative samples. Four unconfined compression tests and one consolidation test were performed on thin walled tube samples. These results are shown on the Record of Boreholes and in Figures 1 to 4 in the Appendix.

* Sheet No 156 of the Contract Drawings.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions at this site comprise of peat of variable thickness below the south approach and south abutment overlying a soft silty clay across the site which in turn is underlain by a sand and gravel deposit. Groundwater levels correspond to creek water level.

4.2 Peat

A 400 mm thick layer of topsoil is present at Borehole 6. In all other boreholes a deposit of very soft brown fibrous peat, varying in thickness from 0.4 m to as much as 6.4 m, was encountered. The peat thickness was greatest in Boreholes 3, 17, 19, 20, D, and E, where it ranged from 4.2 m to 6.4 m. In the remaining boreholes it varied between 0.4 m to 2.0 m.

The moisture content of the peat was between 93 and 504 per cent. The peat exhibits a Von Post decomposition of H5 - H6. N values were 0 (hammer weight) to 2 blows/0.3 m indicating a soft consistency.

4.3 Silty Clay

A grey silty clay deposit was found below the peat or topsoil in all boreholes. In boreholes in which this deposit was fully penetrated, the thickness ranged from 2.6 m (Borehole 4) to 7.6 m (Borehole 1). South of the existing flow channel, the thickness of the clay decreases with increased peat thickness.

The moisture content ranged from 20 to 76 per cent, generally increasing with depth. The lower moisture content values were obtained within an upper desiccated crust found above elevation 83.5 m. Atterberg limit tests results (Figure 1) show the soil to be of medium plasticity (CI). The moisture content in the desiccated crust lies between the liquid and plastic limits of the soil. Below a 1.5 m to 2.5 m thick desiccated crust, the moisture content is higher than the liquid limit, with liquidity indices greater than unity.

N values in the desiccated crust were as high as 12 blows/0.3 m, and much lower below, being 1 to 2 blows/0.3 m at depth. Field vane tests indicated undrained shear strengths in excess of 100 kPa in the desiccated crust, reducing to as low as 12 kPa before once again increasing with depth at a c_u/p_o ratio of about 0.29. The sensitivity of the soil ranged between 2 and 20 with an average value of 8.

Based on the undrained shear strength measurements, this deposit is soft to firm in consistency, with the exception of the desiccated crust which is very stiff.

One consolidation test (Figure 2) indicates a preconsolidation pressure, p_o , of between 140 kPa and 190 kPa. The compression index, C_c , is 2.0. The recompression index, C_r , is 0.025.

4.4 Sand with Silt

The silty clay in Boreholes 1 and 6 is underlain by a sand with silt. This deposit was not fully penetrated. The moisture content averages 19 per cent. Grain size analyses (Figure 3) indicate a fine sand gradation, with silt content ranging between 25 and 45 per cent. N values of 10 blows/0.3 m indicate the deposit to be loose.

4.5 Sand and Gravel (Glacial Till)

A sand and gravel with some silt and occasional cobbles and boulders (glacial till) is present below the silty clay in Boreholes 2 to 5. It was found between elev. 77.0 m and 82.0 m. The deposit was not fully penetrated in any borehole.

The moisture content ranged from 5 to 22 per cent, generally decreasing with depth. A grain size distribution envelope is shown in Figure 4A. The gradation of a silty zone within this deposit is shown in Figure 4B.

With one exception, N values in this deposit ranged from 32 to in excess of 100 blows/0.3 m, generally increasing with depth. The deposit is dense to very dense with localized loose zones near its contact with the silty clay.

5.0 GROUNDWATER CONDITIONS

The groundwater table at this site was generally consistent with the water level in the creek which was at elevation 85.8 m on 1990 10 05, and 85.5 m on 1991 07 02. The ice surface in February 1991 varied between 85.6 m and 86.2 m. Water was observed in the standpipe installations within the sand and gravel glacial till to elevations 86.1 m to 86.2 m.

7.0 CLOSURE


The drilling for this investigation was supervised by A. C. Abel and G. Nnadi. The drilling equipment was rented from F. E. Johnston Drilling Co. Ltd., Ottawa.

Several reviews of this report have been conducted between initial issue and this submission. We are grateful for the many constructive suggestions received in its finalization.

Respectfully Submitted:
STRATA ENGINEERING CORP.



Andrea C. Abel, M. Sc.
Project Engineer



C. Mirza, P. Eng.
Senior Principal

Report Distribution:

M.M. Dillon
Strata File E-90-036A

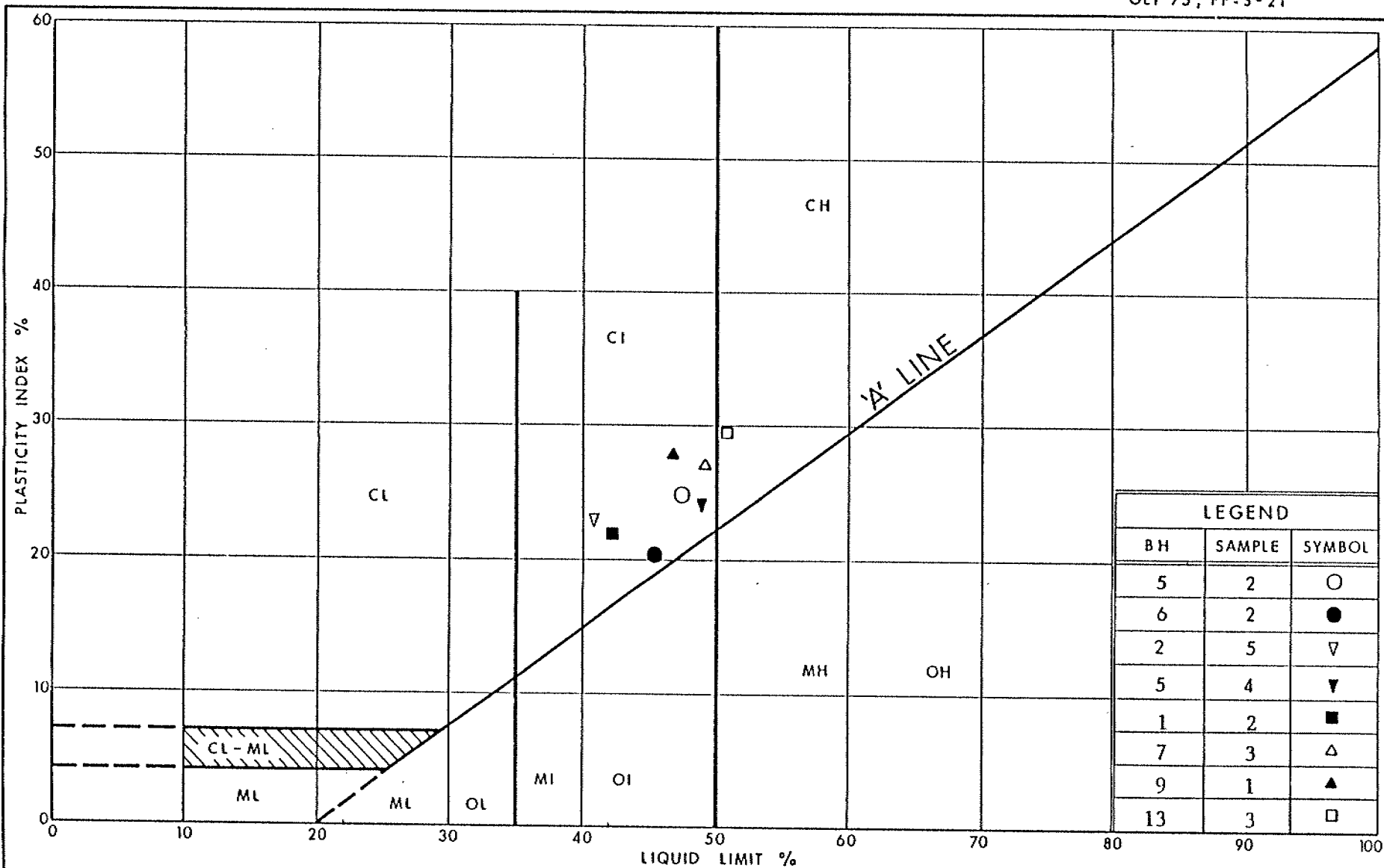
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NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Strata Engineering Corp. (consulting geotechnical engineers for this project), and signed and sealed by C. Mirza, P. Eng. and A.C. Abel, M.Sc. The project was carried out under the technical supervision of M.M. Dillon, the supervising consultant for this project.



D. Dundas
D. Dundas, P. Eng.
Sr. Foundation Engineer

APPENDIX



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Ontario

PLASTICITY CHART

Silty Clay

FIG No 1

W P 371-89-04

Hwy.416/ Cranberry Creek 46

VOID RATIO - PRESSURE CURVES

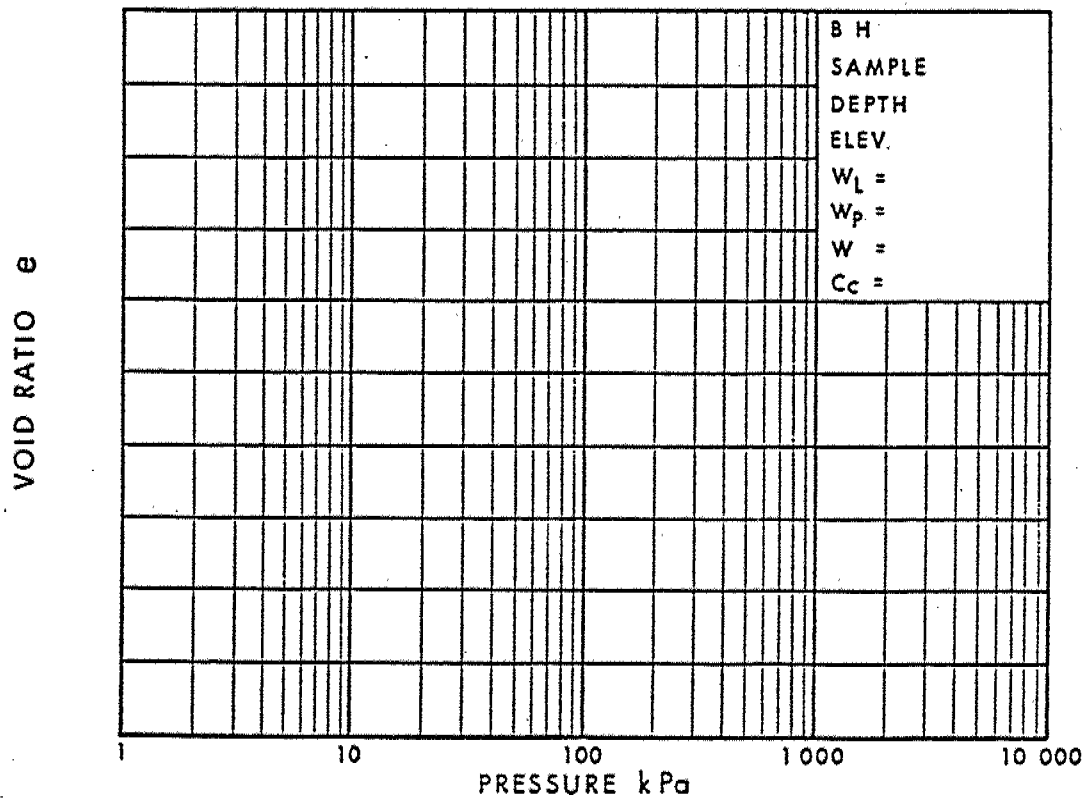
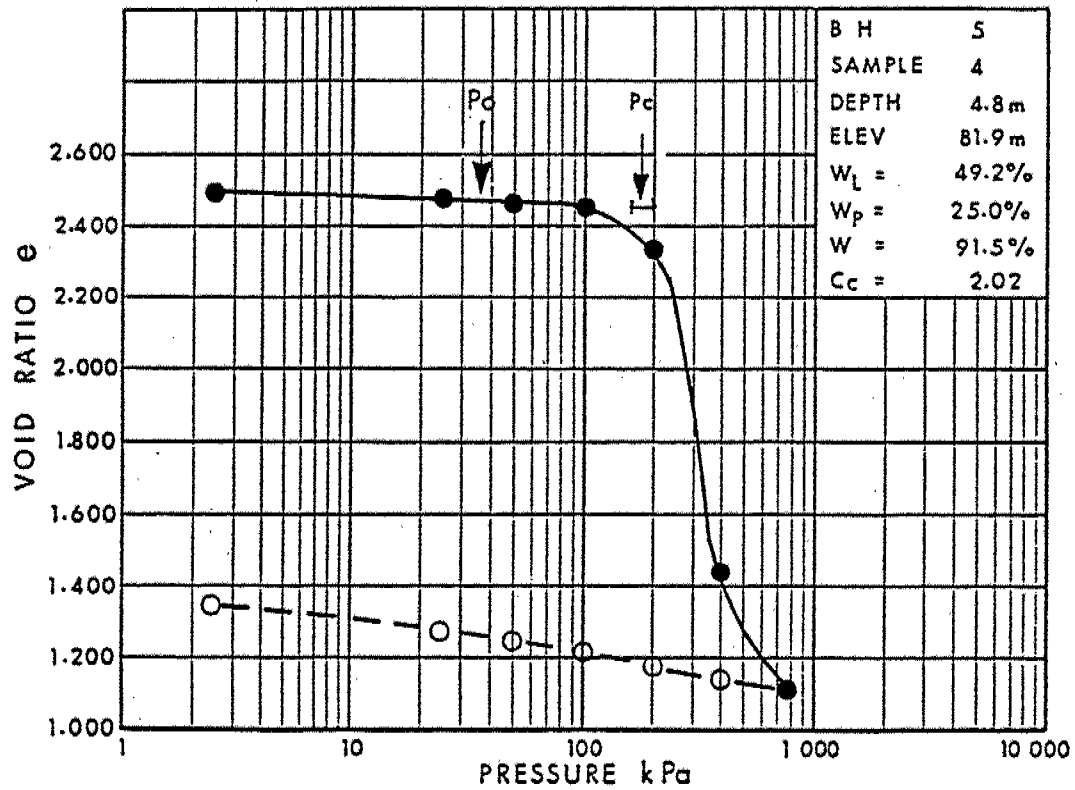
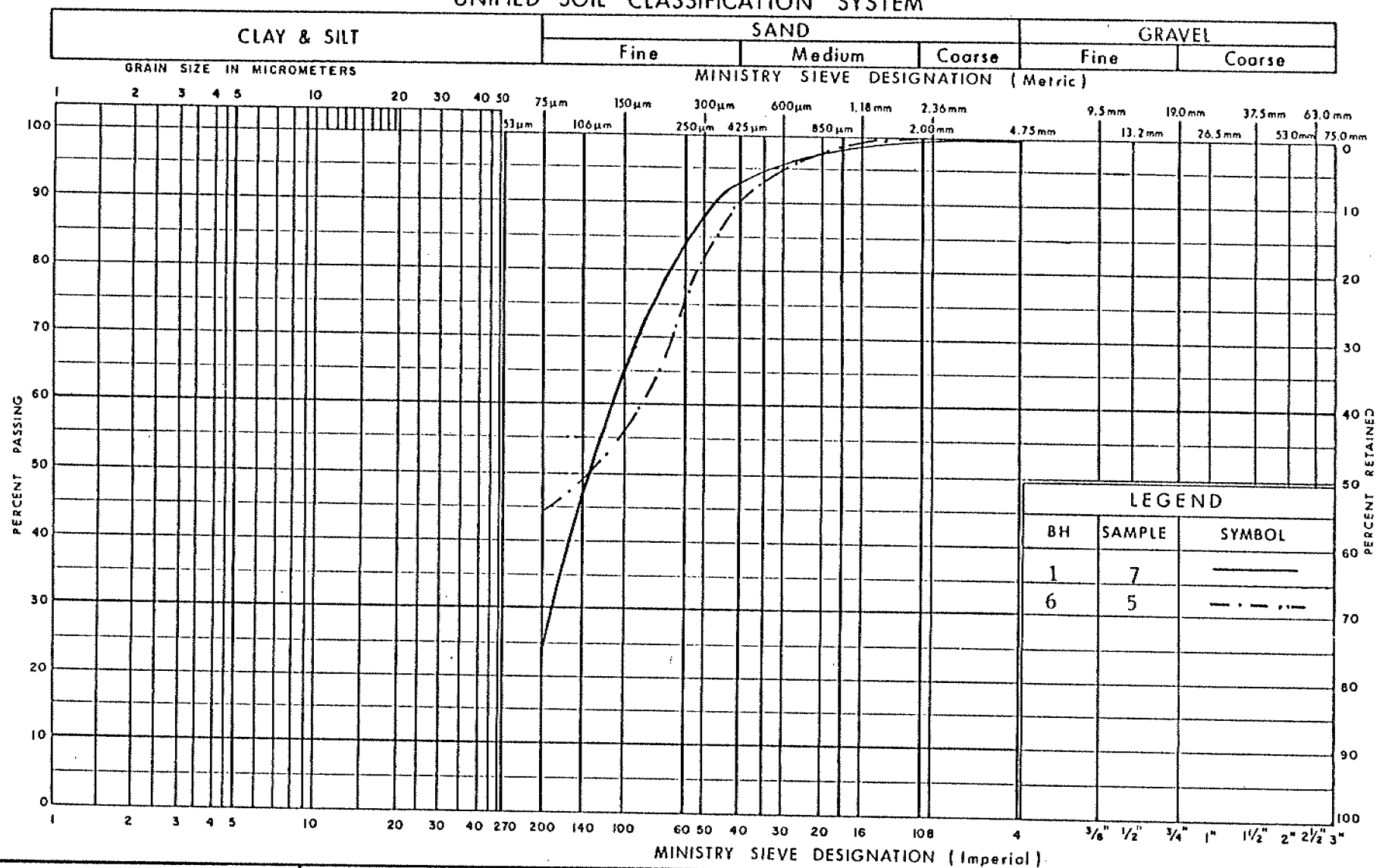


Fig 2

W P 371-89-00

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

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Transportation

GRAIN SIZE DISTRIBUTION

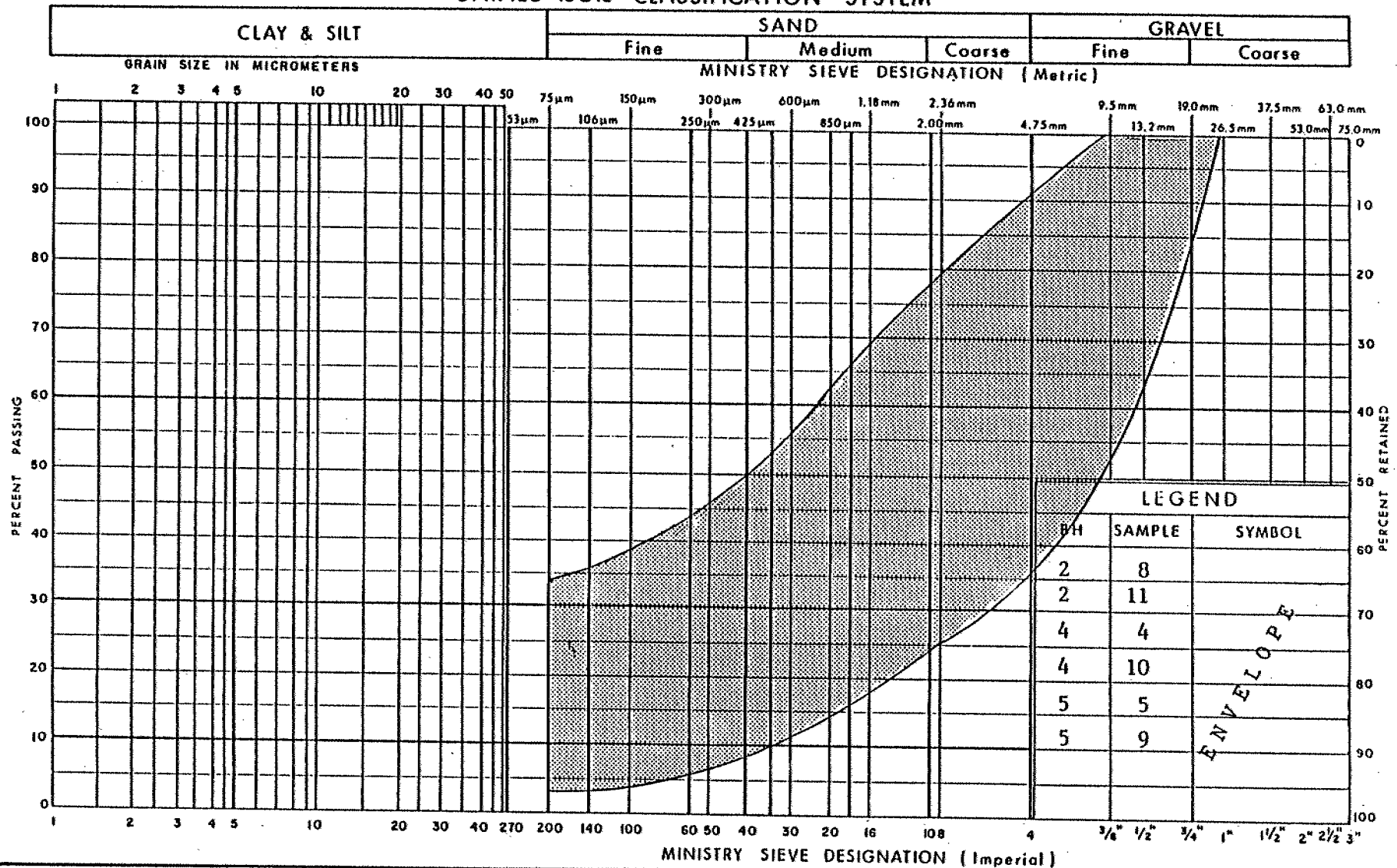
Sand with Silt

FIG No 3

W P 371-89-04

Hwy. 416/ Cranberry Creek 96

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

Sand and Gravel Trace to Some Silt
(Glacial Till)

FIG No 4A

W P 371-89-04

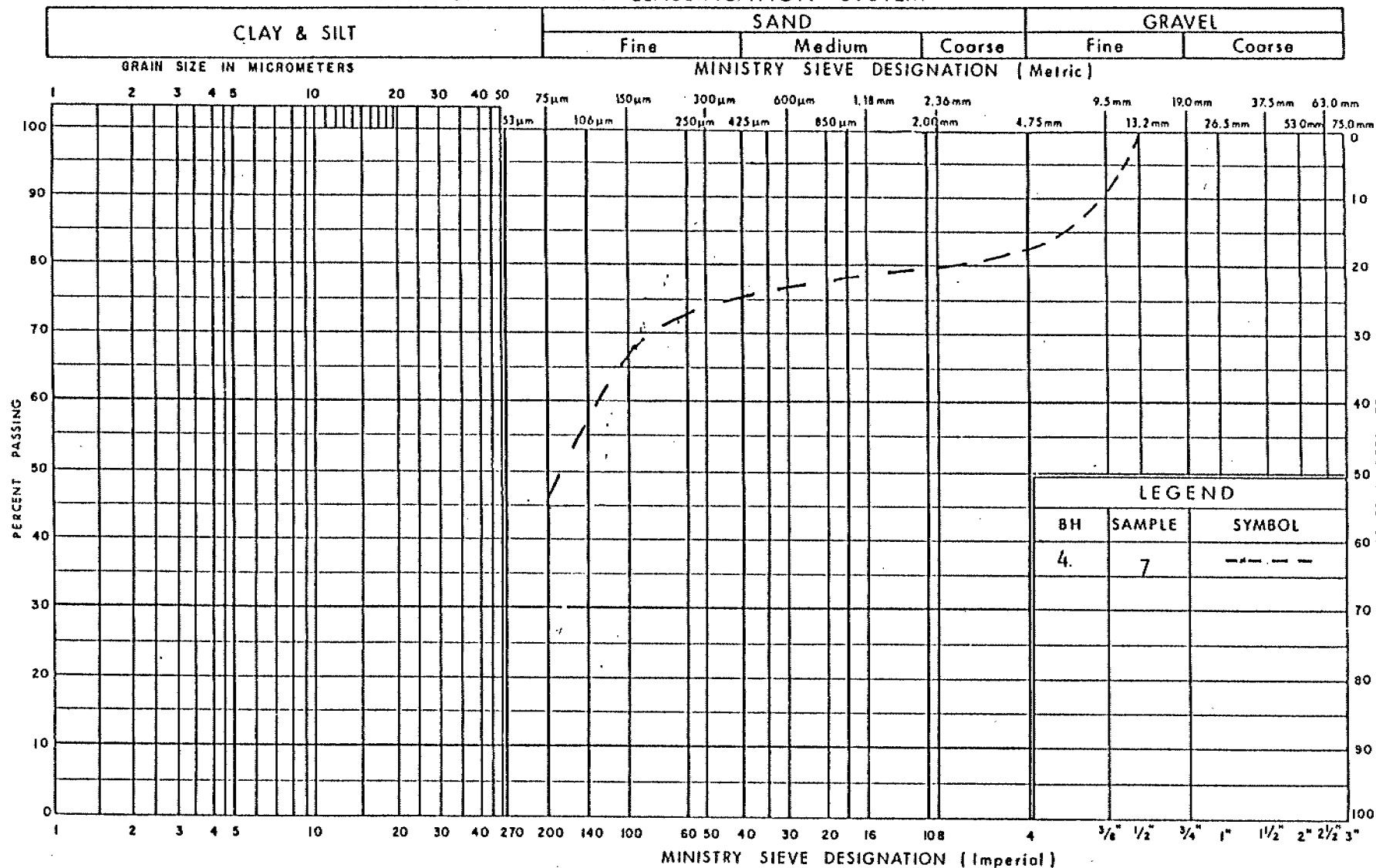
Hwy. 416/ Cranberry Creek



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UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

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Transportation

GRAIN SIZE DISTRIBUTION:

Silty Zone within Sand and Gravel Glacial Till

FIG No 4B

W P 371-89-04

Hwy. 416/ Cranberry Creek

80

RECORD OF BOREHOLE No1

METRIC

W P 371-89-C4

LOCATION N: 4 997 062.0 ; E: 370 056.2

ORIGINATED BY GN

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Test

COMPILED BY AK

DATUM Geodetic

DATE 1991 02 14

CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
86.1	Ice Surface							○ UNCONFINED	+ FIELD VANE									
0.0	Ice							● QUICK TRIAXIAL	× LAB VANE									
0.3	Water							20 40 60 80 100	20 40 60 80 100	20 40 60								
0.5	Peat																	
84.6	Brown V. Soft		1	SS	1		85.0											
1.5	Silty Clay Desiccated Crust Very Stiff		2	SS	5		84.0											
							83.0											
			3	TW	FM		82.0											
	Firm to Soft						81.0											
			4	SS	*		80.0											
							79.0											
	Grey		5	TW	FM		78.0											
							77.0											
77.0							76.0											
9.1	Sand with Silt		7	SS	10									0 74 (26)				
	Loose																	
75.4	Grey																	
10.7	End of Borehole * Penetrated By Weight of Hammer and Rods																	

+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 371-89-04 LOCATION N: 4 997 088.0 ; E: 370 055.5 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 03 CHECKED BY A.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.5	Ground Surface																
0.0	Peat																
	Soft		1	SS	2												
	Brown																
84.5			2	SS	2												
2.0	Silty Clay Desiccated Crust Stiff		3	SS	3												
			4	SS	2												
	Soft to Firm																
			5	TW	PM											15.8	
	Grey		6	TW	PM											15.1	
79.2																	
7.3	Sand and Gravel Some to Trace Silt (Glacial Till)		7	SS	4												
	Loose to Very Dense		8	SS	101												
	occ. Cobbles & Boulders																
	Grey		9	SS	104												
74.2			10	EX	Boulder												
			11	SS	1207 25cm												
12.3	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No3

METRIC

W P 371-89-04 LOCATION N: 4 997 068.0 ; E: 370 043.6 ORIGINATED BY GN
 DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AK
 DATUM Geodetic DATE 1991 02 18 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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	SHEAR STRENGTH kPa					
86.2	Ice Surface							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	WATER CONTENT (%)				
0.0	Ice						86.0							
0.3	Water													
0.5	Probable Peat													
							85.0							
							84.0							
							83.0							
							82.0							
							81.0							
80.0							80.0							
6.2	Probable Silty Clay						79.0							
							78.0							
77.0							77.0							
9.2	Probable Sand and Gravel (Glacial Till)						76.0							
74.9							75.0							
11.3	End of Conetest													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 371-89-04 LOCATION N: 4 997 097.6 : E: 370 036.9 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 01 CHECKED BY A.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
86.0	Ground Surface													
0.0	Peat													
	Soft		1	SS	2									
84.6	Brown													
1.4	Silty Clay		2	SS	5									
	Desiccated Crust													
	Stiff													
	Soft		3	TW	PM									
82.0	Grey													
4.0	Sand and Gravel		4	SS	45									
	Some to Trace Silt													
	(Glacial Till)													
	Occ. Cobbles & Boulders		5	SS	138									
	Dense to Very Dense		6	SS	100/1.5cm									
	Grey													
	Silty Zone		7	SS	29									
	Compact													
	Very Dense		8	SS	50									
			9	SS	100/2.5cm									
73.8														
12.2	End of Borehole		10	SS	181/20cm									

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 371-89-C4 LOCATION N: 4 997 085.7 E: 370 025.6 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 02 CHECKED BY A.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
86.1	Ground Surface							20 40 60 80 100	20 40 60 80 100					GR SA SI CL
0.0	Peat Soft Brown							○ UNCONFINED + FIELD VANE						W.L. on 1990 10 26
85.3								● QUICK TRIAXIAL × LAB VANE						
0.8	Silty Clay Desiccated Crust Very Stiff		1	SS	2									
			2	SS	12									
	Soft to Firm		3	TW	PH								16.1	
	Grey													
			4	TW	PM									
80.2														
5.9	Sand and Gravel Trace to Some Silt (Glacial Till) Dense to Very Dense occ. Cobbles & Boulders Grey		5	SS	32									38 55 (7)
			6	SS	55									
			7	SS	151/23cm									
			8	SS	169/23cm									
73.7			9	SS	189/20cm									11 59 (30)
12.4	End of Borehole													

RECORD OF BOREHOLE No 6

METRIC

W P 371- 89- 04 LOCATION N: 4 997 114.9 ; E: 370 012.3 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger , Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 02 CHECKED BY A.A.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
87.5	Ground Surface															
0.0	Topsoil															
87.1																
0.4	Silty Clay		1	SS	11		87.0									
	Desicated Crust															
	Very Stiff		2	SS	10		86.0									
	Firm to Soft		3	TW	PH		85.0									
82.6							84.0									
4.9	Sand with Silt		4	TW	PM		83.0									
81.7	Loose Grey		5	SS	10		82.0									
5.8	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 371-89-04 LOCATION N: 4 997 076.5 ; E: 370 039.6 ORIGINATED BY G.N.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampling COMPILED BY A.A.
 DATUM Geodetic DATE 1991 07 02 CHECKED BY C. M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80					
85.5	Water Surface															
0.0	Water															
0.3	Peat															
84.6	Soft Brown		1	TP	PM											
0.9	Silty Clay															
	Stiff		2	TP	PM											
	Grey															
82.5			3	TP	PM											
3.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 371-89-04 LOCATION N: 4 997 080.8 ; E: 370 036.6 ORIGINATED BY G.N.
DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampling COMPILED BY A.A.
DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity



W P 371-89-04 LOCATION N: 4 997 086.1 ; E: 370 032.3 ORIGINATED BY G.N.
DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampling COMPILED BY A.A.
DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 10

METRIC

W P 371-89-04 LOCATION N: 4 997 080.0 ; E: 370 028.2 ORIGINATED BY G.N.
DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampler COMPILED BY A.A.
DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

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 _p	W	W _L		
85.5	Water Surface																
0.0	Water																
0.2	Peat																
84.8	Soft Brown																
0.7	Silty Clay																
84.2	Stiff Grey		1	TP	PM												
1.3	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 11

METRIC

W P 371-89-04 LOCATION N: 4 997 074.1 ; E: 370 033.0 ORIGINATED BY G.N.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampling COMPILED BY A.A.
 DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	PLASTIC LIMIT W _p	W	LIQUID LIMIT W _L		
85.5	Water Surface															
0.0	Water															
85.0																
0.5	Peat															
84.4	Soft Brown		1	TP	PM											
1.1	Silty Clay															
83.8	Stiff Grey		2	TP	PM											
1.7	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No13

METRIC

W P 371-89-04 LOCATION N: 4 997 078.5 ; E: 370 042.0 ORIGINATED BY G.N.
DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampling COMPILED BY A.A.
DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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					
85.5	Water Surface																
0.0	Water																
0.3	Peat						85.0										
	Soft		1	TP	PM												
	Brown						84.0										
83.3			2	TP	PM												
2.2	Silty Clay						83.0										
82.7	Soft Grey		3	TP	PM												
2.8	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 14

METRIC

w p 371-89-04

LOCATION N: 4 997 083.6 ; E: 370 037.6

ORIGINATED BY G.N.

DIST 9 HWY 416

BOREMOLE TYPE Hand Auger & Piston Sampling

COMPILED BY A.A.

DATUM Geodetic

DATE 1991 07 02

CHECKED BY C.M.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION.

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 15

METRIC

W P 371-89-04

LOCATION N: 4 997 088.2 ; E: 370 033.8

ORIGINATED BY G.N.

DIST 9 HWY 416

BOREHOLE TYPE Hand Auger & Piston Sampling

COMPILED BY A.A.

DATUM Geodetic

DATE 1991 07 02

CHECKED BY C.M.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

*3, x5 : Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No17

METRIC

W P 371-89-04 LOCATION N: 4 997 090.0 : E: 370 042.2 ORIGINATED BY G. N.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger & Piston Sampling COMPILED BY A.A.
 DATUM Goedetic DATE 1991 07 02 CHECKED BY C. M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.5	Water Surface																
0.0	Water						85.0										
84.8																	
0.7	Peat						84.0										
	Soft		1	TP	PM		83.0										
	Brown						82.0										
							81.0										
80.6																	
4.9	Silty Clay -Soft -Grey																
5.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No18

METRIC

W P 371-89-04 LOCATION N: 4 997 077.0 : E: 370 051.2 ORIGINATED BY G.N.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
 DATUM Geodetic DATE 1991 07 02 CHECKED BY C. M.

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 _p	W		
85.6	Ground Surface															
0.0	Peat															
	Soft															
	Brown															
23.8																
1.8	Silty Clay															
	Soft															
	Grey															
78.7																
6.9	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No19

METRIC

W P 371-89-04 LOCATION N: 4 997 069.1 : E: 370 042.0 ORIGINATED BY G.N.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
 DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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					
85.7	Ground Surface																
0.0	Peat						85.0										W.L. on 1991 07 02
	Soft						84.0										
	Brown						83.0										
							82.0										
80.7							81.0										
5.0	Silty Clay																
	Soft																
79.6	Grey						80.0										
6.1	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 20

METRIC

W P 371-89-04 LOCATION N: 4 997 085.0 ; E: 370 047.6 ORIGINATED BY G.N.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
 DATUM Geodetic DATE 1991 07 02 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.6	Ground Surface																GR SA SI CL
0.0	Peat						85.0										W.L. on 1991 07 02
	Soft						84.0										
	Brown						83.0										
							82.0										
							81.0										
80.3							80.0										
5.3	Silty Clay						80.0										
	Soft																
	Grey						79.0										
78.4																	
7.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No A

METRIC

W P 371-89-04 LOCATION N: 4 997 068.3 ; E: 370 063.8 ORIGINATED BY J.E.
DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
DATUM Geodetic DATE 1991 02 09 CHECKED BY C.M.

[illegible]

⁺3, ^x5: Numbers refer to Sensitivity

20
15 \diamond S (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No B

METRIC

W P 371-89-04 LOCATION N: 4 997 054.8 : E: 370 049.0 ORIGINATED BY J.E.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
 DATUM Geodetic DATE 1991 02 09 CHECKED BY C.M.

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 _p	W		
85.6	Ice Surface															
0.0	Ice															
0.3	Water															
0.5	Peat															
84.6	Soft Brown															
1.0	Silty Clay Soft Grey															
1.3	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE NoC

METRIC

W P 371-89-04 LOCATION N: 4 997 066.0 ; E: 370 039.5 ORIGINATED BY J.E.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
 DATUM Geodetic DATE 1991 02 09 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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					
85.6	Ice Surface																
0.0	Ice																
85.2																	
0.4	Water						85.0										
0.7	Peat																
	Soft						84.0										
	Brown						83.0										
82.5																	
3.1	Silty Clay																
82.2	Soft Grey																
3.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

[illegible]

RECORD OF BOREHOLE No E

METRIC

W P 371-89-04 LOCATION N: 4 997 087.1 ; E: 370 048.0 ORIGINATED BY J.E.
 DIST 9 HWY 416 BOREHOLE TYPE Hand Auger COMPILED BY A.A.
 DATUM Geodetic DATE 1991 02 09 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
85.7	Ice Surface															
0.0	Ice															
0.3	Water															
84.8																
0.9	Peat															
	Soft															
	Brown															
78.8																
6.9	Silty Clay															
78.3	Soft Grey															
7.4	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

FOUNDATION INVESTIGATION REPORT

for

Third Line Road Underpass

W.P. 371-89-03, District 9, Ottawa

Highway 416, Str. Site: 3-575

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by M.M. Dillon Limited to carry out a foundation investigation at a proposed underpass for Highway 416 at Third Line Rd. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests, and to provide a full geotechnical report.

This report follows a preliminary letter report submitted on 1990 12 20.

2.0 SITE AND GEOLOGY

The site is located in Rideau Township approximately 40 km south of Ottawa along Highway 16, as shown in the Key Plan in Drawing 3718903-A.* At present, Third Line Road intersects Highway 16 at an 80° skew at grade.

The topography of the area to the east, south and west of the site is predominantly flat. There are low hills to the north of the site.

Physiographically the area lies within the North Gower Drumlin Field, with the drumlins oriented approximately north-south. This area has been inundated by the Champlain Sea. The drumlins are draped by marine soils consisting of Leda clays.

Bedrock in this area is magnesium limestone to dolostone of the Oxford Group of lower Ordovician age.

3.0 FIELD AND LABORATORY WORK

The field work took place between 1990 10 11 and 22. Eight boreholes were drilled. Five boreholes were located at the proposed pier and abutments. Two boreholes were drilled for the approach ramps of Third Line Road. An additional borehole was drilled between the proposed south east abutment and the centre pier in order to verify the subsurface stratigraphy. The borehole locations are shown on Drawing 3718903-A.*

The borehole locations for the structure were staked by M.M. Dillon personnel who also supplied

* Sheet No 168 of the Contract Drawings.

the ground elevations which are referenced to Geodetic datum.

Drilling was done by means of two bombardier mounted drill rigs. Hollow stem augers were used to advance Boreholes 1 to 4, 7 and 8. Boreholes 5 and 6 were advanced by means of wash boring techniques using N sized casing.

The boreholes were sampled at 0.75 m depth intervals within the upper 6 m and at 1.5 m intervals below this depth. Sampling was done by means of the Standard Penetration Test and the N values noted. In cohesive strata, relatively undisturbed samples were obtained by manually or hydraulically pushing thin walled Shelby Tubes. In situ MTO vane tests were carried out to measure the undrained shear strength of the cohesive strata. Remoulded strengths were also measured to assess the sensitivity of the soil.

Six boreholes were accompanied by dynamic cone penetration tests.

Bedrock was cored in three boreholes.

After the last sample was taken in each borehole the groundwater level was measured. Perforated standpipes with bentonite seals were installed in Boreholes 2, 4, 5 and 6. The water levels in the instrumented holes were monitored over a period of time. All boreholes were backfilled with native soil cuttings. The site was restored to its original condition.

Recovered soil samples were transported to our Don Mills Laboratory where they were visually examined and classified. Tests for index properties such as moisture contents, Atterberg Limits and grain size distribution were conducted on representative samples. Unconfined compression tests were conducted on selected thin walled tube samples. One consolidation test was also performed. The field and laboratory results are shown on the Record of Boreholes and Figures 1 to 5 in the Appendix.

4.0 SUBSURFACE CONDITIONS

4.1 General

The soil conditions are variable across the site. To the south east of the existing Highway 16, a surficial deposit of sandy silt overlies an extensive deposit of clayey silt to silty clay above a sand and gravel glacial till. To the north west of Highway 16 there is a silty sand glacial till above the sand and gravel till. The sand and gravel glacial till overlies limestone bedrock.

4.2 Sandy Silt

A brown sandy silt deposit, is present at the south east approach and abutment areas (in Boreholes 1, 2, 3 and 8 only), from the surface to depths ranging from 1.4 m to 2.1 m. The moisture content of this soil is approximately 30 per cent. Two grain size analyses, shown on Figure 1, indicate the stratum consists of fine sand and silt. The soil is non-cohesive. N values of 4 to 8 blows/0.3 m indicate the stratum to be very loose to loose.

4.3 Silty Sand to Sandy Silt (Glacial Till)

To the north west of Highway 16 there is a deposit of silty sand to sandy silt (glacial till) from ground surface down. The thickness of this deposit diminishes from north west to south east. It was 6.7 m thick in Borehole 6 near the north west abutment and 5.2 m in Borehole 4 near the centre pier. There are numerous cobbles and boulders within this deposit.

The moisture content ranged from 10 to 22 per cent, being higher below the groundwater table. The results of grain size analyses are shown in envelope form on Figure 2A. For silty zones within this deposit, the grain size curves are shown on Figure 2B. This glacial till is a heterogenous mixture of sandy silt to silty sand with some gravel with occasional sandy and silty zones.

N values in this deposit ranged from 13 to in excess of 100 blows/0.3 m with average values being about 35 blows/0.3 m. The deposit is therefore compact to very dense.

4.4 Clayey Silt to Silty Clay

Below the sandy silt to the south east part of this site there is a clayey silt to silty clay stratum whose thickness ranges from 8.5 m (Borehole 1) to 5.1 m (Borehole 8). Due to the decreasing thickness of this deposit it can be surmised that it terminates below the existing highway.

The moisture content of this deposit ranged from 25 to 79 per cent. The lower moisture contents were obtained in a desiccated crust which is approximately 3 m thick. Immediately below the crust the moisture contents are the highest and generally decrease with depth. Atterberg limit tests (Figure 3) indicate low to medium plasticity for this soil. The moisture contents are generally higher than the liquid limit indicating a liquidity index in excess of unity.

Field vane tests gave undrained shear strength values ranging from 20 kPa to 90 kPa. The higher values were obtained within the desiccated crust, generally above elev. 84 m. Unconfined compression tests gave values of 16 kPa to 38 kPa. The sensitivity of the soil ranged from 4 to 10 with most values between 6 and 8. The undrained shear strength values below the desiccated crust generally increase with depth, with a c_u/p_o ratio of about 0.28.

A consolidation test (Figure 4) indicates a preconsolidation pressure, p_e of between 120 kPa and 150 kPa. The compression index C_c was 1.3.

4.5 Sand and Gravel some to trace Silt (Glacial Till)

Below the silty sand to sandy silt (glacial till) to the north west of the existing highway and below the silty clay to clayey silt on the south east side of the highway there is a deposit of poorly sorted sand and gravel with some to trace silt (glacial till). This deposit has randomly occurring cobbles and boulders. Its thickness ranges from 1.7 m to 6.7 m.

The moisture content of this material ranged from 5 to 18 per cent with an average value of 12 per cent. Grain size curves (shown on Figures 5A and 5B) indicate a heterogenous mix of sand gravel and silt sizes with silt content ranging between 5 and 23 per cent.

N values ranged from 42 to in excess of 100 blows/0.3 m indicating the deposit to be dense to very dense.

4.6 Limestone Bedrock

Limestone bedrock was cored in Boreholes 2, 4 and 5. The bedrock elevation ranges from 79.5 m to 77.3 m sloping downwards from north west to south east.

The limestone is thinly bedded and fractured in the top 3 m. Core recoveries were 68 per cent. RQD values ranged from 0 to 48 per cent. Below the upper 3 m the bedrock was of better quality with 100 per cent recoveries and RQD values of 100 per cent.

5.0 GROUNDWATER CONDITIONS

Groundwater level observations are shown below:

Borehole	W.L. Elev.(m)	Depth (m)	Date
1	88.7	0.4	1990/10/18
2	88.8	0.4	1990/10/26
3	88.4	0.4	1990/10/18
4	88.2	1.5	1990/10/26
5	89.1	3.7	1990/10/26
6	88.7	3.7	1991/10/22
7		Dry upon completion	
8	88.7	0.6	1990/10/22

Borehole 7 which was dry was terminated at elevation 89.4 m


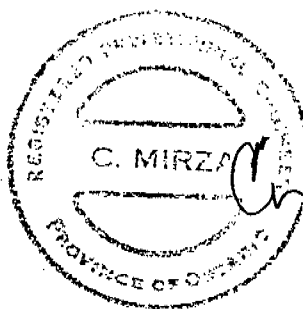
7.0 CLOSURE

Field work for this investigation was supervised by A. C. Abel. Drilling equipment was rented from Marathon and F. E. Johnston Drilling companies, Ottawa.

Respectfully submitted:
STRATA ENGINEERING CORP.



A. C. Abel, M. Sc.
Project Engineer


C. Mirza, P. Eng.
Senior Principal

Report Distribution:
M.M. Dillon
Strata File E-90-036B

15 copies
1 copy

Computer File: E90036B.REP

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Strata Engineering Corp. (consulting geotechnical engineers for this project), and signed and sealed by C. Mirza, P. Eng. and A.C. Abel, M.Sc. The project was carried out under the technical supervision of M.M. Dillon, the supervising consultant for this project.



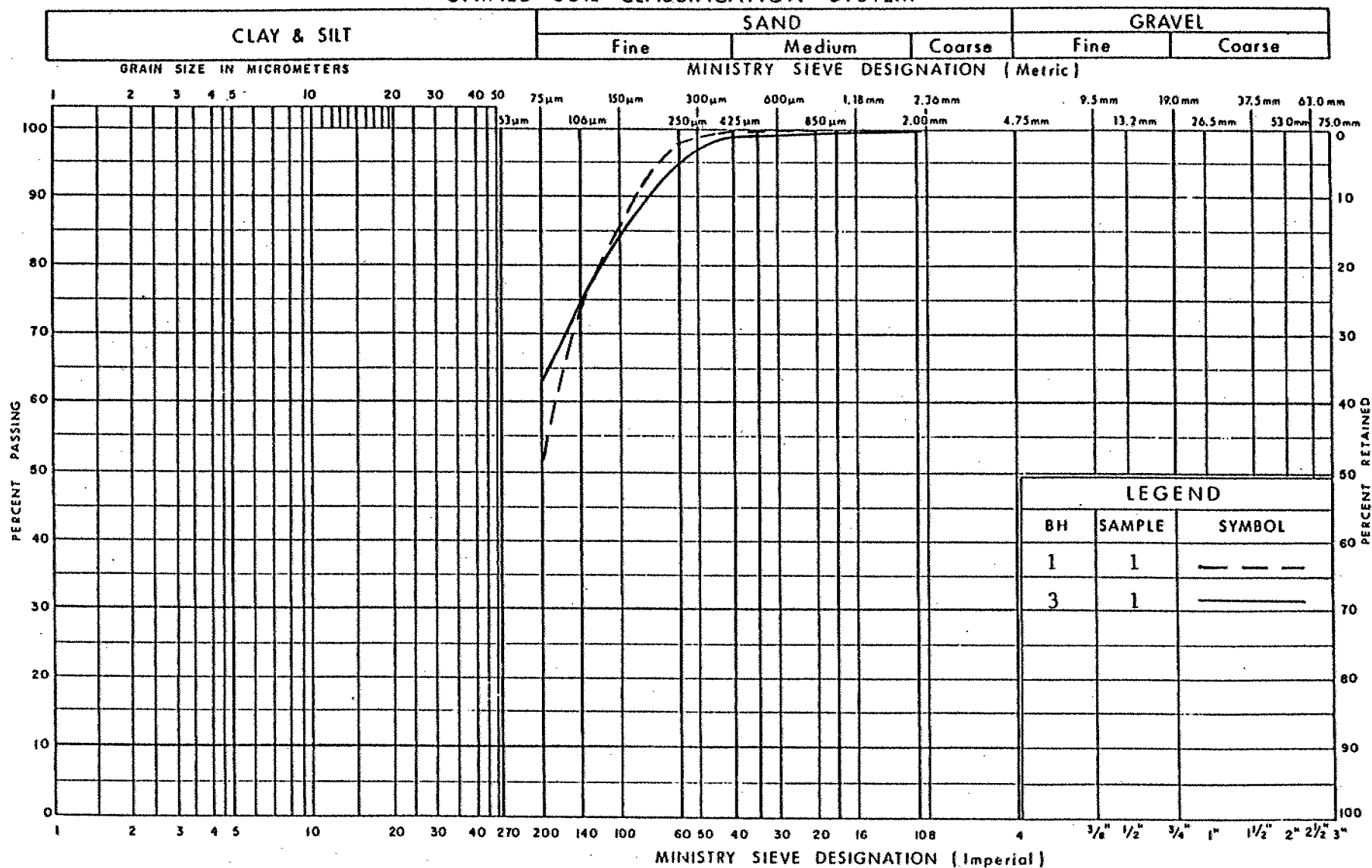
D. Dundas

D. Dundas, P. Eng.

Sr. Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Sandy Silt

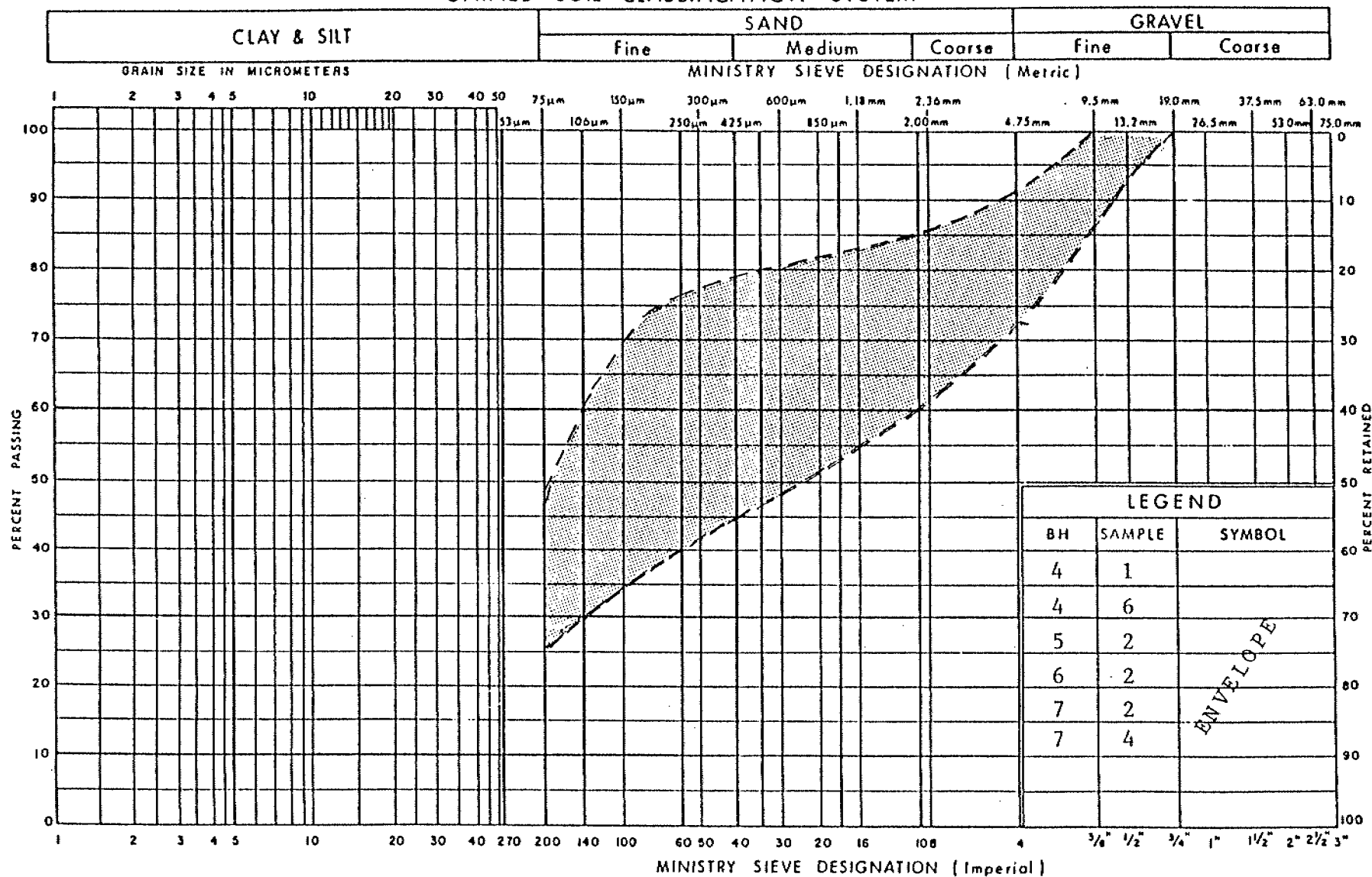
FIG No 1

W P 371-89-03

Thirdline Rd. Underpass

131

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION

Silty Sand to Sandy Silt
with Some Gravel (Glacial Till)

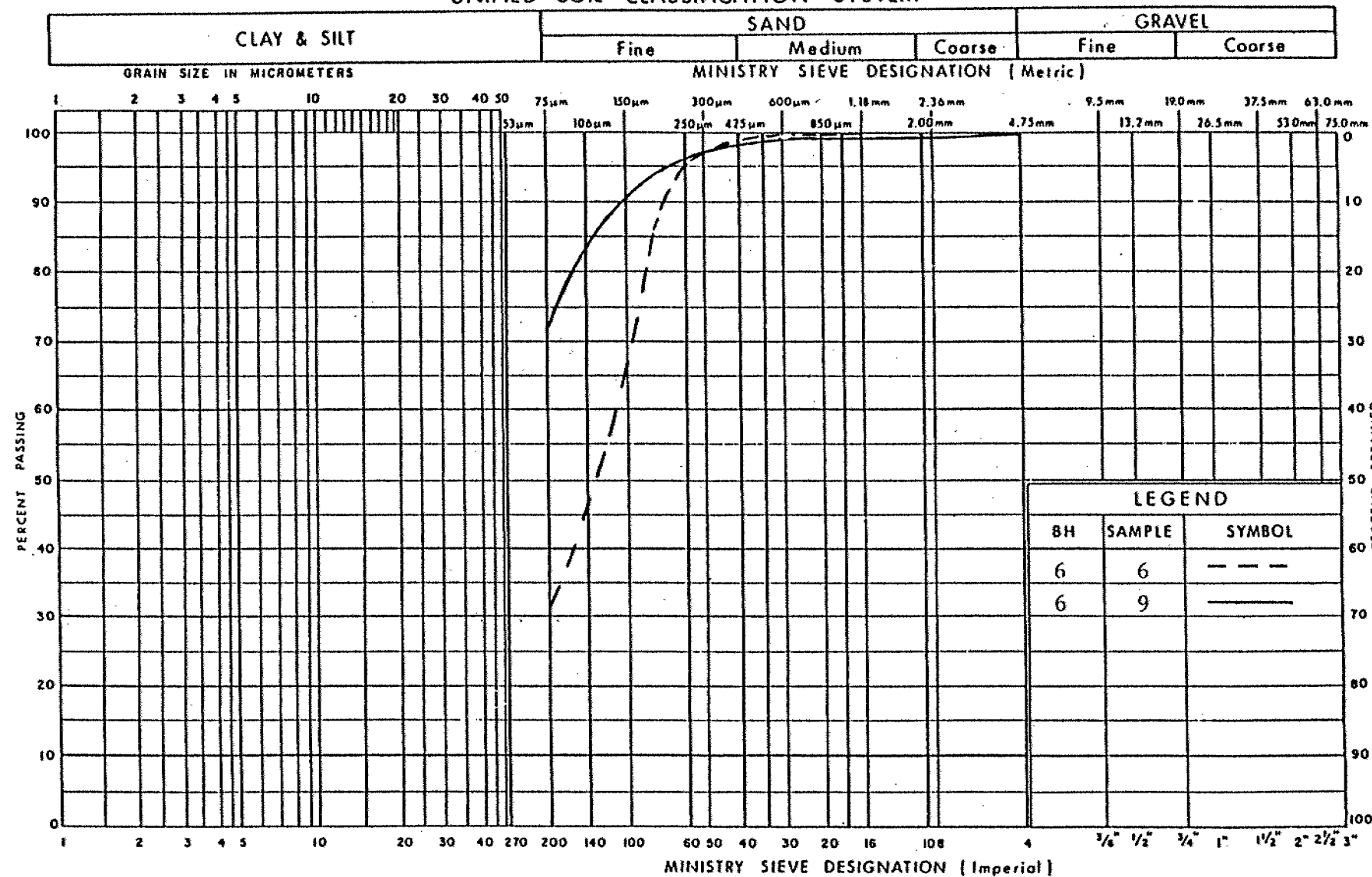
FIG No 2A

W P 371-89-03

Thirdline Rd. Underpass

132

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

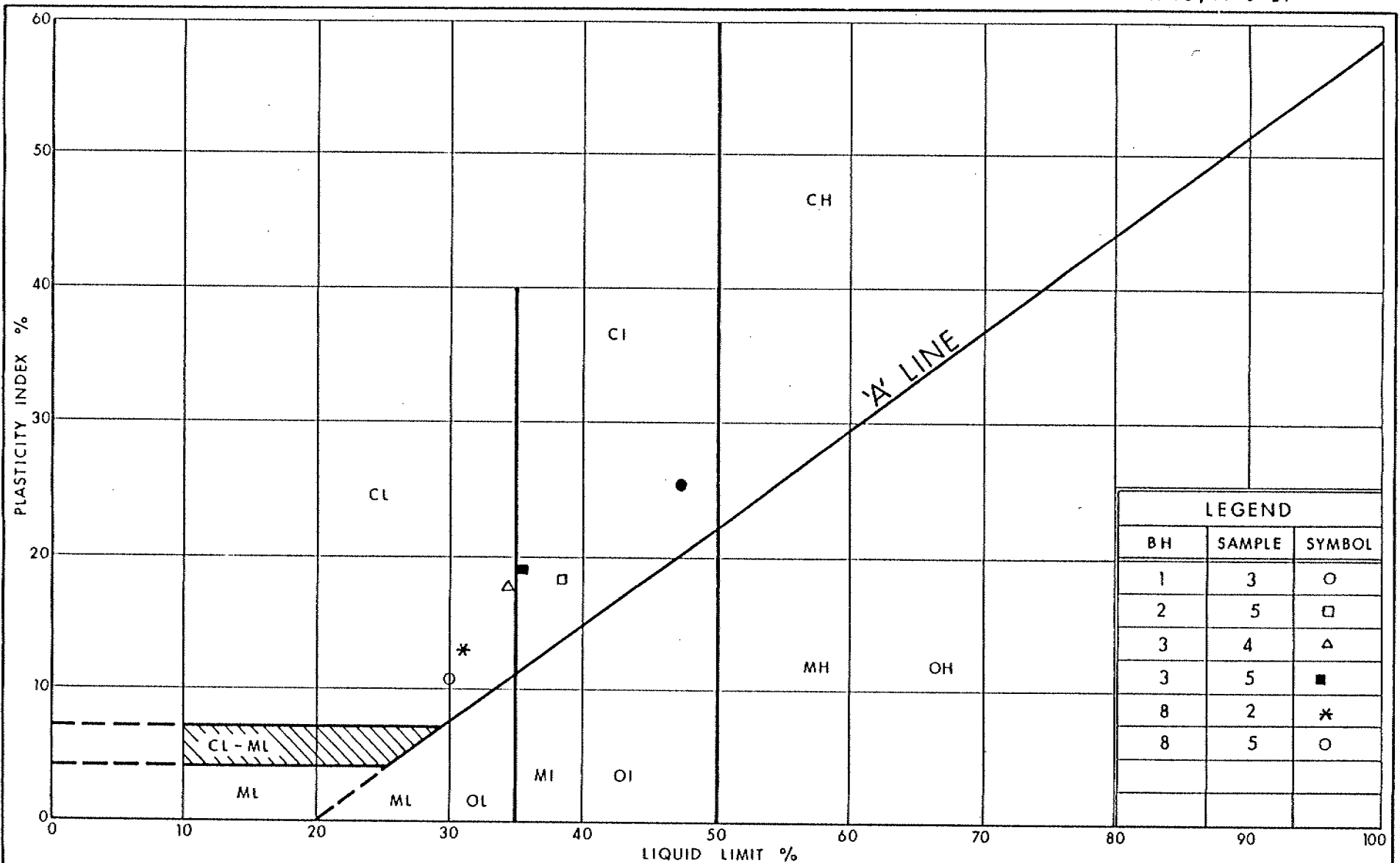
GRAIN SIZE DISTRIBUTION

Fine Sand and Silt Zones
within Glacial Till

FIG No 2B

W P 371-89-03

Thirdline Rd. Underpass



Ministry of
Transportation

Ontario

PLASTICITY CHART

Clayey Silt to Silty Clay

FIG No 3

W P 371-89-03

Thirdline Rd. Underpass

134

VOID RATIO - PRESSURE CURVES

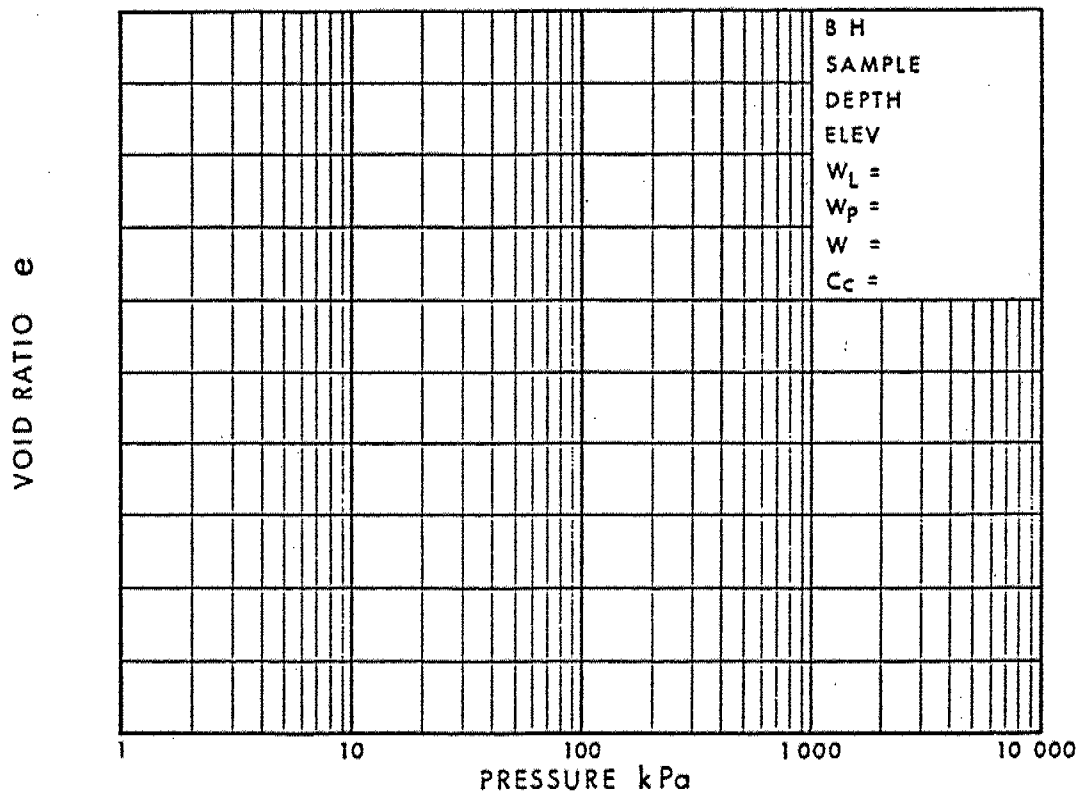
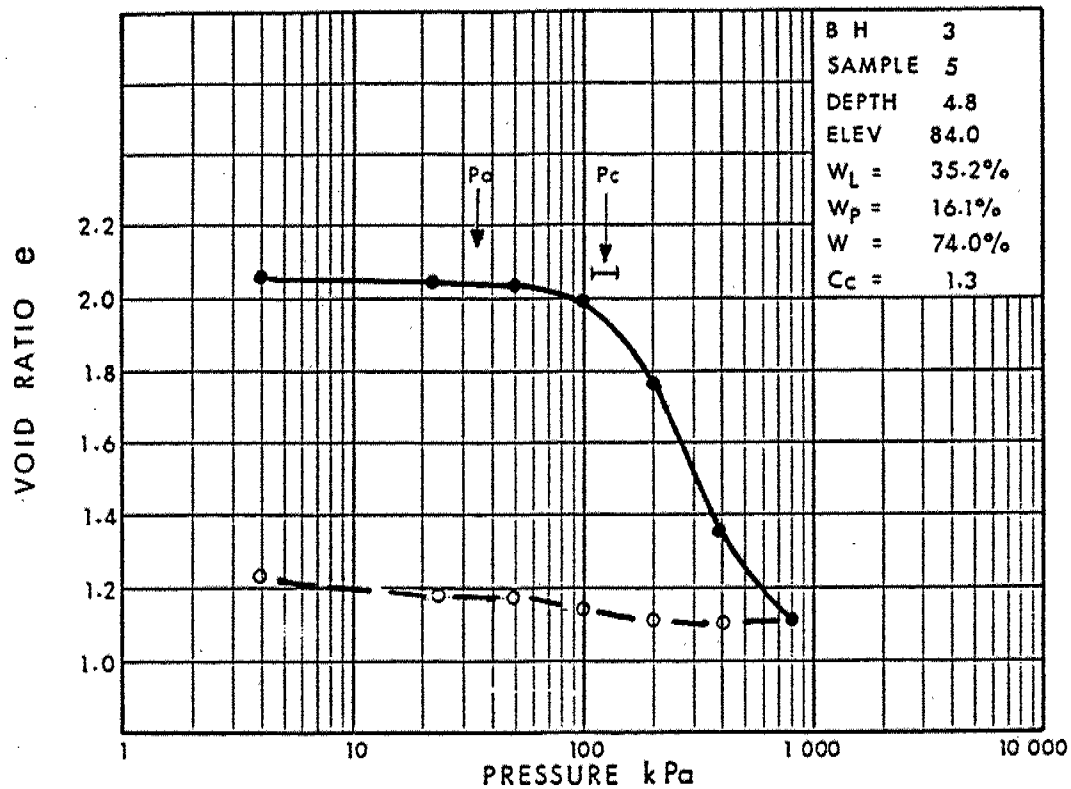
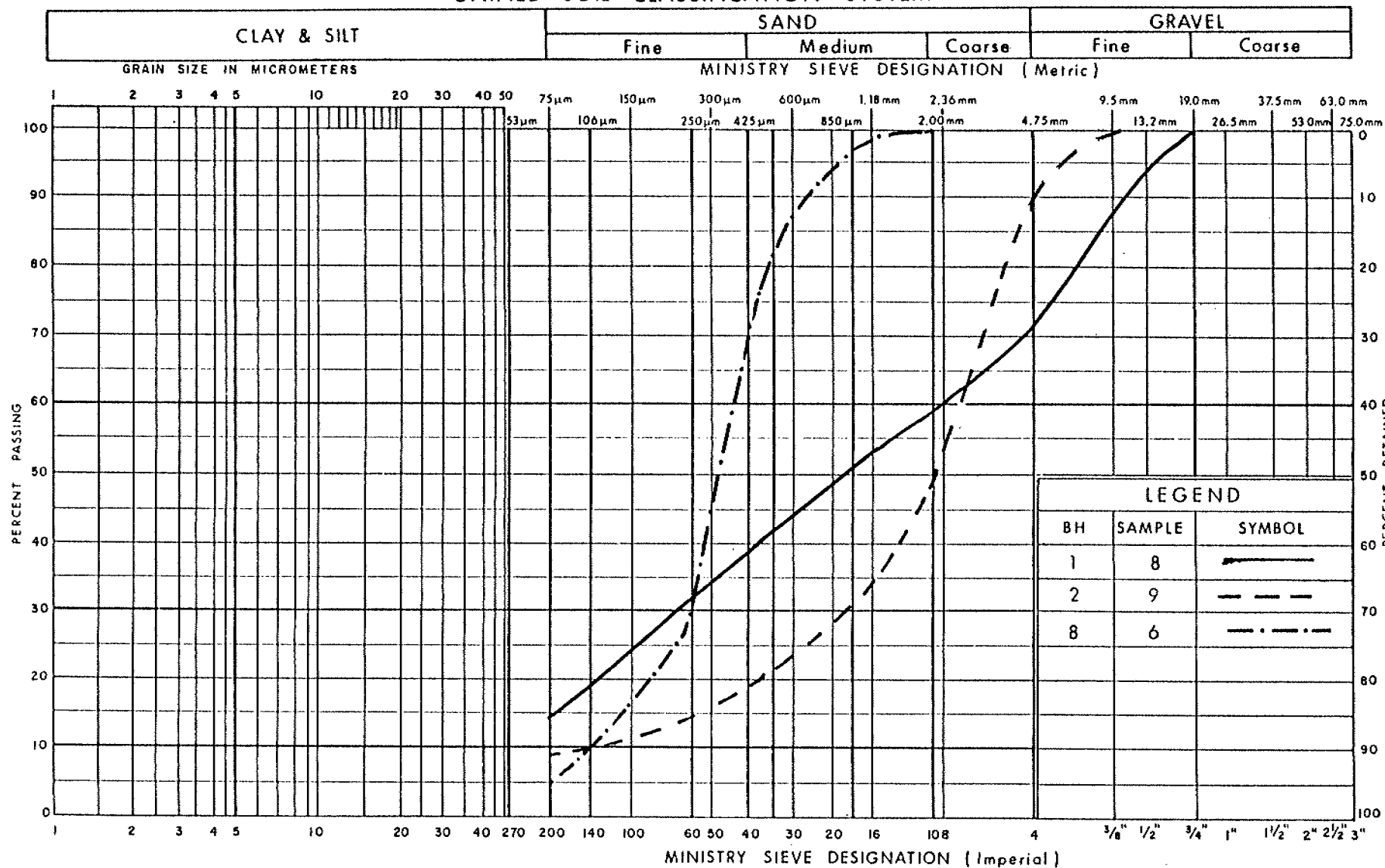


Fig 4

W P 371-89-03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Sand and Gravel
Trace to Some Silt (Glacial Till)

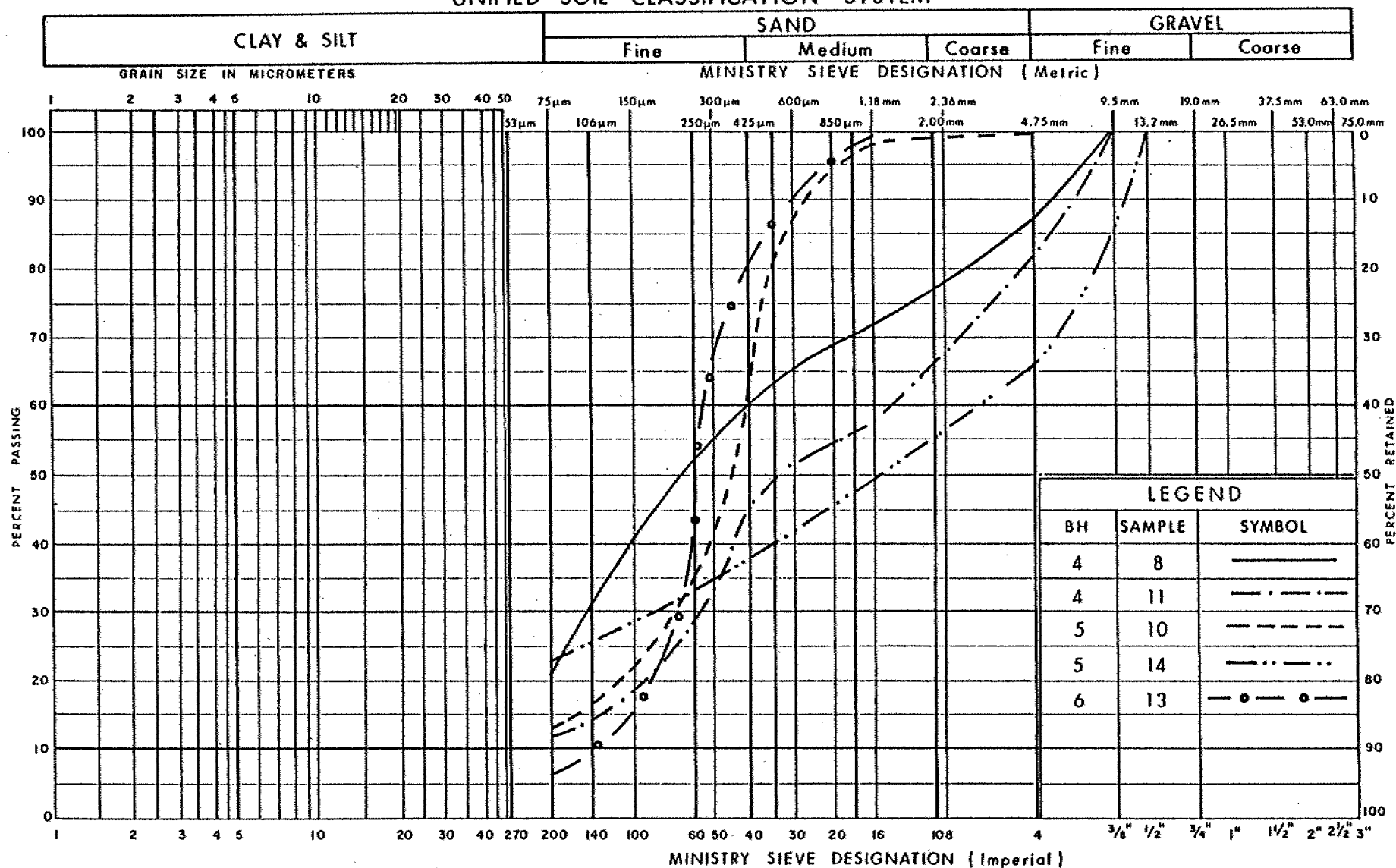
FIG No 5A

W P 371-89-03

Third Line Rd. Underpass

136

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Sand and Gravel
Trace to Some Silt (Glacial Till)

FIG No 5B

W P 371-89-03

Thirdline Rd. Underpass

137



RECORD OF BOREHOLE No1

METRIC

W P 371-89-03

LOCATION N 4,998,513 : E 369,694

ORIGINATED BY A.A.

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger; Dynamic Cone Penetration Test

COMPILED BY A.K.

DATUM Geodetic

DATE 1990 10 15

CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						x LAB VANE	W _p	W	W _L
89.1	Ground Surface																		
0.0	Sandy Silt																		
87.7	Loose Brown		1	SS	6											W.L. on 1990 10 18			
1.4	Clayey Silt to Silty Clay		2	SS	3											0 49 (51)			
	Desiccated Crust Stiff																		
			3	SS	2														
	Soft to Firm																		
			4	TW	PM														
	Grey																		
		5	TW	PM															
		6	TW	PM															
		7	TW	PM															
79.2																			
9.9	Sand and Gravel trace to some Silt (Glacial Till) Very Dense																		
		8	SS	103															
77.5	Grey																		
11.6	End of Borehole Probable Bedrock																		

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 371-89-03 LOCATION N 4,998,506 : E 369,690 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger : Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 11 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	GR SA SI CL		
89.2	Ground Surface													
0.0	Sandy Silt						89.0							W.L. on 1990 10 26
	Very Loose		1	SS	4		88.0							
	Brown		2	SS	4		87.0							
87.1	Clayey Silt to Silty Clay		3	SS	4		87.0							15.6
2.1	Desiccated Crust Firm		4	SS	2		86.0							
	Soft to Firm		5	TW	PM		85.0							
			6	TW	PM		84.0							
	Grey		7	TW	PM		83.0							
			8	SS	9		82.0							
			9	SS	88/20		81.0							
79.8	Sand and Gravel trace to some Silt (Glacial Till)						80.0							12 78 (10)
9.4	Very Dense Grey						79.0							
							78.0							
77.3	Limestone Bedrock		10	BX RC	Rec 68%		77.0							RQD = 36%
11.9	Fractured		11	BX RC	Rec 81%		76.0							RQD = 13%
74.3			12	BX RC	Rec 100%		75.0							RQD = 16%
14.9	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 371-89-03 LOCATION N 4,998,496 ; E 369,706
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test.
DATUM Geodetic DATE 1990 10 15
ORIGINATED BY A.A.
COMPILED BY A.K.
CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
88.8	Ground Surface															
0.0	Sandy Silt															
	Very Loose		1	SS	4		88.0									
87.1	Brown		2	SS	12		87.0									
1.7	Clayey Silt to Silty Clay		3	SS	5		86.0									
			4	TW	PM		85.0									
	Firm		5	TW	PM		84.0									
			6	TW	PM		83.0									
	Grey		7	TW	PM		82.0									
80.6	End of Sampled Borehole						81.0									
8.2	Probable Clayey Silt to Silty Clay						80.0									
79.6	Probable Sand and Gravel (Glacial Till)						79.0									
9.2																
78.8																
10.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 371-89-03 LOCATION N 4,998,546 ; E 369,660 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger; Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 16 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N° VALUES			20	40	60	80	100					
89.7	Ground Surface																
0.0	Silty Sand to Sandy Silt some Gravel (Glacial Till)		1	SS	28		89.0										15 40 (45)
	Compact to Very Dense		2	SS	13		88.0										W.L. on 1990 10 26
	Brown		3	SS	17		87.0										
			4	SS	16		86.0										
			5	SS	100		85.0										
	trace Gravel		6	SS	32		84.5										9 47 (44)
84.5			7	SS	100		84.0										
5.2	Sand and Gravel trace to some Silt (Glacial Till)		8	SS	42		83.0										13 66 (21)
	Dense to Very Dense		9	SS	51		82.0										
	Grey		10	SS	100/25 cm		81.0										
			11	SS	100/16.5 cm		80.0										
78.4			12	RX	Rec		79.0										19 69 (12)
11.3	Limestone Bedrock			RC	76%		78.0										RQD = 11%
77.5	Fractured																
12.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

METRIC

W P 371-89-03

LOCATION N 4,998,586 : E 369,634

ORIGINATED BY A.A.

DIST 9 HWY 416

BOREHOLE TYPE Wash Casing , Dynamic Cone Penetration Test

COMPILED BY A.K.

DATUM Geodetic

DATE 1990 10 17

CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
92.8	Ground Surface													
0.0														
	Silty Sand to Sandy Silt some Gravel (Glacial Till)		1	SS	104		92.0							
			2	SS	50		91.0							18 49 (33)
	Very Dense to Dense		3	BX	Boulder									
			4	SS	40		90.0							
	Brown		5	SS	33									
			6	SS	44		89.0							W. L. on 1990 10 26
			7	SS	47		88.0							
	Grey		8	SS	44		87.0							
			9	SS	34									
86.2							86.0							
6.6	Sand and Gravel trace to some Silt (Glacial Till)		10	SS	59									0 87 (13)
			11	SS	58		85.0							
	Very Dense		12	SS	112		84.0							
	Grey		13	SS	65		83.0							
							82.0							
	Gravelly Zone						81.0							
79.5			14	SS	100/		80.0							34 44 (22)
13.3	Limestone Bedrock		15	BX RC	Rec 82%		79.0							RQD = 0%
	Fractured		16	BX RC	Rec 94%									RQD = 18%
77.8			17	BX	Rec 100%		78.0							RQD = 48%

15.0 Continued on page 2

+3, x5: Numbers refer to
Sensitivity

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



LOCATION N 4,998,586 ; E 369,634

ORIGINATED BY A.A.

BOREHOLE TYPE Wash Casing , Dynamic Cone Penetration Test

COMPILED BY A.K.

DATE 1990 10 17

CHECKED BY C.M.

+3, x5; Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 371-89-03 LOCATION N 4,998,575 ; E 369,626 ORIGINATED BY A.A.
 DIST 9 HWY 416 BOREHOLE TYPE Wash Casing COMPILED BY A.K.
 DATUM Geodetic DATE 1990 10 17 CHECKED BY C.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
92.4	Ground Surface															GR SA SI CL
0.0	Silty Sand to Sandy Silt Some Gravel (Glacial Till)	1	SS	100/16cm		92.0						o				21 52 (27)
	Very Dense	2	SS	138/28cm		91.0						o				
		3	EX	Boulder		90.0						o				W.L. on 1990 10 22 0 68 (32)
	Brown	4	SS	67		89.0						o				
	Fine Sand Zone	5	SS	88		88.0						o				0 32 (68)
		6	SS	104/20cm		87.0						o				
		7	SS	100/25cm		86.0						o				
		8	SS	100/22cm		85.0						o				
	Silty Zone	9	SS	100/25cm		84.0						o				
85.7		10	SS	106/18cm		83.0						o				
6.7	Sand and Gravel trace to some Silt (Glacial Till)	11	SS	110/23cm		82.0						o				
	Very Dense	12	SS	124		81.0						o				
	Grey	13	SS	127/25cm		80.0						o				0 94 (6)
12.4	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 371-89-03 LOCATION N 4,998,595 ; E 369,619 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 17 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
92.7	Ground Surface																
0.0	Silty Sand with Gravel (Glacial Till)		1	SS	74	*	92.0						o				
	Very Dense		2	SS	100		91.0						o				24 47 (29)
	Brown		3	SS	50/77.5cm		90.0						o				
89.4			4	SS	93/28cm								o				
3.3	End of Borehole * Borehole Dry upon Completion																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 371-89-03 LOCATION N 4,998,522 ; E 369,688 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 22 CHECKED BY C.M.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	20 40 60	kg/m ³		
89.3	Ground Surface													GR SA SI CL
0.0	Sandy Silt						89.0							W.L. on 1990 10 22
	Loose													
	Grey		1	SS	8		88.0							
87.1														
2.2	Clayey Silt to Silty Clay						87.0							
			2	SS	6		86.0							
	Firm		3	SS	1		85.0							
			4	SS	1		84.0							
	Grey		5	SS	3		83.0							
82.0							82.0							
7.3	Sand and Gravel tr. to some Silt(Till)													
81.3	V. Dense Grey		6	SS	100/25 cm									0 96 (4)
8.0	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

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Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 370-89-⁰¹~~00~~ DIST 9
HWY 416 STR SITE 3-264

Rideau River Bridge, SBL

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FOUNDATION INVESTIGATION REPORT

For

Rideau River Bridge, SBL

W.P. 370-89-⁰¹~~00~~, Site No. 3-364

Highway 416, District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted for the proposed Rideau River Bridge for the Hwy. 416 southbound lanes. The investigation was carried out at the request of Eastern Region Structural Section. The report applies to a proposed five span bridge structure to support Highway 416 southbound and its approaches between Station 16+355 and 16+800, Highway 416 chainage.

Preliminary recommendations were provided by this office on May 18, 1990 based on previous investigations for the existing bridge at this site.

The foundation investigation for this project was delayed by several months to meet the requirements of Rideau Canal and other authorities.

SITE DESCRIPTION

The site is located about 7 km north of Highway 43 in Kemptville at the Highway 416 crossing over the Rideau River.

The nearest similar structure is a bridge structure which carries Highway 416 over the Rideau River. The existing bridge is presently used for both north and southbound traffic.

The actual site for the proposed bridge is on the south side of the existing bridge. The new bridge will be similar to the existing bridge in length and span geometry.

The river channel is about 280 m wide. The ground surface at the east bank is about 5 m higher than on the west bank. This is due to an already in place approach fill on the east bank which is about 7 m thick and has side slopes of approximately 2H:1V. The existing east approach fill

approximately extends from Station 16+350 to Station 16+475, Highway 416 chainage.

Physiographically the site is located in the Winchester Clay Plain. In this area although the clay plains are dominant, the landscape has some complexity. In many places the underlying till protrudes and there are a number of low drumlins. There are also areas of shallow soil over bedrock (Reference: Chapman and Putnam, The Physiography of Southern Ontario; 3rd Edition, 1984).

INVESTIGATION PROCEDURES

The field investigation for this project was conducted in two sessions. The first time was between July 16 and July 27, 1990 and the second time was between September 5 and September 13, 1990. A total of eleven boreholes (BH 1 through BH 11) were advanced for this investigation. Seven boreholes were accompanied by dynamic cone penetration tests. The boreholes on the ground were advanced using a track mounted auger machine equipped with 83 mm ID hollow stem augers. The boreholes on the river were advanced using washboring techniques with a conventional diamond drill rig adapted for soil sampling purposes. A raft was utilized for the execution of those boreholes located on the river. In non-cohesive soil, samples were recovered by means of 50 mm OD split spoon sampler driven into the soil according to the specification of the Standard Penetration Test (ASTM 1586). Samples were retrieved at intervals ranging from 0.75 m to 1.5 m. In cohesive soil undisturbed samples were also obtained at strategic locations by pushing 54 mm ID shelly tubes. Frequent field vane shear tests were carried out within the cohesive layer in order to determine the undrained and remoulded shear strength of the materials.

During the subsurface investigation selected soil samples were obtained from the river bed and provided to McCormick Rankin & Associates Ltd. for environmental assessment.

The boreholes were staked out by McCormick Rankin & Associates Ltd., the designer for the project. Locations and elevations were also provided by McCormick Rankin & Associates Ltd.

The laboratory testing for representative samples consisted of;

- Grain Size Analyses
- Natural Moisture Content Determinations
- Atterberg Limit Determinations
- Consolidation Test, and
- Unit Weight determinations

The results of the laboratory testing are plotted on the Record of Borehole Sheets (Appendix).

SUBSURFACE CONDITIONS

The record of Borehole sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 3708900-A.

The predominant soil deposit at this site is a glacial till which consists of silty sand to sandy silt material. The glacial till is at the surface at the west bank of the river (El. 86 m to 88 m) and dips to the east as 6.5H:1V to El. 66± m near Station 16+515 m (Highway 416 SB chainage, south of the existing bridge) from where it rises at 12.5H:1V to the east. On the east of the west bank and east of Station of 16+700 the glacial till is overlain by a weak deposit of 6 m to 15 m thick sensitive clay. Within the river channel the silty clay stratum was overlain by approximately 1 m to 3 m thick muck. On the east bank of the river the silty clay was covered with approximately 3 m to 8 m of thick fill material, which was placed for the construction of the east approach.

Following are the detailed descriptions of the soil strata encountered.

Fill Material

A non-cohesive fill material was encountered in boreholes located on the east shore of the river (BH 7 to BH 11). It was anticipated that due to the presence of the underlying thick layer of sensitive clay, consolidation settlement would take place when the approach fill was placed and therefore, it was decided to place the approach fill long before the construction of the new bridge took place. The fill was placed in 1974.

The top elevation of the fill, at the embankment surface, ranged from 89.6 m to 91.5 m. The thickness of the fill ranged from 3.5 m to 7.7 m.

The fill consisted of silty sand to sandy silt material with some gravel and trace of clay.

The Standard Penetration test 'N' value ranged from 4 to 103 blows/0.3 m which suggest that the fill is in a loose to a very dense state. However, the material was rarely loose. Generally the compactness ranged from dense to very dense.

Silty Clay

This cohesive material was encountered in all boreholes located on the east side of the navigational channel (between Pier 1 and Pier 2. This stratum was underlying the east approach fill outside the river channel or 1.1 to 3.1 m thick organic muck at the river bed.

The top elevation of this stratum was lowest in the centre of the river and rose towards the east. The top elevation ranged from 78.3 m to 86.1 m. The thickness of this layer ranged from 5.9 m to 15.2 m increasing from west to east. The thickest layer was encountered close to the east bank of the river (BH 6). Typical properties of the material, based on laboratory and field testings, are as follows:

	<u>Range</u>	<u>Average</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	24-69%	50%	25
Liquid Limit (w _p)	28-52%	40%	25
Plastic Limit (w _L)	17-24%	20%	25
Unit Weight (kN/m ³)	16.1-17.3	16.9%	9
Undrained Shear Strength (kPa) (Field Vane)	12-87	40	52

Undisturbed and remoulded field vane tests provided sensitivity values which were as high as 21. The sensitivity ranged from 2 to 21 averaging about 9. The silty clay is grey in colour and is a marine deposit. Locally this clay is known as Leda clay. Based on the undrained shear strength the consistency of the layer ranged from very soft to stiff. However, generally the material was firm.

Figure 1 illustrates a typical plasticity envelope for this material.

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

Consolidation tests were carried out on selected samples. The results are as follows:

	<u>Range</u>	<u>Average</u>
Initial Void Ratio (e ₀)	0.9159 to 1.5486	1.28
Preconsolidation (P _c), kPa	98 to 215	142
Compression Index (C _c)	0.112 to 0.741	0.43

The results of the consolidation tests are shown on Figure 3 through 7.

The moisture contents of the samples were found to be above liquid limits particularly at lower elevations.

Silty Sand to Sandy Silt (Glacial Till)

This non-cohesive material was encountered in all boreholes. This layer forms the surficial layer at the west bank and underlies the marine silty clay or the organic muck at the other locations. This deposit contains gravel and occasional cobbles and boulders.

The top elevations of this stratum ranges from 66.4 m to 88.1 m. The glacial till dips towards the east at 6.5H:1V and after reaching El. 66.4 m near Station 16+515 (Highway 416 SB chainage, south of the existing bridge) rises at a slope of 12.5H:1V towards the east. Boreholes penetrated 0.9 to 11.9 m in this material. Since all boreholes were terminated in this layer its thickness is undetermined.

Standard Penetration tests conducted in this layer achieved 'N' values ranging from 6 to 192 blows/0.3 m penetration. This suggests that the material is in a loose to a very dense state. However, generally the material is in a dense to a very dense state. Occasional low 'N' values were due to unbalanced hydrostatic pressure.

Grain size analyses were carried out on 15 samples. Figure 8 presents the grain size distribution envelope for this material.

Organic Muck

A black muck was observed overlying the river bed. The muck varied in thickness from 1.1 m to 3.1 m at the borehole locations. The top elevation of muck varied from 80.1 to 84.7 m.

Drilling rods and casing penetrated through the stratum by their own weight which suggested that the deposit has a very soft consistency. No shear strength can be attributed to this stratum.

Groundwater Conditions

The groundwater was measured in open boreholes where possible. Where groundwater was stabilized it was found to be approximately matching with the water level in the river (El. 85.6 m). Groundwater levels are shown on the individual borehole logs (Appendix).

It should be noted that groundwater levels are subject to seasonal fluctuations and may therefore change as the water level in the river changes.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to construct a 5-span structure to carry Hwy. 416 SBL across the Rideau River. The new bridge will be of the same length and have the same span geometry as the existing one and will be located on the south side of the existing bridge.

The existing bridge is a 5-span structure with spans 53.34, 60.96, 60.96, 60.96, and 53.34 m respectively from one end to other. The bridge crosses the Rideau River at about right angles. The river channel is about 280 m wide. The piers and east abutment are founded on piles end-bearing in glacial till. The west abutment is founded on a spread footing on glacial till.

It is understood that the proposed SBL bridge for Highway 416 will be parallel to the existing NBL bridge, at the same grade and at a 37.8 m offset to the south. The grade elevation of the proposed bridge will be 91.6 m at the east abutment, 94.8 m at Station 16+705 (near the main navigational channel) and 94.7 m at the west abutment. The piers and abutments of the new and existing bridges will be aligned.

Maximum height of the approach embankment on the east side would be approximately 7 m and on the west side about 9 m. Due to the presence of a thick layer of silty clay at the proposed east approach, fill for the east approach had already been placed at this site in 1974 to allow most of the settlement to take place before the construction of the new bridge. The maximum height of the existing fill is about 7.25 m, which is about 0.25 m higher than the proposed grade. Therefore, no additional fill will be required for the construction of east approach. No fill has been placed for the construction of west approach.

The existing bridge for Highway 16 is performing well. There are no signs of settlement at the approaches.

Structure Foundations

The west abutment can be supported on a spread footing founded on glacial till. The east abutment and all of the piers can be supported on H-piles or caissons founded on very dense glacial till.

West Abutment

The west abutment footing may be supported on a spread footing founded on glacial till at or below El. 84.5 m. This corresponds to depths equal to or greater than 1.8 m beneath the existing ground surface.

Upon excavation of the footing base a 150 mm concrete working slab should be placed within six hours of exposure.

The recommended bearing capacities for the footing on glacial till, as per the O.H.B.D.C. are as follows:

Factored Bearing Capacity at U.L.S.	=	1020 kPa
Bearing Capacity at S.L.S. Type II	=	500 kPa

An unfactored friction angle of 30° may be assumed to determine sliding resistance between the footing and glacial till.

As an alternative, to avoid any dewatering, the spread footing for the west abutment could be founded on granular pad built up above the groundwater level. To construct the granular pad the soil above El. 85.6 m, the assumed groundwater level, should be removed from a plan area as shown on Figure 10. After the removal of existing material to the specified depth, any soft areas identified by proof-rolling should be removed and replaced with compacted free-draining granular material.

The granular pad will extend 1 m beyond the plan limits of the abutment footing and will slope at 1H:1V as illustrated in Figure 10.

The thickness of granular pad will depend on the required footing elevation but should be at least 2 m thick.

The recommended bearing capacities for the footings, on a granular pad, as per the O.H.B.D.C. are as follows:

Factored Bearing Capacity at U.L.S. = 900 kPa

Bearing Capacity at S.L.S. Type II = 350 kPa

An unfactored friction angle of 35° may be assumed to determine sliding resistance between the footing and the compacted Granular 'A' pad.

East Abutment and Piers

There are two alternatives for the construction of east abutment and pier foundations. Each alternative has some advantages. The details are as follows:

Pile Foundations (Alternative 1)

The east abutment and piers may be founded on end-bearing piles equipped with driving shoes.

After the piles are advanced to the minimum pile penetration elevation (Table 1) pile driving should be controlled by the Hiley Formula as per MTO Standards SS103-10 or SS103-11, assuming ultimate capacities as indicated below.

Table 1

<u>Foundation Location</u>	<u>Reference Borehole</u>	<u>Min. Pile Penetration Elev. (m)</u>	<u>Estimated Tip Elevation (m)</u>
Pier 1	3	73.0	71.0
Pier 2	4	69.0	67.0
Pier 3	5	67.0	65.0
Pier 4	6	66.0	64.0
East Abutment	7	67.0	65.0

For design purposes, the following values, according to the O.H.B.D.C., are recommended for each pile at pier and east abutment locations.

	<u>HP310x79</u>	<u>HP310x110</u>
Factored Axial Capacity at U.L.S.	1150 kN	1600 kN
Axial Capacity at S.L.S. Type II	825 kN	1150 kN
Factored Lateral Capacity at U.L.S.	60 kN	80 kN
Lateral Capacity at S.L.S. Type II	40 kN	60 kN
Ultimate Pile Capacity for Hiley Formula	2475 kN	3450 kN

As stated in the preceding section, the east approach fill was placed 17 years ago (in 1974) to allow for most of the settlement to occur before the construction of the new bridge takes place. Since no more fill will be placed for the construction of east approach, it is anticipated that no significant settlement will take place at the east approach. Therefore, no downdrag forces will act on piles or caissons at the east abutment. It is recommended that full capacities of the piles and caissons should be utilized for the design purposes.

The lateral capacities may be supplemented by the horizontal component of battered piles.

The pile tip elevations in Table 1 are for estimating purposes only. The pile length will depend on the pile cap locations.

Caissons (Alternative 2)

In order to minimize dewatering for the construction of pile cap, consideration can be given to support piers and east abutment on caissons founded on very dense glacial till and extended to the underside of the bridge deck at the pier locations.

Since most of the caissons will be constructed under water, concrete will have to be placed by tremie method, at least to balance the hydrostatic head.

The reinforced concrete caissons will be founded on very dense glacial till ('N' values more than 100 blows/0.3 m). It is recommended that the caissons should be advanced a minimum of 1 m in the very dense glacial till. The recommended founding elevations are as shown in Table 2.

Table 2

<u>Foundation Location</u>	<u>Reference Borehole</u>	<u>Proposed Caisson Base Elev. (m)</u>
Pier 1	3	72.0
Pier 2	4	68.0
Pier 3	5	66.0
Pier 4	6	65.0
East Abutment	7	66.0

The following O.H.B.D.C. capacities are recommended for 0.9 m, 1.2 m and 1.5 m diameter caissons. If larger caissons are considered, contact the Foundation Design Section of specific recommendations.

<u>Caisson Diameter</u>	<u>Factored Capacity at U.L.S.</u>		<u>Bearing Capacity at S.L.S. Type II</u>	
	<u>Axial</u>	<u>Lateral</u>	<u>Axial</u>	<u>Lateral</u>
0.9 m	3290 kN	330 kN	2240 kN	225 kN
1.2 m	5810 kN	580 kN	3950 kN	395 kN
1.5 m	9110 kN	910 kN	6190 kN	620 kN

The horizontal component of battered caissons can be applied to resist lateral force. Battered caissons can be installed at slopes up to 1H:5V.

Frost Protection

Frost protection of 1.8 m of earth cover would be required for footings and pile caps.

Dewatering and Construction Considerations

Construction should be carried out without disturbing the existing structure or the foundation soils for the proposed structure. It is the responsibility of the contractor to propose methods of construction, including dewatering, to fulfil this requirement, and it is recommended that the contract should contain SP's to this effect. The contractor should submit a construction method and a dewatering proposal for review a minimum of 10 working days prior to construction.

In order to carry out construction in the dry, dewatering will be required for excavations below the prevailing groundwater level prior to excavations.

- at the east abutment it is anticipated that the pile/caisson cap will be above the prevailing groundwater. If not, then sheet piles can be used to control groundwater with consideration to the design criteria presented in the subsequent section on piers.
- at the west abutment, the Contractor should be alerted that non-cohesive soil is susceptible to disturbance under conditions of unbalanced hydrostatic head. However, it is anticipated that dewatering can be carried out by a system of oversized excavations with perimeter ditches and sump pumping.
- at the piers, enclosed cofferdams consisting of either sheet piles or prefabricated boxes will be required. Sheet piles should be driven below bases of excavation to a depth at least equal to 75 percent of the hydrostatic head, measured from the base of the excavation, after which sump pumping can be used for dewatering. If the cofferdam is to fulfil any retaining function, then the minimum depth of embedment should be checked using earth pressure parameters. If a prefabricated box is used it will be necessary to seal the outer edges at the base and utilize enough tremie concrete to balance to hydrostatic head before dewatering and construction in the dry.

To minimize dewatering, pile bents could be constructed instead of conventional pile caps. In this case concrete filled steel tubes should be incorporated into the design to enhance rigidity and offer protection against damage. These tubes should extend from the underside of the deck to below frost level or below scour level whichever is deeper.

If caissons are considered as an alternative, this may minimize dewatering. However, the contractor would have to propose a method of installation that maintains the sides and base of the caisson excavation without disturbance.

Lateral Earth Pressure

Backfill to abutments or retaining wall should consist of Granular 'A' or 'B' material for which the following unfactored properties are recommended:

$$\begin{array}{llll} \text{Granular 'A'} & \gamma = 22.8 \text{ kN/m}^3 & \phi = 35^\circ & K_a = 0.27 \quad K_o = 0.43 \\ \text{Granular 'B'} & \gamma = 21.2 \text{ kN/m}^3 & \phi = 30^\circ & K_a = 0.33 \quad K_o = 0.50 \end{array}$$

Lateral pressure should be calculated in accordance with Section 6.6.1.2.1 of the O.H.B.D.C. From a geotechnical perspective a yielding foundation condition may be assumed and hence the active condition will govern the design. If the structure cannot tolerate movement then the at rest condition will govern the design.

Stability of Slopes and Settlement

For the east approach a 7 m thick fill was placed seventeen years ago (in 1974). The fill is underlain by a 5.9 m to 15.2 m thick layer of silty clay. The fill was placed to allow most of the consolidation settlement to take place prior to the construction of the proposed bridge. Consolidation tests were carried out on nine samples from different locations and depths.

Considering the existing fill was placed seventeen years ago and the fill is about 0.25 m higher than required for the construction of east approach, it is estimated that any additional settlement will be less than 50 mm.

On the west approach the maximum height of the fill will be about 9 m. The subsoil on the west approach site consists of competent material. Any settlements at this location are expected to be elastic and will take place during construction. The settlement on the west approach is expected to be less than 25 mm.

Effective stress analyses have been carried out for the east approach fill. The results show that there will be no stability problem. The result of the stability analysis is shown on Figure 9.

Temporary slopes should be maintained at 1H:1V or flatter for embankments up to 5 m. Slopes for embankments between 5 m and 10 m high should be constructed at 1.5H:1V or flatter. Permanent slopes should be maintained at 2H:1V. Slopes as steep as 1H:1V are feasible but would require reinforcement. All slopes should be protected against surficial erosion by establishing vegetation cover. Slopes at abutments should be armoured with 0.6 m thick rock protection to prevent erosion. Such rock protection should extend horizontally 10 m on each side of the abutments and vertically from the high water level to the base of the embankment and 2 m along the river bottom.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of Ken Ahmad.

The equipment used was owned and operated by Johnston Drilling Co. Ltd.

The report was written by Ken Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



A handwritten signature in cursive script, appearing to read "Ken Ahmad".

K. Ahmad, P.Eng.
Foundation Engineer

A handwritten signature in cursive script, appearing to read "M. Devata".

M.S. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 824.2; E 372 462.5 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 90-07-22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
88.1	Ground Surface																
0.0			1	SS	53	/3cm											22 37 30 11
			2	SS	50												
			3	SS	89		86										
			4	SS	40												
			5	SS	34		84										
			6	SS	21												
			7	SS	20		82										
			8	SS	26												
			9	SS	86		80										
			10	SS	70												
77.4							78										34 26 30 10
10.7	End of Borehole																
	• W.L. not established																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 815.3; E 372 486.6 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90-07-16 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	20 40 60 80 100	W _p	W			W _L
86.2	Ground Surface													
0.0	Silty Sand to Sandy Silt With Gravel, Trace Clay Occ. Cobbles and Boulders Compact To Very Dense Brown To Grey (Glacial Till)		1	SS	29	/3cm	86						120/3cm o o o o	10 32 48 10 32 25 33 10 36 22 34 8
			2	SS	52		84							
			3	SS	60									
			4	SS	11		82							
			5	SS	84									
			6	SS	35		80							
			7	SS	27									
			8	SS	109									
78.7														
7.5	End of Borehole													
	* W.L. not established													

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 787.0; E 372 543.0 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90-09-05, 06 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
85.6	River Surface													
0.0	Water													
80.1	River Bottom													
5.5	Organic Clayey Silt													
79.0	Black, Very Soft (Muck)													
6.6	Silty Sand to Sandy Silt Frequent Gravel & Boulder Zone Dense To Very Dense		1	SS	50									
	Grey		2	SS	67									
	(Probable Glacial Till)		3	SS	102	/15cm								91 9 0 0
	Silty Sand to Sandy Silt with Gravel Occ. Cobbles and Boulders Very Dense, Grey		4	SS	192	/23cm								
	(Glacial Till)		5	SS	172	/26cm								
67.1			6	SS	100	/5cm								66 30 (4)
18.5	End of Borehole													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 770.0; E 372 602.0 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90-09-07, 10 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.6	River Surface																
0.0	River Water																
80.2	River Bottom																
5.4	Organic Clayey Silt Black, Very Soft (Muck)																
78.3																	
7.3	Silty Clay Soft To Very Stiff Grey (Marine Deposit)		1	SS	*												
			2	SS	*												
			3	SS	24												
72.4																	
13.2			4	SS	78												
			5	SS	72												
	Silty Sand to Sandy Silt With Gravel, Trace Clay Occ. Cobbles and Boulders Very Dense (Glacial Till)		6	SS	121	/26cm											
			7	SS	103	/15cm											
			8	SS	124	/15cm											
64.2																	
21.4	End of Borehole • Split Spoon sank with its own weight																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 741.5; E 372 655.5 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90-09-11,12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
85.6	River Surface													
0.0	River Water						85							
84.2	River Bottom													
1.4	Organic Clayey Silt Very Soft, Black (Muck)		1	SS	**		83							
81.2							81							
4.4	Silty Clay Soft to Firm, Grey (Marine Deposit)		2	SS	14		79							
			3	TW	PM		77							
			4	SS	1		75							
			5	TW	PM		73							
			6	SS	*		71							
			7	SS	*		69							
70.7			8	SS	43		67							
14.9	Silty Sand to Sandy Silt with Gravel, trace of clay Occ. Cobbles and Boulders Dense to Very Dense, Grey (Glacial Till)		9	SS	56		65							
			10	SS	109									
			11	SS	120	/5cm								
64.2			12	SS	100	/5cm								
21.4	End of Borehole * split spoon sank with its own weight													

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 724.5; E 372 714.5 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE N Casing, Wash-boring, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90-07-12,13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
85.6	River Surface													
0.0	River Water													
84.7	River Bottom													
0.9	Organic Clayey Silt Very Soft, Dark Brown (Muck)													
81.6			1	SS	*									
4.0			2	SS	8									
			3	SS	6									
			4	SS	1									
	Silty Clay Soft to Firm Grey (Marine Deposit)		5	SS	*									
			6	SS	*									
			7	SS	*									
			8	SS	*									
			9	SS	*									
			10	SS	*									
	Silty Clay with Sand and Gravel		11	SS	10									
66.4			12	SS	151									
19.2	Possible Silty Sand to Sandy Silt with Gravel Occ. Cobbles and Boulders Very Dense ('Glacial Till')		13	SS	140									
64.1														
21.5	End of Borehole Possible Bedrock • split spoon sank with its own weight													

RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 370-89-00 LOCATION N 4 993 697.5; E 372 771.5 ORIGINATED BY KA
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
DATUM Geodetic DATE 90 07 17,18,19 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	20 40 60 80 100	W _p W W _L			WATER CONTENT (%)				
91.5	Ground Surface																
0.0	Silty Sand to Sand with Gravel Compact to Very Dense (Fill)		1	SS	24	/3cm /28cm /10cm ↓	91				16.7	32 36 (32)					
			2	SS	50		89					7 73 (20)					
			3	SS	38		120/25cm		87								
			4	SS	77				85								
84.5			5	SS	60				83								
7.0			6	SS	46				81								
			7	SS	22				79								
			8	SS	21				77								
	Silty Clay Soft to Stiff Grey (Marine Deposit)		9	SS	5			75									
			10	TW	PM			73									
			11	SS	4			71									
			12	TW	PM			69									
			13	SS	*			67									
			14	TW	PM			65							16 31 41 12		
			15	SS	*												
			16	TW	PM												
72.2	Silty Sand to Sandy Silt some Gravel, trace of Clay Occ. Cobbles and Boulders Dense to Very Dense (Glacial Till)		17	SS	36												
19.3			18	SS	52												
			19	SS	56												
			20	SS	63												
			21	SS	119												
			22	SS	116												
			23	SS	124	/26cm											
63.9	End of Borehole * split spoon sank with its own weight		24	SS	124	/15cm											
27.6			25														

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 370-89-00

LOCATION N 4 993 683.4; E 372 806.8

ORIGINATED BY KA

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger, Cone Test

COMPILED BY KA

DATUM Geodetic

DATE 90-07-24

CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100						20 40 60
91.0	Ground Surface														
0.0	Silty Sand to Sandy Silt with Gravel Loose to Very Dense Brown (Fill)		1	SS	44									24 32 35 9	
			2	SS	27										
			3	SS	35										
			4	SS	35										
			5	SS	98										
			6	SS	38										43 42 (15)
			7	SS	13										
			8	SS	5										
83.9	Silty Clay trace of Sand Soft to Stiff Grey (Marine Deposit)		9	SS	5								17.3	0 2 55 43	
7.1			10	TW	PM										
			11	SS	*										
			12	TW	PH										
			13	SS	*										
			14	TW	PM									17.2	0 1 48 51
			15	SS	*										
			16	SS	*										
			17	SS	*										
70.2			18	SS	102										20 32 38 10
20.8	NOTE 1 - Description														
69.2															
21.8	End of Borehole														
	NOTE 1 Silty Sand to Sandy Silt some Gravel, trace of Clay Occ. Cobbles and Boulders Very Dense (Glacial Till) * split spoon sank with its own weight														

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 370-89-00 LOCATION N 4 993 669.6; E 372 840.1 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 90 07 25 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
90.2	Ground Surface												
0.0	Silty Sand to Sandy Silt some Gravel, trace of Clay occasional wood chips Dense to Very Dense (Fill)		1	SS	86	/15cm							31 48 (21)
			2	SS	89								
			3	SS	41								
			4	SS	57								
			5	SS	39								
85.0	loose		6	SS	4								
5.2	Brown Grey		7	SS	3								
			8	SS	3								
			9	SS	*								0 0 48 52
	Silty Clay Firm to Stiff		10	TW	PM								
			11	SS	*								
	(Marine Deposit)		12	TW	PM							17.2	
			13	SS	*								
			14	SS	*								
			15	SS	*								0 0 50 50
72.5													
17.7	Silty Sand to Sandy Silt, some Gravel Occ. Cobbles and Boulders Very Dense (Glacial Till)		16	SS	10	**							
70.7													
19.5	End of Borehole												
	* split spoon sank with its own weight ** 'N' value is not representative												

RECORD OF BOREHOLE No 10

1 OF 1 METRIC

W.P. 370-89-00 LOCATION N 4 993 657.1; E 372 870.5 ORIGINATED BY KA
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY KA
 DATUM Geodetic DATE 90 07 26 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100						20 40 60
89.6	Ground Surface														
0.0	Silty Sand to Sandy Silt some Gravel, trace of Clay (Fill)		1	SS	64	/15cm	89							38 30 (32)	
			2	SS	103			87							
			3	SS	101			85							
			4	SS	32			83							
86.1			5	SS	6		81								
3.5			6	SS	4		79								
			7	SS	2		77								
			8	SS	*		75								
			9	TW	PM		73								
			10	SS	*		71								
			11	TW	PM										
			12	SS	*										
			13	TW	PM										
			14	SS	*										
73.4			15	SS	6	**									
16.2	Silty Sand to Sandy Silt some Gravel Occ. Cobbles and Boulders Very Dense (Glacial Till)			16	SS	84									
70.9															
18.7	End of Borehole														
	* split spoon sank with its own weight														
	** 'N' value is not representative														

1 OF 1

METRIC

LOCATION N 4 993 643.2; E 372 852.8

ORIGINATED BY: KA

DIST 9 HWY 416

BOREHOLE TYPE Hollow Stem Auger, Cone Test

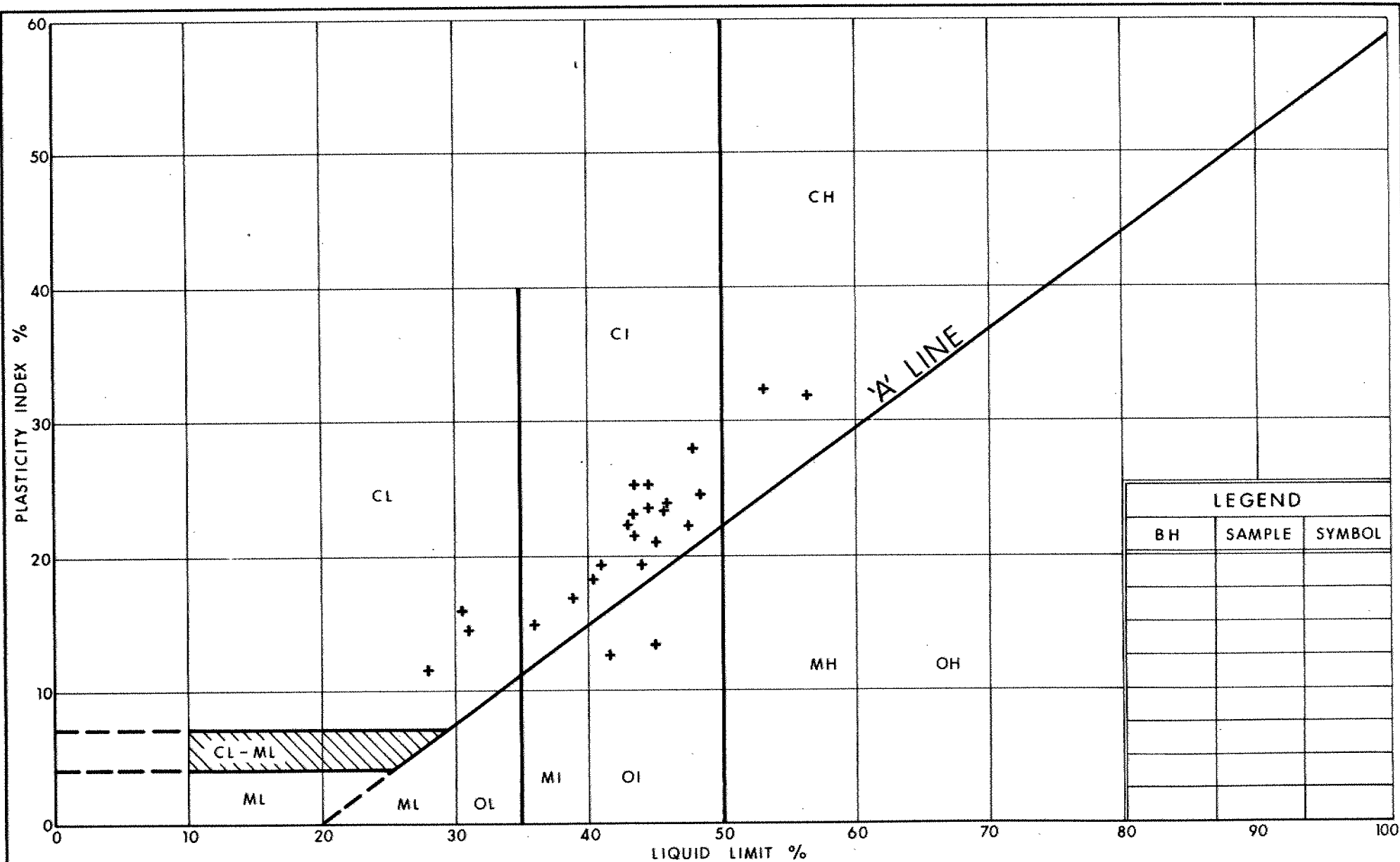
COMPILED BY KA

DATUM Geodetic

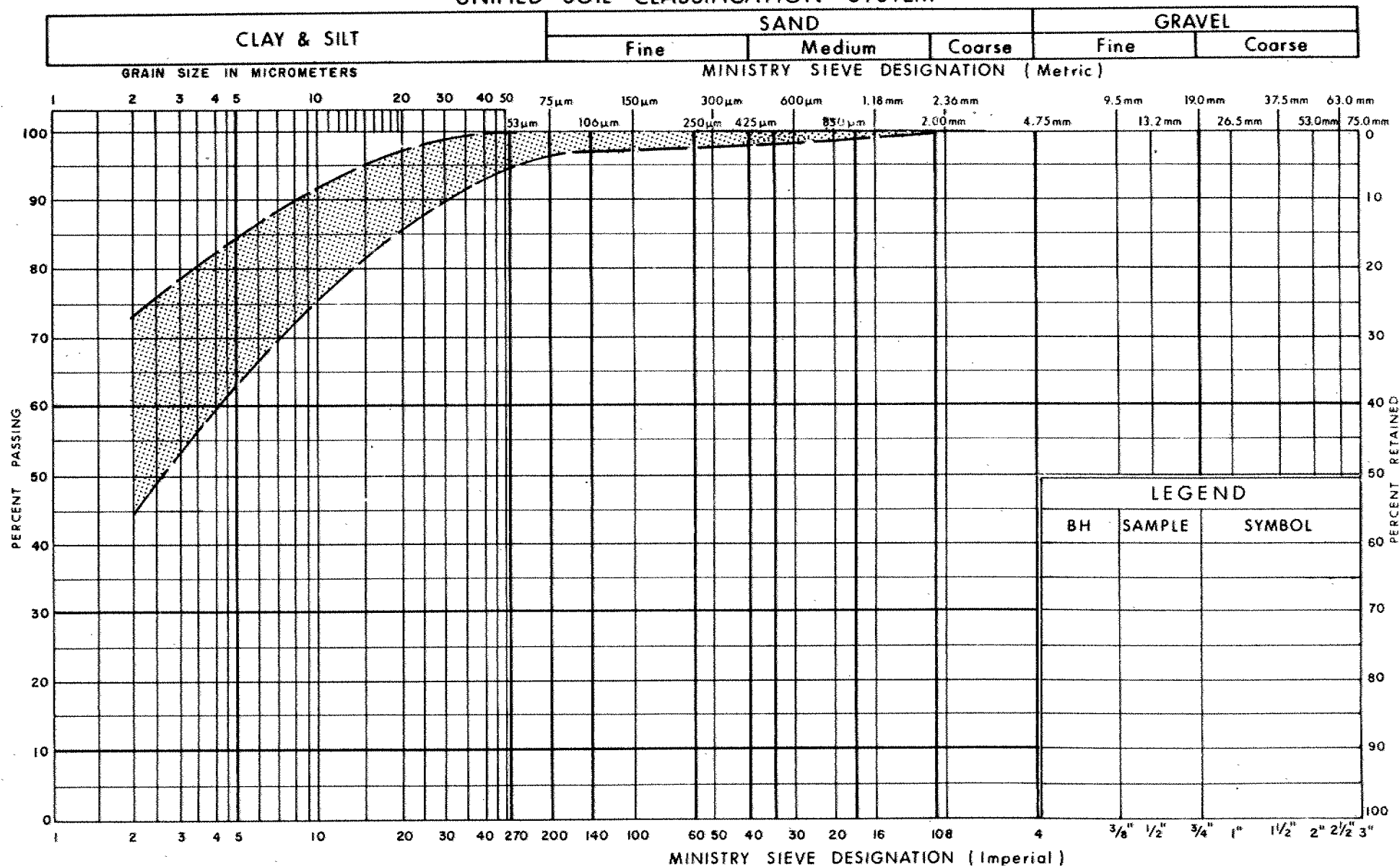
DATE 90 07 27

CHECKED BY DD

+3, x5: Numbers refer to Sensitivity



UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SILTY CLAY

FIG No 2

W P 370-89-00

VOID RATIO - PRESSURE CURVES

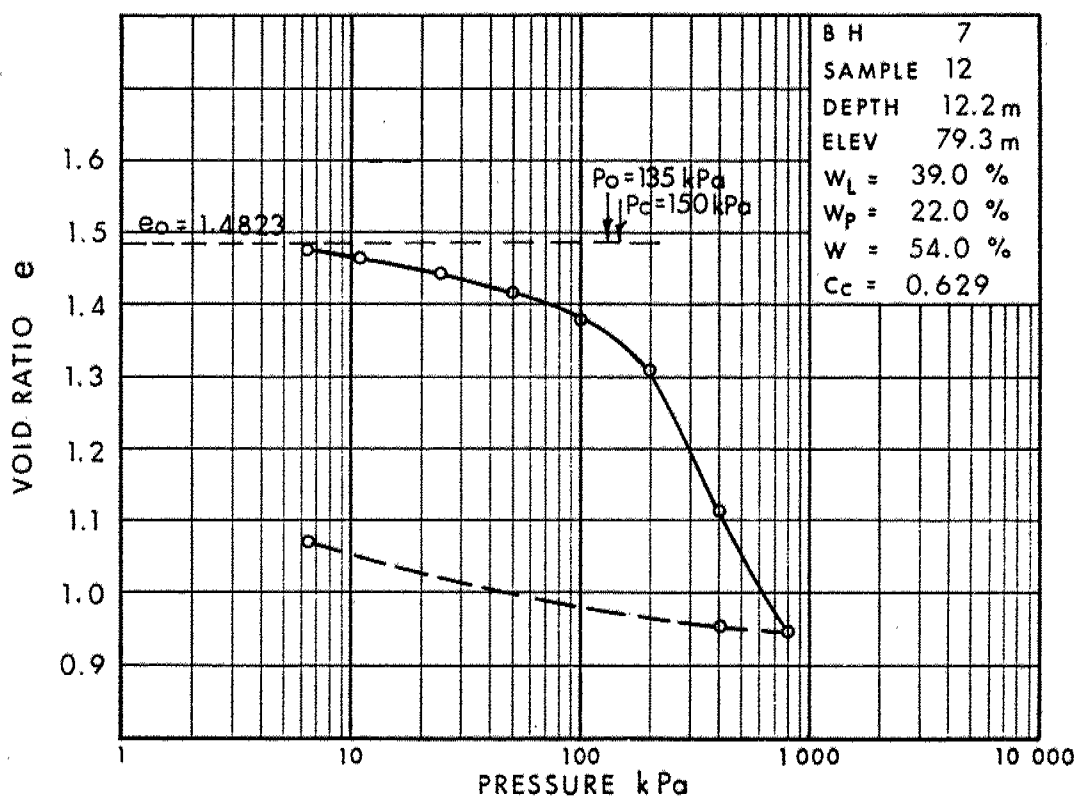
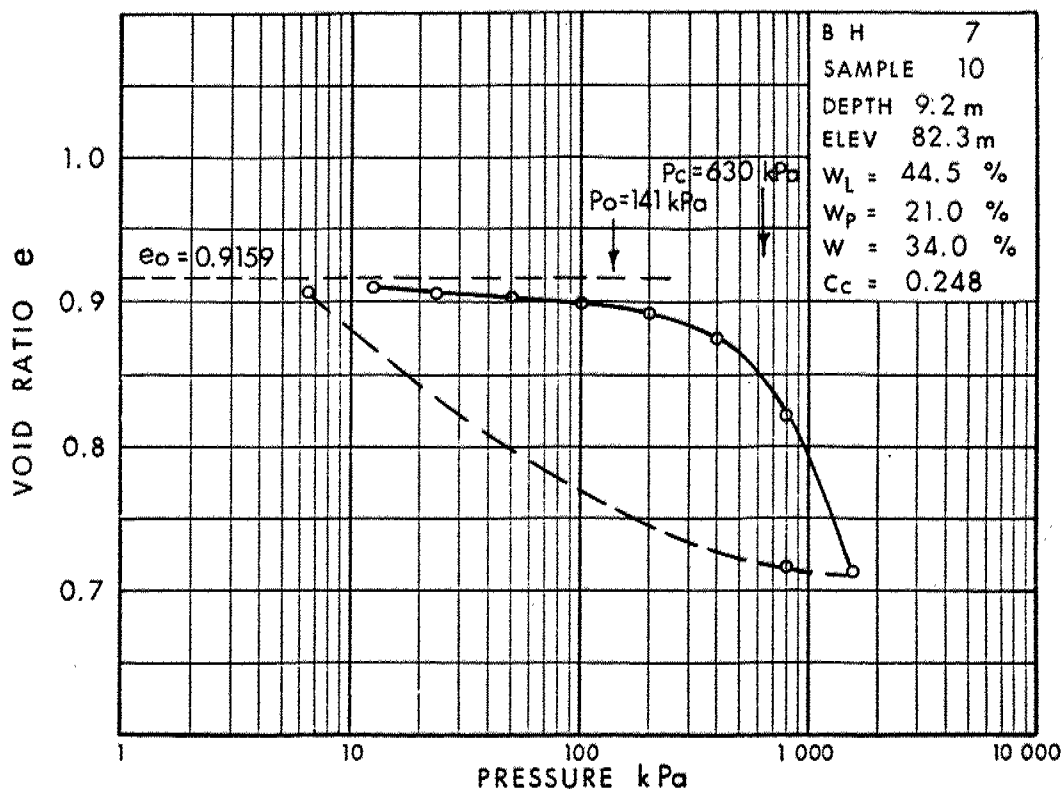


Fig 3

W P 370-89-00

VOID RATIO - PRESSURE CURVES

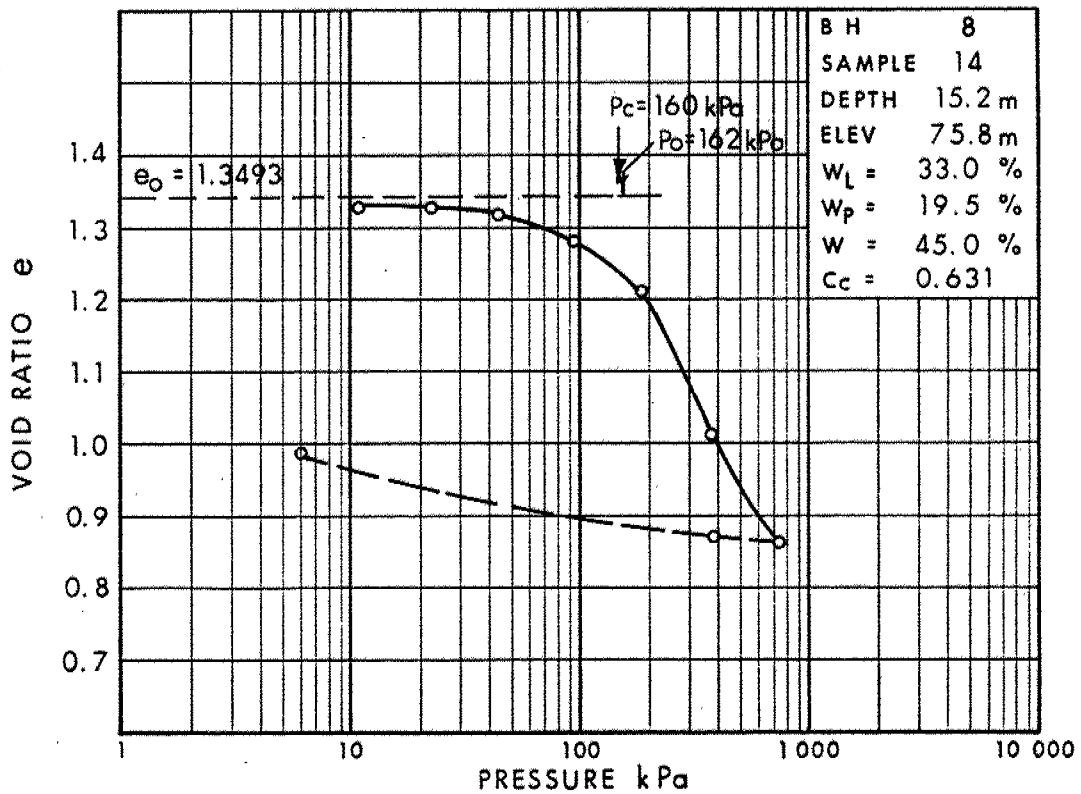
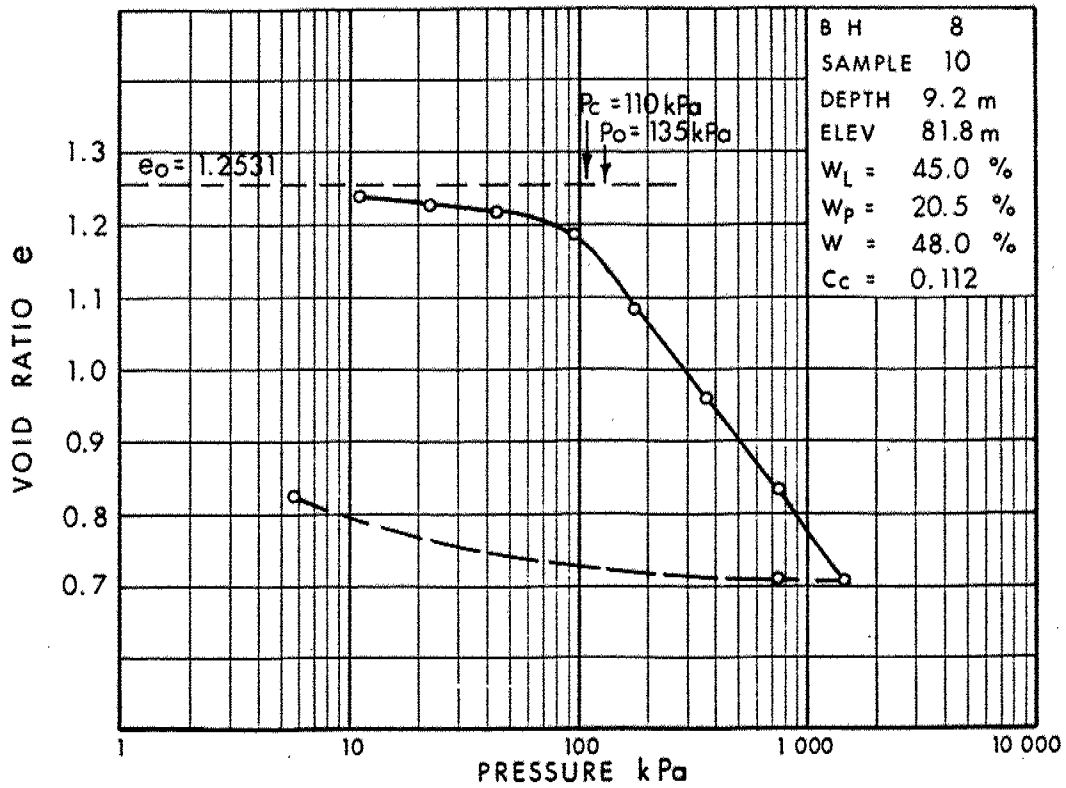


Fig 4

W P 370 - 89 - 00

VOID RATIO - PRESSURE CURVES

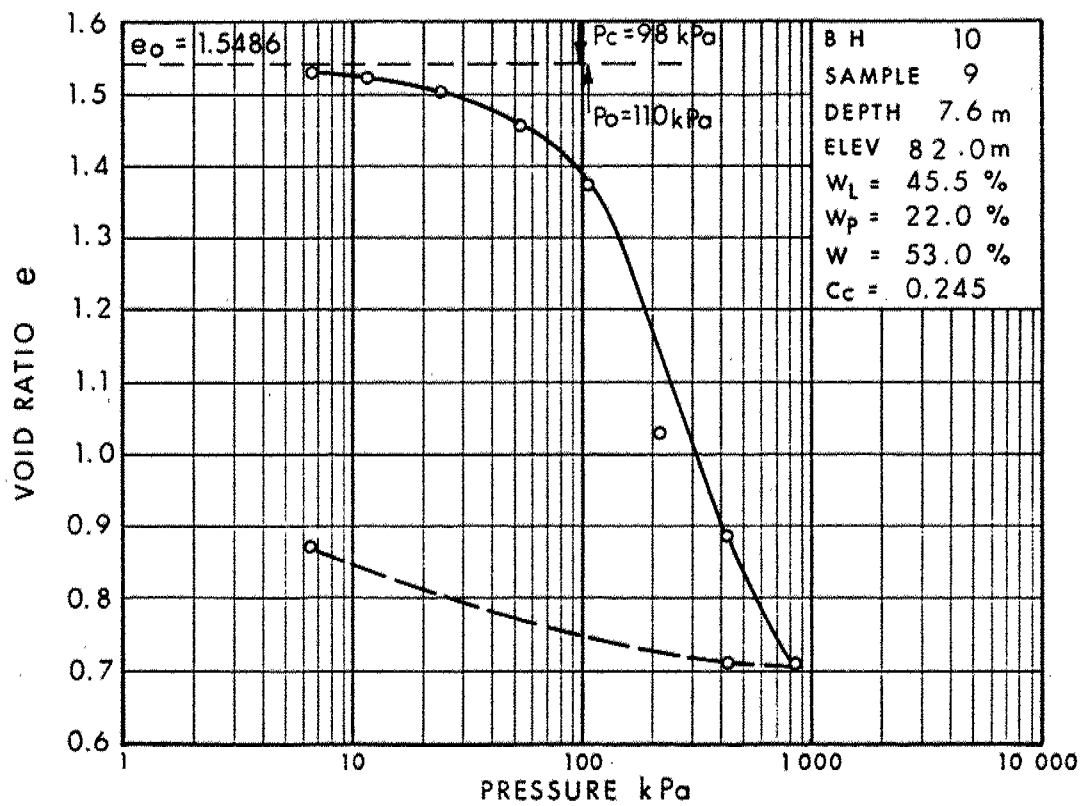
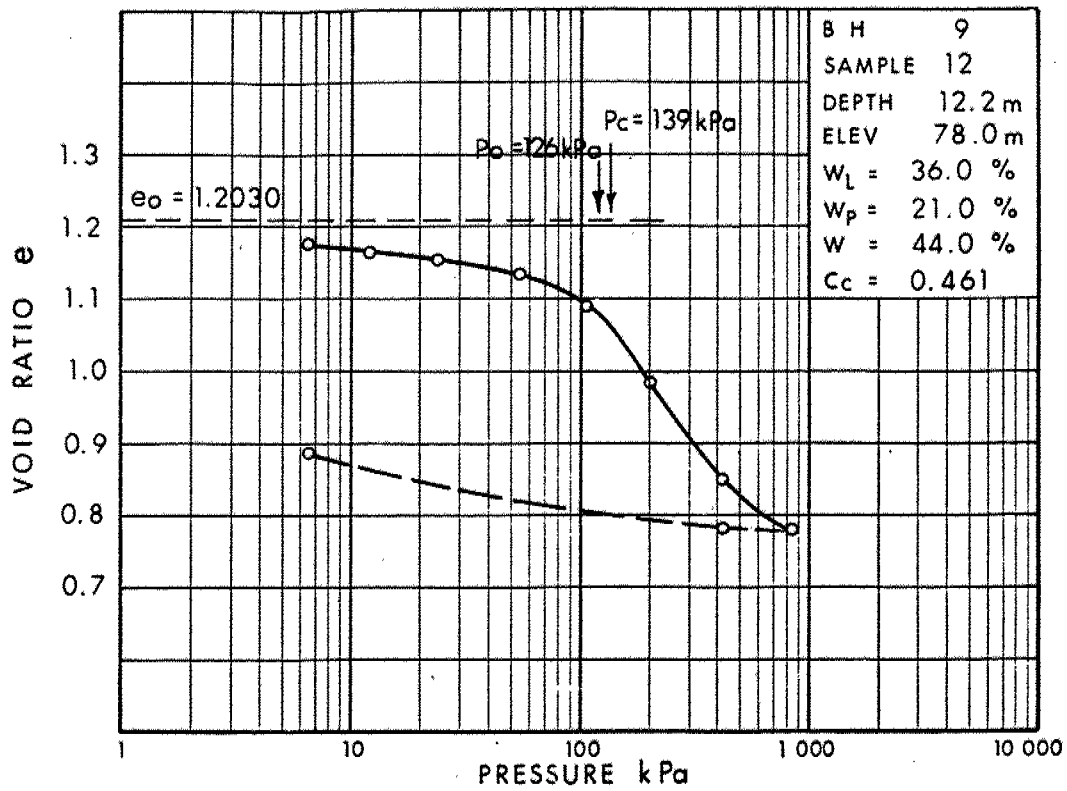
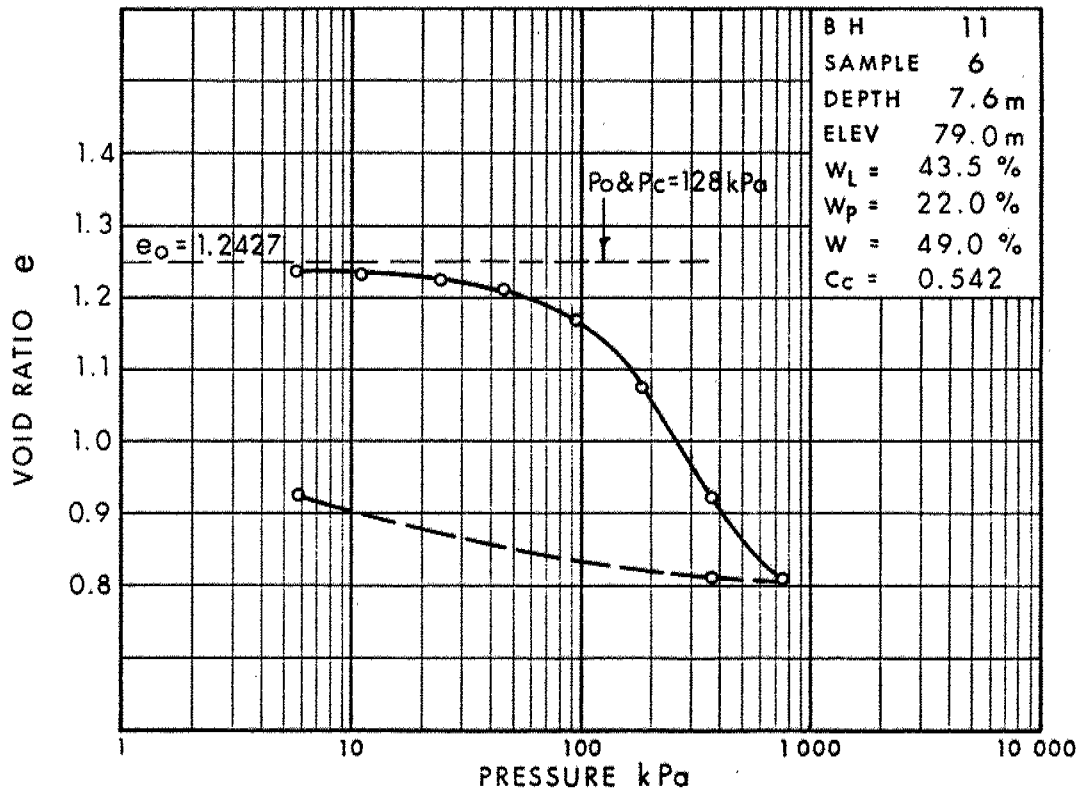
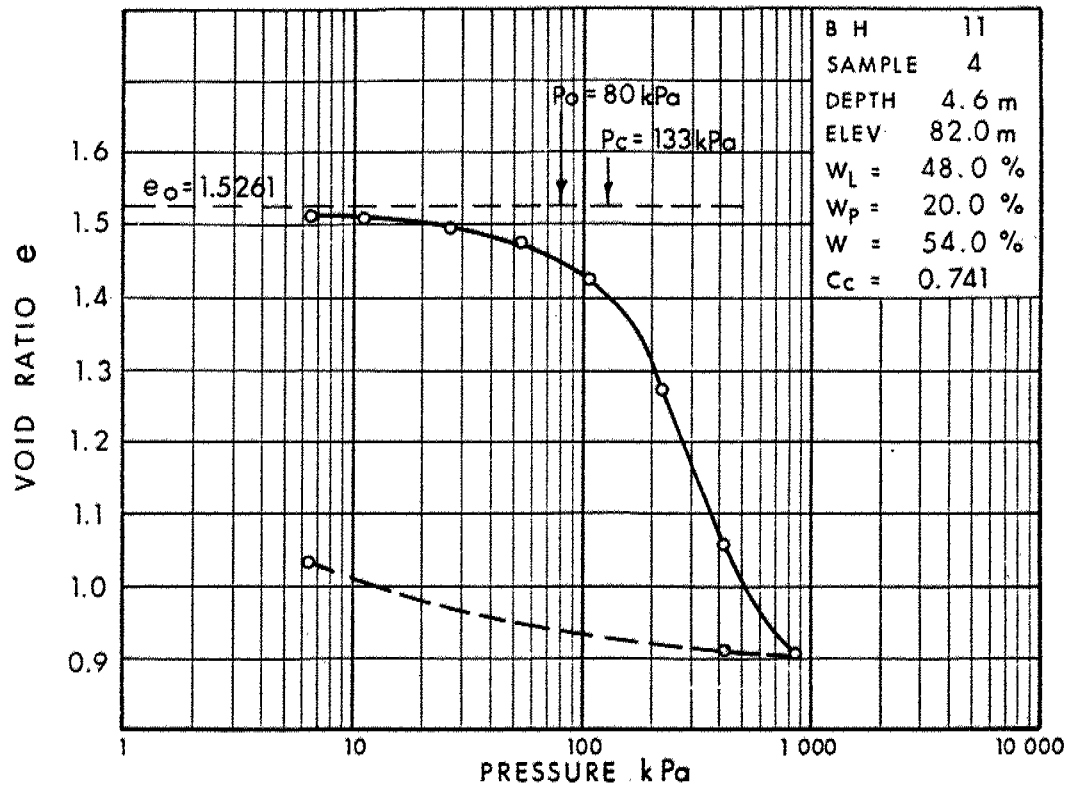


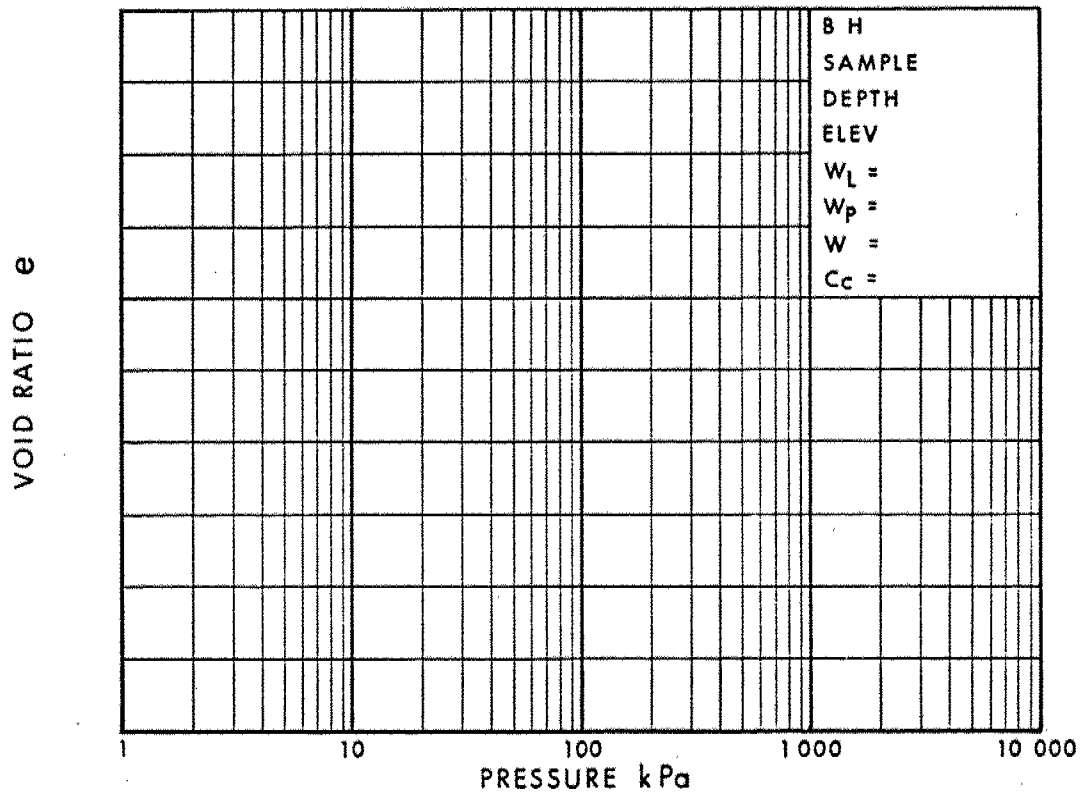
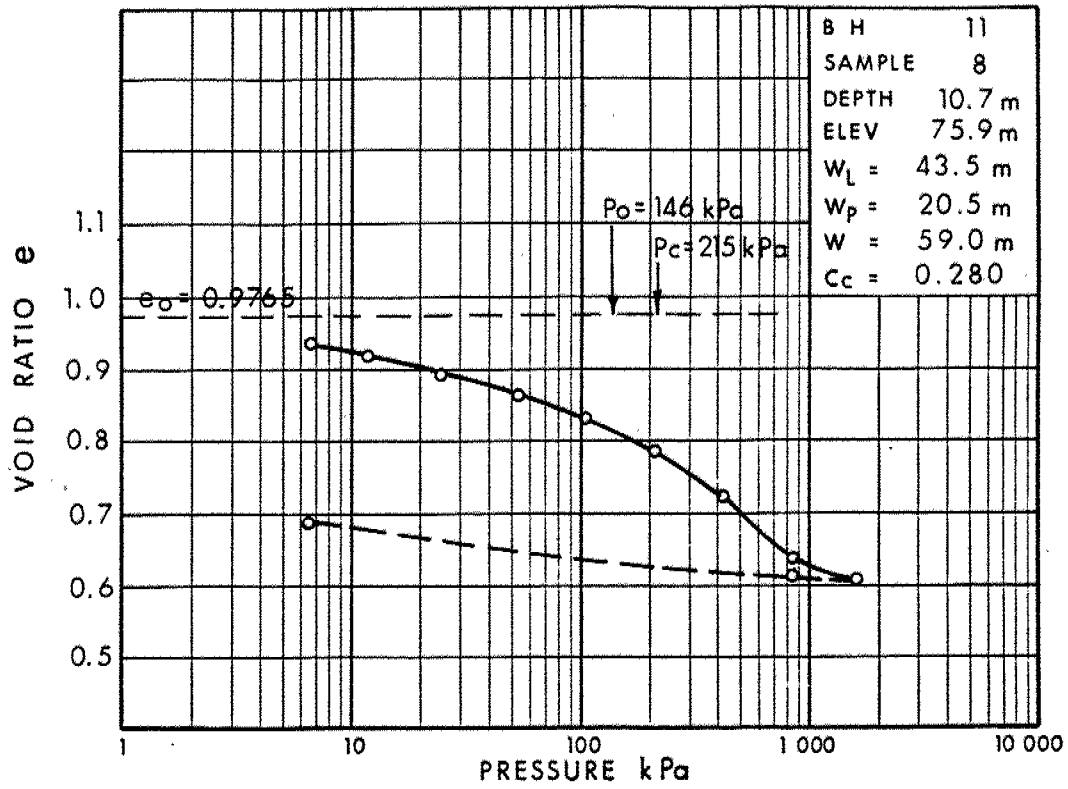
Fig 5

W P 370-89-00

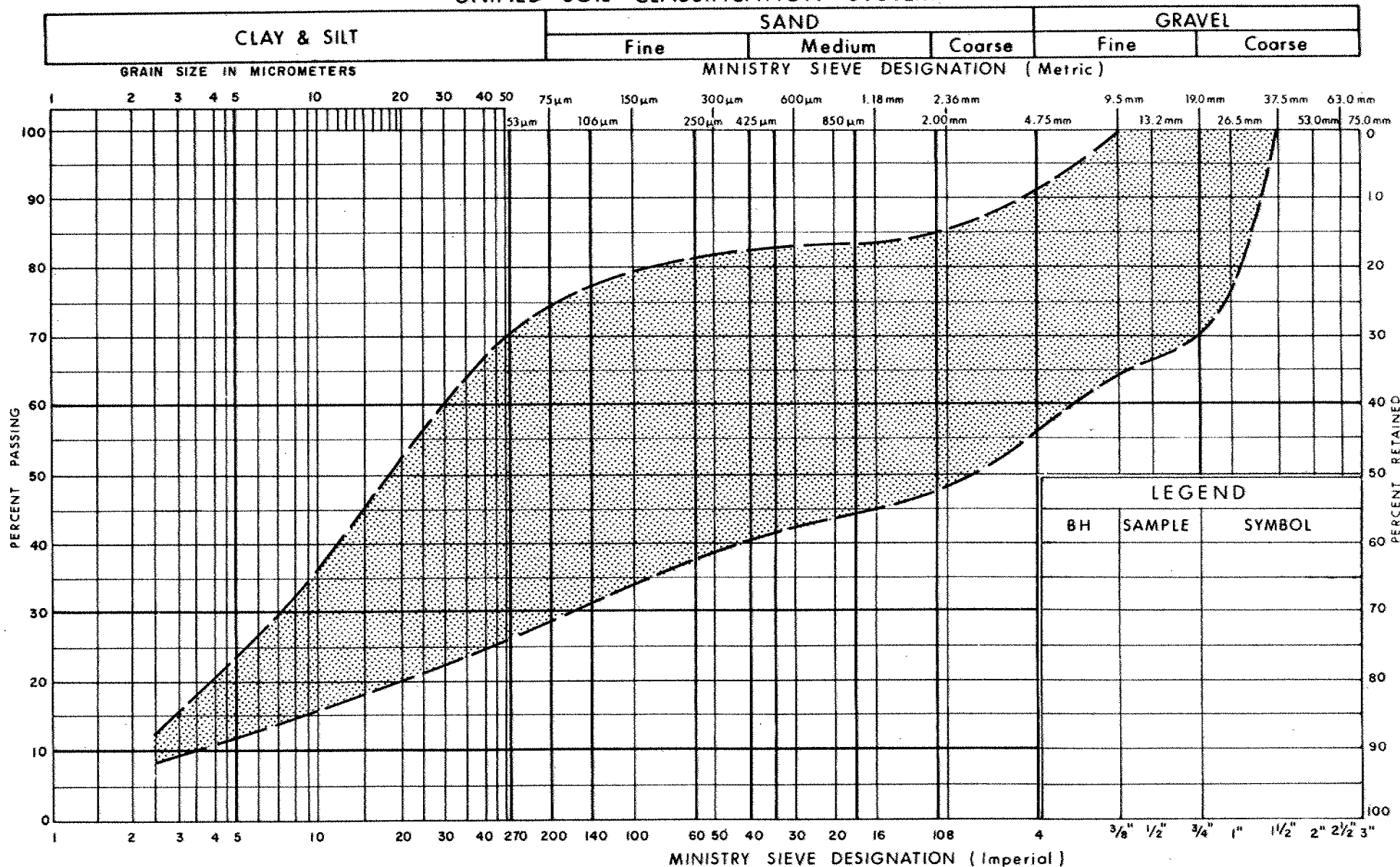
VOID RATIO - PRESSURE CURVES



VOID RATIO - PRESSURE CURVES



UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT (Glacial Till)
WITH GRAVEL, TRACE CLAY, OCC COBBLES AND BOULDERS

FIG No 8

W P 370-89-00

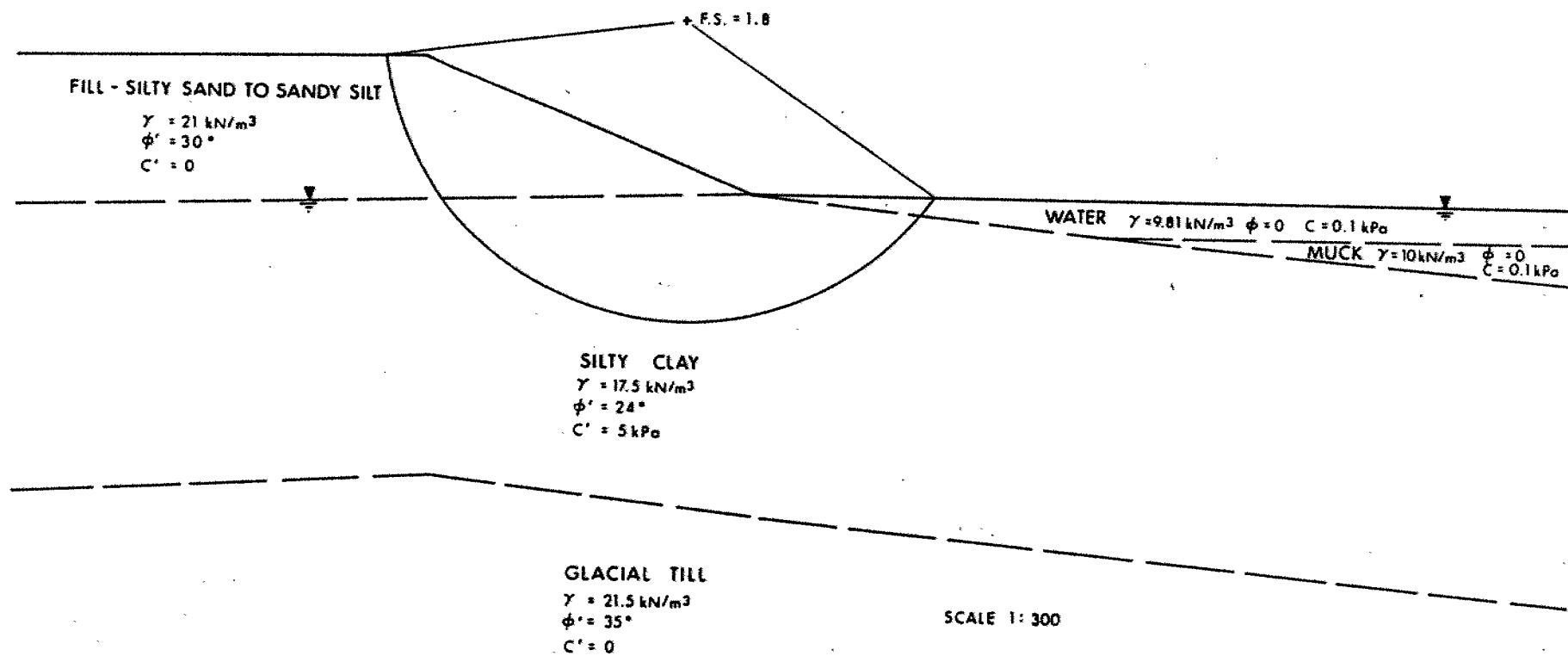
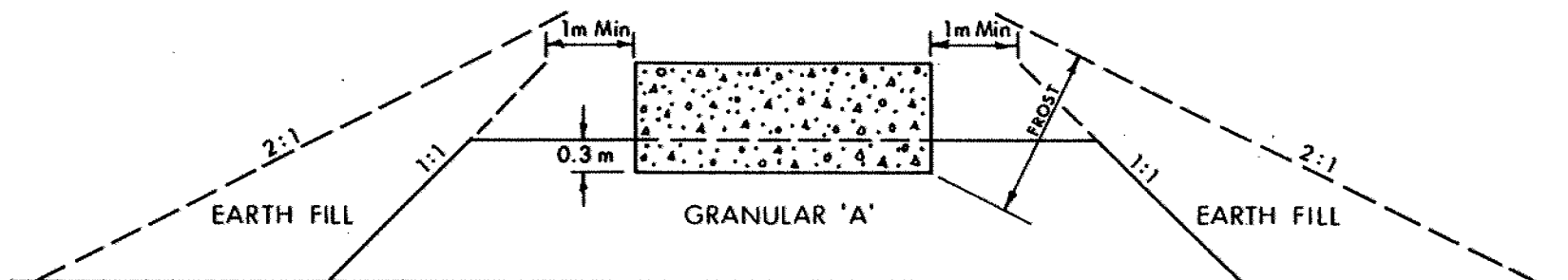
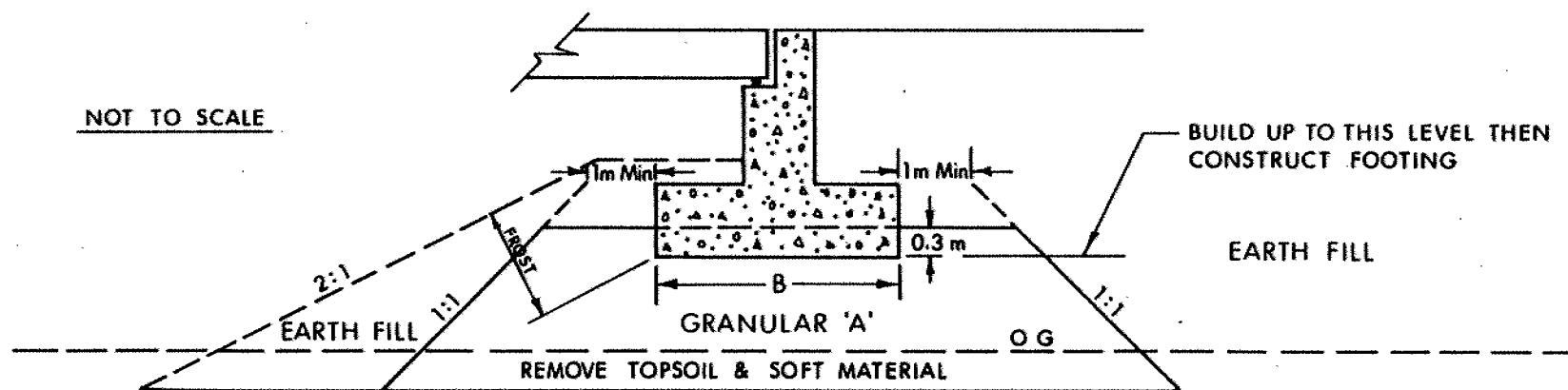


FIG 9

WP 370-89-00



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 10

W P 370-89-00

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

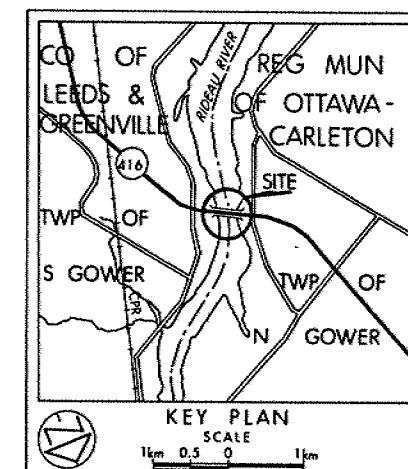
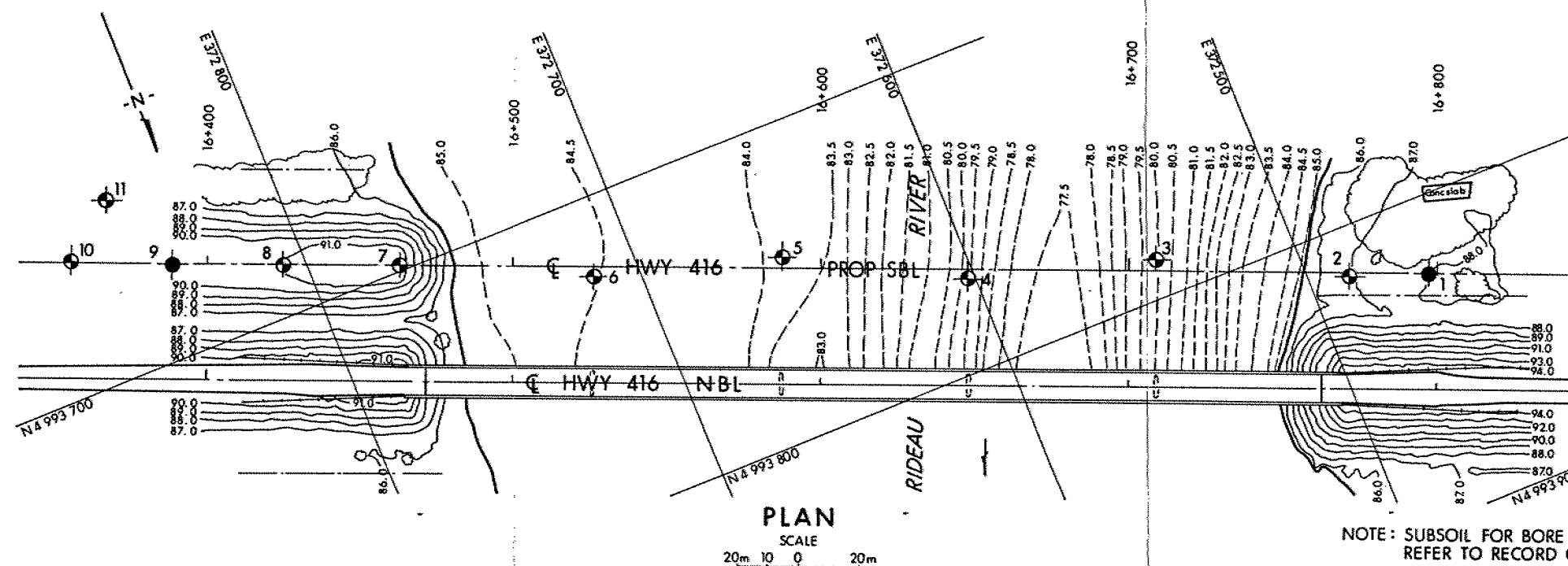
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No 01
WP No 370-89-00



SHEET

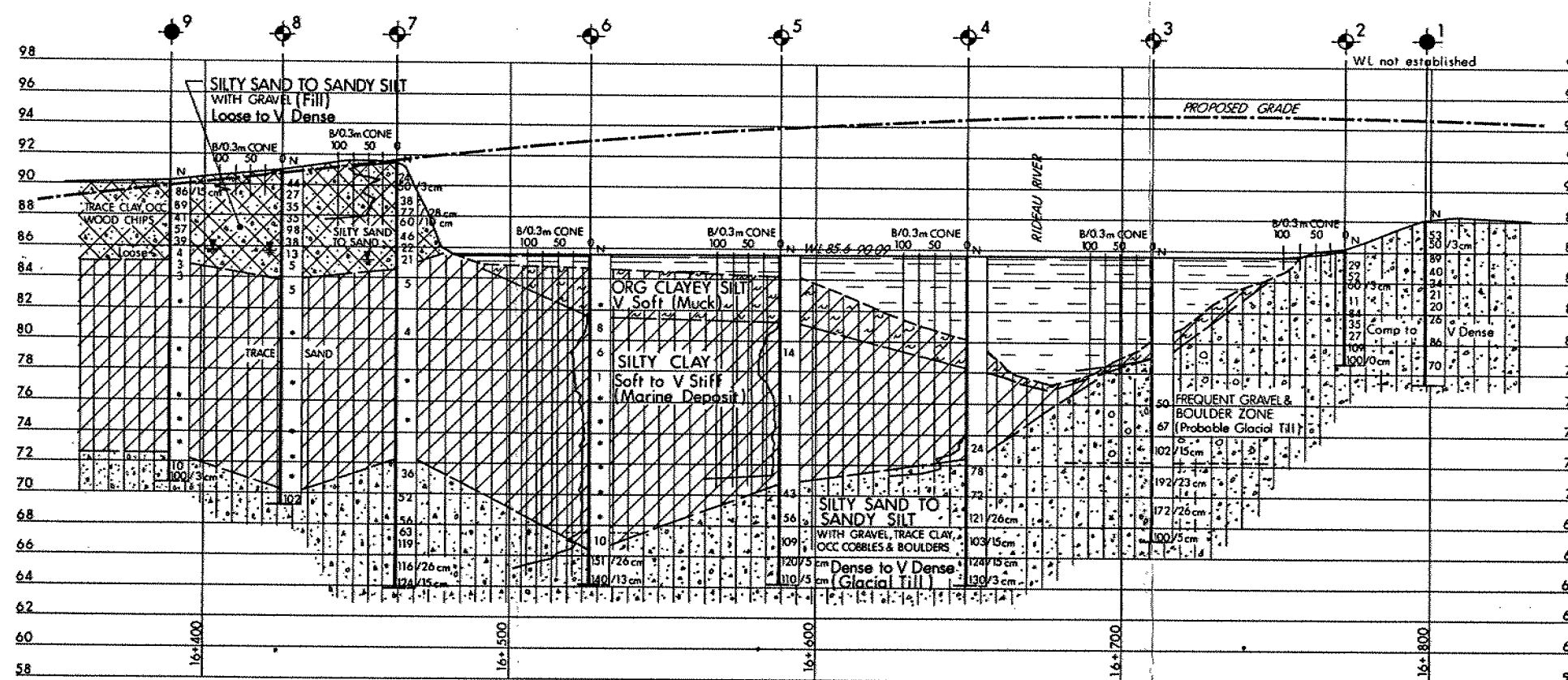
RIDEAU RIVER
BORE HOLE LOCATIONS & SOIL STRATA



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 9007&09
- * Split spoon sunk with its own weight

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	4993 824.2	372 462.5
2	86.2	4993 815.3	372 486.6
3	85.6	4993 787.0	372 543.0
4	85.6	4993 770.0	372 602.0
5	85.6	4993 741.5	372 655.5
6	85.6	4993 724.5	372 714.5
7	91.5	4993 697.5	372 771.5
8	91.0	4993 683.4	372 806.8
9	90.2	4993 669.6	372 840.1
10	89.6	4993 657.1	372 870.5
11	86.6	4993 643.2	372 852.8



PROFILE HWY 416 SBL

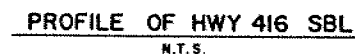
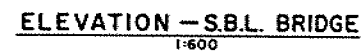
NOTE

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 102-2 of Form 100.

DATE	BY	DESCRIPTION

Geocres No 31G-201	HWY No 416 SBL	DIST 9
SUBM'D K.A. CHECKED	DATE 1991 01 09	SITE 3-264
DRAWN S.O. CHECKED	APPROVED	DWG 3708900-A



1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOOTING LAYOUT
4. FOOTING REINFORCING
5. EAST ABUTMENT
6. WEST ABUTMENT
7. PIERS
8. BEARINGS
9. STRUCTURAL STEEL I
10. STRUCTURAL STEEL II
11. STRUCTURAL STEEL III
12. STRUCTURAL STEEL IV
13. STRUCTURAL STEEL V
14. DECK LAYOUT AND SCREED ELEVATIONS
15. DECK REINFORCING I
16. DECK REINFORCING II
17. BARRIER WALL WITH RAILING
18. RAILING FOR BARRIER WALL
19. EXPANSION JOINTS
20. 1000 MM APPROACH SLAB
21. AS CONSTRUCTED ELEV. & DIM.
22. STANDARD DETAILS I
23. STANDARD DETAILS II
24. PILE DRIVING - STEAM & DIESEL HAMMERS
25. ELECTRICAL EMBEDDED WORK
26. QUANTITIES - STRUCTURE I
27. QUANTITIES - STRUCTURE II

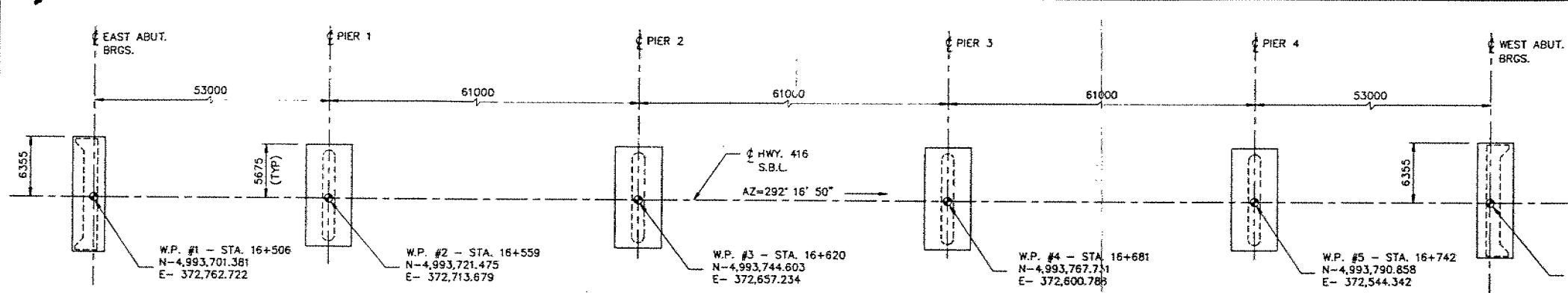
00-3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS

MTCBM. 848016
 EL. 91.876
 TABLET SET IN CONCRETE
 4.98 LT QF 16+498.953
 HWY 416 N.B.L.

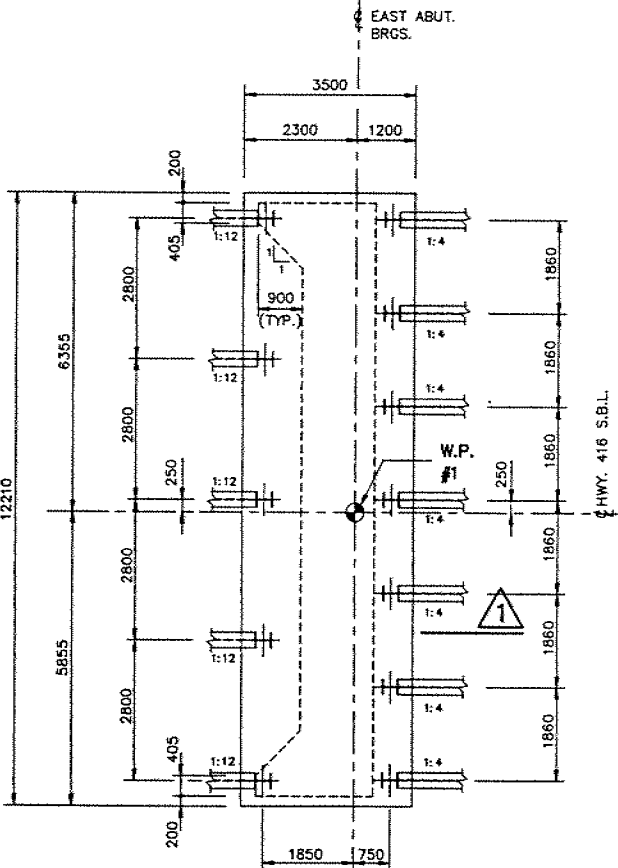
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS									
	DATE	BY	DESCRIPTION						
	DESIGN G.S.S.	CHK B.R.F.	CODE OHBDC-83	LOAD OHBDO-A	DATE	SEPT. '91			
	DRAWN W.K.	CHK G.S.S.	SITE 03-264	STRUCT	SCHEME	OWG. I			

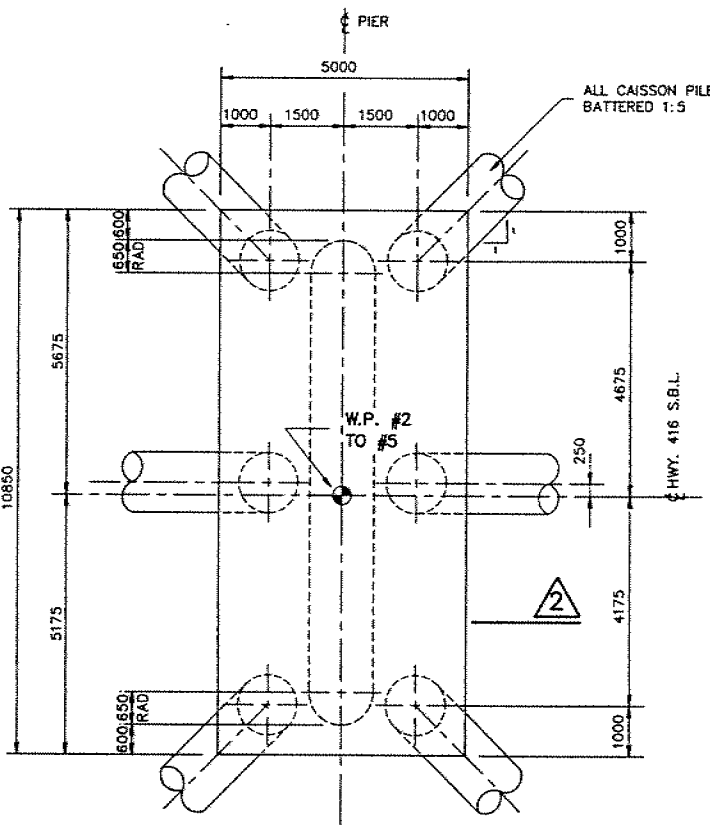
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS ONTARIO PR-D-707 79-106



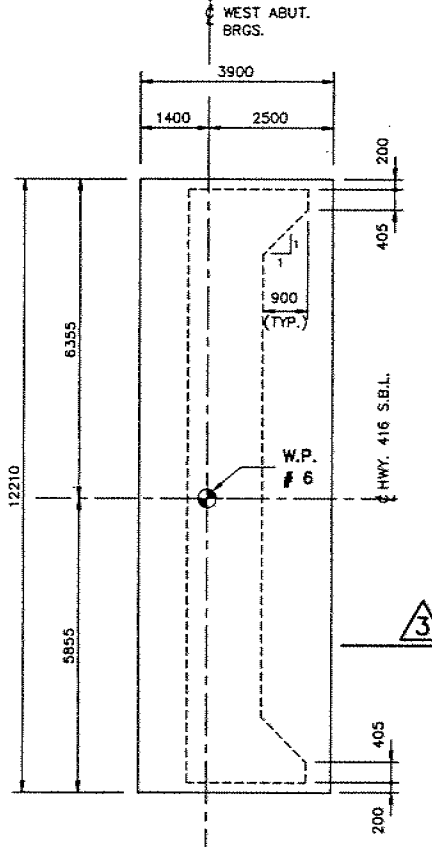
FOOTING LAYOUT
N.T.S.



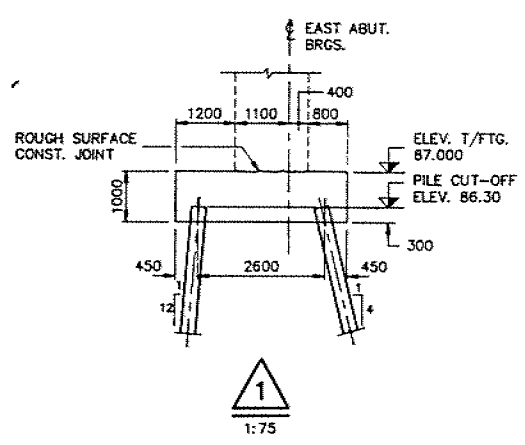
PLAN - EAST ABUTMENT FOOTING
1:75



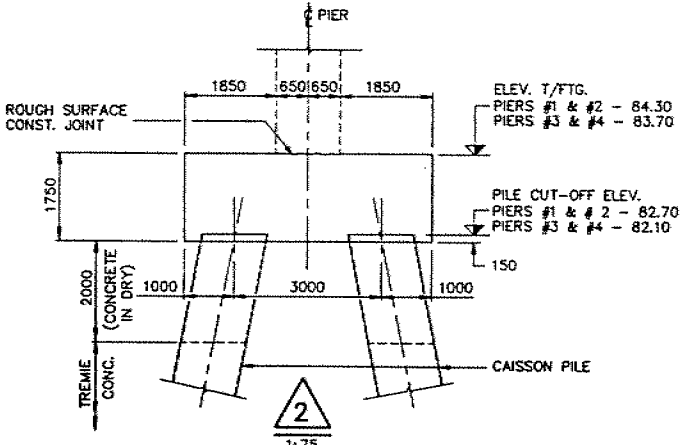
PLAN - TYPICAL PIER FOOTING
1:75



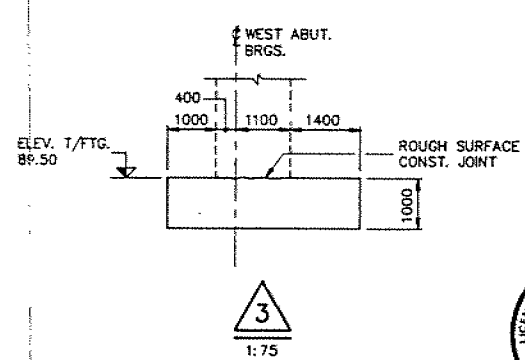
PLAN - WEST ABUTMENT FOOTING
1:75



1
1:75



2
1:75



3
1:75

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

CONT No
WP No 370-89-01

RIDEAU RIVER BRIDGE S.B.L.

FOOTING LAYOUT

DELCAN ENGINEERS PLANNERS AND DESIGNERS

SHEET

- NOTES
- PILE SPACING IS MEASURED AT THE UNDERSIDE OF FOOTINGS.
 - PILE LENGTHS SHOWN ARE THE THEORETICAL LENGTH BELOW CUT-OFF.
 - EAST ABUTMENT PILES TO BE DRIVEN IN ACCORDANCE WITH M.T.O. STANDARD SS 103-10 OR SS 103-11 USING AN ULTIMATE CAPACITY OF 3450 kN PER PILE.

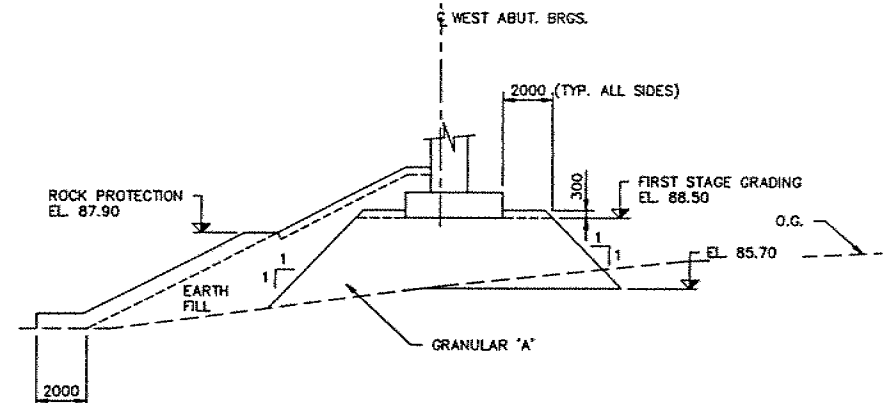
STEEL H-PILE DATA				
LOCATION	BATTER	No. REQ'D	LENGTH	TYPE
EAST	1:4	7	22.0	HP 310X110 WITH DRIVING SHOES
ABUTMENT	1:12	5	21.5	

CAISSON PILE DATA					
LOCATION	BATTER	NO. REQ'D	TIP ELEV.	LENGTH	STEEL LINER
PIER 1	1:5	6	65.00	18.0	1219 O.D. X 11.1 WALL THICKNESS
PIER 2	1:5	6	68.00	17.0	
PIER 3	1:5	6	68.00	14.5	
PIER 4	1:5	6	72.00	10.5	

PILE DESIGN DATA

STEEL 'H' PILES: CAPACITY AT SLS TYPE II 1150kN
FACTORED CAPACITY AT ULS 1600kN

CAISSON PILES: CAPACITY AT SLS TYPE II 3950kN
FACTORED CAPACITY AT ULS 5810kN



WEST ABUTMENT ON COMPACTED GRANULAR 'A'
1:150

- NOTES
- STRIP ALL ORGANIC MATERIAL AND EXCAVATE TO EL. 85.70 UNDER AREA OF GRANULAR 'A'.
 - PROOF ROLL UNDER AREA OF GRANULAR 'A'.
 - PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL.
 - CONSTRUCT CONCRETE FOOTING.
 - PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL.

APPLICABLE DRAWING STANDARDS
DD-3301 SPLICE AND DRIVING SHOE DETAILS FOR STEEL 'H' PILES.



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS		DESCRIPTION			
DATE	BY	DESCRIPTION	DATE	DATE	DWG.
DESIGN	J.W.H.	CHECK	B.R.F.	LOADING	OHBD-A
DRAWING	K.R.S.	CHECK	J.W.H.	SITE No.	03-284
					3

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DISTRICT No 9
CONT No 96-59
WP No 370-89-01



RIDEAU RIVER BRIDGE SBL
GENERAL ARRANGEMENT
SHEET 45

DELCAN

GENERAL NOTES:

CLASS OF CONCRETE 30 MPa

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED.

BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS

CLEAR COVER TO REINFORCING STEEL

FOOTINGS	100 ± 25 mm
ABUTMENTS AND WINGWALLS	
FRONT FACE	80 ± 20 mm
BACK FACE	70 ± 20 mm
PIERS	80 ± 20 mm
DECK	70 ± 20 mm
TOP	40 ± 10 mm
BOTTOM	70 ± 20 mm
REMAINDER	UNLESS OTHERWISE NOTED

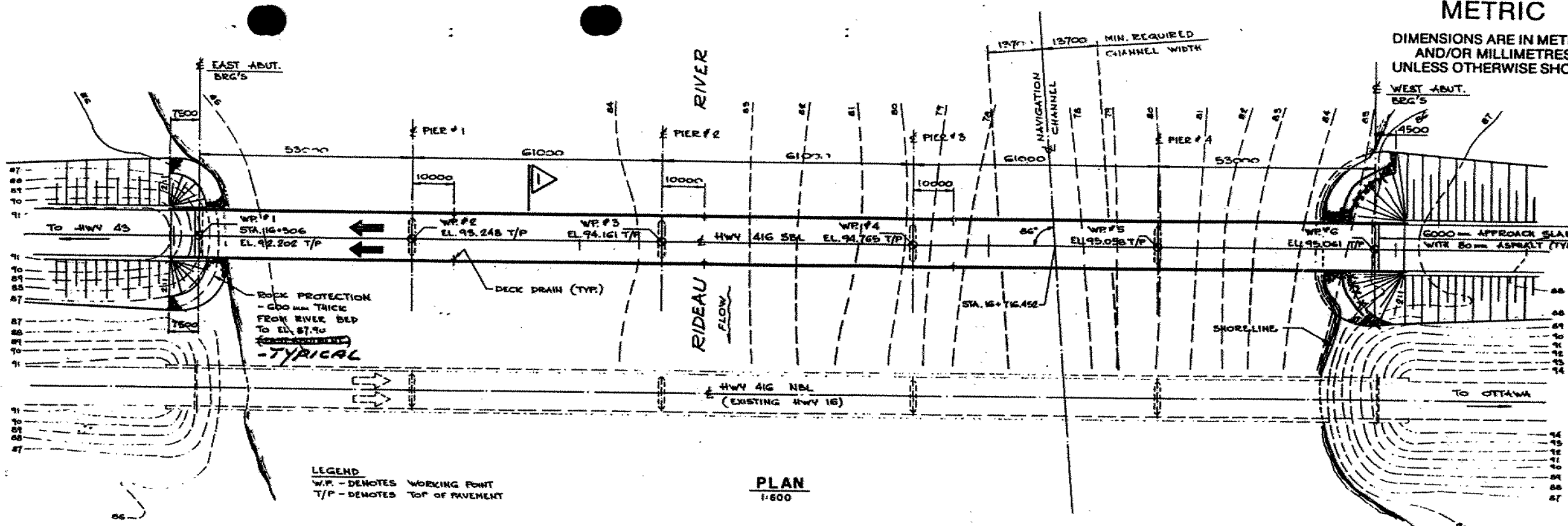
CONSTRUCTION NOTES

THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.

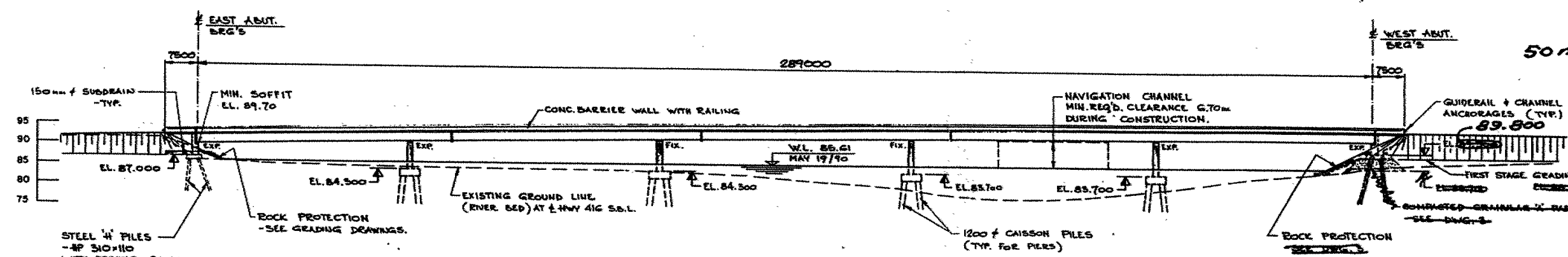
COMPACTED FILL, MAX GRAIN SIZE 50 mm, SHALL BE PLACED UP TO THE BOTTOM OF FOOTING ELEVATION PRIOR TO DRIVING PILES.

LIST OF DRAWINGS

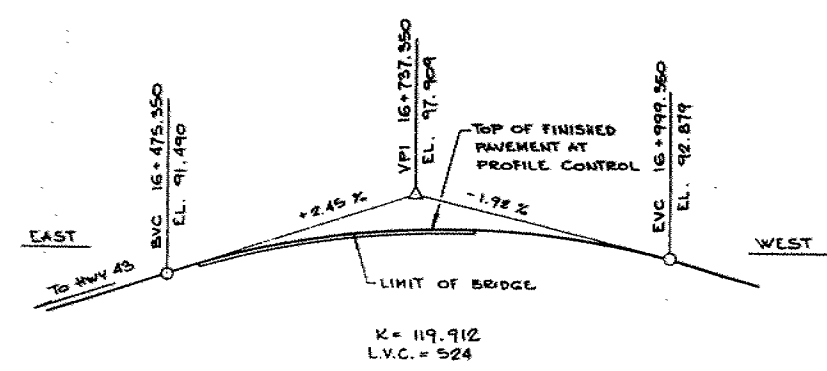
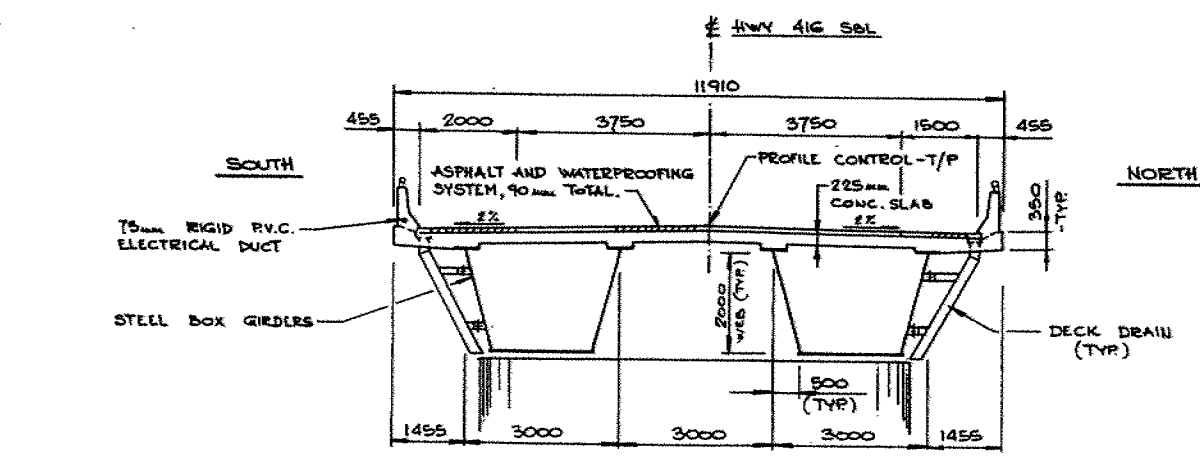
1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOOTING LAYOUT
4. FOOTING REINFORCING
5. EAST ABUTMENT
6. WEST ABUTMENT
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8. BEARINGS
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16. DECK REINFORCING II
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18. RAILING FOR BARRIER WALL
19. EXPANSION JOINTS
20. 6000 mm APPROACH SLAB
21. AS CONSTRUCTED ELEV. & DIM.
22. STANDARD DETAILS I
23. STANDARD DETAILS II
24. PILE DRIVING - STEAM & DIESEL HAMMERS
25. ELECTRICAL EMBEDDED WORK
26. QUANTITIES - STRUCTURE I
27. QUANTITIES - STRUCTURE II



PLAN
1:600



ELEVATION - SBL BRIDGE
1:600



PROFILE OF HWY 416 SBL
N.T.S.

MTCBM. 848016
EL. 91.876
TABLET SET IN CONCRETE
4.98 LT OF 16+498.953
HWY 416 N.B.L.

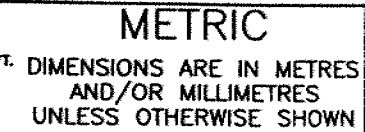


DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

APPLICABLE STANDARD DRAWINGS

OPSD-3501.00 MINIMUM GRANULAR BACKFILL REQUIREMENTS ABUTMENTS

DATE	BY	DESCRIPTION
DESIGN 6.5.5	CHK 8.8.5	CODE 080C-83
DRAWN W.K.	CHK 6.5.5	SITE 03-264
		STRUCT
		SCHEME
		DWG. 1



CONT No 96-59
WP No 370-89-01



RIDEAU RIVER BRIDGE S.B.L.	
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FOOTING LAYOUT

SHEET

47

DELCA **ENGINEERS
PLANNERS
ARCHITECTS**

NOTES

1. PILE SPACING IS MEASURED AT THE UNDERSIDE OF FOOTINGS.
2. PILE LENGTHS SHOWN ARE THE THEORETICAL LENGTH BELOW CUT-OFF.
3.  ABUTMENT PILES TO BE DRIVEN IN ACCORDANCE WITH M.T.O. STANDARD SS 103-10 OR SS 103-11 USING AN ULTIMATE CAPACITY OF 3450 KN PER PILE.

STEEL H-PILE DATA

LOCATION	BATTER	No. REQ'D	LENGTH	TYPE
EAST	1:4	7	22.0	HP 310X110 WITH DRIVING SHOES
ABUTMENT	1:12	5	21.5	
<u>WEST</u>	<u>1:8</u>	<u>7</u>	<u>20.0</u>	
<u>ABUT.</u>	<u>1:12</u>	<u>5</u>	<u>19.5</u>	"

CAISSON PILE DATA

LOCATION	BATTER	NO. REQ'D	TIP ELEV.	LENGTH	STEEL LINER
PIER 1	1:5	6	65.00	18.0	1219 O.D. X 11.1 WALL THICKNESS
PIER 2	1:5	6	66.00	17.0	
PIER 3	1:5	6	68.00	14.5	
PIER 4	1:5	6	72.00	10.5	

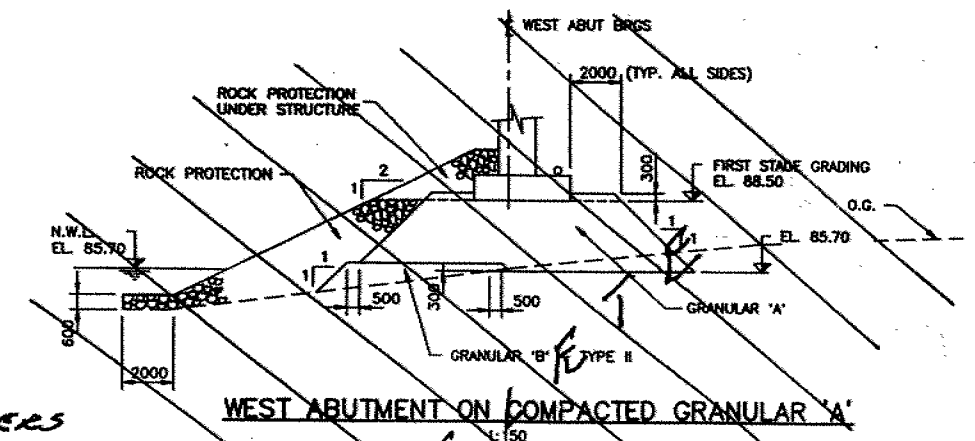
PILE DESIGN DATA

STEEL 'H' PILES:	CAPACITY AT SLS TYPE II	1150kN
	FACTORED CAPACITY AT ULS	1600kN

CAISSON PILES:	CAPACITY AT SLS TYPE II	3950KN
	FACTORED CAPACITY AT ULS	5810KN



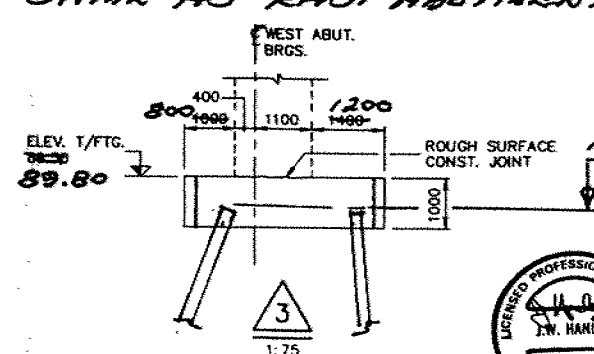
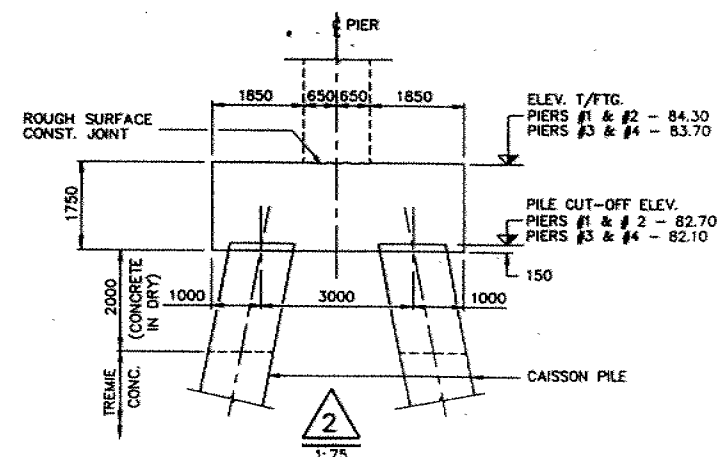
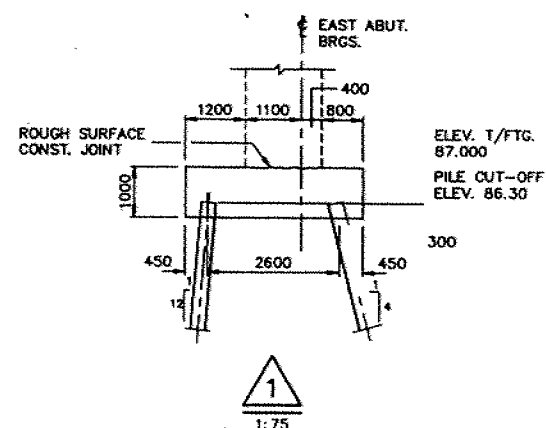
1:75
PILE LAYOUT AND BATTERS
SAME AS EAST ABUTMENT



~~WEST ABUTMENT ON COMPACTED GRANULAR 'A'~~

NOTES

1. STRIP ALL ORGANIC MATERIAL AND EXCAVATE TO EL. 55.70 UNDER AREA OF GRANULAR 'A'.
2. PLACE GRANULAR 'B' - TYPE II.
3. PROOF ROLL UNDER AREA OF GRANULAR 'A'.
4. PLACE GRANULAR 'A' AND ROCK PROTECTION TO BOTTOM OF FOOTING LEVEL.
5. CONSTRUCT CONCRETE FOOTING.
6. PLACE REMAINDER OF GRANULAR 'A' AND ROCK PROTECTION.
7. FOR DETAILS AND LIMITS SEE GRADING DRAWINGS.

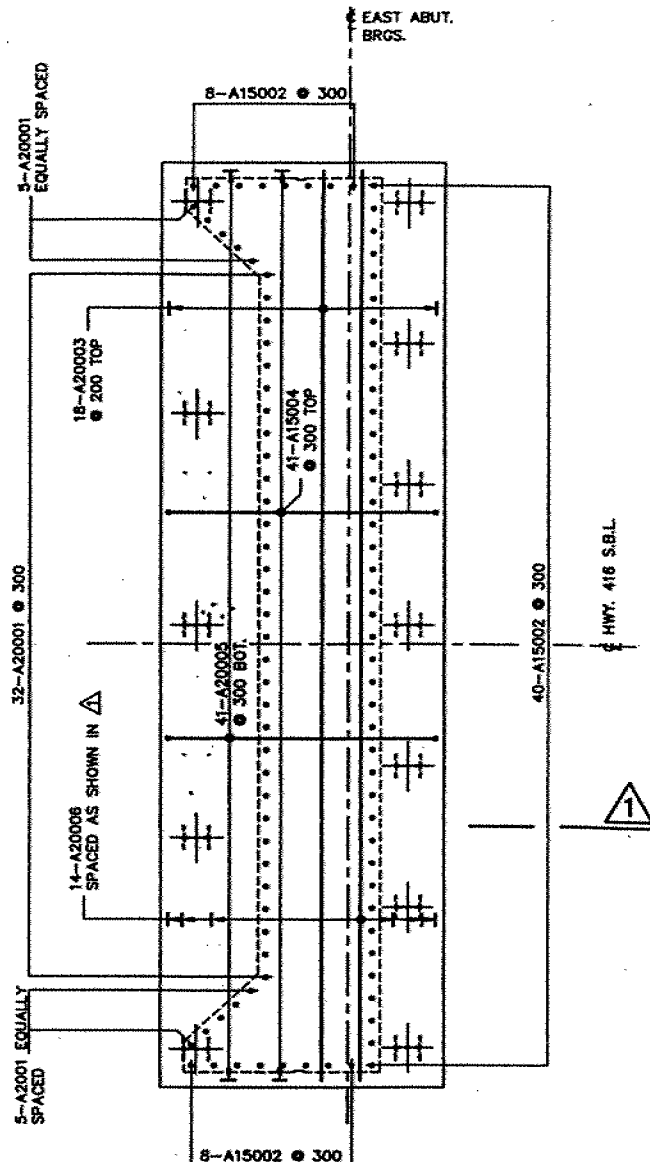


DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

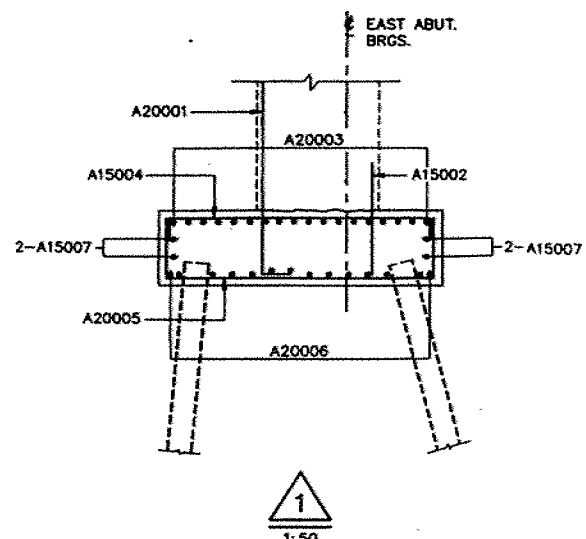
APPLICABLE STANDARD DRAWINGS

OPSD-3301.00 SPICE AND DRIVING SHOE
DETAILS FOR STEEL 'H' PILES.

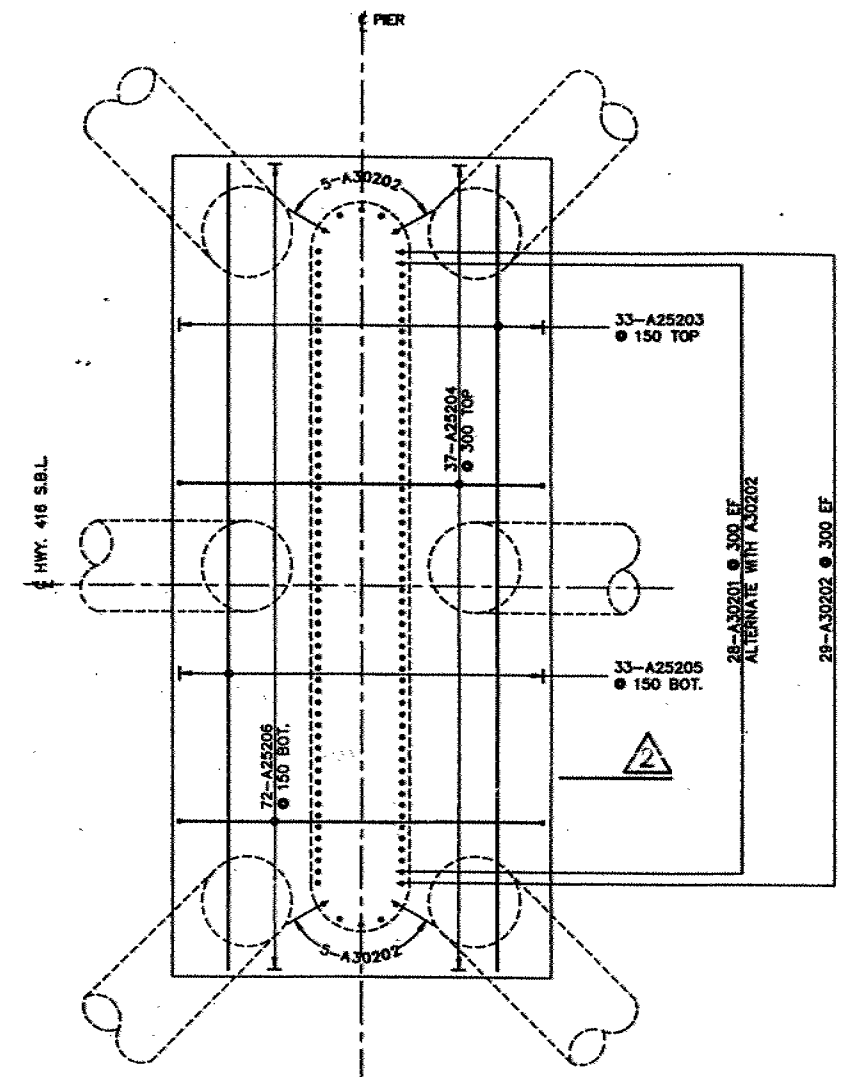
DETAILS FOR STEEL A FILES					
REVISIONS					
	DATE	BY	DESCRIPTION		
	DESIGN J.W.H.	CHECK B.R.F.	LOADING	OHBDG-83-A	DATE SEPT/91
	DRAWING K.R.S.	CHECK J.W.H.	STE No	03-204	DWG. 1



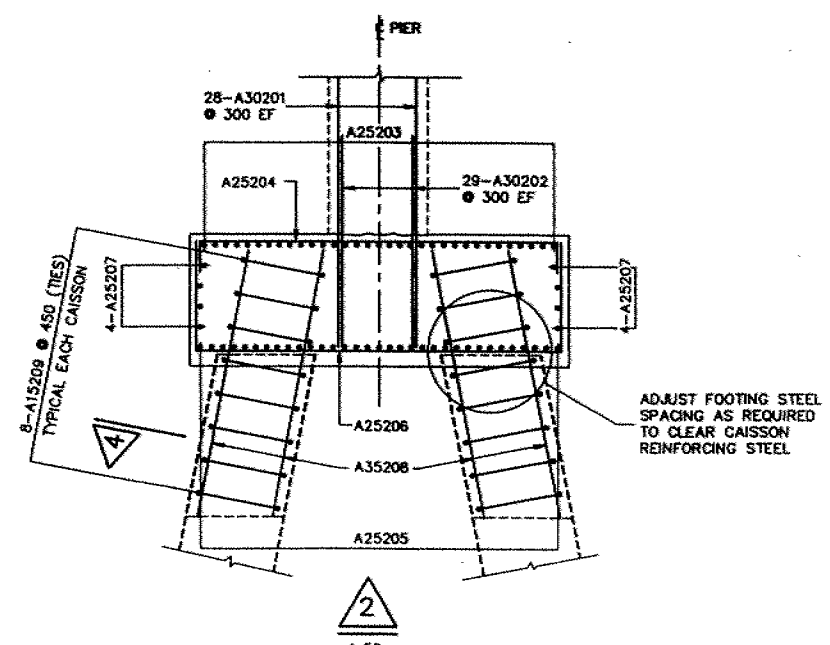
PLAN - EAST ABUTMENT FOOTING
1:50



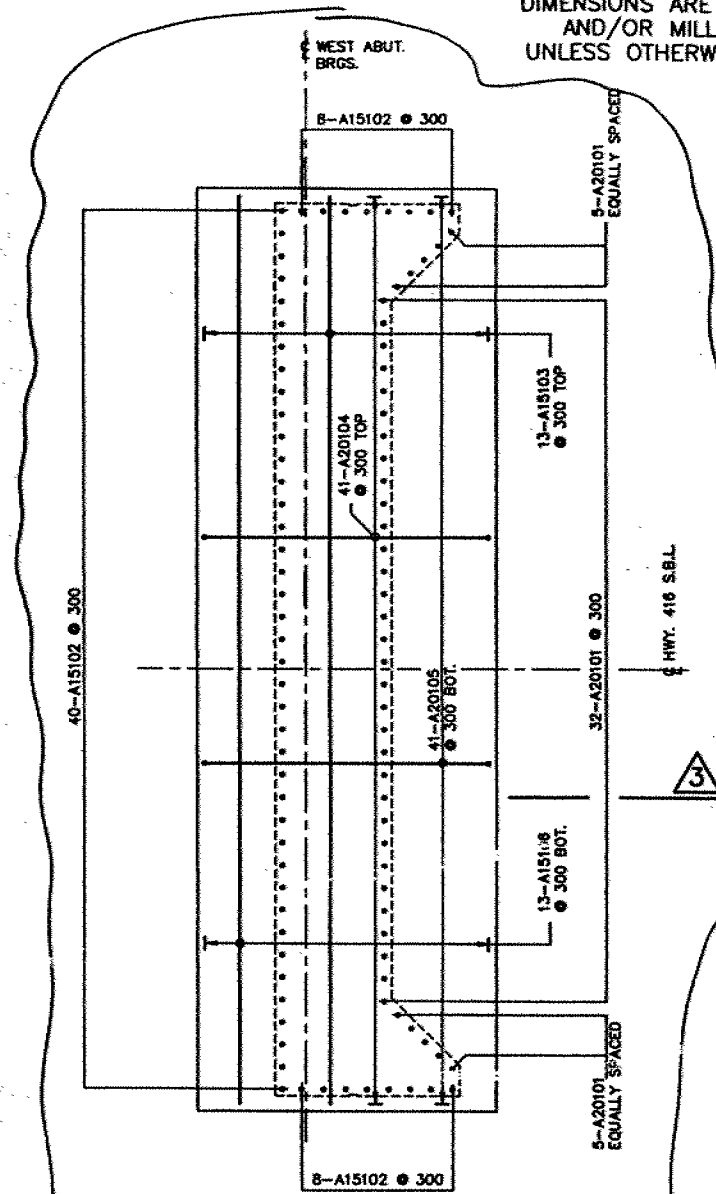
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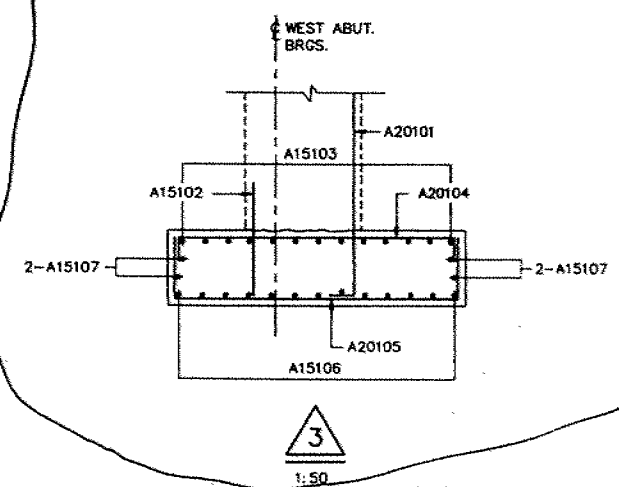
PLAN - TYPICAL PIER FOOTING
1:50



2
1:50



PLAN - WEST ABUTMENT FOOTING
1:50

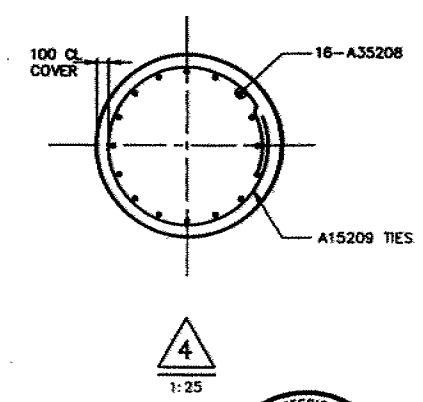


3
1:50

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

CONT. No 96-59 WP No 370-89-01		
RIDEAU RIVER BRIDGE S.B.L.		
FOOTING REINFORCING		SHEET 48
DELCAN		

REVISE FOOTING WIDTH
AND REINFORCING STEEL
DETAILS TO SAME AS
EAST ABUTMENT FOOTING.
INDICATE PILES.



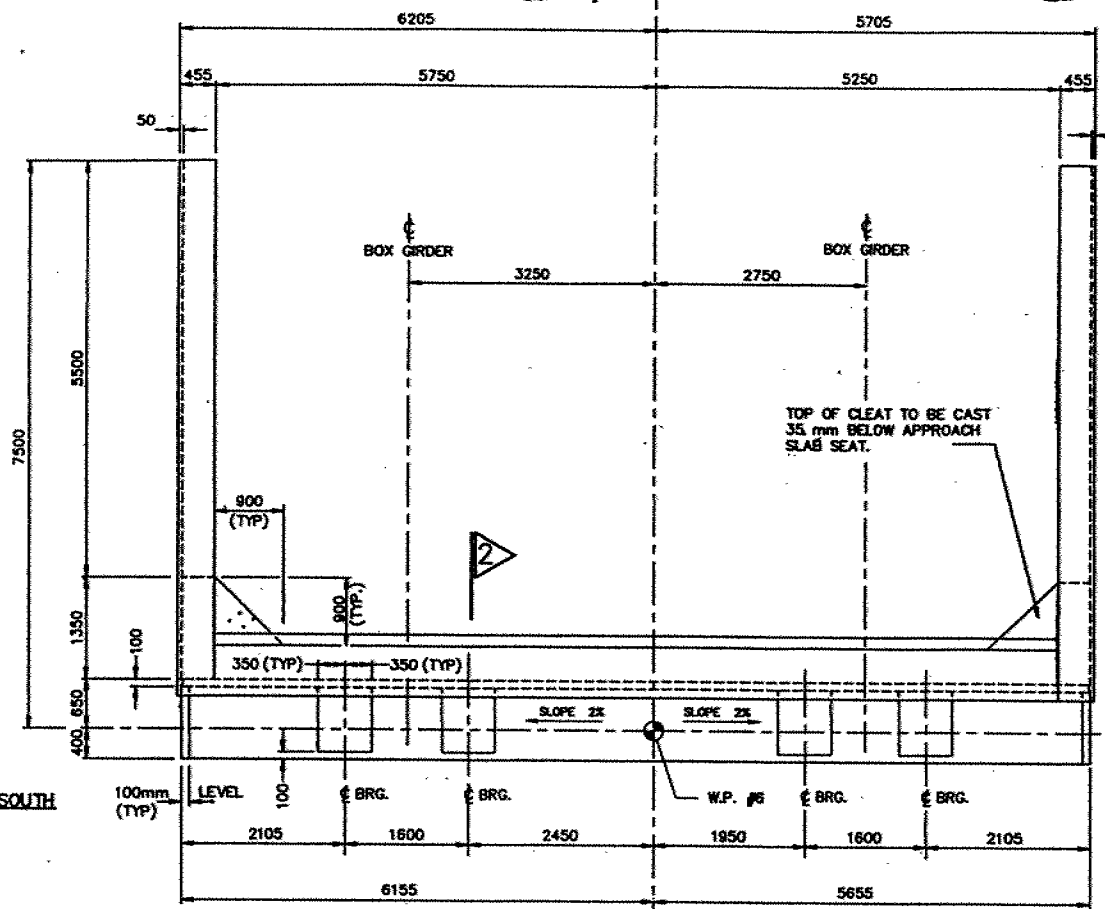
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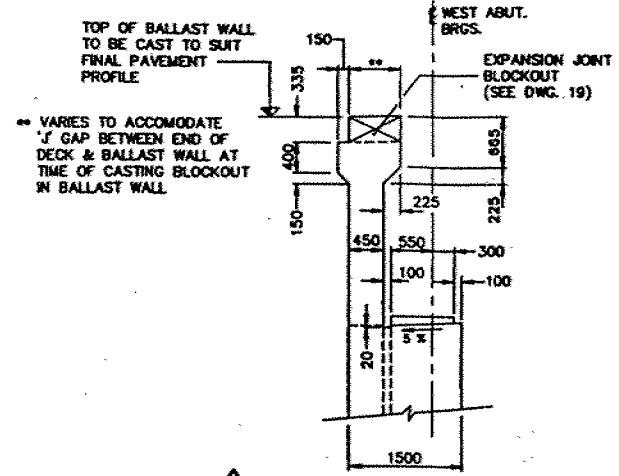
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS									
	DATE	BY	DESCRIPTION						
	DESIGN	J.W.H.	CHECK	B.R.F.	LOADING	OHBOC-83-A		DATE	SEPT./91
	DRAWING	K.R.S.	CHECK	J.W.H.	SITE No.	03-254		DWG.	4

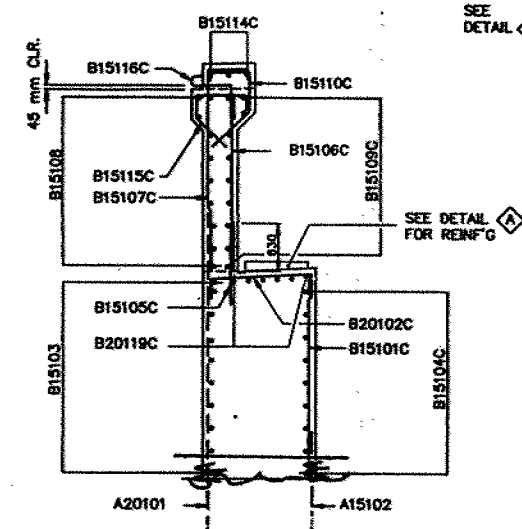
HWY. 416 SBL



PLAN
1:50



2 DIMENSIONS
1:50



2 REINFORCEMENT
1:50

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

CONT No 96-59
WP No 370-89-01

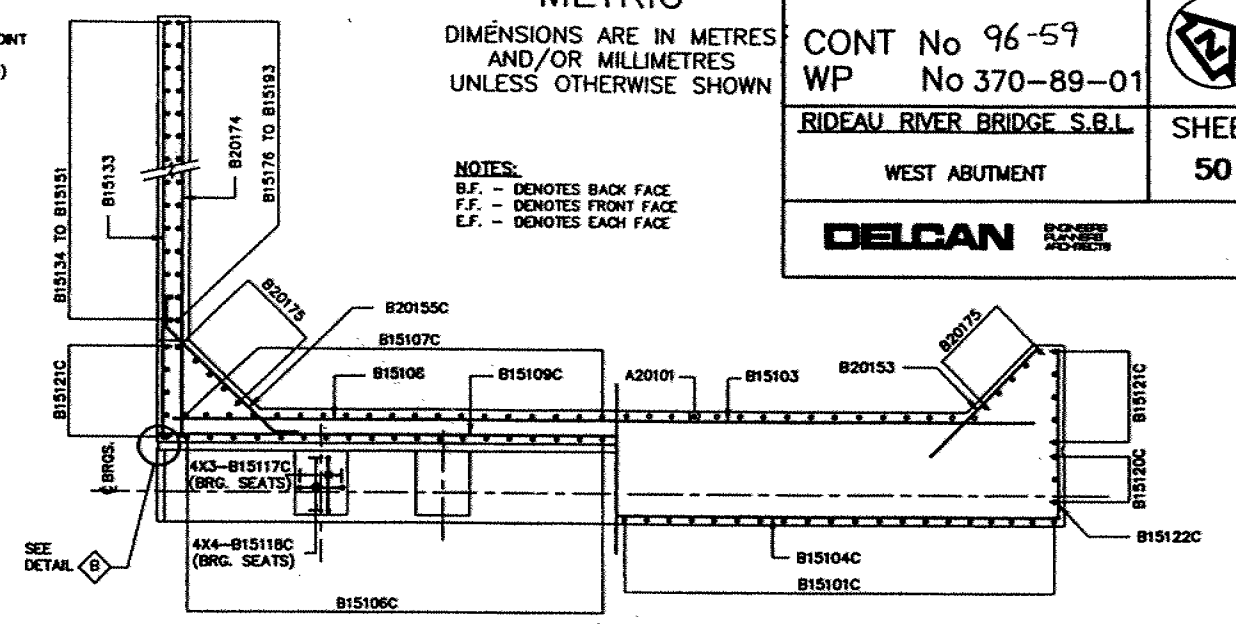
RIDEAU RIVER BRIDGE S.B.L.

WEST ABUTMENT

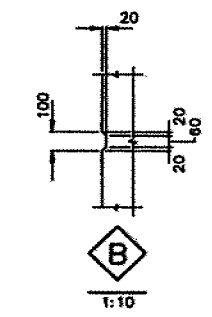
SHEET 50

DELCAN

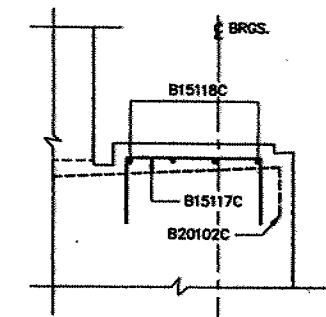
NOTES:
B.F. - DENOTES BACK FACE
F.F. - DENOTES FRONT FACE
E.F. - DENOTES EACH FACE



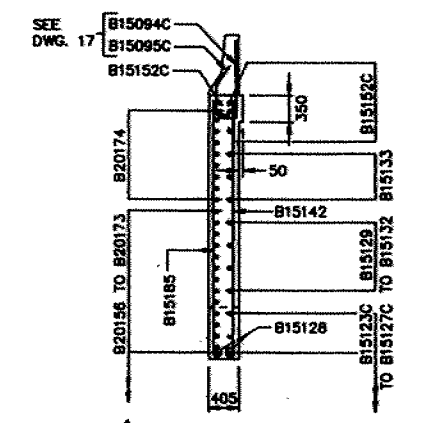
1
1:50



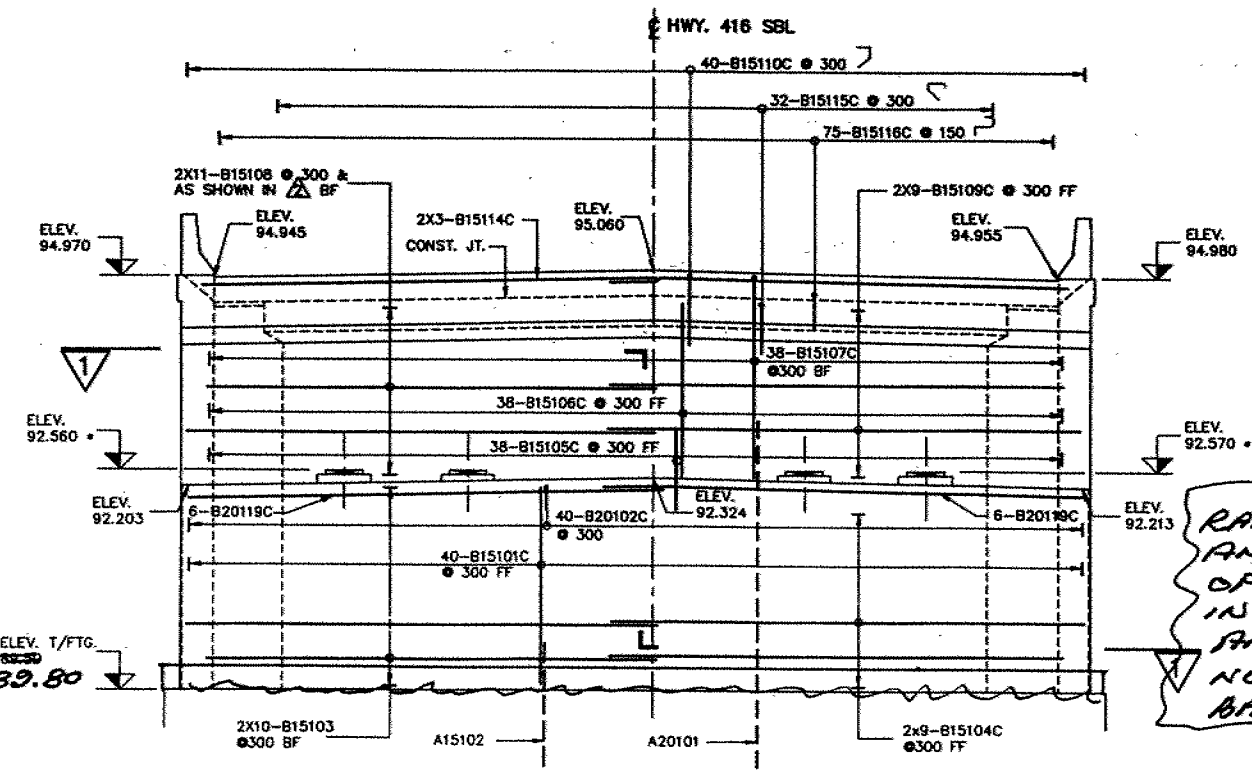
B
1:10



A
1:20



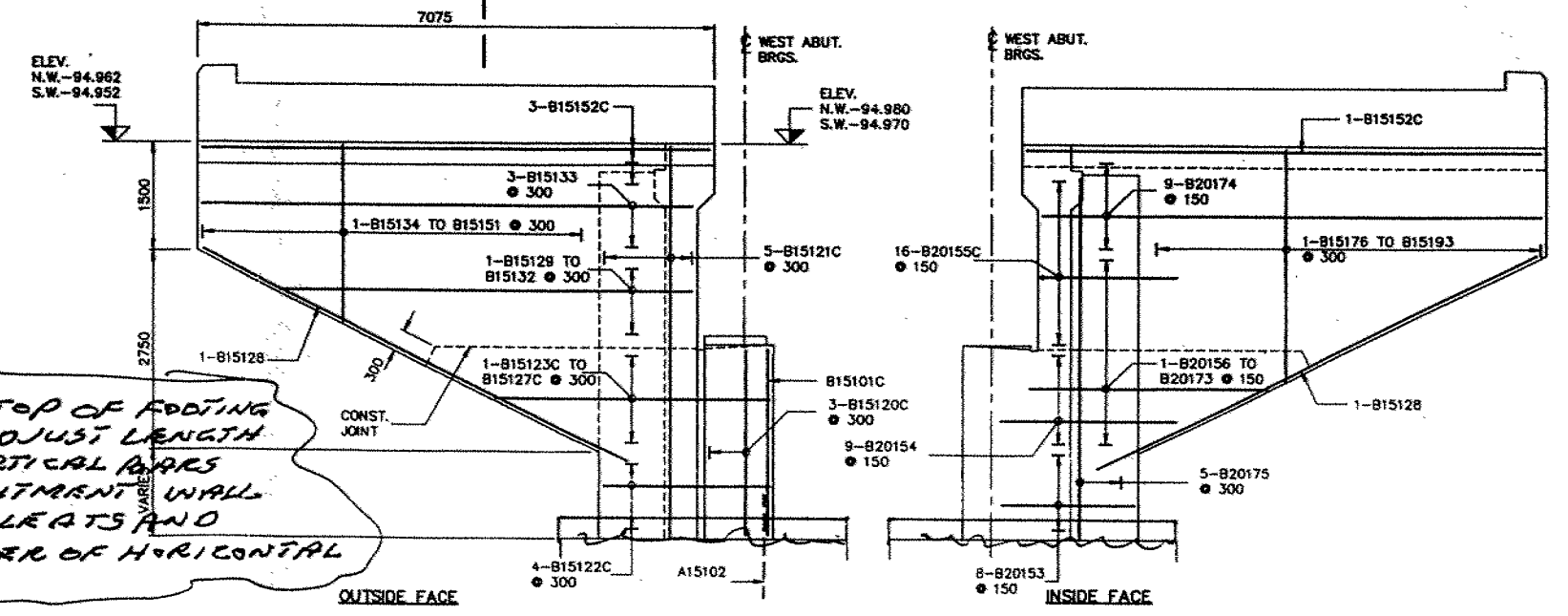
4 TYPICAL SECTION
1:50



ELEVATION
1:50

RAISE TOP OF FOOTING
AND ADJUST LENGTH
OF VERTICAL BARS
IN ABUTMENT WALL
AND CLEATS AND
NUMBER OF HORIZONTAL
BARS.

* THESE ELEVATIONS ARE AT THE TOP OF BEARINGS. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS TO SUIT THE ACTUAL BEARING THICKNESS. WHERE THE ACTUAL BEARING THICKNESS IS DIFFERENT FROM THE ASSUMED BEARING THICKNESS, AS SHOWN ON DWG. 8, THE CONTRACTOR SHALL ALSO ADJUST THE REINFORCEMENT TO SUIT.



OUTSIDE FACE

INSIDE FACE



TYPICAL WINGWALL ELEVATION
1:50

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	J.W.H.	CHECK	B.R.F.
DRAWING	K.R.S.	CHECK	J.W.H.
LOADING			
OHBC			
83-A			
DATE	SEPT./91		
DWG.	6		

QUANTITIES - STRUCTURE

Site No: 3-264

W.P. No. 370-89-01

Drawing No:

Contract No. 96-59

SHEET
70

RIDEAU RIVER BRIDGE (S.B.L)	Unwatering Structure Excavation	Supply Equip. for Driving Piles	Supply Equip. for Installing Caisson Piles	H-Piles - HP 310X110	Caisson Piles	Driving Shoes	*Concrete in Footings	*Concrete in Substructure (30 mpa)	*Concrete in Deck	*Concrete in Barrier Walls	*Concrete in Approach Slabs	Reinforcing Steel Bar	Coated Reinforcing Steel Bar	Fabrication of Structural Steel	Delivery of Structural Steel	Erection of Structural Steel	Steel Barrier Rail	Coating New Structural Steel	Embedded Work in Structure (Ministry)	Bridge Deck Waterproofing					References
LUMP SUM																									
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			100%																						
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TOTALS	100%	100%	100%	499.00	360.00	(P) 24	(P) 465.00	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
UNIT	LS	LS	LS	m	m	each	m3	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	LS	
ITEM No.	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190					
Remarks:																						CHKD. _____ APPR. _____ DATE _____			

MEMORANDUM

(416) 235-3731

To: I. Husain
Design Engineer
Structural Office
7th Floor, Atrium Tower
1201 Wilson Avenue, Downsview

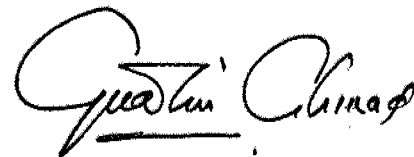
1991 07 23

From: Foundation Design Section
Room 315, Central Region, Downsview, Ontario
Central Region

Re: General Arrangement Drawings Review
Rideau River Bridge SBL
W.P. 370-89-01, Site 03-264
Highway 416, District 9, Ottawa

The General Arrangement Drawings (DWG. P1) dated April 26, 1991 for the above-mentioned structures have been reviewed by this office. The details shown on the drawing are mainly in conformance with our foundation design requirements. However, in view of the cost which will be associated in constructing two different types of deep foundations, we suggest that only one type of deep foundation (piles or caissons) should be opted. We expect that detail of working slab under the granular pad will be shown on the final drawing.

Should you have any further questions, please advise.



Ken Ahmad, P. Eng.
Foundation Engineer

For

D.H. Dundas, P. Eng.
Sr. Foundation Engineer

Structural Section
Eastern Region
355 Counter Street
Postal Bag 4000
Kingston, Ontario
K7L 5A3
Tel. (613) 545-4833
Fax. (613) 545-4821

May 10, 1991

DeLCan Corporation
2001 Thurston Drive
P.O. Box 8004
Ottawa, Ontario
K1G 3H6

Att'n: Mr. G.S. Saunders, P. Eng.

Dear Sir:

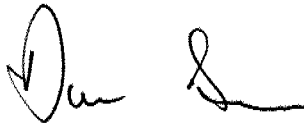
Re: W.P. 370-89-01, Rideau River Bridge, S.B.L.
Highway 416, District 9 - Ottawa

In reference to your letter dated April 26th, 1991, the Ministry's Foundation Design Section has established that Geotextile under the rock protection will not be required.

Planning and Design have the details of the raise in profile for the southbound lanes, and will provide a revised profile alignment as soon as possible.

If further clarification or information is required, please call.

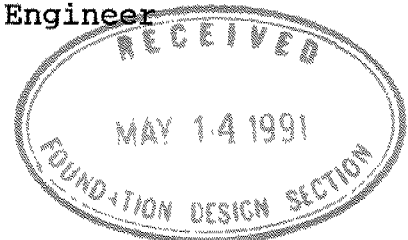
Yours truly



Dan Green, P. Eng.
Structural Engineer

DG:bd

c.c. D. Dundas



MEMORANDUM

To: E. C. Lane
Head
Structural Section
Eastern Region

Date: 90 05 18

Attention: D. Sproule

From: Foundation Design Section
Room 315, Central Building

RE: Preliminary Recommendations
Rideau River Bridge SBL
W.P. 370-89-00; Site 3-264
Hwy. 416, Dist. 9, Ottawa

As you are aware, the authorization to proceed with the foundation investigation for this structure has been delayed to July 1, 1990 or later. Please advise us as soon as you can confirm a date when we are authorized to proceed so that we can reschedule this project and agree on a revised report date. Also, we have not received an E-Plan which will be required to complete our report.

This memo provides preliminary foundation recommendations for planning purposes only. It is understood that a full foundation investigation will be required for design.

The site is located 8 km north of Kemptville at the Hwy. 416 crossing over the Rideau River. The existing bridge is a 5 span structure (53.34, 60.96, 60.96, 60.96, 53.34) crossing the river at right angles. The piers and east abutment are founded on piles end-bearing in glacial till. The west abutment is founded on spread footings on glacial till.

The foundation report for the NBL of the Rideau River Bridge, dated 1969, is enclosed for your reference. It is anticipated that the subsurface conditions for the proposed SBL bridge will be similar to those described in the report with the possible exception of the east approach where subexcavation and embankment construction may have been incorporated into the NBL bridge contract. The conditions at the east approach will be verified during the foundation investigation for the SBL bridge.

To summarize the subsurface conditions reference is made to the stratigraphical profile in the appendix of the NBL bridge report:

- glacial till is at the surface at the west bank of the river (elev. $87\pm$ m)
- the till dips to the east at 8H:1V to elev. $68\pm$ m from where it extends horizontally to the east
- the river channel is approximately 280 m wide
- the east bank is at elev. $85\pm$ m
- east of the west bank, the glacial till is overlain by a weak deposit of sensitive clay extending to the surface
- the river channel is underlain by 3 to 4 m of weak organic material

It is our understanding that the proposed SBL bridge will parallel the existing NBL bridge, at the same grade, and at a 37.8 m offset to the south. The SBL footings are to be adjacent to the NBL footings. Based on this information, the following recommendations are proposed for the SBL bridge foundations.

Structure Foundations

Footing	Foundation Type	Approx. Foundation Elev.(m)
West Abut.	spread footings	87
Pier #1 (West Pier)	H-piles or caissons	73 71
Pier #2 (West Centre Pier)	H-piles or caissons	68 66
Pier #3 (East Centre Pier)	H-piles or caissons	66 64
Pier #4 (East Pier)	H-piles or caissons	66 64
East Abut.	H-pile or caissons	66 64

It is anticipated the following O.H.B.D.C. design values can be assumed:

Spread Footings: Factored Bearing Capacity at U.L.S. = 950 kPa
Bearing Capacity at S.L.S. Type II = 500 kPa

H-Piles:		310 x 79	310 x 110
	* Factored Axial Capacity at U.L.S.	1150 kN	1600 kN
	* Axial Capacity at S.L.S. Type II	825 kN	1150 kN
Caissons:		1.2 m o	1.5 m o
	* Factored Axial Capacity at U.L.S.	3375 kN	5250 kN
	* Axial Capacity at S.L.S. Type II	2250 kN	3500 kN

* If compressible materials are encountered at the east abutment, the capacities will be reduced. This aspect will be discussed in detail in the final report.

Resistance to Lateral Forces

For spread footings, sliding resistance can be computed by assuming an unfactored friction angle of 30° between concrete and glacial till.

For H-piles and caissons, the horizontal component of battered units may be utilized to resist lateral forces. Any lateral resistance provided by vertical units will be assessed in the final report.

Frost Protection

For footings and pile caps, earth cover of 1.8 m (or equivalent insulation) is required for frost protection.

Slope Stability and Settlement

It is anticipated that embankment fills will be less than 5 m high at both approaches.

No slope stability or settlement problems are anticipated at the west approach.

At the east approach, the existing conditions will require verification. As previously noted, it has been reported that part of the east approach to the SBL bridge may have been constructed during the NBL bridge contract. The amount of additional fill required and the properties of the underlying weak clay will have to be determined before slope stability and settlement can be predicted.

Dewatering

Dewatering can be minimized by utilizing pile bent construction or caissons at the pier locations with the pile/caisson cap at the underside of the deck. If H-piles are used they should be protected by a concrete-filled steel tube extending from the underside of the deck to the deeper of frost protection depth or scour. The minimum embedment of the steel tube should be 3 m below the river channel.

If there are any questions, please advise.



D. Dundas, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer