

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 31B-66

DIST. 9 REGION

W.P. No. 610-90-01

CONT. No. 93-75

W. O. No.

STR. SITE No. 16-322

HWY. No.

LOCATION Goodin Service Rd /

South Nation River Crossing

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-75



**Ministry of
Transportation**

Ontario

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3-33	Foundation Investigation Report for Goodin Service Rd./South Nation River W.P. 610-90-01, Site 16-322 Hwy - District 9 Ottawa

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 projects.

EXPLANATION OF TERMS USED IN REPORT

2

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 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_a	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						

FOUNDATION INVESTIGATION REPORT
For
Goodin Service Road/
South Nation River Crossing
W.P. 610-90-01, Site No. 16-322
District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site between 91 10 09 and 91 10 12 and a subsequent investigation conducted between 93 06 01 and 93 06 02.

The initial investigation consisted of three dynamic cone penetration tests and six boreholes extending to depths of 4.0m to 10.7m below ground surface. The 1993 investigation included four dynamic cone penetration tests and a borehole.

SITE DESCRIPTION

The site is located at the South Nation River between Shanly Road and the Goodin Service Road, about 1 km to the east of existing Highway 16, in the Municipal Township of Edwardsburgh, County of Leeds and Grenville. Spencerville village is located several kilometres to the west of the site.

Landuse consists of farmers fields, cattle pastures and residential homes. The terrain is generally flat to gently rolling with short wild grasslands and randomly placed trees. The topography surrounding the South Nation River slopes upward to the north and has a steep embankment approximately 2m high to the south. The

natural ground elevation varied from 88.6m to the south to 86m to the north.

Physiographically, the terrain belongs to the Region known as the "Edwardsburgh Sand Plain". The topography of the sand plain is mostly level although hummocks and ridges appear in places. In all probability, the sand was deposited by the melting glacier known as Kames, and subsequently spread about by the waves of the Champlain Sea. The bedrock in the area is of a Gull River Formation of the Middle Ordovician Period. It consists of silty dolostone with interbedded dolomitic shale layers.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and lab testing conducted on select samples. The procedures employed are discussed below.

Field

The fieldwork for the investigation was carried out between 91 10 09 and 91 10 12 and between 93 06 01 and 93 06 02. During the initial phase of the investigation, four boreholes and three dynamic cone penetration tests were done to the north of the South Nation River and two boreholes to the south. During the 1993 investigation, two dynamic cone penetration tests were carried out at the north abutment area and two dynamic cone penetration tests and a borehole at the south abutment area.

The boreholes were advanced using hollow stem augering techniques through most of the overburden and using BW casing through the bouldery stratum to the surface of bedrock.

Samples of the overburden were retrieved at 0.7m to 1.5m intervals using a 51mm O.D. split spoon sampler, in accordance with the Standard Penetration Test (ASTM D-1586). Conventional BXL size rock cores were recovered from the boulder zones in the glacial till stratum and from bedrock.

All soil samples and rock cores were identified in the field and returned to the laboratory for further examination and testing.

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

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

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

- 1) Atterberg Limits
- 2) Grain Size Distribution
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on Figures and Record of Boreholes sheets included in the Appendix.

SUBSURFACE CONDITIONS

General

The subsoil stratigraphy at the site to the north of the South Nation River consists of 0.7m to 3.4m (average 2.0m) thick layer of

cohesive organic clayey silt with sand. Water logged swampy ground is present locally in the north flood plain area. Wood particles were encountered particularly at the north approach location. Underlying this deposit is a 1.5m to 4.1m thick layer of cohesive clayey silt to silty clay, trace sand which in turn is followed by a layer of heterogeneous mixture of clayey silt, sand and gravel (glacial till) and then dolostone bedrock at El. 79.2m to 79.9m.

To the south of the South Nation River, the subsoil stratigraphy consists of a thin veneer of organics followed by 3.8m to 4.6m thick deposit of clayey silt, trace sand. Underlying this deposit is a 4.1m thick stratum of heterogeneous mixture of clayey silt, sand and gravel with numerous boulders (glacial till). Dolostone bedrock was encountered at depths of 8.5m to 9.2m, at El. 78.4m to 80.1m.

The plan and locations of borings done in 1991 together with the stratigraphic profile derived from this data are shown on Dwg No. 2 of the Contract Drawing. Figure 7 shows the locations of the previous (1991) and most recent (1993) borings done at this site, together with the locations of the abutments of the proposed structure.

The field and laboratory test results are plotted on the Record of Borehole sheets included in the Appendix of this report. A brief description of the various soil strata encountered are given below.

Organic Clayey Silt, with Sand

The encountered thickness of this deposit varied between 0.7m and 3.4m to the north of the river and between 0m and 0.6m to the south of the river.

Grain Size Distribution Test results are shown on Figure 1 in the Appendix, in an envelope form. The deposit is comprised of 0% gravel, 36-37% sand, 45-50% silt and 4-9% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	33.5-84 %	3
Liquid Limit (w_L)	43-46 %	3
Plastic Limit (w_p)	38-41 %	3

From the plasticity chart (Figure 2), the layer can be classified as being organic medium plastic. Organic content tests confirmed the presence of organics to range from 1.6-9.5%.

In this stratum the 'N' values ranged from 2 blows/0.3m to 8 blows/0.3m, thus the material had a very soft to firm consistency.

Clayey Silt to Silty Clay, trace Sand

Underlying the above deposit, a layer of clayey silt to silty clay, trace sand was encountered. The thickness of this stratum ranged between 1.5m and 4.1m to the north of the river and 3.8m and 4.6m to the south of the river.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 3 in the Appendix, in an envelope form. From the above figure it is evident that the layer contains a high percentage of fine materials such as silt and clay. The deposit is comprised primarily of 0-1% gravel, 1-13% sand, 42-70% silt and 25-55% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	20-29.5 %	7
Liquid Limit (w_L)	31-53 %	7
Plastic Limit (w_p)	17-26 %	7
Plastic Index (I_p)	14-27 %	7

From the plasticity chart (Figure 4), the layer can be classified as having low to medium plasticity. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of 18.5 kN/m^3 to 20 kN/m^3 .

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 10 blows/0.3m to 44 blows/0.3m, thus the material can be described as having a stiff to hard consistency.

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

Underlying the clayey silt to silty clay layer, a heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) stratum was encountered in all except two holes located to the south of the river. In these two holes a layer of sand and gravel with numerous cobbles and boulders was encountered. It is possible that this layer is part of the overall glacial till deposit.

The encountered thickness of the glacial till stratum varied between 0.4m to about 4m to the north of the river and was about 4.1m to the south of the river. The presence of numerous cobbles and boulders necessitated the use of rock coring techniques locally to advance the boreholes through this stratum.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 5 in the Appendix, in an envelope form. From the above figure the increased presence of sand and gravel can be seen. The

deposit is comprised of 9-38% gravel, 20-31% sand, 24-49% silt and 8-22% clay.

The results from the Atterburg Limit Tests performed on the fine fraction of this deposit are summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6-11 %	4
Liquid Limit (w_L)	12-20 %	4
Plastic Limit (w_p)	10-13 %	4

From the plasticity chart (Figure 6), the layer can be classified as having low plasticity.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 60 blows/.15m to >120 blows/0.3m. Based on these 'N' values, the material can be described as having a hard consistency.

Bedrock

The glacial till stratum is underlain by dolostone bedrock of the Oxford Formation. The bedrock was encountered at depths of 6.6m to 9.2m below grade, at elevations of 78.4m to 80.1m.

Conventional Rock Coring techniques were applied utilizing BXL core barrels with BW casing. The dolostone bedrock is light grey to dark grey and is fine to medium grained. The rock is generally slightly weathered to unweathered with moderately close to very close spaced fractures. Detailed descriptions of the bedrock are attached in the Appendix entitled "Rock Core Description", which were provided by D.A. Williams, Petrographer.

Core Recoveries and Rock Quality Designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock recoveries varied between 85-100%, while RQD's varied between 58 to 83%. The dolostone bedrock is medium strong rock.

GROUNDWATER CONDITIONS

Observations of groundwater level were carried out by measuring the water levels in open boreholes. Groundwater levels in the boreholes located south of the river were at elevations 86.4m to 86.0m. An artesian groundwater condition was encountered in the boreholes located north of the river, with a pressure head of 1.5m above grade. The artesian condition was encountered immediately on contacting the bedrock surface. After stabilizing the water level, these boreholes were plugged using gravel, cement and matex, a chemical sealant.

The water level in the South Nation River was at El. 85.75m during the 1991 investigation and at about El. 86.0m during the 1993 investigation. It is understood that during high river water conditions, part of the north bank becomes flooded.

Groundwater and river water levels are subject to seasonal fluctuations and hence can vary from the values given above.

MISCELLANEOUS

The fieldwork for the first phase of the investigation (1991) was carried out under the supervision of M. Michalek, Jr. Foundation Engineer and A. Hilderbrand, Student Engineer using equipment owned and operated by F.E. Johnston Drilling Limited. The 1993 investigation was carried out under the supervision of B. Iyer, P. Eng., Senior Foundation Engineer and J. Beckett, Student Engineer using equipment owned and operated by F.E. Johnston Drilling Limited.

The project was carried out under the overall direction of B. Iyer, Senior Foundation Engineer. This report was written by B. Iyer, P. Eng. and approved by M. Devata, P. Eng.



A handwritten signature in black ink, appearing to read "B. Iyer", with a horizontal line drawn underneath it.

B. Iyer, P. Eng.
Senior Foundation Engineer



A handwritten signature in black ink, appearing to read "M. Devata", with a horizontal line drawn underneath it.

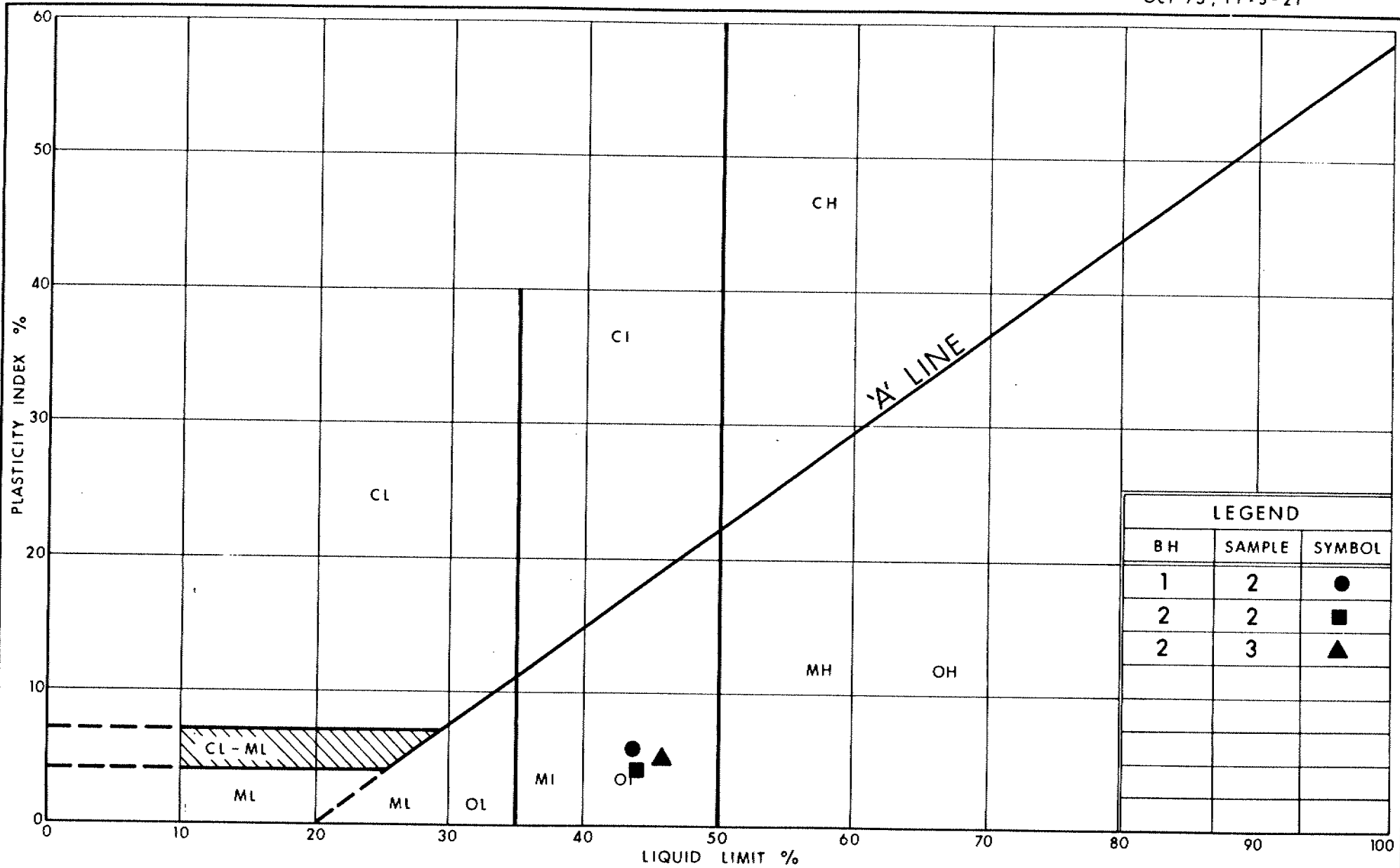
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX



GRAIN SIZE DISTRIBUTION
ORGANIC CLAYEY SILT
WITH SAND

W P 610-90-01



Ontario

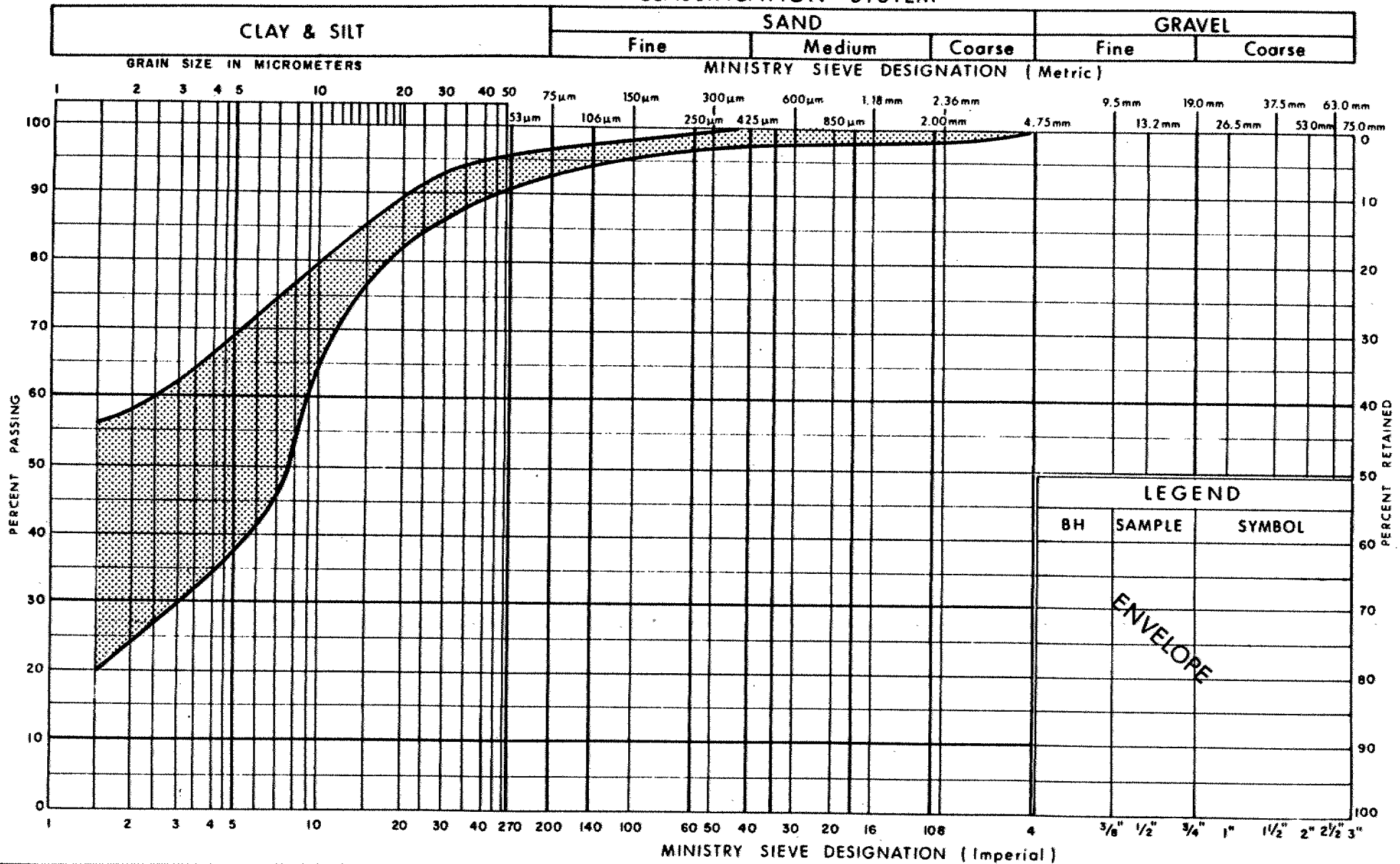
Ministry of
Transportation

PLASTICITY CHART ORGANIC CLAYEY SILT WITH SAND

FIG No 2

W P 610-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

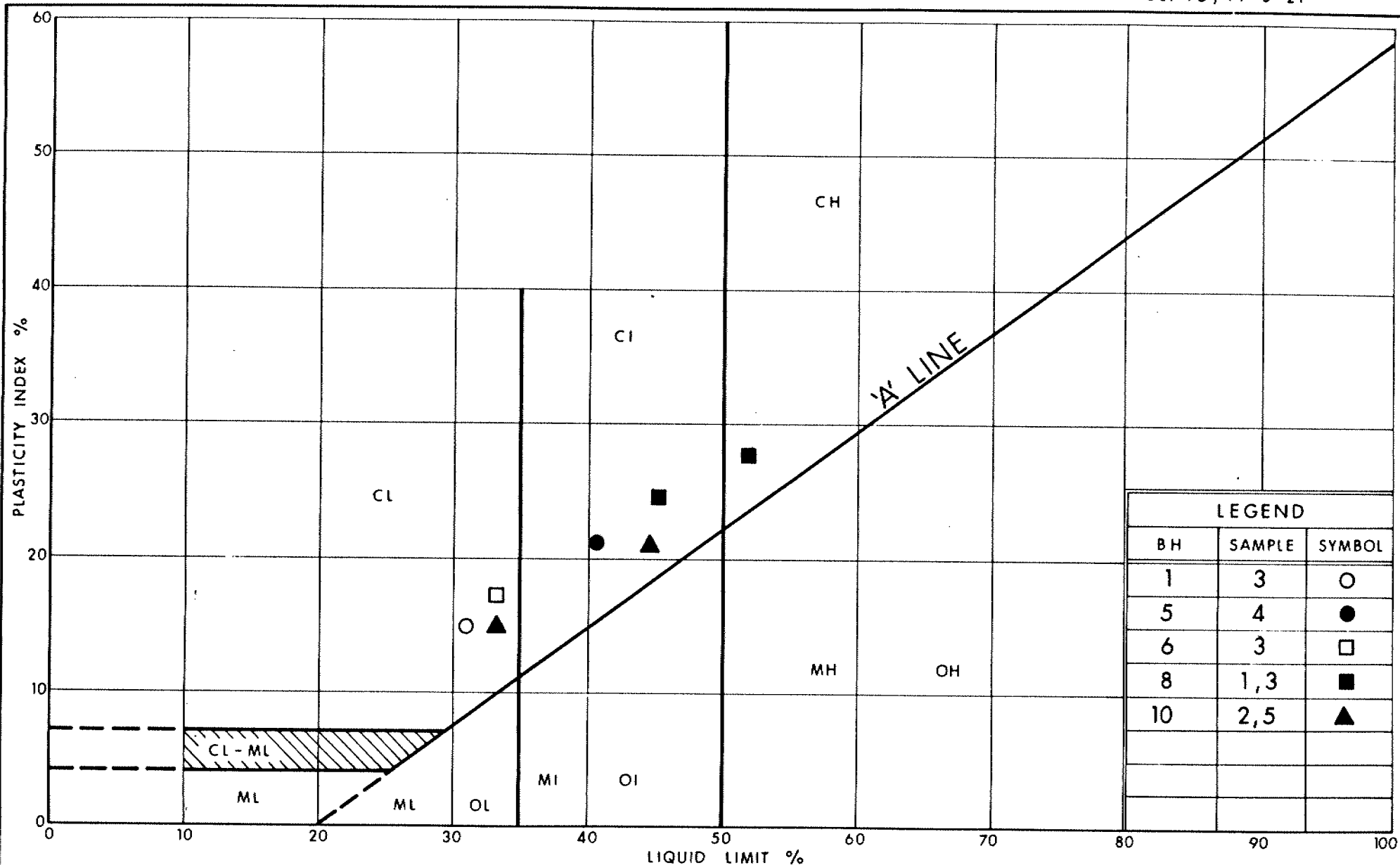


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILTY CLAY
TRACE SAND

FIG No 3

W P 610-90-01



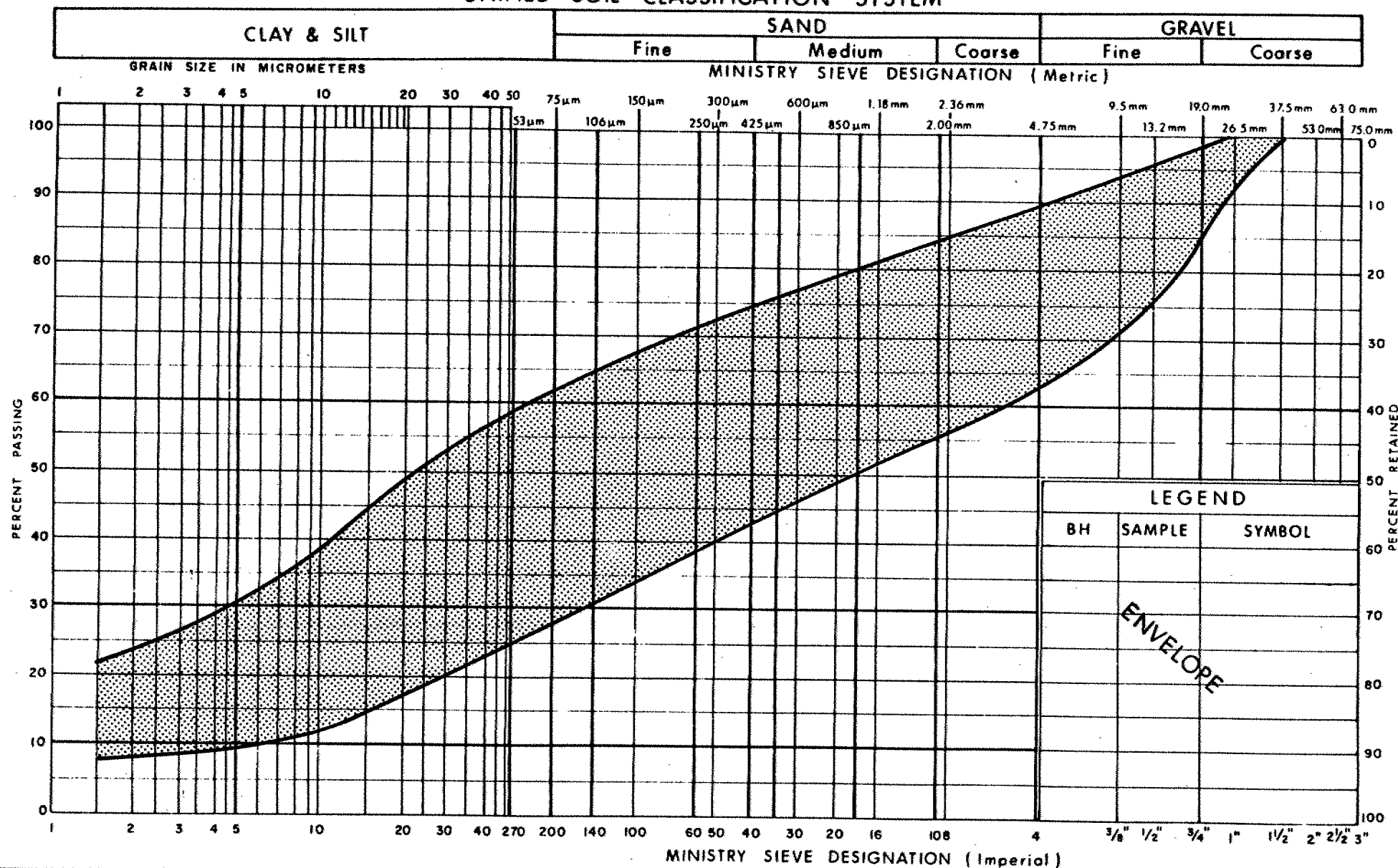
Ministry of
Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT TO SILTY CLAY
TRACE SAND

FIG No 4

W P 610-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

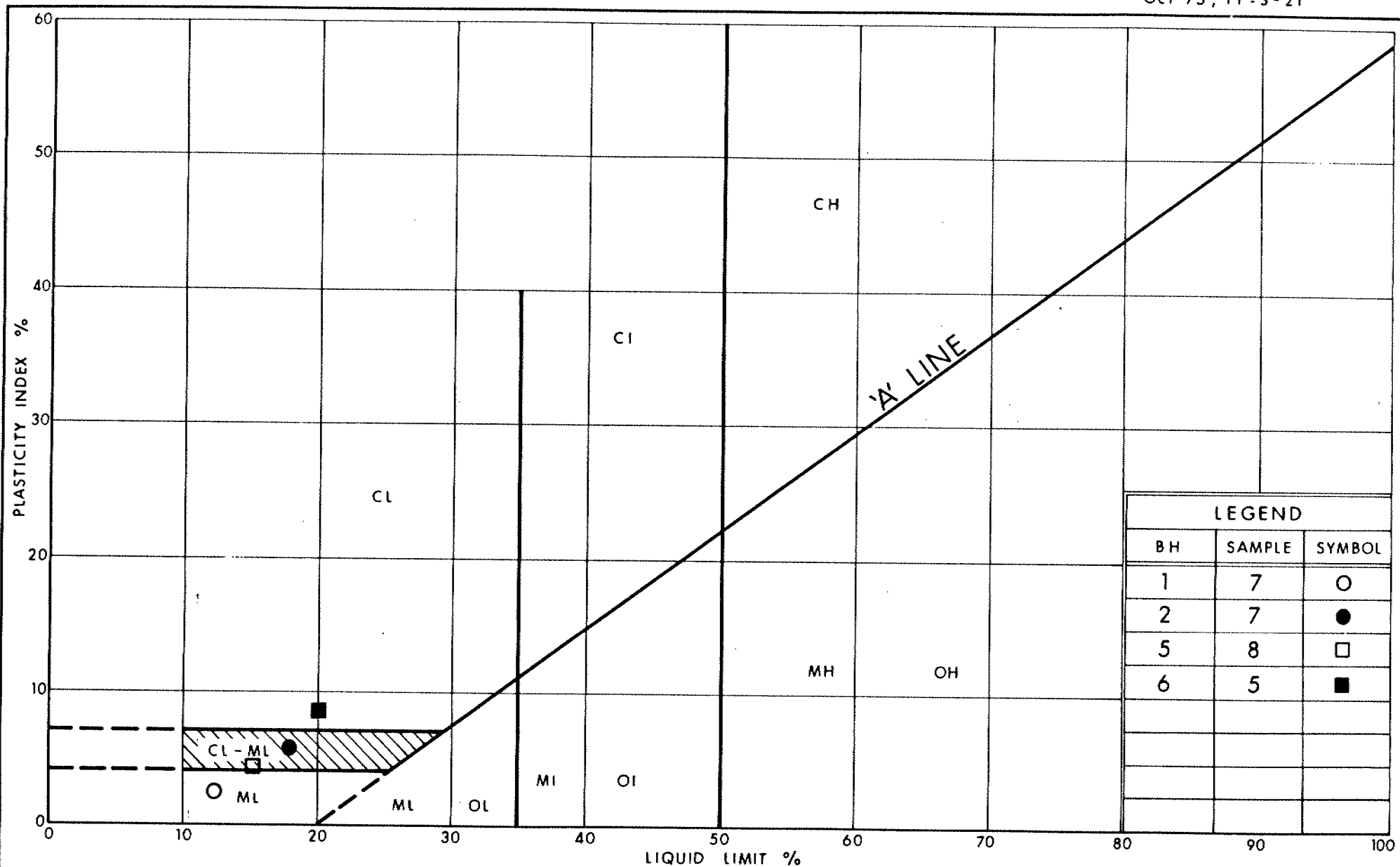


Ministry of
Transportation
Ontario

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
 (GLACIAL TILL)

FIG No 5

W P 610-90-01



Ministry of
Transportation

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
(GLACIAL TILL)

FIG No 6

W P 610-90-01

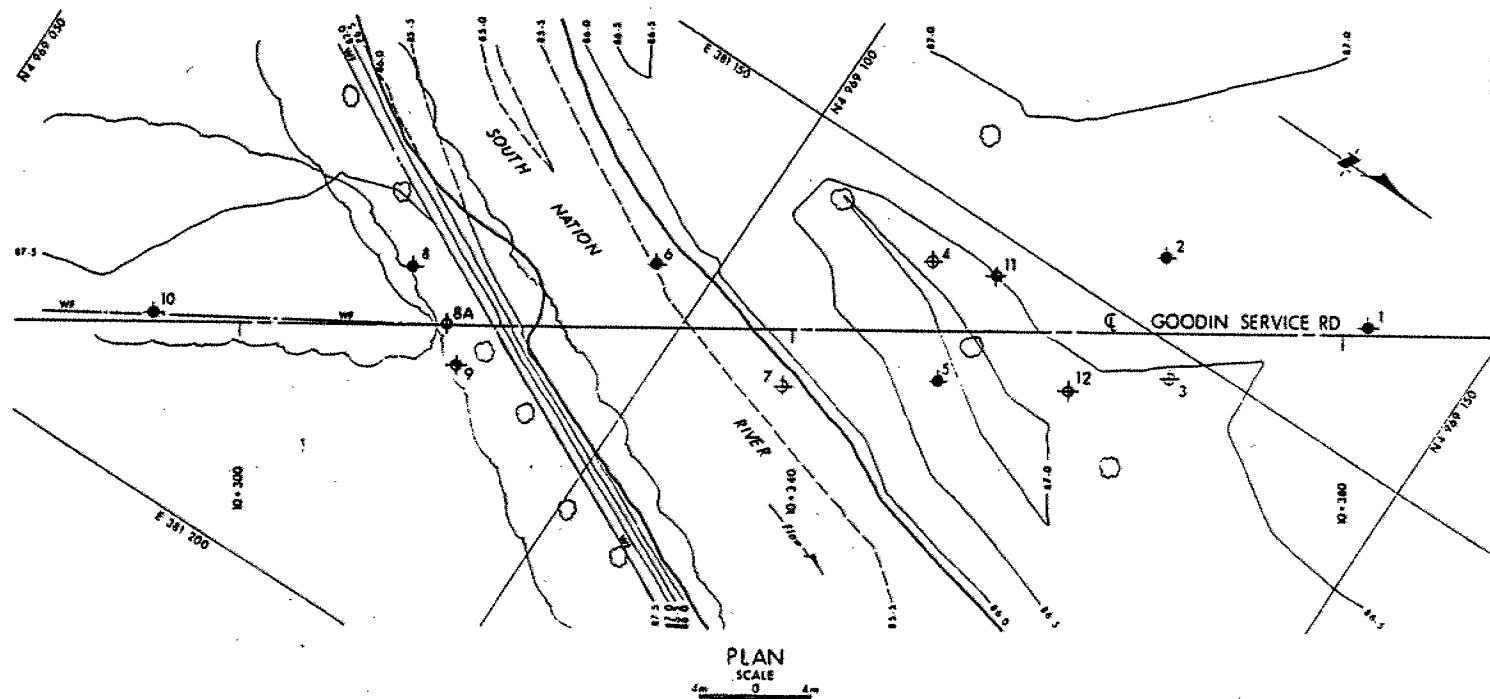


FIG 7

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

CONT No WP No 610-90-01	
SOUTH NATION RIVER CROSSING AT GOODIN SERVICE RD BORE HOLE LOCATIONS & SOIL STRATA	SHEET

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 91.10
	Head ARTESIAN WATER Encountered

Pit	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	86.2	4 969 141.5	381 141.0
2	86.5	4 969 126.5	381 145.0
3	86.5	4 969 131.4	381 152.0
4	87.0	4 969 112.5	381 154.5
5	86.5	4 969 117.5	381 161.5
6	86.0	4 969 096.0	381 165.5
7	85.7	4 969 108.5	381 168.0
8	86.6	4 969 081.5	381 175.5
10	87.5	4 969 067.7	381 188.5
8A	87.6	4 969 086.0	381 178.0
9	87.6	4 969 088.0	381 180.0
11	86.5	4 969 117.0	381 153.0
12	86.7	4 969 126.0	381 157.0

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 141.5; E 381 141.0 ORIGINATED BY M.M.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.






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			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40							60	80	100
86.2	Ground Surface																	
0.0	Organic Clayey Silt With Sand Very Dark Brown Traces of Wood Particles Very Soft		1	SS	2	/46cm	86							0 36 58 6				
84.1			2	SS	1	/46cm	85											
2.1	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		3	SS	12		84						20.0	0 1 69 30				
			4	SS	14		83											
			5	SS	18		82											
			6	SS	13		81											
80.6							80							1 1 77 21				
5.6	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	51									38 30 24 8				
79.2																		
7.1	End of Borehole, Refusal																	
	Probable Bedrock • Artesian Condition with a Head of 1.5 m Encountered within the Bedrock																	

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 810-90-01 LOCATION Co-ords: N 4 969 126.5; E 381 145.0 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	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					10 20 30						
86.5	Ground Surface																		
0.0	Organic Clayey Silt With Sand Very Dark Brown Traces of Wood Particles Very Soft to Firm		1	SS	6	/46cm	86									23.1	0 36 58 6		
2			SS	2	85														
3			SS	1	84														
83.2	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		4	SS	2	/46cm	83									23.1	1 1 70 28		
5			SS	19	82														
6			SS	12	81														
80.3	Heterogeneous Mixture of (Gl. Tin) Clayey Silt, Sand and Gravel Hard		7	SS	120		80									23.1	18 19 50 13		
6.2																			
79.9																			
6.6	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		8	BXL RC	REC 0%		79									23.1	RQD 0%		
9			BXL RC	REC 92%	78														
77.9	End of Borehole						78									23.1	RQD 80%		
8.6																			
	• Artesian Condition with a Head of 1.5 m Encountered within the bedrock																		

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 131.4; E 381 152.0 ORIGINATED BY A.H.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/10 CHECKED BY B.I.

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 (%)					
86.5	Ground Surface													
0.0	Probable Organic Clayey Silt With Sand Very Dark Brown Very Soft													
83.2														
3.3	Probable Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff													
80.4														
6.1	End of Cone Test Possible Till. Cone is still descending at a slow but steady rate. Not Bedrock.													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 610-80-01 LOCATION Co-ords: N 4 969 112.5; E 381 154.5 ORIGINATED BY M.M.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

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			SHEAR STRENGTH kPa						
87.0	Ground Surface							20 40 60 80 100	20 40 60 80 100					
0.0	Probable Organic Clayey Silt With Sand Very Dark Brown Very Soft							20 40 60 80 100	20 40 60 80 100					
83.6														
3.4	Probable Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff													
81.2														
5.8	End of Cone Test Possible Till. Cone is stiff, descending at a slow but steady rate. Not Bedrock.													

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 117.5; E 381 161.5 ORIGINATED BY A.H.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

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			SHEAR STRENGTH kPa								WATER CONTENT (%)				
								20	40	60						80	100	10	20	30
86.5	Ground Surface																			
0.0	Organic Clayey Silt With Sand Soft		1	SS	4										0 37 45 18					
85.6			2	SS	5															
1.0	Clayey Silt to Silty Clay Trace Sand Very Stiff to Hard		3	SS	17															
			4	SS	19															
			5	SS	23															
			6	SS	38															
82.1		7	SS	60	/15cm									1 3 61 35						
4.4	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		8	SS	60	/15cm														
79.8	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		9	BXL RC	REC 93%															
6.6																				
78.6	End of Borehole																			
7.9	• Artesian Condition with a Head of 1.5 m encountered within the Bedrock																			

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 096.0; E 381 165.5 ORIGINATED BY M.M.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.0	Ground Surface																
0.0	Organic Clayey Silt With Sand Trace Clay Very Dark Brown Firm		1	SS	8		85										0 79 17 4
84.6			2	SS	14		84										0 3 42 55
1.4	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		3	SS	23		83									20.0	
83.1			4	SS	76		82										
2.9			5	SS	80	/15cm	81										
			6	SS	100	/15cm	80										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	100	/15cm	79										
79.2			8	BXL RC	REC 95%		78										RQD 58%
6.8	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		9	BXL RC	REC 87%		77										RQD 68%
76.2																	
9.8	End of Borehole • Artesian Condition with a Head of 1.5 m encountered within the Bedrock																

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 610-90-01

LOCATION Co-ords: N 4 969 108.5:E 381 168.0

ORIGINATED BY M.M.

DIST 9 HWY Goodin Ser Rd


BOREHOLE TYPE Dynamic Cone

COMPILED BY A.H.

DATUM Geodetic

DATE 91/10/09

CHECKED BY B.I.

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			SHEAR STRENGTH kPa		WATER CONTENT (%)				
85.7	Ground Surface							20 40 60 80 100		20 40 60 80 100	10 20 30			
0.0	Probable Organic Clayey Silt Very Soft													
84.9														
0.7	Probable Clayey Silt to Silty Clay Trace Sand													
82.8														
2.9	Probable Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)													
81.7														
4.0	End of Cone Test Probable Boulders													

RECORD OF BOREHOLE No 8

1 OF 1 METRIC

W.P. 810-90-01 LOCATION Co-ords: N 4 969 081.5; E 381 175.5 ORIGINATED BY M.M.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
DATUM Geodetic DATE 91/10/11 CHECKED BY B.L.

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			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20	40	60	80	100						
88.6	Ground Surface																	
0.0	Trace Organics																	
	Clayey Silt to Silty Clay		1	SS	24													
	Trace Sand		2	SS	27													
	Very Stiff to Hard																	
	Brown		3	SS	15													
	Grey		4	SS	24													
			5	SS	120													
84.2																		
4.4			6	BXL RC	REC 15%													
	Sand and Gravel																	
	With Numerous Cobbles and		7	BXL RC	REC 31%													
	Boulders																	
			8	BXL RC	REC 18%													
80.1																		
8.5			9	BXL RC	REC 100%													
	Bedrock																	
	Dolostone		10	BXL RC	REC 88%													
	Slightly Weathered to																	
	Unweathered																	
	Medium Strong																	
77.9																		
10.7	End of Borehole																	

METRIC

+3, x⁵: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 088; E 381 180 ORIGINATED BY JB
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core, Dynamic Cone COMPILED BY JB
DATUM Geodetic DATE 93/06/01 CHECKED BY BI

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	w _p	w	w _L		
87.6	Ground Surface													
0.0 87.1 0.5	Topsoil		1	SS	3									
			2	SS	25									
			3	SS	25									
			4	SS	30									
82.5														
5.1			5	SS	76									
			6	BXL RC	REC 27%									
78.4														
9.2			7	BXL RC	REC 85%									
76.9														
10.7	End of Borehole													

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 067.7; E 381 188.5 ORIGINATED BY A.H.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger COMPILED BY A.H.
DATUM Geodetic DATE 91/10/11 CHECKED BY B.I.

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			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W _p W W _L				
87.5 0.0	Ground Surface						20	40	60	80	100	10	20	30			
	Clayey Silt to Silty Clay Trace Sand Stiff to Hard		1	SS	10												0 4 46 50
			2	SS	29												
			3	SS	23												
			4	SS	23												
			5	SS	34												
			6	SS	44												
82.2																	6 13 56 25
5.3 81.7	Sand and Gravel With Numerous Cobbles and Boulders																
5.8	End of Borehole																
	Coring was attempted, but a broken auger tooth blocked the hole to coring.																

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 810-90-01 LOCATION Co-ords: N 4 969 117; E 381 153 ORIGINATED BY JB
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY JB
 DATUM Geodetic DATE 93/06/01 CHECKED BY BI

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								
86.3	Ground Surface												
0.0													
84.7													
1.8													
	Probable Clayey Silt Trace Sand												
80.7													
5.8	End of Cone Test												

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 126; E 381 157 ORIGINATED BY JB
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY JB
 DATUM Geodetic DATE 93/06/01 CHECKED BY BI

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								
86.7	Ground Surface												
0.0	Probable Organics												
85.0													
1.7	Probable Clayey Silt Trace Sand												
80.7													
6.0	End of Cone Test							100/23cm					

ROCK CORE DESCRIPTION **WP 610-90-01**

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	8	7.01-8.63	92	80	7.01-8.63	DOLOSTONE (with calcite-filled vugs in places), light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to close spaced, flat to near vertical, undulating to planar, smooth to rough.
5	9	6.61-7.98	93	83	6.61-7.98	DOLOSTONE (with calcite-filled vugs in places), light olive grey to light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, undulating, smooth.
6	8	6.76-8.28	95	58	6.76-9.81	DOLOSTONE (with calcite-filled vugs in places), light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, undulating, smooth to rough.
	9	8.28-9.81	87	68		
8	6	4.34-5.87	15	0	4.34-8.41	OVERBURDEN (boulder till).
	7	6.10-7.01	31	0	8.41-10.67	DOLOSTONE (with calcite-filled vugs in places), light olive grey to light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered (moderately weathered, 8.41-9.47 m); fractures moderately close to very close spaced, flat to near vertical, undulating, smooth.
	8	7.01-8.53	18	0		
	9	8.53-9.14	100	0		
	10	9.14-10.67	88	62		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section



Ministry
of
Transportation

FILE COPY

1 of 2

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

**ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION**

CONT 93-75

WP 610-90-01

DIST 9

HWY -

STR SITE 16-322

Goodin Service Road/
South Nation River Crossing

DISTRIBUTION

E.C. Lane (2)
Sam Cheng
D.J. Kimmett (2)
D. Hogg (2)
K.G. Bassi
S.J. Dunham
E.A. Joseph
T.A. Hickey (Cover Only)
I. Bullen (Cover Only)
File

FOUNDATION INVESTIGATION REPORT

For

Goodin Service Road/

South Nation River Crossing

W.P. 610-90-01, Site No. 16-322

District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site between 91 10 09 to 91 10 12. It is proposed to construct a two lane three span structure to carry the Goodin Service Road over the South Nation River. The new road links Shanly Road with the Goodin Road.

Three Cone Penetration Tests together with six boreholes were advanced and sampled as part of this project by means of 82 mm ID hollow stem augers and bedrock samples retrieved utilizing BW casing and BXL Rock Core. These boreholes extended down to depths of 4.0 to 10.7 m below the existing ground surface.

SITE DESCRIPTION

The site is located at the South Nation River between Shanly Road and the Goodin Service Road in the Municipal Township of Edwardsburgh, County of Leeds and Grenville. The small Village of Spencerville is located several kilometres west.

Landuse consists of farmers fields, cattle pastures and residential homes. The terrain is generally flat to gently rolling with short wild grasslands and randomly placed trees. The topography surrounding the South Nation River slopes upward to the north and has a steep embankment approximately 2 m high to the south. The natural ground elevation varied from 88.6 m to the south to 86 m to the north.

Physiographically, the terrain belongs to the Region known as the "Edwardsburgh Sand Plain". The topography of the sand plain is mostly level although hummocks and ridges appear in places. In all probability, the sand was deposited by the melting glacier known as kames, and subsequently spread about by the waves of the Champlain Sea. The bedrock in the area is of a Gull River Formation of the Middle Ordovician Period. It consists of silty dolostone with interbedded dolomitic shale layers.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and lab testing conducted on select samples. The procedures employed are discussed below.

Field

The fieldwork for the investigation was carried out between 91 10 09 to 91 10 12 and consisted of a total of six sampled boreholes which were advanced to depths of up to 10.7 m below natural ground surface. Two boreholes were advanced at the approach embankments with four holes at abutment and pier locations. Three Cone Penetration Tests were also conducted at the pier and abutment locations. Two boreholes are located south of the South Nation River at elevations of 87.5 m and 88.6 m with the remaining four and two Cone Tests located north at elevations ranging from 85.7 m to 87.0 m.

The boreholes were advanced using conventional hollow stem augering techniques. Two track mounted continuous flight auger drill rigs were employed for the operation. Conventional rock coring methods were applied in retrieving rock core samples using BXL core barrels with BW casing. In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 6 m and at 1.5 m intervals hereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586).

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

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

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

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

- 1) Atterberg Limits
- 2) Grain Size Distribution
- 3) Unit Weights
- 4) Natural Moisture Contents

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

SUBSURFACE CONDITIONS

General

The subsoil stratigraphy at the site to the north of the South Nation River consists of 2.0-3.3 m of a cohesive organic clayey silt, with sand. Wood particles were encountered particularly at the north approach location. Underlying this deposit is a 3.5 m to 1.5 m thick layer of cohesive clayey silt to silty clay, trace sand which was more predominantly encountered at the north approach ramp location. Resting beneath the above deposit is a 0.4 m (BH 2) to 3.9 m (BH 6) heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) which contained greater percentages of sand and gravel above the bedrock surface. Following the overburden described above is underlain by a dolomitic bedrock encountered at depths ranging of 6.6 m to 7.1 m (elevations of 80 m to 79 m).

The subsoil stratigraphy to the south of the South Nation River consists of a 3.7 m to 5.3 m depth of clayey silt to silty clay, trace sand which is similar in composition to the material found in the north. Underlying the deposit is a

layer of boulders which had to be rock cored continuously to reach solid bedrock. At the south abutment 4.1 m of boulders were encountered placing the bedrock at an elevation of 80 m. The strata resting on the bedrock is described as sand and gravel with numerous cobbles and boulders.

The plan and location of borings and the stratigraphical profile are shown on Dwg. No. 6109001-A in the attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets also included in the Appendix of this report. A brief description of the different soil types is given below.

Organic Clayey Silt, with Sand

The surficial material, encountered exclusively north of the South Nation River consists of a 2.0-3.3. m (approx. elevation 84 m) deep organic clayey silt with sand.

Grain Size Distribution Test results are shown on Figure 1 in the Appendix, in an envelope form. The deposit is comprised of 0% gravel, 36-37% sand, 45-50% silt and 4-9% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	33.5-84 %	3
Liquid Limit (w_L)	36-46 %	4
Plastic Limit (w_p)	18-41 %	5

From the plasticity chart (Figure 2), the layer can be classified as being organic medium plastic. Organic content tests confirmed the presence of organics to range from 1.6-9.5%.

In this stratum the 'N' values ranged from 2 blows/0.3 m to 8 blows/0.3 m this material had a very soft to firm consistency.

Clayey Silt to Silty Clay, trace Sand

Underlying the above material north of the South Nation River and encountered at the surface to the south is a clayey silt to silty clay, trace sand deposit. To the north this deposit had a thickness of 3.5 m to 1.5 m and to the south had a depth of 4.4 m-5.3 m.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 3 in the Appendix, in an envelope form. From the above figure it is evident that the layer contains a high percentage of fine materials such as silt and clay. The deposit is comprised primarily of 0-1% gravel, 1-13% sand, 42-70% silt and 25-55% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	20-29.5 %	7
Liquid Limit (w_L)	31-53 %	7
Plastic Limit (w_p)	17-26 %	7
Plastic Index (I_p)	14-27 %	7

From the plasticity chart (Figure 4), the layer can be classified as having low to medium plasticity. Unit weight measurements carried out on samples from this strata yielded dry unit weights of 18.5 kN/m³ to 20 kN/m³.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 10 blows/0.3 m to 44 blows/0.3 m, thus the material can be described as having a stiff to hard consistency.

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

Encountered only to the north of the South Nation River lying beneath the above deposit is a heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) with a thickness of 0.4 m to 3.9 m decreasing further north.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 5 in the Appendix, in an envelope form. From the above figure the increased presence of sand and gravel can be seen. The deposit is comprised of 9-38% gravel, 20-31% sand, 24-49% silt and 8-22% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this report is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6-11 %	4
Liquid Limit (w_L)	12.5-20 %	4
Plastic Limit (w_p)	10-13 %	4

From the plasticity chart (Figure 6), the layer can be classified as having low plasticity.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 60 blows/.15 m to >120 blows/0.3 m. Based on these 'N' values, the material can be described as having a hard consistency.

Sand and Gravel with Numerous Cobbles and Boulders

Encountered underlying the clayey silt to silty clay, trace sand deposit south of the South Nation River is a layer of sand and gravel with numerous cobbles and boulders 4.1 m thick. Rock Coring techniques were necessary to penetrate this entire layer and into the bedrock surface.

Bedrock

The boulders to the south and the glacial till to the north is directly underlain by dolostone bedrock of the Oxford Formation. The bedrock was encountered at depths of 8.5 m to 6.5 m, elevations of 79.2 m to 80.1 m.

Conventional Rock Coring techniques were applied utilizing BXL core barrels with BW casing. The dolostone bedrock is light grey to dark grey and is fine to medium grained. The rock is generally slightly weathered to unweathered with moderately close to very close spaced fractures. Detailed descriptions of the bedrock are attached in the Appendix entitled "Rock Core Description", which were provided by D.A. Williams, Petrographer.

Core Recoveries and Rock Quality Designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock recoveries varied between 85-100%, while RQD's varied between 58 to 83%. The dolostone bedrock is medium strong rock.

GROUNDWATER CONDITIONS

Observations of the groundwater level was carried out by measuring the water level in open boreholes. An artesian condition was found to exist on the north bank of the South Nation River at the pier and north abutment locations with a pressure head of approximately 1.5 m. This artesian condition is only encountered upon immediate contact of the bedrock surface.

Boreholes containing artesian conditions were plugged as soon as they were stabilized utilizing gravel, cement, and a chemical sealant, matex.

Groundwater levels to the south were found at elevations 86 m to 86.7 m. The water level in the South Nation River at the time of this investigation was at an elevation of 85.75 m.

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

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a three span overpass structure that will carry the proposed Goodin Service Road over the South Nation River. The width of the structure is 11.5 m, comprising of two lanes of traffic with adjoining shoulders with span lengths of 12.5, 20 and 12.5 m.

The proposed profile grade of the bridge structure is approximately El. 91.1 m with the natural ground surface varying from El. 87.3 m to El. 85.7 m (south to north), consequently fills in the order of magnitude of 3.8 m and 5.4 m will be required.

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

- 1) Structure Foundation
- 2) Lateral Earth Pressure
- 3) Slope Stability
- 4) Construction Considerations

1) Structure Foundation

North Abutment

All of the surficial organic clayey silt, some sand must be removed at the abutment location and beneath the north approach ramp. If the fill consists of well compacted Granular 'A' material, consideration may be given to utilizing a shallow spread footing placed as high as possible within the fill. A detailed construction scheme is outlined on Figure 7. For the purposes of the O.H.B.D.C., the following values are recommended for a 3 m wide footing.

Bearing Capacity - North Abutment

- Shallow Spread Footing

Bearing Capacity at S.L.S. Type II (kPa)	350
Factored Capacity at U.L.S. (kPa)	900

In order to ensure the integrity of the approaches it is recommended that all the encountered organic clayey silt be excavated to its full horizontal and vertical extent at areas where fills are required as outlined on Figure 8.

At the base of the footing on compacted granular 'A' core an unfactored coefficient of friction of 0.57 may be used for sliding resistance.

As an alternative north abutment can be designed utilizing steel H-piles driven down to bedrock. Fill material employed in this option should not exceed grain size of 75 mm to prevent pile driving impediment. For purposes of the O.H.B.D.C., the steel H-piles can be designed using axial capacities below.

AXIAL CAPACITY - DRIVEN STEEL H-PILES

Pile Type	Factored Capacity	Axial Capacity	Estimated
	AT U.L.S.	At S.L.S. Type II	Pile Tips
	(kN)	(kN)	El. (m)
HP310x110	1600	1150	79.5+/-
HP310x79	1150	890	79.5+/-

South Abutment

At the south abutment location, the existing clayey silt to silty clay layer is considered suitable for the support of shallow spread footings. For a 3 m wide footing located on the clayey silt deposit at an elevation of 88 m the following values are recommended.

Bearing Capacity - South Abutment

- Shallow Spread Footing

Bearing Capacity at S.L.S. Type II (kPa)	200
Factored Capacity at U.L.S. (kPa)	400

Alternatively, consideration may be given to locate the spread footing on a compacted granular 'A' material placed on the natural clayey silt deposit. For this case the following values are recommended.

Bearing Capacity - South Abutment

- Shallow Spread Footing

Bearing Capacity at S.L.S. Type II (kPa)	350
Factored Capacity at U.L.S. (kPa)	900

An unfactored sliding resistance factor of 0.57 may be utilized for footings resting on granular material.

A detailed construction scheme is outlined on Figure 7.

At this location, a pile foundation option is not favoured due to the existence of boulders below elevation 85+ m which may impede pile installation.

South Pier

The south pier will be located within the South Nation River, between the different strata encountered to the north and south. This pier is recommended to be founded on steel H-piles driven down to the bedrock. For purposes of the O.H.B.D.C., the steel H-piles can be designed using the axial capacities below.

AXIAL CAPACITY - DRIVEN STEEL H-PILES

File Types	Factored Capacity	Axial Capacity	Estimated
	AT U.L.S.	AT S.L.S. II	Pile Tip
	(kN)	(kN)	El. (m)
HP310x110	1150	890	79+/-
HP310x79	750	580	79+/-

As there was a presence of boulders encountered to the south, pile driving may make it difficult to drive down to their desired depths.

At the South Pier where pile driving may be impeded, it is recommended that piles be carefully controlled and monitored in accordance with MTO Standards SS103-10 or SS103-11 and assuming an ultimate capacity as tabulated below:

Ultimate Capacity Employing <u>Hiley Dynamic Formula</u>	
<u>Pile Type</u>	<u>Ultimate Capacity (kN)</u>
HP310x110	2670
HP310x79	1740

To facilitate pile penetration through the glacial till and any boulders, it is recommended that the steel H-piles be equipped with reinforced tips.

North Pier

The north pier is recommended to be founded on steel H-piles driven down to bedrock. For purposes of the O.H.B.D.C., the steel H-piles can be designed using the axial capacities below.

<u>AXIAL CAPACITY - DRIVEN STEEL H-PILES</u>			
<u>Pile Type</u>	Factored Capacity	Axial Capacity	Estimated
	AT U.L.S.	AT S.L.S. II	Pile Tip
	<u>(kN)</u>	<u>(kN)</u>	<u>El. (m)</u>
HP310x110	1600	1150	80+/-
HP310x79	1150	890	80+/-

The capacities pertain to vertical piles only and reductions to account for inclined loading shall conform to factors provided in Section 6.8.3.4.3 of the O.H.B.D.C.

2) Lateral Earth Pressure on Structure

Free draining material such as Granular 'A' or Granular 'B' backfill in accordance with Special Provision No. 109F03 (Latest Revision) shall be used within a wedge behind the abutments and retaining walls bounded by a plane rising at 60° to the horizontal as shown in Figure 6-9.6.1 of the O.H.B.D.C. The application of granular material combined with weep holes in the abutment walls to drain any accumulation of water in the backfill will prevent hydrostatic pressure build-up. Design parameters of the granular backfill are given in the table below.

Backfill Properties

	<u>Gran. 'A'</u>	<u>Gran. 'B'</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³) γ	22.8	21.2
*Coefficient of Active Earth Pressure (K_a)		
- SLS	0.27	0.33
- ULS	0.33	0.4
*Coefficient of Earth Pressure at Rest (K_o)		
- SLS	0.43	0.5
- ULS	0.5	0.58

*These earth pressure coefficients apply to horizontal backfill surfaces only. The appropriate consideration shall be given to account for sloping or surcharging.

Flexible designed abutments would utilize the above Active earth pressures coefficients while Rigid abutments would utilize the above Earth Pressure at Rest coefficients.

3) Slope Stability

Fill heights would be of the order of 3.8 m and 5.4 m at the south and north approaches. At the north approach, it is recommended that the surficial organic

clayey silt (Approx. 2-3 m deep) should be excavated to full depth and replaced by suitable non-cohesive earth material. It is recommended that both the north and south approach embankments be constructed using 2H:1V slopes.

All exposed slopes should be protected against erosion by providing an effective erosional control scheme according to current MTO practices. Rip Rap should be placed according to hydrogeological considerations and should be placed to a height of 1 m above the highest observed water level for the South Nation River.

For fill heights of 3.8 and 5.4 m settlements within the fill in the order of up to 30 to 60 mm can be anticipated. The settlement will take place over a long period of time. In order to minimize the effect of these settlements on the performance of pavement, it is recommended that the approach embankments be built in advance of the construction of the abutments, final grading and paving for as long period as possible.

4) Other Considerations

In the construction of the embankment fills, all softened and/or organic material should be excavated for their full depth within the plan limit prior to fill placement of 25 m from the abutment location, specifically at the north approach.

Excavation of pile caps may extend below existing groundwater level. A dewatering scheme should be considered utilizing sump pumps. All pile caps and shallow spread footings should be constructed in the dry.

In conjunction with the pile installation within the artesian zones, special provisions will be required to control the loss of fines and any further water seepage flow that can develop subsequent to construction. It is therefore recommended that a drainage/filter system be designed below the frost level as illustrated on Figure 9 in the Appendix.

The possibility of utilizing a single span structure was discussed. Should this option be considered, the recommendation for the north and south abutments would

most likely still be valid, however this office would provide detailed specifications upon request.

All pile caps and shallow spread footings shall be protected against frost protection by providing a minimum 1.8 m earth cover.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Michalek, Jr. Foundation Engineer and A. Hilderbrand, Student Engineer, utilizing equipment owned and operated by Johnston Drilling Limited.

The project was carried out under the general supervision of B. Iyer, Senior Foundation Engineer. The report was written by M. Michalek, reviewed by Dr. B. Iyer, P. Eng. and approved by M. Devata, P. Eng.



M. Michalek

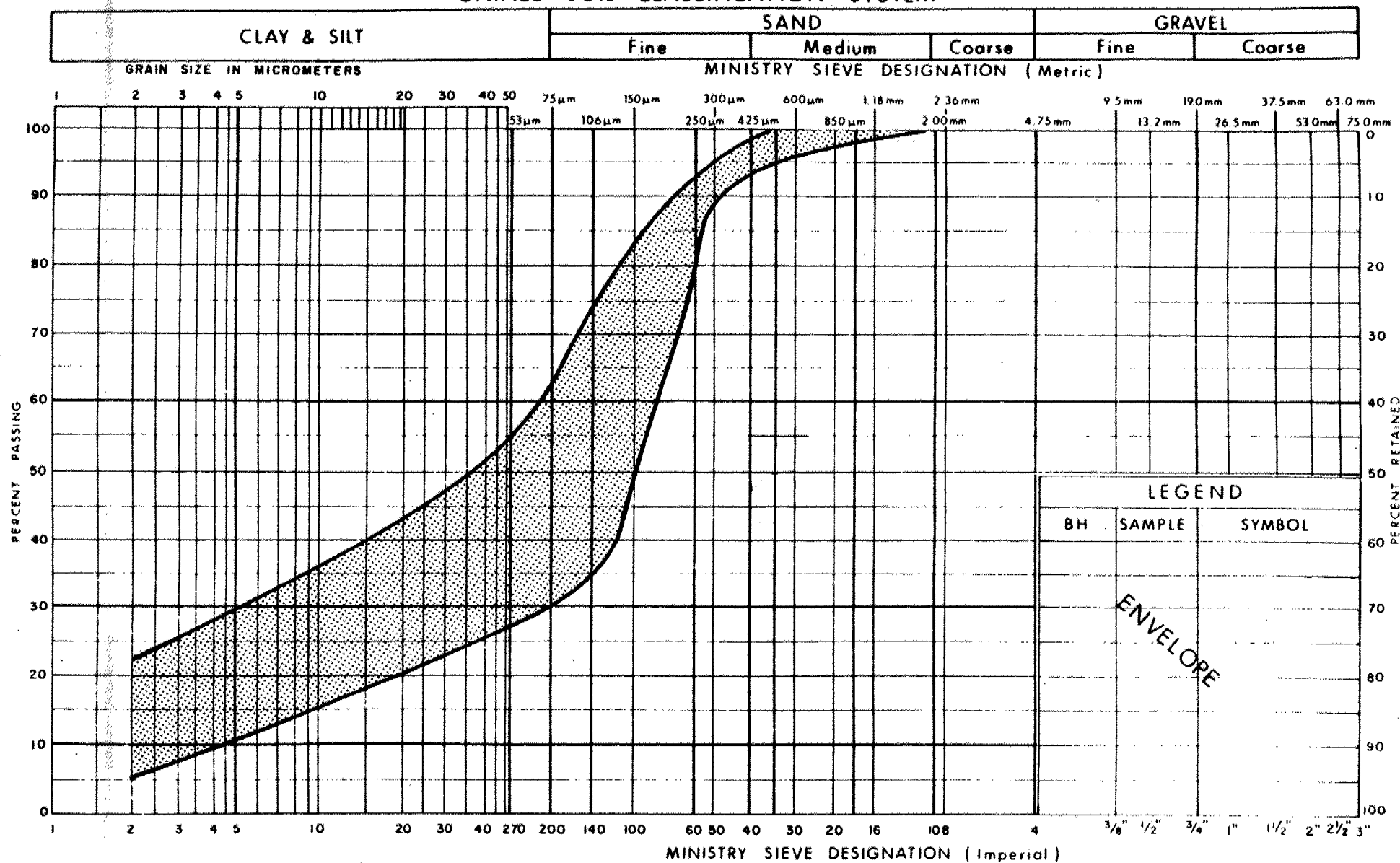
Junior Foundation Engineer

M. Devata, P.Eng.

Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



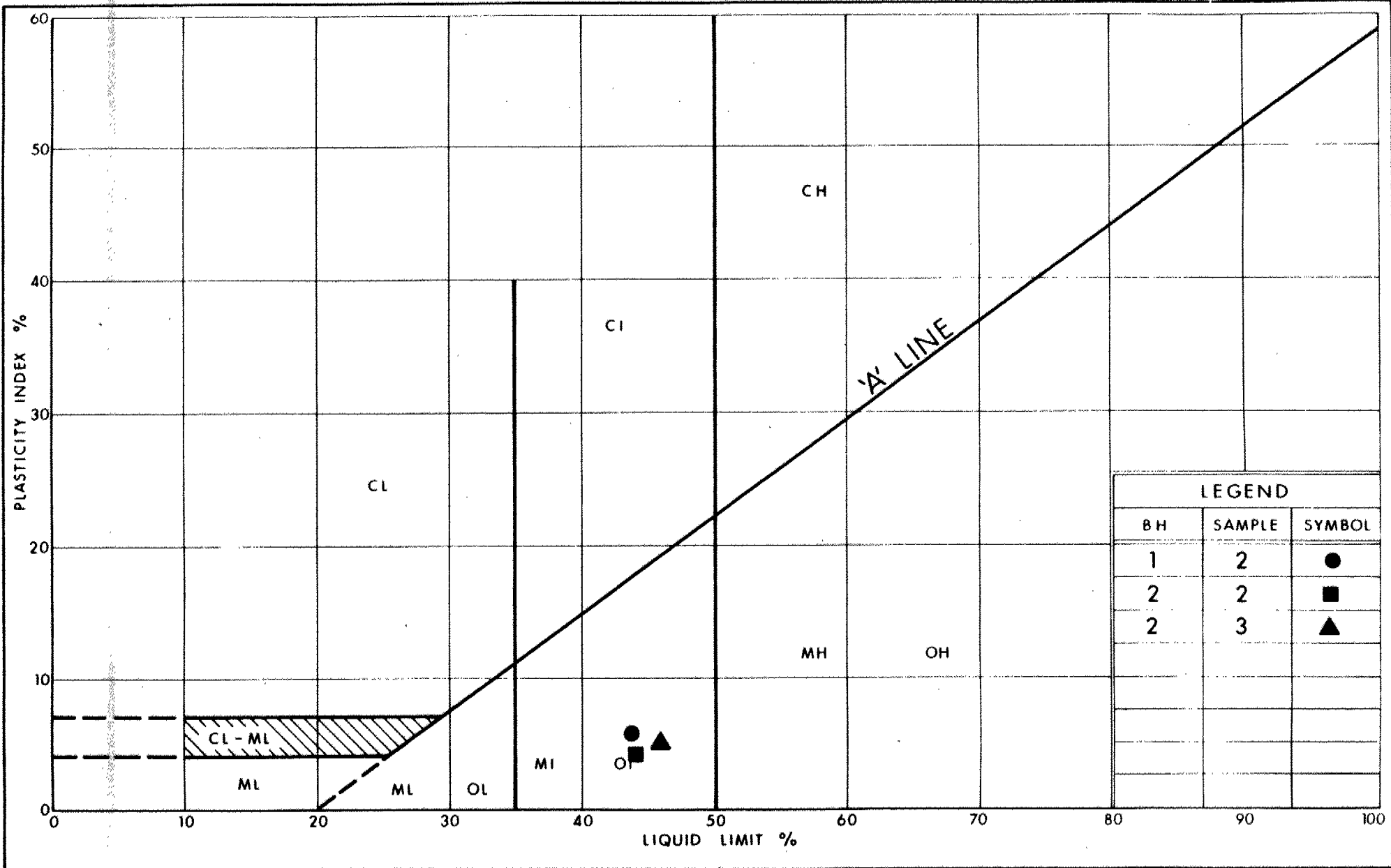
Ontario

Ministry of
Transportation

**GRAIN SIZE DISTRIBUTION
ORGANIC CLAYEY SILT
WITH SAND**

FIG No 1

W P 610-90-01

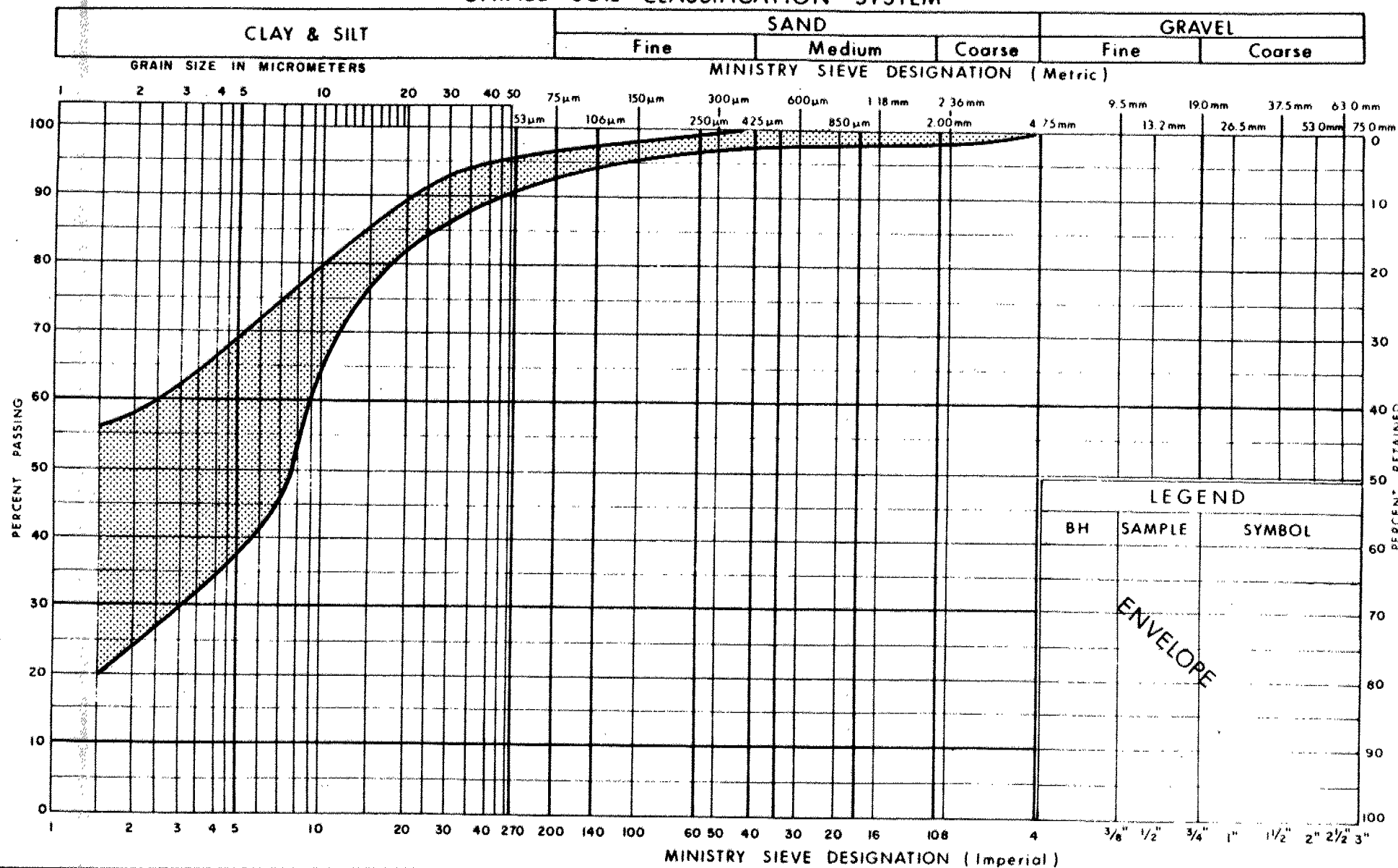


Ministry of
Transportation

PLASTICITY CHART ORGANIC CLAYEY SILT WITH SAND

FIG No 2
W P 610-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

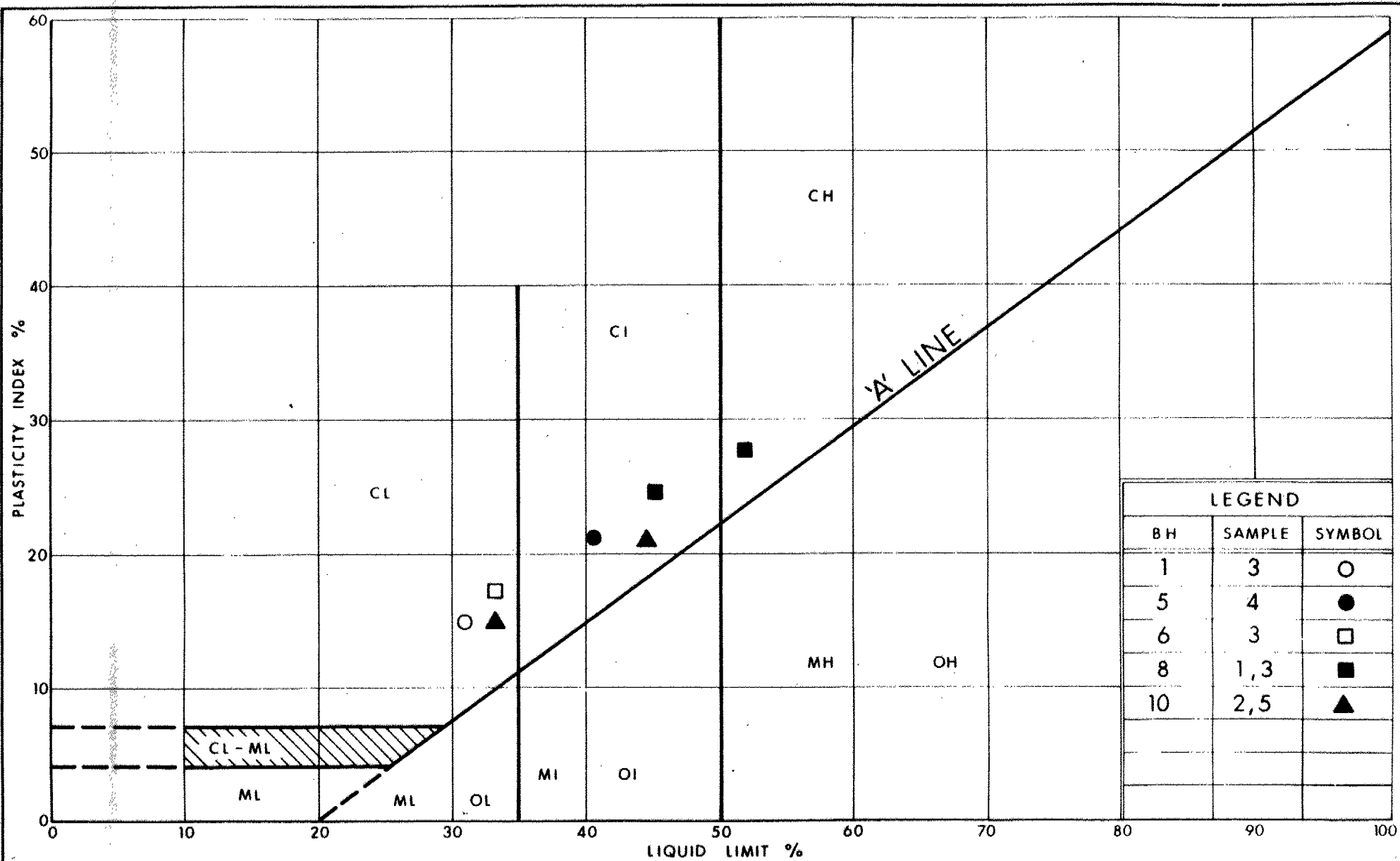


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILTY CLAY
TRACE SAND

FIG No 3

W P 610-90-01



Ministry of
Transportation

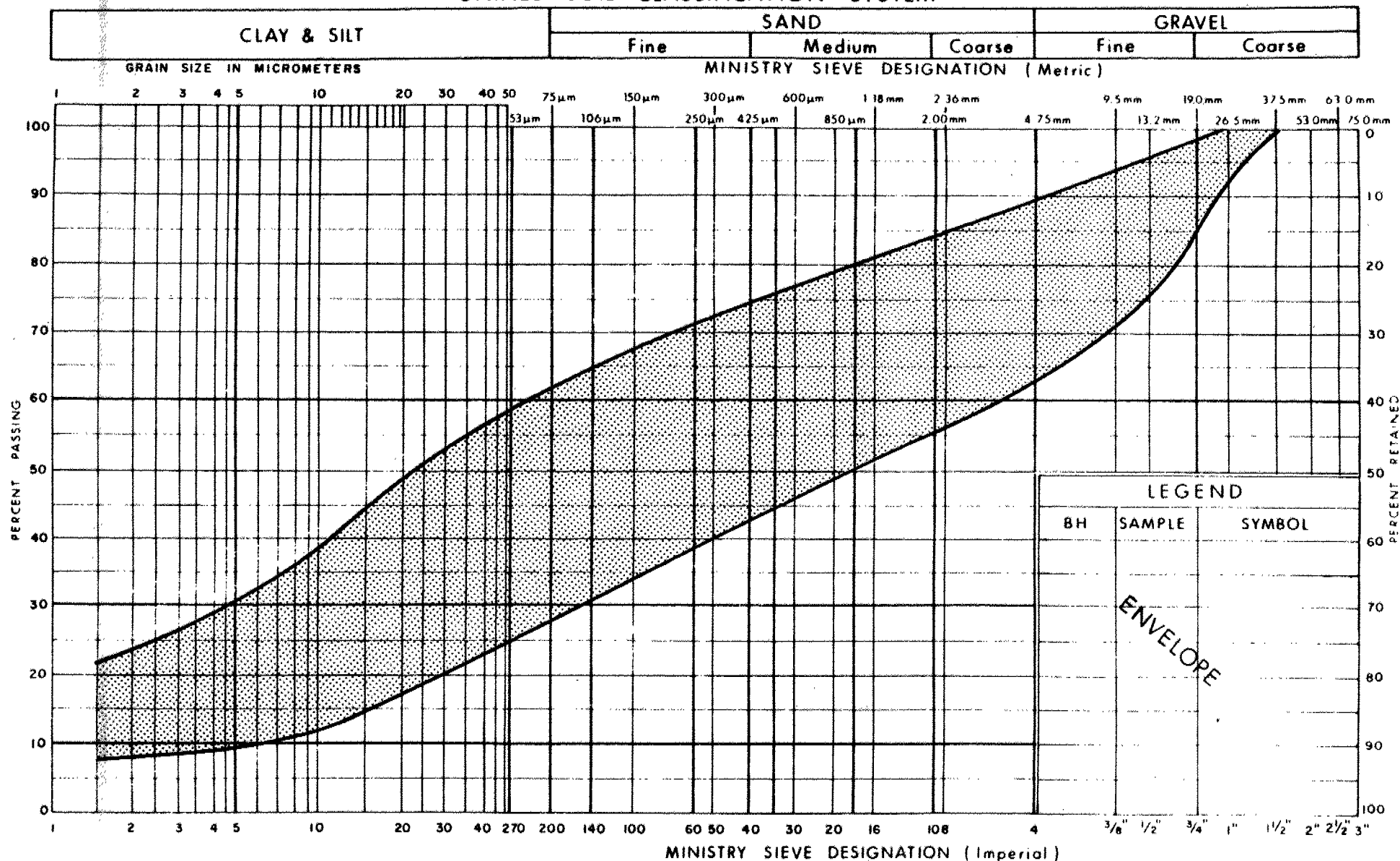
Ontario

PLASTICITY CHART CLAYEY SILT TO SILTY CLAY TRACE SAND

FIG No 4

W P 610-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



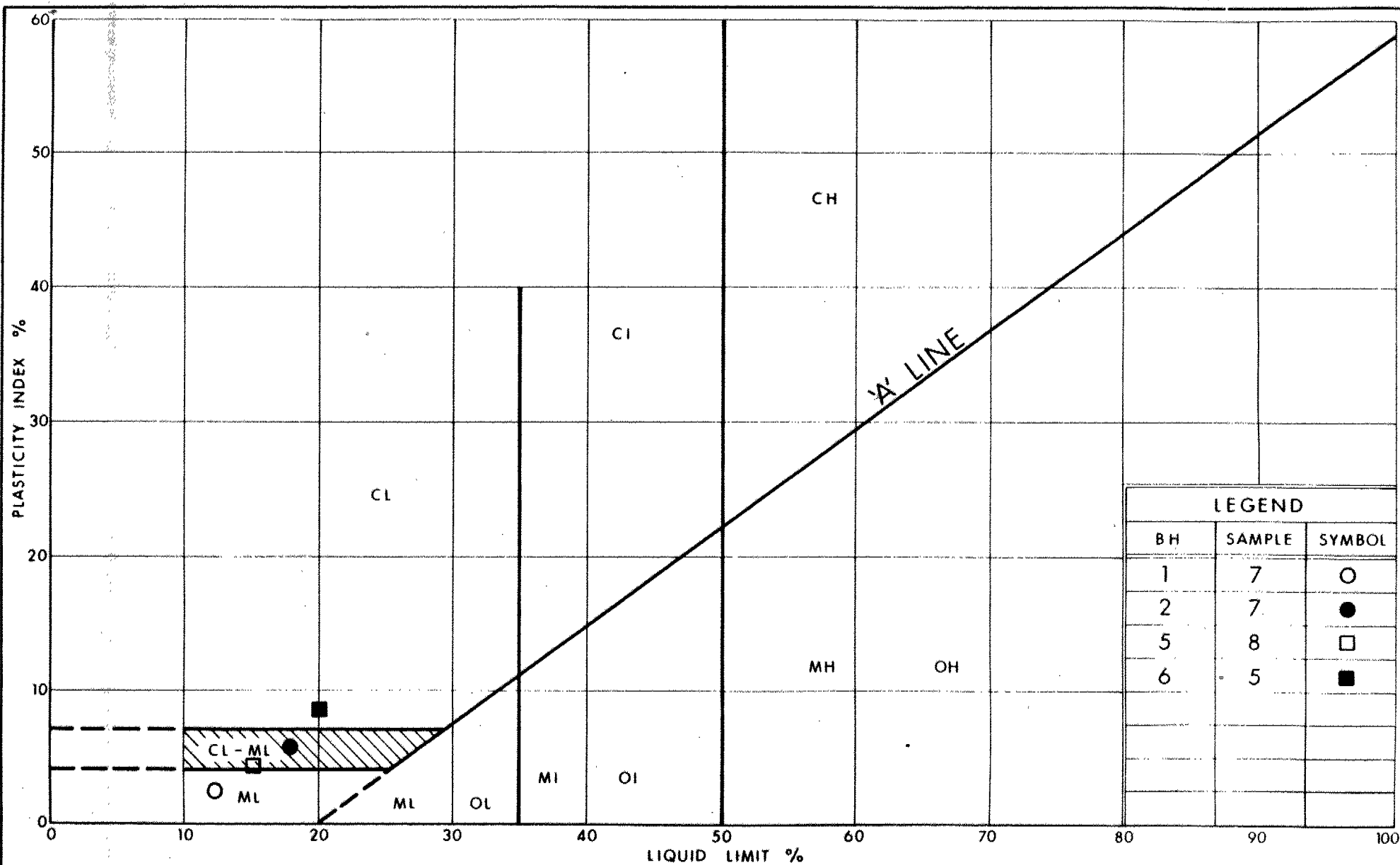
Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
 (GLACIAL TILL)

FIG No 5

W P 610-90-01

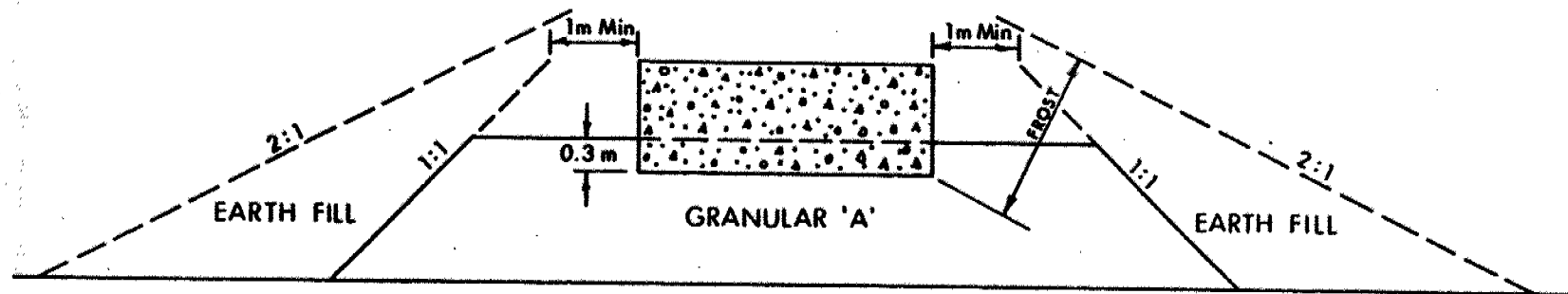


Ministry of
Transportation

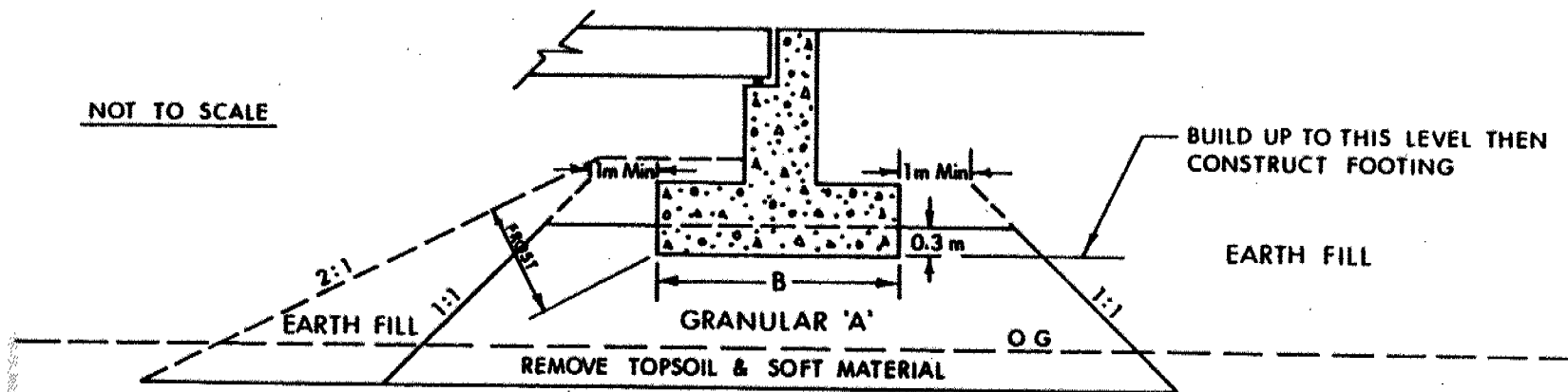
PLASTICITY CHART
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
 (GLACIAL TILL)

FIG No 6

W P 610-90-01



X SECTION



LONGITUDINAL SECTION

NOTES:

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



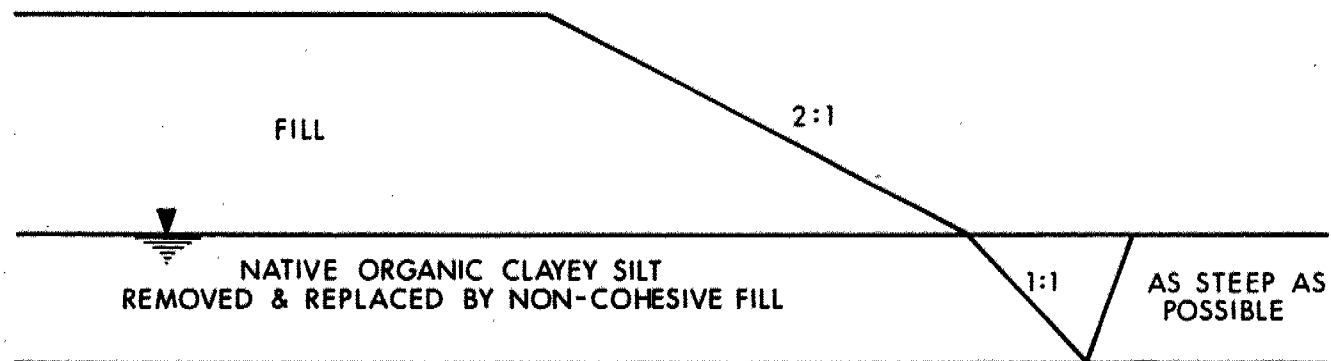
Ministry of
Transportation

Ontario

**ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE**

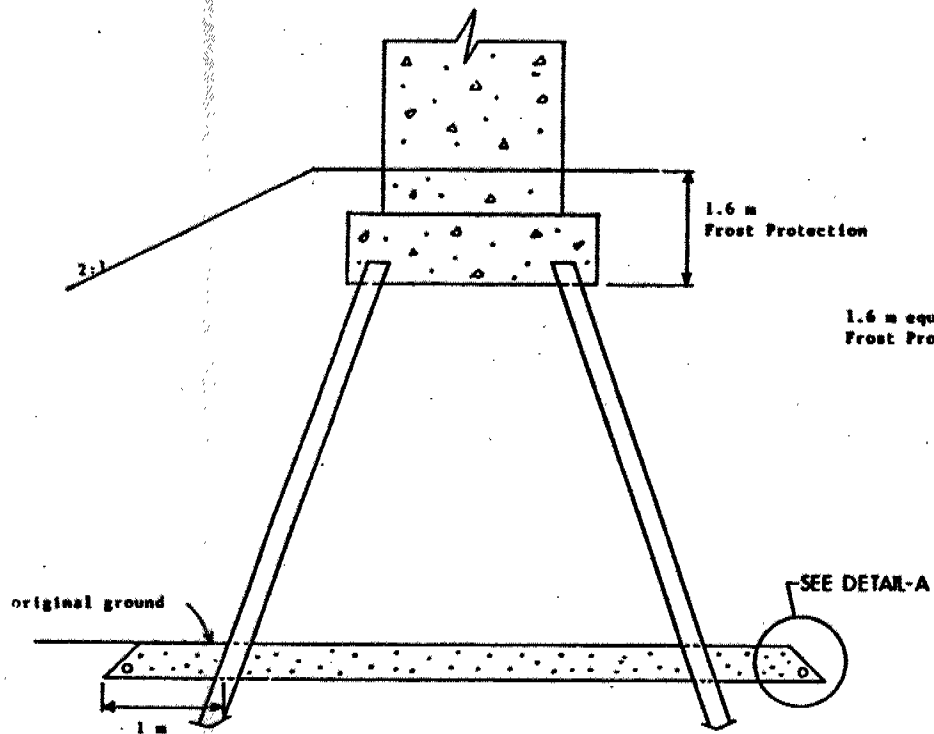
FIG No 7

W P 610-90-01

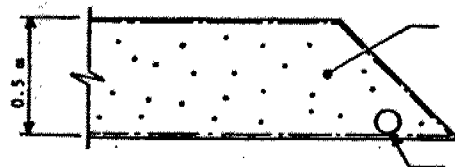


BACKFILL PLACEMENT NORTH APPROACH ABUTMENT

WP 610-90-01
FIG No 8



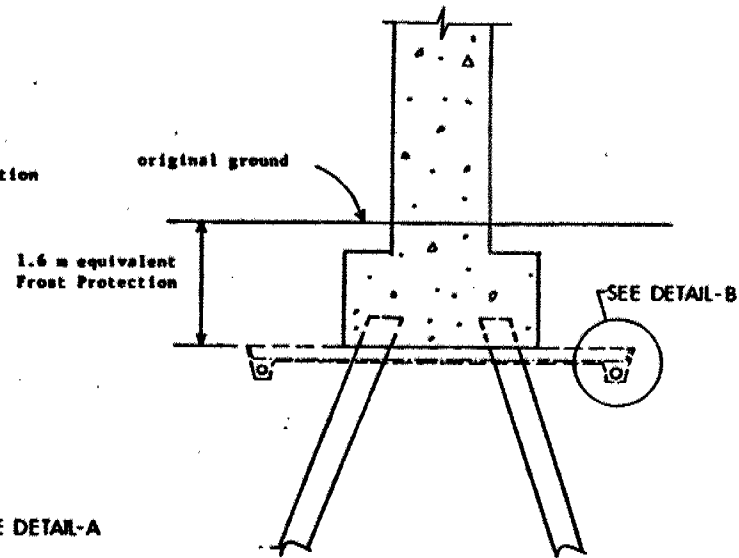
ABUTMENT SECTION (TYP)



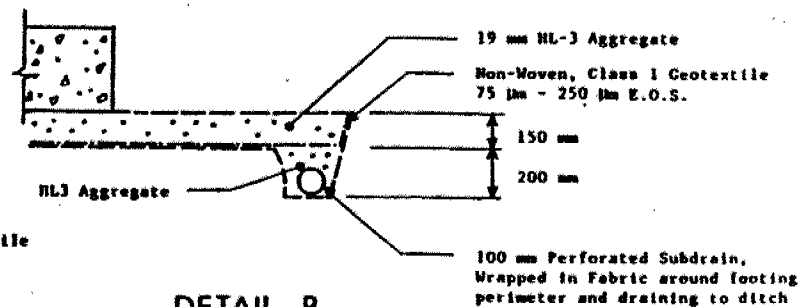
DETAIL A

19 mm HL-3 Aggregate
Completely wrapped in
non-woven, Class I Geotextile
75 μ m - 250 μ m E.O.S.

100 mm Perforated
Subdrain, wrapped in
Fabric around perimeter
of blanket and draining
to ditch



PIER SECTION (TYP)



DETAIL B

NOTES:

1. The drainage blankets should be in place prior to pile driving
2. The geotextile should be cut with a 300 mm x 300 mm "x" at locations where piles will penetrate. This is applicable only to the pier locations
3. If blanket at pier locations is disturbed during pile driving, the blanket should be restored to the details shown on this drawing after the completion of the pile driving

FIGURE 9 - DRAINAGE BLANKET DETAILS
FOR ABUTMENTS & PIERS

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 63.5 kg, 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 1" 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^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 141.5; E 381 141.0 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

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					
86.2	Ground Surface																
0.0	Organic Clayey Silt With Sand Very Dark Brown Traces of Wood Particles Very Soft		1	SS	2	/46cm	86										0 36 58 6
84.1			2	SS	1	/46cm	85										
2.1	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		3	SS	12		84									20.0	0 1 89 30
			4	SS	14		83										
			5	SS	18		82										
			6	SS	13		81										1 1 77 21
80.6	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	51		80										38 30 24 8
5.6																	
79.2	End of Borehole, Refusal																
7.1	Probable Bedrock • Artersion Condition with a Head of 1.5 m Encountered within the Bedrock																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 126.5; E 381 145.0 ORIGINATED BY M.M.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	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 80 100					10 20 30	
86.5	Ground Surface																		
0.0	Organic Clayey Silt With Sand Very Dark Brown Traces of Wood Particles Very Soft to Firm		1	SS	6	/46cm	86										0 36 58 6		
			2	SS	2		85												Over Dried => WL=38, WP=38 Air Dried => WL=46, WP=41, w=142 Organic Content = 9.5
			3	SS	1		84												WL=46, WP=41, 46 w=83.5
83.2	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		4	SS	2	/46cm	83										1 1 70 28		
3.3			5	SS	19		82												
			6	SS	12		81												
80.3	Heterogeneous Mixture of (Cl. Till) Clayey Silt, Sand and Gravel Hard		7	SS	120		80									23.1	18 19 50 13		
6.2 79.9			8	BXL RC	REC 0%		79											RQD 0%	
6.6			9	BXL RC	REC 92%		78												RQD 80%
77.9	End of Borehole																		
8.6																			
	• Artesian Condition with a Head of 1.5 m Encountered within the bedrock																		

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 810-90-01 LOCATION Co-ords: N 4 969 131.4; E 381 152.0 ORIGINATED BY A.H.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/10 CHECKED BY B.J.

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			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL * LAB VANE	WATER CONTENT (%) 20 40 60 80 100					
86.5	Ground Surface													
0.0	Probable Organic Clayey Silt With Sand Very Dark Brown Very Soft													
83.2														
3.3	Probable Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff													
80.4														
6.1	End of Cone Test Possible Till. Cone is still descending at a slow but steady rate. Not Bedrock.													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 112.5; E 381 154.5 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT UNIT			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		
87.0	Ground Surface													
0.0	Probable Organic Clayey Silt With Sand Very Dark Brown Very Soft													
83.6														
3.4	Probable Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff													
81.2														
5.8	End of Cone Test Possible Till. Cone is stiff, descending at a slow but steady rate. Not Bedrock.													

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 989 117.5; E 381 161.5 ORIGINATED BY A.H.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

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					
86.5	Ground Surface															
0.0	Organic Clayey Silt With Sand Soft		1	SS	4											0 37 45 18
85.6			2	SS	5											
1.0			3	SS	17											
	Clayey Silt to Silty Clay Trace Sand Very Stiff to Hard		4	SS	19										19.2	0 3 57 40
			5	SS	23											
82.1			6	SS	38											1 3 61 35
4.4			7	SS	60	/15cm										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		8	SS	60	/15cm										
79.9			9	BXL RC	REC 93%										22.1	36 28 28 8
6.6	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong															RQD 83%
78.6																
7.9	End of Borehole															
	* Artesian Condition with a Head of 1.5 m encountered within the Bedrock															

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 810-90-01 LOCATION Co-ords: N 4 959 096.0; E 381 165.5 ORIGINATED BY V.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

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	WATER CONTENT (%) 7	UNIT WEIGHT 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						
86.0	Ground Surface																	
0.0	Organic Clayey Silt With Sand Trace Clay Very Dark Brown Firm		1	SS	8		85											0 79 17 4
84.6 1.4	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		2	SS	14		84											0 3 42 55
83.1			3	SS	23		83											
2.9			4	SS	76		82											
			5	SS	80	/15cm	81											
			6	SS	100	/15cm	80											
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	100	/15cm	79											
79.2			8	BXL RC	REC 95%		78											RQD 58%
6.8	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		9	BXL RC	REC 87%		77											RQD 68%
76.2																		
9.8	End of Borehole - Artesian Condition with a Head of 1.5 m encountered within the Bedrock																	

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 610-90-01

LOCATION Co-ords: N 4 969 108.5;E 381 168.0

ORIGINATED BY W.M.

DIST 9 HWY Goodin Ser Rd

BOREHOLE TYPE Dynamic Cone

COMPILED BY A.H.

DATUM Geodetic

DATE 91/10/09

CHECKED BY B.L.

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			20	40	60	80	100					
85.7	Ground Surface															
0.0	Probable Organic Clayey Silt Very Soft															
84.8																
0.7	Probable Clayey Silt to Silty Clay Trace Sand															
82.8																
2.9	Probable Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)															
81.7																
4.0	End of Cone Test Probable Boulders															

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 988 081.5; E 381 175.5 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/11 CHECKED BY B.J.

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		
88.6	Ground Surface													
0.0	Trace Organics													
	Clayey Silt to Silty Clay		1	SS	24								18.5	0 5 44 51
	Trace Sand		2	SS	27									
	Very Stiff to Hard													
	Brown		3	SS	15								19.7	0 3 43 54
	Grey		4	SS	24									
			5	SS	120									
84.2														
4.4			6	BXL RC	REC 13%									NOO 0%
	Sand and Gravel													
	With Numerous Cobbles and		7	BXL RC	REC 31%									NOO 0%
	Boulders													
			8	BXL RC	REC 18%									NOO 0%
80.1														
8.5			9	BXL RC	REC 100%									NOO 0%
	Bedrock													
	Dolostone		10	BXL RC	REC 88%									NOO 62%
	Slightly Weathered to													
	Unweathered													
	Medium Strong													
77.9														
10.7	End of Borehole													

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 057.7; E 381 188.5 ORIGINATED BY A.H.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/11 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT 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	W _p	W	W _L		
87.5 0.0	Ground Surface																
	Clayey Silt to Silty Clay Trace Sand Stiff to Hard		1	SS	10												
			2	SS	29												
			3	SS	23												
			4	SS	23												
			5	SS	34												
			6	SS	44												
82.2																	
5.3 81.7	Sand and Gravel With Numerous Cobbles and Boulders																
5.8	End of Borehole																
	Coring was attempted, but a broken auger tooth blocked the hole to coring.																

ROCK CORE DESCRIPTION **WP 610-90-01**

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	8	7.01-8.63	92	80	7.01-8.63	DOLOSTONE (with calcite-filled vugs in places), light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to close spaced, flat to near vertical, undulating to planar, smooth to rough.
5	9	6.61-7.98	93	83	6.61-7.98	DOLOSTONE (with calcite-filled vugs in places), light olive grey to light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, undulating, smooth.
6	8	6.76-8.28	95	58	6.76-9.81	DOLOSTONE (with calcite-filled vugs in places), light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, undulating, smooth to rough.
	9	8.28-9.81	87	68		
8	6	4.34-5.87	15	0	4.34-8.41	OVERBURDEN (boulder till).
	7	6.10-7.01	31	0	8.41-10.67	DOLOSTONE (with calcite-filled vugs in places), light olive grey to light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered (moderately weathered, 8.41-9.47 m); fractures moderately close to very close spaced, flat to near vertical, undulating, smooth.
	8	7.01-8.53	18	0		
	9	8.53-9.14	100	0		
	10	9.14-10.67	88	62		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

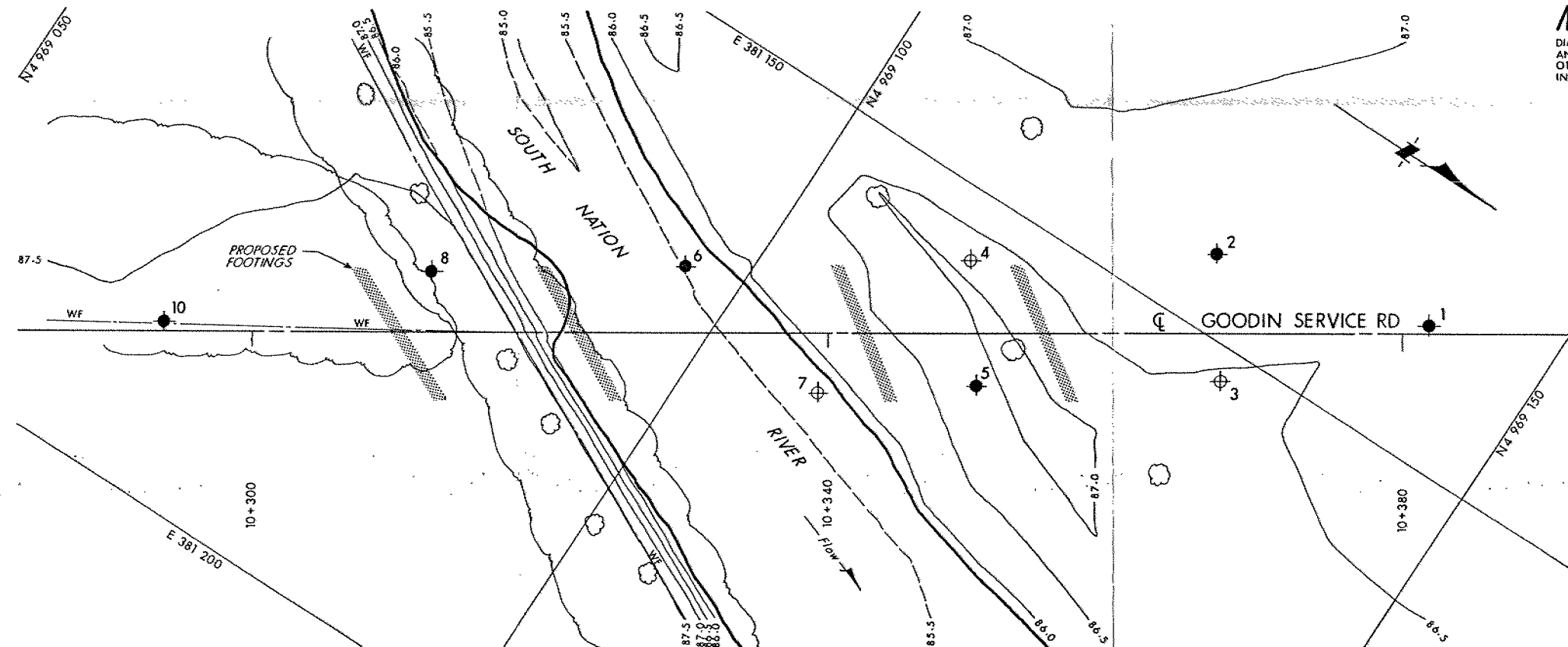
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 610-90-01

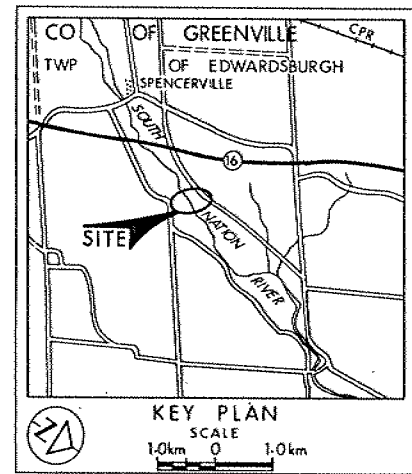
SOUTH NATION RIVER
CROSSING AT GOODIN SERVICE RD
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



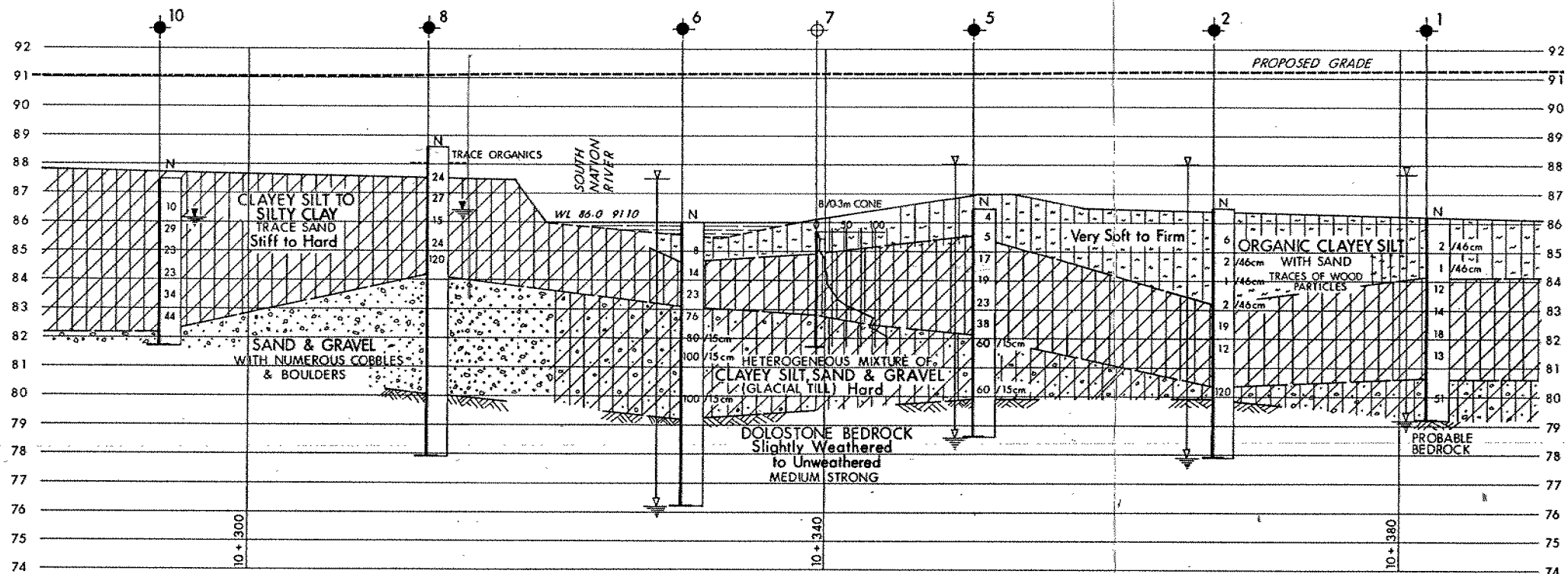
PLAN
SCALE
4m 0 4m



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)
- WL at time of investigation 91 10
- ▽ Head ARTESIAN WATER
- ▽ Encountered

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	86.2	4 969 141.5	381 141.0
2	86.5	4 969 126.5	381 145.0
3	86.5	4 969 131.4	381 152.0
4	87.0	4 969 112.5	381 154.5
5	86.5	4 969 117.5	381 161.5
6	86.0	4 969 096.0	381 165.5
7	85.7	4 969 108.5	381 168.0
8	88.6	4 969 081.5	381 175.5
10	87.5	4 969 067.7	381 188.5



PROFILE GOODIN SERVICE RD

SCALE
4m 0 4m Hor
2m 0 2m Vert

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 31B-66

HWY No GOODIN SERVICE RD	DIST 9
SUBM'D MM CHECKED	DATE 92 01 03
DRAWN DT CHECKED	APPROVED
	SITE 16-322
	DWG 6109001-A



Ministry
of
Transportation

FILE COPY

2 of 2

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 610-90-01

DIST 9

HWY -

STR SITE 16-322

Goodin Service Road/
South Nation River Crossing

CONT 93-75

DISTRIBUTION

E.C. Lane (2)
Sam Cheng
D.J. Kimmett (2)
D. Hogg (2)
B. Farago
G.E. Greene
E.A. Joseph
T.A. Hickey (Cover Only)
F. Bacchus (Cover Only)
File ✓

FOUNDATION INVESTIGATION REPORT
For
Goodin Service Road/
South Nation River Crossing
W.P. 610-90-01, Site No. 16-322
District 9, Ottawa

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site between 91 10 09 and 91 10 12 and a subsequent investigation conducted between 93 06 01 and 93 06 02.

The initial investigation consisted of three dynamic cone penetration tests and six boreholes extending to depths of 4.0m to 10.7m below ground surface. The 1993 investigation included four dynamic cone penetration tests and a borehole.

SITE DESCRIPTION

The site is located at the South Nation River between Shanly Road and the Goodin Service Road, about 1 km to the east of existing Highway 16, in the Municipal Township of Edwardsburgh, County of Leeds and Grenville. Spencerville village is located several kilometres to the west of the site.

Landuse consists of farmers fields, cattle pastures and residential homes. The terrain is generally flat to gently rolling with short wild grasslands and randomly placed trees. The topography surrounding the South Nation River slopes upward to the north and has a steep embankment approximately 2m high to the south. The

natural ground elevation varied from 88.6m to the south to 86m to the north.

Physiographically, the terrain belongs to the Region known as the "Edwardsburgh Sand Plain". The topography of the sand plain is mostly level although hummocks and ridges appear in places. In all probability, the sand was deposited by the melting glacier known as Kames, and subsequently spread about by the waves of the Champlain Sea. The bedrock in the area is of a Gull River Formation of the Middle Ordovician Period. It consists of silty dolostone with interbedded dolomitic shale layers.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and lab testing conducted on select samples. The procedures employed are discussed below.

Field

The fieldwork for the investigation was carried out between 91 10 09 and 91 10 12 and between 93 06 01 and 93 06 02. During the initial phase of the investigation, four boreholes and three dynamic cone penetration tests were done to the north of the South Nation River and two boreholes to the south. During the 1993 investigation, two dynamic cone penetration tests were carried out at the north abutment area and two dynamic cone penetration tests and a borehole at the south abutment area.

The boreholes were advanced using hollow stem augering techniques through most of the overburden and using BW casing through the bouldery stratum to the surface of bedrock.

Samples of the overburden were retrieved at 0.7m to 1.5m intervals using a 51mm O.D. split spoon sampler, in accordance with the Standard Penetration Test (ASTM D-1586). Conventional BXL size rock cores were recovered from the boulder zones in the glacial till stratum and from bedrock.

All soil samples and rock cores were identified in the field and returned to the laboratory for further examination and testing.

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

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

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

- 1) Atterberg Limits
- 2) Grain Size Distribution
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on Figures and Record of Boreholes sheets included in the Appendix.

SUBSURFACE CONDITIONS

General

The subsoil stratigraphy at the site to the north of the South Nation River consists of 0.7m to 3.4m (average 2.0m) thick layer of

cohesive organic clayey silt with sand. Water logged swampy ground is present locally in the north flood plain area. Wood particles were encountered particularly at the north approach location. Underlying this deposit is a 1.5m to 4.1m thick layer of cohesive clayey silt to silty clay, trace sand which in turn is followed by a layer of heterogeneous mixture of clayey silt, sand and gravel (glacial till) and then dolostone bedrock at El. 79.2m to 79.9m.

To the south of the South Nation River, the subsoil stratigraphy consists of a thin veneer of organics followed by 3.8m to 4.6m thick deposit of clayey silt, trace sand. Underlying this deposit is a 4.1m thick stratum of heterogeneous mixture of clayey silt, sand and gravel with numerous boulders (glacial till). Dolostone bedrock was encountered at depths of 8.5m to 9.2m, at El. 78.4m to 80.1m.

The plan and locations of borings done in 1991 together with the stratigraphic profile derived from this data are shown on Dwg No. 2 of the Contract Drawing. Figure 7 shows the locations of the previous (1991) and most recent (1993) borings done at this site, together with the locations of the abutments of the proposed structure.

The field and laboratory test results are plotted on the Record of Borehole sheets included in the Appendix of this report. A brief description of the various soil strata encountered are given below.

Organic Clayey Silt, with Sand

The encountered thickness of this deposit varied between 0.7m and 3.4m to the north of the river and between 0m and 0.6m to the south of the river.

Grain Size Distribution Test results are shown on Figure 1 in the Appendix, in an envelope form. The deposit is comprised of 0% gravel, 36-37% sand, 45-50% silt and 4-9% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	33.5-84 %	3
Liquid Limit (w_L)	43-46 %	3
Plastic Limit (w_p)	38-41 %	3

From the plasticity chart (Figure 2), the layer can be classified as being organic medium plastic. Organic content tests confirmed the presence of organics to range from 1.6-9.5%.

In this stratum the 'N' values ranged from 2 blows/0.3m to 8 blows/0.3m, thus the material had a very soft to firm consistency.

Clayey Silt to Silty Clay, trace Sand

Underlying the above deposit, a layer of clayey silt to silty clay, trace sand was encountered. The thickness of this stratum ranged between 1.5m and 4.1m to the north of the river and 3.8m and 4.6m to the south of the river.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 3 in the Appendix, in an envelope form. From the above figure it is evident that the layer contains a high percentage of fine materials such as silt and clay. The deposit is comprised primarily of 0-1% gravel, 1-13% sand, 42-70% silt and 25-55% clay.

The results from the Atterberg Limit Tests performed on the fine fraction of this deposit is summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	20-29.5 %	7
Liquid Limit (w_L)	31-53 %	7
Plastic Limit (w_p)	17-26 %	7
Plastic Index (I_p)	14-27 %	7

From the plasticity chart (Figure 4), the layer can be classified as having low to medium plasticity. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of 18.5 kN/m^3 to 20 kN/m^3 .

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 10 blows/0.3m to 44 blows/0.3m, thus the material can be described as having a stiff to hard consistency.

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

Underlying the clayey silt to silty clay layer, a heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) stratum was encountered in all except two holes located to the south of the river. In these two holes a layer of sand and gravel with numerous cobbles and boulders was encountered. It is possible that this layer is part of the overall glacial till deposit.

The encountered thickness of the glacial till stratum varied between 0.4m to about 4m to the north of the river and was about 4.1m to the south of the river. The presence of numerous cobbles and boulders necessitated the use of rock coring techniques locally to advance the boreholes through this stratum.

Results of Grain Size Distribution Tests on this deposit are shown on Figure 5 in the Appendix, in an envelope form. From the above figure the increased presence of sand and gravel can be seen. The

deposit is comprised of 9-38% gravel, 20-31% sand, 24-49% silt and 8-22% clay.

The results from the Atterburg Limit Tests performed on the fine fraction of this deposit are summarized as follows.

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	6-11 %	4
Liquid Limit (w_L)	12-20 %	4
Plastic Limit (w_p)	10-13 %	4

From the plasticity chart (Figure 6), the layer can be classified as having low plasticity.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 60 blows/.15m to >120 blows/0.3m. Based on these 'N' values, the material can be described as having a hard consistency.

Bedrock

The glacial till stratum is underlain by dolostone bedrock of the Oxford Formation. The bedrock was encountered at depths of 6.6m to 9.2m below grade, at elevations of 78.4m to 80.1m.

Conventional Rock Coring techniques were applied utilizing BXL core barrels with BW casing. The dolostone bedrock is light grey to dark grey and is fine to medium grained. The rock is generally slightly weathered to unweathered with moderately close to very close spaced fractures. Detailed descriptions of the bedrock are attached in the Appendix entitled "Rock Core Description", which were provided by D.A. Williams, Petrographer.

Core Recoveries and Rock Quality Designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock recoveries varied between 85-100%, while RQD's varied between 58 to 83%. The dolostone bedrock is medium strong rock.

GROUNDWATER CONDITIONS

Observations of groundwater level were carried out by measuring the water levels in open boreholes. Groundwater levels in the boreholes located south of the river were at elevations 86.4m to 86.0m. An artesian groundwater condition was encountered in the boreholes located north of the river, with a pressure head of 1.5m above grade. The artesian condition was encountered immediately on contacting the bedrock surface. After stabilizing the water level, these boreholes were plugged using gravel, cement and matex, a chemical sealant.

The water level in the South Nation River was at El. 85.75m during the 1991 investigation and at about El. 86.0m during the 1993 investigation. It is understood that during high river water conditions, part of the north bank becomes flooded.

Groundwater and river water levels are subject to seasonal fluctuations and hence can vary from the values given above.

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

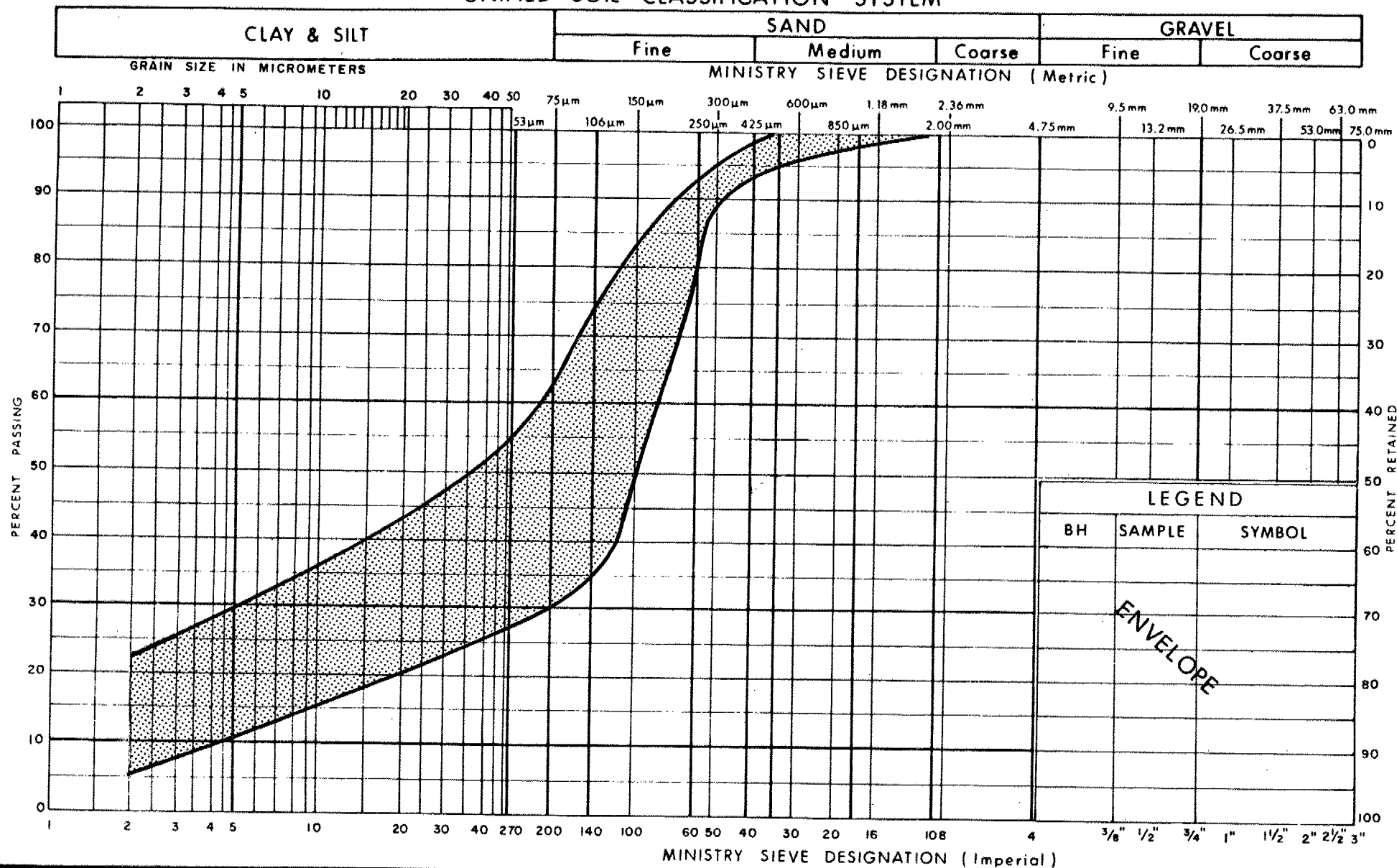
MECHANICAL PROPERTIES OF SOIL

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	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						

UNIFIED SOIL CLASSIFICATION SYSTEM



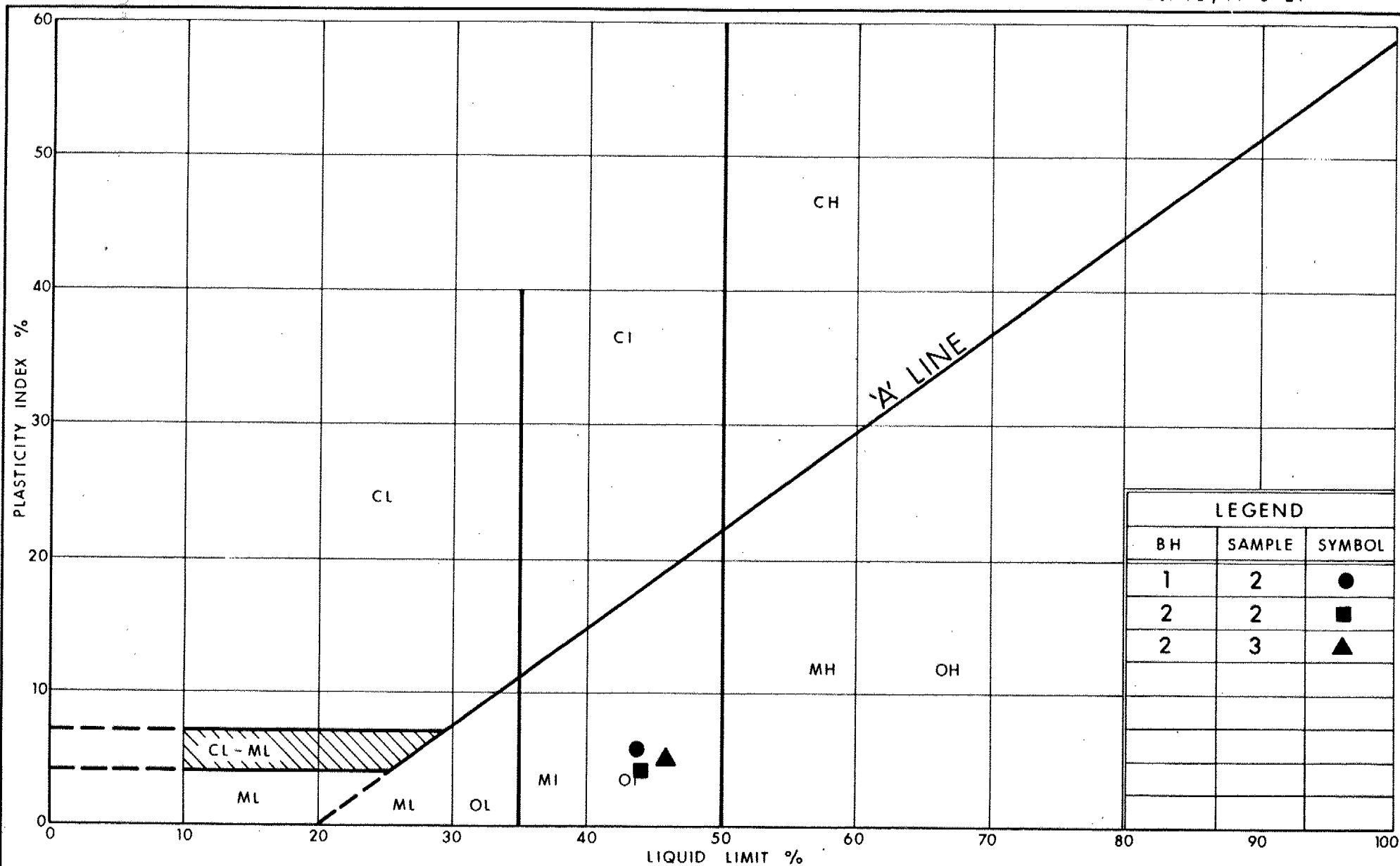
Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
ORGANIC CLAYEY SILT
WITH SAND

FIG No 1

W P 610-90-01



Ministry of
Transportation

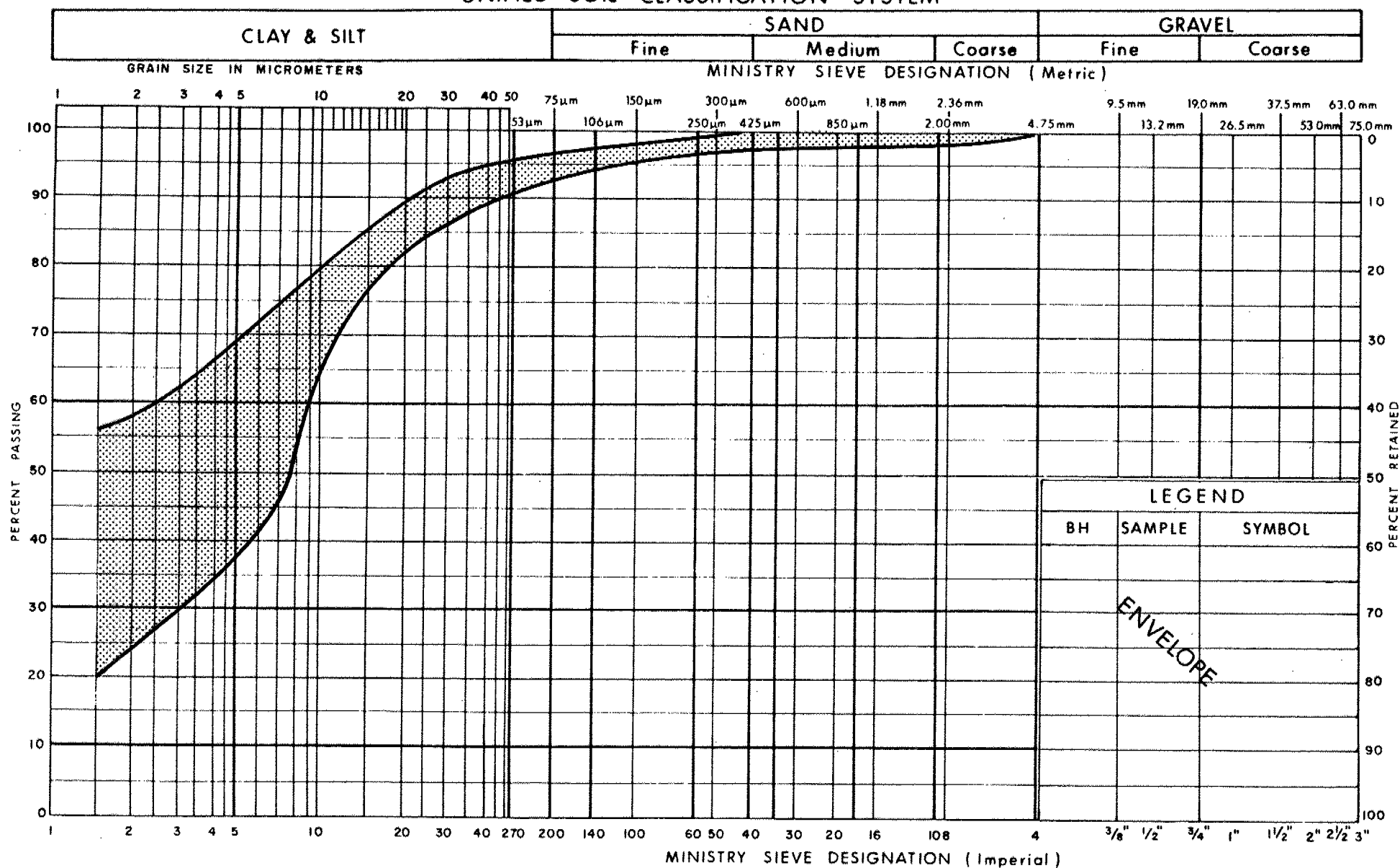
Ontario

PLASTICITY CHART ORGANIC CLAYEY SILT WITH SAND

FIG No 2

W P 610-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

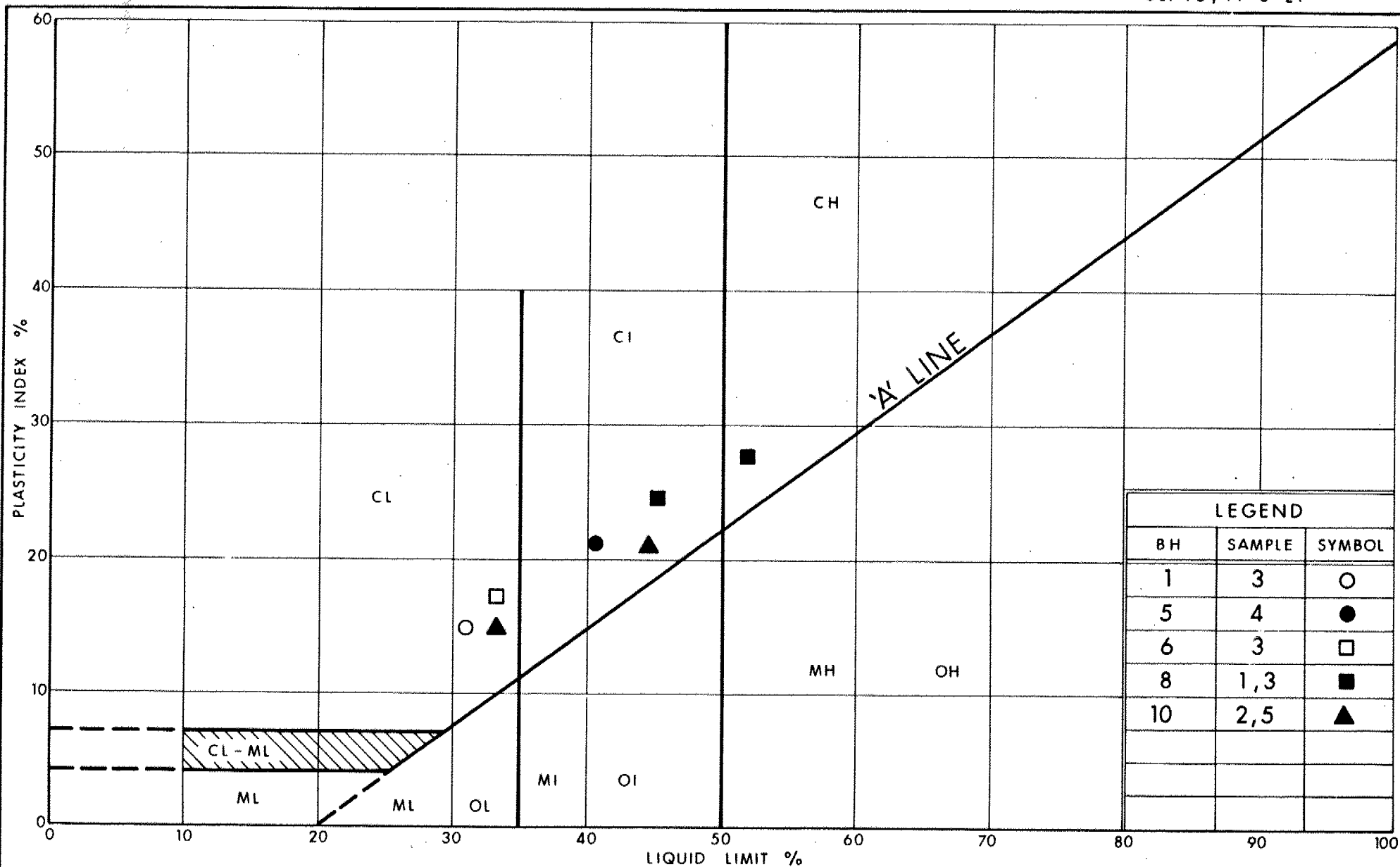


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILTY CLAY
TRACE SAND

FIG No 3

W P 610-90-01



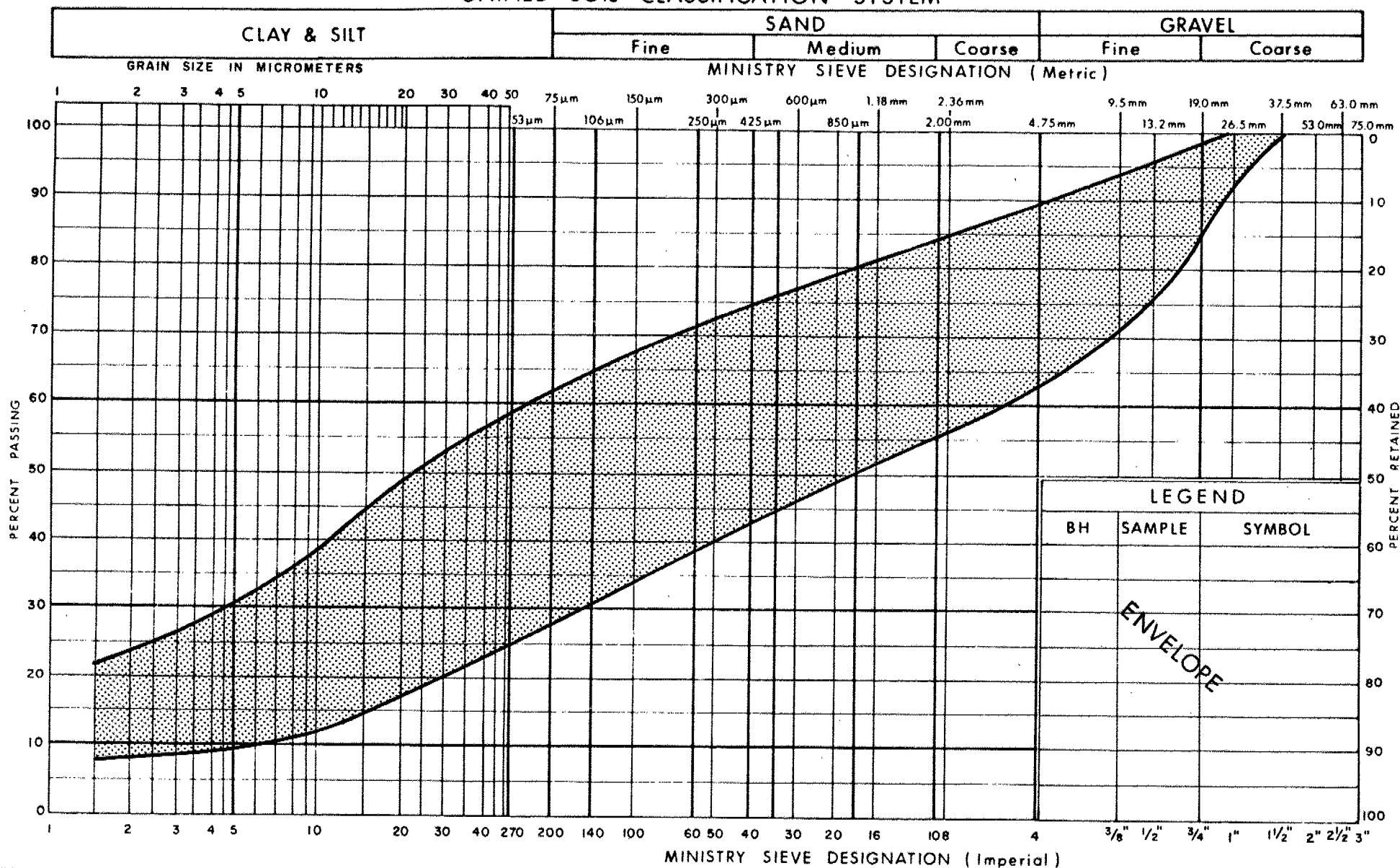
Ministry of
Transportation
Ontario

PLASTICITY CHART CLAYEY SILT TO SILTY CLAY TRACE SAND

FIG No 4

W P 610-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

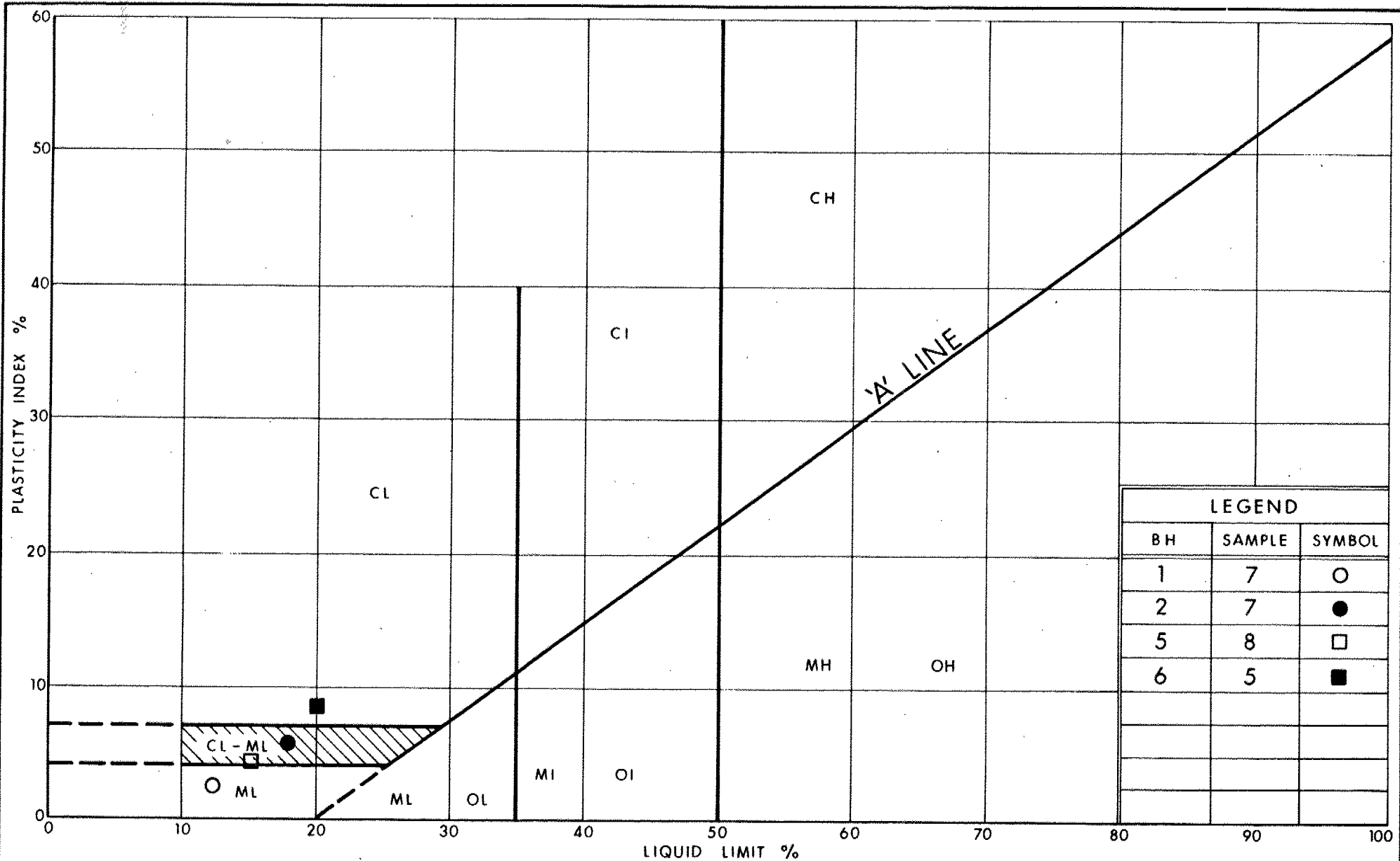


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
 (GLACIAL TILL)

FIG No 5

W P 610-90-01

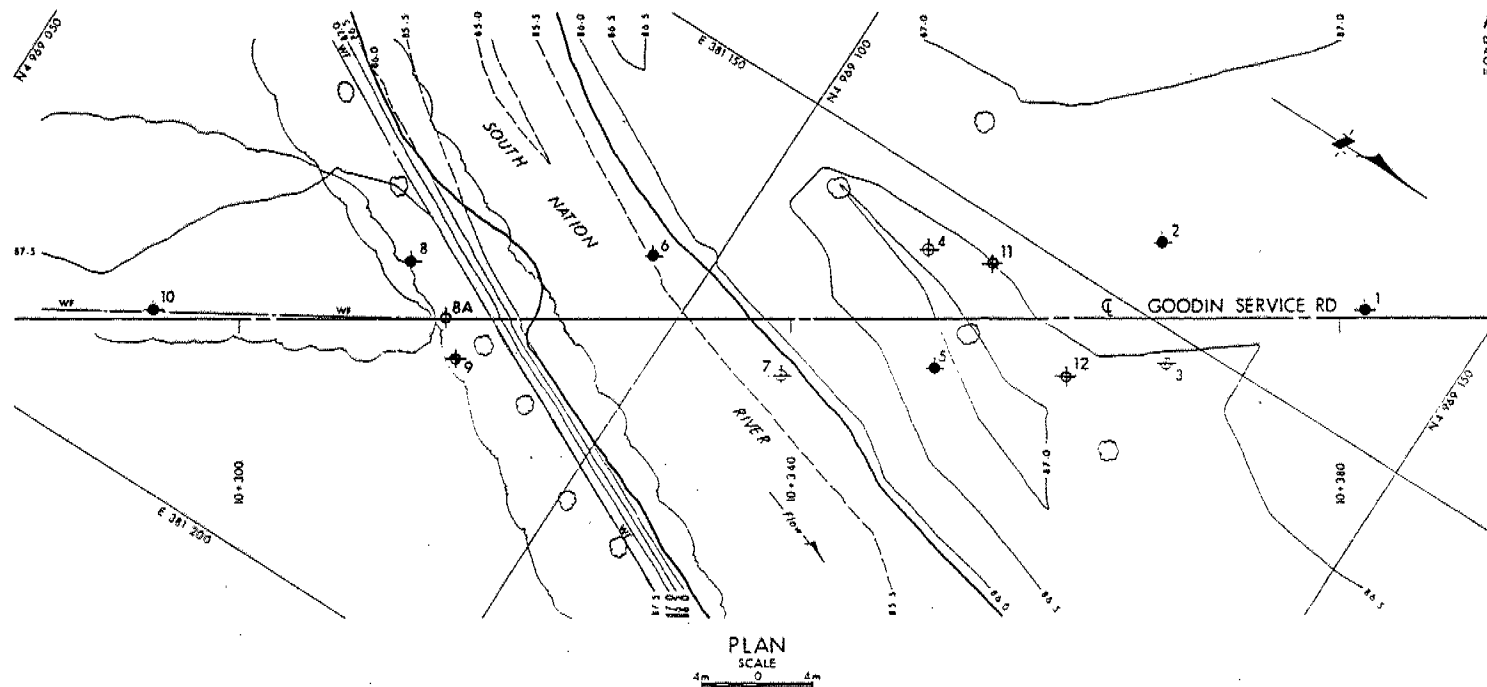


Ministry of
Transportation
Ontario

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL
(GLACIAL TILL)

FIG No 6

W P 610-90-01



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

CONT No
 WP No 610-90-01



**SOUTH NATION RIVER
 CROSSING AT GOODIN SERVICE RD
 BORE HOLE LOCATIONS & SOIL STRATA**

SHEET

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 at time of investigation 91 10
- Head
 ARTESIAN WATER
 Encountered




No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	86.2	4 969 141.5	381 141.0
2	86.5	4 969 126.5	381 145.0
3	86.5	4 969 131.4	381 152.0
4	87.0	4 969 112.5	381 154.5
5	86.5	4 969 117.5	381 161.5
6	86.0	4 969 096.0	381 165.5
7	85.7	4 969 108.5	381 168.0
8	88.6	4 969 081.5	381 175.5
10	87.5	4 969 067.7	381 188.5
8A	87.6	4 969 086.0	381 178.0
9	87.6	4 969 088.0	381 180.0
11	86.5	4 969 117.0	381 153.0
12	86.7	4 969 126.0	381 157.0

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 141.5; E 381 141.0 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)						
								20 40 60 80 100	20 40 60 80 100	10 20 30	7					
86.2	Ground Surface															
0.0	Organic Clayey Silt With Sand Very Dark Brown Traces of Wood Particles Very Soft		1	SS	2	/46cm	86								0 36 58 6	
84.1			2	SS	1	/46cm	85									Oven Dried=> WL=43,WP=38 Air Dried=> WL=59,WP=49,w=120 Organic Content=14
2.1	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		3	SS	12		84							20.0	0 1 69 30	
			4	SS	14		83									
			5	SS	18		82									
			6	SS	13		81									1 1 77 21
80.6							80									
5.6	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	51		80								38 30 24 8	
79.2																
7.1	End of Borehole, Refusal															
	Probable Bedrock • Artesian Condition with a Head of 1.5 m Encountered within the Bedrock															

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 959 126.5; E 381 145.0 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

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		
86.5	Ground Surface													
0.0	Organic Clayey Silt With Sand Very Dark Brown Traces of Wood Particles Very Soft to Firm		1	SS	6		86							
			2	SS	2	/46cm	85							
			3	SS	1	/46cm	84							
			4	SS	2	/46cm	83							
83.2	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		5	SS	19		82							
3.3			6	SS	12		81							
			7	SS	120		80							
80.3	Heterogeneous Mixture of (Gl. Till) Clayey Silt, Sand and Gravel Hard		8	BXL RC	REC 0%		79							
6.2			9	BXL RC	REC 92%		78							
79.9														
6.6	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong													
77.9	End of Borehole													
8.6														

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 131.4; E 381 152.0 ORIGINATED BY A.H.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/10 CHECKED BY B.J.

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
86.5	Ground Surface															
0.0	Probable Organic Clayey Silt With Sand Very Dark Brown Very Soft															
83.2																
3.3	Probable Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff															
80.4																
6.1	End of Cone Test Possible Till. Cone is still descending at a slow but steady rate. Not Bedrock.															

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 112.5; E 381 154.5 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
87.0	Ground Surface													
0.0	Probable Organic Clayey Silt With Sand Very Dark Brown Very Soft													
83.6														
3.4	Probable Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff													
81.2														
5.8	End of Cone Test Possible Till. Cone is stiff, descending at a slow but steady rate. Not Bedrock.													

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 989 117.5; E 381 161.5 ORIGINATED BY A.H.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
86.5	Ground Surface													
0.0	Organic Clayey Silt With Sand Soft		1	SS	4		86							0 37 45 18
85.6			2	SS	5									
1.0			3	SS	17		85							
			4	SS	19		84						19.2	0 3 57 40
			5	SS	23		83							
82.1			6	SS	38		82							1 3 61 35
4.4	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		7	SS	60	/15cm	81							
79.9			8	SS	60	/15cm	80						22.1	36 28 28 8
6.6	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		9	BXL RC	REC 93%		79							RQD 83%
78.6														
7.9	End of Borehole													
	• Artesian Condition with a Head of 1.5 m encountered within the Bedrock													

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 096.0; E 381 165.5 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

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		
86.0	Ground Surface													
84.6	Organic Clayey Silt With Sand Trace Clay Very Dark Brown Firm		1	SS	8		85							0 79 17 4
83.1	Clayey Silt to Silty Clay Trace Sand Stiff to Very Stiff		2	SS	14		84							0 3 42 55
82.9			3	SS	23									
82.9			4	SS	76		83							
82.9			5	SS	80	/15cm	82							
82.9			6	SS	100	/15cm	81							
82.9			7	SS	100	/15cm	80							
79.2	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard						79							RQD 58%
78.8	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		8	BXL RC	REC 95%		78							
77.2			9	BXL RC	REC 87%		77							RQD 68%
76.2	End of Borehole • Artesian Condition with a Head of 1.5 m encountered within the Bedrock													

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4° 9' 69" 108.5; E 381° 168.0 ORIGINATED BY M.M.
DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY A.H.
DATUM Geodetic DATE 91/10/09 CHECKED BY B.I.

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
85.7	Ground Surface																		
0.0	Probable Organic Clayey Silt Very Soft																		
84.9																			
0.7	Probable Clayey Silt to Silty Clay Trace Sand																		
82.8																			
2.9	Probable Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)																		
81.7																			
4.0	End of Cone Test Probable Boulders																		

RECORD OF BOREHOLE No 8

1 OF 1 METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 081.5; E 381 175.5 ORIGINATED BY M.M.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger, BXL Rock Core COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/11 CHECKED BY B.I.

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		
88.6	Ground Surface													
0.0	Trace Organics													
	Clayey Silt to Silty Clay		1	SS	24		88						WL=53, WP=28, 53	18.5 0 5 44 51
	Trace Sand		2	SS	27		87							
	Very Stiff to Hard		3	SS	15		86						WL=46, WP=22, 46	19.7 0 3 43 54
	Brown Grey		4	SS	24		85							
			5	SS	120		84							
84.2			6	BXL RC	REC 15%		83							RQD 0%
4.4	Sand and Gravel With Numerous Cobbles and Boulders		7	BXL RC	REC 31%		82							RQD 0%
			8	BXL RC	REC 18%		81							RQD 0%
80.1			9	BXL RC	REC 100%		80							RQD 0%
8.5	Bedrock Dolostone Slightly Weathered to Unweathered Medium Strong		10	BXL RC	REC 88%		79							RQD 62%
77.9							78							
10.7	End of Borehole													

RECORD OF BOREHOLE No 8A

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 086; E 381 178 ORIGINATED BY JB
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY JB
 DATUM Geodetic DATE 93/06/01 CHECKED BY BI

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		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	W _P W W _L		
87.6	Ground Surface											
0.0 87.1	Probable Organic Topsoil											
0.5	Probable Clayey Silt Trace Sand											
84.2												
3.4	End of Cone Test							100/28cm				

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 067.7; E 381 188.5 ORIGINATED BY A.H.
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE H.S. Auger COMPILED BY A.H.
 DATUM Geodetic DATE 91/10/11 CHECKED BY B.I.

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					
87.5	Ground Surface																
0.0																	
			1	SS	10												
			2	SS	29												0 4 46 50
			3	SS	23												
			4	SS	23												
			5	SS	34												
			6	SS	44												6 13 56 25
82.2																	
5.3	Sand and Gravel																
81.7	With Numerous Cobbles and Boulders																
5.8	End of Borehole																
	Coring was attempted, but a broken auger tooth blocked the hole to coring.																

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 117; E 381 153 ORIGINATED BY JB
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY JB
 DATUM Geodetic DATE 93/06/01 CHECKED BY BI

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			SHEAR STRENGTH kPa	WATER CONTENT (%)					
86.5	Ground Surface													
0.0														
84.7	Probable Organics													
1.8														
	Probable Clayey Silt Trace Sand													
80.7														
5.8	End of Cone Test													

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

W.P. 610-90-01 LOCATION Co-ords: N 4 969 126; E 381 157 ORIGINATED BY JB
 DIST 9 HWY Goodin Ser Rd BOREHOLE TYPE Dynamic Cone COMPILED BY JB
 DATUM Geodetic DATE 93/06/01 CHECKED BY BJ

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			SHEAR STRENGTH kPa						
86.7	Ground Surface							20 40 60 80 100	20 40 60					
0.0	Probable Organics							86						
85.0								85						
1.7	Probable Clayey Silt Trace Sand							84						
								83						
								82						
80.7								81						
6.0	End of Cone Test													
														</

ROCK CORE DESCRIPTION

WP 610-90-01

Page 1 of 1

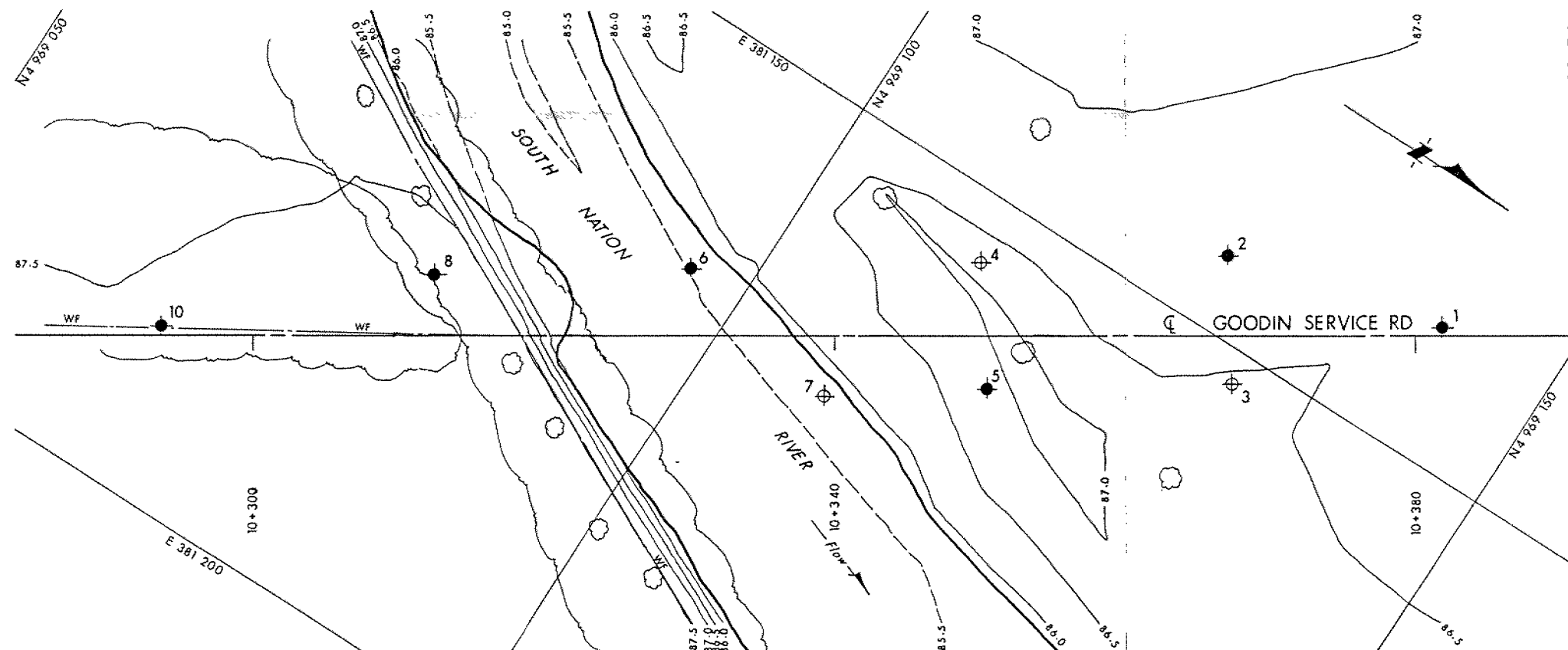
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	8	7.01-8.63	92	80	7.01-8.63	DOLOSTONE (with calcite-filled vugs in places), light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to close spaced, flat to near vertical, undulating to planar, smooth to rough.
5	9	6.61-7.98	93	83	6.61-7.98	DOLOSTONE (with calcite-filled vugs in places), light olive grey to light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, undulating, smooth.
6	8	6.76-8.28	95	58	6.76-9.81	DOLOSTONE (with calcite-filled vugs in places), light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to very close spaced, flat to near vertical, undulating, smooth to rough.
	9	8.28-9.81	87	68		
8	6	4.34-5.87	15	0	4.34-8.41	OVERBURDEN (boulder till).
	7	6.10-7.01	31	0	8.41-10.67	DOLOSTONE (with calcite-filled vugs in places), light olive grey to light grey to dark grey; fine to medium grained; medium strong; unweathered to slightly weathered (moderately weathered, 8.41-9.47 m); fractures moderately close to very close spaced, flat to near vertical, undulating, smooth.
	8	7.01-8.53	18	0		
	9	8.53-9.14	100	0		
	10	9.14-10.67	88	62		

*CR = CORE RECOVERY

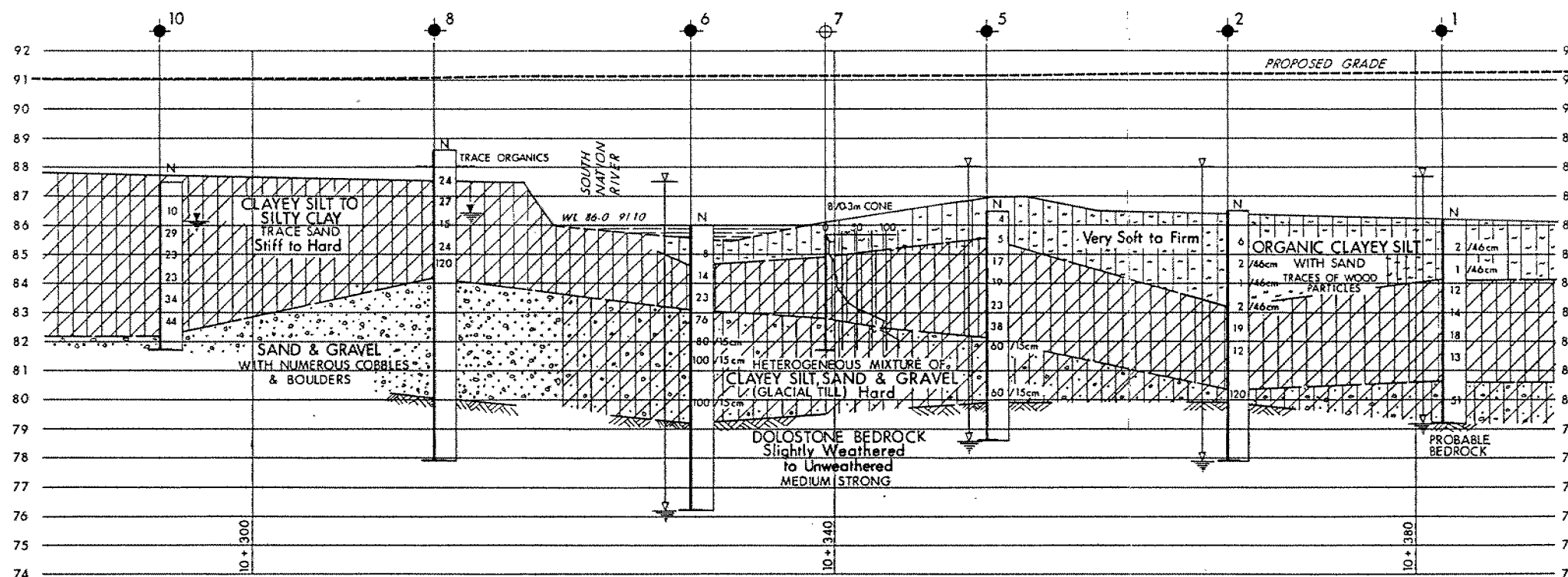
*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section



PLAN
SCALE
0 4m



PROFILE GOODIN SERVICE RD

SCALE
4m 0 4m Hor
2m 0 2m Vert

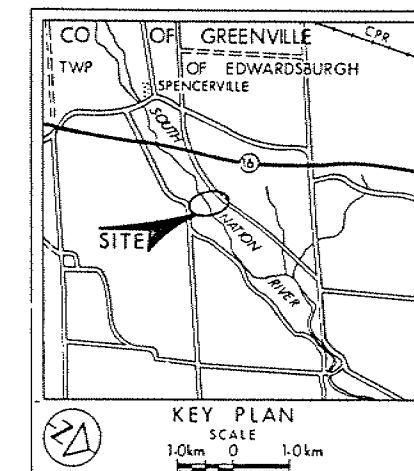
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 610-90-01

SOUTH NATION RIVER
CROSSING AT GOODIN SERVICE RD
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



KEY PLAN
SCALE
0 1.0km

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)
- WL at time of investigation 91 10
- ▽ Head
- ARTESIAN WATER
- Encountered

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	86.2	4 969 141.5	381 141.0
2	86.5	4 969 126.5	381 145.0
3	86.5	4 969 131.4	381 152.0
4	87.0	4 969 112.5	381 154.5
5	86.5	4 969 117.5	381 161.5
6	86.0	4 969 096.0	381 165.5
7	85.7	4 969 108.5	381 168.0
8	88.6	4 969 081.5	381 175.5
10	87.5	4 969 067.7	381 188.5

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.

REV.	DATE	BY	DESCRIPTION
1			

Geocres No 318-66

HWY No GOODIN SERVICE RD	DIST 9
SUBMD MM CHECKED	DATE 92 01 03
DRAWN DT CHECKED	APPROVED

SITE 16-322
DWG 2



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

DIST. No. 9
CONT No 93-75
WP No 610-90-01



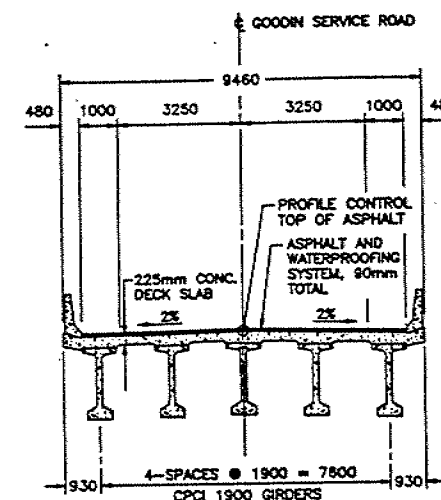
GOODIN SERVICE ROAD BRIDGE
GENERAL ARRANGEMENT

SHEET
39

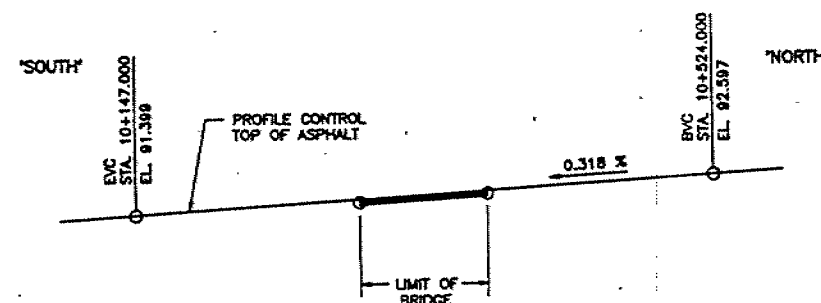
Wyllie & Ufnal
consulting engineers

GENERAL NOTES:

- CLASS OF CONCRETE:**
PRESTRESSED GIRDERS _____ 40 MPa
REMAINDER (UNLESS NOTED) _____ 30 MPa
- CLEAR COVER TO REINFORCING STEEL:**
FOOTINGS _____ 100 ± 25mm
ABUTMENTS & WINGWALLS:
FRONT FACE _____ 80 ± 20mm
BACK FACE _____ 70 ± 20mm
DECK:
TOP _____ 70 ± 20mm
BOTTOM _____ 40 ± 10mm
REMAINDER (UNLESS NOTED) _____ 70 ± 20mm
- REINFORCING STEEL:**
REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX C DENOTE COATED BARS.
- 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.
GRANULAR 'B' TYPE II, MAXIMUM GRAIN SIZE 75mm AND COMPACTED GRANULAR 'A' PAD SHALL BE PLACED UP TO THE BOTTOM OF FOOTING ELEVATION PRIOR DRIVING PILES.



1 : 100



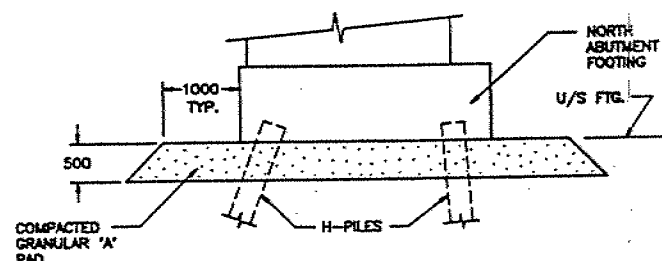
PROFILE OF GOODIN SERVICE ROAD
N. T. S.

LIST OF DRAWINGS

- GENERAL ARRANGEMENT
- BOREHOLE LOCATIONS & SOIL STRATA
- FOOTING LAYOUT AND REINFORCING
- ABUTMENT LAYOUT
- ABUTMENT REINFORCING
- PRESTRESSED GIRDERS
- DECK LAYOUT AND SCREED ELEV'S
- DECK REINFORCING
- JOINT ANCHORAGE AND ARMOURING
- BARRIER WALL WITHOUT RAILING
- 6000mm APPROACH SLAB
- STANDARD DETAILS
- QUANTITIES - STRUCTURE I
- QUANTITIES - STRUCTURE II

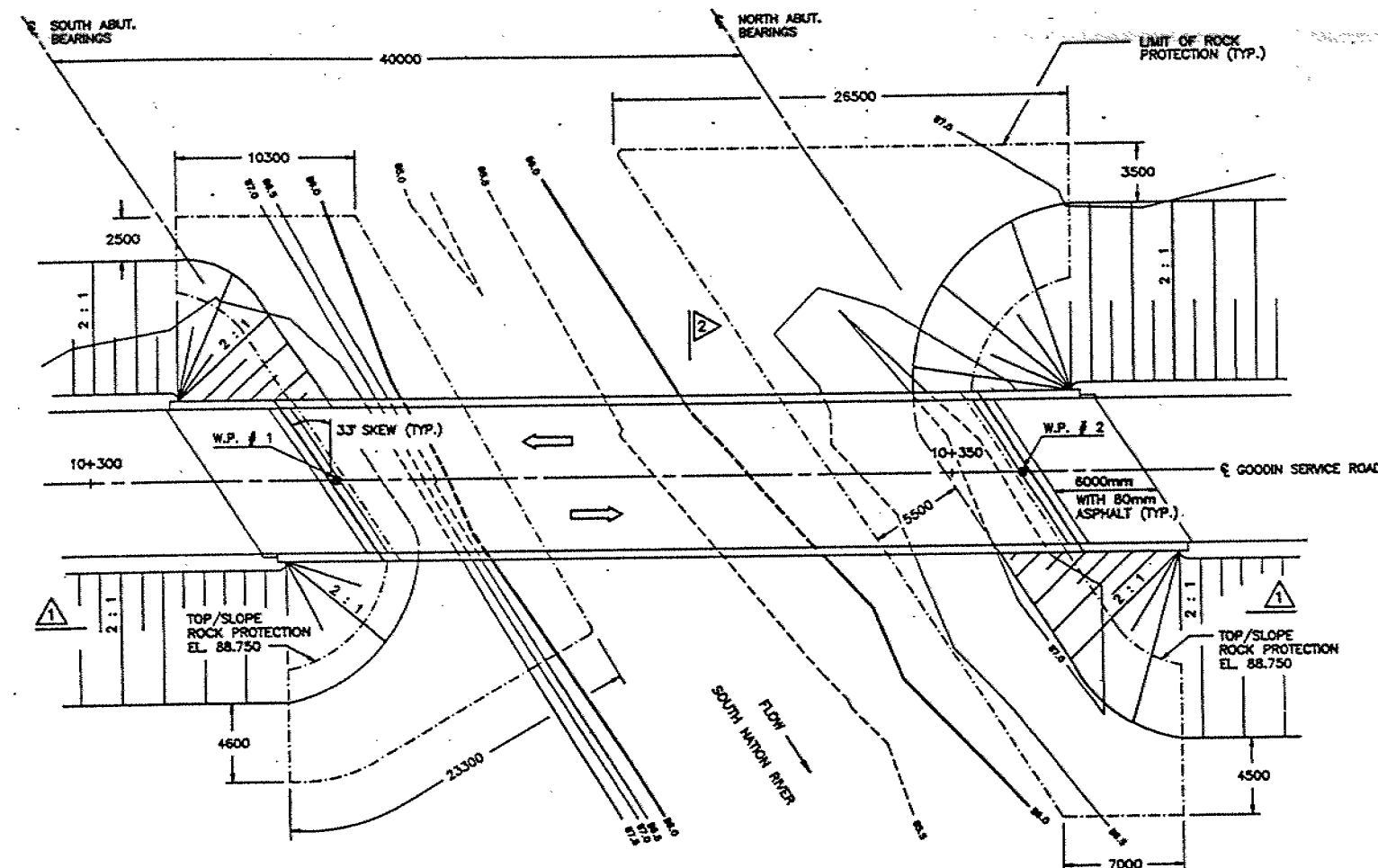
APPLICABLE STANDARD DWG.

OPSD-3501.00 GRANULAR BACKFILL REQUIREMENTS

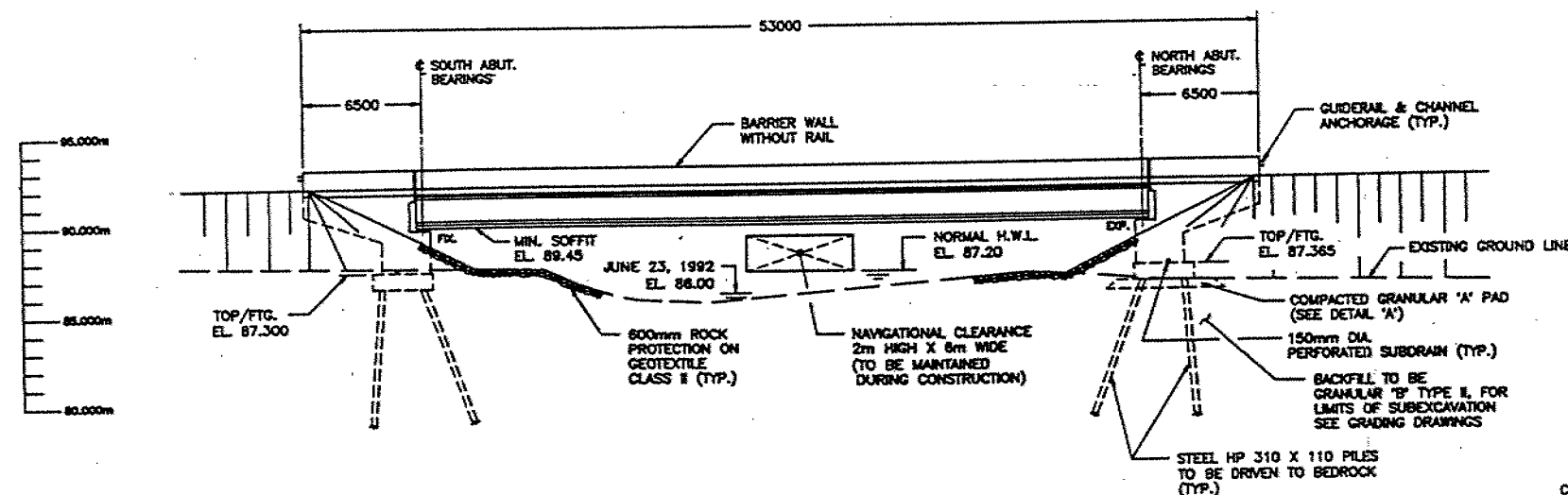


DETAIL 'A'
N. T. S.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



PLAN
1 : 200



1 : 200

BM ELEV. 91.844m

CEM 77U006
TABLET IN CONC. BASE FOR
GUIDERAIL ON S.W. SIDE OF
ROAD, AT E.W. END OF BRIDGE
CARRYING HWY. 16 OVER THE
SOUTH NATION RIVER
QUAD 44075 "SPENCERVILLE"

REVISION	DATE	BY	DESCRIPTION
DESIGN	ASW	CHK	MPW
DRAWN	RC	CHK	ASW
CODE	0480C-1003	LOAD CLASS	C1
DATE	SEPT. 1992	SCHEME	DWG. 1

NORTH FOR
CONSTRUCTION

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

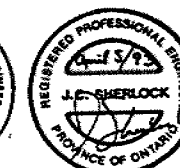
DIST. No. 9
CONT No 93-75
WP No 610-90-01



GOODIN SERVICE ROAD BRIDGE
FOOTING LAYOUT & REINFORCING

SHEET
41

Wyllie & Ufnal
consulting engineers



NOTES:

O.F. DENOTES OUTSIDE FACE
I.F. DENOTES INSIDE FACE
E.F. DENOTES EACH FACE
B. DENOTES BOTTOM
T. DENOTES TOP

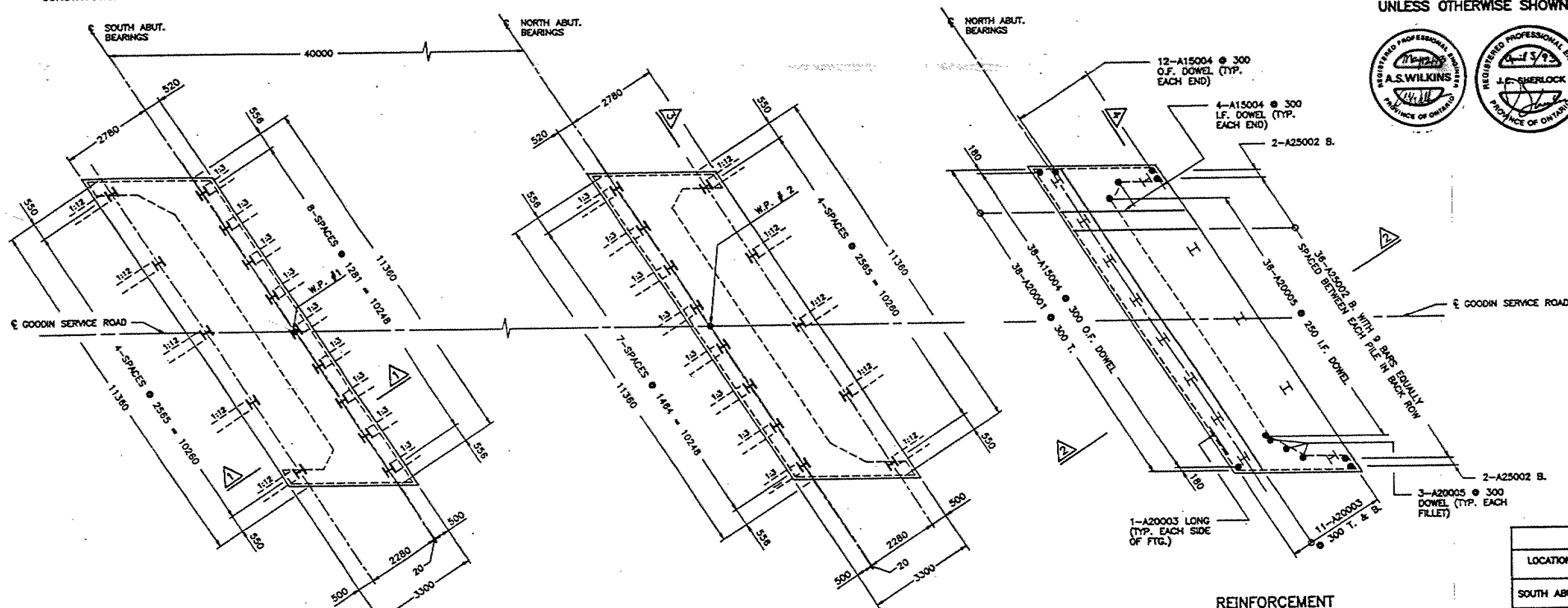
PILES NOTES:

- ALL PILES SHALL HAVE DRIVING SHOES
- PILES TO BE DRIVEN TO BEDROCK
- PILE SPACING IS MEASURED AT THE UNDERSIDE OF FOOTINGS

PILE DESIGN DATA		
LOCATION	MAXIMUM COMBINED FACTORED LOADS	
	U.L.S.	S.L.S. TYPE II
SOUTH ABUT.	1200 kN	850 kN
NORTH ABUT.	1600 kN	1150 kN

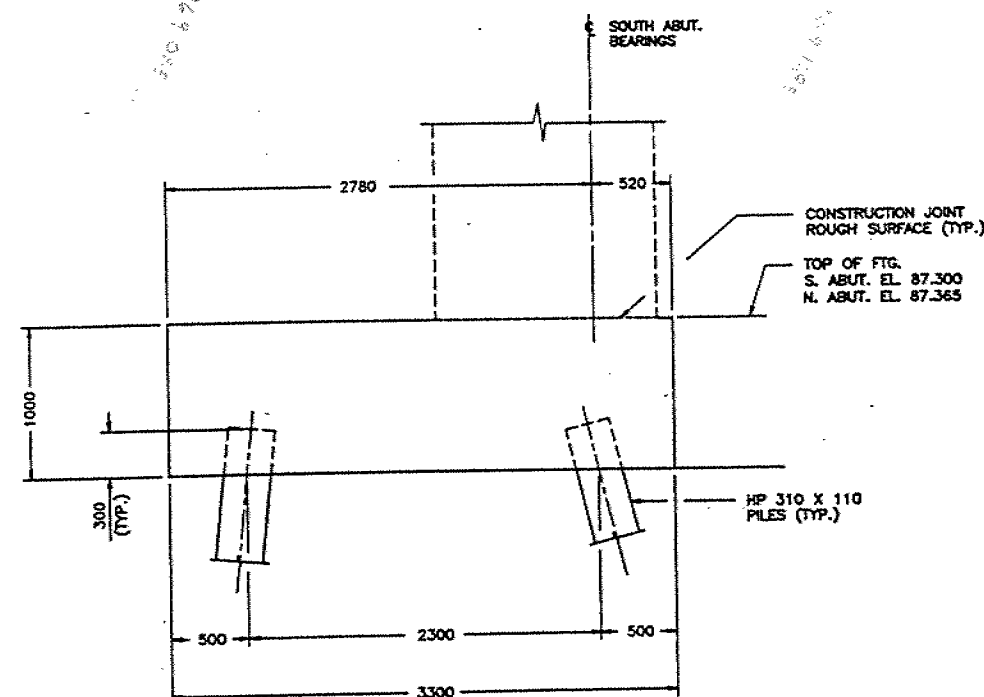
PILE DATA					
LOCATION	TYPE	No. REQ'D	BATTER	PILE CUT-OFF ELEVATION	LENGTH
SOUTH ABUT.	HP 310x110	9	1 : 3	88.600	7000
	HP 310x110	5	1 : 12	88.600	7000
NORTH ABUT.	HP 310x110	8	1 : 3	88.670	7500
	HP 310x110	5	1 : 12	88.670	7500

• PILE LENGTHS SHOWN IN TABLE ARE THE THEORETICAL LENGTH BELOW CUT-OFF

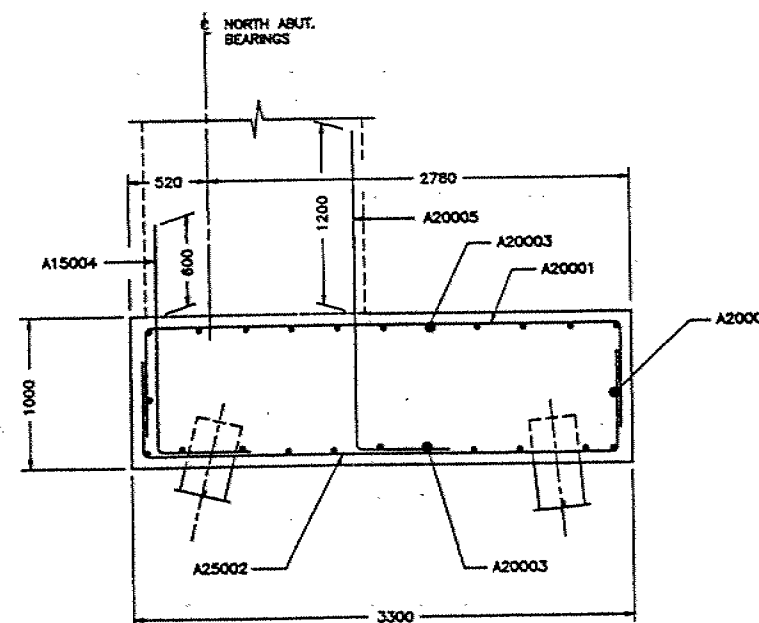


PILE LAYOUT PLAN
1 : 75

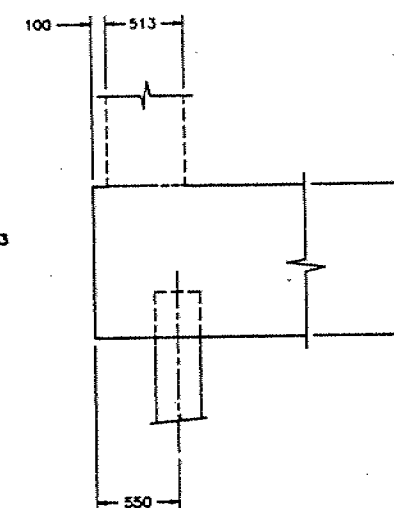
REINFORCEMENT PLAN - NORTH ABUTMENT
(REINFORCING SIMILAR FOR BOTH FOOTINGS)
1 : 75



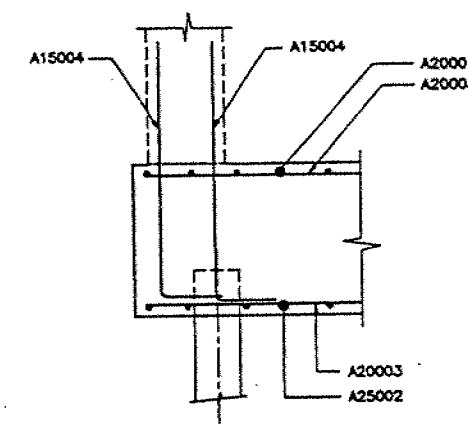
1
(LAYOUT SIMILAR FOR BOTH ABUT. FOOTINGS)
1 : 25



2
(REINFORCING SIMILAR FOR BOTH ABUT. FOOTINGS)
1 : 25



3
1 : 25



4
1 : 25

APPLICABLE STANDARD DWG.

OPSD-3301.00 SPLICE AND DRIVING SHOE DETAILS FOR STEEL "H" PILES

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION
DESIGN	ASW	CHK JS
DRAWN	IC	CHK ASW
SITE	16-322	STRUCT
SCHEME		DWG. 3

Gerald Edwards
Area Construction Engineer
Construction Office
Kingston, Ontario

August 18, 1993

FROM: Structural Section
Eastern Region - Kingston

RE: Contract 93-75, Goodin Service Road Bridge
Site 16-322
Hwy 416, District 9 - Ottawa

Contract drawings for the above project (Sheet 39) indicate a 500 mm thick compacted Granular "A" pad under the north abutment footing.

As discussed at the Pework Meeting, the following revisions are requested:

- 500 mm thick granular pad to be provided at the underside of both abutment footings;
- pad shall be constructed of 19 mm clear stone, rather than Granular "A";
- pad dimensions provided on Sheet 39 (Detail "A") to be used;
- 100 mm diameter subdrain, wrapped in geotextile, shall be placed around the perimeter of the pad and outlet to the ditch;
- pad shall be completely wrapped in geotextile;
- geotextile shall be cut with a 300 mm x 300 mm "X" at locations where piles will penetrate.

Please incorporate the above detail during construction.

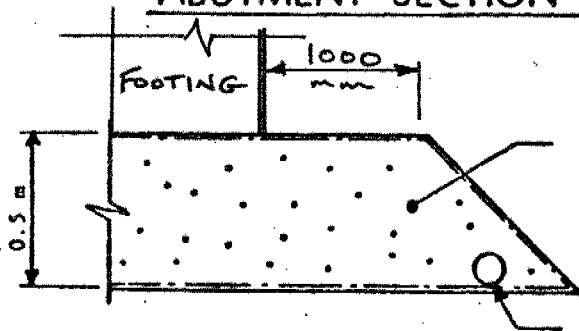


D.G. Sproule
Senior Structural Engineer

DGS/bd
attach.

c.c. B. Iyer ←

ABUTMENT SECTION (TYP)



19mm CLEAR STONE

Completely wrapped in
non-woven, Class I Geotextile*
75 μ m - 250 μ m E.O.S.

100 mm Perforated
Subdrain, wrapped in
Fabric around perimeter
of blanket and draining
to ditch

* OR CL-II,
NON-WOVEN, 75-150
MM FOS as
specified on
SHEET 1B.

FIGURE 'A' - DRAINAGE BLANKET DETAILS
FOR ABUTMENTS

NOTES:

1. The drainage blankets should be in place prior to pile driving
2. The geotextile should be cut with a 300 mm x 300 mm "x" at locations where piles will penetrate.
3. If blanket is disturbed during pile driving, the blanket should be restored to the details shown on this drawing after the completion of the pile driving

memorandum



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

Date: 1993 05 28

Attn: D.G. Sproule

From: Foundation Design Section
Room 315, Central Bldg.
Downsview

Re: Final Drawing Review
Highway 416, Goodin Service Rd. Bridge
W.P. 610-90-01
District 9, Ottawa

We are pleased to provide our comments on the final drawings (general arrangement, grading and piling drawings) for the above noted project as follows:

1. With regard to the typical sections on Sheet 18, we understand that a 0.75 m minimum berm will be introduced at the earth/rock fill interface of the typical section for the north embankment slopes. The approach fill slopes and south embankment slopes will be 2H:1V earth fill slopes as recommended in the foundation report.
2. In order to prevent loss of fines due to artesian conditions, a 500 mm thick pad should be provided at the underside of the pile cap at both abutment locations. It is recommended to employ the typical details shown in Figure A attached. This scheme has been used successfully in previous highway projects.

We understand that the above items will be included as contract addenda. Should there be any questions, please call our office.

A handwritten signature in black ink, appearing to read "D. Kwok", written over a horizontal line.

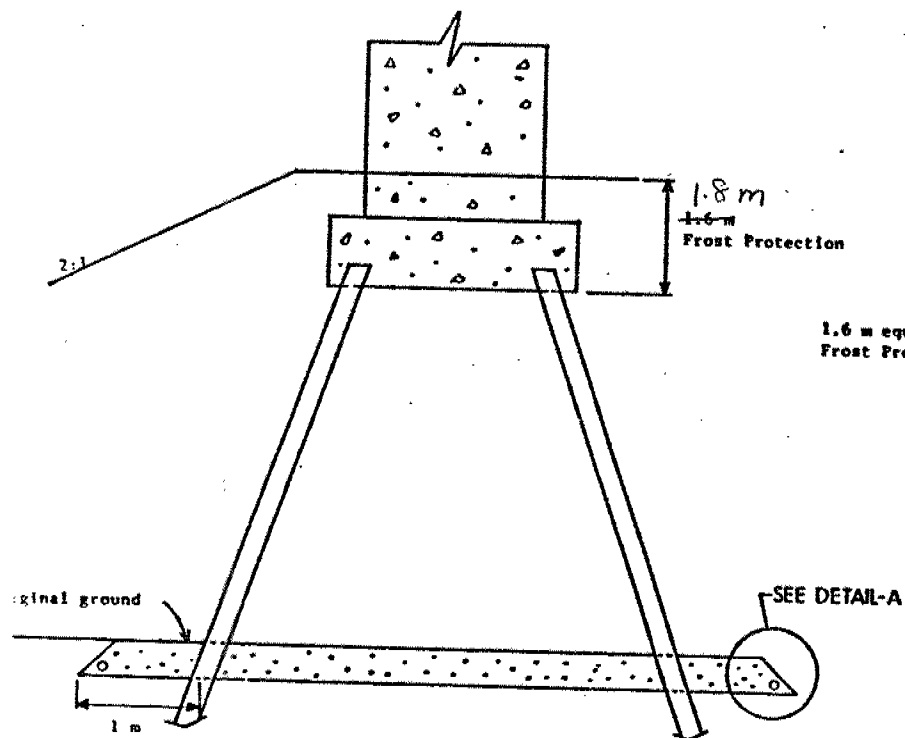
D. Kwok, P. Eng.
Project Foundation Eng.

for

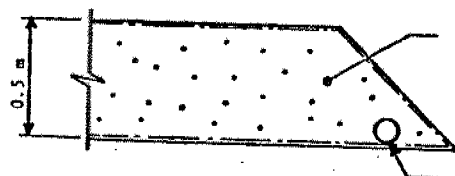
M. Devata, P. Eng.
Chief Foundation Eng.

MD/DK/jb

c.c. - D.J. Kimmett
(P. & D., Eastern Reg.)



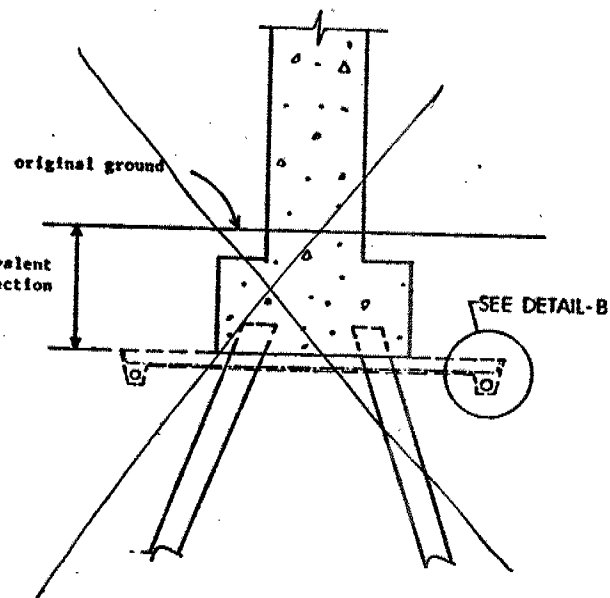
ABUTMENT SECTION (TYP)



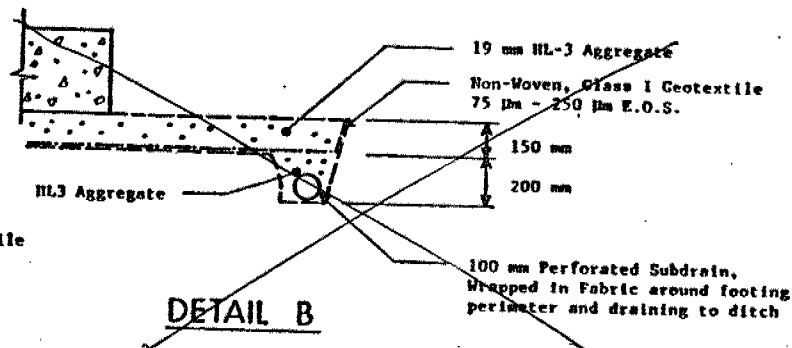
DETAIL A

19 mm HL-3 Aggregate
Completely wrapped in
non-woven, Class I Geotextile
75 μ m - 250 μ m E.O.S.

100 mm Perforated
Subdrain, wrapped in
Fabric around perimeter
of blanket and draining
to ditch



PIER SECTION (TYP)



DETAIL B

NOTES:

1. The drainage blankets should be in place prior to pile driving
2. The geotextile should be cut with a 300 mm x 300 mm "x" at locations where piles will penetrate. This is applicable only to the pier locations
3. If blanket at pier locations is disturbed during pile driving, the blanket should be restored to the details shown on this drawing after the completion of the pile driving

FIGURE 'A' - DRAINAGE BLANKET DETAILS
FOR ABUTMENTS & PIERS

MEMORANDUM



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

Attn: D.G. Sproule

From: Foundation Design Section
Room 315, Central Building

Subject: Approach Fill Slopes
Highway 416 - Goodin Service Road Bridge
W.P. 610-90-01
District 9, Ottawa

Date: May 5, 1993

This is in reply to your memo dated 1993 04 23.

The forward and transverse slope details recommended by us shall be used for a minimum of 30 m behind the abutment structure. Beyond this point, the slope geometry may be changed to suit that recommended by the Geotechnical Section.

Please call if you need further elaboration on this subject.

BI/jb

A handwritten signature in cursive script, appearing to read "B. Iyer", written over a horizontal line.

B. Iyer, P, Eng.
Sr. Foundation Engineer

FOX

(416) 235-5240

MEMORANDUM

Telephone: (613) 545-4793
Fax: (613) 545-4821

May 5, 1993

Mr. M. Devata, P. Eng.
Chief Foundation Engineer
Foundation Design Section
Engineering Materials Office
Downsview, Ontario

Att'n: Dr. B. Iyer

From: Structural Section
Eastern Region - Kingston

Re: W.P. 610-90-01. South Nation River Bridge
Highway 416, District 9 - Ottawa

As recently discussed, the Foundation Report specifies 2:1 forward/transverse approach fill slopes. You confirmed this configuration is applicable within 30 m of the structure. The Regional Geotechnical Section proposed earth fill at 2:1 overlying rock fill at 1.5:1 in the sub-excavated area (attached typical section). This configuration was inadvertently extended to the north wingwall limit (attached plan). The grading drawings and quantities have been prepared accordingly. The structure General Arrangement Drawing does not indicate the slope transition.

Please review and advise if the proposed configuration is acceptable for use within 30 m of the north abutment. Since the Executive Review is this Friday, your comments regarding the above would be appreciated as soon as possible.

Thank you.



D.G. Sproule, P. Eng.
Sr. Structural Engineer
Highway 416

DGS:bd

Encl.

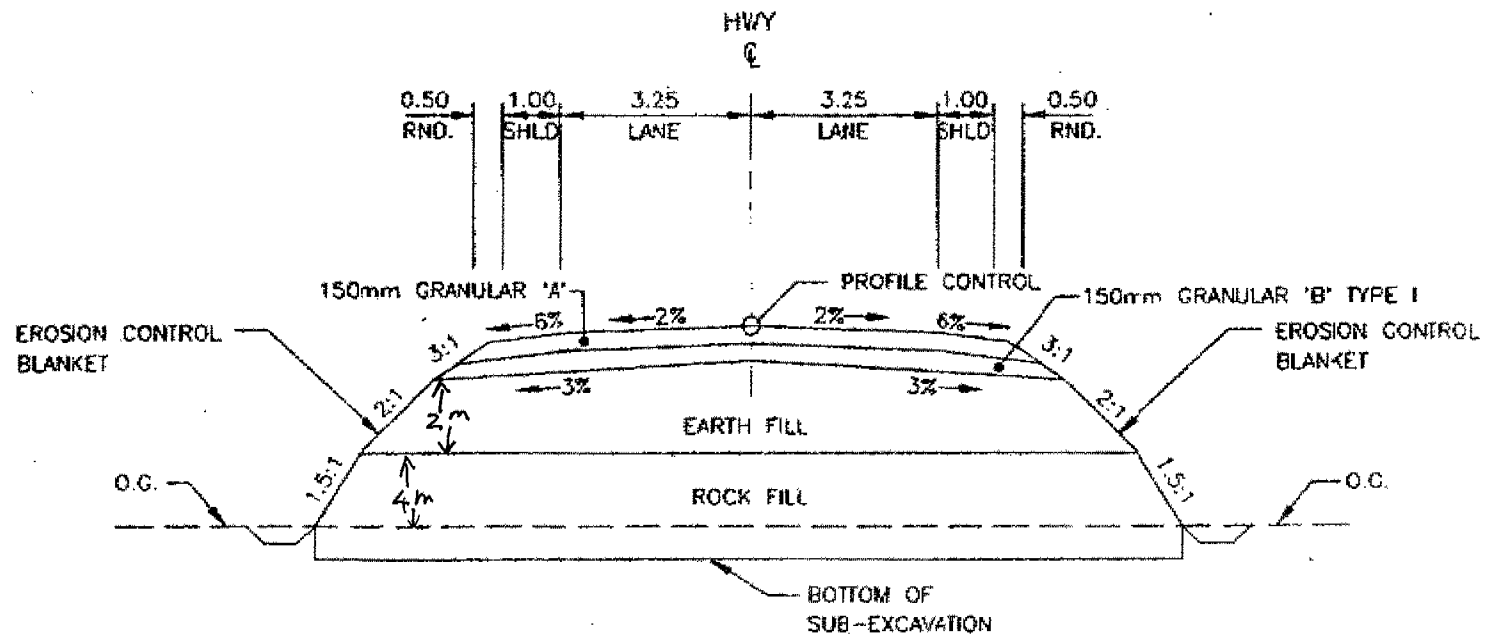
1993 05 07.

Danwyn not in. Talked to Oasi Islam.
Advised that the section proposed is
not acceptable in the approach fill area.
Danwyn/Eng? to follow up.

Baku

Pg 001 (3)

3-40-2
Ld

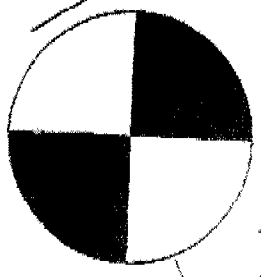


Earthfill $\gamma = 20$ $\phi = 30$ $c = 0$

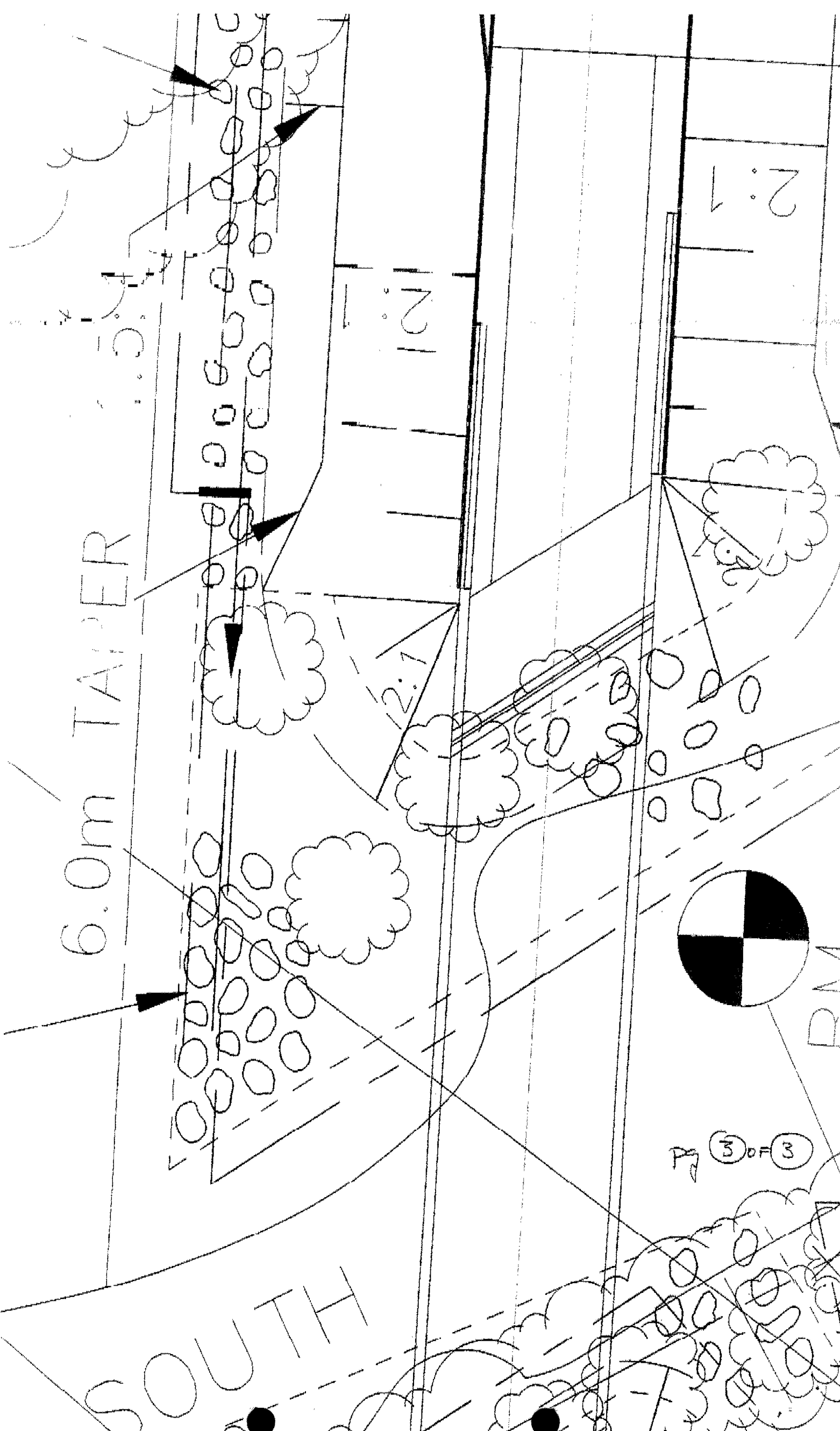
Rockfill $\gamma = 18$ $\phi = 35$ $c = 0$ SERVICE ROAD TYPICAL
TANGENT SECTION
STA 10+370 to STA 10+506

SOUTH

Pg 3 of 3



BNV



M E M O R A N D U M

(613) 545-4793

April 23rd, 1993

To: Mr. M. Devata, P.Eng.
Foundation Design Section
3rd Floor, Central Building,
1201 Wilson Ave., Downsview

Attn: Dr. B. Iyer, P.Eng.
Senior Foundation Engineer

From: Structural Section
Eastern Region, Kingston

Re: WP 610-90-01, Goodin Service Road Bridge,
Hwy 416, District 9 - Ottawa

Balu:

As discussed yesterday, the transverse north approach fill slopes consist of 2:1 earth fill over 1.5:1 rock fill. The rock fill is placed in the sub-excavated area and extends vertically to the 100 year high water level (see Typical Section Sheet 18).

Forward and transverse slopes of 2:1 were used at the north abutment. As indicated on Sheet 6, the 6m long transition from 2:1 to 1.5:1 commences at the end of the wing wall, just beyond the slope protection.

For your information the Granular B Type II is specified as uncompacted on Sheet 7 because it is placed in the water filled sub-excavation.

Please review and call me on Monday to discuss the above.



A handwritten signature in cursive script that reads "D.G. Sproule".

D.G. Sproule,
Senior Structural
Engineer, Hwy 416

MEMORANDUM



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

Date: March 18, 1993

From: Foundation Design Section
Room 315, Central Building

Subject: Preliminary G.A. Drawing Review
Highway 416 - Goodin Service Road Bridge
W.P. 610-90-01
District 9, Ottawa

We refer to your memorandum dated 93 03 05 and the preliminary general arrangement drawing attached therein for the above-noted structure, and have the following comments.

1. It is indicated in the drawing that the piles at the north abutment location are to be driven to bedrock. As mentioned before in our memorandum dated 93 02 15 (copy attached), piles at the south abutment may encounter refusal within the bouldery stratum above bedrock. It is envisaged that some piles can be driven to bedrock surface with strict construction control. However, if difficulties are encountered during construction in driving piles to bedrock, this matter should be referred to this office without delay. The G.A. drawing should contain notes to distinguish the different piling conditions for the two abutments.
2. Foundation investigation carried out at site has encountered artesian condition in some of the boreholes drilled into bedrock. Driving piles to bedrock may open up flow channels alongside the pile shafts. To prevent loss of fines, it is recommended to place a 500 mm thick pad at the underside of the pile cap comprised of compacted Granular 'A' material as a filter. The pad should be constructed prior to pile driving. The contractor should be alerted by means of an NSSP in the contract document or drawing notes.
3. All pile caps should have a minimum 1.8m earth cover for frost protection. The frost cover shown on the drawing does not appear to be adequate.
4. The piles should be provided with standard MTO tip reinforcement as per OPSD 3301.

A handwritten signature in black ink, appearing to be "D. Kwok", written over a horizontal line.

D. Kwok, P.Eng.
Project Foundation Engineer
for

B. Iyer, P. Eng.
Sr. Foundation Engineer

BI/hh
cc: I. Husain, Structural Office

memorandum



To: E.C. Lane
Head, Structural Section

Date: February 15, 1993

Attn: D. Sproule

From: Foundation Design Section
Room 315, Central Building

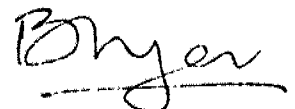
Subject: Foundation Recommendations
Hwy 416 - Goodin Service Road Bridge
District 9, Ottawa

From consideration of a single span structure at the reference site, we recommend that 310 x 110 steel H piles be used at both abutments.

1. At the south abutment, the piles may encounter refusal at the bedrock surface (El. 80 m +/-) or within the sand and gravel with numerous cobbles and boulders stratum (say at El. 83 m +/-). For estimating purposes, use an average tip El. of 81.5 m.
2. To account for the presence of cobbles and boulders in the stratum overlying bedrock which may impede the installation of piles to bedrock surface, especially at the south abutment location, the design capacities of 310 x 110 steel H piles shall be taken as follows:

factored ULS capacity	1200 kN
SLS Type II capacity	850 kN
3. At the north abutment, the piles will terminate on the bedrock surface, at about El. 79.5 m.
4. The piles should be provided with standard MTO tip reinforcement as per OPSD 3301.
5. All pile caps shall be provided with minimum 1.8 m earth cover for frost protection purposes.

Please call if you need further input from us on this project.

A handwritten signature in dark ink, appearing to read "Balu Iyer".

Balu Iyer, P.Eng.
Sr. Foundation Engineer

MEMORANDUM

Telephone: (613) 545-4793
Fax: (613) 545-4821

To: File March 4, 1993

From: Structural Section
Eastern Region - Kingston

Re: W.P. 610-90-01, Goodin Service Road
District 9 - Ottawa

Buried toe berm proposal of February 12th, 1993, was reviewed with B. Iyer, Sr. Foundation Engineer.

- proposed along forward edge of approach fill given close proximity to river. Optional along transverse limits.
- establishing berm along toe will facilitate subsequent excavation for north approach fill.
- could be completed in strips or as a continuous operation. Some granular placed may be excavated to ensure complete removal of organic clayey silt. Width of 3 m considered adequate to accommodate equipment.

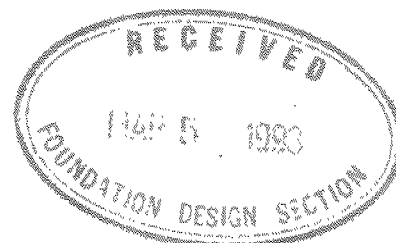
Toe berm is one method available to ensure the complete removal of the soft material within the limits prescribed. Other methods are acceptable (i.e. progressing from north bank with excavation/backfill operation). End result - operation must result in all organic clayey silt material being excavated and replaced to limits indicated.

ORIGINAL SIGNED BY:

D.G. Sproule, P. Eng.
Sr. Structural Engineer
Highway 416

DGS:bd

c.c. B. Iyer
T. Comfort
F. Pinder



memorandum



To: E.C. Lane
Head, Structural Section

Date: February 15, 1993

Attn: D. Sproule

From: Foundation Design Section
Room 315, Central Building

Subject: Foundation Recommendations
Hwy 416 - Goodin Service Road Bridge
District 9, Ottawa

From consideration of a single span structure at the reference site, we recommend that 310 x 110 steel H piles be used at both abutments.

1. At the south abutment, the piles may encounter refusal at the bedrock surface (El. 80 m +/-) or within the sand and gravel with numerous cobbles and boulders stratum (say at El. 83 m +/-). For estimating purposes, use an average tip El. of 81.5 m.
2. To account for the presence of cobbles and boulders in the stratum overlying bedrock which may impede the installation of piles to bedrock surface, especially at the south abutment location, the design capacities of 310 x 110 steel H piles shall be taken as follows:

factored ULS capacity	1200 kN
SLS Type II capacity	850 kN

3. At the north abutment, the piles will terminate on the bedrock surface, at about El. 79.5 m.
4. The piles should be provided with standard MTO tip reinforcement as per OPSD 3301.
5. All pile caps shall be provided with minimum 1.8 m earth cover for frost protection purposes.

Please call if you need further input from us on this project.

A handwritten signature in dark ink, appearing to read "B. Iyer", with a horizontal line underneath.

Balu Iyer, P.Eng.
Sr. Foundation Engineer

b:\6109001.memo

MEMORANDUM



To: S. Cheng
Head, Geotechnical Section
Eastern Region

Date: February 12, 1993

Att: F. Pinder

From: Foundation Design Section
Room 315, Central Building

Subject: Excavation for and Construction of Approach Fill
North Abutment
Goodin Service Rd. - South Nation River Crossing
W.P. 610-90-01/W.P. 526-91-00
District 9, Ottawa

This is in response to your memo dated 1993 02 09 regarding above subject.

The excavation details shown on figure 8 of the foundation report would generally apply for the north abutment. However, with the presently proposed single span design, the excavation would be in close proximity of the river. Therefore, the following additional comments are provided.

- i) Carry out the excavation preferably when the river water level is low.
- ii) Excavate and remove the organic soil at the toe of the approach fill in strips, simultaneously backfilling the excavated area with suitable granular fill.
- iii) Once a "buried toe berm" has been constructed as described above, carry out excavation and removal of the organic soil behind the "toe berm" and replace the same using suitable granular soil. The "toe berm" will be required in the forward direction and is optional in the transverse direction.

With the construction of the approach fill carried out as discussed above, very little, if any, of granular fill will be lost into the underlying native soil or due to lateral displacement of the foundation soil.

Please call if you need further assistance in this project.

A handwritten signature in cursive script, appearing to read "B. Iyer", with a horizontal line underneath.

B. Iyer, P. Eng.
Sr. Foundation Engineer

BI/hh
cc: T. Comfort, P&D Section
D. Sproule, Structural Section

memorandum



TO: B. Iyer
Sr. Foundation Engineer
Foundation Design Section
Downsview

DATE: February 9, 1993.

FROM: Geotechnical Section
Eastern Region

(613) 545-4864

RE: W.P. 526-91-00, Hwy. 416 Service Rd.
Str. Site 16-322
County Rd. 21 (Shanly Rd.) N'ly to
Goodin Rd., 1.3km,
District 9, Ottawa.

W.P. 600-90-01

Further to our discussions in January, I have attached a sketch illustrating the proposed excavation and fill treatment at the north abutment. The Foundation recommendations detailed in your report dated February 21, 1992, were adhered to, although some interpretation was required.

Would you please comment on the attached drawing. In particular, I draw your attention to the sub-excavation details in the vicinity of the north abutment and also to the structure and sub-excavation backfill.

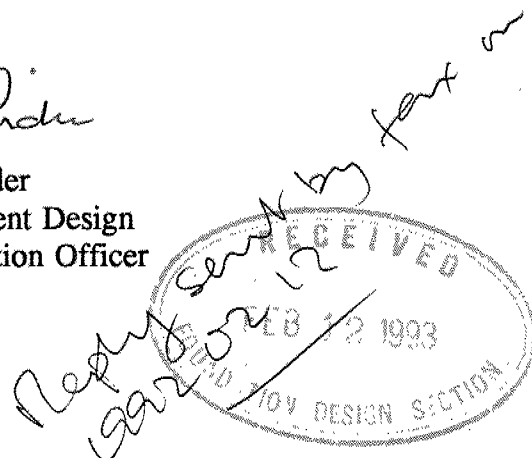
Also, would you please provide an estimate of the quantity of granular backfill that will be lost, if any, through the instantaneous compression of the underlying native soil (clayey silt to silty clay) or through lateral displacement into the softer over burden soil (organic clayey silt with sand). The only concern here is that a large enough quantity will be allowed for in the design.

Could you please expedite your review since this project is currently scheduled for 1993 award and Planning and Design is quite anxious.

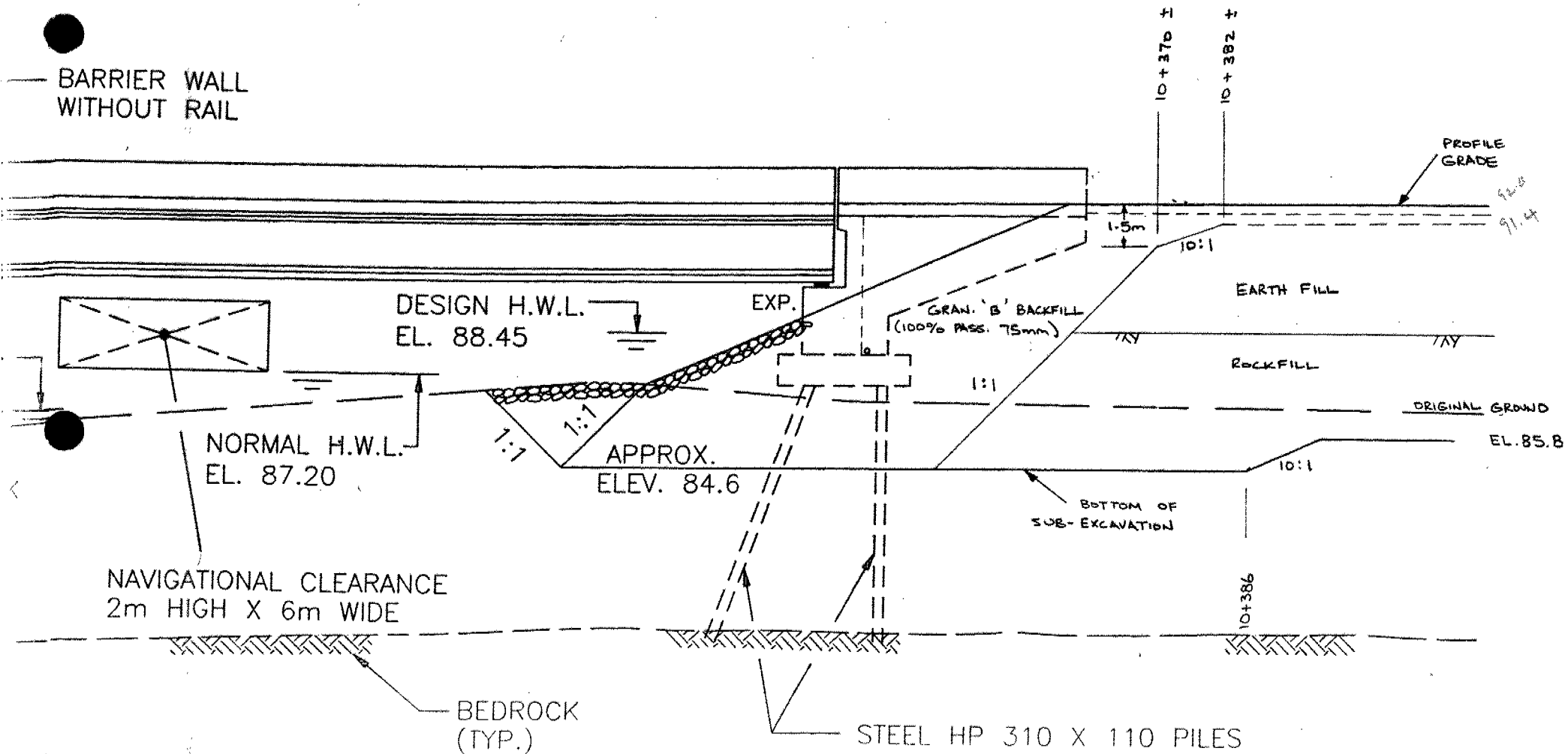
If you require more information, please contact our office.

cc: T. Comfort
D. Sproule

F. Pinder
F. Pinder
Pavement Design
Evaluation Officer



GOODIN / SHANLY SERVICE ROAD



MEMORANDUM

Telephone: (613) 545-4793
Fax: (613) 545-4821

Mr. M. Devata, P. Eng.
Chief Foundation Engineer
Foundation Design Section
Engineering Materials Office
Downsview, Ontario

November 25, 1992

Att'n: Mr. B. Iyer, P. Eng.

From: Structural Section
Eastern Region - Kingston

Re: W.P. 610-90-01, Goodin Service Road
Site 16-322, District 9 - Ottawa

The single span configuration for the above structure places the south abutment at Sta. 10+314. Our discussion, in response to my memo of September 30th, 1992, indicated that caissons would address scour, bearing capacity, dewatering and environmental issues. The single span configuration and type of structure had to be reviewed by the Structural Office before there was any point in pursuing details of the caisson alternative. The Preliminary Review Committee approved the General Arrangement Drawing, which indicated caissons at the south abutment, at their November 5th meeting. The issue of using caissons also for the north abutment was noted by the Committee.

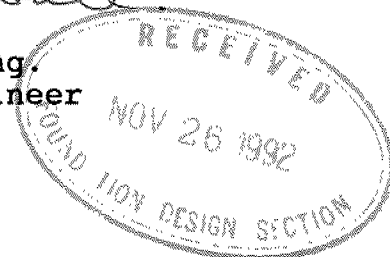
Additional foundation recommendations are required for the caisson design. We previously discussed the use of small diameter caissons with tremie given the artesian condition at the bedrock surface. Any additional information regarding the caisson detail (i.e. H-pile with tremie and liner extracted, tremie with liner left in place ... etc.) would be much appreciated.

The Regional Structural Section is supervising the detailed design of this structure. The superstructure design is proceeding and the above recommendations would be appreciated as soon as convenient. Please call if you require any additional information.

Dawn Sproule

D.G. Sproule, P. Eng.
Sr. Structural Engineer
Highway 416

DGS:bd



MEMORANDUM

Telephone: (613) 545-4793
Fax: (613) 545-4821

Mr. M. Devata, P. Eng.
Chief Foundation Engineer
Foundation Design Section
Engineering Materials Office
Downsview, Ontario

September 30, 1992

Att'n: Mr. B. Iyer, P. Eng.

From: Structural Section
Eastern Region - Kingston

Re: W.P. 610-90-01
Highway 416, District 9 - Ottawa
Goodin Service Road

The single span structure currently being designed at the above site locates the south abutment at Sta. 10+314. The Foundation Report and your subsequent letter of March 27th, 1992, recommended a spread footing at or above el. 86.0 with SLS and USL capacities of 200 and 400 KPa respectively. These capacities are relatively low and, although rock protection is proposed for the forward fills, there is concern for potential scour associated with a footing founded on a spread footing if not located 1.5 m below the river bed (OHBDC 1-7.3.3.2). Borehole No. 8 indicates that 1.5 m below the river bed coincides approximately with the top of the "Sand and Gravel - Numerous Cobbles and Boulders" stratum.

Foundation options which increase the bearing capacity while providing the required scour protection are of interest. Scour protection can be addressed either by lowering the footing or providing a scour resistant configuration/material (i.e. rockfill, sheet piling, H-piles, etc.).

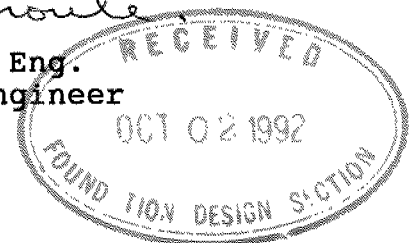
Additional considerations include: cost, constructability, environmental impact/approvals, etc. Attached find a "Preliminary" General Arrangement Drawing.

Please review the above and advise regarding available alternatives. Thank you.

Dawyn Sproule

D.G. Sproule, P. Eng.
Sr. Structural Engineer
Highway 416

DGS:bd



memorandum



To: D.G. Sproule
Structural Section
Eastern Region

Date: 1992 03 27

From: Foundation Design Section
Room 315, Central Building

Re: Goodin Service Road
South Nation River
W.P. 610-90-01
District 9, Ottawa

Construction of the south abutment may be carried out as shown on the sketch which accompanied your memo dated 1992 03 17, provided that

1. the footing is founded at or above El. 86.0 m., and
2. the footing is designed using an SLS type II capacity of 200 kPa and a factored ULS capacity of 400 kPa.

With the above conditions, the centreline of the south abutment bearings may be located at about Stn. 10+314. (see attached sketch)

Please call if you need further input on this project.

A handwritten signature in dark ink, appearing to read "B. Iyer", with a horizontal line drawn underneath it.

Dr. B. Iyer, P. Eng.
Sr. Foundation Engineer

BI/bi

8

10+31.0

10+314.0

10+31.0

TRACE ORG'S

CLAYEY SILT to
SILTY CLAY

SOUTH NATION RIVER

SAND & GRAVEL

HETEROGENEOUS Mixture of
CLAYEY SILT, SAND & GRAVEL
(GLACIAL TILL)

DOLOSTONE BEDROCK
SLIGHTLY WEATHERED
to UNWEATHERED

92 03 24

Re NRP 610-90-01

SOUTH NATION RIVER BRIDGE

Toe of forward
slope @ 320.5

ht. of fill = 91.4 - 86.0
~ 5.5 m.

@ 2:1 slope Hor \approx 11.0 m.
dist

Crest of slope @ 309.5

See attached sketch

of South abut.
barrings @ 314 - 314.5

PROVIDED

- Footing at El. 86. designed using
200 kPa / 400 kPa as per
Foundation Report.

memorandum



613-545-4821

To: D.G. Sproule
Structural Section
Eastern Region

From: Foundation Design Section
Room 315, Central Building
Downsview

Re: South Nation River Bridge
Hwy. 416 - Site 16-322
W.P. 610-90-01
District 9, Ottawa

Date: 1992 03 13

This is in reply to your memo dated 1992 03 04 regarding the above project.

From consideration of the stability of the forward slope, the south abutment should be moved to approximate Station 10+305. This would allow the construction of a 2H to 1V approach fill from above existing grade, with about 4 to 5 m wide berm to the crest of the existing slope to the river.

The north abutment may be located as shown or may be moved closer to the river, if so desired.

The design of abutment foundation shall be carried out using recommendations given in the foundation report.

From slope stability standpoint, it is considered that a 6 m high embankment may be constructed using 2H to 1V slopes, provided all organics encountered within the limits of the embankment fill are excavated and replaced by suitable fill as discussed in the foundation report.

Please contact us if you require further elaboration on items covered above.

A handwritten signature in dark ink, appearing to read "B. Iyer", written over a horizontal line.

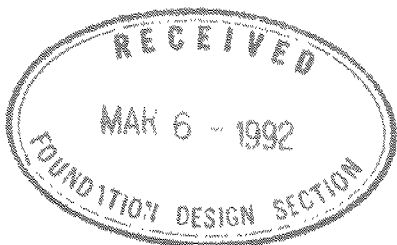
Dr. B. Iyer, P. Eng.
Sr. Foundation Engineer

BI/jb

MINISTRY OF TRANSPORTATION

F A X G R A M

MAIL



Structural Section
Eastern Region
355 Counter Street
Postal Bag 4000
Kingston, Ontario
K7L 5A3

Date: 92 03 04

TO: Dr. Balu Iyer, P.Eng.
Foundation Design Section,
3rd Floor, Central Building, Downsview.

FAX NO. 416-235-5240

FROM: D.G. Sproule, P. Eng.
Senior Structural Engineer

FAX NO. 613-545-4821 TELEPHONE NO. 613-545-4793

Re: WP 610-90-01, Site 16-322, S. Nation River Bridge
Hwy 416, District 9 - Ottawa

Balu:

As discussed yesterday, a single span (38.5m) structure has been adopted at the above site, rather than the three span structure originally proposed. However, two (2) single span options are available (see attached sketch):

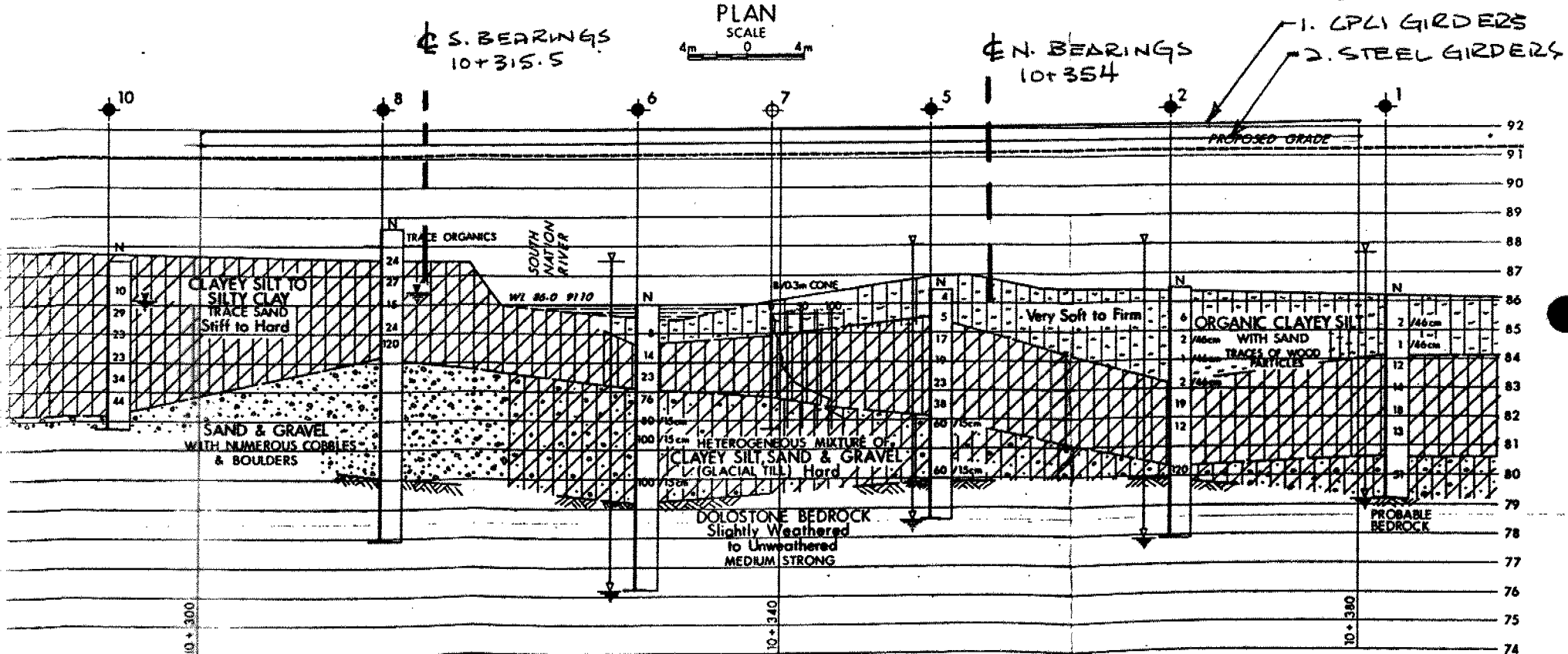
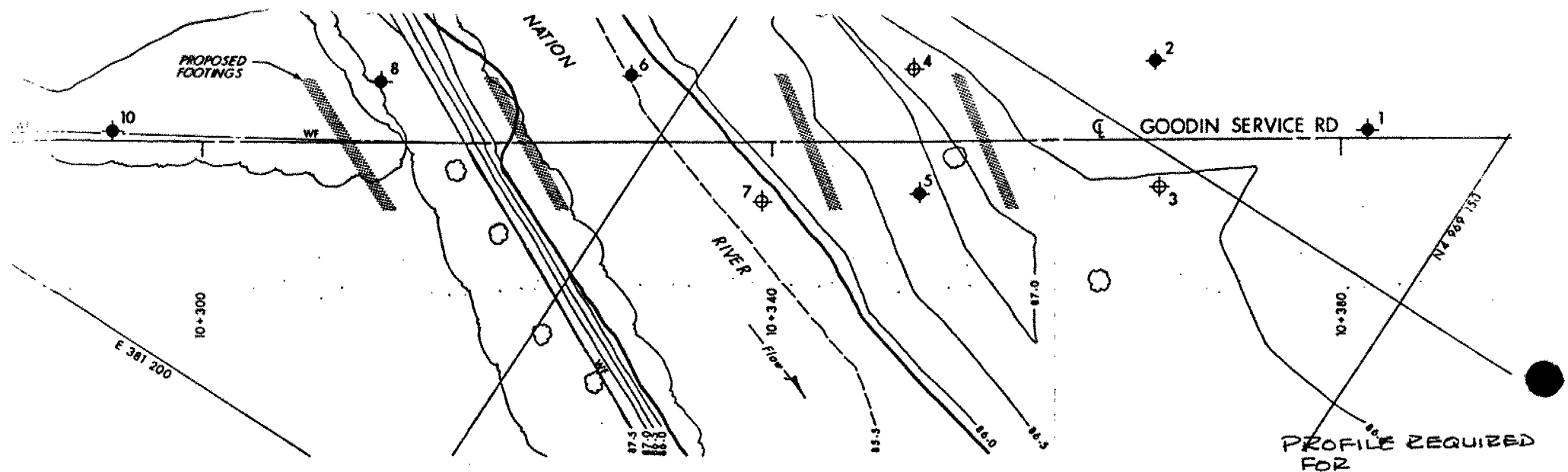
- steel girders, which result in the profile being raised to El. 91.6m and fill heights of 3.8m and 5.6m at the south and north approaches respectively.

- CPCI girders, which result in the profile being raised to El. 92.0m and fill heights of 4.2m and 6.0m at the south and north approaches respectively.

Fill heights for the steel option basically correspond to those indicated in the Foundation Report for 2:1 approach fill slopes. However, would the increase to 6.0m at the north approach for the CPCI option alter your recommendations for the slopes/berms? Your preliminary comments regarding ~~regarding~~ the above are required to complete the structural planning. Full details will be submitted at a future date for final recommendations.

Please advise accordingly. Thank you.

Darwyn Sproule.
Darwyn Sproule



6 PROFILE GOODIN SERVICE RD

memorandum



To: S. Cheng
Head, Geotechnical Section
Eastern Region

Date: 92/01/06

Att: F. Pinter
Geotechnical Engineer

Frm: Foundation Design section
315 Central Building, Downsview

Re: W.P. 610-90-01
Goodin Service Rd approach fill to South Nation River

As per our discussion on Dec. 18/91 I am forwarding along with this memo our final borehole log sheets for the field investigation we completed for the bridge crossing of the South Nation River. North of the South Nation River our field investigation extended only to Sta. 10+382 approximately for which we can only comment on. In this area we encountered the topsoil to contain organics. Atterberg Limit Tests together with Organic Content tests seem to confirm our initial field description of this material. Our concern with this material is with increased settlements if it is not removed beneath the approach embankments. Thus we recommend its entire removal beneath the approach embankments, which according to our field investigation would be 3.3m to 2.1 m deep, or at what ever depth it is found upon its removal in the vicinity of the abutments.

As to answering your second question concerning the use of "Suitable" embankment material our only concern is with erosion protection of the embankment fill. Any standard fill material is suitable as long an erosion protection scheme is implemented. The type of erosion protection necessary depends on the type of fill material chosen.

(*) - TALK TO FRANK - PINTER
ON MARCH 10
- WANTED TO KNOW WHAT
TYPE OF FILL HE CAN USE
ON NORTH - ORGANICS, REMOVED REPLACEMENT
- SPECIFIED ANY GRAN. A'B', ROCKCRETE
THAT HAS NO CLAY CAN BE USED
AS LONG AS NON-COHESIVE

M. Michalek
Jr. Foundation Engineer

For:

Dr. B. Iyer, P. Eng.
Sr. Foundation
Engineer

SEND
TO

B. Iyer, Senior Foundation Engineer
 Attn: M. Michalek, Junior Foundation Engineer
 Rm. 315, Central Bldg.



FROM

F. Pinter

DEPT.

Eastern Region Geotechnical

DATE

Dec. 18, /91.

SUBJECT

W.P. 610-90-01, (Goodin) Service Rd. Approach Fills to South Nation River Str.

As per our discussion today, I would be interested in receiving / reviewing your borehole information for the approach fills, to supplement our own info.

We have 16 shallow boreholes between STA. 10+225 and STA. 10+550 which indicate (generally) 350mm of Sandy Topsoil over varying depths of silty sand (SM) and /or clayey silt, some sand. Laboratory testing for organics is still pending, but our field notes do not note any.

Also, I would like clarification of Section 3) of

REPLY your "preliminary comments" dated Nov. 14 /91.

1. excavation of organic silty sand - to what depth?
2. use of "suitable" embankment material. what did you have in mind? I thought granular backfill or rock to the high waterline would be appropriate.

We would like to continue your recommended treatment for uniformity if applicable.

Thanks, Frank. 545-4864

REPLY FROM

erosion / protect only

REPLY DATE

memorandum



235-3731

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

Date: 1991 11 14

From: Foundation Design Section
Room 315, Central Building

Attn: Dan Greene (Sarah Clark)
Structural Engineer

Subject: Goodin Service Road/
South Nation River Crossing
W.P. 610-90-01, Site No. 16-322
District 9, Ottawa

This memorandum summarizes the results of a foundation investigation conducted at the aforementioned site and provides preliminary comments pertaining to the structure foundation and related earth works. These comments have been submitted in advance of the final report to assist in expediting the design so that conformance to project scheduling can be met. The final report will be submitted in the near future.

PROPOSED STRUCTURE

It is proposed to construct a two lane three span structure to carry a proposed new Service Road over the South Nation River. The new road links Shanly Road with the Goodin Service Road located in the Municipal Township of Edwardsburgh, Region of Leeds and Grenville. Approach fills in the order of magnitude of 5.5 m and 3.8 m to the north and south respectively. The proposed structure calls for the top of pavement to be at an approximate elevation of 91.4 to 91.8 m with a grade of +1.053%.

SITE DESCRIPTION

The site is located approximately 1 km east of Hwy. 16 between Shanly Road and Goodin Service Road. The small village of spencerville is located several kilometers west. The topography consists of farmers fields, cattle pastures and residential homes. The terrain is generally flat to gently rolling with short wild grasslands and randomly placed trees. The topography slopes upward to the north of the South Nation River and has a steep embankment approximately 2 m high to the south. The natural ground elevation varied from 88.6 m to the south to 86 m to the north.

.../2

Physiographically, the terrain belongs to the Region known as the "Edwardsburg Sand Plain". The topography of the sand plain is mostly level or gently undulating, although hummocks and ridges appear in places. In all probability, the sand was deposited by the melting glacier as kames, and subsequently spread about by the waves of the Champlain Sea. The bedrock in the area is of a Gull River Formation of the middle ordovician period. It consists of silty dolostone with interbedded dolomitic shale layers.

INVESTIGATION PROCEDURES

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

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 91 10 09 to 91 10 12 and consisted of a total of six sampled boreholes which were advanced to depths up to 10.7 m below nature ground surface. Two boreholes were advanced at the approach embankments with four holes at abutment and pier locations. Three cone penetration tests were also conducted at the pier and abutment locations.

Two boreholes are located south of the South Nation River at elevations of 87.5 m and 88.6 m with the remaining four and two cone tests located north at elevations ranging from 85.7 m to 86.5 m.

The boreholes were advanced using conventional hollow stem augering techniques. Two track mounted continuous flight auger drill rigs were employed for the operation. Conventional rock coring methods were applied in retrieving rock core samples using BXL core barrels with BW casing. In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 6 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved by A split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586).

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

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

Survey information related to the location and elevations of boreholes was provided by the Eastern Region Surveys and Plans.

SUBSURFACE CONDITIONS

General

The subsoil stratigraphy at the site to the north of the South Nation River consisted of 3-1.37 m of a silty sand, trace clay, trace gravel with organics (peat like). Wood particles were encountered particularly at the north approach location. The 'N' values obtained from the Standard Penetration Test ranged from 1 to 8 blows/0.3 m indicating the material to have a very loose to loose consistency. Underlying this deposit is a 3.25 m to 1.5 m thick layer of clayey silt with 'N' values ranging from 12 to 38 blows/0.3 m but generally with values of 19 blows/0.3. This cohesive layer had a stiff to hard consistency and was more predominantly encountered at the north approach ramp location. Underlying the clayey silt deposit is a 4 m to 1 m clayey silt, glacial till with a higher percentage of gravel and sand than the previous layer. 'N' values ranged from 51 blows/0.3 m to >120 blows/0.3 m which had a hard consistency. Underlying the overburden described above is a dolomitic bedrock of medium strength, unweathered to slightly weathered. Elevation varied from depths of 6.5 to 7.1 m (elevations of 80 m to 79 m) (see Appendix, Table of Boreholes).

To the south of the South Nation River a clayey silt, trace sand deposit was encountered from the surface down to depths ranging 5.3 m to 3.7 m. This layer was similar to that found in the north. 'N' values were also of a better quality at the surface deposit than those of the north boreholes. Similar blow counts were encountered as those in the north clayey silt ranging from 19 blows/0.3 m to 44 blows/0.3 m. this indicates a very stiff to hard consistency. Underlying the deposit is a layer of boulders which has to be rock cored continuously to reach a solid bedrock. At the south abutment 4.5 m of boulders were encountered placing the bedrock at an elevation of 80 m. Thus the bedrock level remained relatively flat through out the site and of the same composition. Detailed descriptions of the rock are attached in the Appendix entitled "Rock Core Description".

GROUNDWATER CONDITIONS

Observations of the groundwater level was carried out by measuring the water level in open boreholes. An artesian condition was found to exist on the north bank of the South Nation River at the pier and north abutment locations with a pressure head of approximately 1.5 m. This artesian condition is only encountered upon intersecting the bedrock surface. If the artesian condition is avoided by not penetrating the bedrock water table elevations appear to coincide with the elevation of the South Nation River at 85.7 m.

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

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a three span overpass structure that will carry the proposed Service Road (unnamed) over the South Nation River), the width of the structure is 11.5 m comprised of two lanes of traffic with adjoining shoulders.

The proposed profile grade of the bridge structure is approximately 91.7 m with the nature ground surface varying from 88.6 m to 86.5 m (south to north), consequently fills in the order of magnitude of 5.4 m and 3.8 m will be required.

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

- 1) Structure Foundation
- 2) Lateral Earth Pressure
- 3) Slope Stability
- 4) Construction Consideration

1) Structure Foundation

The surficial soils at the site are unsuitable for the support of conventional, shallow spread footings. Shallow spread footings could be implemented only at the abutment locations if the surficial 1.8 m to 3 m of very loose organics are removed and the footings are placed as high as possible perched within the fills, with a granular pad used to replace the excavated material for the footings to be founded on. This option may prove economically unsuitable and only available at the abutment locations. Consequently it is recommended that abutment and pier foundations be founded on end-bearing steel H-piles driven down to the bedrock. Fill material employed in this option should not exceed a Grain Size of 75 mm to prevent pile driving impediment. For purposes of the O.H.B.D.C., the steel H-piles can be designed using the axial capacities below.

Axial Capacity - Driven Steel H-Piles

Pile Type	Structure	Factored Capacity	Bearing Capacity	Estimated
		at U.L.S. (kN)	at S.L.S. (kN)	Pile Tips El. (m)
HP310x110	N.Abutment	1600	1150	79.5±
	S.Abutment	1600	1150	80±
	N.Pier	1600	1150	80±
	S.Pier	1600	1150	79±

Axial Capacity - Driven Steel H-Piles

<u>Pile Type</u>	<u>Structure</u>	Factored Capacity	Bearing Capacity	Estimated
		at U.L.S. (kN)	at S.L.S. (kN)	Pile Tips El. (m)
HP310x79	N.Abutment	1150	890	79.5±
	S.Abutment	1150	890	80±
	N.Pier	1150	890	80±
	S.Pier	1150	890	79±

*NOTE: A high presence of boulders may make it difficult to drive piles down to their desired depths at the south abutment location. Boulders were encountered at an elevation of 84 m.

The capacities pertain to vertical piles only and reductions to account for inclined loading shall conform to factors provided in Section 6.8.3.4.3 of the O.H.B.D.C.

In view of the presence of boulders at the bedrock surface, it is recommended that pile installations be carefully controlled and monitored employing the Hiley Dynamic Driving Formula in accordance with MTO Standards SS103-10 or SS103-11 and assuming an ultimate capacity as tabulated below.

Ultimate Capacity Employing
Hiley Dynamic Formula

<u>Pile Type</u>	<u>Ultimate Capacity (kN)</u>
HP310x110	3450
HP310x110	2670

To facilitate pile penetration through the clayey silt (Glacial Till) and boulders it is recommended that the steel H-piles be equipped with reinforced tips.

Pile spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. for centrally loaded piles equal load sharing of the deep foundation units can be assumed. The design of eccentric loaded deep foundation units shall comply with Section 6.8.3.4.2 of the O.H.B.D.C.

All pile caps shall be protected against frost protection by providing a minimum 1.8 earth cover or equivalent frost protection pile caps should be located as high as possible within the fills.

2) Lateral Earth Pressure on Structure

Free draining material such as Granular 'A' or Granular 'B' shall

be used within a wedge behind the abutments and retaining walls bounded by a plane rising at 60° to the horizontal as shown in Figure 6-9.6.1 of the O.H.B.D.C. The application of granular material combined with weep holes in the abutment walls to drain any accumulation of water in the backfill will prevent hydrostatic pressure build-up. Design parameters of the soil are given in the table below.

Backfill Properties

	<u>Gran. 'A'</u>	<u>Gran. 'B'</u>
Angle of Internal Friction (°)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2
*Coefficient of Active Earth Pressure (K _a)		
- SLS	0.27	0.33
- ULS	0.33	0.4
*Coefficient of Earth Pressure at Rest (K _o)		
- SLS	0.43	0.5
- ULS	0.5	0.58

* These earth pressure coefficients apply to horizontal backfill surfaces only. The appropriate consideration shall be given to account for sloping.

3) Slope Stability

Fill heights would be of the order of 3.8 m and 5.4 m at the south and north approaches. At the north approach, it is recommended that the surficial organic silty sand should be excavated and replaced by suitable embankment material fill. It is considered that both north and south approach embankments shall be constructed using a 2H:1V slope, along the forward and transverse directions.

All exposed slopes should be protected from erosional forces by providing an effective erosional control protection scheme. Settlements in the order of magnitude of 60 mm are anticipated due to elastic recompression of the native subsoil and settlements within the fills under its own weight.

4) Construction Considerations

Excavations to remove the surficial organic silty sand in the north abutment area may require the use of sheet piles driven into the lower clayey silt deposit.

FRANK
PINDER
54T-4862

Now
FAIR
BACK

Excavations is about 1.8 m depths would also be involved for the construction of the pile caps at the pier locations. Such excavations would extend below existing river level. It is therefore considered that sheet piles would be required at these locations also.

Fills placed at the abutment locations where pile driving will be involved shall consist of maximum particle sizes of not more than 75 mm.

In the construction of the embankment fills, all softened and/or organic material should be excavated for their full depth within the plan limits prior to fill placement.

Embankment fills should be placed and compacted as specified in OPSS 206.07.07 and OPSS 501 series.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Michalek, Foundation Engineering and A. Hilderbrand, Student Engineer, utilizing equipment owned and operated by Johnston Drilling Limited.

The project was carried out under the general supervision of B. Iyer, Senior Foundation Engineer. The report was written by M. Michalek, reviewed and approved by B. Iyer.

MARTIN MICHALEK

M. Michalek
Junior Foundation Engineer

for

B. Iyer, P.Eng.
Senior Foundation Engineer