

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 96-38



Ministry of
Transportation

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

EXPLANATION OF TERMS USED IN REPORT

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 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
P	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
Highway 403 and Shaver Road Underpass
W.P. 65-67-03, Site 36-259
Central Region

Introduction

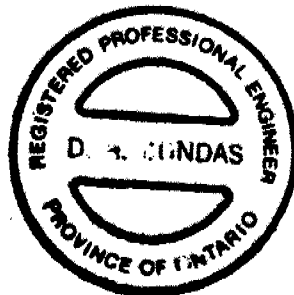
The attached report, dated October 1991, was prepared based on a different configuration for the structure. In May 1995, three additional borings were advanced (BH's 100, 101 and 108) to obtain information required for the present design. The new boreholes are appended and shown in plan and in cross section on Drawing No. 2, Sheet 397, of the Contract Drawings. The borehole data from BH's 100, 101 and 108 has not been incorporated into the text component of the Foundation Investigation Report.

Miscellaneous

The fieldwork for the foundation investigation carried out in July 1991 was supervised by T. Sangiuliano, Foundation Engineer and L. Dametto, Engineering Student. The drilling equipment was owned and operated by Atcost Soil Drilling Limited. Rock core identification and logging was carried out by D. Williams, Petrographer, Soils & Aggregates Section.

The subsequent fieldwork was conducted in May 1995 under the supervision of K. Ahmad, Foundation Engineer and Deanna Brooker, Engineering Student, utilizing drilling equipment owned and operated by K & S Drilling.

The attached report was prepared by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



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

FOUNDATION INVESTIGATION REPORT
For
Hwy. 403 and Shaver Road Underpass
W.P. 65-67-03, Site 36-259
District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the abovementioned site.

This structure

is a component of the proposed Hwy. 403 roadway between Ancaster and Brantford.

SITE DESCRIPTION AND GEOLOGY

The site is located at the existing Shaver Road between Hwy. 2 and Jerseyville Road in the Town of Ancaster, Regional Municipality of Hamilton-Wentworth. The site is approximately at mid-distance (0.5 km) between Hwy. 2 and Jerseyville Road, and is located approximately 3 km east of Hwy. 52.

The existing Shaver Road is a two lane asphaltic roadway supported by a shallow embankment approximately 1 metre in height at the site location. The embankment is elevated above the surrounding area. The site is located in a valley and is situated at the toe of a slope present at the northern limits of the site. A gradual rise in grade occurs southwardly towards Hwy. 2.

Rolling terrain predominates the general site area. On the east side of the existing Shaver Road, wetlands consisting of cattails and marshland vegetation extends from the roadway for a distance of approximately 50 metres. Sparse large trees are also present within this area. Beyond this distance, tall dense coniferous and deciduous trees exist. On the west side of the site, and also beyond the site limits, residential homes are present.

Physiographically, the site is located within the geological domain known as the Haldimand clay plain. The Haldimand clay plain occupies the area lying between the Niagara Escarpment and Lake Erie. The entire area was submerged in Lake

Warren, a glacial lake formed during the retreat of the Wisconsin glacialiation (approximately 12,000 years ago). Lacustrine clays and silts were deposited as the lake gradually receded due to the deposition of sediments during isostatic land rebound. The lacustrine clays and silts are overlain by deltaic sandy silts deposited as a result of a great discharge of meltwater between the ice front and the moraines creating the delta from west to east as the glacier withdrew.

Drainage of this belt is controlled by the Grand River which has cut a deep valley in the clay and silt. Consequently, there has been much dissection by tributary drainage.

The underlying bedrock at the site consists of weak to medium strong dolostones of the Paleozoic era. At the site, the overburden has a thickness of approximately 27 to 28 metres.

INVESTIGATION PROCEDURES

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

Field Investigation

The fieldwork for this project was carried out under two separate stages. The initial stage, was implemented between 76 02 25-26 inclusive and consisted of one sampled borehole (BH 10, formerly BH 14) advanced to a depth of 24.8 metres and one dynamic cone penetration test advanced to a depth of 15.2 m. This initial first stage provided information to facilitate the planning and design of the proposed Hwy. 403 route between the cities of Ancaster and Brantford.

The second stage of the fieldwork was carried out between 91 06 27 and 91 07 05 inclusive and consisted of a total of six (6) sampled boreholes reflecting the greater extent of this subsequent fieldwork.

The scope of the subsequent field investigation was to provide detailed soils/rock data to facilitate the design and construction of the proposed structure and related earthworks. Four (4) boreholes accompanied by two (2) dynamic cone penetration tests were advanced at the proposed abutment structure foundation locations and a total of two (2) boreholes were advanced at the proposed approach fills east and west of the structure. The boreholes at the structure locations were advanced to depths ranging from 27.9 m to 30 m whilst the dynamic cone penetration tests were driven to depths ranging from 7.6 m to 10.4 m. The approach fill boreholes were advanced to depths of 12.6 m.

The boreholes were advanced through the overburden using track mounted boring units employing conventional continuous flight hollow stem augering techniques and also casing/washboring techniques. Conventional rock coring techniques were used to retrieve up 3 m of rock core.

In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 4.6 m and at 1.5 m intervals beyond this surficial depth to approximately 15 m depth. Subsoil samples were retrieved at 3 m intervals below the 15 m depth. Subsoil samples were taken at 1.5 m intervals only at the approach locations.

Subsoil samples were generally retrieved in accordance with the Standard Penetration Test (ASTM D 1586) and hence were disturbed during the testing. All subsoil samples were identified in the field and then properly sealed to preserve natural moisture contents. Disturbed samples were placed in plastic containers and then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests conducted, as described in the subsequent section of this report.

Rock core samples were also identified in the field and rock recoveries and Rock Quality Designations (RQD) measured. The rock cores were then transported to the laboratory in conventional core boxes and detailed rock core logs were produced by an in-house geologist.

In situ vane tests were also carried out to determine the undrained shear strength of the weaker cohesive soils at the site. The test was carried out in accordance with ASTM D 2573 using the Standard MTO 'N' vane. Remoulded shear strengths were also obtained where applicable.

Groundwater levels were obtained by measuring the levels in the open boreholes throughout the duration of the field investigation. All open boreholes were backfilled at the completion of the fieldwork.

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

Laboratory Analyses

To determine the pertinent physical properties of the soil, various laboratory tests were conducted. The tests included:

- 1) Natural Moisture Content
- 2) Atterberg Limits
- 3) Grain Size Analysis

Laboratory test results are shown on the borehole logs and corresponding figures attached in the Appendix. These results have been summarized in the subsequent section of this report entitled 'Subsurface Conditions'.

SUBSURFACE CONDITIONS

General

The ground surface elevation at the boreholes at the site ranged from 230.7 m to 234.2 m. The subsurface conditions across the site are generally uniform and consists of an extensive surficial deposit comprised of a cohesionless sandy silt to silt with random layers of clayey silt to silty clay. The deposit has a thickness in the order of 18.3 m. The sandy silt to silt material generally has a denseness ranging from loose to dense with random very loose and very dense zones. The interbedded clayey silt layers, which range in thickness up to 300 mm are generally very stiff in consistency.

The surficial cohesionless deposit is underlain by a cohesive clayey silt stratum that contains layers of silt. This deposit extends to the bedrock surface and has a thickness in the order of 9 m. The clayey silt is generally

of very stiff consistency and the silt layers ranging in thickness up to 300 mm have a compact denseness.

The overburden is underlain by bedrock of the Amabel Formation and consists of dolostone. The bedrock surface is relatively flat and at an elevation ranging from 204.3 m to 205.1 m.

A plan of the site illustrating the locations and elevations of the boreholes is shown on Dwg. No. 656703-A*. Subsoil stratigraphical sections illustrating the subsurface conditions at the site are also provided. The boundaries between the various soil types in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical sections and also on the individual Record of Borehole sheets in the Appendix.

Sandy Silt to Silt with random layers of Clayey Silt to Silty Clay

The surficial native deposit at the site consists of an extensive cohesionless sandy silt to silt with random layers of cohesive clayey silt to silty clay. Traces of black organics are also present within the surficial 1 to 1.5 m with greater concentrations present east of the existing Shaver Road where wetter conditions prevail. This deposit extends from the ground surface to depths in the order of 18.3 m. The deposit is oxidized and therefore brown in colour for the surficial 1.5 m to 3 m and unoxidized and hence grey in colour below these depths.

A grain size distribution envelope illustrating the gradation of this deposit is shown on Figure 1 in the Appendix. The envelope reveals large percentages of silt with varying percentages of sand. The silty material exhibits a non-plastic behaviour and this non-plasticity in addition to the creation of unbalanced hydrostatic head caused during the borehole advancement beneath the groundwater table manifested itself in borehole soil cave-in.

Cohesive layers are also randomly interbedded within the deposit. These layers range in thickness from 25 mm to 300 mm. Figure 2 in the Appendix illustrates the results of Atterberg Limit Tests conducted on selected samples of these

* Dwg. No. 2, Sheet 397, of the Contract Drawings.

layers and these results have been summarized in Table 1 below. The test results reveal that the layers range from a low to intermediate plasticity and hence can be categorized as clayey silt to silty clay. Natural moisture contents, also summarized in Table 1 below, are within the plastic and liquid limits, but generally approaching the liquid limit of the soil.

Table 1 - Clayey Silt Interlayers

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Contents (w%)	25-30	7
Liquid Limit (w _L %)	25-39	7
Plastic Limit (w _p %)	16-21	7
Plasticity Index (I _p %)	7-21	7

The denseness of the sandy silt to silt material was determined by evaluating the 'N' values derived by the Standard Penetration Test. Based on 'N' values ranging from 2 blows/0.3 m to 72 blows/0.3 m, this material can be categorized as having a very loose to very dense state of denseness. However, the lower 'N' values may be attributable to disturbance caused by unbalanced hydrostatic head and in general 'N' values were less than 30 blows/0.3 m. Consequently, it can be concluded that the deposit is generally in a loose to compact state of denseness.

The consistency of the clayey silt to silty clay interbeds was also determined by evaluating the 'N' values derived from the Standard Penetration Test and also by attempting to conduct in situ vane tests within the thicker layers. It was not possible to torque vanes within the clayey silt stratum, and although the developed resistance may have been attributable to confining silt layers, the clayey silt layers can be categorized as having a very stiff consistency. The 'N' values measured during the penetration of this material ranged from 10 blows/0.3 m to 40 blows/0.3 m confirming the very stiff consistency.

Clayey Silt with layers of Silt

The surficial abovementioned native deposit is underlain by a cohesive deposit of clayey silt that contains layers of cohesionless silt. This stratum extends to the bedrock surface and has a thickness in the order of magnitude of 9 m.

The interbedded layers of silt were determined to have thicknesses ranging from 50 mm to at least 450 mm. It is possible that greater thicknesses may be present, but this was not verified because samples were retrieved at 3 m intervals within this deposit.

Atterberg Limit Tests were carried out to determine the behaviour and plasticity of the material and the results are shown on Figure 3 and summarized in Table 2 below. The results confirm that the soil is of low plasticity and hence can be identified as a clayey silt.

Table 2 - Clayey Silt

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Contents (w%)	25-31	8
Liquid Limit (w_L %)	24-34	8
Plastic Limit (w_p %)	16-25	8
Plasticity Index (I_p %)	6-18	8

A grain size distribution envelope illustrating the gradation of the interbedded silt layers is shown graphically on Figure 4 in the Appendix. The envelope reveals primarily silt percentages with minor traces of sand and clay.

The consistency of the cohesive clayey silt material and the denseness of the cohesionless silt layers was determined by evaluating the 'N' values measured in conducting the Standard Penetration Test. Based on 'N' values ranging from 10 blows/0.3 m to 33 blows/0.3 m in the cohesive clayey silt material and 'N' values ranging from 14 blows/0.3 m to 41 blows/0.3 m in the cohesionless silt, it is concluded that the clayey silt material has a very stiff consistency and the silt material has a denseness ranging from compact to dense but is generally compact.

Bedrock

The overburden at the site is underlain by dolostone bedrock of the Amabel Formation at an elevation of approximately 204.3 m to 205.1 m. The bedrock

surface is relatively flat and uniform across the site. The bedrock was cored in BQ and BXL size up to 3 m in depth at the proposed structure foundation locations.

The dolostone bedrock is a fine to medium grained chemical sedimentary rock that typically is composed of magnesium carbonate compounds and calcite crystals. The rock is unweathered that is featured by a porous "vug" texture and stylolites. The rock is light grey to medium dark grey in colour and contains thin horizontal beds and closely spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Description of Rock Core".

An assessment of the quality and strength of the rock was carried out by measuring core recoveries and Rock Quality Designations (RQD) in the field and hardness testing in the laboratory. Recoveries ranged from 97% to 100% and RQD's ranged from 69% to 92% indicating that the rock is of fair to excellent quality. Rock strengths can be described as medium strong.

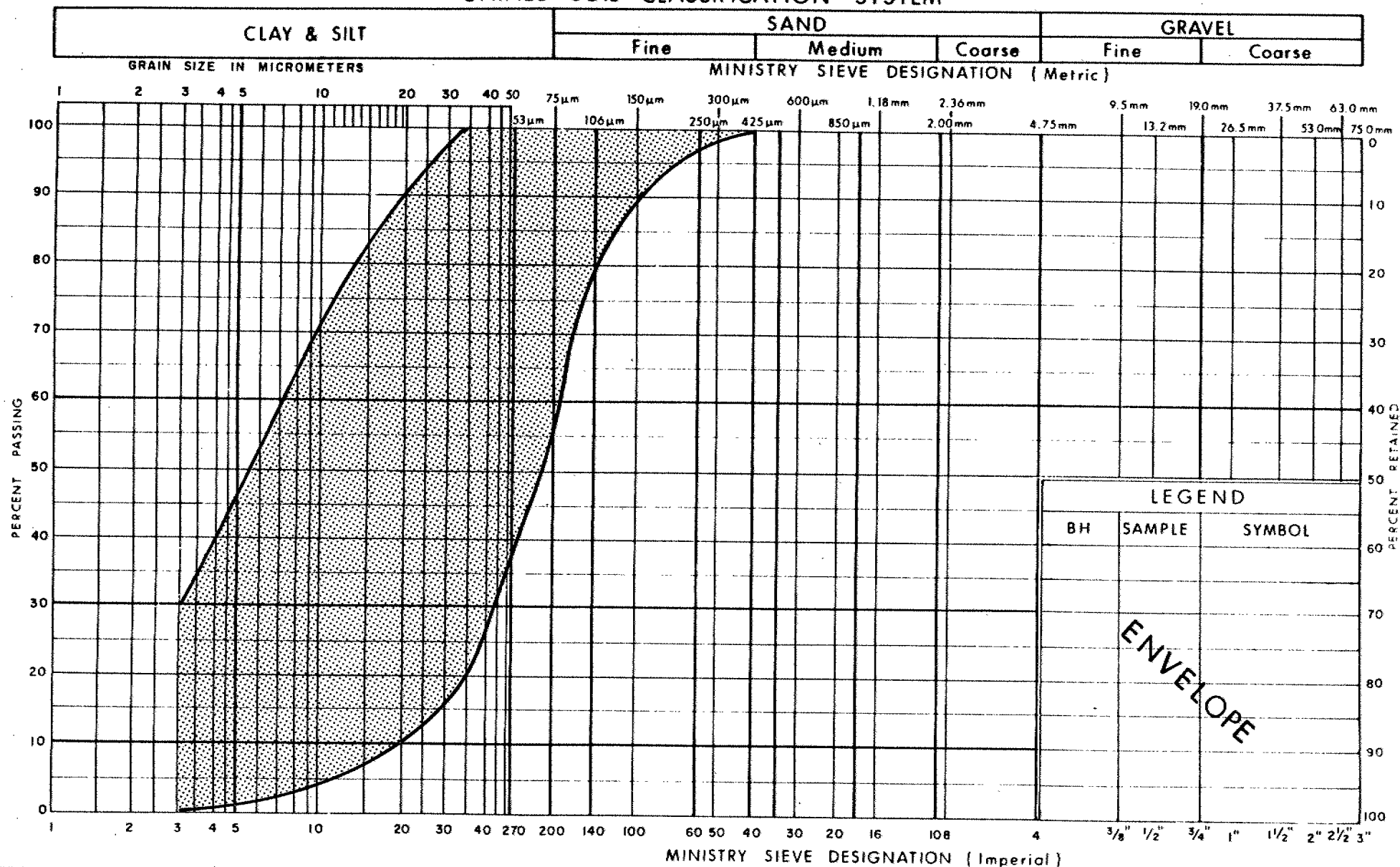
GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes throughout the duration of the field investigation. Groundwater levels determined at the time of investigation were generally within 1 (one) m below the ground surface (elevation 230.0 m to 233.2 m).

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

A P P E N D I X

UNIFIED SOIL CLASSIFICATION SYSTEM



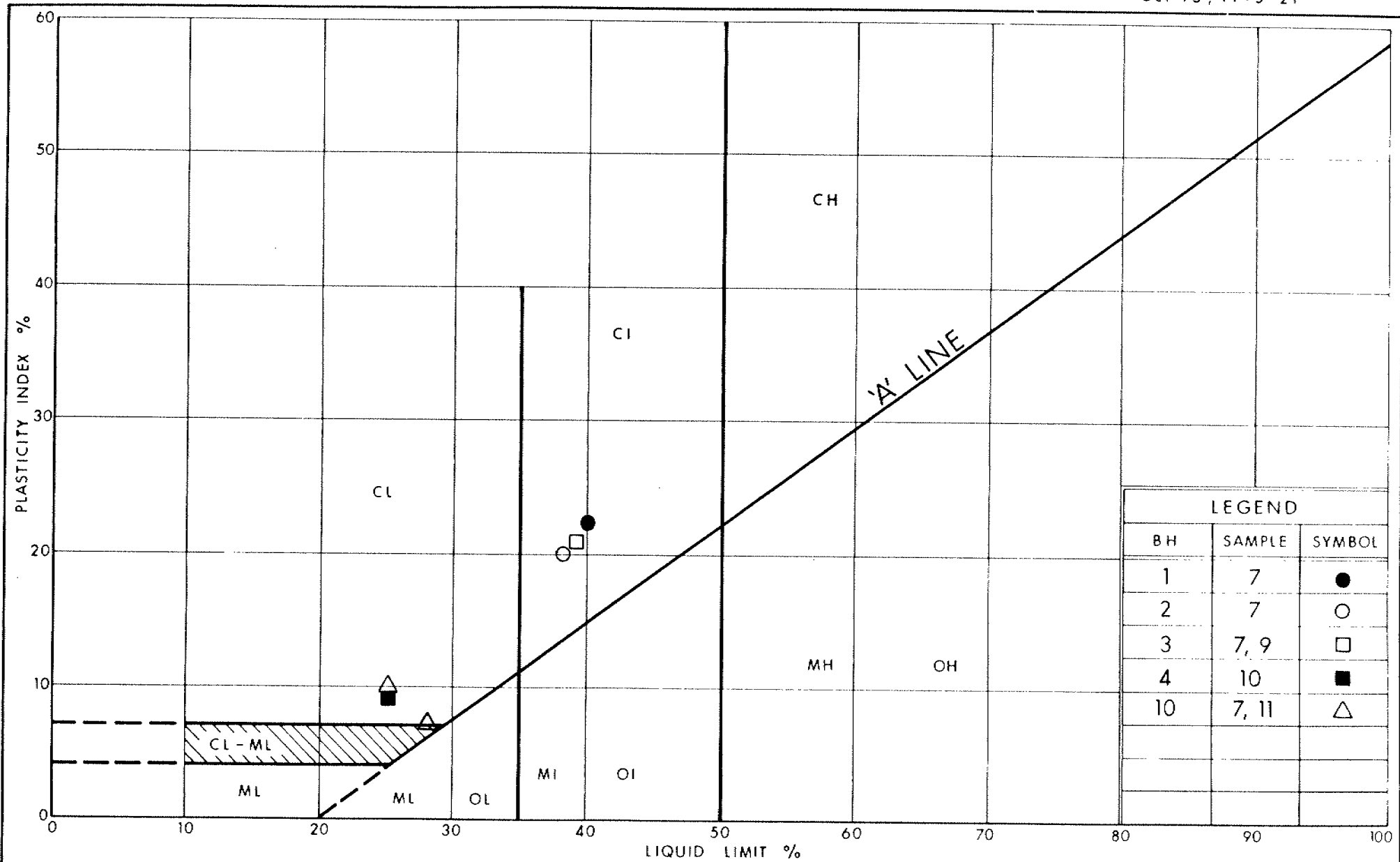
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GRAIN SIZE DISTRIBUTION

SANDY SILT TO SILT

FIG No 1

W P 65-67-03

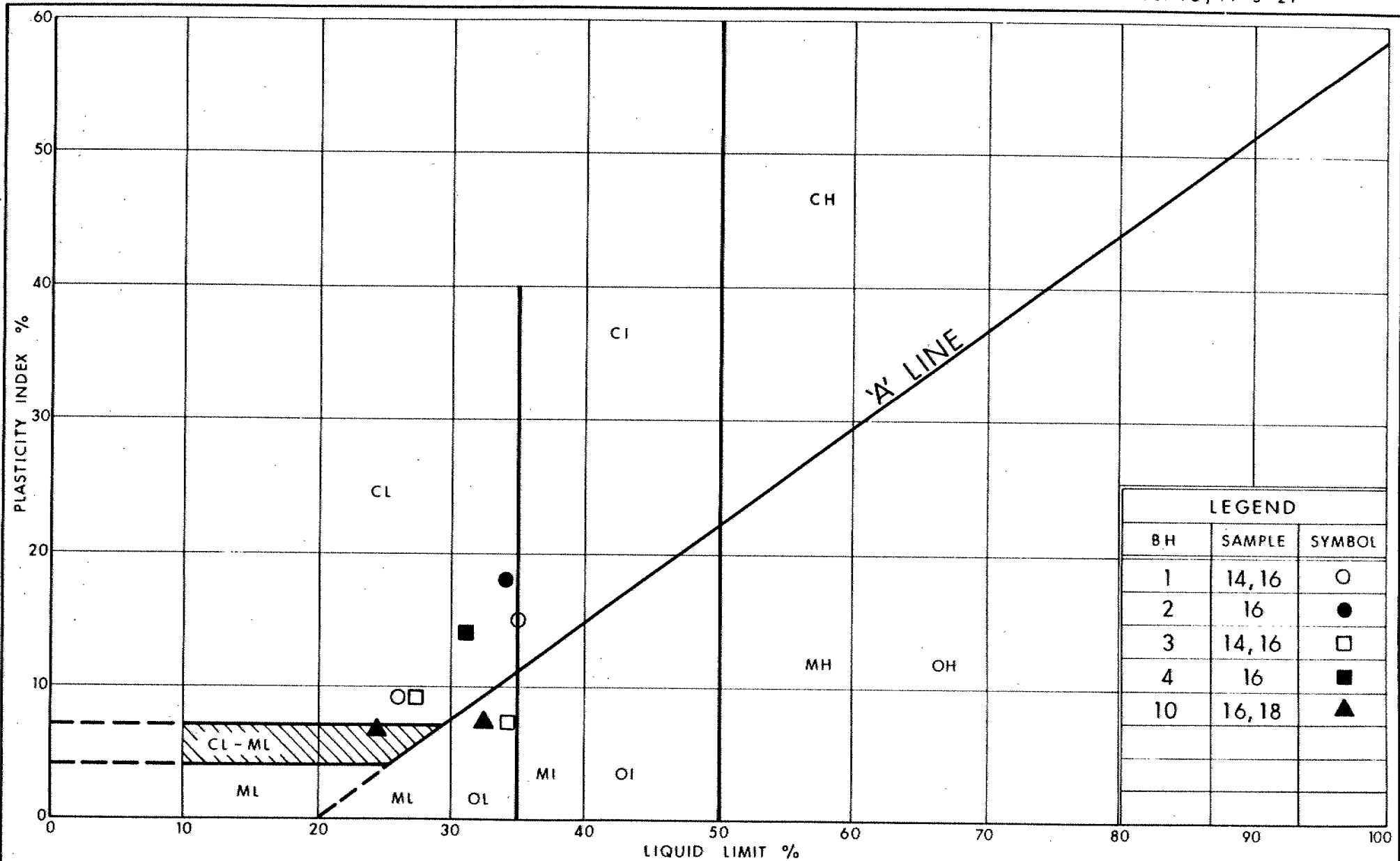


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PLASTICITY CHART CLAYEY SILT TO SILTY CLAY LAYERS INTERBEDDED WITHIN SANDY SILT TO SILT

FIG No 2

W P 65-67-03



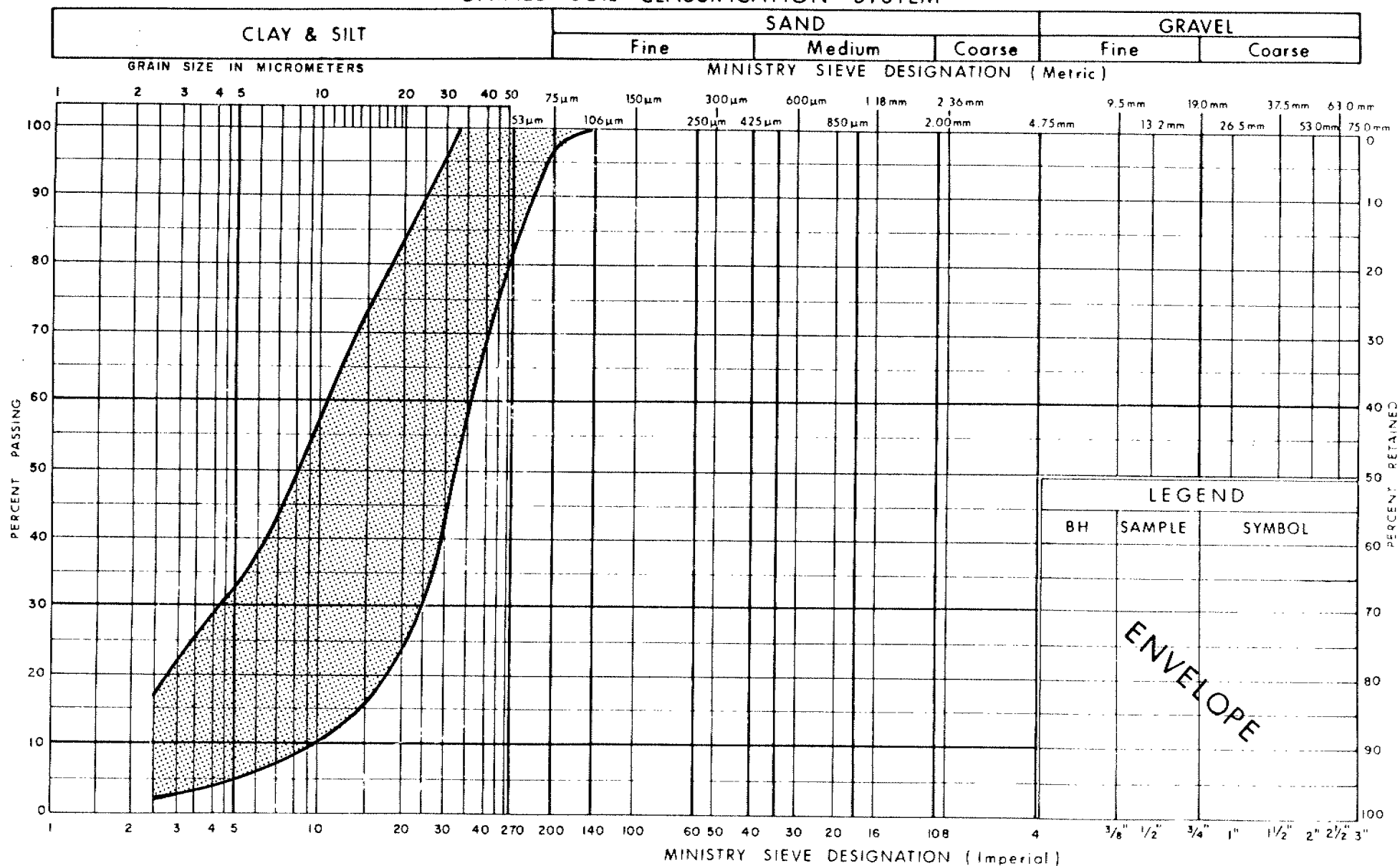
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PLASTICITY CHART CLAYEY SILT

FIG No 3

W P 65-67-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
SILT LAYERS
INTERBEDDED IN CLAYEY SILT STRATUM

FIG No 4

W P 65-67-03

RECORD OF BOREHOLE No 1										1 OF 1		METRIC	
W.P. 65-67-03		LOCATION		Co-ords: N 4 785 289.4; E 262 872.8				ORIGINATED BY TS					
DIST 4 HWY 403		BOREHOLE TYPE		HS Auger, BW Casing, Washboring, Rock Coring				COMPILED BY TS					
DATUM Geodetic		DATE		91 07 02-04				CHECKED BY PP					
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
232.0	Ground Surface												
0.0	trace Organics Brown Grey		1	SS	13								0 26 74 0
			2	SS	5								
			3	SS	5								
			4	SS	5								
			5	SS	9								
			6	SS	10								0 5 95 0
	Sandy Silt to Silt with random layers of Clayey Silt to Silty Clay Loose to Compact		7	SS	6								
			8	SS	18								
			9	SS	28								
			10	SS	16								0 21 77 2
			11	SS	45								
			12	SS	10								
			13	SS	29								0 1 95 4
213.7			14	SS	20								
18.3			15	SS	16								0 0 89 11
	Clayey Silt with layers of Silt Grey, Very Stiff		16	SS	11								
204.8			17	SS	*								
27.4	Bedrock - Dolostone		18	RC	REC								
203.0	Light Grey, Unweathered, Medium Strong				100%								RQD = 69%
29.0	End of Borehole • Sampler Bouncing												

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

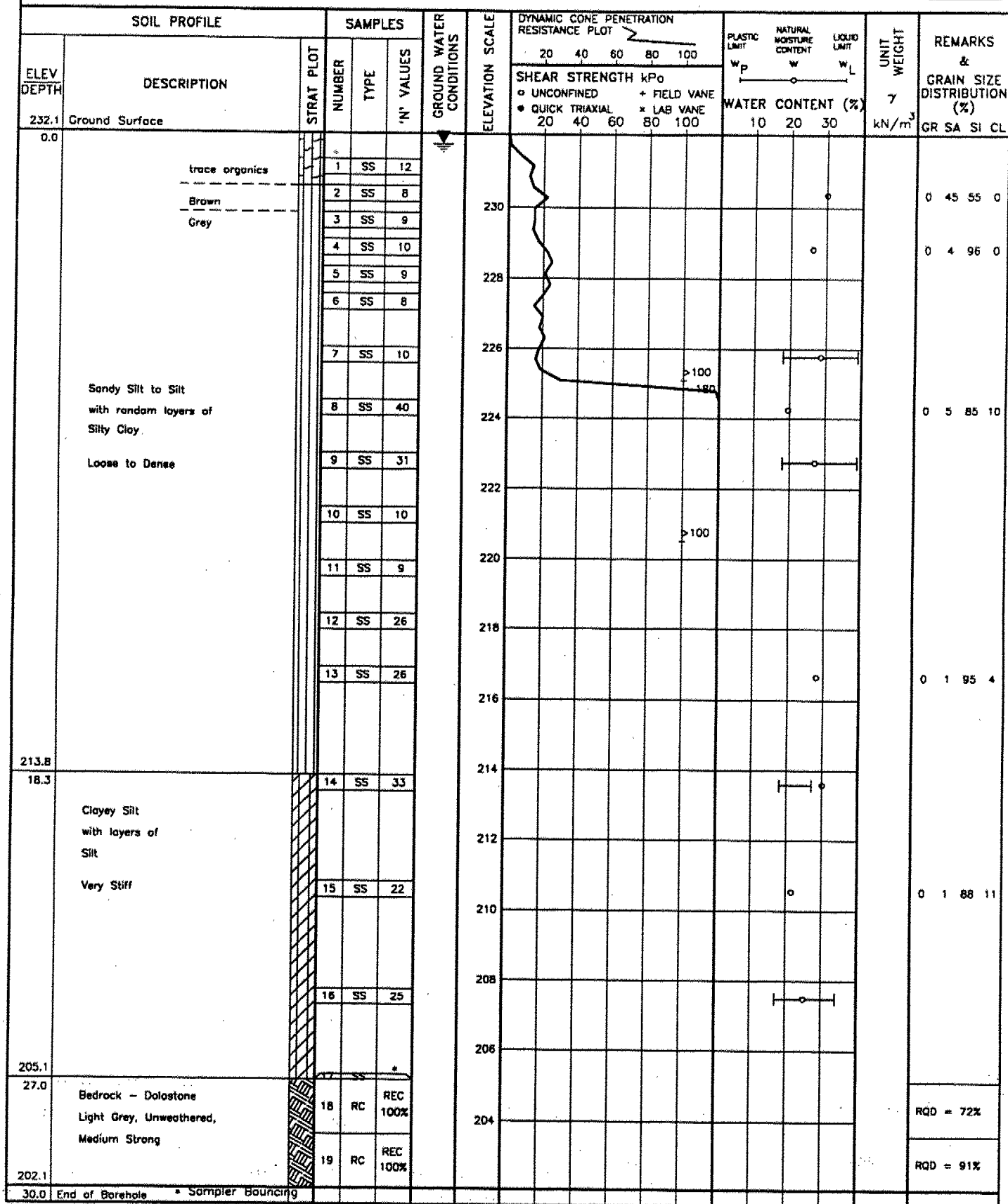
W.P. 65-67-03 LOCATION Co-ords: N 4 785 268.2; E 262 876.8 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring, Cone COMPILED BY TS
DATUM Geodetic DATE 91 06 28 to 91 07 02 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100					
231.4	Ground Surface												
0.0													
	trace Black Organics		1	SS	15								
			2	SS	10								0 33 67 0
	Brown		3	SS	4								
	Grey		4	SS	5								0 3 94 3
			5	SS	7								
			6	SS	5								
			7	SS	7								
	Sandy Silt to Silt with random layers of Silty Clay		8	SS	15								
			9	SS	18								
	Loose to Dense		10	SS	7								
			11	SS	10								
			12	SS	12								
			13	SS	36								
213.1			14	SS	18								0 2 93 5
18.3			15	SS	14								
	Clayey Silt with layers of Silt		16	SS	10								0 0 87 13
	Stiff to Very Stiff		17	SS	**								0 0 89 11
204.4			18	RC	REC 97%								
27.0	Bedrock - Dolostone Light Grey, Unweathered, Medium Strong		19	RC	REC 100%								RQD = 92%
202.0													RQD = 88%
29.4	End of Borehole * GWL not established ** Sampler Bouncing												

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 310.6; E 262 887.4 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring, Cone COMPILED BY TS
DATUM Geodetic DATE 91 06 27 to 91 07 02 CHECKED BY PP



+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 265.6; E 262 897.6 ORIGINATED BY LD
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS
DATUM Geodetic DATE 91 07 03-04 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
230.7	Ground Surface															
0.0	some Organics		1	SS	2		230									
	Black, Very Loose		2	SS	11											
	Grey		3	SS	11		228									
			4	SS	15											0 3 97 0
			5	SS	16		226									
			6	SS	24											
	Compact		7	SS	49		224									
	Dense to Very Dense		8	SS	49											
			9	SS	39		222									
	Sandy Silt to Silt		10	SS	55		220									0 0 71 29
	with random layers of		11	SS	72		218									
	Clayey Silt		12	SS	50		216									0 1 95 4
			13	SS	64		214									
212.4			14	SS	20		212									
18.3	Clayey Silt						210									
	with layers of						208									
	Silt		15	SS	41		206									
	Grey, Very Stiff		16	SS	22		204									
204.3																
26.4	Bedrock - Dolostone		17	RC	REC 100%											
202.8	Light Grey, Unweathered, Medium Strong															RQD = 83%
27.9	End of Borehole															

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 276.2; E 262 836.8 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY TS
DATUM Geodetic DATE 91 07 05 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
234.2	Ground Surface												
0.0													
	trace Organics		1	SS	7								
			2	SS	12								
	Brown		3	SS	14								
	Grey		4	SS	7								
	Silt, some Sand to Silt with random layers of Clayey Silt		5	SS	9								
	Loose to Compact		6	SS	13								
			7	SS	29								
221.6			8	SS	25								
12.6	End of Borehole												

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 277.8; E 262 920.4 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 07 05 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _P	W		
230.9	Ground Surface															
0.0	trace Organics		1	SS	11											
			2	SS	12											
	Sandy Silt to Silt with random layers of Clayey Silt		3	SS	14											
	Grey, Compact		4	SS	15											
	Very Dense		5	SS	66											
			6	SS	24											
			7	SS	16											
218.3			8	SS	22											
12.6	End of Borehole															

RECORD OF BOREHOLE No 10 * 1 OF 1 METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 288.3; E 262 896.1 ORIGINATED BY BW
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger, Dynamic Cone Test COMPILED BY BW
 DATUM Geodetic DATE 76 02 25-26 CHECKED BY PP

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			20 40 60 80 100	20 40 60 80 100					
230.9	Ground Surface												
0.0	trace organics		1	SS	6								0 27 70 3
			2	SS	8								0 21 77 2
			3	SS	12								
			4	SS	8								
			5	SS	10								
			6	SS	6								
			7	SS	6								
			8	TW	PH								
	Silt, some Sand to Silt with random layers of Clayey Silt		9	TW	PH							20.3	0 1 92 7
	Loose to Compact		10	SS	18							19.2	0 3 96 1
			11	SS	10								0 0 98 2
			12	TW	PH								
			13	TW	PH								
			14	SS	25								0 28 71 1
			15	SS	13								
212.6													
18.3	Clayey Silt with layers of Silt		16	SS	18								0 0 55 45
	Stiff to Very Stiff		17	SS	12								0 4 94 2
206.1													
24.8	End of Borehole		18	SS	9								0 0 99 1
	* Formerly BH 14 (WP 65-67-01)												

RECORD OF BOREHOLE No 100

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Coords: N 4 785 249.5; E 262 883.4 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
DATUM Geodetic DATE 1995 05 23 CHECKED BY KA

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
230.2	Ground Surface															
0.0	Organic Clayey Silt, some Sand dk. brown, moist		1	SS	1											
			2	SS	1											
			3	SS	5											
	Silt with random layers of Silty Clay		4	SS	4											0 2 95 3
			5	SS	5											0 1 96 3
			6	SS	15											
	Silty Clay		7	SS	9											0 0 55 45
			8	SS	8											
	very loose to compact Greyish-Brown to Brown		9	SS	17											0 1 94 5
220.6			10	SS	22											
9.6	End of Borehole															

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 65-67-03

LOCATION

Coords: N 4 785 328.9; E 262 868.4

ORIGINATED BY DB

DIST CR HWY 403

BOREHOLE TYPE HS Auger, NX Casing, Washboring

COMPILED BY DB

DATUM Geodetic

DATE

1995 06 02

CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
233.9	Ground Surface																
0.0																	
			1	SS	12		232										0 12 83 5
			2	SS	26		230										
			3	SS	11		228										0 5 90 5
	Sandy Silt to Silt		4	SS	9		226										
	with random layers of Silty Clay		5	SS	12		224										
	Greyish-Brown to Brown		6	SS	18		222										
			7	SS	19		220										
	Loose to Dense		8	SS	10		218										0 11 85 4
			9	SS	33		216										
			10	SS	10		214										0 3 88 9
213.5							212										
20.4			11	SS	22		210										
	Silty Clay to Clayey Silt		12	SS	34		208										
	with layers of Silt		13	SS	9		206										
	stiff to hard																
204.4																	
29.5	End of Borehole • Tricone Bouncing Probable Bedrock																

RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Coords: N 4 785 251.3; E 262 901.6
DIST CR HWY 403 BOREHOLE TYPE HS Auger, NX Casing, Washboring
DATUM Geodetic DATE 1995 06 01
ORIGINATED BY DB
COMPILED BY DB
CHECKED BY KA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20						40
230.3	Ground Surface													
0.0														
			1	SS	11									
			2	SS	8									
			3	SS	12									
			4	SS	17									
	Silt with random layers of Clayey Silt		5	SS	28									
	Greyish-Brown to Brown		6	SS	9									
	loose to compact		7	SS	11									
			8	SS	5									
			9	SS	24									
212.9														
17.4			10	SS	19									
	Clayey Silt with layers of Silt		11	SS	10									
	Greyish-Brown to Brown		12	SS	10									
	stiff to compact													
204.4														
25.9	End of Borehole • Tricone Bouncing Probable Bedrock													

ROCK CORE DESCRIPTION **WP 65-67-03**

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	18	27.43-28.96	100	69	27.43-28.96	DOLOSTONE with stylolites and abundant vugs containing calcite crystals, light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to dipping, undulating, smooth to rough.
2	18	27.03-27.84	97	92	27.03-29.36	DOLOSTONE with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures wide to very close spaced, flat to dipping, undulating, smooth to rough.
	19	27.84-29.36	100	88		
3	18	26.97-28.50	100	72	26.97-30.02	DOLOSTONE with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to dipping, undulating, smooth to rough.
	19	28.50-30.02	100	91		
4	17	26.37-27.89	100	83	26.37-27.89	DOLOSTONE with stylolites and abundant vugs containing calcite crystals (including calcite-gypsum-sphalerite-filled vug 5 cm in diameter at 27.79 m), light olive grey to medium 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.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

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

Logged by: DAW, Soils and Aggregates Section

FOUNDATION INVESTIGATION REPORT
For
Three Concrete Culverts at Highway 403 and Shaver Road
W.P. 116-87-00, Central Region

Introduction

This report summarizes the results of a foundation investigation carried out for three culverts proposed in the vicinity of Highway 403 and Shaver Road. They are identified as follows:

Culvert 7	Highway 403 Crossing at Sta 27+615
Culvert 24	Shaver Road Crossing at Sta 10+072
Culvert 26	Shaver Road Crossing at Sta 10+165

Site Description

The site is located at the existing Shaver Road between Highway 2 and Jerseyville Road in the Town of Ancaster, Regional Municipality of Hamilton-Wentworth. The terrain is generally hilly, with wetlands present in low lying areas. Land use is agricultural and residential.

Physiographically, the site is located in the region known as the Haldimand Clay Plain. Lacustrine and deltaic deposits of clays and silts are typical of this depositional environment.

Field Investigation

The fieldwork for this project was carried out between 95 05 24 and 95 05 30. Six borings were conducted using a track-mounted auger machine. The boreholes were advanced with hollow stem augers, solid stem augers, and washboring techniques.

Two boreholes were advanced at each culvert location:

		Borehole No.
Culvert 7	Highway 403 Crossing at Sta 27+615	106A and 107A
Culvert 24	Shaver Road Crossing at Sta 10+072	102A and 105A
Culvert 26	Shaver Road Crossing at Sta 10+165	103A and 104A

The soil samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specifications outlined in ASTM D-1586 for the Standard Penetration Test.

Borehole elevations and coordinates were provided by MTO Central Region Surveys and Plans Office.

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the recovered material. Tests included the grain size distribution analyses, natural moisture content and Atterberg Limits.

The results of the field and laboratory tests are plotted on the Record of Borehole sheets appended to this report. Borehole locations and stratigraphical sections of the subsurface conditions are shown on Drawing No. 1168700-A, Sheet No. 230-1, of the Contract Drawings.

Subsurface Conditions

The subsurface conditions encountered at boreholes 102A through 107A are generally uniform and consist largely of non-cohesive sandy silt to silt. The sandy silt to silt deposit was present from ground surface (El. 229.3 to 231.3) to the depth at which the boreholes were terminated (El. 218.2 to 218.7). Some organic material was present within 1.3 m of ground surface. Random layers of clayey silt to silty clay were encountered ranging in thickness up to 1.8 m.

The N values obtained in the sandy silt to silt deposit vary from 0 to 32, but more typically from 4 to 15. Based on these N values, the denseness ranges from very loose to dense, but more typically from loose to compact.

Groundwater levels observed in the boreholes during the investigation were found to be close to ground surface, from 0.1 to 0.9 m below surface elevations.

The high water table together with the non-cohesive nature of the subsurface material result in subsurface conditions that are highly sensitive to disturbance created by unbalanced hydrostatic head.

Miscellaneous

The fieldwork was conducted in May 1995 under the supervision of K. Ahmad, Foundation Engineer and Deanna Brooker, Engineering Student, utilizing drilling equipment owned and operated by K & S Drilling. The factual portion of the report was prepared by B. Bennett, Foundation Engineer.



A handwritten signature in black ink that reads "D. Dundas".

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

APPENDIX

RECORD OF BOREHOLE No 102A

1 OF 1

METRIC

W.P. 116-87-00 LOCATION Coords: N 4 785 211.0; E 262 885.8 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE SS Auger, NX Casing COMPILED BY DB
DATUM Geodetic DATE 1995 05 24 CHECKED BY KA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L					
229.5	Ground Surface																
0.0																	
	Sandy Silt to Silt with random layers of Silty Clay Silty Clay Greyish-Brown Brown loose to dense Silty Clay Greyish-Brown		1	SS	4											0 17 80 3	
			2	SS	5												
			3	SS	6												
			4	SS	5												
			5	SS	13												
			6	SS	11												0 0 96 4
			7	SS	18												
			8	SS	25												
			9	SS	22												0 3 91 6
			10	SS	10												
218.4			11	SS	32												
11.1	End of Borehole																

RECORD OF BOREHOLE No 103A

1 OF 1

METRIC

W.P. 116-87-00

LOCATION Coords: N 4 785 128.9; E 262 910.0

ORIGINATED BY DB

DIST CR HWY 403

BOREHOLE TYPE SS Auger, HS Auger

COMPILED BY DB

DATUM Geodetic

DATE 1995 05 25

CHECKED BY KA

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 C
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	w _p	w	w _L		
229.3	Ground Surface																
0.0	Silt with random layers of Silty Clay Brown loose to compact		1	SS	7	▼	228										
			2	SS	8		226										
			3	SS	7												
			4	SS	10												
			5	SS	9		224										
			6	SS	5												
			7	SS	7												
			8	SS	17		222										
			9	SS	25												
			10	SS	23		220										
218.2				11	SS		11										
11.1	End of Borehole																

RECORD OF BOREHOLE No 104A

1 OF 1

METRIC

W.P. 116-87-00

LOCATION Coords: N 4 785 133.7; E 262 930.8

ORIGINATED BY DB

DIST CR HWY 403

BOREHOLE TYPE HS Auger

COMPILED BY DB

DATUM Geodetic

DATE 1995 05 26

CHECKED BY KA

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
229.4	Ground Surface															
0.0	Organic-Clayey Silt (Fill)		1	SS	4											
			2	SS	7											
			3	SS	16											
	Silt with some sand		4	SS	5											
	with random layers of Clayey Silt		5	SS	4											
			6	SS	4											
	Clayey Silt		7	SS	6											
			8	SS	15											
	Brown		9	SS	16											
	loose to compact		10	SS	7											
218.3			11	SS	18											
11.1	End of Borehole															

RECORD OF BOREHOLE No 105A

1 OF 1

METRIC

W.P. 116-87-00

LOCATION Coords: N 4 785 232.4; E 262 917.9

ORIGINATED BY DB

DIST CR HWY 403

BOREHOLE TYPE HS Auger

COMPILED BY DB

DATUM Geodetic

DATE 1995 05 29

CHECKED BY KA

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					
230.9	Ground Surface																
0.0	Sandy Silt to Silt with random layers of Silty Clay Silty Clay moist, brown Brown very loose to compact		1	SS	9		230										
			2	SS	4												
			3	SS	8												
			4	SS	3		228										0 21 74 5
			5	SS	6												
			6	SS	10		226										0 0 95 5
			7	SS	12												
			8	SS	9		224										
			9	SS	25												
			10	SS	26		222										0 2 90 8
			11	SS	7		220										
218.3			12	SS	0												
12.6	End of Borehole																

RECORD OF BOREHOLE No 106A

1 OF 1

METRIC

W.P. 116-87-00

LOCATION Coords: N 4 785 258.9; E 262 932.1

ORIGINATED BY DB

DIST CR HWY 403

BOREHOLE TYPE HS Auger

COMPILED BY DB

DATUM Geodetic

DATE 1995 05 30

CHECKED BY KA

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 C
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
231.3	Ground Surface												
0.0			1	SS	12								
			2	SS	10								
			3	SS	15								
	Silt with random layers of Silty Clay		4	SS	16								
			5	SS	8								
			6	SS	6								
			7	SS	9								
	Silty Clay, Brown		8	SS	6								
			9	SS	18								
	Brown		10	SS	17								
	very loose to compact		11	SS	0								
218.7			12	SS	12								
12.6	End of Borehole												

RECORD OF BOREHOLE No 107A

1 OF 1

METRIC

W.P. 116-87-00

LOCATION _____ Coords: N 4 785 310.0; E 262 921.0

ORIGINATED BY DB

DIST CR HWY 403BOREHOLE TYPE HS Auger

COMPILED BY DB

DATUM Geodetic

DATE 1995 05 30

CHECKED BY KA

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Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 96-38

WP 65-67-03 DIST 4
HWY 403 STR SITE 36-259

Hwy. 403 and Shaver Road Overpass

Changed to V'Pass

DISTRIBUTION

V.F. Boehnke (3)
G. Cautillo
J. Cullen (2)
A. Wittenberg
K.G. Bassi
S.J. Dunham
E.A. Joseph
I. Harrod (Cover Only)
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FOUNDATION INVESTIGATION REPORT

For

Hwy. 403 and Shaver Road ~~Overpass~~ Underpass

W.P. 65-67-03, Site 36-259

District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the abovementioned site. It is proposed to construct a rigid frame tunnel-like structure to facilitate the Hwy. 403 overpass at Shaver Road. This structure is a component of the proposed Hwy. 403 roadway between Ancaster and Brantford.

SITE DESCRIPTION AND GEOLOGY

The site is located at the existing Shaver Road between Hwy. 2 and Jerseyville Road in the Town of Ancaster, Regional Municipality of Hamilton-Wentworth. The site is approximately at mid-distance (0.5 km) between Hwy. 2 and Jerseyville Road, and is located approximately 3 km east of Hwy. 52.

The existing Shaver Road is a two lane asphaltic roadway supported by a shallow embankment approximately 1 metre in height at the site location. The embankment is elevated above the surrounding area. The site is located in a valley and is situated at the toe of a slope present at the northern limits of the site. A gradual rise in grade occurs southwardly towards Hwy. 2.

Rolling terrain predominates the general site area. On the east side of the existing Shaver Road, wetlands consisting of cattails and marshland vegetation extends from the roadway for a distance of approximately 50 metres. Sparse large trees are also present within this area. Beyond this distance, tall dense coniferous and deciduous trees exist. On the west side of the site, and also beyond the site limits, residential homes are present.

Physiographically, the site is located within the geological domain known as the Haldimand clay plain. The Haldimand clay plain occupies the area lying between the Niagara Escarpment and Lake Erie. The entire area was submerged in Lake

Warren, a glacial lake formed during the retreat of the Wisconsin glacialiation (approximately 12,000 years ago). Lacustrine clays and silts were deposited as the lake gradually receded due to the deposition of sediments during isostatic land rebound. The lacustrine clays and silts are overlain by deltaic sandy silts deposited as a result of a great discharge of meltwater between the ice front and the moraines creating the delta from west to east as the glacier withdrew.

Drainage of this belt is controlled by the Grand River which has cut a deep valley in the clay and silt. Consequently, there has been much dissection by tributary drainage.

The underlying bedrock at the site consists of weak to medium strong dolostones of the Paleozoic era. At the site, the overburden has a thickness of approximately 27 to 28 metres.

INVESTIGATION PROCEDURES

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

Field Investigation

The fieldwork for this project was carried out under two separate stages. The initial stage, was implemented between 76 02 25-26 inclusive and consisted of one sampled borehole (BH 10, formerly BH 14) advanced to a depth of 24.8 metres and one dynamic cone penetration test advanced to a depth of 15.2 m. This initial first stage provided information to facilitate the planning and design of the proposed Hwy. 403 route between the cities of Ancaster and Brantford.

The second stage of the fieldwork was carried out between 91 06 27 and 91 07 05 inclusive and consisted of a total of seven (7) sampled boreholes reflecting the greater extent of this subsequent fieldwork.

The scope of the subsequent field investigation was to provide detailed soils/rock data to facilitate the design and construction of the proposed structure and related earthworks. Four (4) boreholes accompanied by two (2) dynamic cone penetration tests were advanced at the proposed abutment structure foundation locations and a total of two (2) boreholes were advanced at the proposed approach fills east and west of the structure. The boreholes at the structure locations were advanced to depths ranging from 27.9 m to 30 m whilst the dynamic cone penetration tests were driven to depths ranging from 7.6 m to 10.4 m. The approach fill boreholes were advanced to depths of 12.6 m.

The boreholes were advanced through the overburden using track mounted boring units employing conventional continuous flight hollow stem augering techniques and also casing/washboring techniques. Conventional rock coring techniques were used to retrieve up 3 m of rock core.

In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 4.6 m and at 1.5 m intervals beyond this surficial depth to approximately 15 m depth. Subsoil samples were retrieved at 3 m intervals below the 15 m depth. Subsoil samples were taken at 1.5 m intervals only at the approach locations.

Subsoil samples were generally retrieved in accordance with the Standard Penetration Test (ASTM D 1586) and hence were disturbed during the testing. All subsoil samples were identified in the field and then properly sealed to preserve natural moisture contents. Disturbed samples were placed in plastic containers and then transported to the laboratory where additional visual classifications were carried out and pertinent laboratory tests conducted, as described in the subsequent section of this report.

Rock core samples were also identified in the field and rock recoveries and Rock Quality Designations (RQD) measured. The rock cores were then transported to the laboratory in conventional core boxes and detailed rock core logs were produced by an in-house geologist.

In situ vane tests were also carried out to determine the undrained shear strength of the weaker cohesive soils at the site. The test was carried out in accordance with ASTM D 2573 using the Standard MTO 'N' vane. Remoulded shear strengths were also obtained where applicable.

Groundwater levels were obtained by measuring the levels in the open boreholes throughout the duration of the field investigation. All open boreholes were backfilled at the completion of the fieldwork.

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

Laboratory Analyses

To determine the pertinent physical properties of the soil, various laboratory tests were conducted. The tests included:

- 1) Natural Moisture Content
- 2) Atterberg Limits
- 3) Grain Size Analysis

Laboratory test results are shown on the borehole logs and corresponding figures attached in the Appendix. These results have been summarized in the subsequent section of this report entitled 'Subsurface Conditions'.

SUBSURFACE CONDITIONS

General

The ground surface elevation at the boreholes at the site ranged from 230.7 m to 234.2 m. The subsurface conditions across the site are generally uniform and consists of an extensive surficial deposit comprised of a cohesionless sandy silt to silt with random layers of clayey silt to silty clay. The deposit has a thickness in the order of 18.3 m. The sandy silt to silt material generally has a denseness ranging from loose to dense with random very loose and very dense zones. The interbedded clayey silt layers, which range in thickness up to 300 mm are generally very stiff in consistency.

The surficial cohesionless deposit is underlain by a cohesive clayey silt stratum that contains layers of silt. This deposit extends to the bedrock surface and has a thickness in the order of 9 m. The clayey silt is generally

of very stiff consistency and the silt layers ranging in thickness up to 300 mm have a compact denseness.

The overburden is underlain by bedrock of the Amabel Formation and consists of dolostone. The bedrock surface is relatively flat and at an elevation ranging from 204.3 m to 205.1 m.

A plan of the site illustrating the locations and elevations of the boreholes is shown on Dwg. No. 656703-A in the Appendix. Subsoil stratigraphical sections illustrating the subsurface conditions at the site are also provided. The boundaries between the various soil types in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the stratigraphical sections and also on the individual Record of Borehole sheets in the Appendix.

Sandy Silt to Silt with random layers of Clayey Silt to Silty Clay

The surficial native deposit at the site consists of an extensive cohesionless sandy silt to silt with random layers of cohesive clayey silt to silty clay. Traces of black organics are also present within the surficial 1 to 1.5 m with greater concentrations present east of the existing Shaver Road where wetter conditions prevail. This deposit extends from the ground surface to depths in the order of 18.3 m. The deposit is oxidized and therefore brown in colour for the surficial 1.5 m to 3 m and unoxidized and hence grey in colour below these depths.

A grain size distribution envelope illustrating the gradation of this deposit is shown on Figure 1 in the Appendix. The envelope reveals large percentages of silt with varying percentages of sand. The silty material exhibits a non-plastic behaviour and this non-plasticity in addition to the creation of unbalanced hydrostatic head caused during the borehole advancement beneath the groundwater table manifested itself in borehole soil cave-in.

Cohesive layers are also randomly interbedded within the deposit. These layers range in thickness from 25 mm to 300 mm. Figure 2 in the Appendix illustrates the results of Atterberg Limit Tests conducted on selected samples of these

layers and these results have been summarized in Table 1 below. The test results reveal that the layers range from a low to intermediate plasticity and hence can be categorized as clayey silt to silty clay. Natural moisture contents, also summarized in Table 1 below, are within the plastic and liquid limits, but generally approaching the liquid limit of the soil.

Table 1 - Clayey Silt Interlayers

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Contents (w%)	25-30	7
Liquid Limit (w_L %)	25-39	7
Plastic Limit (w_p %)	16-21	7
Plasticity Index (I_p %)	7-21	7

The denseness of the sandy silt to silt material was determined by evaluating the 'N' values derived by the Standard Penetration Test. Based on 'N' values ranging from 2 blows/0.3 m to 72 blows/0.3 m, this material can be categorized as having a very loose to very dense state of denseness. However, the lower 'N' values may be attributable to disturbance caused by unbalanced hydrostatic head and in general 'N' values were less than 30 blows/0.3 m. Consequently, it can be concluded that the deposit is generally in a loose to compact state of denseness.

The consistency of the clayey silt to silty clay interbeds was also determined by evaluating the 'N' values derived from the Standard Penetration Test and also by attempting to conduct in situ vane tests within the thicker layers. It was not possible to torque vanes within the clayey silt stratum, and although the developed resistance may have been attributable to confining silt layers, the clayey silt layers can be categorized as having a very stiff consistency. The 'N' values measured during the penetration of this material ranged from 10 blows/0.3 m to 40 blows/0.3 m confirming the very stiff consistency.

Clayey Silt with layers of Silt

The surficial abovementioned native deposit is underlain by a cohesive deposit of clayey silt that contains layers of cohesionless silt. This stratum extends to the bedrock surface and has a thickness in the order of magnitude of 9 m.

The interbedded layers of silt were determined to have thicknesses ranging from 50 mm to at least 450 mm. It is possible that greater thicknesses may be present, but this was not verified because samples were retrieved at 3 m intervals within this deposit.

Atterberg Limit Tests were carried out to determine the behaviour and plasticity of the material and the results are shown on Figure 3 and summarized in Table 2 below. The results confirm that the soil is of low plasticity and hence can be identified as a clayey silt.

Table 2 - Clayey Silt

	<u>Range</u>	<u># of Tests</u>
Natural Moisture Contents (w%)	25-31	8
Liquid Limit (w_L %)	24-34	8
Plastic Limit (w_p %)	16-25	8
Plasticity Index (I_p %)	6-18	8

A grain size distribution envelope illustrating the gradation of the interbedded silt layers is shown graphically on Figure 4 in the Appendix. The envelope reveals primarily silt percentages with minor traces of sand and clay.

The consistency of the cohesive clayey silt material and the denseness of the cohesionless silt layers was determined by evaluating the 'N' values measured in conducting the Standard Penetration Test. Based on 'N' values ranging from 10 blows/0.3 m to 33 blows/0.3 m in the cohesive clayey silt material and 'N' values ranging from 14 blows/0.3 m to 41 blows/0.3 m in the cohesionless silt, it is concluded that the clayey silt material has a very stiff consistency and the silt material has a denseness ranging from compact to dense but is generally compact.

Bedrock

The overburden at the site is underlain by dolostone bedrock of the Amabel Formation at an elevation of approximately 204.3 m to 205.1 m. The bedrock

surface is relatively flat and uniform across the site. The bedrock was cored in BQ and BXL size up to 3 m in depth at the proposed structure foundation locations.

The dolostone bedrock is a fine to medium grained chemical sedimentary rock that typically is composed of magnesium carbonate compounds and calcite crystals. The rock is unweathered that is featured by a porous "vug" texture and stylolites. The rock is light grey to medium dark grey in colour and contains thin horizontal beds and closely spaced vertical fractures. Detailed descriptions of the bedrock are attached in the Appendix in a report entitled "Description of Rock Core".

An assessment of the quality and strength of the rock was carried out by measuring core recoveries and Rock Quality Designations (RQD) in the field and hardness testing in the laboratory. Recoveries ranged from 97% to 100% and RQD's ranged from 69% to 92% indicating that the rock is of fair to excellent quality. Rock strengths can be described as medium strong.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water levels in the open boreholes throughout the duration of the field investigation. Groundwater levels determined at the time of investigation were generally within 1 (one) m below the ground surface (elevation 230.0 m to 233.2 m).

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

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a single span, rigid frame "tunnel-like" that will carry the proposed Hwy. 403 over Shaver Road. The rigid frame structure spans a distance of 18 m and will facilitate a highway width of approximately 40 m. The highway is initially planned for two (2) eastbound lanes and three (3) westbound lanes with a divided median. It is ultimately planned to widen the highway to occupy the initially proposed median. The structure is one of many structures proposed in conjunction with the Hwy. 403 connection between Hwy. 2 in Ancaster to Brantford.

Shaver Road will remain along its existing alignment and will initially consist of two (2) 3.25 m lanes with one (1) m shoulders. The bridge span, however, is of sufficient width to enable an ultimate planned widening of Shaver Road to four (4) lanes.

The proposed profile grade of the Hwy. 403 overpass is approximately at 240.8 m with a 4.3 percent downward sloping gradient from east to west. The proposed profile grade of Shaver Road is 233.4 m. The existing ground surface at the site varies from 230.7 m to 235.6 m. Consequently, approach fills in the order of magnitude ranging from approximately 5 to 10 m will be required at the approaches to the structure. Approximately 1 to 2 m of additional fill material will be required in the construction of Shaver Road.

A plan illustrating the roadway and highway alignments and the proposed structure foundation locations is attached on Dwg. No. 656703-A in the Appendix. The proposed profile grades have also been superimposed on a profile stratigraphical section illustrated on Dwg. No. 656703-A.

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 Foundations
- 2) Reinforced Earth Walls
- 3) Approach Embankments
- 4) Construction Considerations

1) Structure Foundations

The surficial sandy silt to silt deposit with random interlayers of clayey silt is considered unsuitable for the support of economical conventional spread footings at the site. Consequently, it is recommended that all structure foundations be supported on deep foundation units. The bedrock present at this site provides an end-bearing stratum and consequently, structure foundations can be supported on end-bearing steel H-piles driven to the bedrock surface. Table 4 below provides recommended axial bearing capacities for steel H-piles driven to bedrock.

The capacities, however, apply to vertical piles and appropriate considerations shall be given to inclined piles. Any reduction to account for inclined loadings shall be carried out in conformance with the factors given in Section 6.8.3.4.3 of the O.H.B.D.C.

Table 4 - Axial Capacities

<u>Structure</u> <u>Foundation</u>	<u>Pile</u> <u>Types</u>	<u>Factored Capacity</u> <u>at U.L.S. (kN)</u>	<u>Bearing Capacity</u> <u>at S.L.S. Type (kN)</u>	<u>Estimated</u> <u>Pile Tip</u> <u>Elv. (m)</u>
West Abutment	HP310x110	1600	1150	204.5±
	HP310x79	1150	890	
East Abutment	HP310x110	1600	1150	205±
	HP310x79	1150	890	

Major consideration should be given to "perching" the pile caps within the fill material to avoid dewatering that would otherwise be required for pile cap excavation within the native cohesionless surficial soils. To avoid any pile driving impediment, the fill material should be restricted to a maximum 75 mm grain size.

Resistance to lateral loads can be achieved by inclining the piles at a batter. The lateral resistance for vertical and battered piles shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

Pile spacing shall conform with Section 6.8.3.10 of the O.H.B.D.C. Adjacent piles should be checked for heaving during pile installation. For centrally loaded piles, equal load sharing on the deep foundation units can be assumed. The design of eccentric loaded deep foundations 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 penetration by providing a minimum 1.2 m earth cover or equivalent frost protection.

All piles shall be driven to the bedrock surface. To facilitate the installation of the steel H-piles, it is recommended that the piles be equipped with reinforced tips as illustrated on MTO Standard Drawing DD-3301. The steel H-piles shall be spliced in accordance with OPSS 903.07.01.03 and as shown on the abovementioned Drawing DD-3301.

2) Reinforced Earth Walls

Should the application of reinforced earth walls prove to be an economical alternative, consideration can be given to employing reinforced earth abutment and/or retaining walls. It is recommended that in view of the very loose to loose denseness of the surficial sandy silt to silt deposit, that the reinforced earth walls be designed to resist horizontal loadings only and that vertical and/or inclined loadings be supported on deep foundation units as discussed in the previous section.

A non-standard provision (NSSP) that addresses the supply and installation of the reinforced earth wall shall be included in the contract documents.

3) Approach Embankments

Approach fills in the order of magnitude of 5 to 10 m will be required for the structure approach embankments. Discussion of the stability, settlement,

lateral earth pressures on the structure and construction of the approach embankments are provided below.

(a) Stability

In view of the cohesionless nature of the surficial sandy silt to silt deposit and the fact that the clayey silt to silty clay interbeds are of very stiff consistency and minor thickness, there are no deep-seated (external) slope stability problems anticipated for the proposed embankment fill heights constructed at 2H:1V slopes. However, to avoid surficial slope instabilities, it is recommended that for fill heights exceeding 8 m, the embankments be constructed at 2H:1V slopes with a nominal 2 m midheight berm sloped at a 2% gradient to facilitate surface runoff away from the slope. The midheight berm pertains to slopes both in the longitudinal and transverse directions.

All exposed slopes should be protected from erosional forces by providing an effective erosional control protection scheme.

(b) Settlement

Settlements induced as a result of the applied embankment loading will be the result of the elastic compression of the native subsoil and as a result of settlements within the fill material itself. It is anticipated that approximately 50 mm of settlement attributable to the elastic compression of the native subsoil will be realized. These settlements will be elastic in nature and hence will occur almost immediately. Settlements within the fill itself can amount to approximately 25 to 50 mm due to its self weight. These settlements will be immediate in nature if a granular fill material is used. For fill materials that are cohesive, settlements will be more time dependent, but should be realized within a three (3) month time period following the fill placement.

(c) Backfill to Structure

It is recommended that Granular 'A' or Granular 'B' 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 Table 6 below.

Table 6 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ) (Unfactored)	35°	30°
Unit Weight (kN/m ³) γ	22.8	21.2
*Coefficient of Active Earth Pressure (Ka)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure at Rest (Ko)		
- S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

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

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

(d) Embankment Construction

In the construction of the embankment fills, all organic material should be excavated for their full depth within the plan limits prior to fill placement. The presence of organics occurs generally within the surficial 1 to 1.5 m and is more evident on the east side of the existing Shaver Road at the location of the existing wetland area. To facilitate any excavation required within the cohesionless surficial organic enriched sandy silt to silt, a dewatering scheme will be required. One method of achieving this subexcavation is to excavate an initial pilot trench within the central area of the planned area and sump pumping the drained water seepage from this trench. the excavation can then proceed laterally in sequence until the entire area is effectively drained

to facilitate the excavation. This dewatering scheme, illustrated on Figure 5 in the Appendix, controls and contains any soil sloughing within the confines of the excavation.

The contractor shall submit his proposal of subexcavation and dewatering for review by this office prior to construction.

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

The subgrade shall be effectively proof-rolled prior to fill placement. In addition, in view of the saturated cohesionless nature of the surficial soils, it may be necessary to place a granular blanket on the surface following subexcavation to enable the execution of the various construction activities.

The approach fills shall be placed behind the abutment walls in such a manner that the maximum difference in elevation at either abutment does not exceed 300 mm at any time. Heavy compaction equipment should not be used behind the abutment walls within a lateral distance equal to the current height of fill above the wall footing in order to avoid imposing damages or excessive deflection to the wall during the fill placement.

4) Construction Considerations

Dewatering

As previously discussed, any excavation within the native surficial cohesionless sandy silts and silts will require a dewatering scheme. A dewatering scheme is therefore required not only for any subexcavation within the approach fill area, but also for any pile cap construction within this material. It is hereby reiterated that a dewatering scheme can be avoided should the abutments be perched within the approach fill material. Alternatively, two dewatering schemes are suggested below. The alternative that is the most economical and technically feasible shall be selected. It is recommended that the contractor submit any dewatering proposal for review by this office.

Gravity Drainage

A gravity drainage scheme within an oversized excavation similar to the procedure discussed previously in conjunction with the approach area subexcavation is also applicable for the excavation of pile caps. Drainage can be achieved by employing perimeter ditches within a gravity system in conjunction with a sumping discharge system. An illustration of this scheme is provided on Figure 6 in the Appendix.

Cofferdam Construction


Alternatively, dewatering may be achieved by carrying out the excavation from within an enclosure formed of interlocking steel sheeting (cofferdam). In order to prevent 'boiling' at the base of the excavation, it is recommended that the sheeting be driven to a depth below the footing base equal to the unbalanced hydrostatic head existing above this level (see Figure 7).

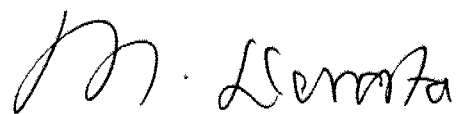
MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, and L. Dametto, Engineering Student, utilizing equipment owned and operated by Atcost Soil Drilling Ltd. Logging of rock core in the laboratory was carried out by D. Williams, Petrographer.

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

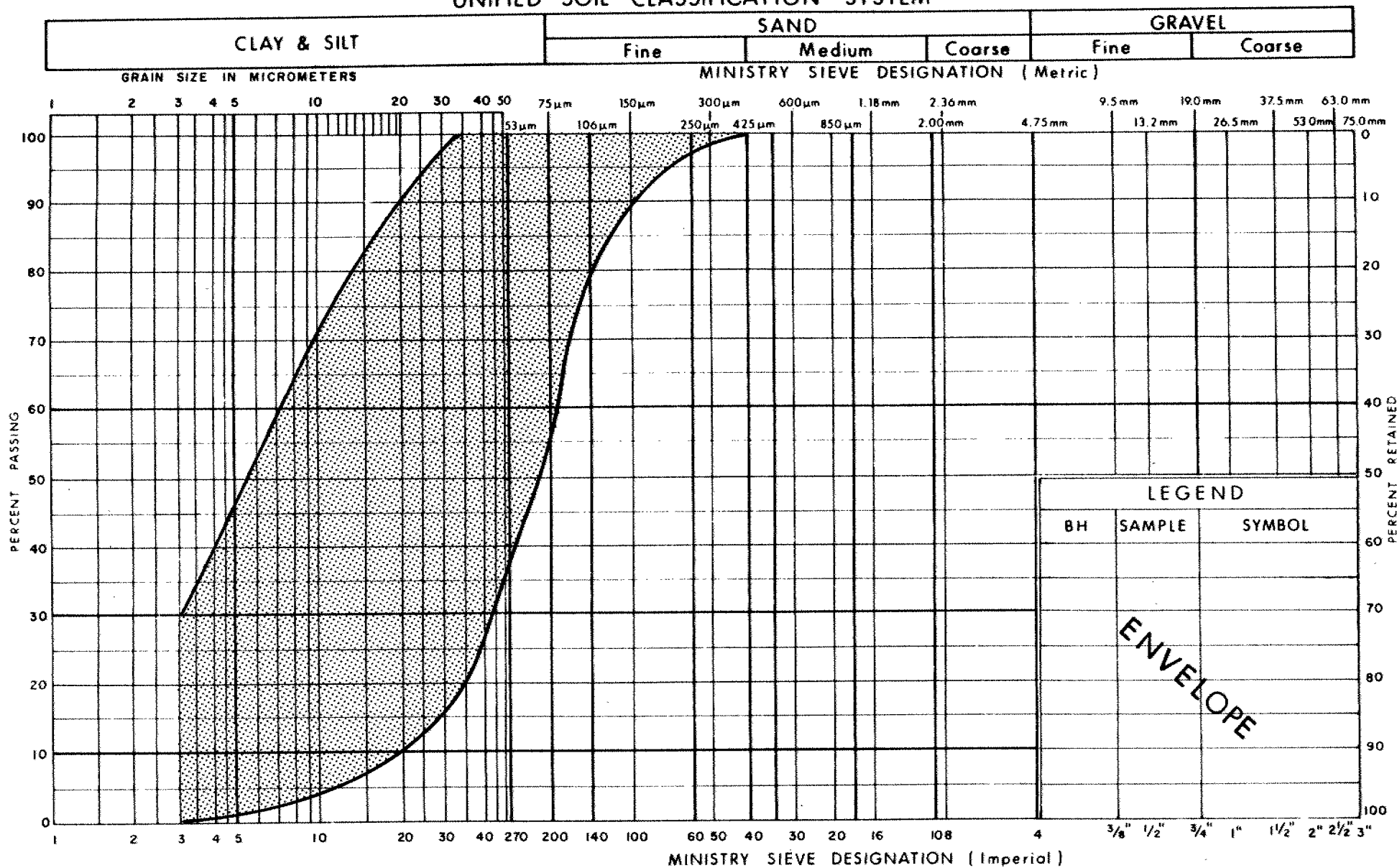



T. Sangiuliano, P.Eng.
Foundation Engineer


M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



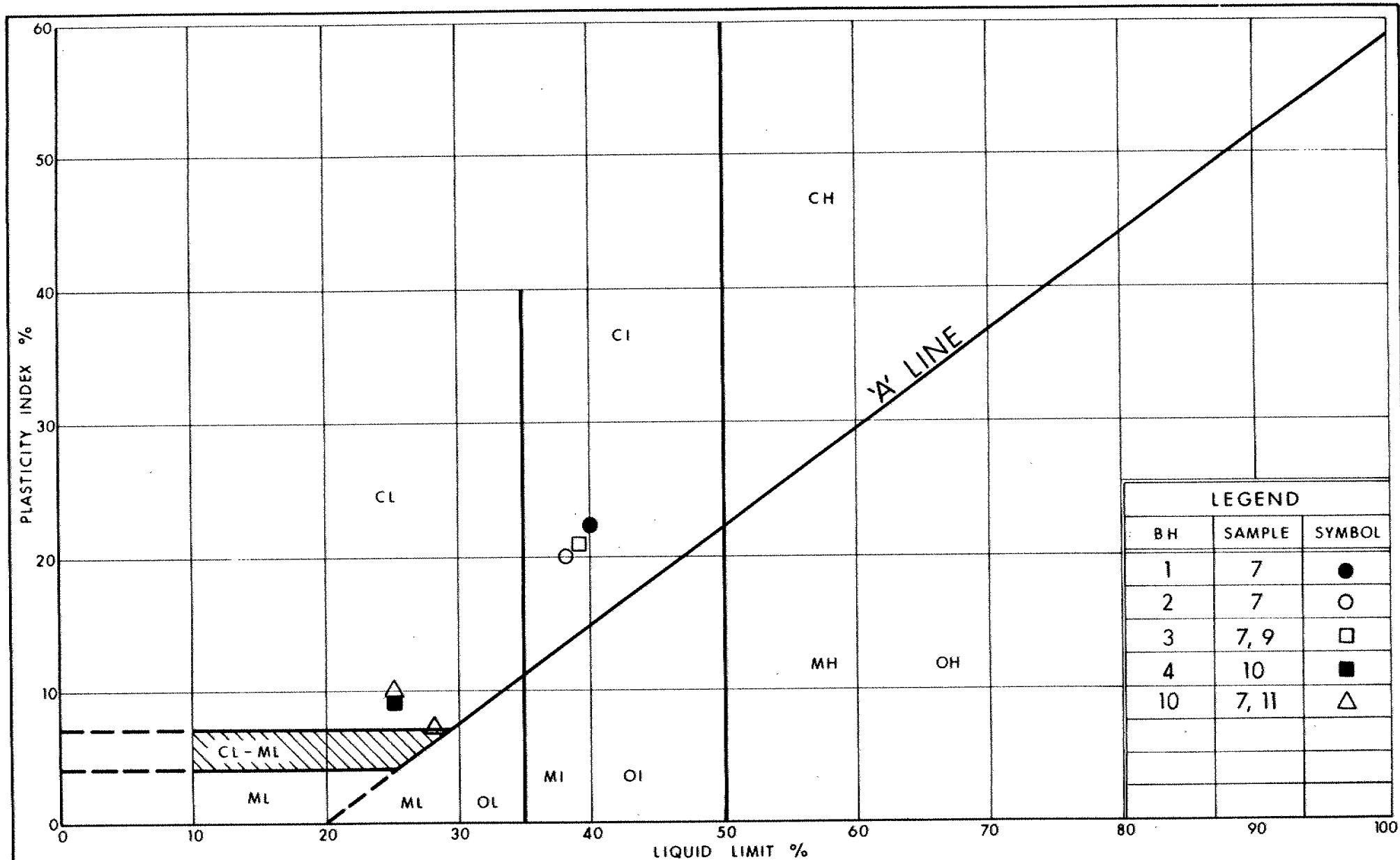
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

SANDY SILT TO SILT

FIG No 1

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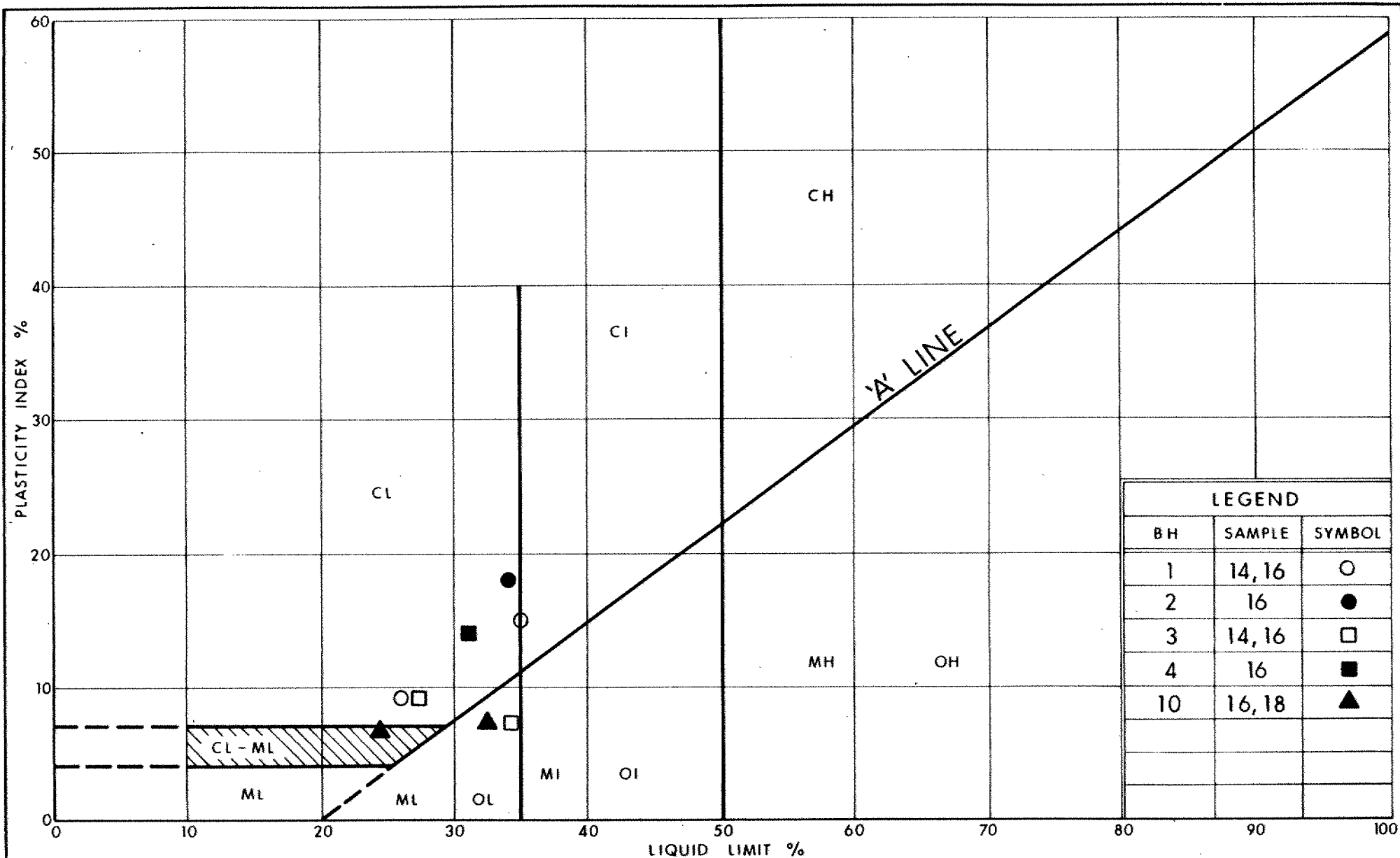
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Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT TO SILTY CLAY LAYERS INTERBEDDED WITHIN SANDY SILT TO SILT

FIG No 2

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Ontario

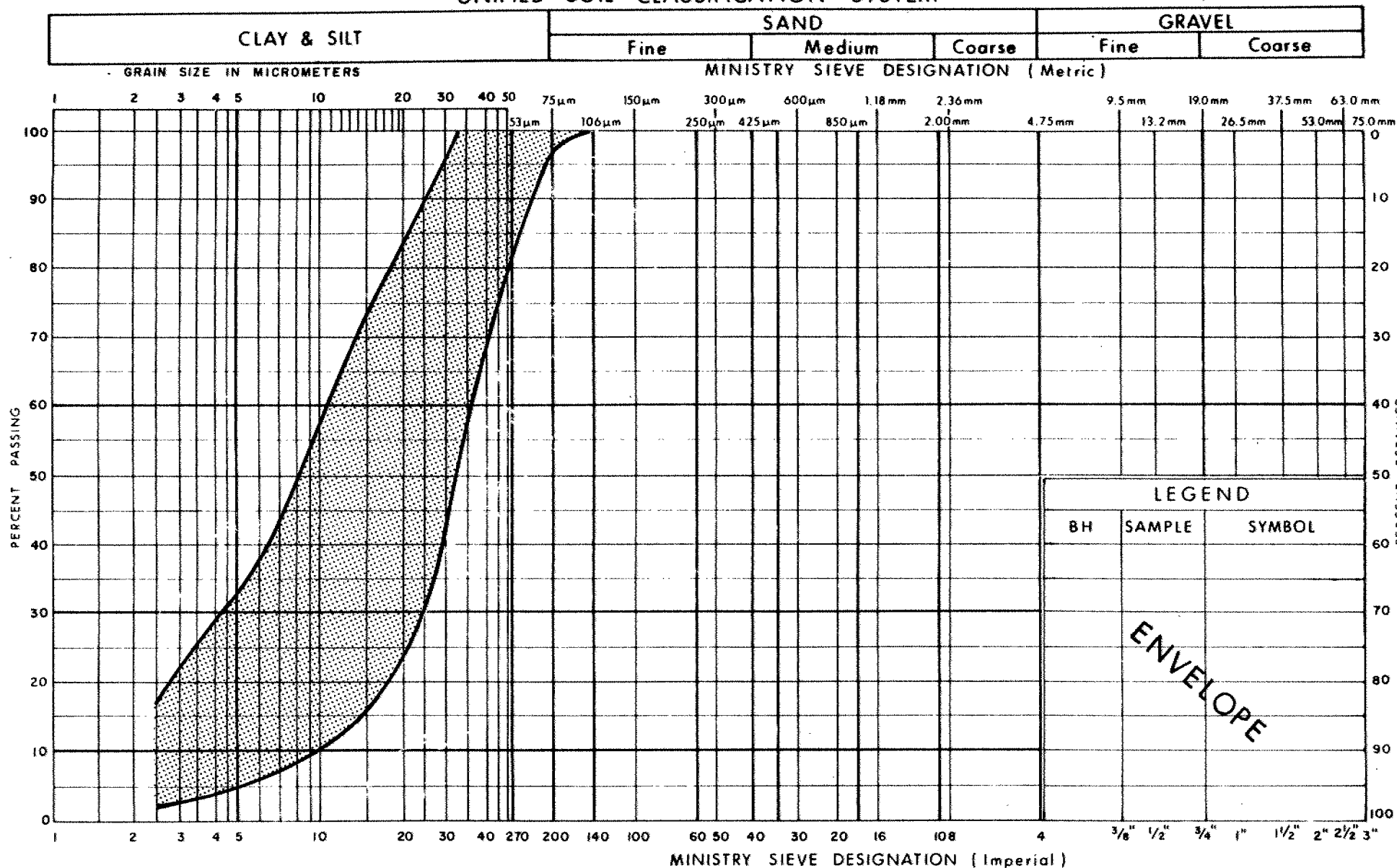
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PLASTICITY CHART CLAYEY SILT

FIG No 3

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UNIFIED SOIL CLASSIFICATION SYSTEM



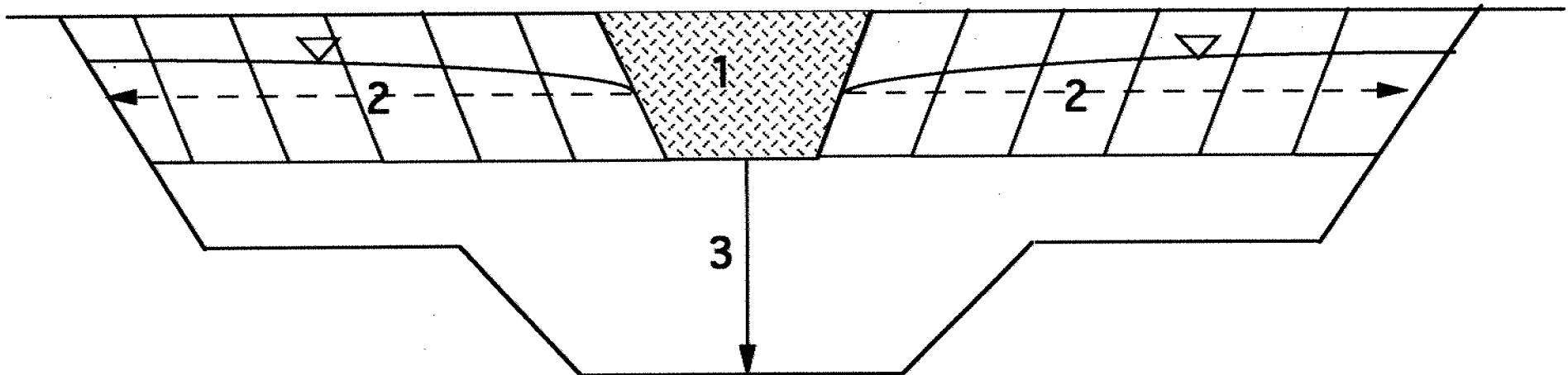
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GRAIN SIZE DISTRIBUTION
SILT LAYERS
INTERBEDDED IN CLAYEY SILT STRATUM

FIG No 4

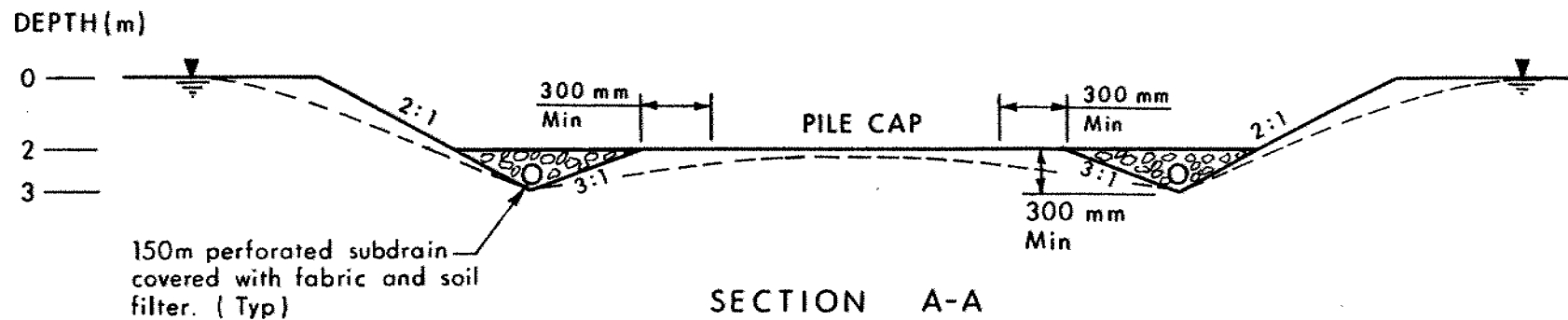
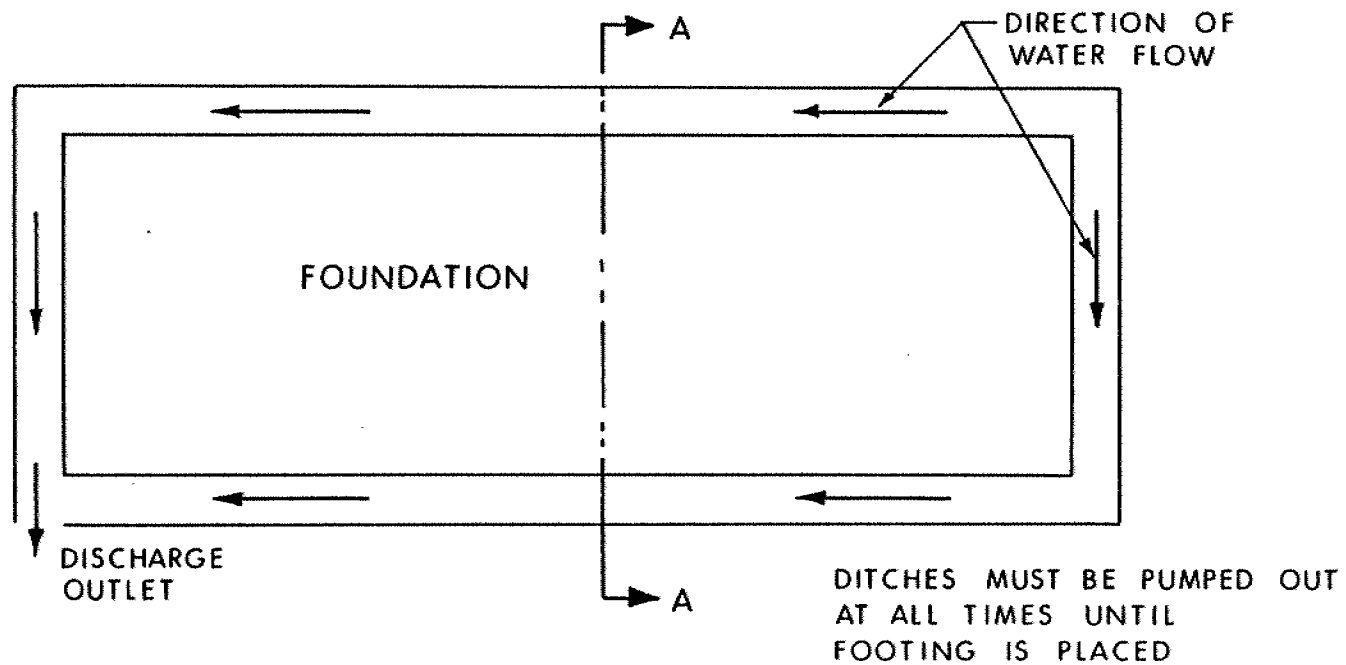
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FIG. 5 - GRAVITY DRAINAGE SCHEME



- 1 EXCAVATE INITIAL SUMP PUMP TRENCH AND ALLOW GRAVITY DRAINAGE
- 2 EXCAVATE Laterally TO EDGE OF EXCAVATION, ALLOWING GRAVITY DRAINAGE IN PROCESS
- 3 PROGRESS TO DESIGNED DEPTH BY REPEATING (1) AND (2)

WP 65-67-03

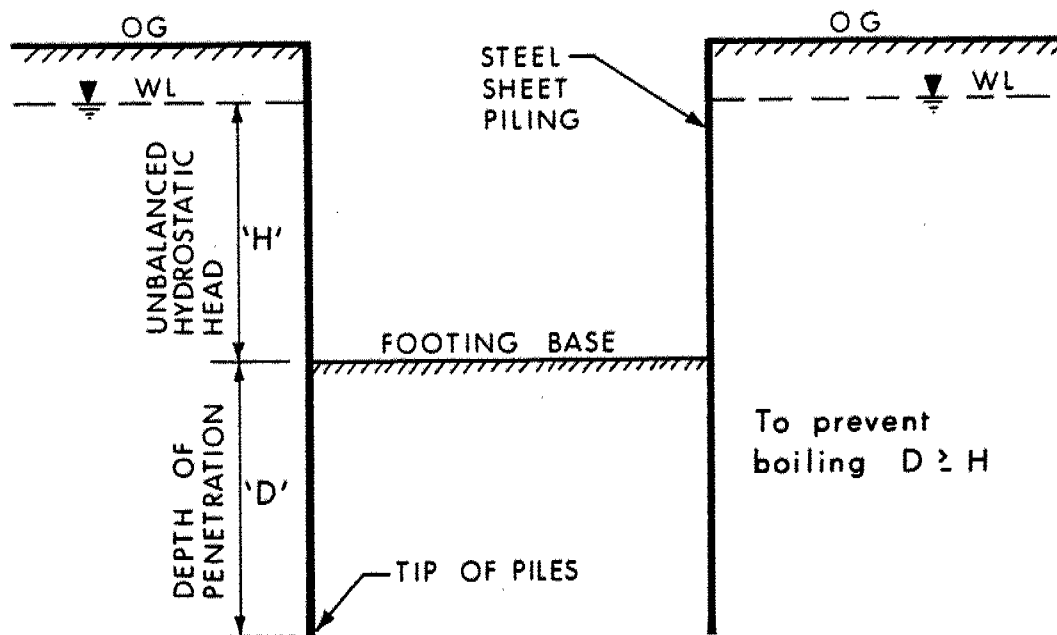


SECTION A-A
(NTS)

DEWATERING SCHEME - PERIMETER DITCHES

WP 65-67-03

FIG 6



COFFERDAM CONSTRUCTION

WP 65-67-03

FIG 7

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 289.4; E 262 872.8 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS
DATUM Geodetic DATE 91 07 02-04 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
232.0	Ground Surface															
0.0	trace Organics Brown ----- Grey		1	SS	13											0 26 74 0
			2	SS	5		230						o			
			3	SS	5											
			4	SS	5											
			5	SS	9		228									
			6	SS	10								o			0 5 95 0
	Sandy Silt to Silt with random layers of Clayey Silt to Silty Clay		7	SS	6		226									
			8	SS	18											
	Loose to Compact		9	SS	28		224									
			10	SS	16		222									
			11	SS	45		220						o			0 21 77 2
	----- Dense -----		12	SS	10		218									
			13	SS	29		216						o			0 1 95 4
213.7			14	SS	20		214									
18.3			15	SS	16		212									
	Clayey Silt with layers of Silt		16	SS	11		210						o			0 0 89 11
	Grey, Very Stiff		17	SS	*		208									
204.6			18	RC	REC		206									
27.4	Bedrock - Dolostone						204									
203.0	Light Grey, Unweathered, Medium Strong				100%											ROD = 69%
29.0	End of Borehole * Sampler Bouncing															

RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 268.2; E 262 876.8 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring, Cone COMPILED BY TS
DATUM Geodetic DATE 91 06 28 to 91 07 02 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
231.4	Ground Surface													
0.0														
	trace Black Organics		1	SS	15		230							0 33 67 0
			2	SS	10									
	Brown		3	SS	4									
	Grey		4	SS	5		228							0 3 94 3
			5	SS	7									
			6	SS	5									
			7	SS	7		226							
	Sandy Silt to Silt with random layers of Silty Clay		8	SS	15		224							
			9	SS	18		222							
	Loose to Dense		10	SS	7									
			11	SS	10		220							
			12	SS	12		218							0 2 93 5
			13	SS	36		216							
							214							
213.1			14	SS	18		212							0 0 87 13
18.3							210							0 0 89 11
	Clayey Silt with layers of Silt		15	SS	14		208							
	Stiff to Very Stiff		16	SS	10		206							
204.4			17	SS	**		204							
27.0	Bedrock - Dolostone		18	RC	REC 97%									RQD = 92%
	Light Grey, Unweathered, Medium Strong		19	RC	REC 100%									RQD = 88%
202.0														
29.4	End of Borehole													
	* GWL not established ** Sampler Bouncing													

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 310.6; E 262 887.4 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring, Cone COMPILED BY TS
DATUM Geodetic DATE 91 06 27 to 91 07 02 CHECKED BY PP

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
232.1	Ground Surface													
0.0														
	trace organics		1	SS	12									0 45 55 0
	Brown		2	SS	8		230							0 4 96 0
	Gray		3	SS	9									
			4	SS	10									
			5	SS	9		228							
			6	SS	8									
			7	SS	10		226							
	Sandy Silt to Silt with random layers of Silty Clay		8	SS	40									0 5 85 10
	Loose to Dense		9	SS	31		224							
			10	SS	10									
			11	SS	9		222							
			12	SS	26		220							
			13	SS	26		218							
							216							0 1 95 4
213.8							214							
18.3	Clayey Silt with layers of Silt		14	SS	33		212							0 1 88 11
	Very Stiff		15	SS	22		210							
			16	SS	25		208							
205.1							206							
27.0	Bedrock - Dolostone Light Gray, Unweathered, Medium Strong		18	RC	REC 100%		204							RQD = 72%
			19	RC	REC 100%									RQD = 91%
202.1														
30.0	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 265.6; E 282 897.6 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger, BW Casing, Washboring, Rock Coring COMPILED BY TS
 DATUM Geodetic DATE 91 07 03-04 CHECKED BY PP

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		
230.7	Ground Surface												
0.0	some Organics		1	SS	2	230							
	Black, Very Loose		2	SS	11								
	Grey		3	SS	11	228							
			4	SS	15								0 3 97 0
			5	SS	16								
			6	SS	24	226							
	Compact		7	SS	49								
	Dense to Very Dense		8	SS	49	224							
			9	SS	39								
	Sandy Silt to Silt with random layers of Clayey Silt		10	SS	55	220							0 0 71 29
			11	SS	72								
			12	SS	50	218							
			13	SS	64								
						216							0 1 95 4
						214							
212.4			14	SS	20	212							
18.3	Clayey Silt with layers of Silt					210							
	Grey, Very Stiff		15	SS	41								
						208							
			16	SS	22	206							
204.3													
26.4	Bedrock - Dolostone		17	RC	REC 100%	204							
202.8	Light Grey, Unweathered, Medium Strong												RQD = 83%
27.9	End of Borehole												

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 276.2; E 282 836.8 ORIGINATED BY TS
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 07 05 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
234.2	Ground Surface																
0.0																	
	trace Organics		1	SS	7												
			2	SS	12												
	Brown		3	SS	14												
	Grey		4	SS	7												
	Silt, some Sand to Silt with random layers of Clayey Silt		5	SS	9												
			6	SS	13												
	Loose to Compact		7	SS	29												
221.6			8	SS	25												
12.6	End of Borehole																

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 277.8; E 262 920.4 ORIGINATED BY LD
 DIST 4 HWY 403 BOREHOLE TYPE HS Auger COMPILED BY TS
 DATUM Geodetic DATE 91 07 05 CHECKED BY PP

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					
230.9	Ground Surface																
0.0																	
	trace Organics		1	SS	11		230										
			2	SS	12		228										
	Sandy Silt to Silt with random layers of Clayey Silt		3	SS	14		226										
	Grey, Compact		4	SS	15		224										
	Very Dense		5	SS	66		222										
			6	SS	24		220										
			7	SS	16												
218.3			8	SS	22												
12.6	End of Borehole																

RECORD OF BOREHOLE No 10 *

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Co-ords: N 4 785 288.3; E 262 896.1 ORIGINATED BY BYV
DIST 4 HWY 403 BOREHOLE TYPE HS Auger, Dynamic Cone Test COMPILED BY BYV
DATUM Geodetic DATE 76 02 25-26 CHECKED BY PP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
230.9	Ground Surface												
0.0	trace organics		1	SS	6								0 27 70 3
			2	SS	8								0 21 77 2
			3	SS	12								
			4	SS	8								
			5	SS	10								
			6	SS	6								0 1 92 7
			7	SS	6								
			8	TW	PH							20.3	
	Silt, some Sand to Silt with random layers of Clayey Silt		9	TW	PH							19.2	0 3 96 1
	Loose to Compact		10	SS	18								0 0 98 2
			11	SS	10								
			12	TW	PH								0 28 71 1
			13	TW	PH								
			14	SS	25								
			15	SS	13								0 0 98 2
212.6			16	SS	18								0 0 55 45 0 4 94 2
18.3	Clayey Silt with layers of Silt		17	SS	12								0 0 99 1
	Stiff to Very Stiff												
206.1			18	SS	9								
24.8	End of Borehole												
	* Formerly BH 14 (WP 65-67-01)												

ROCK CORE DESCRIPTION WP 65-67-03

Page 1 of 1

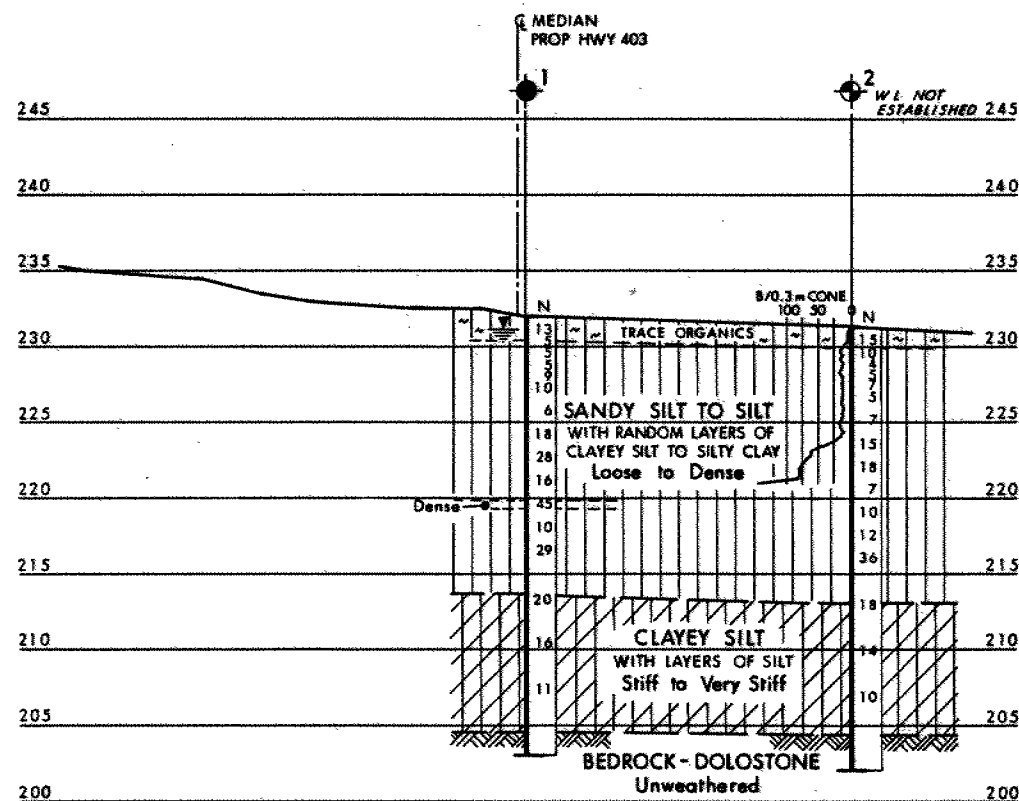
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	18	27.43-28.96	100	69	27.43-28.96	DOLOSTONE with stylolites and abundant vugs containing calcite crystals, light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to dipping, undulating, smooth to rough.
2	18	27.03-27.84	97	92	27.03-29.36	DOLOSTONE with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures wide to very close spaced, flat to dipping, undulating, smooth to rough.
	19	27.84-29.36	100	88		
3	18	26.97-28.50	100	72	26.97-30.02	DOLOSTONE with stylolites and abundant vugs containing calcite crystals, light grey to light olive grey to medium dark grey; fine to medium grained; medium strong; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to dipping, undulating, smooth to rough.
	19	28.50-30.02	100	91		
4	17	26.37-27.89	100	83	26.37-27.89	DOLOSTONE with stylolites and abundant vugs containing calcite crystals (including calcite-gypsum-sphalerite-filled vug 5 cm in diameter at 27.79 m), light olive grey to medium 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.

*CR = CORE RECOVERY

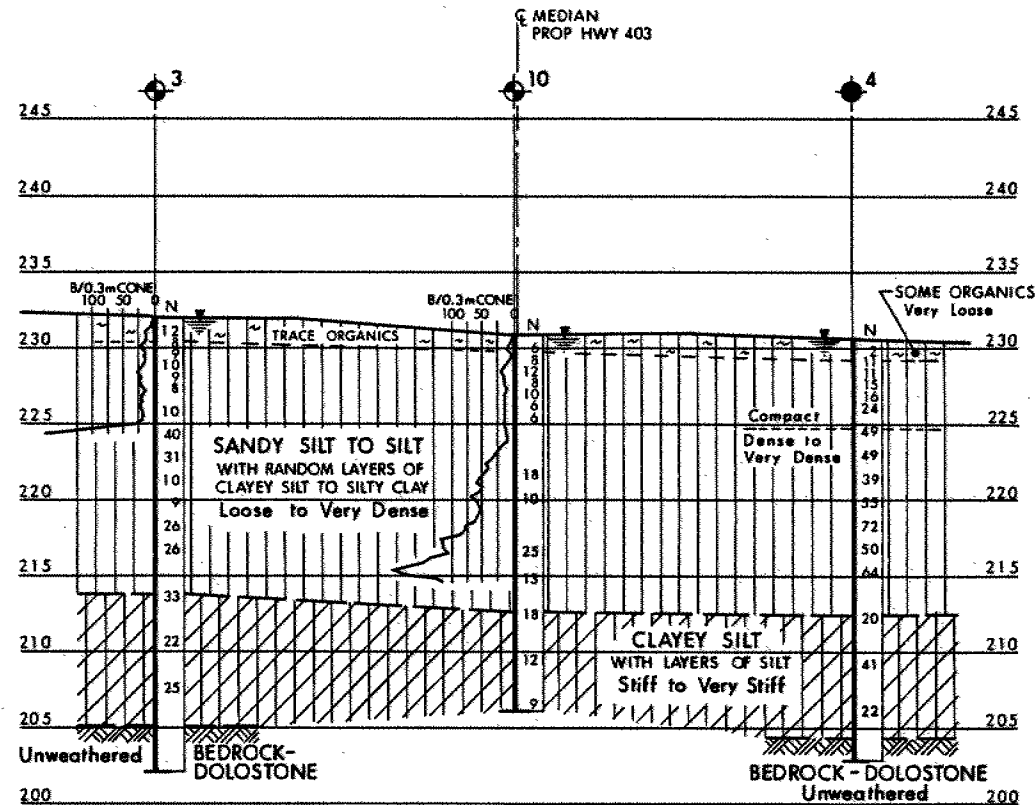
*RQD = ROCK QUALITY DESIGNATION

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

Logged by: DAW, Soils and Aggregates Section

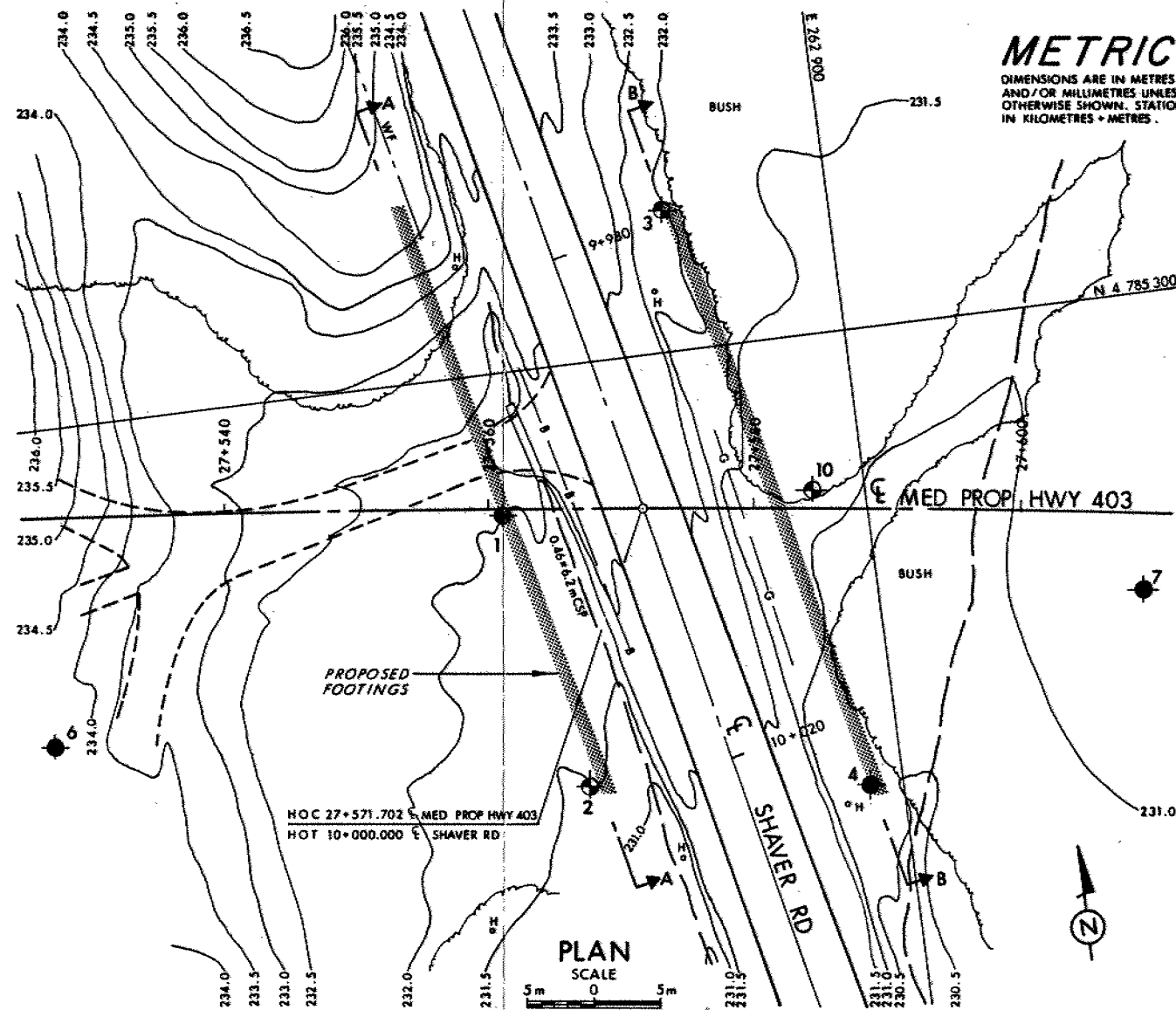


SECTION A-A



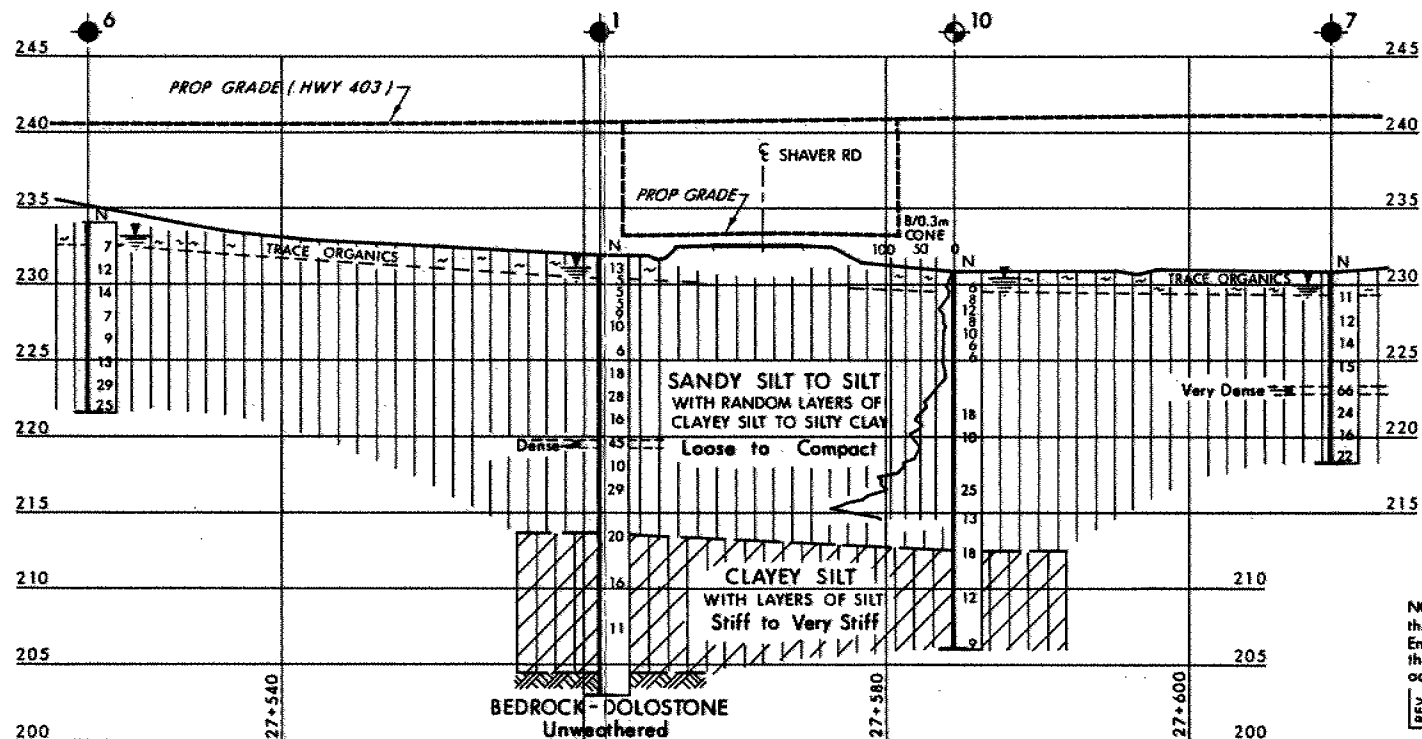
SECTION B-B

SCALE
5m 0 5m



PLAN

SCALE
5m 0 5m



PROFILE PROPOSED HWY 403 (MED)

SCALE
5m 0 5m

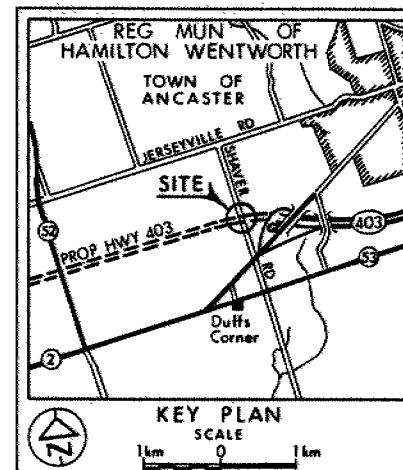
CONT No
WP No 65-67-03

SHAVER ROAD

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 1976 02 and 1991 06 & 07

No.	ELEVATION	CO-ORDINATES NORTH	EAST
1	232.0	4785 289.4	262 872.8
2	231.4	4785 268.2	262 876.8
3	232.1	4785 310.6	262 887.4
4	230.7	4785 265.6	262 897.6
6	234.2	4785 276.2	262 836.8
7	230.9	4785 277.8	262 920.4
10	230.9	4785 288.3	262 896.1

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
------	------	----	-------------

Geocres No 40 P1-84

HWY No 403	SUBMD T5	CHECKED 75	DATE 1991 10 16	DIST 4
DRAWN RS	CHECKED 61	APPROVED		SITE 36-239
				DWG 656703-A

FILE COPY
ADDENDUM
TO ORIGINAL
REPORT

FOUNDATION INVESTIGATION REPORT

For

Highway 403 and Shaver Road Underpass

W.P. 65-67-03, Site 36-259

Central Region

GEOCREG # AOP1-84

CONT 96-38

Introduction

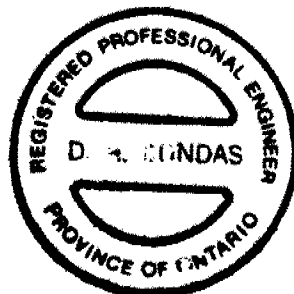
The attached report, dated October 1991, was prepared based on a different configuration for the structure. In May 1995, three additional borings were advanced (BH's 100, 101 and 108) to obtain information required for the present design. The new boreholes are appended and shown in plan and in cross section on Drawing No. 2, Sheet 397, of the Contract Drawings. The borehole data from BH's 100, 101 and 108 has not been incorporated into the text component of the Foundation Investigation Report.

Miscellaneous

The fieldwork for the foundation investigation carried out in July 1991 was supervised by T. Sangiuliano, Foundation Engineer and L. Dametto, Engineering Student. The drilling equipment was owned and operated by Atcost Soil Drilling Limited. Rock core identification and logging was carried out by D. Williams, Petrographer, Soils & Aggregates Section.

The subsequent fieldwork was conducted in May 1995 under the supervision of K. Ahmad, Foundation Engineer and Deanna Brooker, Engineering Student, utilizing drilling equipment owned and operated by K & S Drilling.

The attached report was prepared by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



D. Dundas

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

RECORD OF BOREHOLE No 100

1 OF 1

METRIC

W.P. 85-67-03 LOCATION Coords: N 4 785 249.5; E 262 883.4 ORIGINATED BY DB
 DIST CR HWY 403 BOREHOLE TYPE SS Auger COMPILED BY DB
 DATUM Geodetic DATE 1995 05 23 CHECKED BY KA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
230.2	Ground Surface												
0.0	Organic Clayey Silt, some Sand dk. brown, moist		1	SS	1								
			2	SS	1								
			3	SS	5								
	Silt with random layers of Silty Clay		4	SS	4								
			5	SS	5								
			6	SS	15								
	Silty Clay		7	SS	9								
			8	SS	8								
	very loose to compact Greyish-Brown to Brown		9	SS	17								
220.6			10	SS	22								
9.6	End of Borehole												

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Coords: N 4 785 328.9; E 262 868.4 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE HS Auger, NX Casing, Washboring COMPILED BY DB
DATUM Geodetic DATE 1995 06 02 CHECKED BY KA

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	WATER CONTENT (%)		
233.9	Ground Surface														
0.0															
			1	SS	12		232								0 12 83 5
			2	SS	26		230								
			3	SS	11		228								0 5 90 5
	Sandy Silt to Silt		4	SS	9		226								
	with random layers of Silty Clay		5	SS	12		224								
	Greyish-Brown to Brown		6	SS	18		222								0 11 85 4
	Loose to Dense		7	SS	19		220								
			8	SS	10		218								
			9	SS	33		216								0 3 88 9
			10	SS	10		214								
213.5							212								
20.4			11	SS	22		210								
	Silty Clay to Clayey Silt		12	SS	34		208								
	with layers of Silt		13	SS	9		206								
	stiff to hard														
204.4															
29.5	End of Borehole * Tricone Bouncing Probable Bedrock														

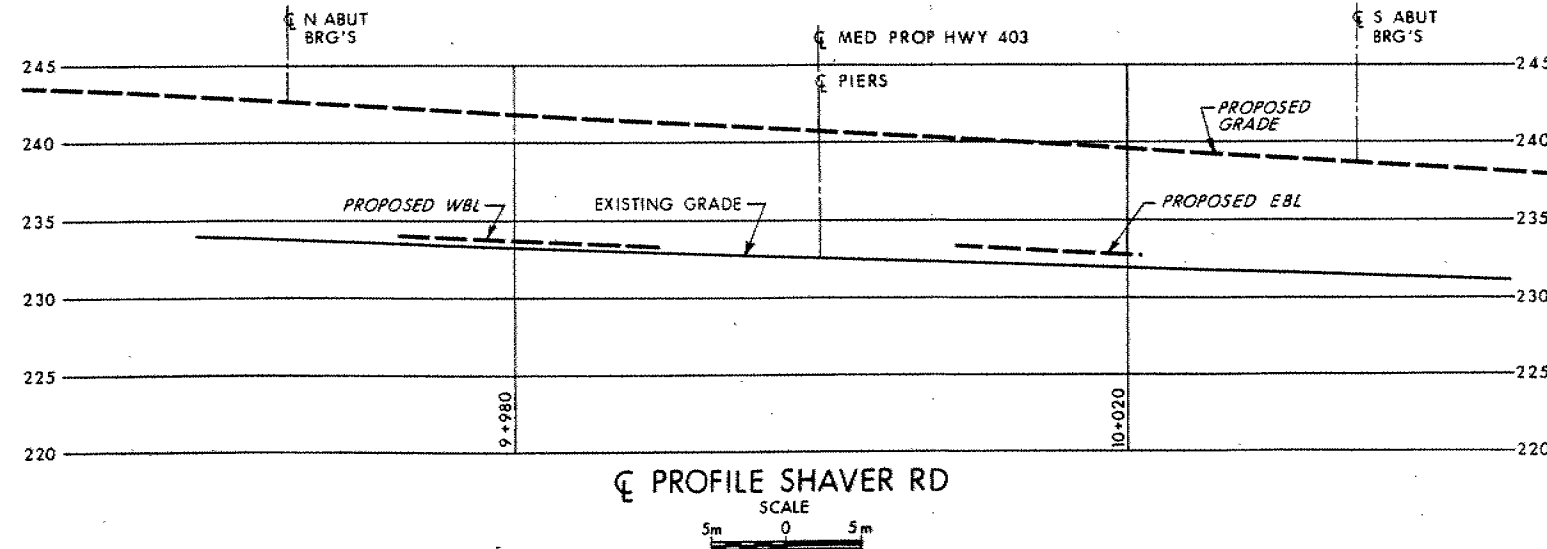
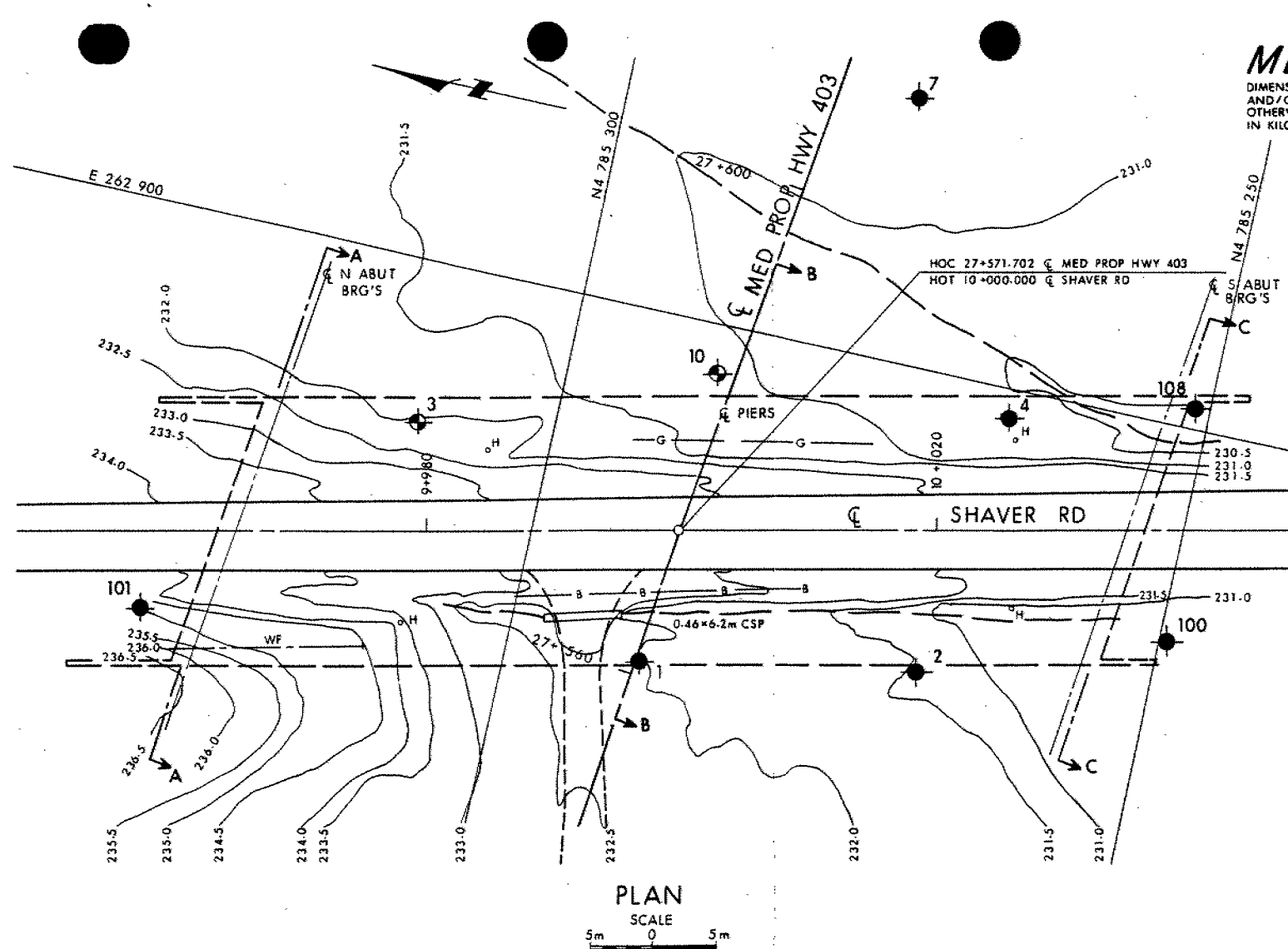
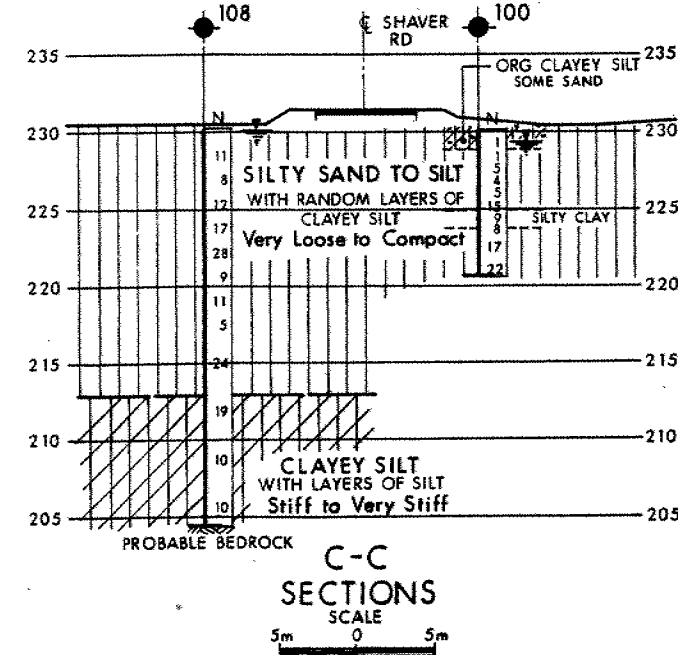
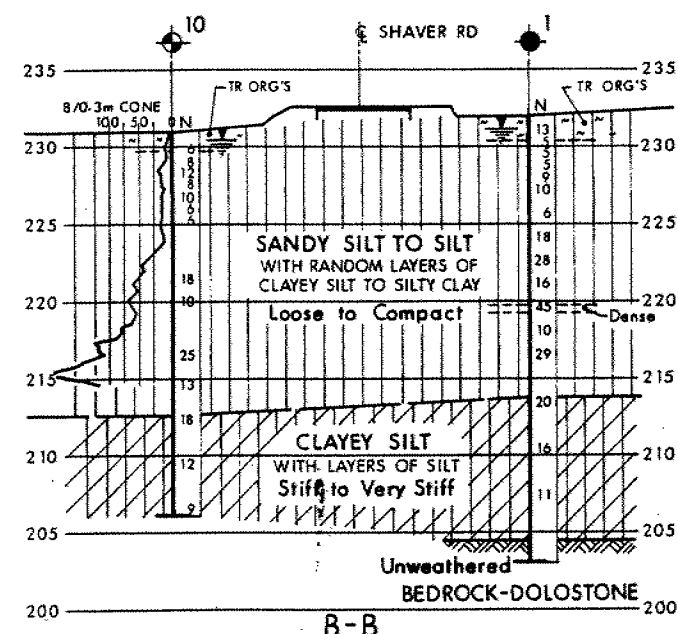
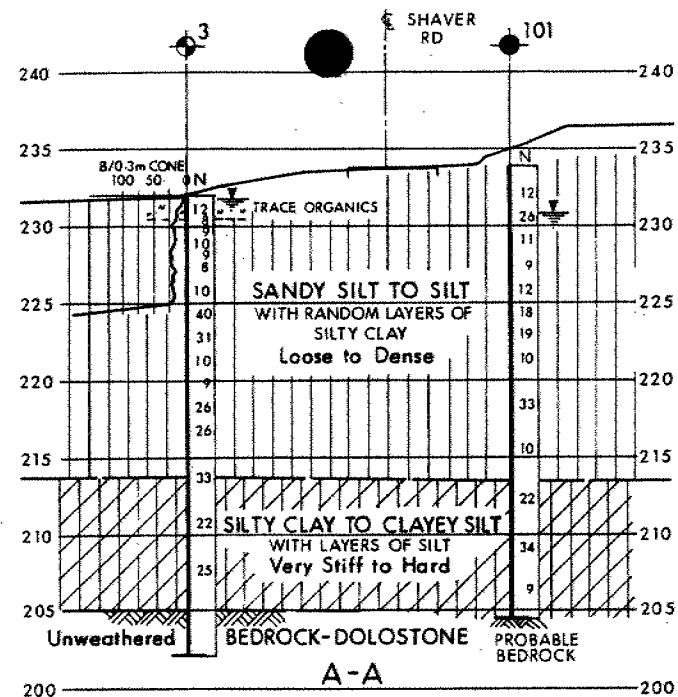
RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 65-67-03 LOCATION Coords: N 4 785 251.3; E 262 901.6 ORIGINATED BY DB
DIST CR HWY 403 BOREHOLE TYPE HS Auger, NX Coaming, Washboring COMPILED BY DB
DATUM Geodetic DATE 1995 06 01 CHECKED BY KA

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				
230.3	Ground Surface																					
0.0	Silt with random layers of Clayey Silt Greyish-Brown to Brown loose to compact		1	SS	11		230										0 3 93 4					
								228														
			2	SS	8			226														
			3	SS	12			224										0 1 88 11				
			4	SS	17			222														
			5	SS	28			220														
			6	SS	9			218														
			7	SS	11			216														
			8	SS	5			214														
			9	SS	24		212										0 3 95 2					
212.9	Clayey Silt with layers of Silt Greyish-Brown to Brown stiff to compact		10	SS	19		210															
17.4								208														
			11	SS	10			206														
			12	SS	10																	
204.4	End of Borehole • Tricone Bouncing Probable Bedrock																					
25.9																						



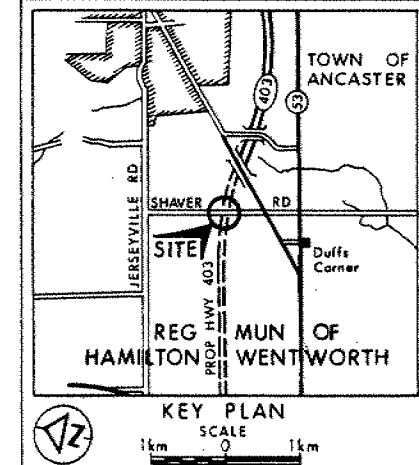
NOTES:
 - For Subsoil information of BH-2, 4, 6 & 7 refer to Record of Borehole sheets
 - BH-6 is outside boundaries of Plan limits

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

CONT No 96-38
 WP No 65-67-03

SHAVER RD UNDERPASS
 BORE HOLE LOCATIONS & SOIL STRATA

SHEET
 397



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
 1976 02, 1991 06, 1991 07,
 1995 05 and 1995 06

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	232.0	4785 289.4	262 872.8
2	231.4	4785 268.2	262 876.8
3	232.1	4785 310.6	262 887.4
4	230.7	4785 265.6	262 897.6
6	234.2	4785 276.2	262 836.8
7	230.9	4785 277.8	262 920.4
10	230.9	4785 288.3	262 896.1
100	230.2	4785 249.5	262 883.4
101	233.9	4785 328.9	262 868.4
108	230.3	4785 251.3	262 901.6

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

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

REV	DATE	BY	DESCRIPTION
1			

Geocres No 40P1-84

HWY No 403	DIST CR
SUBMD KA [CHECKED] DATE 1995 08 18	SITE 36-2597V2
DRAWN DT [CHECKED] APPROVED	DWG 2



memorandum

To: V.F. Boehnke, P. Eng.
Head, Structural Section
Central Region

1995 03 23

Attn.: John K. Lam, P. Eng.


From: Pavements and Foundation Section
Room 315, Central Building
Downsview, Ontario

Re: Preliminary General Arrangement Drawings
Shaver Road Underpass NBL & SBL, Site 36-259
Highway 403, Hamilton-Wentworth
W.P. 65-67-03, Hwy 403, Central Region

We have reviewed the General Arrangement Drawings for the above mentioned project. It is understood that now there will be a two span underpass structure rather than a single span overpass structure as originally planned. Consequently, the new bridge orientation will be perpendicular to the original scheme. Although, the Foundation investigation and recommendations were based on the original scheme, there will be no change to the Foundation recommendations due to the revised scheme.

As advised to Andrew Burgess of Structural Office on March 1, 1995, the bridge should be designed as per the Foundation recommendations provided for the overpass structure. However, supplemental boreholes may be required to confirm our design assumptions as well as to provide sufficient subsurface information for the contract package.

Please submit a request to authorize us to carry out this work.


K.S.Q. Ahmad, P. Eng.
Foundation Engineer

For

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

memorandum



To: V. Boehnke
Head, Structural Section
Central Region

Attn: J. Lam
Senior Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Re: General Arrangement Drawing Review
Shaver Road Overpass at Highway 403
W.P. 65-67-03, Site 36-259
District 4, Burlington

Date: 92 04 16

The General Arrangement Drawing for the above mentioned structure has been reviewed and the following comments pertaining to the foundation and geotechnical related items are provided.

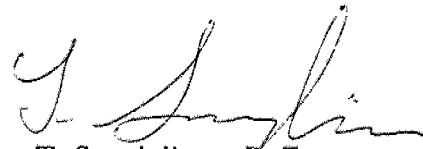
1. Approach Embankments

As indicated in the original foundation investigation report, approach embankments exceeding eight(8) metres in height shall be constructed at 2H:1V slopes with a nominal 2 metre mid-height berm to ensure the internal stability of the approach fills. It appears that the approach slopes at the south end of the structure do not satisfy this requirement.

It is also recommended that a comment should be included on the final design drawings that states that all loosened and/or organic material with the plan limits of the approach embankments shall be removed prior to embankment fill placement.

2. Reinforced Earth Retaining Wall Specifications

It is hereby reminded that a non standard special provision outlining the scope, material and construction of the reinforced earth retaining wall shall be included in the contract documents.


T. Sangiuliano, P. Eng.
Foundation Engineer

for

P. Payer, P. Eng.
Senior Foundation Engineer

memorandum



To: V. Boehnke
Head, Structural Section
Central Region
4th Floor, Atrium Tower

Date: 92 01 28

Att: D. Wong

From: Foundation Design Section
Room 315, Central Building

Re: Hwy 403 and Shaver Rd. Overpass
WP 65-67-03, District 4, Burlington
Reinforced Earth Wall Proposal

A facsimile copy of Reinforced Earth Company Ltd. proposal as outlined in their letter dated January 27, 1992, has been reviewed by this office. The proposal designed to accommodate immediate settlements anticipated as a result of the elastic compression of the native subsoils at the site, entails a construction sequence that enables these settlements to be realized prior to connecting the reinforcing steel strips into the ballast wall.

From a foundation and geotechnical perspective, this proposal is deemed acceptable.

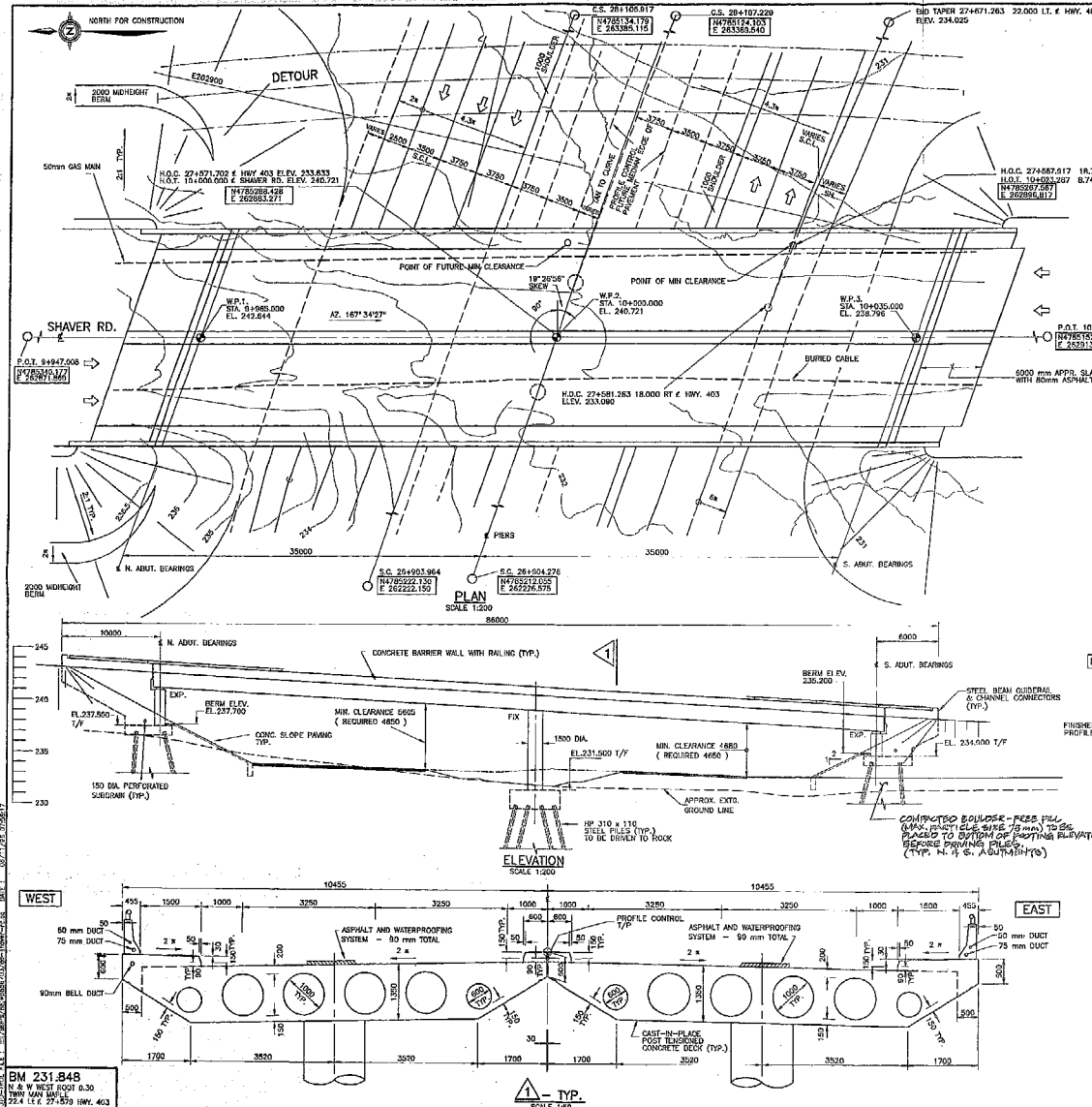
If you have any further questions regarding this proposal, please do not hesitate to contact this office.

A handwritten signature in dark ink, appearing to read "T. Sangiuliano".


T. Sangiuliano, P. Eng.
Foundation Engineer

for

P. Payer, P. Eng.
Sr. Foundation Engineer



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

CONT No 96-38 WP No 65-67-03	
SHAWER ROAD UNDERPASS NBL & SBL HWY 403, HAMILTON-WENTWORTH GENERAL ARRANGEMENT	SHEET 396

GENERAL NOTES

CLASS OF CONCRETE

DECK & PIER COLUMNS	35 MPa
REMAINDER	30 MPa

CLEAR COVER TO REINFORCING STEEL

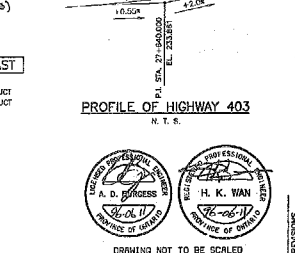
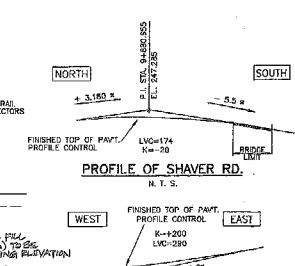
FOOTINGS	100 ± 25
DECK: TOP	70 ± 20
BOTTOM	50 ± 10
REMAINDER (UNLESS OTHERWISE SPECIFIED)	70 ± 20

REINFORCING STEEL
REINFORCING STEEL SHALL BE GRADE 400 UNLESS NOTED OTHERWISE.
BAR MARKS WITH PUFFINBERGER OR CLIPPER "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.
THE EXISTING ACTUAL HYDRO CABLES, BURIED CABLES AND THE 600mm GAS MAIN IN THE VICINITY OF THE BRIDGE STRUCTURES SHALL BE RELOCATED BY HIGHWAY ENGINEERING PRIOR TO CONSTRUCTION.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOUNDATION & PILING LAYOUT
4. FOOTING & PIER BENT
5. NORTH ASSEMBLY
6. SOUTH ASSEMBLY
7. MINOR DETAILS I
8. MINOR DETAILS II
9. DECK DETAILS
10. LONGITUDINAL TENDONS I
11. LONGITUDINAL TENDONS II
12. TRANSVERSE TENDONS
13. DECK REINFORCEMENT I
14. DECK REINFORCEMENT II
15. DECK REINFORCEMENT III
16. DECK REINFORCEMENT IV
17. JOINT ANCHORAGE AND ANCHOURING WITH INJECTION HOSE SYSTEM-ASSEMBLY
18. JOINT ANCHORAGE AND ANCHOURING WITH INJECTION HOSE SYSTEM-DETAILS
19. BARRIER WALL WITH RAILING
20. RAILING FOR BARRIER WALL
21. 6000 mm APPROACH SLAB
22. DETAILS OF CONG. SLOPE PAVING
23. STANDARD DETAILS
24. ELECTRICAL EMULGEOLED WORK
25. QUANTITIES - STRUCTURE



APPLICABLE STANDARD DRAWINGS

OPSD 902.09 STEEL BEAM GUIDE RAIL EMBEDDED CONNECTION FOR NEW STRUCTURES	DESCRIPTION	DATE	1995
OPSD 3501.00 GRANULAR BACKFILL REQUIREMENTS (ASSEMBLIES)	DESIGNER	DATE	1995

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

BM 231.848
11.8 M WEST FOOT 6.30
78M VAN WAY
22.4 M E 27.55M HWY 403