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DIST. 9 REGION

W.P. No. 120-87-00

CONT. No. 90-36

W. O. No.

STR. SITE No.

HWY. No. 416/417

LOCATION High Mast Lights

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 90-36



Ministry of
Transportation

1

INDEX

PAGE NO;

DESCRIPTION

1 & 2.

INDEX

3.

ABBREVIATIONS & SYMBOLS

4 - 339

FOUNDATION INVESTIGATION REPORT
FOR:

Hwy 417/416 Interchange
High Mast Lighting
WP 120-87-00 Site-
Dist 9, Ottawa

Culvert Underneath Ramp Hwy417W
Hwy 416 & Hwy 417 EBL Culverts 1&2 (4)
WP 120-87-00A Site-
Dist 9, Ottawa

Culvert Underneath Prop.Hwy417 WBL
Culvert 5,
WP 120-87-00B Site-
Dist 9, Ottawa

Culvert Underneath Acres Rd.
Culvert 11,
WP 120-87-00C Site-
Dist 9, ottawa

Retaining Wall- New Hwy 417 W.B.L.
WP 120-87-00D Site -
Dist 9, Ottawa

Ramp 417 E.B. - 416 S.B
WP 120-87-01 Site-
Dist 9, Ottawa

.....2

Graham Cr. North & South Section
WP 120-87-03 & 09 Site-3-537
Hwy 417, Dist 9, Ottawa

South to West Ramp Over Hwy 417E.B
WP 120-87-04 Site 3-52-531
Hwy 417 Dist9, Ottawa

E-S Ramp over Hwy 417
WP 120-87-05 Site 3-52-532
Hwy 417 Dist 9, Ottawa

EastBound Hwy 417 At Acres Rd.
WP 120-87-06 Site 3-52-533
Hwy 417 Dist 9, Ottawa

South to East Ramp For Hwy 416 &
417, Over Acres Rd.
WP 120-87-07 Site 3-52-534
Hwy 416/417 Dist 9, Ottawa

East to South Ramp For Hwy 416/417
Over Acres rd.
WP 120-87-08 Site 3-52-535
Hwy 416/417 Dist 9, Ottawa

Hwy 417 W.B. at Acres Rd &
Associated Ramps
WP 120-87-10 Site 3-536
Hwy 417 Dist 9, Ottawa

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

MINISTRY OF TRANSPORTATION OF ONTARIO

GEOTECHNICAL INVESTIGATION

HWY 417/416 INTERCHANGE
HIGH MAST LIGHTING (HML)

WP 120-87-00

DIST 9

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation for the High Mast Lighting (HML) to be constructed at the proposed Highway 417 interchange at Highway 416. The proposed interchange is to be located in Nepean, Ontario at the existing Highway 417 between Richmond Road and Moodie Drive.

2 Field Investigation

Prior to the onset of the drilling investigation, the borehole locations were identified in the field. The necessary utility check clearances were obtained by members of our site personnel. Only one borehole (Borehole 89-12, located at HML C-17) needed to be relocated due to the presence of underground utilities. This borehole was shifted about 16 metres north of the actual location in order to avoid the newly constructed Watts Creek Sewage Pumping Station force main.

The field work for this investigation was carried out between July 11, and 15, 1989 under the full-time direction of Mr. R. Haché, P.Eng. of Jacques, Whitford Limited. A total of 20 boreholes, (numbered 89-1 to 89-13, 89-15, 89-16, 89-18 to 89-20, 89-22 and 89-24) and four (4) Dynamic Cone Penetration Holes (numbered 89-14, 89-17, 89-21 and 89-23) were put down at or near the proposed HML locations.

The test locations and all proposed HML sites are indicated on Drawings No. 1208700-1, -2, and -3.

The corresponding HML number is plotted beside each test location where boreholes or Penetration Tests were carried out. In addition, the drawings show the locations of selected previous MTO boreholes that were used to infer the soil stratigraphy at HML locations not tested. Although other boreholes were drilled within the limits of this site, only those referenced in this report are shown on the drawings.

The boreholes and cone tests were put down to depths ranging from 3.8 to 12.5 metres beneath the existing ground surface using both truck mounted and track mounted CME power auger drills suitably equipped for soil and bedrock sampling and testing. The boreholes were advanced in soil using hollow-stem augers and in bedrock using BX core equipment. Boreholes and cone tests were extended at least 10 m into overburden or to bedrock. Bedrock was proven by coring in the boreholes and inferred by refusal at the cone test locations.

The soils were sampled in most boreholes at nominal one metre spacings by conducting Standard Penetration Tests. Three (3) open-ended Shelby tube samples were also obtained to further define the soil stratigraphy at critical locations. An estimate of the shearing strength of cohesive soil deposits was obtained by conducting pocket penetrometer tests on all cohesive samples and by conducting insitu vane shear tests at selected depths in Boreholes 89-6, 89-9, 89-10, 89-11, 89-13, 89-15, 89-16, 89-19, 89-20, 89-22 and 89-24.

Bedrock was proven by coring in Boreholes 89-1, 89-3, 89-15, 89-16, 89-18 to 89-20 and 89-22. The retrieved core was immediately logged in the field by our experienced site personnel and stored in core boxes.

All soil samples recovered were stored in moisture-proof bags and were sent to our laboratory with the bedrock samples for detailed classification and testing.

Standpipe piezometers were installed in all boreholes prior to backfilling. All boreholes were carefully backfilled to the ground surface using soil cuttings. Imported granular materials were also used for backfilling the boreholes where the soil cuttings were insufficient.

Dynamic Cone Penetration Tests were carried out without augering and sampling at the four test locations noted above. Dynamic Cone Penetration Tests were also performed within (or adjacent to) selected auger borehole locations to further define the overburden characteristics or to determine the depth to inferred bedrock.

3 Survey

The proposed HML locations were surveyed in plan and elevation by MTO staff prior to the onset of the field investigation. Any boreholes not put down at the exact HML locations were surveyed by our field personnel.

4 Laboratory Testing

To identify the behaviour and properties of the soil and bedrock samples collected during the field investigation, the following laboratory testing was carried out:

1. Detailed visual description.
2. Natural moisture content testing.
3. Gradation sieve and hydrometer testing.
4. Atterberg Limit testing.
5. Specific gravity testing.
6. Volumetric unit weight testing of soil and bedrock.
7. Point load testing of bedrock.

5.0 RESULTS OF THE INVESTIGATION

5.1 Surface Conditions

The topography of the area is generally flat to undulating at the proposed HML locations. The maximum change in ground surface between all boreholes drilled was 4.7 metres.

Most of the HML locations are located within the grassed median between the existing Highway 417 eastbound and westbound lanes. The remaining boreholes are located on either side of the Highway 417 lanes in grassed or treed areas. Some of the HMLs are located outside of the existing highway right-of-way in open or farmed fields.

Drainage of the site is generally provided by the highway ditches that are connected to the existing creeks. It is noted that some of the proposed HMLs are located within or adjacent to these ditches.

5.2 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix .

A layer of rootmat, consisting of grass, topsoil and rootlets was observed immediately beneath the ground surface at all borehole locations. The thickness of the rootmat was observed to range from between 100 and 300 mm at the borehole locations.

A brief discussion of the observed subsurface conditions is provided below. However, the Borehole Records should be used to determine the soil conditions at a particular location.

5.2.1 Fill

Fill materials were observed at some borehole locations. The fill characteristics vary depending upon location and proximity to existing roadways.

At Boreholes 89-1, 89-3 and 89-4, the fill was observed to consist mostly of very loose to compact, sand and silt to clayey sand. The thickness of this fill ranges from 1.4 to 5.5 metres. Organics were observed in some locations of this fill.

At Borehole 89-7, a loose sand and clay fill material of 0.7 metres in thickness was observed.

Firm to very stiff clay fill is present in several of the boreholes drilled within the grassed median at the west end of the site (Boreholes 89-16, 89-18, and 89-22). Where observed, the thickness of this clay fill varies from 1.1 to 2.2 metres. Roots and cobbles were noted at some locations within the clay fill.

5.2.2 Silty Clay

The most predominate overburden stratum observed in the boreholes drilled during this investigation is a silty clay material that contains interbedded layers, lenses and seams of silt and sand. This material was noted in all boreholes except Boreholes 89-1, 89-2, 89-3, 89-5 and 89-18.

This material has been defined as a silty clay due to its cohesive nature. However, it is noted that the silty clay has frequent interbedded sand and silt layers, particularly in the upper portion of the soils that were drilled at the eastern section of the site. It also becomes quite silty with depth. Grain size tests carried out on the silty clay indicate that there is no gravel in this material and the sand content varies from 2% to 43%.

The thickness of the silty clay ranges from 1.3 metres to 11 metres at the borehole locations. At most locations, the upper two (2) to three (3) metres of this material is weathered and relatively stiffer than the underlying material.

The results of laboratory testing of the silty clay are provided on the Borehole Records and are summarized below:

<u>Property</u>	<u>Range</u>	<u>#Tests</u>	<u>Average</u>
Moisture Content (%)	18 - 59	49	33
Liquid Limit (%)	23 - 34	4	28
Plastic Limit (%)	9 - 19	4	15
Plasticity Index (%)	12 - 15	4	14
Specific Gravity	2.77 - 2.78	2	2.78
Unit Weight (kN/m ³)	17.5 - 18.0	3	17.7
C _u - Field Vane (kPa)	32 - 92	19	68
Sensitivity	2 - 16	15	7

Based on the above testing and visual identification, this material can generally be classified as an inorganic, silty clay with intermediate to low plasticity. The soil has generally a firm to stiff consistency with a low to high sensitivity.

5.2.3 Sand/Silty Sand

A sand layer was noted at Boreholes 89-1, 89-2, and Boreholes 89-4 to 89-12 inclusive, and Borehole 89-14. This sand material was observed to underlie the silty clay material described above where the silty clay was noted. Otherwise the sand was overlain by rootmat or fill. With the exception of Borehole 89-10, where the thickness of the sand is only one (1) metre, the above noted boreholes were terminated in the sand.

This deposit can generally be described as a medium to coarse sand with a trace to some silt and gravel. Cobbles were encountered within the sand at some locations. The sand is a non-cohesive material. The density of the sand varies from loose to dense based on "N" values, and is typically compact.

5.2.4 Glacial Till

A layer of glacial till was encountered beneath the silty clay at Boreholes 89-15 to 89-17, and Boreholes 89-20 to 89-23 inclusive. The deposit ranges in thickness from 0.6 to 1.7 metres at the borehole locations.

The till consists of a clayey sand with some gravel. No boulders were encountered in the till at these test locations. The behaviour of the till is expected to be that of a non-cohesive nature. The density of the till is compact on the basis of "N" values.

5.2.5 Bedrock

Bedrock was confirmed by coring in Boreholes 89-1, 89-3, 89-15, 89-16, 89-18, 89-19, 89-20 and 89-22. The depth to bedrock from the existing ground surface ranges from 1.2 to 7.9 metres in these boreholes. Inferred bedrock was encountered by augering and/or penetration testing at depths of between 3.8 and 11.0 metres at Boreholes 89-10, 89-14, 89-17, 89-21, 89-23, and 89-24.

Detailed visual identification of the bedrock cores suggests they consist of shale with lenses of sandstone, likely of the Ottawa Formation at Boreholes 89-1 and 89-3, and consist of sandstone and dolostone, probably of the March Formation at Borehole 89-15. The bedrock encountered at Borehole 89-16 and west of this point consists of sandstone, likely of the Nepean Formation.

The results of point load strength tests carried out on selected core samples are summarized on the Borehole Records. The point load tests were carried out diametrically on BX size rock cores. Due to the horizontal bedding present in the shale and in the sandstone/sandy dolomite encountered, the point load test results are likely to be affected by horizontal planes of weakness. The more homogeneous sandstone encountered in Boreholes 89-16 to 89-22 are less likely to be influenced by planes of weakness. Due to the nature of the test, the results are considered to be a lower bound. The results suggest that the uniaxial compressive strength of the bedrock (q_u) ranges between 26 and 153 MPa.

Core recoveries varied from between 70% and 100% with an average of 96%. Rock Quality Designations (RQD) varied from 0% to 100% with an average value of 68%. Lower RQD values were generally noted in the upper one (1) metre of the bedrock.

5.3 Groundwater

Groundwater level observations within standpipes were read several days after installation on July 22, 1989. These readings are provided on the Borehole Records.

Groundwater was observed in every standpipe at a depth below existing ground surface that varied between 1.1 and 5.5 metres. The elevation of the groundwater level ranged from 60.9 to 65.8 metres Geodetic.

Fluctuations in the groundwater levels due to seasonal variations or in response to a particular precipitation event should be anticipated.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Jacques, Whitford Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.

APPENDIX

RECORD OF BOREHOLE No 3-1

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 619.2; E 358 552.6 ORIGINATED BY JF
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY JF
 DATUM Geodetic DATE 88 07 15 CHECKED BY TCK

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			VALUES	20					
66.2	Ground Level												
0.0	Silty Clay to Clayey Silt, Some Sand	Brown	1	SS	15								
64.2	Soft to Stiff	Grey	2	TW	PH							17.9	0 22 43 35
2.1	Clayey Silt with interbedded Sandy Silt		3	SS	2								
62.3	Soft to Firm		4	SS	4								0 34 48 18
4.0	Silty Sand to Sand Some/Trace of Gravel Compact to Dense		5	SS	25								
			6	SS	24								16 81 3 0
			7	SS	20								
			8	SS	41								
52.4													
13.9	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) V. Dense		9	SS	55	15cm							30 57 (13)
50.8													
15.5	End of Borehole												

RECORD OF BOREHOLE No 4-2										METRIC				
W P 120-87-07		LOCATION Co-Ords N 5 022 603.6; E 358 595.4				ORIGINATED BY JBF								
DIST 9 HWY 416/417		BOREHOLE TYPE Hollowstem Augers, Washboring, Cone Test				COMPILED BY JBF								
DATUM Geodetic		DATE 88 07 14-15				CHECKED BY TCK								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
66.3	Ground Level													
0.0	Silty Clay to Clayey Silt		1	SS	13									0 19 23 58
	Some Sand		2	TW	PH									18.4
63.8	Soft to Stiff													
2.5	Clayey Silt with interbedded sandy silt	3	SS	2										0 22 31 47
		4	TW	PH										0 18 46 36
60.7	Soft to Firm													
5.6		5	SS	*										
	Silty Sand to Sand some to trace of Gravel	6	SS	10										
		7	SS	19										
	Very loose to Dense													
		8	SS	35										6 69 17 8
52.4														
13.9	Het mixture of Sand, Gravel and Boulders													
50.6	Dense (Glacial Till)		9	SS	36									
15.7	END OF BOREHOLE													
	* Weight of Rods													

RECORD OF BOREHOLE No 4-5

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 687.7; E 358 702.6 ORIGINATED BY BWBF/TCK
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washbore, Rock Core, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 09-11 CHECKED BY TCK

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
								SHEAR STRENGTH kPa								WATER CONTENT (%)	

65.0	Ground Level														
0.0	Clayey Silt (Fill)	⊗	1	CS	-										
64.4			2	SS	12		64								0 37 38 25
0.6			3	SS	15										2 63 19 16
			4	SS	5		62								
			5	SS	5		60								
	Silty Sand to Sand		6	SS	2		58								
	Trace of Gravel		7	SS	4		56								
	Occ. Silt Seams		8	SS	38		54								
			9	SS	31		52								
			10	SS	34		50								
			11	SS	55		48								
			12	RC	-		46								
			13	SS	73/		44								
			14	RC	REC		42								
			15	RC	REC		40								
41.9			16	RC	REC/		38								
23.1	Het. Mixture of Sand, Gravel and Boulders	⊗	17	RC	REC/	100%									
	Very Dense (Glacial Till)	⊗													
38.7	Bedrock	⊗													
26.3	Silty Dolostone	⊗													
37.6	END OF BOREHOLE														
27.4															

RECORD OF BOREHOLE No 5

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 485; E 358 270 ORIGINATED BY RP
DIST 9 HWY 417 BOREHOLE TYPE Nx Rock Core COMPILED BY KJ
DATUM Geodetic DATE September 13, 1988 CHECKED BY MT

[illegible]

+3, x5: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 6B

METRIC

W P 124-87-01 LOCATION Co-Ords N 5022 887.8; E 359235.6 ORIGINATED BY MS
 DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, BX Rock Core COMPILED BY MS
 DATUM Geodetic DATE 88 08 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE - PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
67.8	Ground Surface																
0.0	Sand and Gravel (Fill)					*											
66.6																	
1.2	Bedrock		1	RC	REC	76%	66									RQD = 0%	
65.4	Sandstone		2	RC	REC	65%										RQD = 0%	
2.4	END OF BOREHOLE																
	* Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-11

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 711.9; E 358 484.4 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 18 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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					
65.9	Ground Surface													
0.0	Silty Caly Grey Firm to Stiff		1	SS	8		64						19.9	0 4 48 48
			2	SS	3									
63.0			3	TW	PH								17.9	0 5 51 44
2.9	Clayey Silt with interbedded Silty Sand		4	SS	3		62							0 11 53 36
61.3	Soft		5	SS	2									
4.6			6	SS	2		60							0 42 37 21
			7	SS	6		58							
	Sand		8	SS	4		56							
	Trace of Silt		9	SS	6		54							2 76 (22)
	Trace of Gravel		10	SS	22		52							
			11	SS	85		50							0 90 (10)
	Loose to Compact		12	SS	50		48							
	Dense to V. Dense		13	SS	36		46							0 93 (7)
41.5			14	RC	REC	94%	42							ROD = 0
24.4	Het. Mixt. of Sand, Gravel, Boulders (Glacial Till)		15	RC	REC	28%	40							RQD = 0
39.4			16	RC	REC	38%	38							RQD = 11%
26.5	Bedrock Silty Dolostone		17	RC	REC	90%								RQD = 63%
37.2														
28.7	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 553; E 358 080 ORIGINATED BY RP
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY KJ
DATUM Geodetic DATE September 14, 1988 CHECKED BY MT

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					
66.1	Ground Level																
65.9	Topsoil																
0.2	Silty Clay, some sand, occasional sand partings		1	SS	10												
	Firm to Very Stiff Brown becoming grey at approximately 64.7m		2	SS	8												
64.3			3	SS	2												
1.8	Clayey Silt, with interbedded silty sand and sandy silt layers																
	Firm to Very Stiff grey		4	TW	PH												
			5	TW	PH												
			6	TW	PH												
60.0																	
6.1	Sandy Silt, some gravel, trace clay		7	SS	54												
	Very Dense Grey																
58.8	(Glacial Till)																
7.3	End of Borehole Auger Refusal on probable bedrock																

+3, x⁵: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 560; E 358 000 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY KJ
 DATUM Geodetic DATE September 14, 1988 CHECKED BY MT

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					
66.0	Ground Level																
65.8	Topsoil																
0.2	Silty Clay, ---, some sand, occasional sand partings		1	SS	12		Seal							0			
	Firm to Very Stiff		2	SS	6		65							0			
64.2	Brown becoming grey at approximately 64.5m		3	SS	1									0			
1.8	Clayey Silt, with interbedded sandy silt and silty sand layers		4	TW	PH									0		23.3	0 20 53 27
	Firm to Very Stiff grey		5	SS	2									0			
			6	SS	2		Sept 14/88							0			
			7	TW	PH		60							0		23.5	
			8	SS	1		Water level Oct 1/88							0			
57.5																	
8.5	End of Borehole Auger Refusal on probable bedrock																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 89-1

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,910.0; E 359,479.0 (HML C-1) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)		
68.0	Ground Surface													
0.0	Fill, Sand and Silt trace organics: Brownish grey		1	SS	5		67							
66.6	Loose													
1.4	Sandy, Gravelly, Silt to Sand, traces of silt and gravel. Light grey Loose to dense		2	SS	9		66							
			3	SS	40		65							
63.2			4	SS	20/15cm		64							
4.8	Bedrock Shale with lenses of Sandstone. Gray to light grey Very poor to good		5	RC BX	REC 94%		63							
			6	RC BX	REC 100%		62							
60.2			7	RC BX	REC 96%		61							
7.8	End of Borehole *q _u (MPa) obtained from point load test.													

RECORD OF BOREHOLE No 89-2

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,818.0; E 359,232.0 (HML C-3) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
66.0	Ground Surface											
0.0	Sandy, Clayey, Silt											
	Brownish grey											
	Compact		1	SS	10							
64.5												
1.5	Sand, trace silt.		2	SS	6							
	Grey											
	Loose											
			3	SS	5							
			4	SS	5							
	Very stiff, silty clay zones encountered in samples 3 and 5.											
			5	SS	7							
			6	SS	8							
			7	SS	6							
56.2												
9.8	End of Borehole											
	Inferred Sand											
54.6												
11.4	End of Cone Test											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-3

METRIC

W P 120-87-00 LOCATION Co-ords N 5,023,067.0; E 359,363.0 (HML C-4) ORIGINATED BY R.H.
 DIST 9 HWY 417 3 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	W	LIQUID LIMIT W _L	WATER CONTENT (%)		
70.2	Ground Surface													
0.0	Fill, Clayey Sand, trace gravel. Brownish grey Very loose to compact		1	SS	10									
			2	SS	7									
			3	SS	3									
			4	SS	17									
64.7	Bedrock Shale with lenses of Sandstone. Grey to light grey Fair		5	RC BX	REC 100%									
5.5			6	RC BX	REC 96%									
62.1	End of Borehole													
8.1	*q _u (MPa) obtained from point load test.													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-4

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,890.0; E 359,174.0 (HML C-5) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
67.6	Ground Surface													
0.0	Silty Sand, some gravel; FILL. Dark grey Very loose to Compact		1	SS	26									
			2	SS	2									
64.9														
2.7	Silty Clay, some sand. Grey stiff		3	SS	4									
63.6														
4.0	Sand, trace silt, trace to some gravel. Grey to greyish brown Loose to compact -cobble 4.0m to 4.6m 5.0m to 6.1m -Clayey silt zone at 7.8m		4	SS	11									
			5	SS	14									
			6	SS	5									
			7	SS	11									
57.8														
9.8	End of Borehole													

RECORD OF BOREHOLE No 89-5

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,797.0; E 359,092.0 (HML C-6) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.8 0.0	Ground Surface										
	Sand, trace to some silt, trace gravel. Gravelly zones noted during drilling. Grey Compact		1	SS	11						10 76 (14)
			2	SS	17						
			3	SS	25						
			4	SS	24						
60.6	End of Borehole										8 90 (2)
5.2	Inferred Sand										
56.0	End of Cone Test										
9.8											

Standpipe

Cone Penetration Test from end of Borehole

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-6

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,658.0; E 359,071.0 (HML C-7) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 12, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
66.4	Ground Surface													
0.0	Sand and Clay. Brown Very stiff		1	SS	16									0 59 (41)
			2	SS	4									
			3	SS	6									
62.3	Silty Clay, interbedded with sandy silt. Grey Firm to Stiff		4	SS	1									
4.1			5	SS	1									
			6	SS	32									
59.1	Sand, trace silt and gravel. Grey Dense		7	SS	55									
7.3														
56.7	End of Borehole													
9.7	Inferred Sand													
55.7														
10.7	End of Cone Test													

Standpipe

Cone Penetration Test
from end of Borehole

5.2
5.8

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-7

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,737.0; E 358,823.0 (HML C-9) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
66.4	Ground Surface													
0.0	Fill, Sand and Clay.													
65.7	Brown Loose													
0.7			1	SS	11									
	Brown ----- Grey		2	SS	4									
			3	SS	2									
	Silty Clay, interbedded sandy silt. Firm to stiff		4	SS	2									
			5	SS	2									
			6	SS	2									
56.8			7	SS	5									
56.6	*													
9.8	End of Borehole													
	Inferred Sand													
53.9														
12.5	End of Cone Test													
	*Sand, trace gravel Grey Loose													

Standpipe

Cone Penetration Test
from end of Borehole

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-8

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,793.0; E 358,653.0 (HML C-11) ORIGINATED BY R.H.
 DIST 9 HWY 417 Q 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 12, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.9	Ground Surface										
0.0	Silty Clay, some to trace sand. Greyish brown Stiff		1	SS	11						
64.5			2	SS	11						
1.4											
	Sand, trace silt and gravel. Loose to dense		3	SS	6						
			4	SS	23						
			5	SS	24						
			6	SS	38						
			7	SS	47						
56.1											
9.8	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-9

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,685.0; E 358,328.0 (HML C-13) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa					
65.5	Ground Surface												
0.0													
	Greyish brown		1	SS	4								
	Grey												
	Silty Clay, interbedded with sandy silt.		2	SS	2								
	Stiff												
			3	SS	2								
			4	SS	1								
			5	SS	3								
55.7			6	SS	5								
9.8	End of Borehole												
	Inferred Silty Clay												
54.5													
11.0	Inferred Sand												
53.5													
12.0	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-10

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,641.0; E 358, 176.0 (HML C-14) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

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					
65.8	Ground Surface												
0.0													
	Clayey Silt, interbedded with sandy silt.		1	SS	2								
	Grey Stiff		2	TW	PH								
			3	SS	4								
			4	SS	2								
			5	SS	5								
57.7													
8.1	Silty Sand, trace gravel.												
	Grey												
56.7	Compact												
9.1	End of Borehole (Split spoon refusal on possible bedrock)												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-11

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,525.0; E 358,637.0 (HML C-16) ORIGINATED BY R.H.
 DIST 9 HWY 417 & 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

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					
66.5	Ground Surface												
0.0	Silty Clay, interbedded with sandy silt. Greyish brown Very stiff		1	SS	8								0 35 (65)
			2	SS	4								
			3	SS	1								
	Silty Clay, interbedded with sandy silt. Grey Firm to stiff		4	SS	1								3 78 (19)
			5	SS	1								
59.2													3 78 (19)
7.3	Sand, trace to some silt, trace gravel. Grey Compact		6	SS	22								
			7	SS	16								
56.7													
9.8	End of Borehole												

RECORD OF BOREHOLE No 89-12

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,536.0; E 358,476.5 (HML C-17) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		WATER CONTENT (%)			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L			
66.3	Ground Surface													
0.0	Silty Clay, interbedded with sandy silt. Greyish brown Very stiff to stiff		1	SS	15									
			2	SS	4									
	Silty Clay, interbedded with sandy silt. Grey Firm		3	SS	1									
61.1			4	SS	1									
5.2	Sand, trace silt. Grey Compact to dense -cobbles and gravel from 5.5m to 5.8m		5	SS	15									
			6	SS	14									
			7	SS	50									
56.5														
9.8	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-13

METRIC

W P 120-87-00 LOCATION Co-Ord. N 5,022,537.0; E 357,805.0 (HML C-21) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
66.7	Ground Surface													
0.0	Silty Clay, interbedded with sandy silt. Grey Stiff		1	SS	5									
			2	SS	2									
			3	SS	2									
			4	SS	2									
			5	SS	2									
			6	SS	3									
56.9	End of Borehole													
9.8														

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 89-14

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,507.0; E 357,656.0 (HML C-22) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L			
66.2	Ground Surface													
0.0	Inferred Silty clay.													
60.3														
5.9	Inferred Sand													
59.0														
7.2	End of Dynamic Cone Penetration Test (Cone Refusal on inferred Bedrock)							100/0 cm						

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 89-15

METRIC

W P 120-87-00 LOCATION Co-ords. N 5,022,471.0; E 357,512.0 (HML C-23) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Augers, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 12, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

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					
66.6	Ground Surface													
0.0	Silty Clay. Grey Very stiff to firm		1	SS	7									
	Interbedded with sandy silt		2	TW	PH									
62.2														
4.4	Clayey Sand, some gravel; Till		3	SS	18									
61.6	Grey Compact													
5.0	Bedrock		4	RC	REC									
	Interbedded Sandstone and Sandy Dolomite.			BX	95%									
	Light grey		5	RC	REC									
	Poor to fair			BX	93%									
58.8														
7.8	End of Borehole													
	*q _u (MPa) obtained from point load test.													

RECORD OF BOREHOLE No 89-16

METRIC

W P 120-87-00 LOCATION Co-Ords. N 5,022,387.0; E 357,225.0 (HML C-25) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								20 40 60 80 100	20 40 60 80 100						20 40 60	
66.8	Ground Surface															
0.0	Fill, Clay, trace debris. Brown Firm															
65.7			1	SS	17											
1.1	Silty Clay, interbedded with sandy silt. Grey Stiff		2	SS	10											
63.4			3	SS	13											
3.4	Clayey Sand, some gravel; Till. Grey Compact		4	SS	20											
61.8			5	RC BX	REC 97%											
5.0	Bedrock Sandstone Light grey Fair to excellent		6	RC BX	REC 100%											
59.0			7	RC BX	REC 100%											
7.8	End of Borehole *q _u (MPa) obtained from point load test.															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-17

METRIC

W P 120-87-00 LOCATION Co-ords. N 5,022,345.0; E 357,082.0 (HML C-26) ORIGINATED BY R.H.
 DIST 9 HWY 417 C 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
66.4	Ground Surface										
0.0	Inferred Silty Clay.										
63.1											
3.3											
62.6	Inferred Till										
3.8	End of Dynamic Cone Penetration Test (Refusal on inferred Bedrock)										

RECORD OF BOREHOLE No 89-18

METRIC

W P 120-87-00 LOCATION Co-Ord N 5,022,305.0; E 356,938.0 (HML C-27) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

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					
66.1	Ground Surface												
0.0	Fill, Silty Clay. Brown												
64.9	Firm												
1.2	Bedrock Sandstone Light grey Good to excellent.		1	RC BX	REC 89%								
			2	RC BX	REC 100%								
			3	RC BX	REC 100%								
61.8													
4.3	End of Borehole *qu(MPa) obtained from point load test.												

RECORD OF BOREHOLE No 89-19

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,215.0; E 356,693.0 (HML C-29) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	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									
65.7	Ground Surface													
0.0	Silty Clay, interbedded with sandy silt. Grey Stiff		1	SS	3		65							
			2	SS	2		64							
			3	SS	37		63							
61.9	Bedrock Sandstone Light grey Fair to good		4	RC BX	REC 94%		62						RQD=65 %	
3.8			5	RC BX	REC 91%		61						RQD=83 %	
59.1							60							
6.6	End of Borehole													

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

RECORD OF BOREHOLE No 89-20

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,142.0; E 356,566.0 (HML C-30) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

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
66.2	Ground Surface																
0.0	Silty Clay, interbedded with Sandy Silt. Firm to stiff		1	SS	3												
			2	SS	2												
			3	TW	PH												
			4	SS	2												
60.0	Till, Clayey Sand, some gravel. Grey compact		5	SS	9												
6.2																	
58.3	Bedrock Sandstone Light grey		6	SS	12/7	5cm											
7.9																	
			7	RC	REC												
				BX	100%												
			8	RC	REC												
				BX	90%												
56.4	Poor to Fair																
9.8	End of Borehole																
	*q _u (MPa) obtained from point load test.																

RECORD OF BOREHOLE No 89-21

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,249.0; E 356,534.0 (HML C-31) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH kPa	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									
66.7 0.0	Ground Surface													
	Inferred Silty Clay.													
60.6														
6.1	Inferred Till.													
59.7														
7.0	End of Cone Test (Cone Penetration Test refusal on inferred Bedrock)													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-22

METRIC

W P 120-87-00 LOCATION Co-Ord. N 5,022,252.0; E 356,405.0 (HML C-32) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT LIMIT			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	W _p	W		
68.2	Ground Surface												
0.0	Fill, silty clay, trace roots, to silt and sand, occasional cobbles		1	SS	11								
	Brown to dark grey												
	Very stiff		2	SS	15								
66.0													
2.2	Silty Clay, interbedded with sandy silt.		3	SS	2								
	Grey												
	Firm to stiff		4	SS	3								
62.4													
5.8	Clayey Sand, some gravel; Till		5	SS	17								
	Grey Compact												
61.4													
6.8	Bedrock		6	RC BX	REC 85%								
	Sandstone												
	Light grey		7	RC BX	REC 100%								
	Fair to good												
58.4													
9.8	End of Borehole												
	*q _u (MPa) obtained from point load test.												

METRIC

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 89-24

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,021,883.1; E 356,479.0 (HML C-34) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger; Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa	W _p	W	W _L		
68.0	Ground Surface												
0.0													
	Silty Clay, interbedded with sandy silt.		1	SS	10								
			2	SS	4								
			3	SS	1								
	Greyish brown Grey												
			4	SS	1								
			5	SS	1								
			6	SS	1								
			7	SS	1								
58.2													
9.8	End of Borehole												
	Inferred Silty Clay												
57.0													
11.0	End of Cone Test												
	(Dynamic Cone refusal on inferred Bedrock)												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT
For
Culvert Structures Underneath Ramp Hwy. 417 W
-Hwy. 416 S and Hwy. 417 E.B.L.
Culvert Nos #1* and #2*
W.P. 120-87-00A
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of 89 11 01 to 89 11 03. Two 3.5 m span culvert structures are proposed to construct underneath Hwy. 417 Eastbound (Culvert #2*) and Ramp Hwy. 417 W to Hwy. 416 Southbound (Culvert #1)*.

Six boreholes (BH #C1-1 to BH #C1-3 and BH #C2-1 to BH #C2-3) were advanced and sampled with a conventional diamond drill (BW casing and BXL Rock Core barrel) adopted for rock sampling purposes. In addition, cone penetration tests were carried out at five locations to delineate the inferred bedrock surface for alternative alignment of the proposed culverts. These boreholes extended down to depths ranging from 0.4 to 9.0 metres below the existing ground surface.

This report contains factual information obtained from this investigation pertaining to Culvert Nos. #1* and #2* as shown on Drawing No. 1208700A-A.

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located in the corn field and cattle ranch immediately south of the existing Hwy. 417 between the Acres Road and Moodie Drive in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for agricultural and dairy farming purposes. A new municipal pumping station exists north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area; an illustration of the numerous normal faults that dominate the region. It appears that the site is divided by a fault. The bedrock in the area is of the March Formation west of the fault, and the Rockcliffe and Gull River Formation east of the fault which are of the middle Ordovician period. The March Formation consists of interbedded quartz sandstone and sandy dolostone, whereas the Rockcliffe and Gull River Formation consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The site is transversed by a north-south trending fault which is a geologic structure reportedly common to the area. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

FIELD INVESTIGATION AND LABORATORY ANALYSIS

The fieldwork for the site investigation was carried out between November 1 and November 3, 1989 and consisted of six (6) sampled boreholes accompanied by dynamic cone penetration tests and additional five (5) dynamic cone test holes. Among these, three (3) boreholes and four (4) dynamic cone holes were put down for the Culvert No. #1* and three (3) boreholes and one (1) dynamic cone hole were driven for the Culvert No. #2*. Soil samples were retrieved generally at 1.5 m interval by a split spoon sampler according to the Standard Penetration Test (ASTM D1586). In situ vane tests were also carried out in cohesive soil. Samples were identified in the field and then returned to the laboratory for appropriate testing. Bedrock was cored at three borehole locations from about 1.6 m to 1.8 m depths using conventional rock coring methods.

Water levels were obtained in the open boreholes during the fieldwork and in two piezometers installed afterwards. Survey information related to location and elevation of boreholes was provided by Eastern Region Surveys and Plans.

* SEE PAGE 52

To identify the properties of the soil, the following laboratory tests were performed:

1. Atterberg Limit Tests
2. Grain Size Analysis
3. Natural Moisture Content

Laboratory test results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

As previously mentioned, the site is transversed by a north-south trending geologic structure of fault as shown on Drawing No. 1208700A-A. Based on observed surficial features and information from the site investigation, the ground surface at the proposed Culverts #1* and #2* to the east of the fault is comprised of approximately 60 percent exposed bedrock or bedrock covered with less than 0.4 metre of overburden. The bedrock consists of sandstone of the March Formation. The area west of the fault is underlain by 1.5 to 5.8 m of soft to firm clayey silt underlain by a thin layer of loose silty sand (0.7 to 1.6 m). Further underlying this layer is a deposit of loose to very dense heterogeneous mixture of silt, sand, and gravel and boulders (cohesionless Glacial Till). Approximately 1.6 to 4.1 m of the till deposit was found before encountering the interbedded quartz sandstone bedrock.

It should be noted that in the vicinity of southern part of the Culvert #1* and Northern part of Culvert #2*, the proposed culverts will seat on a loose Glacial Till up to 4.5 m at the southern end and 1.0 m at the Northern end, respectively. Topsoil, consisted of organic sandy silt, was found at BH #C1-2.

A detailed description of the subsurface conditions encountered is given below.

Topsoil

Topsoil was encountered at one borehole location. The material consists of a dark brown organic sandy silt. The thickness of this layer is about 0.4 m at

* SEE PAGE 52

BH #C1-2 as shown on Record of Borehole sheets. Grain size distribution test was carried out on this material. Figure 1 in the Appendix shows the test result. Through the grain size distribution curve and visual observation, the material classified as a sandy silt.

Clayey Silt with Interbedded Sandy Silt

This stratum occurred from the ground surface to a depth of 1.5 to 5.8 m. This material changes in colour from brown to grey at approximate elevation 65.0 m.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 2 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	24.5-38.0	29.5
Liquid Limit (w_L)	25.0-38.0	30.4
Plastic Limit (w_p)	13.0-16.5	14.5
Plasticity Index (I_p)	12.0-21.5	15.9

From the plasticity chart, it is evident that the layer can be classified as an inorganic clayey silt with interbedded sandy silt of low plasticity (CL or CL-ML). Grain size distribution tests were carried out on these materials. Figure 3 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil was determined by in situ vane tests. The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

<u>Undrained Shear Strength</u>	<u>C_u (kPa)</u>	<u>Sensitivity</u>
Field Vane	20-60 (Avg. 47 kPa)	3.2-6.5

Due to the irregular nature of the deposit, which reveals numerous seams and layers of sandy silt interbedded within the clayey silt, the results provided

in the above table are not necessarily indicative of the shear strength of the clayey silt portion. In view of this consideration, the consistency of the clayey silt portion can be described as soft to stiff. The sandy silt portion was generally very loose in denseness. For design purposes an undrained shear strength of 45 kPa can be assumed for this stratum.

Silty Sand

This deposit was encountered below the clayey silt with interbedded sandy silt layer. The thickness of this layer ranges from 0.7 m at BH #C1-3 to 1.6 m at BH #C1-1 and BH #C2-2.

This deposit contains a minor variation in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel was encountered. Grain size distribution curve indicates that the soil can be classified to a silty sand. This layer is basically non-plastic. Figure 4 in the Appendix shows the result of Grain Size Distribution test.

In this stratum, the 'N' values ranged from 3 to 32 blows/0.3 m indicating a state of compaction described as very loose to dense.

Heterogeneous mixture of Silt, Sand and Gravel and Boulders (Glacial Till)

Underlying the silty sand, a heterogeneous mixture of silt, sand and gravel, and boulders of glacial origin was encountered. The thickness of this stratum ranges from 1.6 m at BH #C2-2 to 3.2 m at BH #C1-1. Figure 5 shows the results of Grain size distribution tests in an envelope form for this material.

In this stratum, the 'N' values ranged from 2 to over 26 blows/0.3 m indicating a state of compaction described as very loose to compact.

Bedrock

As discussed previously, a north-south trending geologic structure transverses

the site with an approximately 60 percent exposed bedrock or bedrock covered with a thin veneer of overburden at the east of the fault. Exposed bedrock was cored at one location. Up to 1.6 m of rock core samples was obtained at BH #C2-1.

The bedrock consists of a March Formation comprised of interbedded quartz sandstone.

Detailed descriptions of the bedrock are attached in the Appendix, entitled "Description of Rock Core". Core Recoveries (CR) and Rock Quality Designation (RQD) values were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core Recoveries (CR) range between 78 and 100 percent and Rock Quality Designation (RQD) values range from 23 to 81 percent. Based on the results and through visual laboratory examination, the rock can be classified as medium strong to strong and predominantly unweathered.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes and two piezometers installed in BH #C1-1 and BH #C2-3. Groundwater levels in the boreholes were found to range between elevation 63.6 m at BH #C2-3 and elevation 64.7 m at BH #C1-3. This corresponds to depths of 1.4 m to 0.9 m below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Foundation Design Engineer, and Dale Colquhoun, Visiting Engineer

from Jamaica. The equipment was owned and operated by Marathon Drilling Co. and Johnston Drilling Co., Ottawa.

The project was carried out by Tae C. Kim under the general supervision of Dr. B. Iyer. This report was written by Tae C. Kim, Foundation Design Engineer, reviewed by Dr. B. Iyer, Sr. Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



Tae C. Kim

Tae C. Kim, P.Eng.
Foundation Design Engineer

M. Devata

M. Devata, P.Eng.
Chief Foundation Engineer

- * CULVERTS C1 & C2 HAVE BEEN REPLACED BY A SINGLE CULVERT NUMBERED 4 FOR THIS CONTRACT

APPENDIX

RECORD OF BOREHOLE No C1-1										METRIC	
W P 120-87-00A		LOCATION Co-ords: N 5 022 399.2; E 358 171.9				ORIGINATED BY DC					
DIST 9 HWY 416/417		BOREHOLE TYPE H.S. Auger, BW Casing, BXL Core & Cone Test				COMPILED BY TCK					
DATUM Geodetic		DATE 89 11 02				CHECKED BY TCK					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	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						
65.6	Ground Surface										
0.0	Clayey Silt With Interbedded Brown Sandy Silt Grey		1	SS	2						0 17 45 38
63.8	Soft to Firm										
1.8	Silty Sand V. Loose		2	SS	3						9 47 36 8
62.2											
3.4	Het. Mixture of Silt, Sand and Gravel (Glacial Till)		3	SS	16						
			4	SS	6						
	Loose to V. Dense										
59.0			5	SS	40/						11 45 36 8
6.6	Sandstone Bedrock		6	RC	100%						RQD = 0%
			7	RC	92%						RQD = 23%
57.2											
8.4	End of Borehole										
<p>Piezometer Installation</p> <p>P-1 (Tip at 4.57m BGS)</p> <p>0 - 1.52m Backfill</p> <p>1.52 - 1.83m Bentonite Seal</p> <p>1.83 - 4.12m Backfill</p> <p>4.12 - 4.57m Pea Gravel</p> <p>4.57 - 8.40m Backfill</p>											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C1-2

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 451.5; E 358 190.5 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TCK
DATUM Geodetic DATE 89 11 02 CHECKED BY TCK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
65.8	Ground Surface															
65.4	Organic Sandy Silt (Topsoil)		1	CS	*											0 42 47 11
0.4	End of Borehole															
	Auger Refusal at Bedrock															
	* Borehole Dry															

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No C1-3

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 419.7; E 358 178.6 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 02 CHECKED BY TCK

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					
65.6	Ground Surface													GR SA SI CL
0.0	Brown Grey Clayey Silt With Interbedded Sandy Silt Layer		1	SS	2		64	6.5						0 23 52 25
			2	SS	2									
			3	SS	2		62	3.2						
61.0	Soft to Stiff													
4.6	Silty Sand		4	SS	PH									
60.3	V. Loose													
5.3	Het. Mixture of Silt, Sand and Gravel (Glacial Till) V. Loose to V. Dense		5	SS	4		60							30 43 22 5
57.3			6	SS	2		58							
8.3	End of Borehole Auger Refusal at Probable Bedrock							26/Bouncing at 8.2m BGS						

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C1-4

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 425.5; E 358 181.0 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 02 CHECKED BY TCK

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No C1-5

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 455.6; E 358 178.8 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 02 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPo ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT Wl WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.2	Ground Surface										GR SA SI CL
0.0	Inferred Clayey Silt With Interbedded Sand Silt Layers						64				
63.5											
1.7	End of Cone Test							50/Bouncing at 1.7m BGS			
	Cone Refusal at Probable Bedrock										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C1-6

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 429.3; E 358 169.4 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 02 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
65.2	Ground Surface													
0.0														
	Inferred Clayey Silt With Interbedded Sandy Silt Layers													
59.4														
5.8														
58.5	Inferred Silty Sand													
6.7														
	Inferred Het. Mixture of Silt, Sand and Gravel (Glacial Till)													
56.2														
9.0	End of Cone Test													
	Cone Refusal at Probable Bedrock													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No C1-7

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 402.7; E 358 161.5 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 03 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.6	Ground Surface										
0.0	Inferred Clayey Silt With Interbedded Sandy Silt										
62.6											
3.0	Inferred Silty Sand										
61.6											
4.0	Inferred Het. Mixture of Silt, Sand and Gravel (Glacial Till)										
57.5											
8.1	End of Cone Test										
	Cone Refusal at Probable Bedrock										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C2-2

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 535.5; E 358 219.2 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, BW Casing, BXL Core and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 01 and 02 CHECKED BY TCK

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					
65.7	Ground Surface												GR SA SI CL
0.0	Clayey Silt With Interbedded Sandy Silt Layers, Grey Soft to Stiff		1	SS	7	Seal							0 11 54 35
63.6													
2.1	Silty Sand Loose		2	SS	4								
62.0			3	SS	4								
3.7	Het. Mixture of Silt, Sand and Gravel (Glacial Till) Loose to Compact		4	SS	5	P-1							25 44 20 11
60.4			5	SS	26								
5.3	Sandstone Bedrock		6	BXL RC	REC 78%								RQD = 63%
58.7													
7.0	End of Borehole												
	Piezometer Installation P-1 (Tip at 4.3m BGS) 0 - 1.52m Backfill 1.52 - 1.83m Bentonite Seal 1.83 - 3.35m Backfill 3.35 - 4.36m Pea Gravel 4.36 - 7.00m Cased with Natural Material												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No C2-3

METRIC

W P 120-87-00A LOCATION Co-ords: N 5 022 510.4; E 358 210.0 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 02 CHECKED BY TCK

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

METRIC

OFFICE REPORT ON SOIL EXPLORATION

[illegible]

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION **WP 120-87-00**

Page 1 of 1.

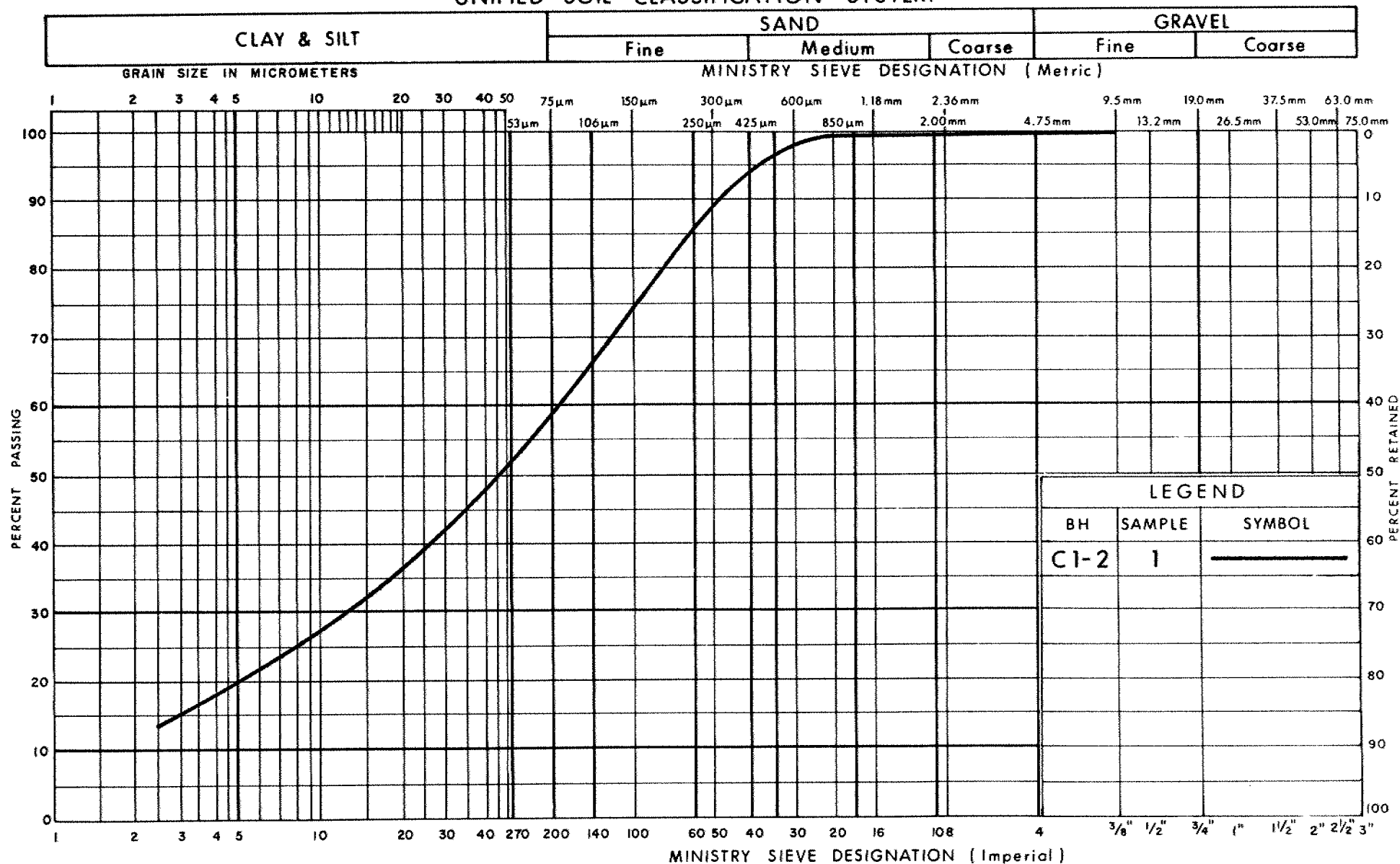
CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
C1-1	6	6.63-6.73	100	0	6.63-8.41	SANDSTONE , medium light to very light grey, stained moderate yellow brown, laminated dark grey; medium grained; medium strong to strong rock; slightly weathered to unweathered; very close spaced fractures: horizontal, rough, irregular.
	7	6.73-8.41	92	23		
C2-1	1	0.00-1.63	95	81	0.00-1.63	SANDSTONE , very light to light grey, stained moderate yellow brown, laminated dark grey; medium grained; medium strong to strong rock; slightly weathered to unweathered; very close to moderately close spaced fractures: horizontal, rough, irregular.
C2-2	6	5.26-6.96	78	63	5.26-6.96	SANDSTONE , very light to medium grey, stained moderate yellow brown, laminated dark grey; medium to fine grained; medium strong to strong rock; slightly weathered to unweathered; close to moderately close spaced fractures: horizontal, rough, irregular.

*CR = CORE RECOVERY
 *RQD = ROCK QUALITY DESIGNATION

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

Logged by: SAS, Soils and Aggregates Section.

UNIFIED SOIL CLASSIFICATION SYSTEM

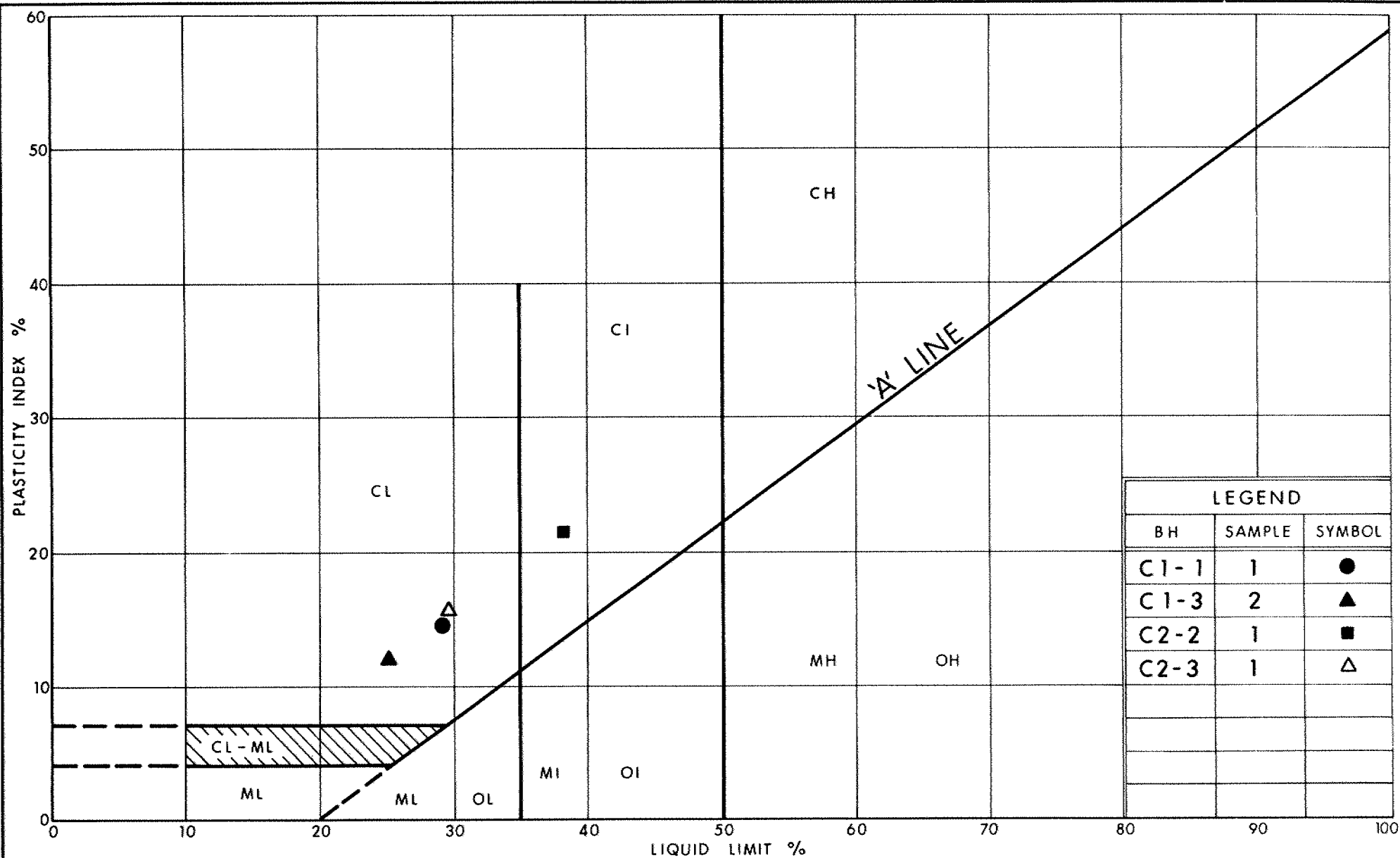


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GRAIN SIZE DISTRIBUTION ORGANIC SANDY SILT (Topsoil)

FIG No 1

W P 120-87-00A



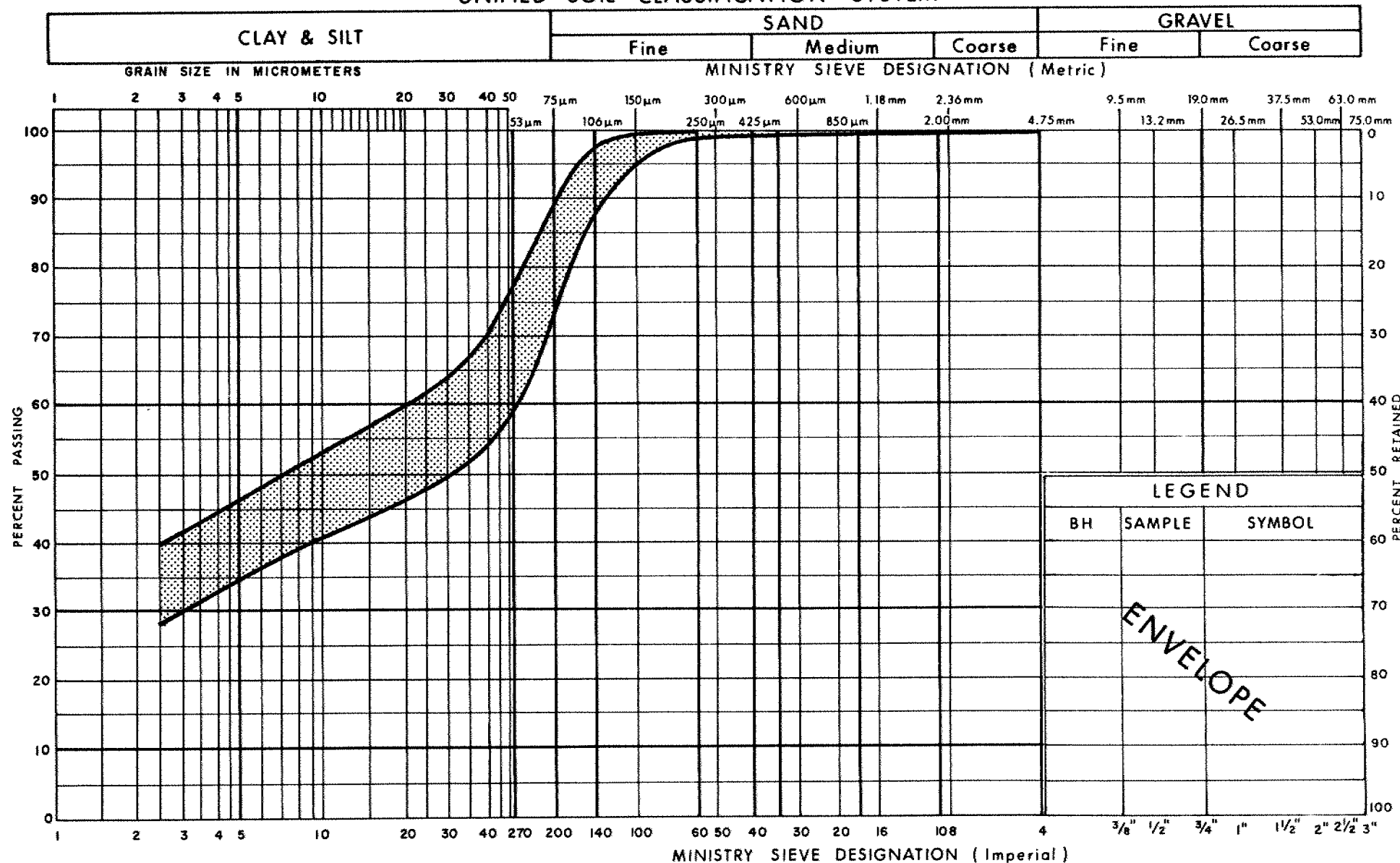
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Ontario

PLASTICITY CHART CLAYEY SILT, WITH INTERBEDDED SANDY SILT

FIG No 2

W P 120-87-00A

UNIFIED SOIL CLASSIFICATION SYSTEM



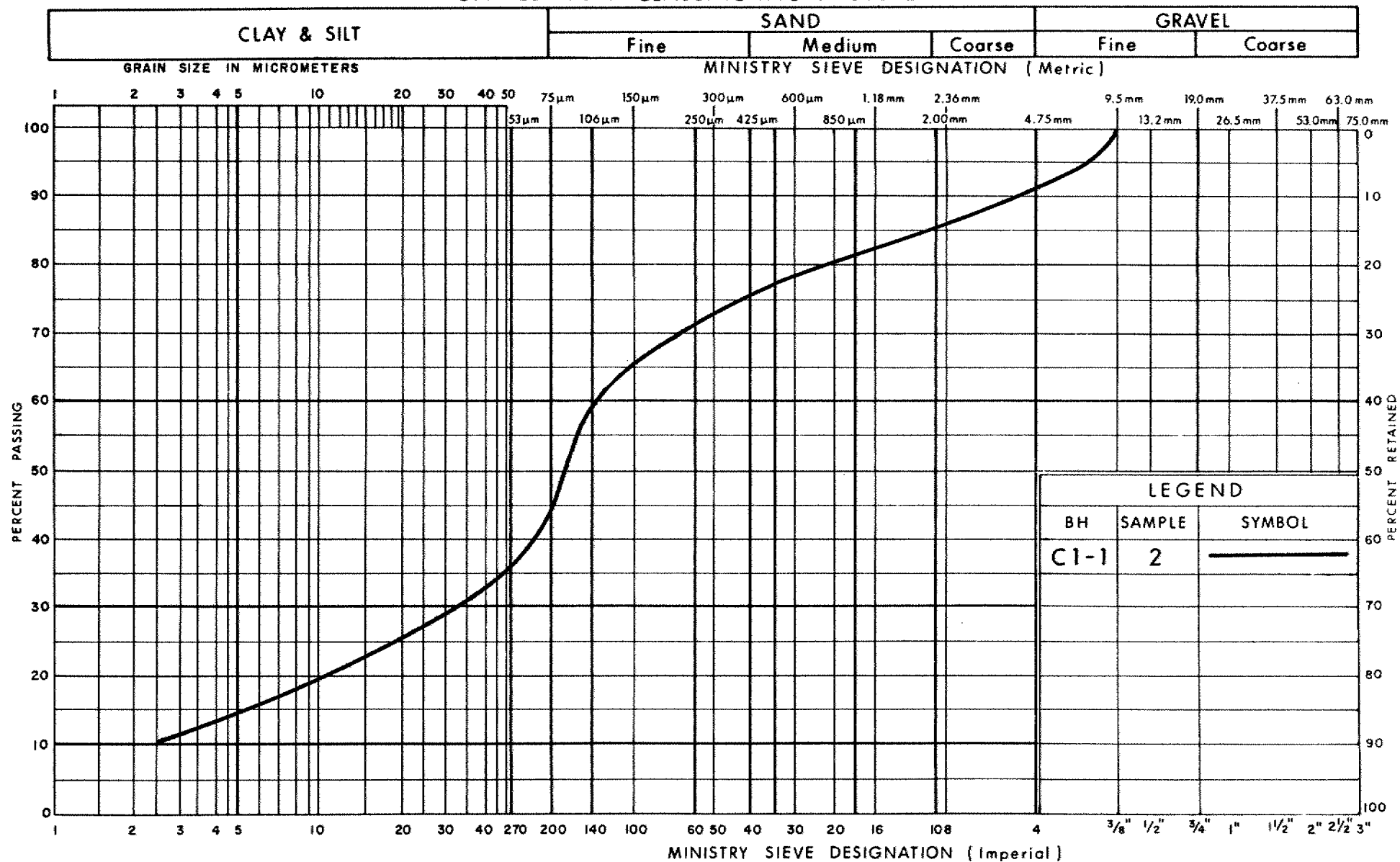
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT, WITH INTERBEDDED SANDY SILT

FIG No 3

W P 120-87-00A

UNIFIED SOIL CLASSIFICATION SYSTEM



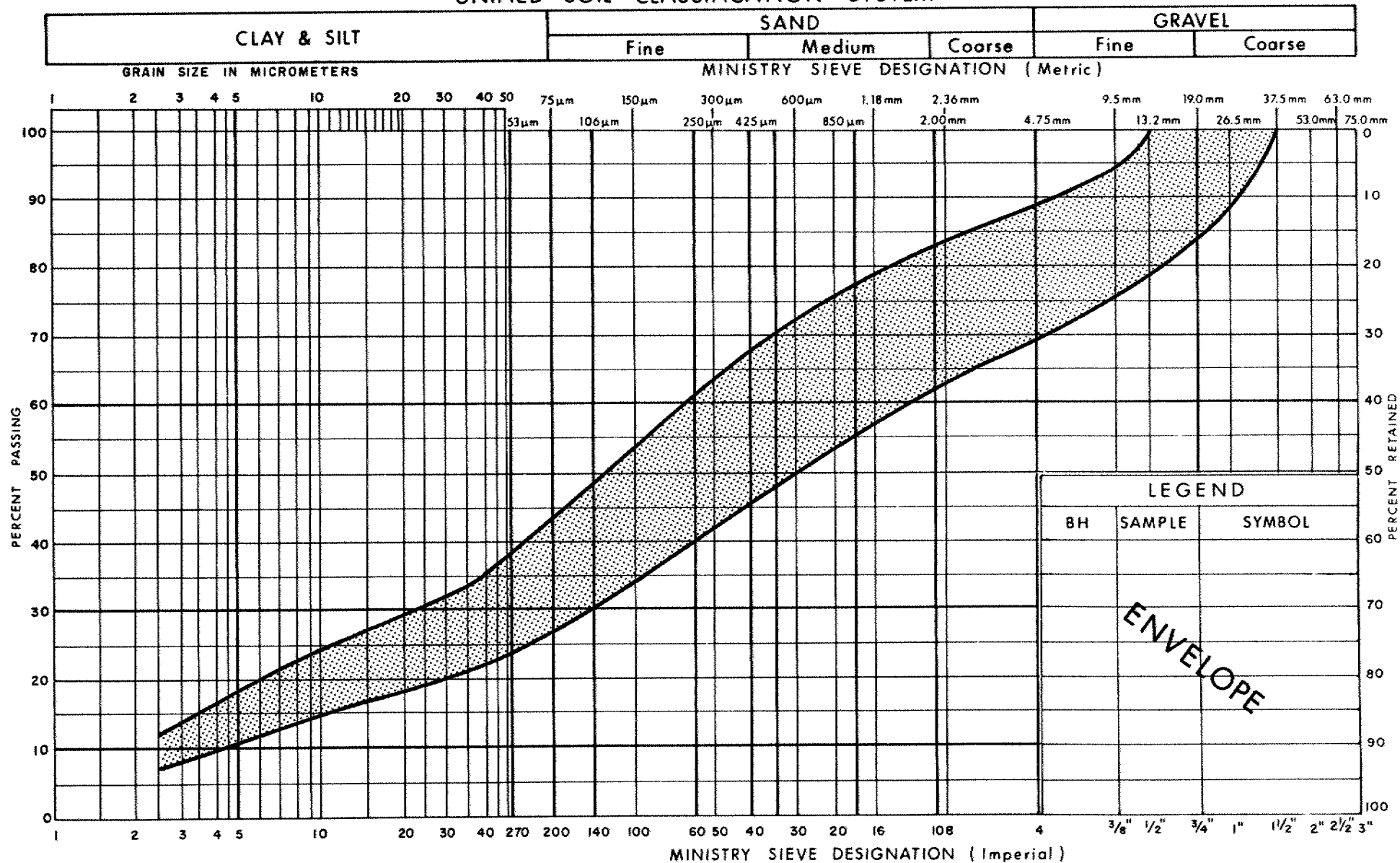
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GRAIN SIZE DISTRIBUTION
SILTY SAND

FIG No 4

W P 120-87-00A

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
 HET MIXTURE OF
 SILT, SAND & GRAVEL (Glacial Till)

FIG No 5

W P 120-87-00A

FOUNDATION INVESTIGATION REPORT
For
Culvert Structure Underneath the Proposed
Hwy. 417 Westbound Lane
Culvert No. #5
W.P. 120-87-00B
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of 89 10 31 to 89 11 01. A 3.0 m span culvert structure is proposed to carry Hwy. 417 Westbound Lane (Culvert No. #5).

Two boreholes (BH #C3-1 and BH #C3-2) were advanced and sampled by means of hollow stem augers with a conventional Cone Penetration Tests. These boreholes extended down to depth of 11.9 metres below the existing ground surface.

This report contains factual information obtained from this investigation pertaining to Culvert No. #5 as shown on Drawing No. 1208700B-A.

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located in the corn field and underneath the existing Hwy. 417 Eastbound Lane between the Acres Road and Moodie Drive in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediately vicinity being used for agricultural and dairy farming purposes. A new municipal pumping station exists north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area; an illustration of the numerous normal faults that dominate the region. It appears that the site is divided by a fault. The

bedrock in the area is of the March Formation west of the fault, and the Rockcliffe and Gull River Formation east of the fault which are of the middle Ordovician period. The March Formation consists of interbedded quartz sandstone and sandy dolostone, whereas the Rockcliffe and Gull River Formation consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The site is transversed by a north- south trending fault which is a geologic structure reportedly common to the area. The overburden was deposited during and immediately following the Wisconsinan glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The surficial layer consists of a generally soft to stiff cohesive silty clay to clayey silt which extends to a maximum thickness of 4.8 m. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of sandy silt. The maximum thickness of this deposit is about 4.6 m. A deep deposit of silty sand is the subsequent underlying deposit. However, it should be noted that this deposit was not proven for the full depth. The proven thickness down to a depth of 11.9 m below the ground surface is about 4.1 m at BH #C3-1. It should be also noted that under the existing Hwy. 417 Eastbound lane, sand and gravel subgrade fill material was found. But no samples were taken from the site.

A detailed description of the subsurface conditions encountered is given below.

Silty Clay to Clayey Silt

This stratum was encountered in two boreholes (BH #C3-1 and BH #C3-2). This material consists of a silty clay to clayey silt ranging in thickness between 4.1 and 4.8 m. The material changes in colour from brown to grey at approximately elevation of 64.5 m.

Two Atterberg Limit tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Ranges (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	43.5-45.0	44.3
Liquid Limit (w_L)	34.5-48.5	41.5
Plastic Limit (w_p)	15.0-20.5	17.8
Plasticity Index (I_p)	19.5-28.0	23.8

From the plasticity chart, it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these material. Figure 2 in Appendix shows the results.

Undrained shear strength of the soil were determined by in situ vane tests. The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

<u>Test</u>	<u>Undrained Shear Strength (C_u, kPa)</u>	<u>Sensitivity</u>
Field Vane	70-72 (Avg. 71 kPa)	4.5-9

Recommended shear strength for this deposit can be estimated to be about 70 kPa. Based on this result, the soil has stiff consistency. The sensitivity of the soil is generally moderate to high.

Clayey Silt with Interbedded Sandy Silt

Underlying the surficial deposit of silty clay to clayey silt, a layer of grey clayey silt with interbedded sandy silt was encountered. This stratum extends to depths ranging from 7.8 m to 9.4 m below the ground surface. The thickness of the stratum varies between 3.7 and 4.6 m.

The results from the 4 Atterberg Limit test performed on this material are summarized as follows:

<u>Property</u>	<u>Ranges (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	27.5-42.6	33.1
Liquid Limit (w_L)	21.0-30.5	26.8
Plastic Limit (w_p)	12.5-16.5	14.1
Plasticity Index (I_p)	6.5-15.0	12.6
Unit Weight (kN/m^3)	17.8-19.2	18.5

From the plasticity chart (Figure 3), it is evident that the layer can be classified as an inorganic clayey silt with interbedded sandy silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 4 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil was determined both by in situ vane tests and laboratory tests, namely unconfined compression tests. The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

<u>Undrained Shear Strength</u>	<u>kPa</u>	<u>Average (kPa)</u>	<u>Sensitivity</u>
Field Vane (5 tests)	52-80	64	4.3-7.0
Laboratory Results (2 tests)	35-63	50	

Due to the irregular nature of the deposit, that reveals numerous seams and layers of sandy silt interbedded within the clayey silt, the results provided in the above table are not necessarily indicative of the shear strength of the clayey silt portion. In view of this consideration, the consistency of the clayey silt portion can be described as firm to stiff. The sandy silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 65 kPa can be assumed for this stratum.

The result (e-log P curves) of a consolidation test on a representative sample is shown on Figure 5. This test indicated that the clayey silt has been preconsolidated in the past to an effective pressure of 236 kPa ($P_c - P_o$) in excess of the existing effective overburden pressure. The detail of the result is as follows:

<u>Parameters</u>	<u>Results</u>
Preconsolidation pressure, P_c (kPa)	315
Initial Void Ratio (e_o)	1.009
Compression Index (C_c)	0.562

Silty Sand

This deposit was encountered below the clayey silt with interbedded sandy silt layer. The proven thickness of this layer ranges from 2.5 m at BH #C3-2 to 4.1 m at BH #C3-2.

This deposit contains a minor variation in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel was encountered. Grain size distribution curve indicate that the soil can be classified to a silty sand. This layer is basically non-plastic. Figure 6 in the Appendix shows the result of Grain size distribution tests.

In this stratum, the 'N' values ranged from 19 to over 100 blows/0.3 m indicating a state of compaction described as compact to very dense. However, at certain locations low resistance (1 below/0.3 m) encountered. This may be attributed to 'boiling' of subsoil due to unbalanced hydrostatic head and consequently do not represent the undisturbed denseness of the soil.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes and a piezometer installed in BH #C3-2. Groundwater levels in the boreholes were found to range between elevation 63.1 m at BH #C3-1 and elevation 63.7 m at BH #C3-2. This corresponds to depths of 2.6 m to 1.7 m below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Foundation Design Engineer, and Dale Colquhoun, visiting Engineer from Jamaica. The equipment was owned and operated by Marathon Drilling Co. and Johnston Drilling Co., Ottawa.

The project was carried out by Tae C. Kim under the general supervision of Dr. B. Iyer. This report was written by Tae C. Kim, Foundation Design Engineer, reviewed by Dr. B. Iyer, Sr. Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



Tae C. Kim

Tae C. Kim, P.Eng.
Foundation Design Engineer

M. Devata

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No C3-1

METRIC

W P 120-87-00B LOCATION Co-ords: N 5 022 603.0; E 358 242.2 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 89 10 31 CHECKED BY TCK

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					
65.7	Ground Surface													
0.0	Grey		1	SS	8									
	Silty Clay to Clayey Silt		2	SS	2									
	Soft to Stiff													
61.6			3	SS	4									
4.1	Clayey Silt With Interbedded Sandy Silt Layers		4	TW	PM									
	Firm to Stiff		5	SS	16									
57.9														
7.8	Silty Sand, Some Gravel, Trace Clay		6	SS	1									
	Loose to V. Dense		7	SS	1									
53.8			8	SS	70									
11.9	End of Borehole													

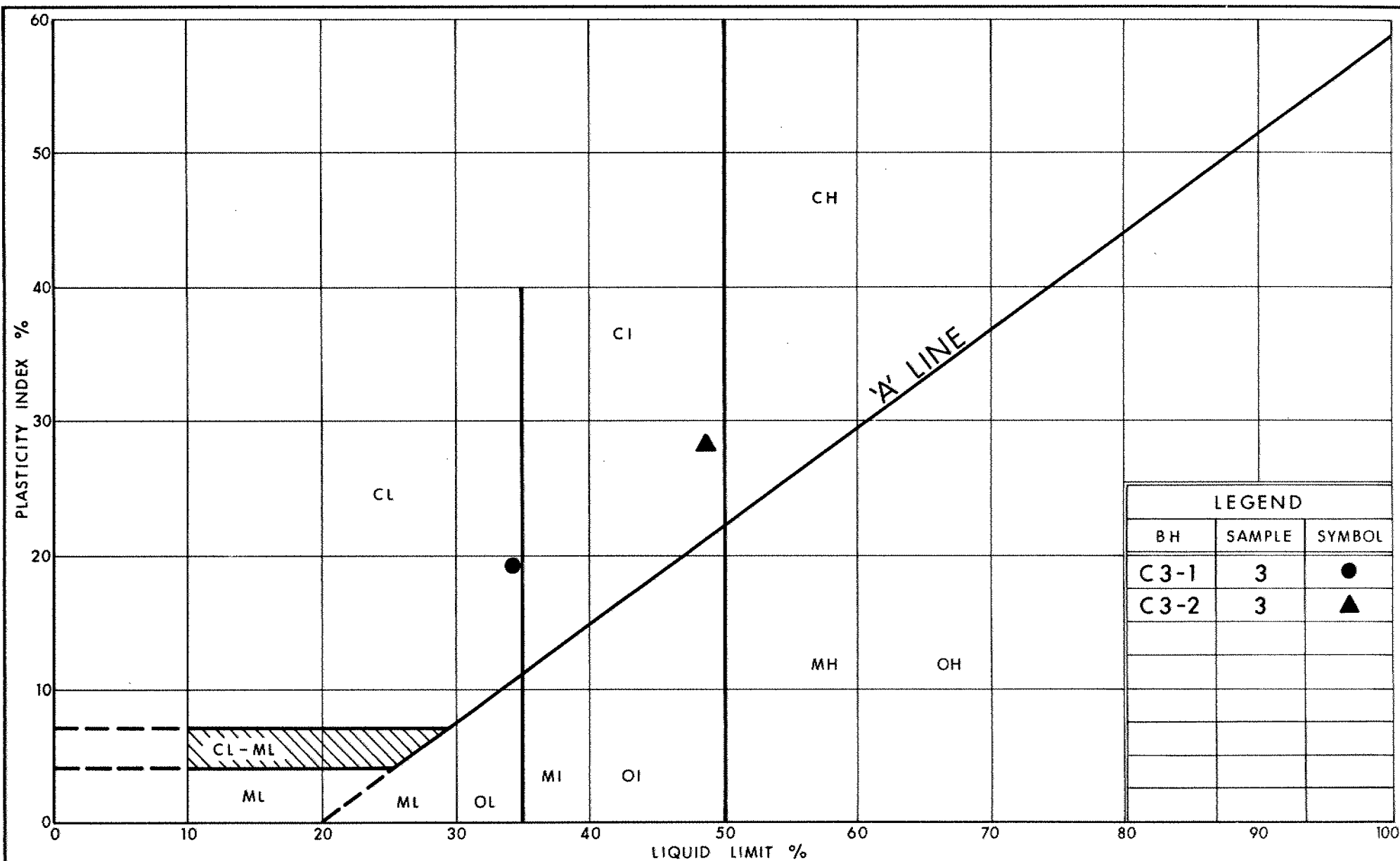
RECORD OF BOREHOLE No C3-2

METRIC

W P 120-87-00B LOCATION Co-ords: N 5 022 659.5; E 358 262.0 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 01 CHECKED BY TCK

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					
65.4	Ground Surface													
0.0	Brown Grey Silty Clay to Clayey Silt Soft to Stiff		1	SS	9		64							
			2	SS	3		62	4.5					W=43.5% W _L =48.5%	0 2 48 50
60.6			3	SS	2	Seal								
4.8	Clayey Silt With Interbedded Sandy Silt Layers Stiff		4	TW	PM	P-1 Seal	60	4.5					17.8 W=42.6%	0 4 49 47
			5	SS	1		58	7						
			6	SS	1		56	1.7						0 30 43 27
56.0	Silty Sand, Some Gravel, Trace to Some Clay Compact to V. Dense		7	SS	19		54							6 48 26 20
9.4			8	SS	90/	20cm		110, 26cm						
53.5														
11.9	End of Borehole													
	<u>Piezometer Installation</u> <u>P-1 (Tip at 5.0m BGS)</u> 0 - 4.08m Backfill 4.08 - 4.42m Bentonite Seal 4.42 - 5.12m Pea Gravel 5.12 - 5.24m Bentonite Seal 5.24 - 11.90m Backfill													

OFFICE REPORT ON SOIL EXPLORATION



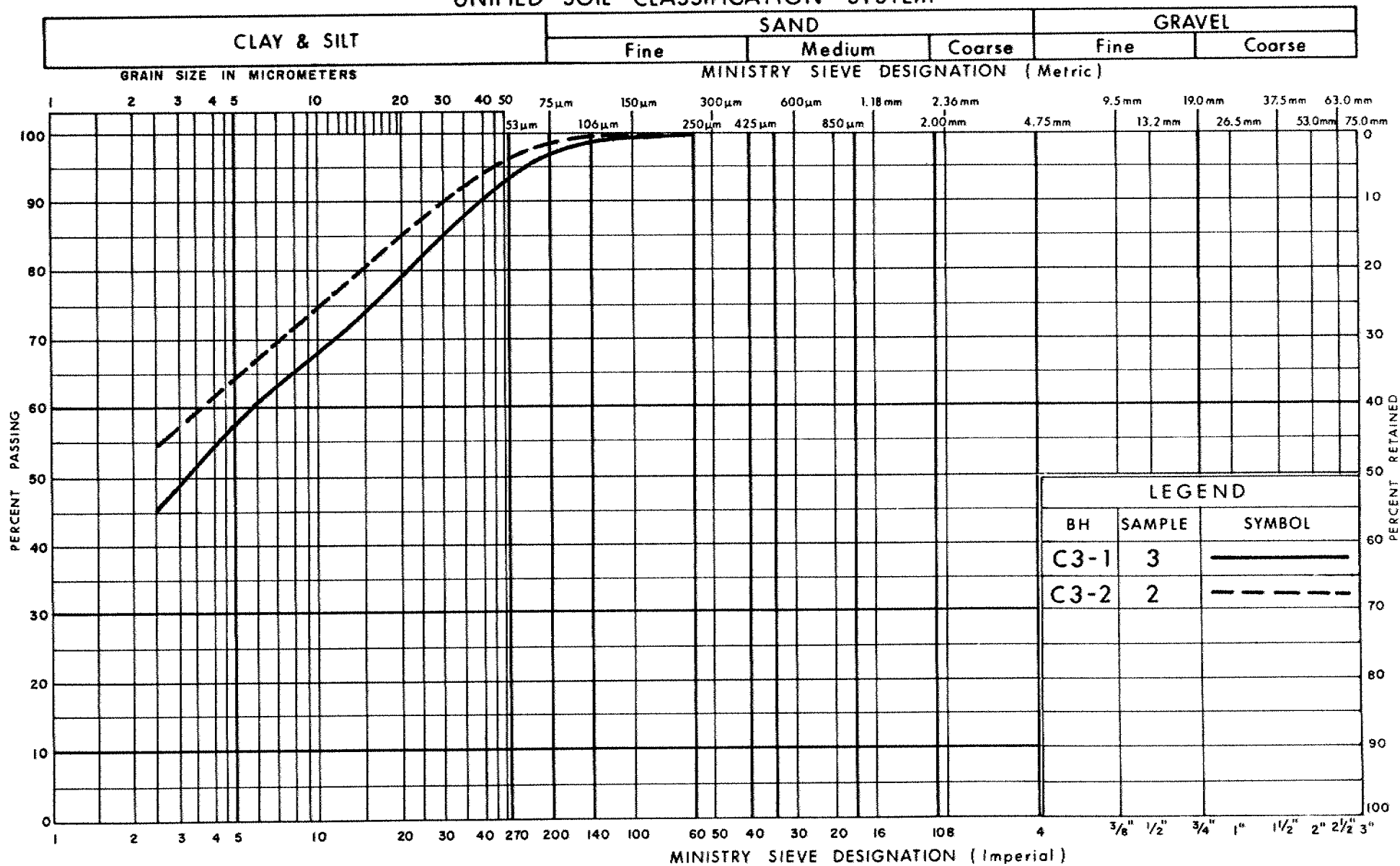
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PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-00B

UNIFIED SOIL CLASSIFICATION SYSTEM

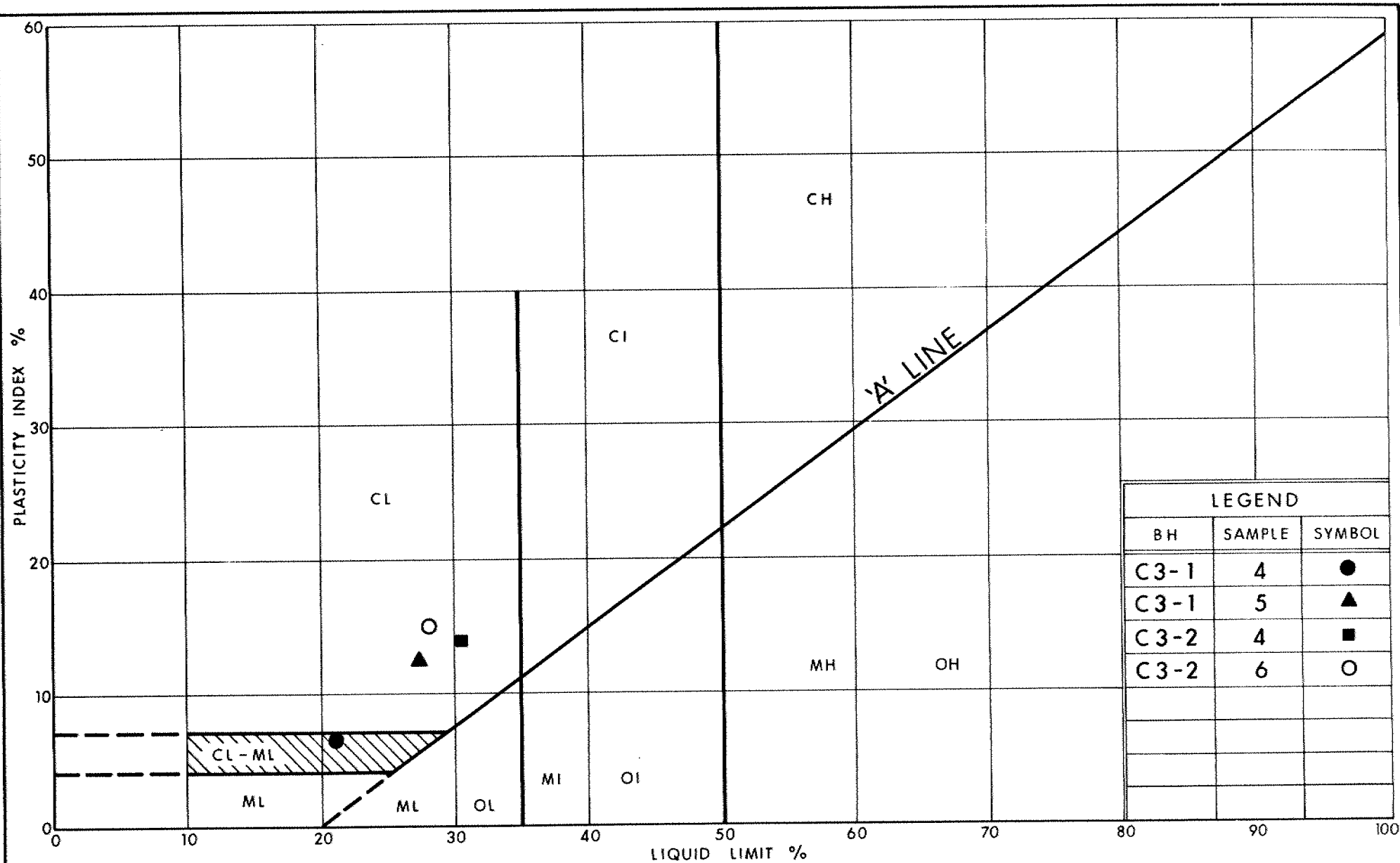


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GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

FIG No 2

W P 120-87-00B



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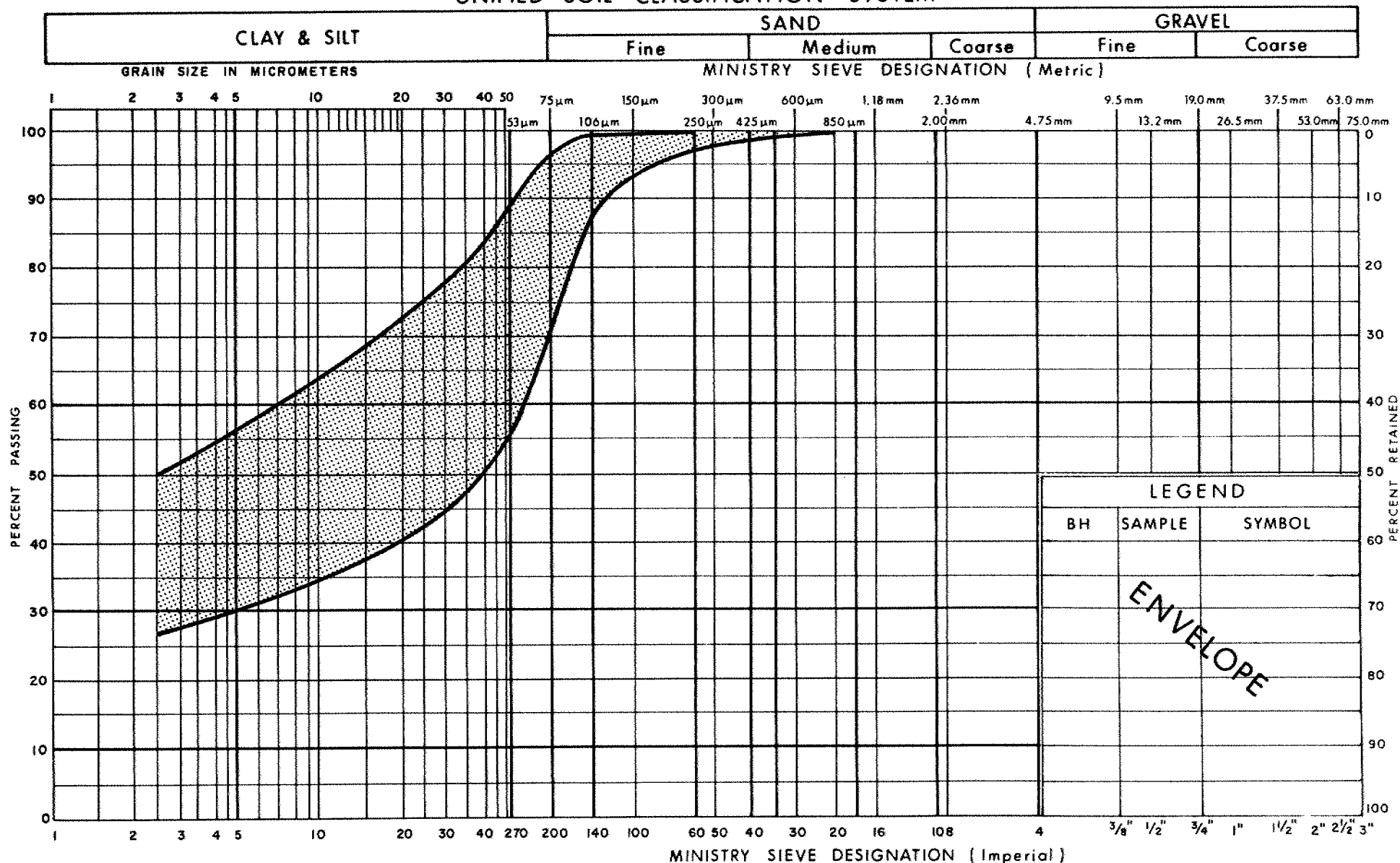
Ontario

PLASTICITY CHART CLAYEY SILT WITH INTERBEDDED SANDY SILT

FIG No 3

W P 120-87-00B

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH INTERBEDDED SANDY SILT

FIG No 4

W P 120-87-00B

VOID RATIO - PRESSURE CURVES

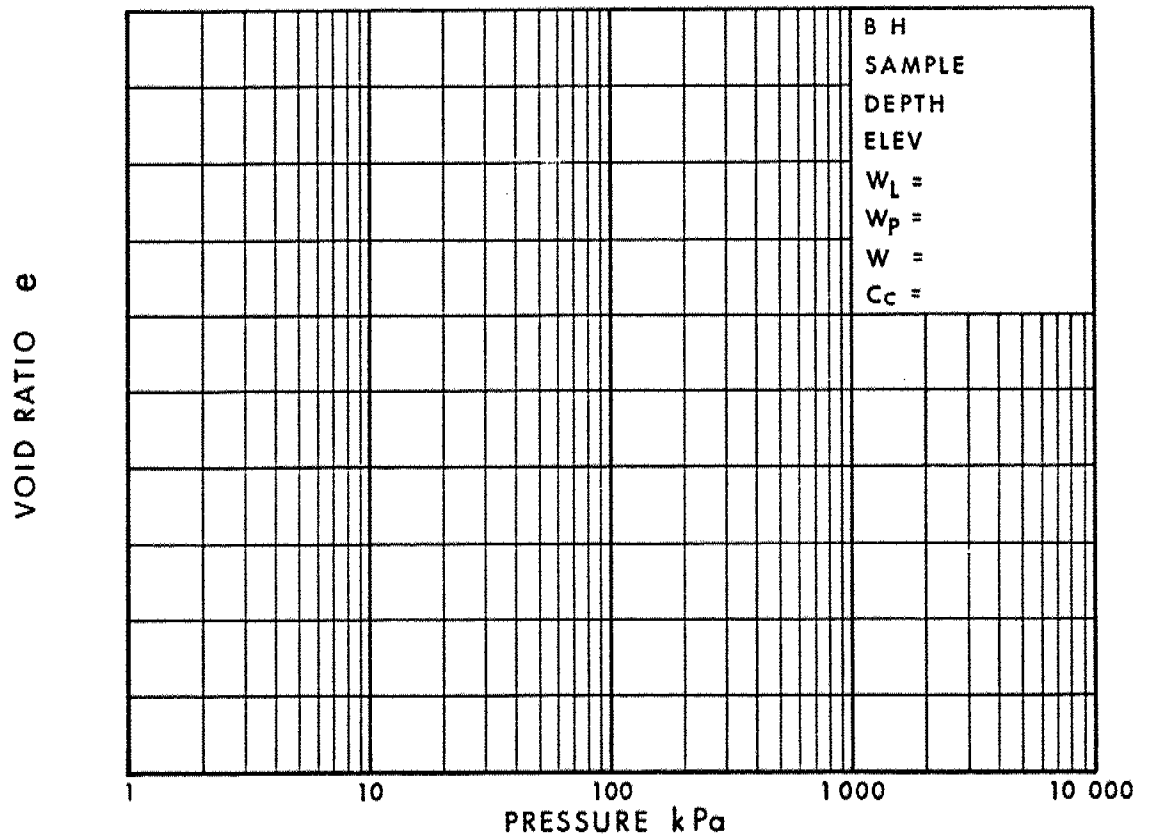
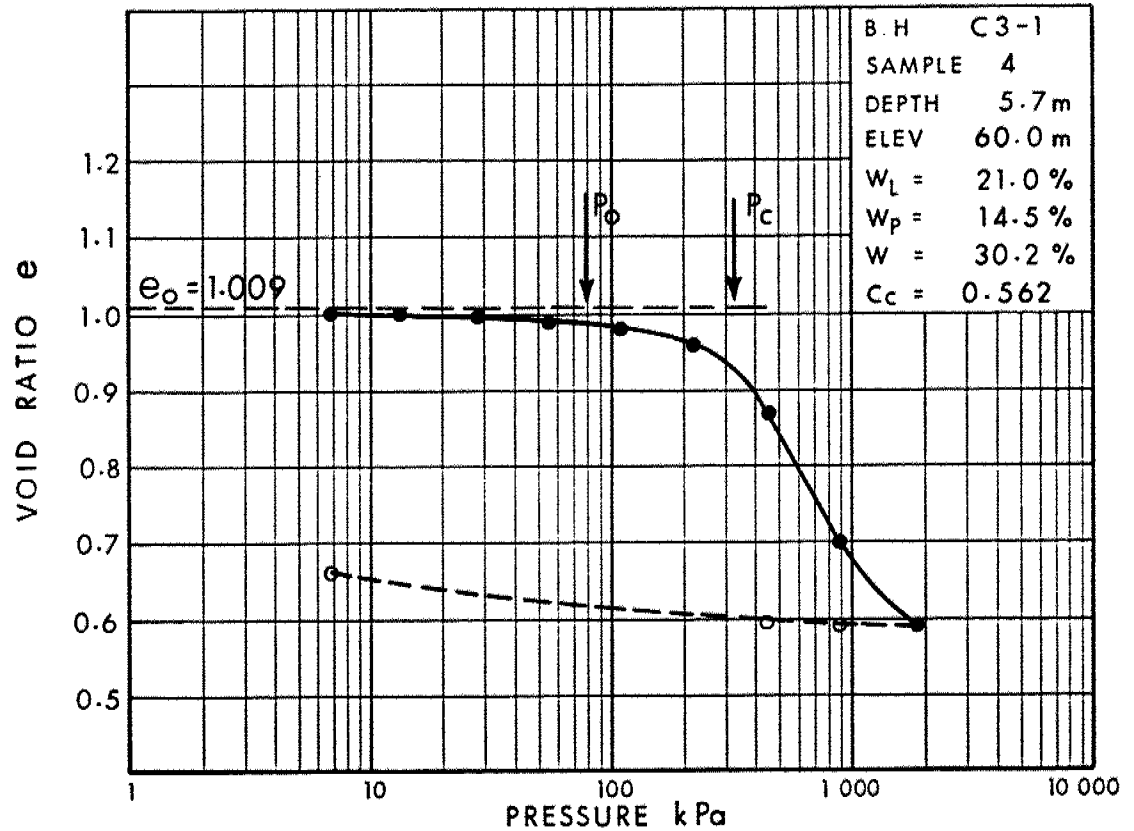
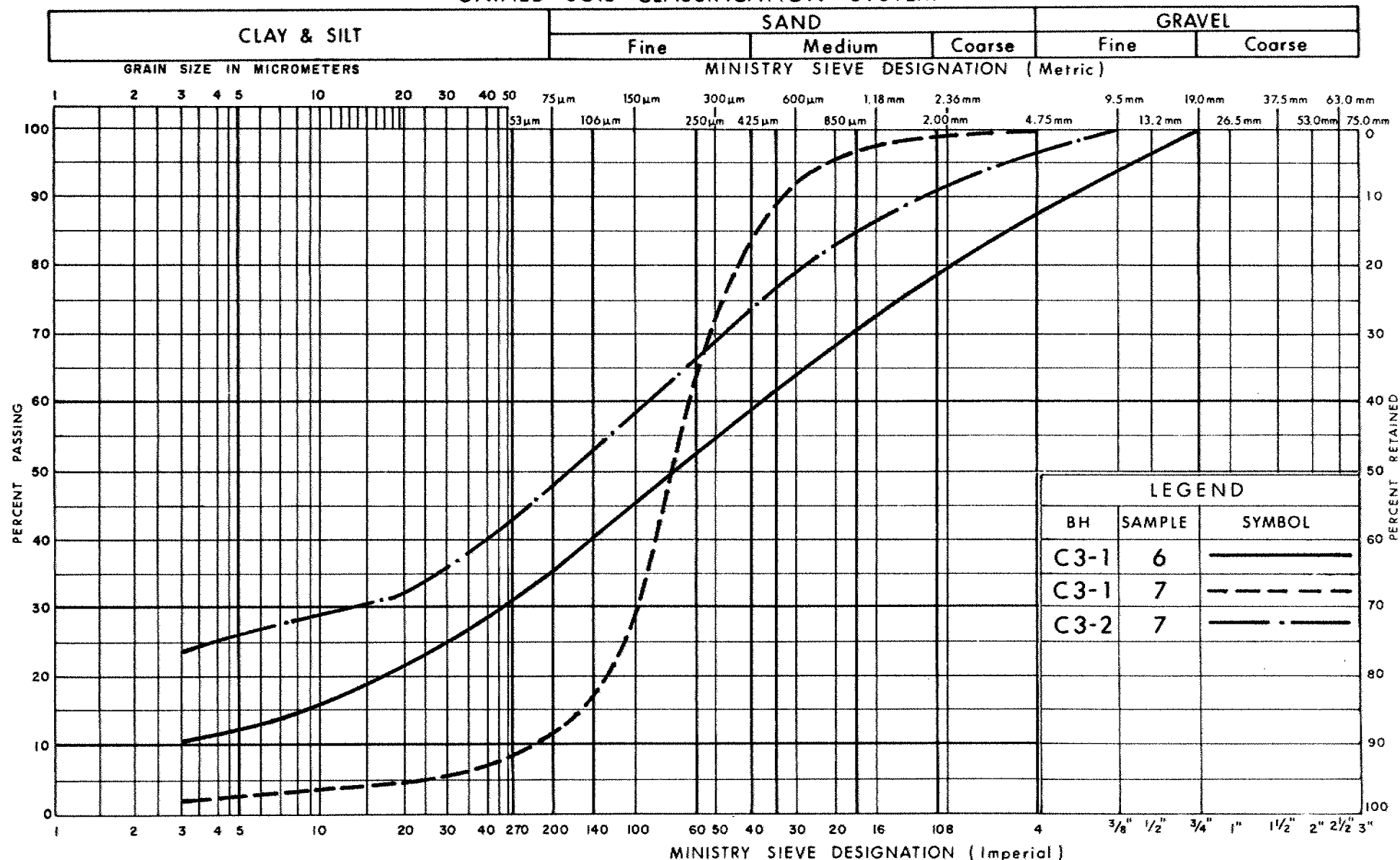


Fig 5

W P 120-87-00B

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GRAIN SIZE DISTRIBUTION
SILTY SAND

FIG No 6

W P 120-87-00B

FOUNDATION INVESTIGATION REPORT
For
Culvert Structure Underneath the Acres Road
Culvert No. # 11
W.P. 120-87-00C
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of 89 11 06 to 89 11 07. A 4.0 m span culvert structure is proposed to remove and replace the existing corrugated steel culvert that under passes the existing Acres Road.

Two boreholes (BH #C4-1 and BH #C4-2) were advanced and sampled by means of hollow stem augers with a conventional Cone Penetration Tests. These boreholes extended down to depths of 11.1 to 14.2 metres below the existing ground surface.

This report contains factual information obtained from this investigation pertaining to Culvert No. #11 as shown on Drawing No. 1208700C-A.

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located underneath the existing Acres Road immediately north of the existing Hwy. 417 in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediately vicinity being used for residential purposes. A new municipal pumping station exists west of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area; an illustration of the numerous normal faults that dominate the region. It appears that the site is divided by a fault. The

bedrock in the area is of the March Formation west of the fault, and the Rockcliffe and Gull River Formation east of the fault which are of the middle Ordovician period. The March Formation consists of interbedded quartz sandstone and sandy dolostone, whereas the Rockcliffe and Gull River Formation consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The site is transversed by a north-south trending fault which is a geologic structure reportedly common to the area. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The surficial layer consists of a generally soft to stiff cohesive silty clay to clayey silt or clayey silt with interbedded sandy silt layers which extends to a maximum thickness of 6.2 m. A deep deposit of silty sand to sand is the subsequent underlying deposit at both BH #C4-1 and BH #C4-2. However, it should be noted that this deposit was not proven for the full depth. The proven thickness down to a depth of 14.2 m below the ground surface is about 5.5 m at BH #C4-2. Within the existing embankment of Acres Road, sand with gravel fill was encountered at both boreholes from the ground surface. The maximum thickness of embankment fill is about 3.5 m at BH #C4-1.

A detailed description of the subsurface conditions encountered is given below.

Silty Clay to Clayey Silt

This stratum was encountered in a borehole (BH #C4-2). This material consists of a silty clay to clayey silt in the thickness of 6.2 m. The material is grey in colour from the intersurface with overlying sand fill.

Two Atterberg Limit tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Ranges (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	34.5-40.0	37.3
Liquid Limit (w_L)	34.5-55.5	45.0
Plastic Limit (w_p)	17.5-20.5	19.0
Plasticity Index (I_p)	17.0-35.0	21.0

From the plasticity chart, it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these materials. Figure 2 in Appendix shows the results.

Undrained shear strength of the soil were determined by in situ vane tests and by laboratory test (unconfined compression test). The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

<u>Test</u>	<u>Undrained Shear Strength (C_u, kPa)</u>	<u>Sensitivity</u>
Field Vane (2 tests)	64-96 (Avg. 80 kPa)	4.6-6.4
Unconfined Compression Test	68 kPa	

Recommended shear strength for this deposit can be estimated to be about 80 kPa. Based on this result, the soil has stiff consistency. The sensitivity of the soil is generally moderate to high.

The results (e-log P curves) of a consolidation test on a representative sample is shown on Figure 3. This test indicated that the Clayey Silt has been preconsolidated in the past to an effective pressure of 100 kPa ($P_c - P_o$) in excess of the existing effective overburden pressure. The detail of the result is as follows:

<u>Parameters</u>	<u>Result</u>
Preconsolidation pressure, P_c (kPa)	240
Initial Void Ratio (e_0)	0.997
Compression Index (C_c)	0.448

Clayey Silt with Interbedded Sandy Silt

Underlying the surficial deposit of road way sand with gravel fill, a layer of grey clayey silt with interbedded sandy silt was encountered at BH #C4-1. This stratum extends to depth of 6.1 m below the ground surface and was found within silty sand deposit at BH #C4-2. The thickness of the stratum was found to be about 2.6 m at BH #C4-1.

The results from the 2 Atterberg Limit tests performed on this material are summarized as follows:

<u>Property</u>	<u>Ranges (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	32.0-35.5	33.8
Liquid Limit (w_L)	21.0-28.5	24.8
Plastic Limit (w_p)	12.0-13.5	12.8
Plasticity Index (I_p)	9.0-15.0	12.0

From the plasticity chart (Figure 4), it is evident that the layer can be classified as an inorganic clayey silt with interbedded sandy silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 5 in the Appendix shows the results.

Undrained shear strength of the soil was determined by in situ vane tests. The results are plotted on the Record of Borehole sheets in the Appendix and summarized as follows:

<u>Undrained Shear Strength.</u>	<u>kPa</u>	<u>Average (kPa)</u>	<u>Sensitivity</u>
Field Vane (2 tests)	52-76	64	23-3.7

Due to the irregular nature of the deposit, that reveals numerous seams and layers of sandy silt interbedded within the clayey silt, the results provided in the above table are not necessarily indicative of the shear strength of the clayey silt portion. In view of this consideration, the consistency of the clayey silt portion can be described as firm to stiff. The sandy silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 65 kPa can be assumed for this stratum.

Silty Sand

This deposit was encountered below silty clay to clayey silt layer or the clayey silt with interbedded sandy silt layer. The proven thickness of this layer ranges from 5.0 m at BH #C4-1 to 5.5 m at BH #C4-2.

This deposit contains a minor variation in gravel content and irregular layer of clayey silt throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel was encountered. Grain size distribution curves indicate that the soil can be classified to a silty sand to sand. This layer is basically non-plastic. Figure 6 in the Appendix shows the result of Grain Size Distribution test.

In this stratum, the 'N' values ranged from 5 to 21 blows/0.3 m indicating a state of compaction described as loose to compact. However, at certain locations low resistance (1 blow/0.3 m) encountered. This may be attributed to 'boiling' of subsoil due to unbalanced hydrostatic head and consequently do not represent the undisturbed denseness of the soil.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes and a piezometer installed in BH #C4-1. Groundwater levels in the boreholes were found to range between elevation 60.6 m at BH #C4-1 and elevation 58.5 m at BH #C4-2. This corresponds to depths of 4.5 m to 9.6 m below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Foundation Design Engineer, and Dale Colquhoun, visiting Engineer from Jamaica. The equipment was owned and operated by Marathon Drilling Co. and Johnston Drilling Co., Ottawa.

The project was carried out by Tae C. Kim under the general supervision of Dr. B. Iyer. This report was written by Tae C. Kim, Foundation Design Engineer, reviewed by Dr. B. Iyer, Sr. Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



Tae C. Kim
Tae C. Kim, P.Eng.
Foundation Design Engineer

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

APPENDIX

RECORD OF BOREHOLE No C4-1

METRIC

W P 120-87-00G LOCATION Co-ords: N 5 022 935.8; E 358 381.0 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 06 and 07 CHECKED BY TCK

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					
65.1	Ground Surface													GR SA SI CL
0.0	Sand and Gravel (Fill)		1	SS	11									11 79 9 1
			2	SS	5									
			3	SS	3									
61.6	Brown Clayey Silt With Interbedded Sandy Silt Layers (Stiff)		4	SS	5									
3.5			5	SS	7									0 24 37 39
59.0	Silty Sand to Sand Trace to Some Gravel Loose to Compact		6	SS	1									
6.1			7	TW	PH									0 58 27 15
			8	SS	15									
54.0			9	SS	21									17 77 5 1
11.1	End of Borehole		10	SS	20									
52.9	End of Cone Test													
12.2	<u>Piezometer Installation</u> <u>P-1 (Tip at 5.3m BGS)</u> 0 - 4.66m Backfill 4.66 - 4.84m Bentonite Seal 4.84 - 5.03m Backfill 5.03 - 5.64m Pea Gravel 5.64 - 5.79m Bentonite Seal 5.79 - 6.10m Pea Gravel 6.10 - 11.10m Backfill													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C4-2

METRIC

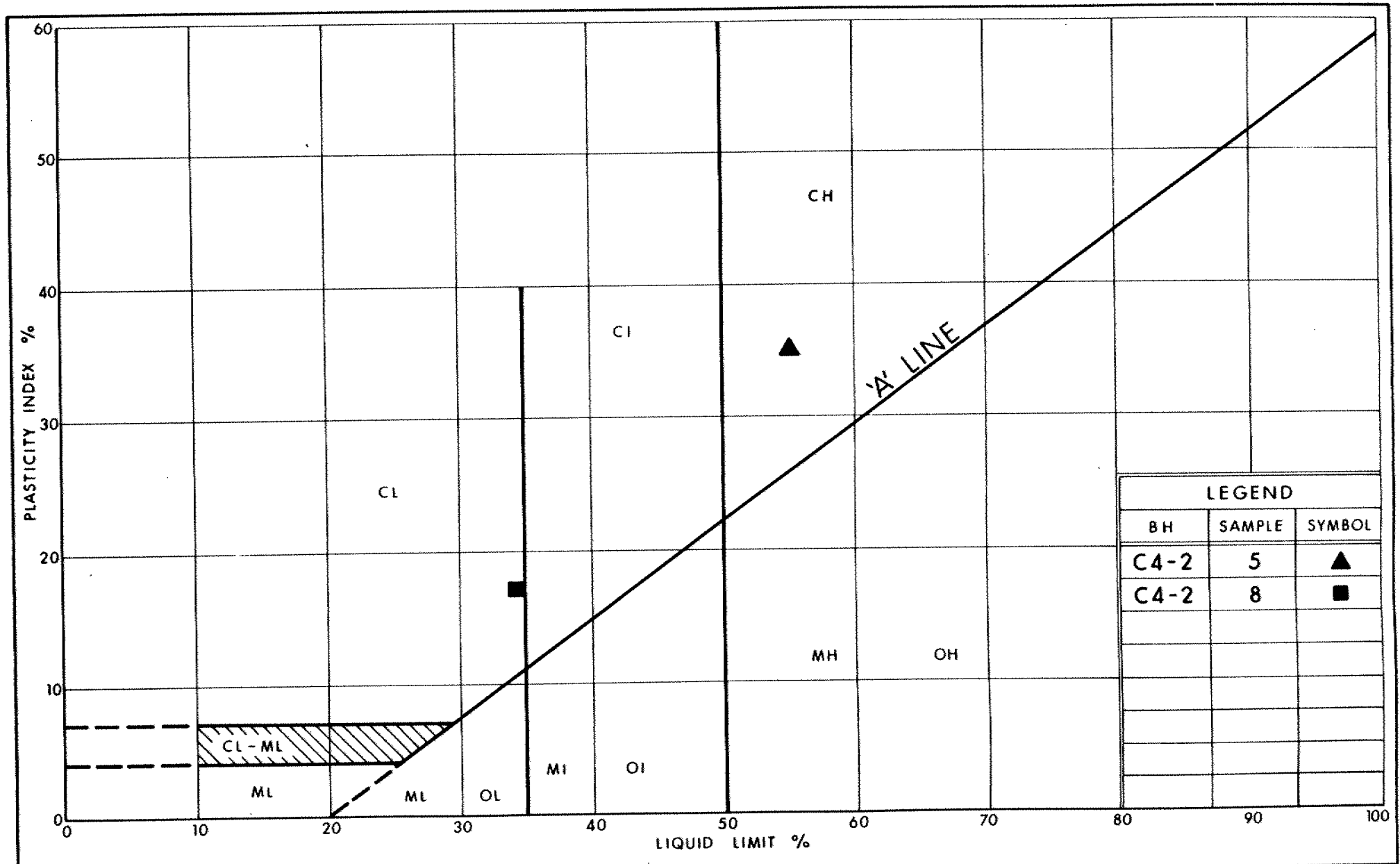
W P 120-87-00C LOCATION Co-ords: N 5 022 879.6; E 358 360.3 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 06 and 07 CHECKED BY TCK

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					
68.1	Ground Surface													
0.0	Sand and Gravel (Fill)		1	SS	27	18cm	68							
65.6			2	SS	31		66							
2.5	Brown Grey Silty Clay to Clayey Silt		3	SS	9		64							
			4	SS	14		62							
			5	SS	8		60							
			6	SS	6		58							
			7	SS	1		56							
59.4			8	TH	21		54							
8.7	Silty Sand to Sand Occasional Clayey Silt Layers Loose to Compact		9	SS	21									
			10	SS	5									
	Clayey Silt		11	SS	2									
53.9			12	SS	1									
14.2	End of Borehole													
	*Water Level not Stabilized													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



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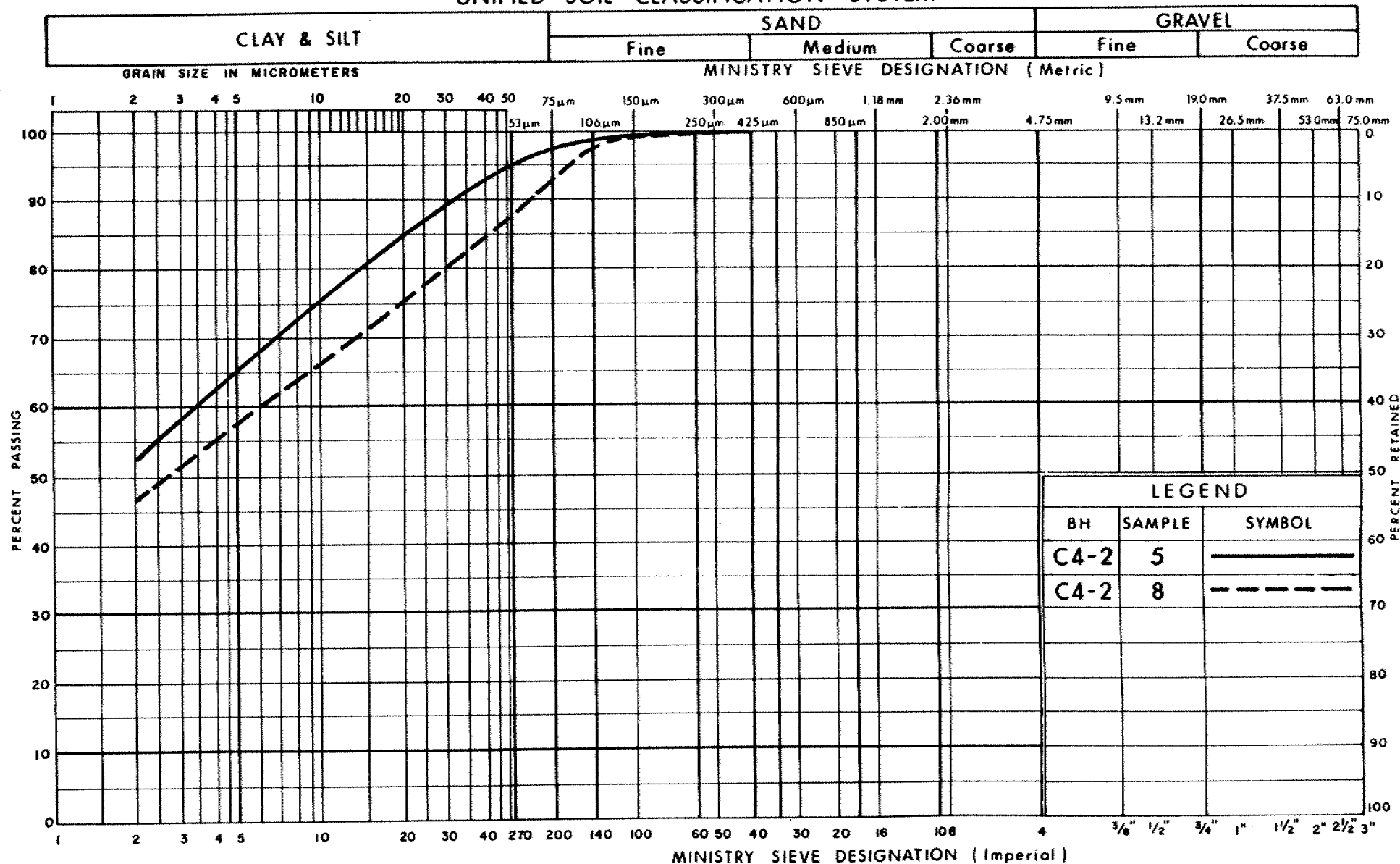
Ontario

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-00C

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

FIG No 2

W P 120-87-00 C

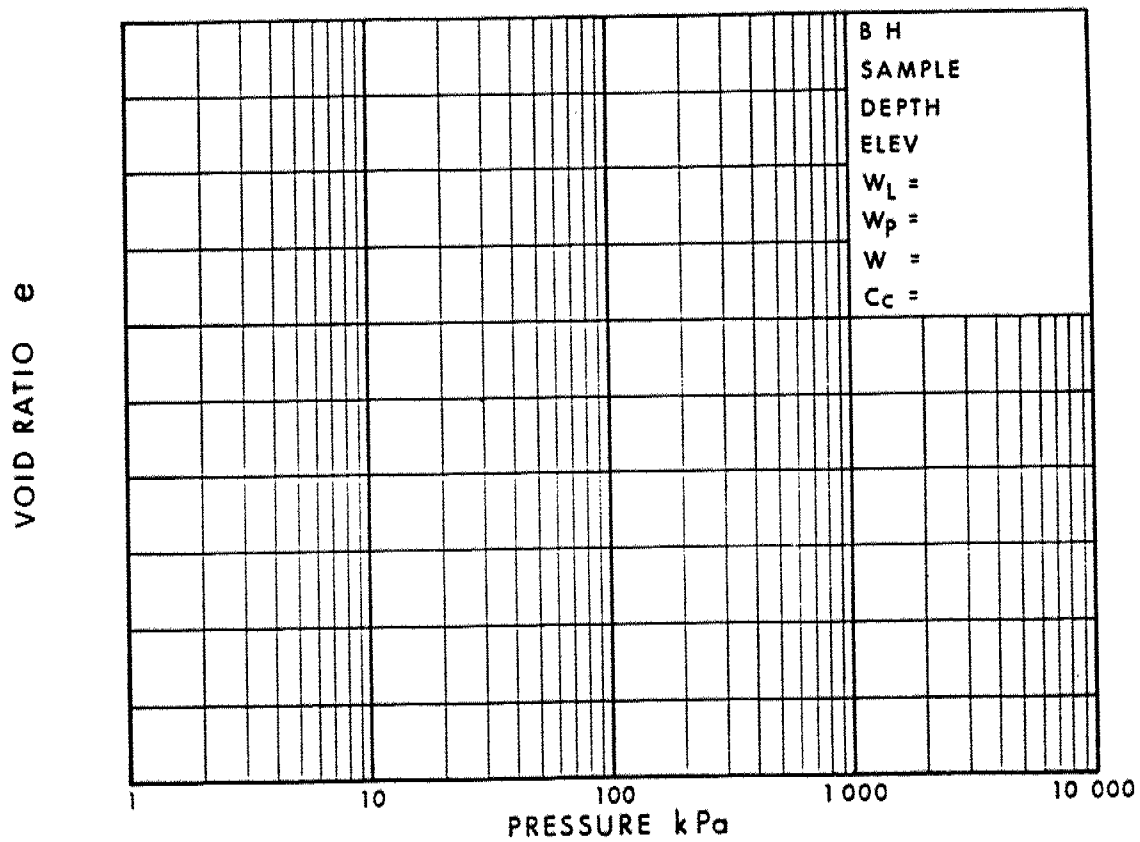
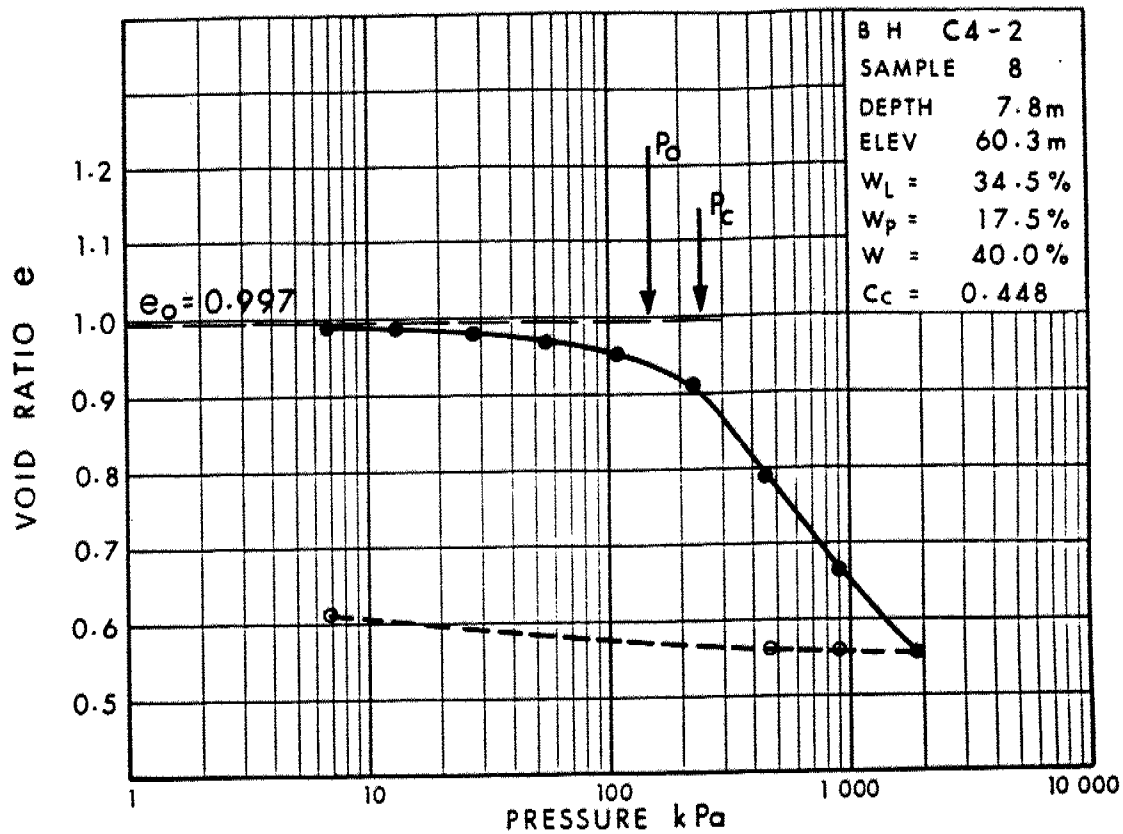
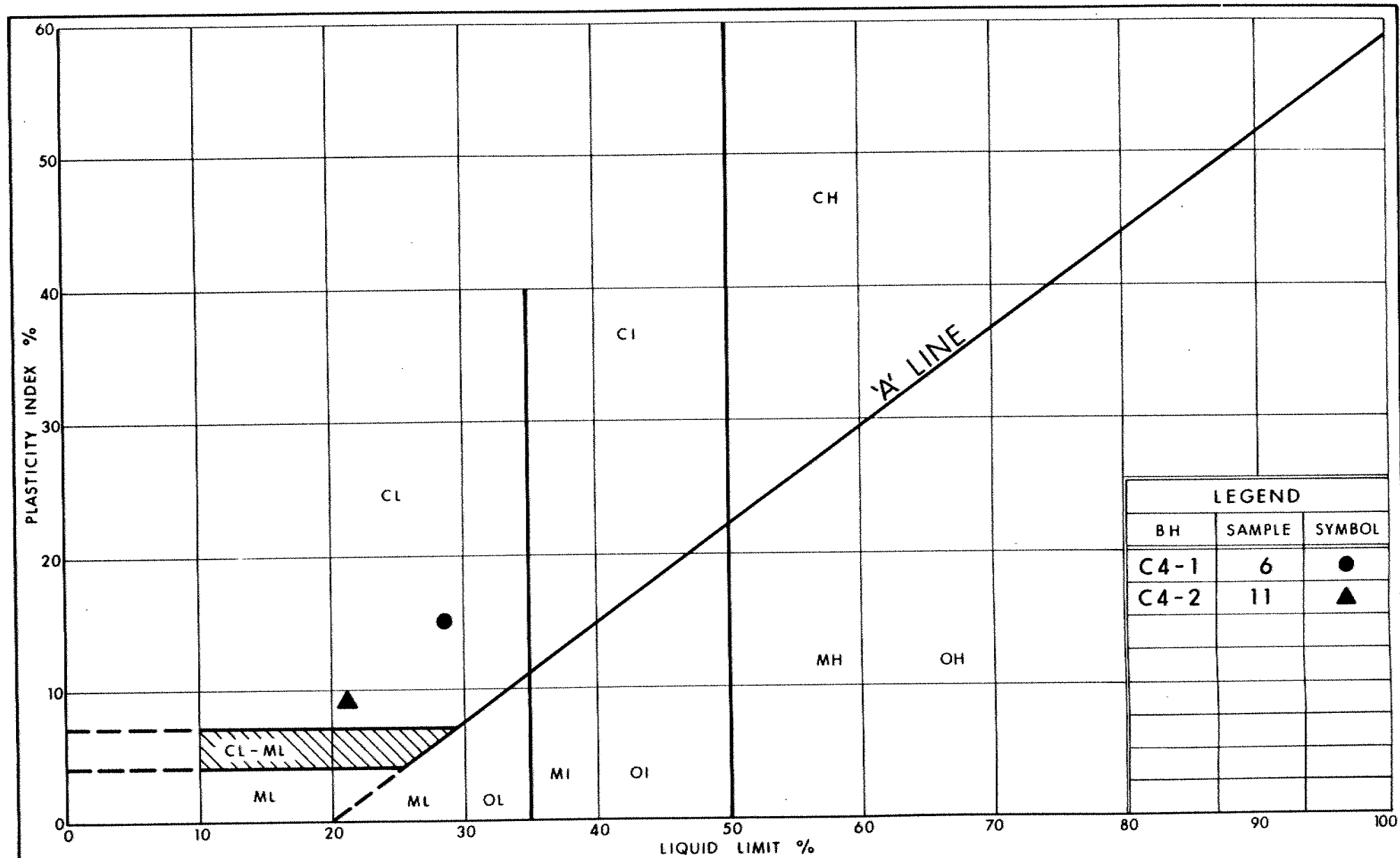


Fig 3



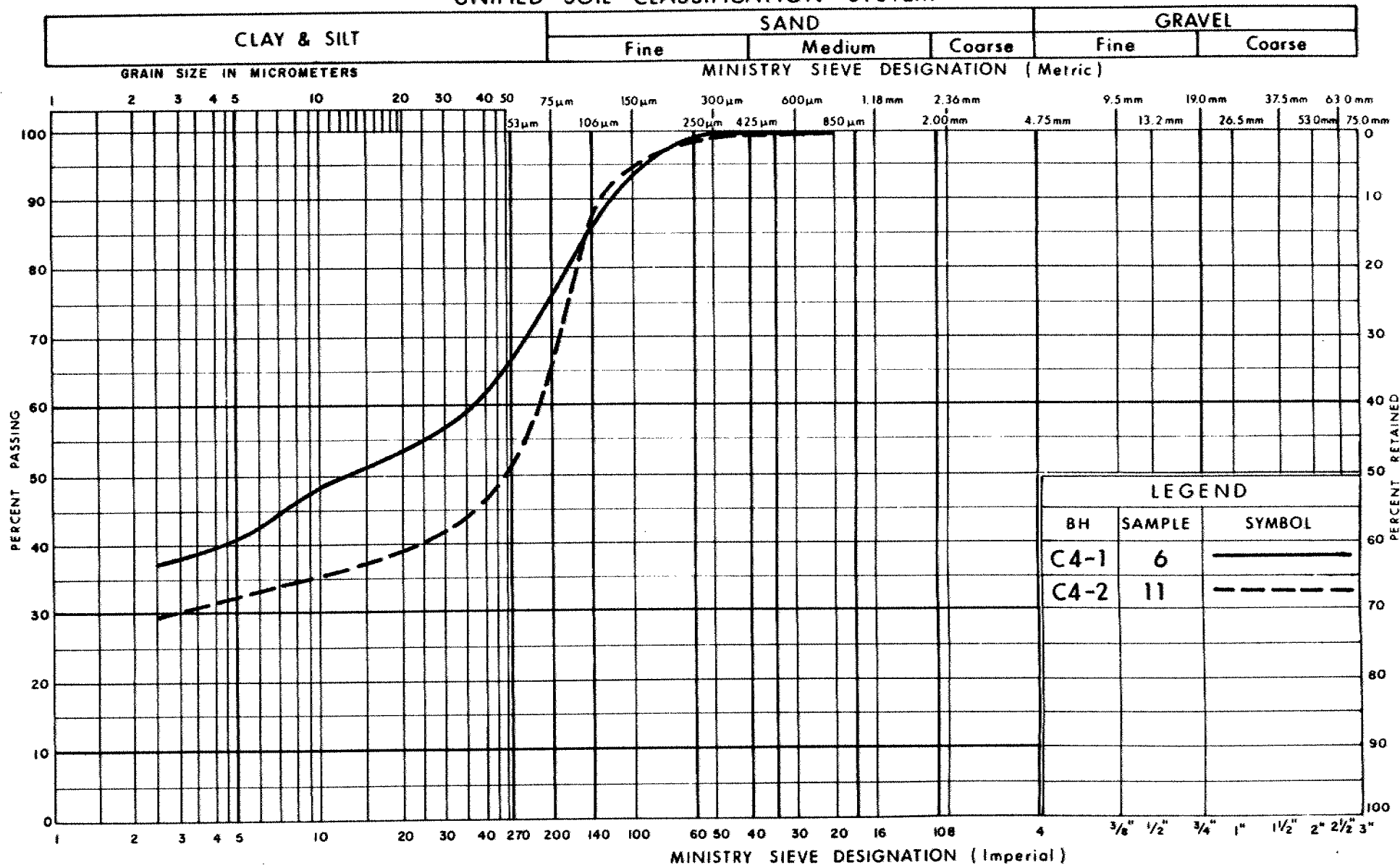
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Ontario

PLASTICITY CHART CLAYEY SILT WITH INTERBEDDED SANDY SILT

FIG No 4

W P 120-87-00 C

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

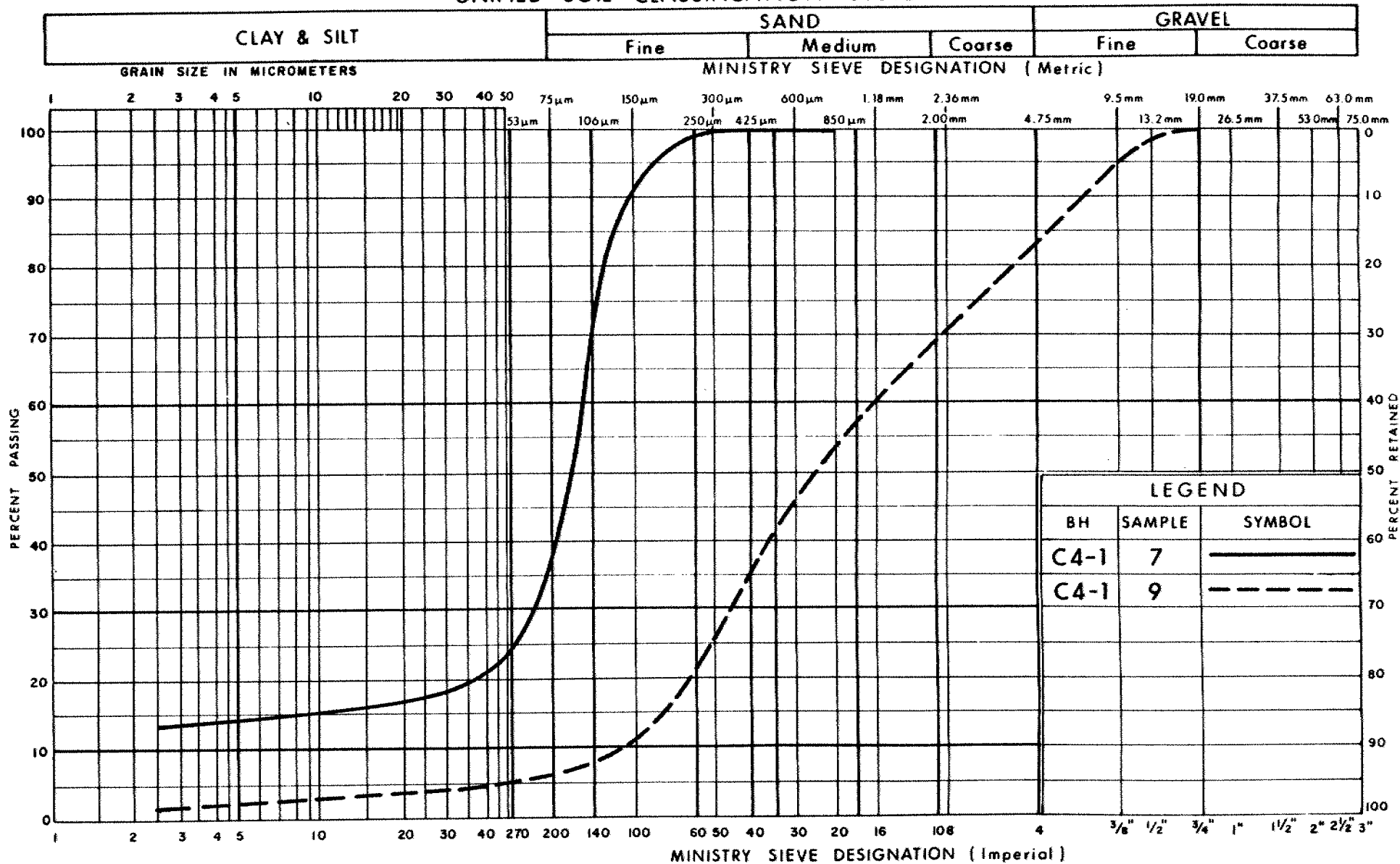
GRAIN SIZE DISTRIBUTION

CLAYEY SILT WITH INTERBEDDED SANDY SILT

FIG No 5

W P 120-87-00C

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND TRACE TO SOME GRAVEL

FIG No 6

W P 120-87-00 C

FOUNDATION INVESTIGATION REPORT
For
A Median Retaining Wall along the South
Shoulder of the New Hwy. 417 W.B.L.
from Station 16+675 to Station 16+790
W.P. 120-87-00D
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of 89 11 03 to 89 11 04. A 115 m long median retaining wall is proposed to construct along the South shoulder of the new Hwy. 417 Westbound lane between Sta. 16+675 and Sta. 16+790.

Four boreholes (BH #R-1 and BH #R-4) were advanced and sampled as part of this project by means of hollow stem augers. These boreholes extended down to depth of 9.6 m below the ground surface. In addition to split spoon sampling in all boreholes, cone penetration tests were conducted in the vicinity of the boreholes.

This report contains factual information obtained from this investigation pertaining to the retaining wall as shown on Drawing No. 1208700D-A.

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located in the median lane immediately north of the existing Hwy. 417 eastbound lane between Richmond Road and existing Acres Road in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediately vicinity being used for commercial purposes. Residential development exists east of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also

evident within the area; an illustration of the numerous normal faults that dominate the region. The bedrock in the area is of the Rockcliffe and Gull River Formations of the middle Ordovician period. It consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The overburden was deposited during and immediately following the Wisconsinan glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

SUBSURFACE CONDITIONS

The subsoil conditions are generally quite variable across the site. The upper 4 to 6 m of the subsoil consists of interbedded layers of silty clay to clayey silt and sandy silt or silty sand. The consistency of the silty clay to clayey silt layers varies from soft to hard, whereas the denseness of the sand layers may be described as loose to compact. The stratigraphy is quite irregular and reference should be made to the individual borehole log sheets. Beneath this layered deposit is a deposit of sandy silt to sand. The denseness of this deposit generally varies from loose to dense. However, this deposit was not proven for the full depth.

It should be noted that in the vicinity of the east end of retaining wall near BH #R-4 a layer of silty clay to clayey silt is gradually diminished. In stead, silty sand with some clayey silt layers was encountered at BH #R-4. In certain areas sand fill was encountered near the road way at two boreholes (BH #R-1 and #R-2).

A detailed description of the subsurface conditions encountered is given below.

Fill material

The fill material was encountered in the vicinity of the west portion of the site at two borehole locations (BH #R-1 and #R-2). This fill consists of a brown sand and gravel. The thickness of this layer is found to be 1.4 m at both boreholes as shown on the Record of Borehole sheets. No Grain size distribution

analysis was carried out. However, through visual observation, it is apparent that the fill material can be classified as a sand and gravel.

Silty Clay to Clayey Silt

This stratum was encountered in most of the boreholes except near the east portion of the site (BH #R-4). This material consists of a silty clay to clayey silt ranging in thickness between 1.5 and 2.3 m. The material is grey in colour.

Three Atterberg Limit Tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	25.0-46.5	34.7
Liquid Limit (w_L)	21.0-43.0	38.0
Plastic Limit (w_p)	14.0-19.0	16.7
Plasticity Index (I_p)	17.0-26.0	21.3

From the plasticity chart (see Figure 1) it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results.

Undrained shear strength of the soil was determined by in situ vane tests. The results are plotted on the Record of Borehole sheets in Appendix. As shown on the borehole logs, in situ vane tests were not successful probably due to some sand seam within this layer. However based on the Standard Penetration Tests, the soil has generally a soft to stiff consistency.

Clayey Silt with Interbedded Layers of Sandy Silt

This deposit occurred underlying the silty clay to clayey silt layer or underlying a thick layer of silty sand to a depth of 4.4 to 6.3 m. The thickness of the individual layers varies between 0.7 m at BH #R-2 and 5.6 m at BH #R-3.

The results from five Atterberg Limit Tests performed on this material are summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	15.0-33.5	27.7
Liquid Limit (w_L)	21.0-26.5	23.9
Plastic Limit (w_p)	11.5-14.5	13.1
Plasticity Index (I_p)	8.5-14.0	10.8

From the plasticity chart (Figure 3), it is evident that the layer can be classified as an inorganic clayey silt with interbedded sandy silt with low plasticity (CL).

Grain size distribution tests were carried out on these materials. Figure 4 in the Appendix shows the results in an envelope form.

Undrained shear strength measurements were determined by in situ vane tests and the result varies from 58 to 68 kPa. Due to the irregular nature of the deposit, that reveals numerous seams and layers of sandy silt interbedded within the clayey silt, the results provided in the above are not necessarily indicative of the shear strength of the clayey silt portion. In view of this consideration, the consistency of the clayey silt portion can be described as firm to stiff. The sandy silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 65 kPa can be assumed for this stratum.

Silty Sand to Sand

This deposit encountered at various depths from ground surface to the end of boreholes. However, below an elevation of about 60.6 m, this granular deposit extended as a continuous layer to proven depth of 9.6 m below the ground surface. The thickness of the layers varies from 0.7 to 5.2 m.

This deposit contains minor variations in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some

locations, considerable gravel was encountered. Grain size distribution analysis indicate that the soil varies between a silty sand to sand. This layer is basically non-plastic. Figure 5 in the Appendix shows the results of grain size distribution tests in an envelope form.

In this stratum, the 'N' values generally ranged from 2 to 36 blows/0.3 m indicating a state of compaction described as very loose to dense.

However, at certain locations no resistance was encountered and the samples penetrated by its own weight. This may be attributed to 'boiling' of subsoil due to unbalanced hydrostatic head and consequently do not represent the undisturbed denseness of the soil.

No rock samples was cored at the location.

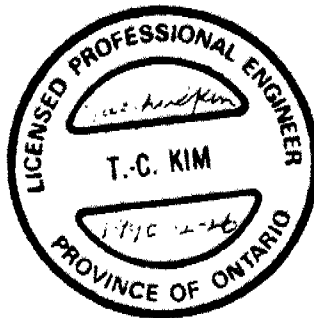
GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater level in the boreholes was found to range from 60.9 m at BH #R-1 to 63.7 m at BH #R-4 which corresponds to depths of 4.5 m to 2.5 m below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Foundation Design Engineer, and Dale Colquhoun, visiting Engineer from Jamaica. The equipment was owned and operated by Marathon Drilling Co. and Johnston Drilling Co., Ottawa.

The project was carried out by Tae C. Kim under the general supervision of Dr. B. Iyer. This report was written by Tae C. Kim, Foundation Design Engineer, reviewed by Dr. B. Iyer, Sr. Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



Tae C. Kim

Tae C. Kim, P.Eng.

Foundation Design Engineer

M. Devata

M. Devata, P.Eng.

Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No R-1

METRIC

W P 120-87-00D LOCATION Co-ords: N 5 022 796.4; E 358 855.0 ORIGINATED BY DC
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 03 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
66.2	Ground Surface													GR SA SI CL
0.0	Sand and Gravel (Fill) Brown Grey		1	SS	19		66							
64.8			2	SS	9		64							
1.4	Silty Clay to Clayey Silt Soft to Stiff		3	SS	2		62							0 2 46 52
62.5			4	SS	13		62							0 39 34 27
3.7	Silty Sand, Compact		5	SS	1		60							
61.8			6	SS	2		58							
4.4	Clayey Silt With Interbedded Sandy Silt Soft to Firm		7	SS	11		56							
59.9			8	SS	13									
6.3	Silty Sand to Sand, Trace to Some Gravel Loose to Compact													
56.6														
9.6	End of Borehole													
55.5														
10.7	End of Cone Test													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No R-2

METRIC

W P 122-87-00D LOCATION Co-ords: N 5 022 805.0; E 358 903.0 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 04 CHECKED BY TCK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
66.2	Ground Surface												
0.0	Sand and Gravel Compact (Fill)		1	SS	15								
64.8	Brown		2	SS	7								
1.4	Grey		3	SS	4								
63.3	Silty Clay to Clayey Silt Firm		4	SS	PH								
2.9	Silty Sand, Loose		5	SS	1								
62.5	Clayey Silt With Interbedded Sandy Silt Layers Soft		6	SS	1								
3.7			7	SS	5								
61.8			8	SS	11								
4.4			9	SS	8								
56.6	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No R-3

METRIC

W P 120-87-00D LOCATION Co-ords: N 5 022 814.1; E 358 952.1 ORIGINATED BY DG
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
DATUM Geodetic DATE 89 11 04 CHECKED BY TCK

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					
66.2	Ground Surface													GR SA SI CL
0.0	Grey Silty Clay to Clayey Silt Stiff		1	SS	8		66							0 13 64 23
64.5			2	SS	21		64							0 61 24 15
1.7	Silty Sand		3	SS	3		64							
	Clayey Silt With Interbedded Sandy Silt Layers Soft to Stiff		4	SS	2		62							0 29 44 27
60.6			5	SS	2		62							
5.6	Silty Sand to Sand Trace to Some Gravel		6	SS	3		60							3 57 27 13
	Clayey Silt		7	SS	7		58							1 33 42 24
56.6	Loose to Compact		8	SS	34									
9.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

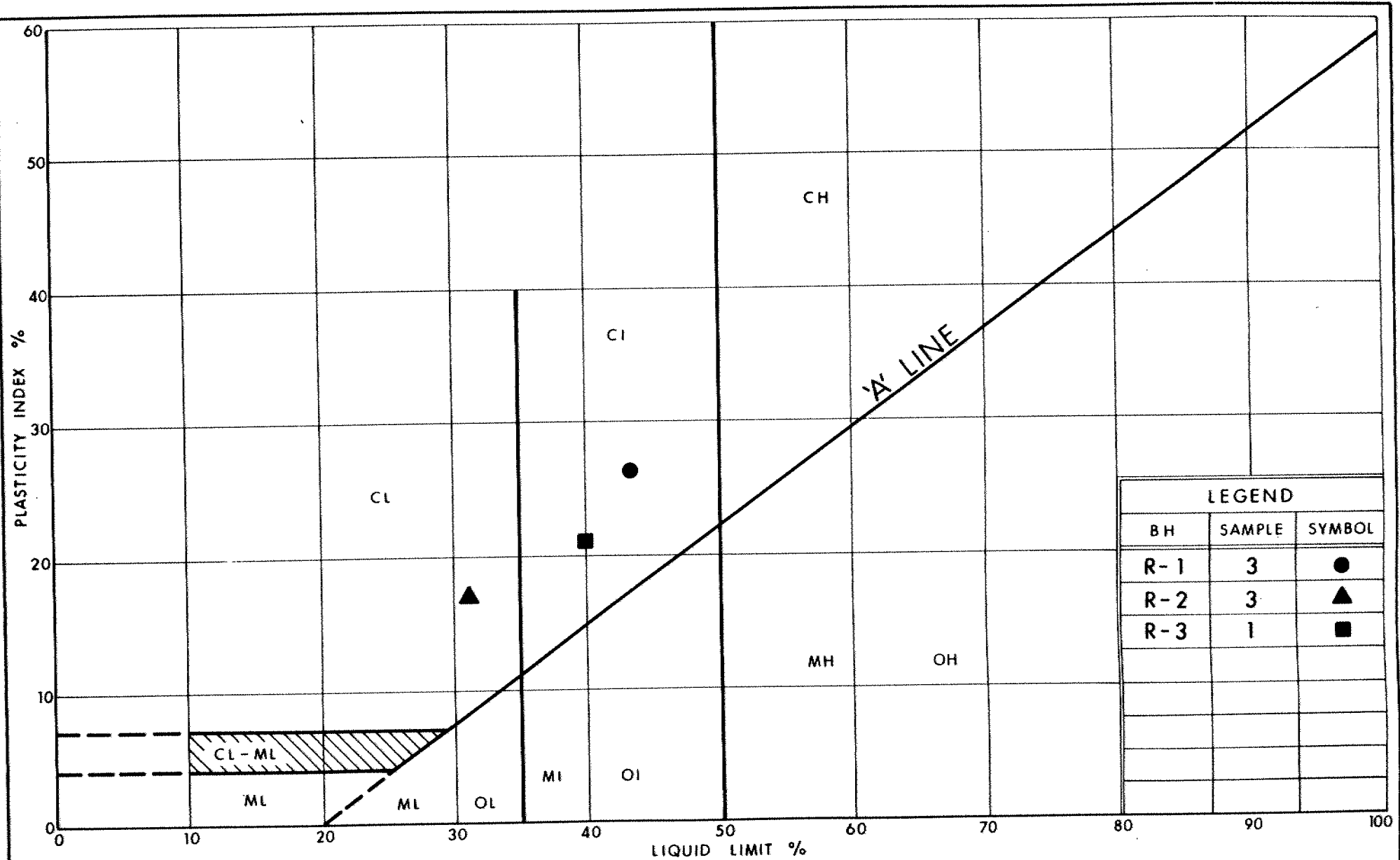
RECORD OF BOREHOLE No R-4

METRIC

W P 130-87-00D LOCATION Co-ords: N 5 022 822.8; E 359 002.3 ORIGINATED BY DC
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 89 11 03 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
66.7	Ground Surface												
0.0	Silty Sand With Some Clayey Silt Layers Very Loose to Compact		1	SS	9		66						0 38 48 14
			2	SS	7		64						
			3	SS	3								
			4	SS	2								
			5	SS	2								
59.8	Silty Sand to Sand, Trace to Some Gravel Loose to Dense		6	SS	17		60						1 72 17 10
6.4			7	SS	2								
56.6	Clayey Silt		8	SS	36		58						3 73 14 10
9.6	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION



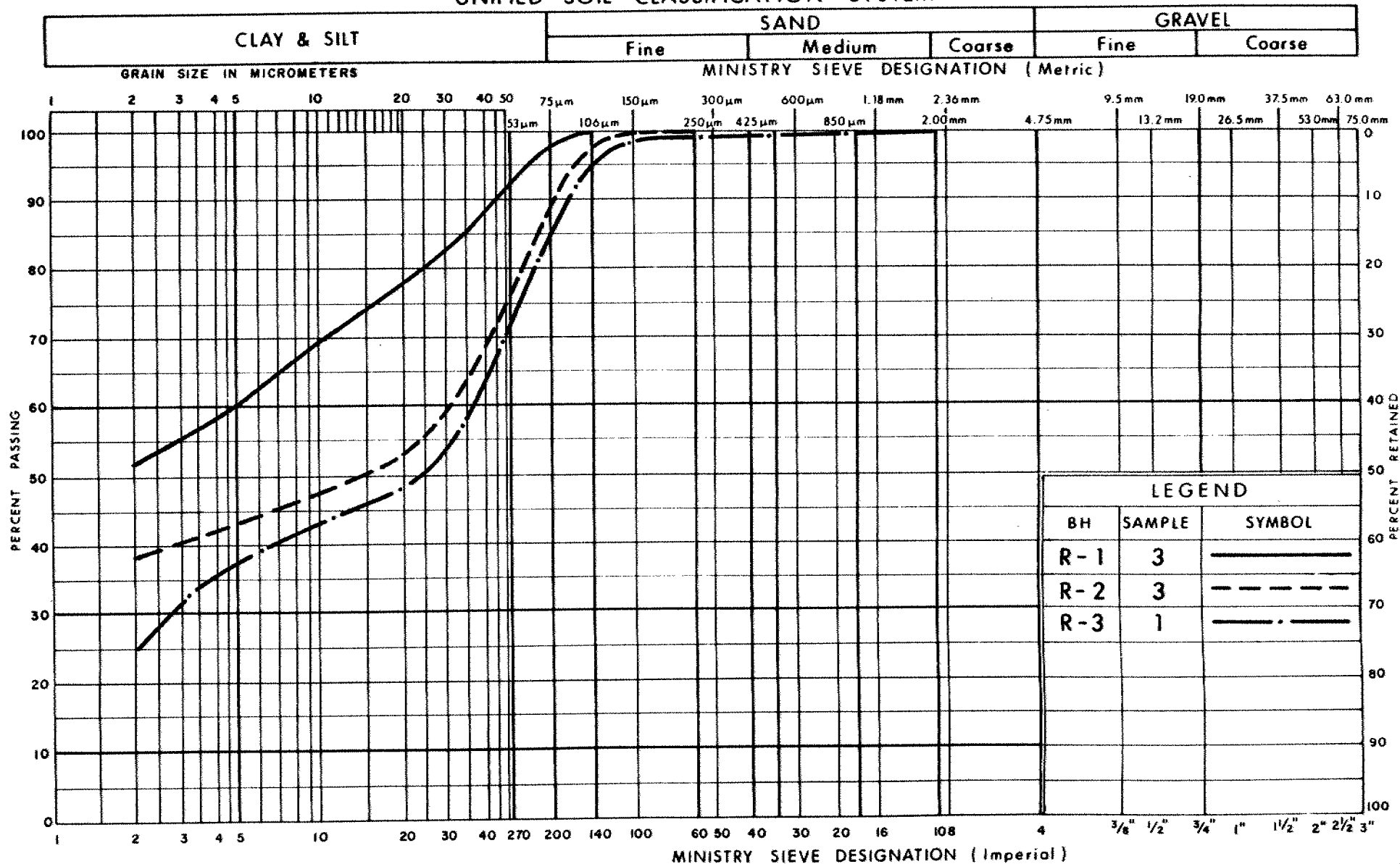
Ministry of
Transportation

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-00 D

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

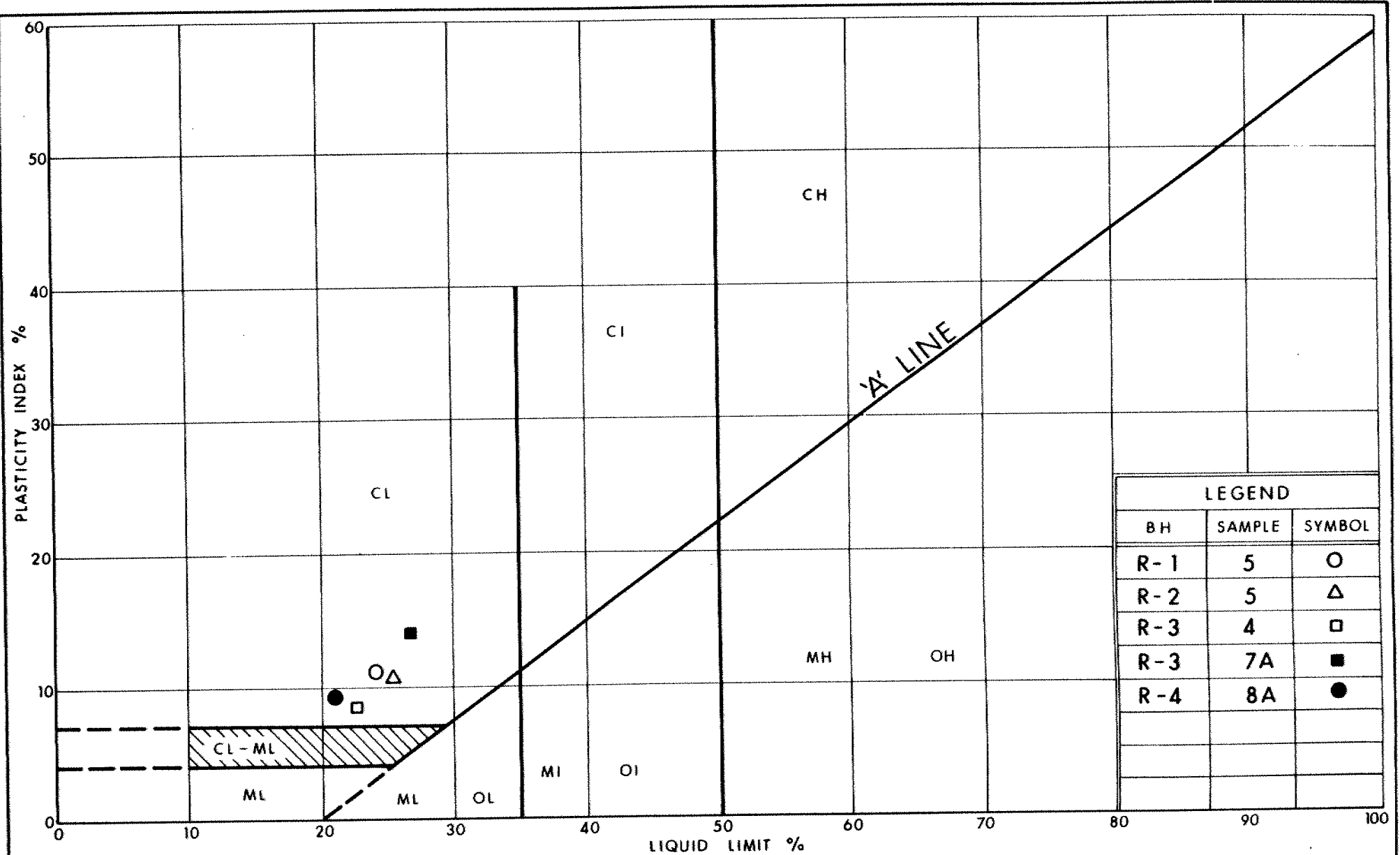
FIG No 2

W P 120-87-00 D



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Ontario



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Transportation

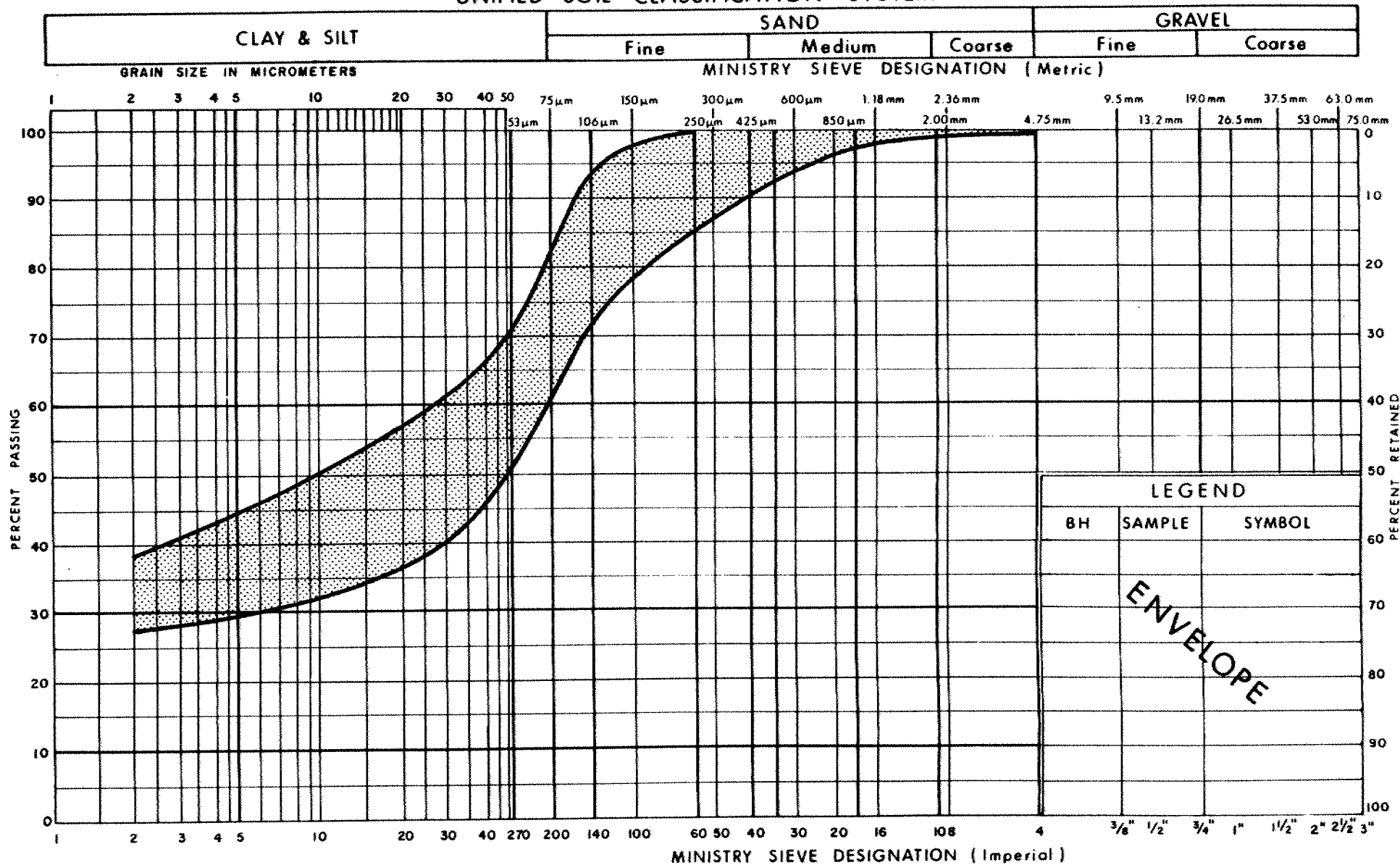
Ontario

PLASTICITY CHART CLAYEY SILT WITH INTERBEDDED SANDY SILT

FIG No 3

W P 120-87-00 D

UNIFIED SOIL CLASSIFICATION SYSTEM



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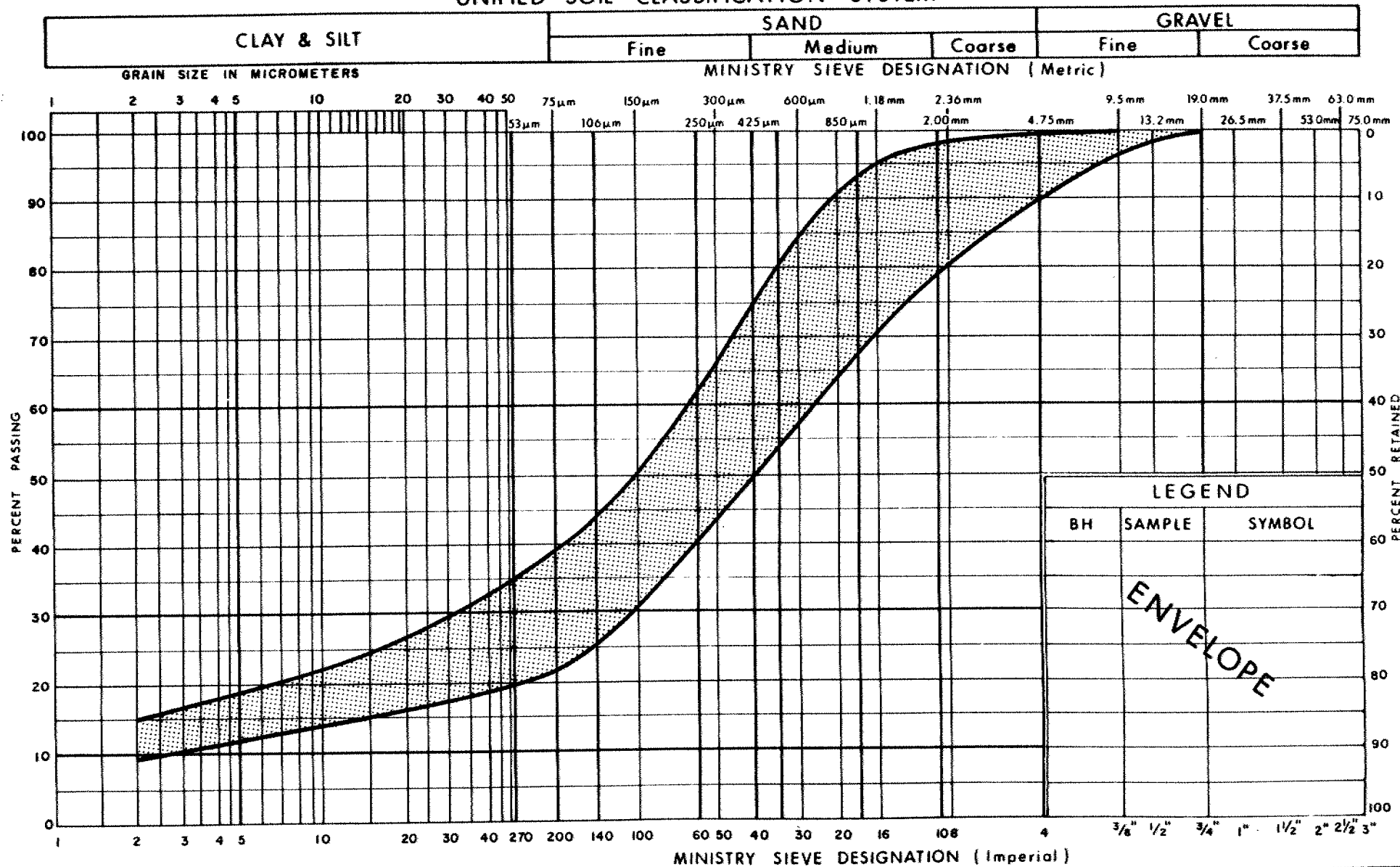
GRAIN SIZE DISTRIBUTION

CLAYEY SILT WITH INTERBEDDED SANDY SILT

FIG No 4

W P 120-87-00D

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND TRACE TO SOME GRAVEL

FIG No 5

W P 120-87-00D

FOUNDATION INVESTIGATION REPORT
For
Ramp 417 EB - 416 SB
(Station 15+780 to Station 16+220)
WP 120-87-01
District 9, Ottawa

INTRODUCTION

This report summarizes the results of a geotechnical site investigation implemented for stability and settlement analysis of the aforementioned ramp. The investigation was carried out between 88 07 26 and 88 07 27 and consisted of six sampled boreholes accompanied with two dynamic cone tests. The boreholes ranged in depth from 0.3 m to 9.2 m below existing ground surface and were advanced using hollow stem continuous flight augers. Bedrock outcrops were present from Station 15+960 to the southern limit of the site.

SITE DESCRIPTION AND GEOLOGY

Located in the City of Nepean, Ottawa-Carleton Municipality, the site traverses an area that spans from Hwy. 417, approximately 0.5 km west of the existing Acres Road and turns to parallel the existing Acres Road approximately 0.25 km west.

The north-western portion of the site is used primarily for agriculture and consists of low lying flat terrain. Bedrock outcrops populate the southern portion of the site. This general area is used for grazing cattle.

A swampy bog and lagoon zone is present in a depression adjacent to an existing fault scarp that separates the two distinct areas previously described. The fault scarp is located at approximate station 15+960.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the Lowlands of the St. Lawrence. The deposit consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region.

The bedrock in the area is of the Gull River Formation of the Middle Ordovician Period. It consists of interbedded silty dolostone, shaley limestone and fine grained quartz sandstone. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

SUBSURFACE CONDITIONS

General

Subsoil conditions change dramatically from one area of the site to another. A prominent fault scarp separates the varying subsurface conditions. Northwest of the scarp, overburden consists of 2.0 m to 7.0 m of clayey silt with interbedded silty sand overlying a minimum thickness of 1.4 m of a heterogeneous mixture of silt, sand and gravel (glacial till). Bedrock or perhaps boulders, a possible constituent of the till deposit, was inferred at locations where the augers met practical refusal. South of the scarp, bedrock outcrops are scattered throughout the area.

The boundaries between the various soil types, in situ and laboratory test results as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are also provided on Dwg. 1208701-A.

A detailed description of the subsurface conditions encountered is given below.

Clayey Silt with interbedded Silty Sand

This surficial deposit of clayey silt with interbedded silty sand extends for a maximum thickness of 7.0 m. The interbedded silty sand exists as seams of a few millimetres in thickness to layers up to 100 mm in thickness and is generally of a loose relative density. Atterberg Limits testing were performed in the laboratory to evaluate the behaviour of the cohesive portion of the deposit and the results are plotted on Figure 1 and tabulated in Table 1 below:

Table 1

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	27-39	33
Liquid Limit (w _L %)	21.5-34	27.4
Plasticity Index (I _p %)	9-19	13.5
Liquidity Index (I _L)	1.0-1.7	1.5

The results reveal that the cohesive soil is of low plasticity and that the in situ moisture contents generally exceed the liquid limit of the soil.

Grain size distribution curves for the deposit as determined by mechanical analyses are provided on Figure 2.

The undrained shear strength of the soil as determined by in situ vane tests produced values in the 40 to 50 kPa range. Based on these values, it can be concluded that the cohesive soil is of a soft to firm consistency. However, it should be reminded that these values are not necessarily indicative of the true shear strength in view of the presence of the silty sand seams. In consideration of this, a value of 40 kPa has been selected for design purposes.

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

Underlying the clayey silt with interbedded silty sand exists a cohesionless glacial deposit consisting of a heterogeneous mixture of silt, sand and gravel. This deposit has a relative density ranging from compact to very dense but is generally dense.

Grain size distribution curves for the deposit are provided on Figure 3 in the Appendix.

Bedrock

Bedrock outcrops exist predominantly south of Station 16+000. Bedrock can be inferred to exist at an approximate elevation of 56 to 57 m between Stations 15+800 and 15+850. At the location of BH R3, bedrock can be inferred to exist at an approximate elevation of 61.8 m. No rock cores were obtained.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of J. Fellenius and M. Schnarr, Student Engineers, utilizing equipment owned and operated by Marathon Drilling Co. This report was written by T. Sangiuliano and reviewed by M.S. Devata, Chief Foundation Engineer.



T. Sangiuliano
T. Sangiuliano, P.Eng.
Foundation Engineer

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

APPENDIX

RECORD OF BOREHOLE No R1

METRIC

W P 120-87-01 LOCATION Co-ords. N 5 022 460.4; E 358 088.3 ORIGINATED BY JF
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 26 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
66.0	Ground Surface													
0.0	Clayey Silt With Interbedded Silty Sand Grey Soft to Firm		1	SS	2									0 13 55 32
			2	SS	1								0 10 43 47	
			3	TW	PH									
			4	SS	2									
59.0			5	SS	80									
7.0	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Very Dense													
57.6	End of Borehole (Auger Refusal) Probable Bedrock													
8.4														

RECORD OF BOREHOLE No R2

METRIC

W P 120-87-01 LOCATION Co-ords. N 5 022 444.3; E 358 134.4 ORIGINATED BY JF
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 26 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH kPa 20 40 60 80 100	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES									
65.8 0.0	Ground Surface													
	Clayey Silt With Interbedded Silty Sand Very Soft to Firm		1	SS	5									
			2	SS	2									
			3	TW	PH									
59.7 6.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Compact to Very Dense		4	SS	15									0 12 46 42
			5	SS	15									15 42 35 8
			6	SS	25	7 cm								
56.6 9.2	End of Borehole (Auger Refusal) Probable Bedrock													

RECORD OF BOREHOLE No R3

METRIC

W P 120-87-01 LOCATION Co-ords. N 5 022 424.8; E 358 178.7 ORIGINATED BY MS
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 07 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)	10 20 30				
65.5	Ground Surface																
0.0	Clayey Silt With Interbedded Silty Sand Grey, Soft		1	SS	4												
63.5																	
2.0	Het. Mixture of Silt Sand, Gravel and Boulders (Glaical Till)		2	CS	-												
61.8																	
3.7	End of Borehole Auger Refusal Probable Bedrock																

RECORD OF BOREHOLE No R4

METRIC

W P 120-87-01 LOCATION Co-ords. N 5 022 371.4; E 358 265.7 ORIGINATED BY MS
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 07 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
68.5	Ground Surface																
0.0 68.2	Clayey Silt		1	CS	-	*											
0.3	End of Borehole (Auger Refusal) Probable Bedrock																
	* Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No R5

METRIC

W P 120-87-01 LOCATION Co-ords. N 5 022 340.2; E 358 303.1 ORIGINATED BY MS
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 07 27 CHECKED BY

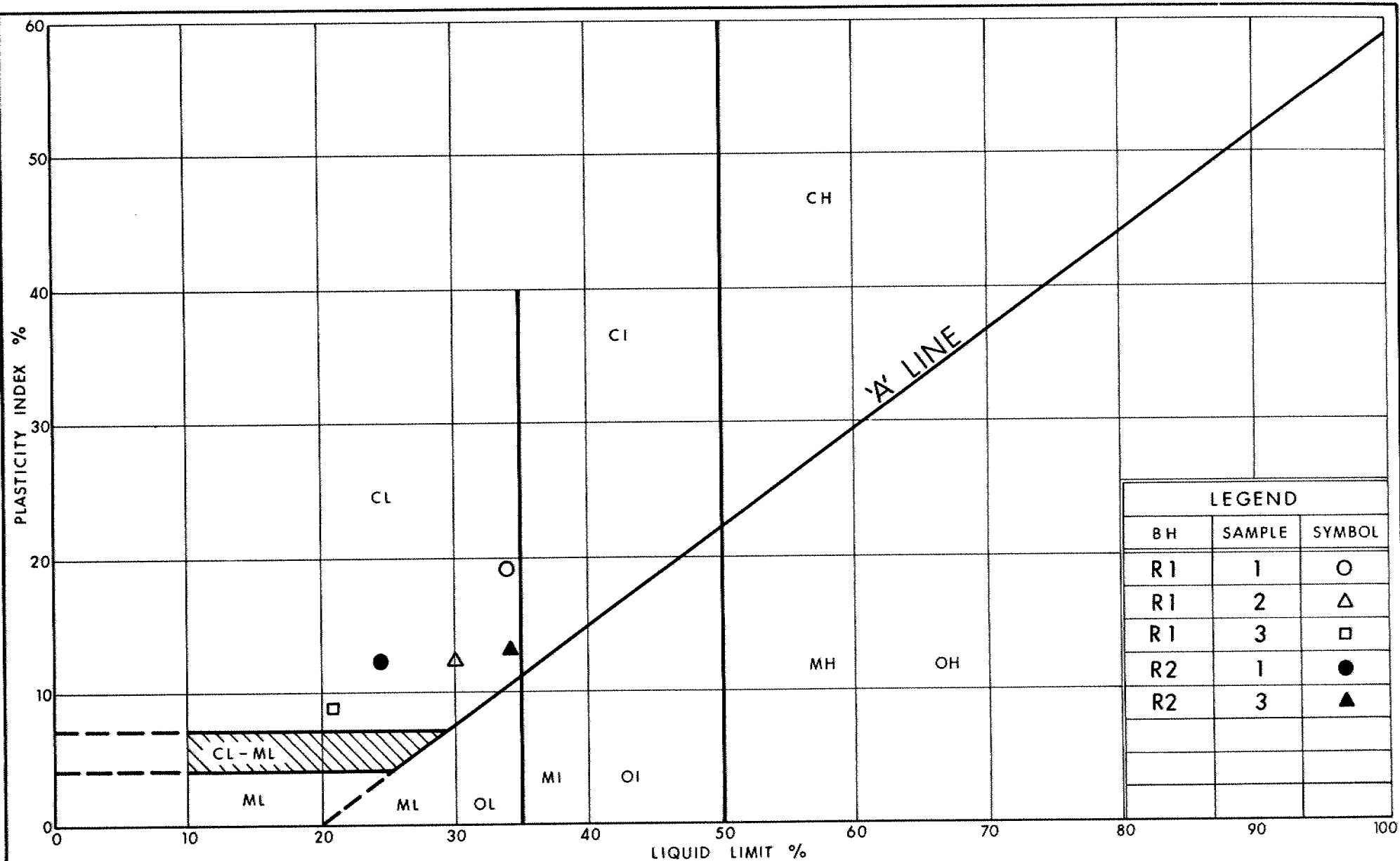
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
69.6	Ground Surface																
0.0	Heterogeneous Mixture of Silt, Sand, Gravel and Boulders (Glacial Till)		1	CS	-	*											
67.8							68										
1.8	End of Borehole (Auger Refusal) Probable Bedrock * Borehole Dry																

RECORD OF BOREHOLE No R6

METRIC

W P 120-87-01 LOCATION Co-ords. N 5 022 302.9; E 358 337.1 ORIGINATED BY JF
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 07 27 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
68.3	Ground Surface															
0.0 68.0	Clayey Silt		1	CS	-	*										
0.3	End of Borehole (Auger Refusal) Probable Bedrock)															
	* Borehole Dry															



Ministry of
Transportation

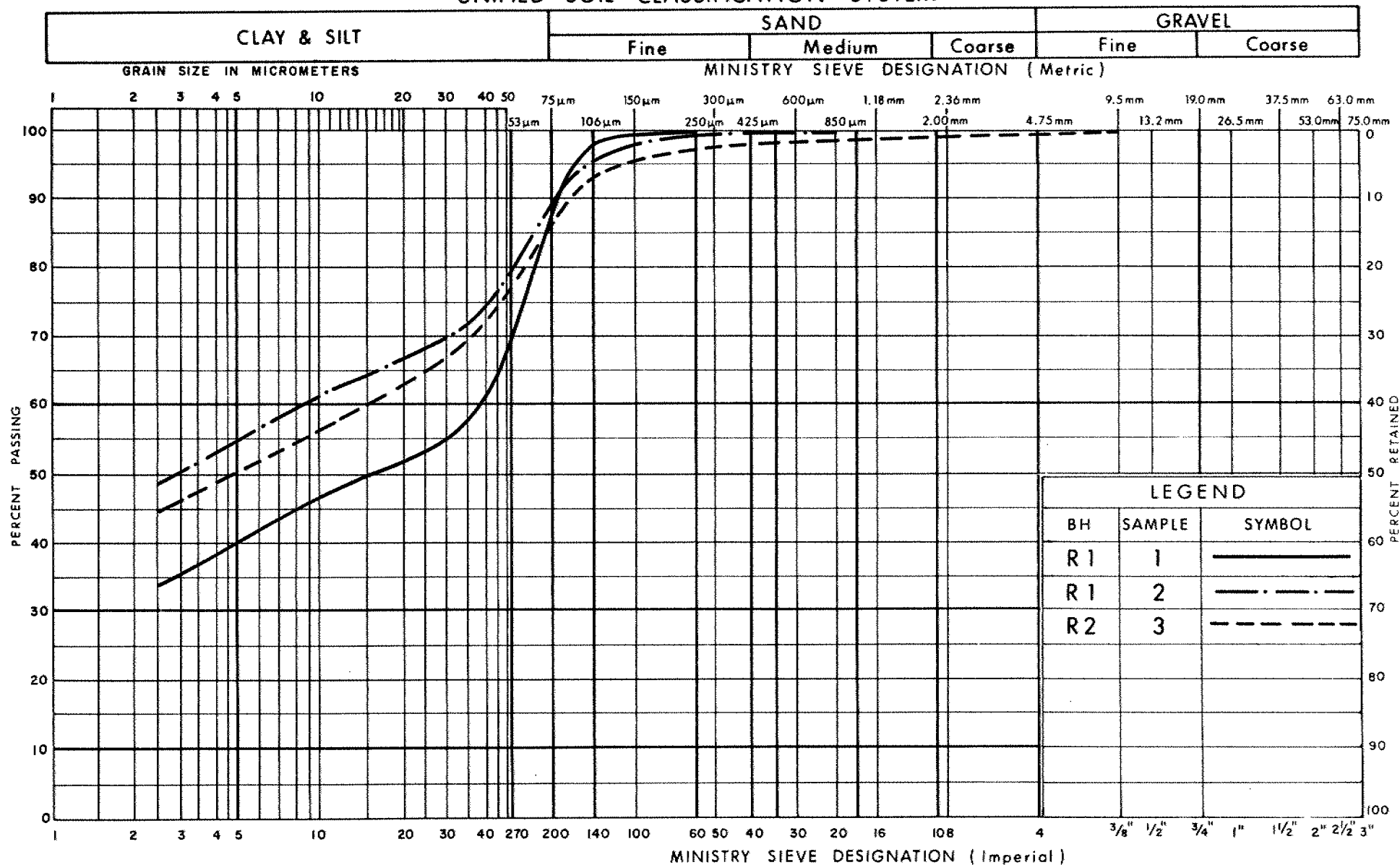
Ontario

PLASTICITY CHART CLAYEY SILT, WITH INTERBEDDED SILTY SAND

FIG No 1

W P 120-87-01

UNIFIED SOIL CLASSIFICATION SYSTEM



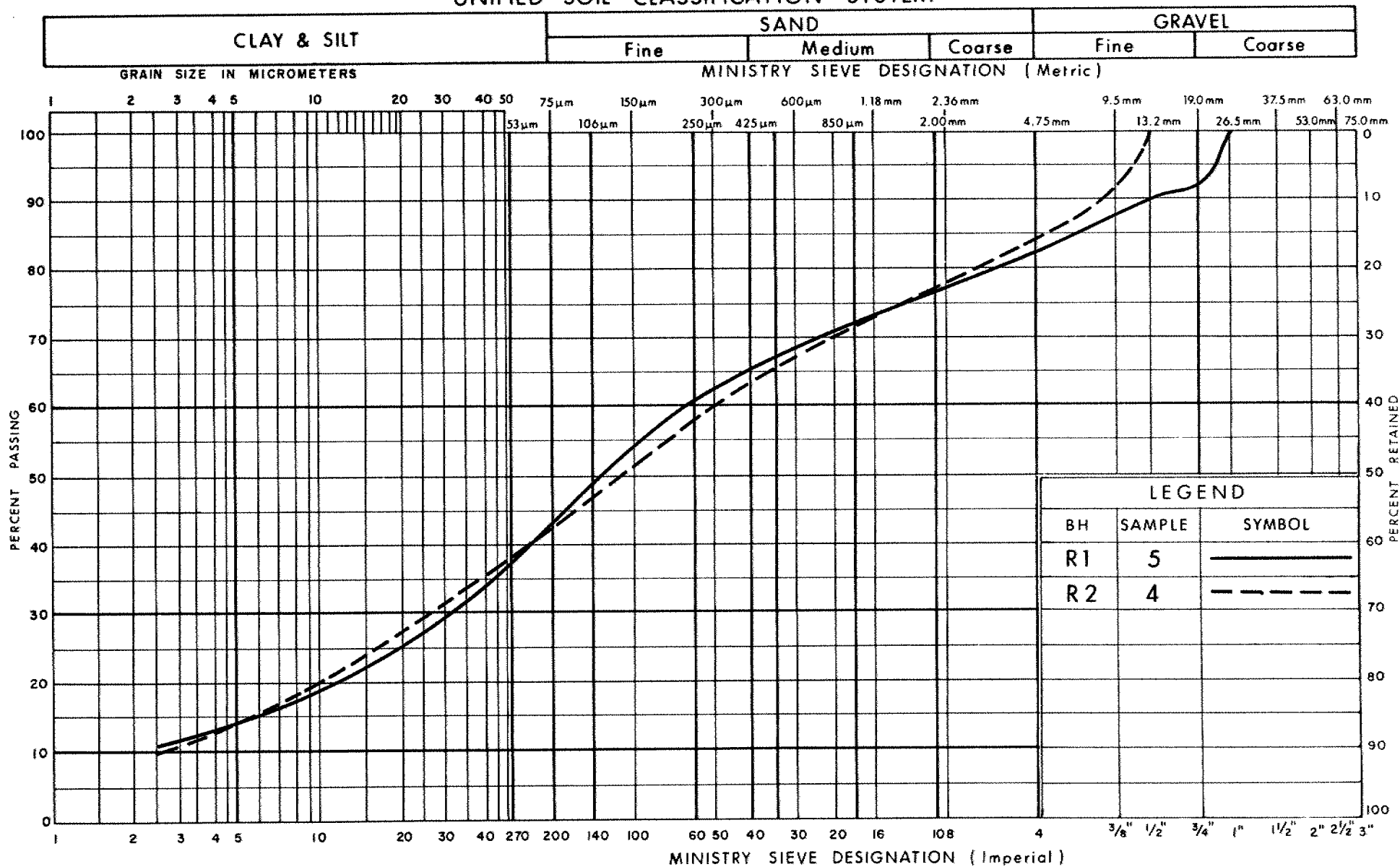
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, WITH INTERBEDDED SILTY SAND

FIG No 2

W P 120-87-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 120-87-01

For
Graham Creek Structure North Section
Structure #14
WP 120-87-03, Site 3-537
Hwy. 417, District 9, Ottawa

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation implemented at the aforementioned site. It is proposed to remove and replace the existing Graham Creek culvert that underpasses the existing Hwy. 417 and Richmond Road ramp. The most northern 44 m of the existing culvert will be modified by removing the top slab and west retaining wall.

SITE DESCRIPTION AND GEOLOGY

The site is situated at the location of the existing Graham Creek culvert that underpasses the existing Hwy. 417 and Richmond Road ramp approximately 200 metres east of the Hwy. 417/Acres Road underpass in the City of Nepean Ottawa-Carleton Municipality. The northerly flowing waters of Graham Creek meander in a valley approximately 20 metres wide immediately adjacent and south of the existing structure. Gabion retaining walls exist on the slopes at the outlet of the culvert. Approximately 5 metres of fill cover the roof of the existing culvert.

The surrounding terrain is generally flat and consists primarily of grassland. A condominium complex exists approximately 500 metres northeast of the culvert outlet.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the Lowlands of the St. Lawrence. The deposit consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region.

The bedrock in the area is of the Gull River Formation of the Middle Ordovician Period. It consists of interbedded silty dolostone, shaley limestone and fine grained quartz sandstone. The overburden was deposited during and immediately

following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 88 07 21 and 88 07 28 and consisted of four sampled boreholes accompanied by dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques were used to advance the boreholes in the overburden. Subsoil samples were retrieved at selected intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Samples were identified in the field and then returned to the laboratory for applicable testing. Bedrock was proven at BH #14-2 using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

LABORATORY ANALYSES

To identify the behaviour, gradation and properties of the soil, various laboratory testing were performed. These tests included:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Direct Shear Tests

Laboratory test results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

Underlying approximately 5 metres of fill consisting of a mixture of clayey silt, silt, sand and gravel used in the construction of the existing culvert, the main deposit at the site consists of a significant thickness of a cohesionless sand. This deposit has a thickness ranging from 15.2 metres to 19.4 metres and contains traces of silt and gravel. Its relative density ranges from loose to very dense but generally it can be classified as dense. Underlying the sand layer is a heterogeneous mixture of sand, gravel and boulders (glacial till) that in turn overlies the bedrock composed of silty dolostone with interbedded limestone. The vertical extent of the till deposit was not established across the site but is 2.1 metres in thickness in the area of BH 14.2.

The boundaries between the various soil types, in situ and laboratory test results as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are also provided on Dwg. 1208703-A.* The plan includes locations and stratigraphical profiles of borholes advanced in conjunction with structure 6 (culvert extension).

A detailed description of the subsurface conditions encountered is given below.

Fill Material (Mixture of Clayey Silt-Silt, Sand and Gravel)

The surficial fill material used in the construction of the existing culvert varies in composition and behaviour at different locations along the length of the culvert. Basically, the fill south of the existing Richmond Road ramp is a cohesionless mixture of sand, silt and gravel. The surficial fill material north of the Richmond Road ramp contains a greater percentage of fines and consequently exhibits a cohesive behaviour. It consists of a mixture of clayey silt, sand and gravel and is of low plasticity. The thickness of the fill ranges from 3.5 to 5.0 metres.

Grain size distribution curves illustrating the composition of the fill is provided on Figure 1. Atterberg Limits performed on the fine grained portion of the fill are plotted on Figure 2.

* DWG NO 2 OF THE CONTRACT DWG'S

Based on 'N' values obtained from the Standard Penetration Test, this fill material is generally in a compact state of condition.

Sand

The predominant deposit at the site and underlying the fill material is a poorly graded cohesionless sand that ranges in thickness from 15.2 m to 19.4 m. This sand layer also contains traces of gravel and silt. Typical grain size distribution curves are plotted in envelope form on Figure No. 3.

The relative density of the cohesionless deposit varies from loose to very dense with 'N' values obtained from the Standard Penetration Test ranging from 5 blows/0.3 m to 120 blows/0.25 m. Generally, the deposit is in a compact to dense state of condition.

Direct shear tests were performed on selected samples of the deposit in the laboratory to determine the angle of internal friction. Results revealed values ranging from 31 to 33.5° and are summarized in Table 1 below.

Table 1

Sample	Angle of Internal Friction (°)
BH 14-2, SS6	31
BH 14-2, SS9	33.5
BH 14-4, SS5A	32.5

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the predominant deposit of the deposit of sand exists a heterogeneous mixture of sand, gravel and boulders of glacial origin. This stratum was not explored to its vertical extent over the entire site but a thickness of 2.1 metres exists in the area of BH 14-2. Rock Coring methods were required to penetrate the larger sizes of the deposit.

Bedrock

The glacial till deposit is underlain by bedrock of the Gull River Formation and was proven at BH 14-2 by obtaining 1.4 metres of rock core samples. The bedrock consists of a silty dolostone which is a clastic sedimentary rock. Detailed descriptions of the bedrock are attached in the Appendix, entitled "Description of Rock Core".

Core recoveries and rock quality designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on the results and thorough visual laboratory examination, the rock can be classified as medium strong to strong and unweathered.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 60.5 m to 61.0 m which corresponds approximately to the surface of the native sand deposit.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of J. Fellenius, Student Engineer and T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Marathon Drilling Co. and Johnston Drilling Co. Rock Core Descriptions were provided by Mr. S. Senior, Geologist. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer.



T. Sangiuliano
T. Sangiuliano, P.Eng.
Foundation Engineer

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

APPENDIX

RECORD OF BOREHOLE No 6-1

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 702.0; E 358 757.4 ORIGINATED BY JBF
 DIST 9 HWY 417 BOREHOLE TYPE H-S Augers "B" Casing, Washboring & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 21 CHECKED BY

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	WATER CONTENT (%)					
65.9	Ground Surface													
0.0	Clayey Silt Some Sand, trace Gravel Brown, stiff to hard		1	SS	30	*								1 35 39 25
63.6	Occ.Zones of Organics		2	SS	14									1 29 55 15
2.3			3	SS	11									
			4	SS	8									
			5	SS	17									
			6	SS	19									
	Sand		7	SS	27									
	Trace Silt, Trace Gravel		8	SS	18									0 96 (4)
	Loose to		9	SS	32									
	Very Dense													0 83 (17)
			10	SS	41									
			11	SS	56									
47.2	Ret.mixture of sand, Gravel, Boulders (Glacial Till)		12	SS	76									0 96 (4)
18.7			13	RC	-									
46.1														
19.8	END OF BOREHOLE													
	* Water Level Not Established													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6-2

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 707.2; E 358 733.3 ORIGINATED BY JP
 DIST 9 HWY 417 BOREHOLE TYPE Washboring, "N"-Casing & BXL Rock Core COMPILED BY TS
 DATUM Geodetic DATE 88 07 25 to 28 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
61.4	Ground Surface													GR SA SI CL
0.0														
	Brown Grey		1	SS	9		60							10 85 (5)
			2	SS	7									
			3	SS	23									
	Sand		4	SS	28		58							6 91 (3)
	Trace Silt		5	SS	25									
			6	RC	-									
	Trace Gravel		7	SS	39		56							
	Loose to Very Dense		8	SS	35									2 71 (27)
							54							
			9	SS	55									
							52							0 92 (8)
			10	SS	69									
							50							
			11	SS	71									
							48							
			12	SS	59									
							46							
			13	SS	75/	15cm								
44.3							44							
17.1	Het. mixture of Sand, Gravel and Boulders (Glacial Till)		14	RC	-		42							
							40							
39.6			15	SS	100									47 43 (10)
21.8	Bedrock		16	RC	REC	48%								ROD = 19%
	Dolostone		17	BXL	REC									ROD = 55%
37.8	Unweathered			RC	85%									ROD = 45%
23.6	END OF BOREHOLE		18	RC	REC	94%	38							

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6-3

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 721.6; E 358 699.2 ORIGINATED BY JBF
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Washboring COMPILED BY TS
DATUM Geodetic DATE 88 07 21-22 CHECKED BY

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
62.0	Ground Surface												
0.0			1	SS	2								0 59 31 10
			2	SS	5								0 98 (2)
			3	SS	20								0 98 (2)
			4	SS	22								1 97 (2)
	Sand Trace of Silt Grey occasional		5	SS	44								0 98 (2)
	Zones of Silty Sand		6	SS	47								1 97 (2)
	Loose to Very Dense		7	SS	89								0 49 50 1
			8	SS	94								0 97 (3)
			9	SS	72								17 74 (9)
			10	SS	103/	15cm							0 97 (3)
			11	SS	124								17 74 (9)
	Some Gravel		12	SS	113								
40.2													
21.8	END OF BOREHOLE												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6-4

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 729.9; E 358 737.4 ORIGINATED BY JBF
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Washboring & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 22 CHECKED BY


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp W W _L				
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			WATER CONTENT (%) 10 20 30		
65.7	Ground Surface												
0.0	Brown Grey Sand Trace of Silt Trace of Gravel Compact to Very Dense		1	SS	19	*						14 71 (15) 0 93 (7) 1 98 (1) 0 92 (8)	
			2	SS	73								
			3	SS	37								
			4	SS	16								
			5	SS	38								
			6	SS	60								
			7	SS	53								
53.1					8			SS	36				
12.6	END OF BOREHOLE												
	* Water Level not established												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 14-1

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 737.7; E 358 692.0 ORIGINATED BY JBF
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Washboring & Cone Test COMPILED BY JBF
DATUM Geodetic DATE 88 07 21 CHECKED BY

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	SHEAR STRENGTH kPa					
66.1	Ground Surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						GR SA SI CL
0.0	Mixture of Sand, Silt and Gravel		1	SS	5		66							
	(Fill)		2	SS	17		64							9 59 24 8
61.5	Brown loose to Compact						62							
4.6	Sand Trace Silt Trace Gravel Compact to Very Dense	Brown Grey	3	SS	27		60							5 88 (7)
			4	SS	44									19 73 (8)
			5	SS	62									
			6	SS	95									0 90 (10)
			7	SS	46									2 91 (7)
			8	SS	49									
			9	SS	16									
			10	SS	18									
			11	SS	31									
			12	SS	55									
					13	SS	53							
			14	SS	120/	25cm							0 98 (2)	
46.3														
19.8	Het. Mixture of Sand, Gravel, Boulders (Glacial Till)													
44.3	Grey, very dense		15	SS	73									
21.8	END OF BOREHOLE													

RECORD OF BOREHOLE No 14-2

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 758.9; E 358 645.1 ORIGINATED BY TS
 DIST 9 HWY 417 BOREHOLE TYPE Cone Test, R-S Auger, B-Casing, Washbore & BXL Rock Core COMPILED BY TS
 DATUM Geodetic DATE 88 07 22-23 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)	10 20 30					
65.6	Ground Surface														
0.0	Mixture of Clayey Silt and Gravel (Fill) Brown, compact		1	SS	18	*	64								
			2	SS	15		62							2 72 19 7	
60.6			3	SS	21		60							6 70 20 4	
5.0			4	SS	5		58							5 88 (7)	
	Sand	Brown Grey	5	SS	12		56							4 90 (6)	
	Trace Silt		6	SS	23		54							1 90 (9)	
	Trace Gravel		7	SS	25		52							1 90 (9)	
	Trace Gravel		8	SS	19		50							0 91 (9)	
	Compact		9	SS	30		48								
	To		10	SS	55		46								
	Very Dense		11	SS	38		44							13 78 (9)	
			12	SS	33		42								
			13	SS	32		40								
			14	SS	36										
			15	SS	97										
41.2			16	SS	54										
24.4	Het Mixture of Sand, Gravel and Boulders, Very Dense														
39.1	(Glacial Till)		17	RC	REC	100%								RQD = 41%	
26.5	Bedrock		18	BXL	REC									RQD = 64%	
37.9	Dolostone Unweathered			RC	95%										
27.7	END OF BOREHOLE * Water Level not established. Hole caved in at 2.1m depth.														

+3, x5 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 14-3

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 791.6; E 358 619.6 ORIGINATED BY JBF
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, & Cone Test COMPILED BY JBF
DATUM Geodetic DATE 88 07 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%)					
65.4	Ground Surface													
0.0	Mixture of Clayey Silt, Sand, and Gravel Brown, Very Stiff (Fill)		1	SS	27	*	64							
61.9			2	SS	17		62						6 48 32 14	
3.5	Sand trace Silt Occ. Gravelly Zones Compact to Very Dense Grey		3	SS	18		60						29 58 13 0	
			4	SS	30		58						0 89 (11)	
			5	SS	50		56							
			6	SS	19		54						0 94 (6)	
			7	SS	61									
52.8			8	SS	26									
12.6	END OF BOREHOLE						52							
							50							
							48							
							46							
43.8							44							
21.6	END OF CONE TEST													
	* Water level not established. Hole caved in at 4.6m depth													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 14-4

METRIC

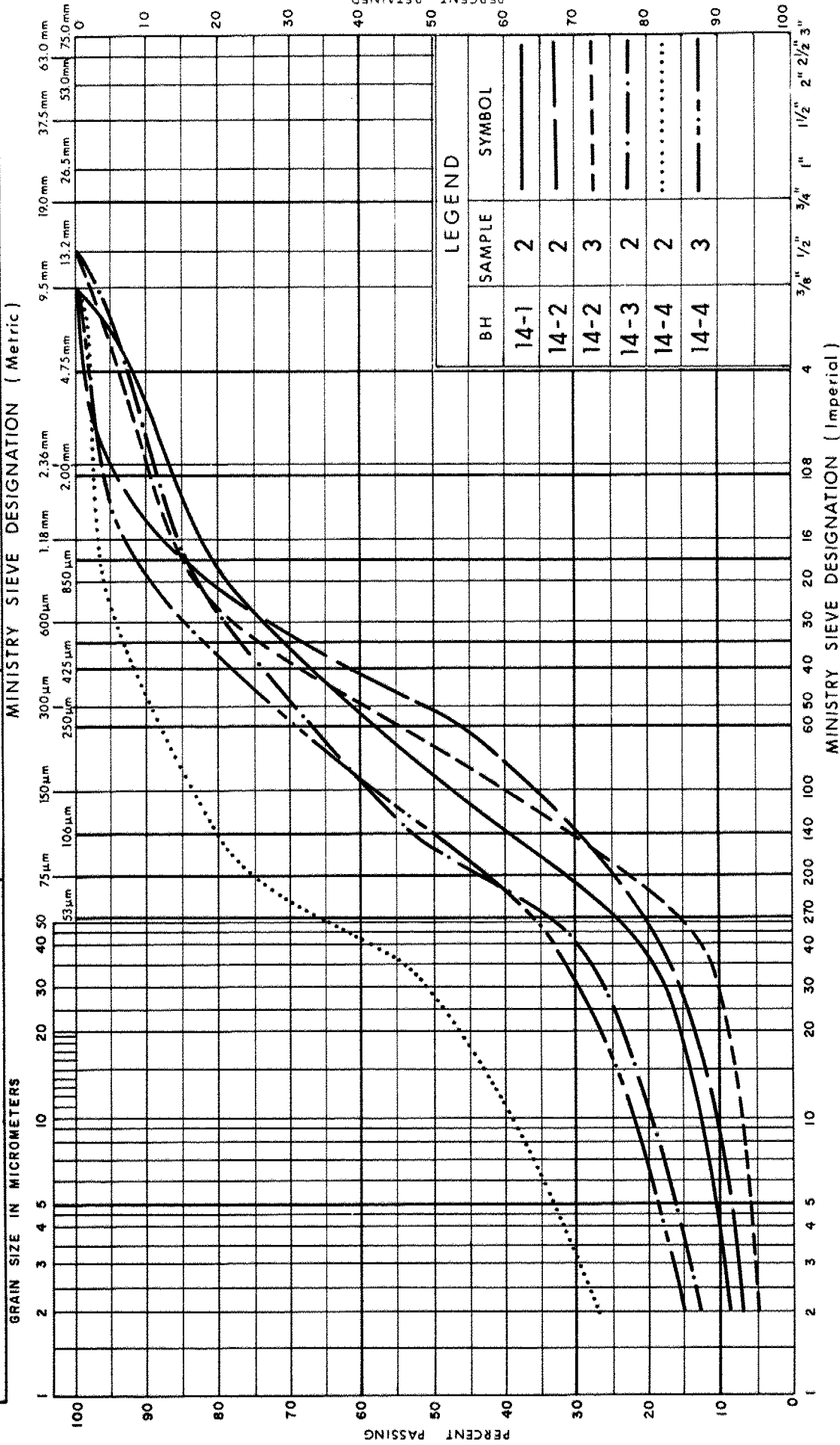
W P 120-87-03 LOCATION Co-Ords N 5 022 787.1; E 358 600.4 ORIGINATED BY TS
DIST 9 HWY 417 BOREHOLE TYPE Cone Test, H-S Auger, Washbore COMPILED BY JBE
DATUM Geodetic DATE 88 07 22 CHECKED BY

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					
65.6	Ground Surface													
0.0	Mix of Clayey Silt, Sand and Gravel Grey, Firm (Fill)		1	CS	-	*	64							2 19 51 28
			2	SS	7									
61.6			3	SS	5		62							2 55 28 15
4.0			4	SS	19		60							1 90 5 4
	Sand Trace Silt Trace Gravel Compact to Dense	Brown Grey	5	SS	8		58							1 97 (2)
			6	SS	29		56							0 90 (10)
			7	SS	29		54							
			8	SS	47									
53.0			9	SS	33									
12.6	END OF BOREHOLE						52							
							50							
							48							
							46							
							44							
							42							
41.2														
24.4	END OF CONE TEST													
	* Water level not established. Hole caved in at 4.6m depth.													

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



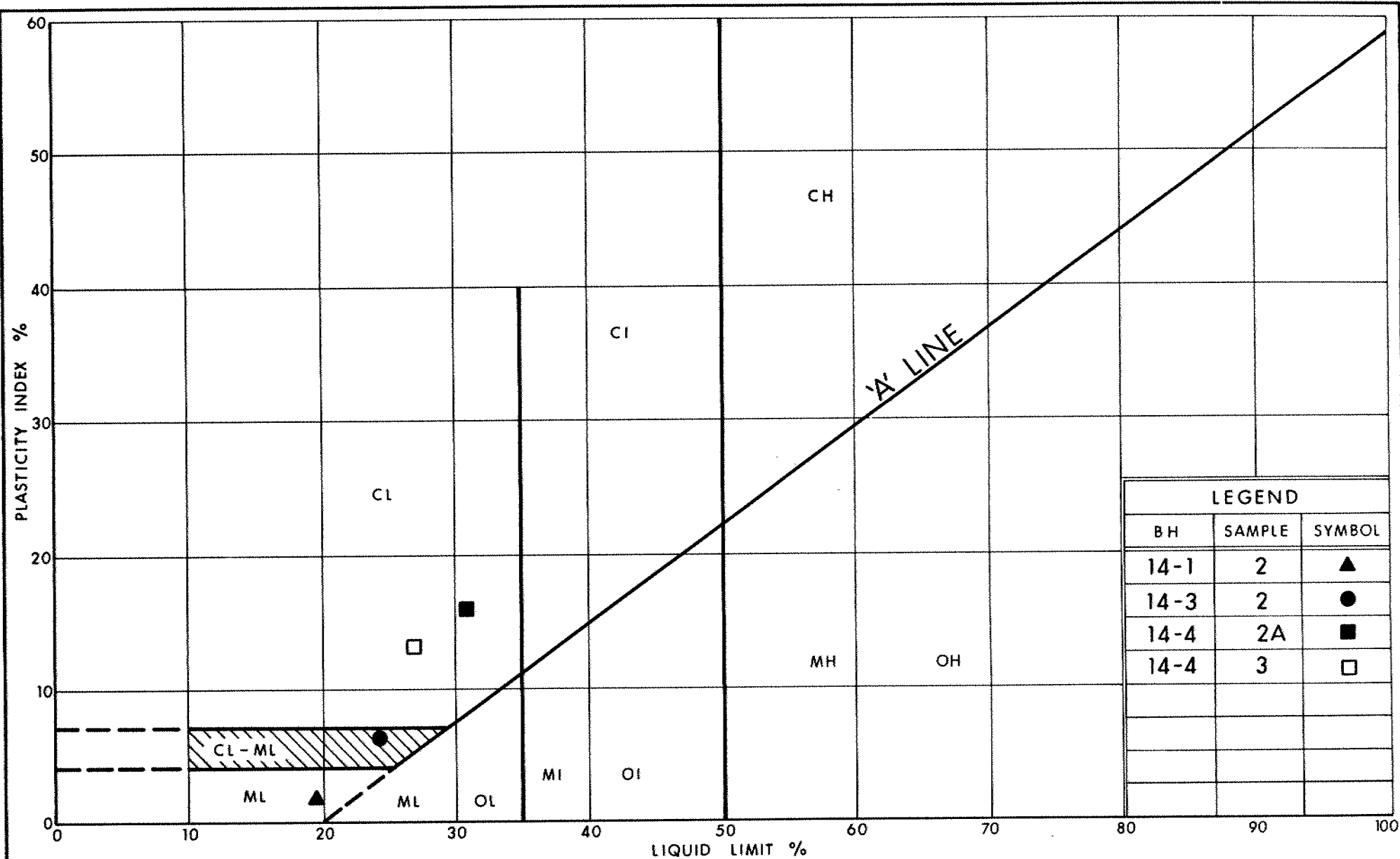
Ministry of
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GRAIN SIZE DISTRIBUTION MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Fill)

FIG No 1

W P 120-87-03



Ministry of
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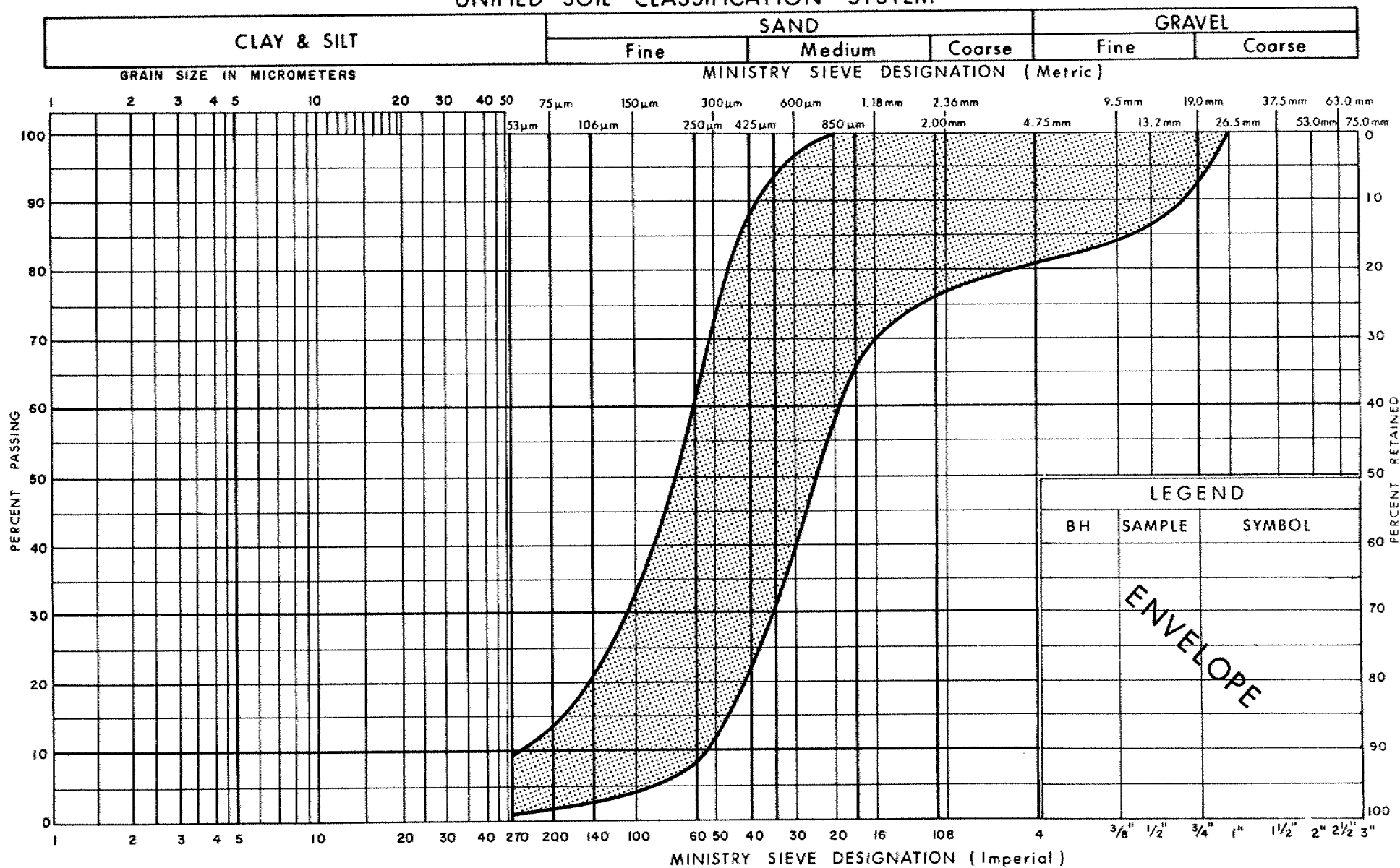
Ontario

PLASTICITY CHART
MIXTURE OF
CLAYEY SILT, SILT, SAND & GRAVEL (Fill)

FIG No 2

W P 120-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
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GRAIN SIZE DISTRIBUTION
SAND, TRACE OF SILT, TRACE GRAVEL

FIG No 3

W P 120-87-03

DESCRIPTION OF ROCK CORE - WP 120-87-03

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
14-2	26.21-26.82	100	41	26.21-27.76	SILTY DOLOSTONE , medium grey to dark grey, fine grained thinly bedded; medium strong to strong rock; slightly weathered to unweathered; close to moderately close spaced fractures: flat, rough, irregular; minor SANDSTONE bed (2 cm) at 26.26 m
	26.82-27.76	95	64		

NOTE: Depths are approximated in zones of poor core recovery.

1../1

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

FOUNDATION INVESTIGATION REPORT
For
Graham Creek Structure South Section
Structure #6
WP 120-87-09, Site 3-537
Hwy. 417, District 9, Ottawa

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation implemented at the aforementioned site. The proposed culvert is to be located immediately south of the existing Graham Creek culvert.

SITE DESCRIPTION AND GEOLOGY

The site is located immediately south and adjacent to the existing Graham Creek culvert that underpasses the existing Hwy. 417 in the City of Nepean, Ottawa-Carleton Municipality. The northly flowing waters of Graham Creek meander in a valley that is approximately 20 metres wide. The creek channel is approximately 6 metres in width and the water depth varies from 0.5 metre to 1 metre. The side slopes of the valley are roughly 2H:1V and covered with vegetation, grassland and trees. The slopes appear to be stable.

The surrounding terrain is generally flat and consists primarily of grassland. On the west side of the valley the land is presently used for agriculture.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the Lowlands of the St. Lawrence. The deposit consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region.

The bedrock in the area is of the Gull River Formation of the Middle Ordovician Period. It consists of interbedded silty dolostone, shaley limestone and fine grained quartz sandstone. The overburden was deposited during and immediately

following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 88 07 21 and 88 07 28 and consisted of four sampled boreholes accompanied by two dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques were used to advance the boreholes in the overburden. Subsoil samples were retrieved at selected intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). The samples were identified in the field and then returned to the laboratory for applicable testing. Bedrock was proven at BH #6-2 using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

LABORATORY ANALYSES

To identify the behaviour, gradation and properties of the soil, various laboratory testing were performed. These tests included:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Direct Shear Tests

Laboratory test results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

Underlying a thin deposit of clayey silt (2.3 m) that was encountered at the eastern ridge of the Graham Creek valley (BH 6-1), the main deposit at the site consists of a significant thickness of a cohesionless sand. This deposit extends from the surface of the creek's channel to a minimum thickness of 16.4 metres. This sand layer contains traces of silt and gravel and also random zones of silty sand. Its relative density ranges from loose to very dense, but generally it can be classified as compact to dense. Underlying the sand layer is a heterogeneous mixture of sand, gravel and boulders (glacial till) that in turn overlies the bedrock composed of interbedded limestone and silty dolostone. The vertical extent of the till deposit was not established across the site but is 4.9 m in thickness in the area of BH 6-2.

The boundaries between the various soil types, in situ and laboratory test results as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are also provided on Dwg. 1208709-A.* The plan includes locations and stratigraphical profiles of boreholes advanced in conjunction with structure 14 (culvert replacement).

A detailed description of the subsurface conditions encountered is given below.

Clayey Silt, some sand, trace gravel

Encountered at the eastern ridge of the Graham Creek valley and extending to a thickness of 2.3 m at BH 6-1, exists a layer of a cohesive clayey silt mixed with some sand and a trace of gravel. The deposit is brown in colour and possesses inclusions of organics of varying concentrations. This presence of organics influences the behaviour of the deposit as indicated by Atterberg Limits obtained on samples of the deposit. A summary of the indices of the basic cohesive material matrix is provided in Table 1 below and the results are plotted on Figure 1. Grain size distribution curves for the material as determined by mechanical analyses is given on Figure 2.

Table 1

	<u>Range</u>
Natural Moisture Content (w%)	16-21
Liquid Limit (w _L %)	33.5-35
Plastic Limit (w _p %)	21-25.5

* DWG NO 2 OF THE CONTRACT DWG'S

It is evident from the results that the deposit is predominantly of low plasticity ranging from a clayey silt to an organic silt depending on the organic content. 'N' values obtained from the Standard Penetration Test indicate that the deposit has a consistency ranging from stiff to hard.

Sand

The predominant deposit at the site consists of a poorly graded cohesionless sand that extends for a minimum thickness of 16.4 m. This sand layer contains traces of gravel and silt and at random elevations, zones of silty sand are present. Minor variations in gravel content also exist at lower elevations within the deposit, perhaps an indication of the contact with the underlying deposit of the heterogeneous mixture of sand, gravel and boulders (glacial till). Typical grain size distribution curves are plotted in envelope form on Figure 3.

The relative density of the cohesionless deposit varies from very loose to very dense with 'N' values obtained from the Standard Penetration Test ranging from 2 blows/0.3 m to 103 blows/.15 m. Generally, the upper 4-5 metres of the deposit is compact while the relative density of this deposit below this level is dense to very dense.

Direct shear tests were performed on selected samples of the deposit in the laboratory to determine the angle of internal friction. Results revealed values ranging from 30 to 35°.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the predominant deposit of sand exists a heterogeneous mixture of sand, gravel and boulders of glacial origin. This stratum was not explored to its vertical extent over the entire site but a thickness of 4.9 metres exists in the area of BH 6-2. Rock Coring methods were required to penetrate the larger sizes of the deposit. The elevation of the surface of this deposit varies from 47.2 m to 40.0 m. A grain size distribution curve of a sample of this material, excluding boulder sizes, is provided on Figure 4.

Bedrock

The glacial till deposit is underlain by bedrock of the Gull River Formation and was proven at BH 6-2 by obtaining 1.6 metres of rock core samples. The bedrock consists of a silty to argillaceous dolostone which is a clastic sedimentary rock. Detailed descriptions of the bedrock are attached in the Appendix, entitled "Description of Rock Core".

Core recoveries and rock quality designations (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core recoveries ranged from 85 to 94% and RQD's ranged from 45 to 55%. Based on these results and thorough visual laboratory examination, the rock can be classified as medium strong to strong rock and unweathered.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 60.4 to 60.8 m which coincides with the water level in the flowing creek.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of J. Fellenius, Student Engineer and T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Marathon Drilling Co. and Johnston Drilling Co. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer.



T. Sangiuliano
T. Sangiuliano, P.Eng.
Foundation Engineer

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

APPENDIX

RECORD OF BOREHOLE No 6-1

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 702.0; E 358 757.4 ORIGINATED BY JBF
 DIST 9 HWY 417 BOREHOLE TYPE H-S Augers "R" Casing, Washboring & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 21 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	WL	10 20 30		
65.9	Ground Surface													
0.0	Clayey Silt Some Sand, trace Gravel Brown, stiff to hard		1	SS	30	*								1 35 39 25
63.6	Occ.Zones of Organics		2	SS	14									1 29 55 15
2.3			3	SS	11									
			4	SS	8									8 68 14 10
			5	SS	17									
			6	SS	19									
			7	SS	27									0 96 (4)
			8	SS	18									
			9	SS	32									0 83 (17)
			10	SS	41									
			11	SS	56									
47.2	Het.mixture of sand, Gravel, Boulders (Glacial Till)		12	SS	76									0 96 (4)
18.7			13	RC	-									
46.1														
19.8	END OF BOREHOLE													
	* Water Level Not Established													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6-2

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 707.2; E 358 733.3 ORIGINATED BY JF
 DIST 9 HWY 417 BOREHOLE TYPE Washboring, "N"-Casing & BXL Rock Core COMPILED BY TS
 DATUM Geodetic DATE 88 07 25 to 28 CHECKED BY

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					
61.4	Ground Surface																GR SA SI CL
0.0																	
			1	SS	9		60										10 85 (5)
			2	SS	7												
			3	SS	23												
			4	SS	28		58										6 91 (3)
			5	SS	25												
			6	RC	-												
			7	SS	39		56										
			8	SS	35												2 71 (27)
			9	SS	55		54										
			10	SS	69		52										0 92 (8)
			11	SS	71		50										
			12	SS	59		48										
			13	SS	75/	15cm	46										
44.3							44										
17.1	Het. mixture of Sand, Gravel and Boulders (Glacial Till)		14	RC	-		42										
39.6			15	SS	100		40										47 43 (10)
21.8	Bedrock		16	RC	REC	48%											RQD = 19%
	Dolostone		17	BXL RC	REC 85%												RQD = 55%
37.8	Unweathered		18	RC	REC	94%	38										RQD = 45%
23.6	END OF BOREHOLE																

RECORD OF BOREHOLE No 6-3

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 721.6; E 358 699.2 ORIGINATED BY JBE
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Washboring COMPILED BY TS
 DATUM Geodetic DATE 88 07 21-22 CHECKED BY

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
62.0	Ground Surface															
0.0			1	SS	2										0 59 31 10	
			2	SS	5											
			3	SS	20										0 98 (2)	
			4	SS	22											
	Sand Trace of Silt Grey occasional		5	SS	44										0 98 (2)	
	Zones of Silty Sand		6	SS	47										1 97 (2)	
	Loose to Very Dense		7	SS	89											
			8	SS	94										0 49 50 1	
			9	SS	72											
			10	SS	103/	15cm									0 97 (3)	
			11	SS	124										17 74 (9)	
	Some Gravel															
			12	SS	113											
40.2																
21.8	END OF BOREHOLE															



RECORD OF BOREHOLE No 6-4

METRIC

W P 120-87-09 LOCATION Co-Ords N 5 022 729.9; E 358 737.4 ORIGINATED BY TRF
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Washboring & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
65.7	Ground Surface												
0.0						*							
			1	SS	19								
			2	SS	73								14 71 (15)
			3	SS	37								0 93 (7)
			4	SS	16								1 98 (1)
			5	SS	38								
			6	SS	60								
			7	SS	53								0 92 (8)
			8	SS	36								
53.1													
12.6	END OF BOREHOLE												
	* Water Level not established												



RECORD OF BOREHOLE No 14-1

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 737.7; E 358 692.0 ORIGINATED BY JBF
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Washboring & Cone Test COMPILED BY JBF
DATUM Geodetic DATE 88 07 21 CHECKED BY

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20 40 60 80 100	W _p	W	W _L		
66.1	Ground Surface												GR SA SI CL
0.0	Mixture of Sand, Silt and Gravel (Fill)		1	SS	5								
	Brown loose to Compact		2	SS	17								9 59 24 8
61.5			3	SS	27								5 88 (7)
4.6	Brown Grey Sand		4	SS	44								19 73 (8)
	Trace Silt		5	SS	62								0 90 (10)
	Trace Gravel		6	SS	95								2 91 (7)
	Compact to Very Dense		7	SS	46								
			8	SS	49								
			9	SS	16								
			10	SS	18								
			11	SS	31								0 98 (2)
			12	SS	55								
			13	SS	53								
			14	SS	120/ 25cm								
46.3													
19.8	Het. Mixture of Sand, Gravel, Boulders (Glacial Till)												
44.3	Grey, very dense		15	SS	73								
21.8	END OF BOREHOLE												

RECORD OF BOREHOLE No 14-2

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 758.9; E 358 645.1 ORIGINATED BY TS
 DIST 9 HWY 417 BOREHOLE TYPE Cone Test, H-S Auger, B-Casing, Washbore & BXL Rock Core COMPILED BY TS
 DATUM Geodetic DATE 88 07 22-23 CHECKED BY

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				
65.6	Ground Surface															
0.0	Mixture of Clayey Silt and Gravel					*										
	(Fill)		1	SS	18		64									
	Brown, compact		2	SS	15		62									2 72 19 7
60.6			3	SS	21		60									6 70 20 4
5.0	Sand		4	SS	5		58									5 88 (7)
	Trace Silt		5	SS	12		56									4 90 (6)
	Trace Gravel		6	SS	23		54									1 90 (9)
	Compact		7	SS	25		52									1 90 (9)
	To		8	SS	19		50									
	Very Dense		9	SS	30		48									
			10	SS	55		46									
			11	SS	38		44									
			12	SS	33		42									
			13	SS	32		40									
			14	SS	36		38									
			15	SS	97											
41.2			16	SS	54											
24.4	Het Mixture of Sand, Gravel and Boulders, Very Dense		17	RC	REC	100%										RQD = 41%
39.1	(Glacial Till)		18	BXL RC	REC 95%											RQD = 64%
26.5	Bedrock Dolostone Unweathered															
37.9																
27.7	END OF BOREHOLE * Water Level not established. Hole caved in at 2.1m depth.															

RECORD OF BOREHOLE No 14-3

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 791.6; E 358 619.6 ORIGINATED BY JBF
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, & Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 23 CHECKED BY

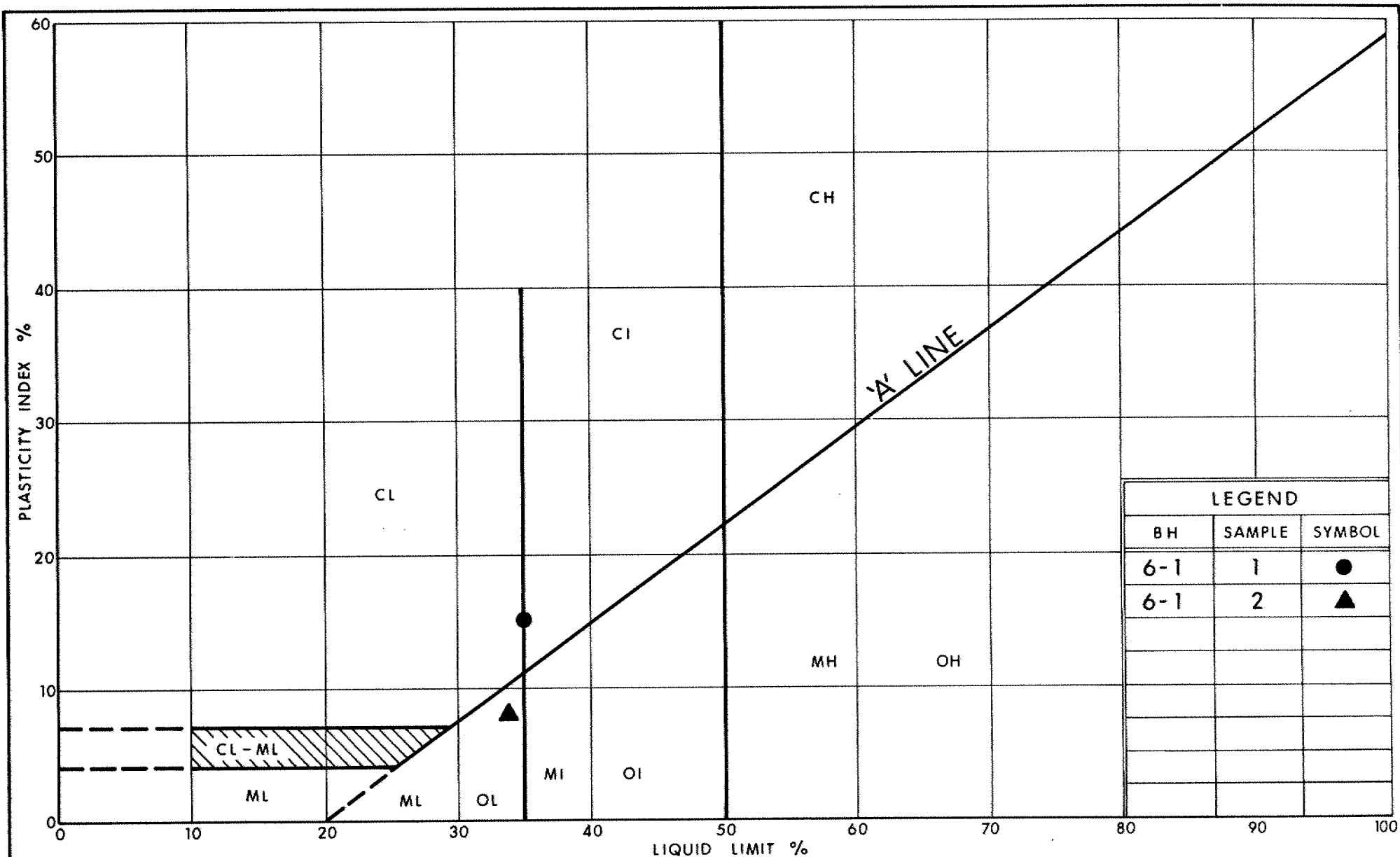
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W_p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W_L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
65.4	Ground Surface												
0.0	Mixture of Clayey Silt, Sand, and Gravel Brown, Very Stiff (Fill)	X	1	SS	27	*	64						
61.9		X	2	SS	17		62						6 48 32 14
3.5	Sand trace Silt Occ. Gravelly Zones Compact to Very Dense Grey	.	3	SS	18		60						
		.	4	SS	30		58						29 58 13 0
		.	5	SS	50		56						0 89 (11)
		.	6	SS	19		54						0 94 (6)
		.	7	SS	61								
52.8		.	8	SS	26								
12.6	END OF BOREHOLE						52						
							50						
							48						
							46						
43.8							44						
21.6	END OF CONE TEST * Water level not established. Hole caved in at 4.6m depth												

RECORD OF BOREHOLE No 14-4

METRIC

W P 120-87-03 LOCATION Co-Ords N 5 022 787.1; E 358 600.4 ORIGINATED BY TS
 DIST 9 HWY 417 BOREHOLE TYPE Cone Test, H-S Auger, Washbore COMPILED BY JBF
 DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
65.6	Ground Surface													
0.0	Mix of Clayey Silt, Sand and Gravel Grey, Firm (Fill)		1	CS	-	*								2 19 51 28
			2	SS	7		64							
61.6			3	SS	5		62							2 55 28 15
4.0			4	SS	19		60							1 90 5 4
	Sand Trace Silt Trace Gravel Compact to Dense	Brown Grey	5	SS	8		58							1 97 (2)
			6	SS	29		56							0 90 (10)
			7	SS	29		54							
			8	SS	47									
53.0			9	SS	33									
12.6	END OF BOREHOLE													
							52							
							50							
							48							
							46							
							44							
							42							
41.2														
24.4	END OF CONE TEST													
	* Water level not established. Hole caved in at 4.6m depth.													



Ministry of
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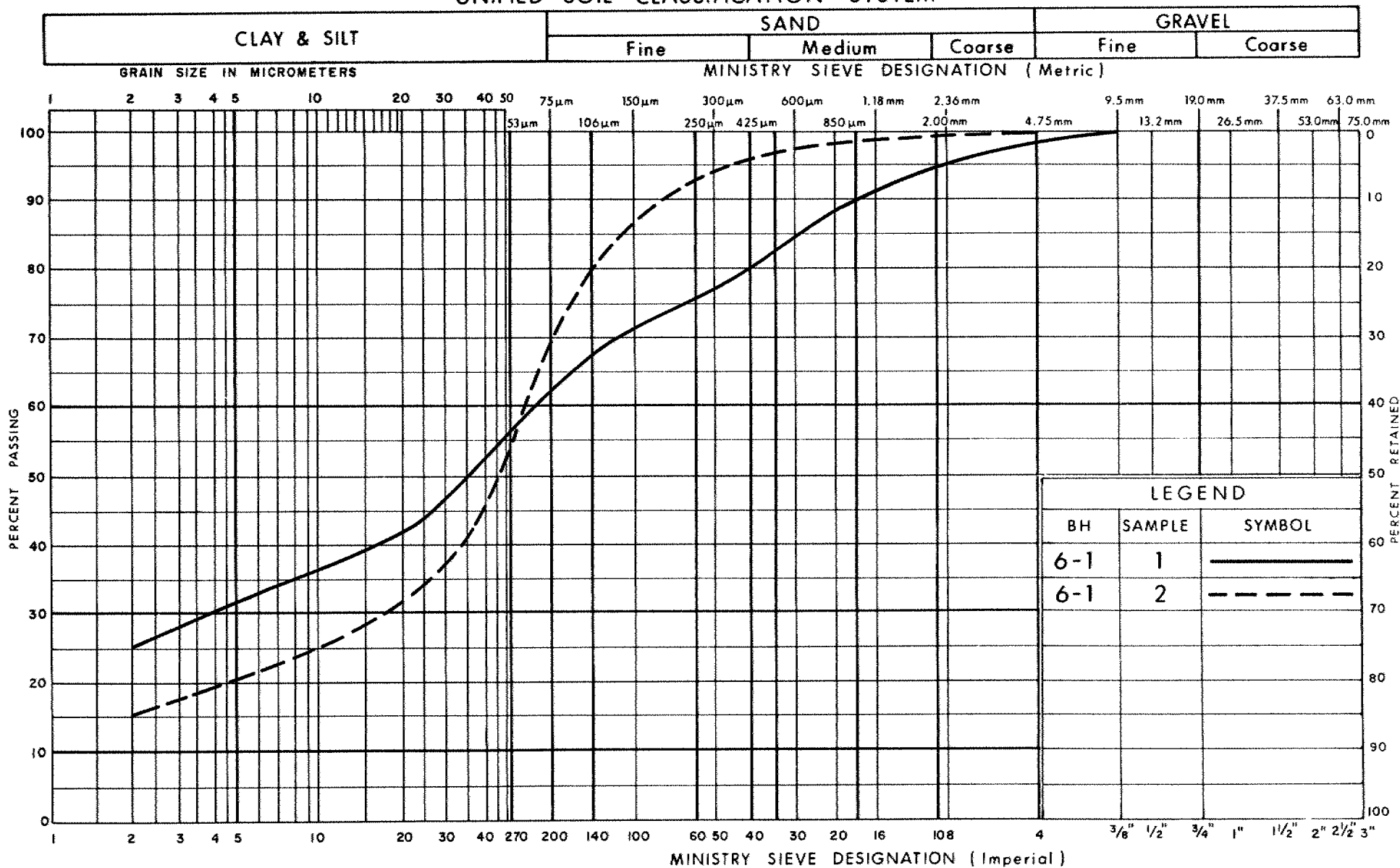
Ontario

PLASTICITY CHART CLAYEY SILT, SOME SAND, TRACE GRAVEL OCC ZONES OF ORGANICS

FIG No 1

W P 120-87-09

UNIFIED SOIL CLASSIFICATION SYSTEM



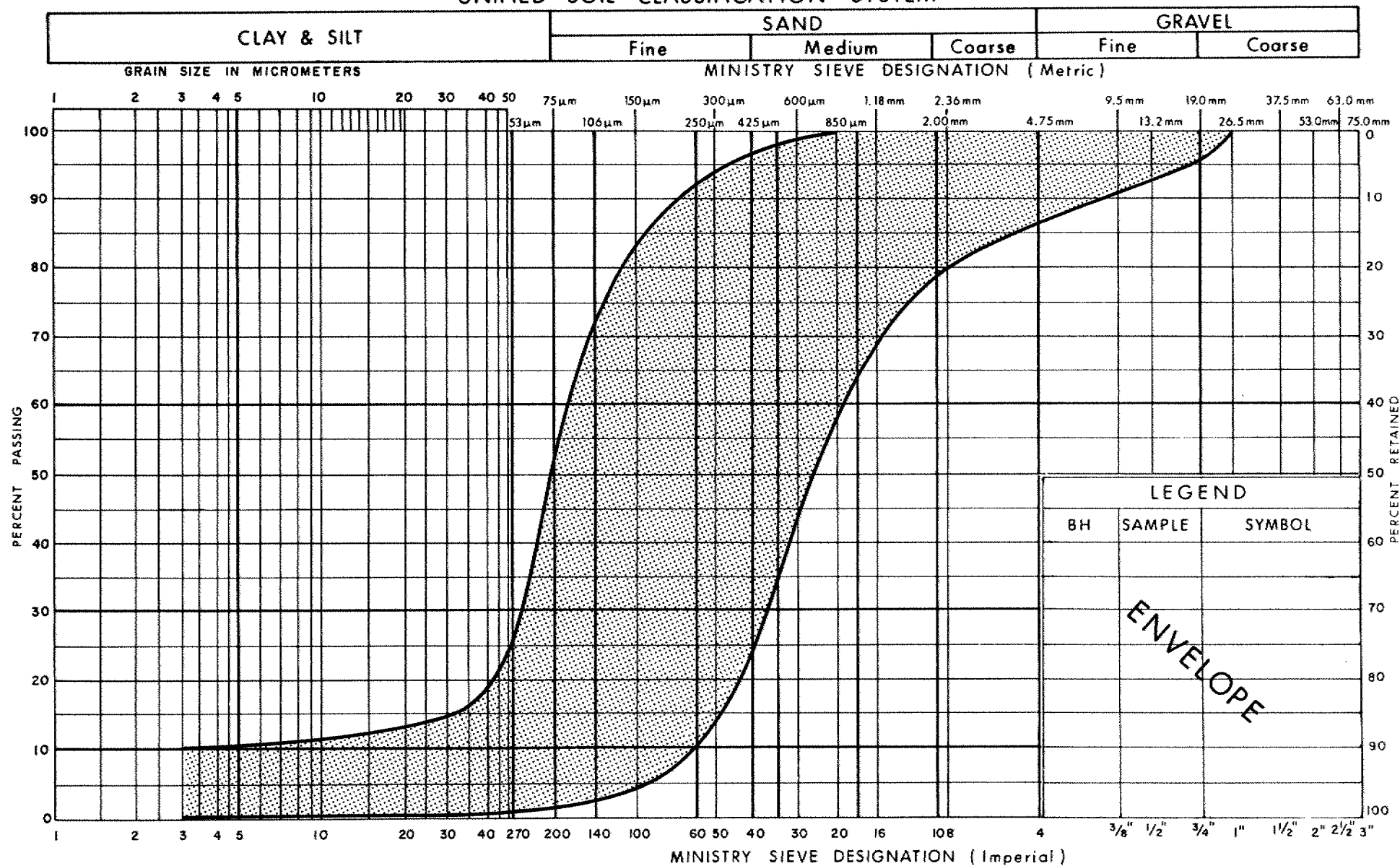
Ministry of
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT, SOME SAND, TRACE GRAVEL
OCC ZONES OF ORGANICS

FIG No 2

W P 120-87-09

UNIFIED SOIL CLASSIFICATION SYSTEM



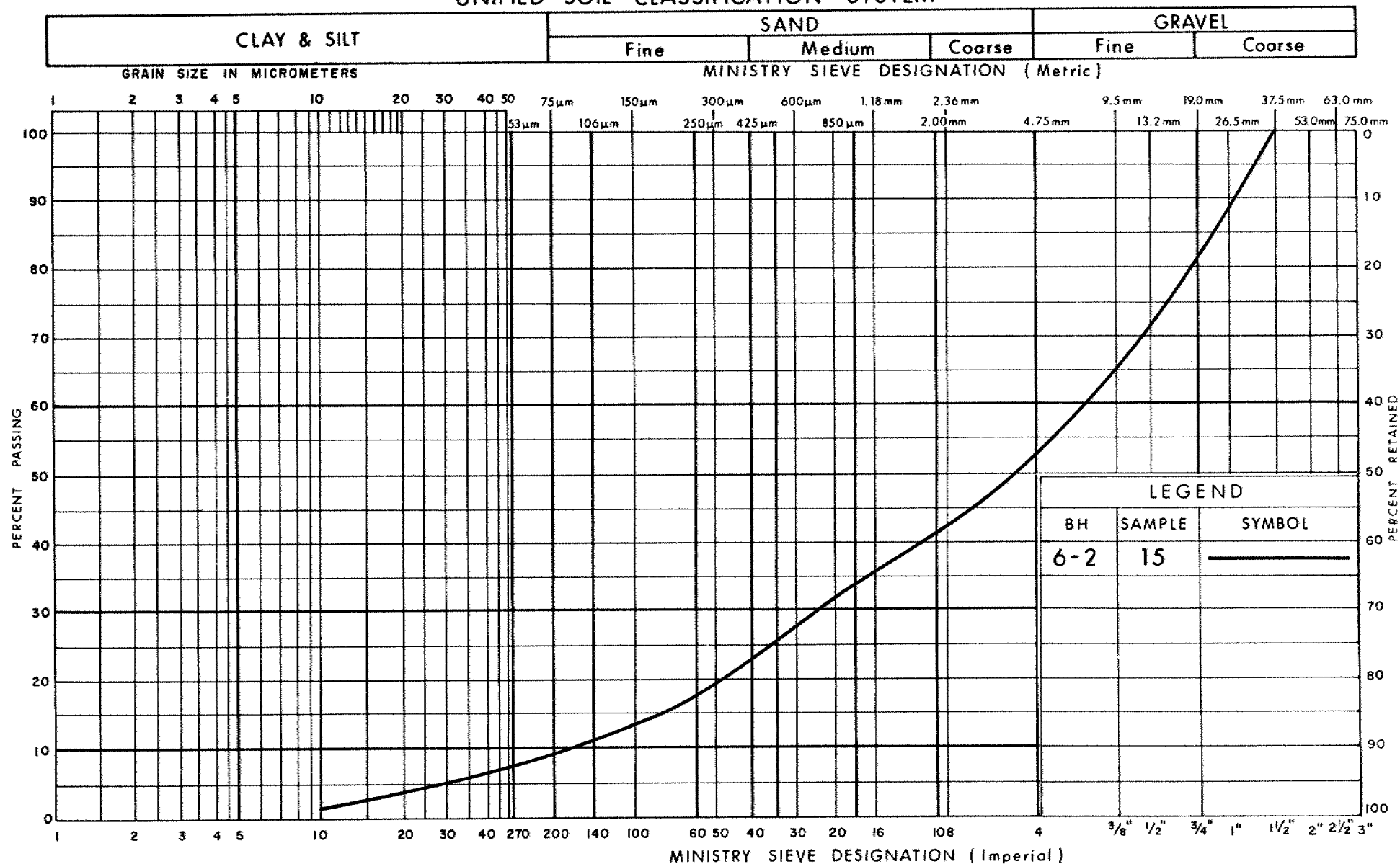
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SAND, TRACE OF SILT, TRACE OF GRAVEL
OCC SILTY SAND ZONES

FIG No 3

W P 120-87-09

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 4

W P 120-87-09

DESCRIPTION OF ROCK CORE - WP 120-87-09

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
6-2	15.24-18.29	8	NA	15.24-21.83	OVERBURDEN , foreign and locally derived bedrock material.
	18.29-21.34	NOT	CORED	21.83-22.96	SILTY DOLOSTONE , medium grey; fine grained, thick bedded; medium strong to strong rock; slightly weathered to unweathered; close spaced fractures: horizontal, smooth, undulating, slightly open to closed
	21.34-21.95	48	19		
	21.95-23.16	85	55		
	23.16-23.57	94	45	22.96-23.57	ARGILLACEOUS DOLOSTONE , dark grey; thin bedded; slightly weathered to unweathered; medium strong rock; close to very close spaced fractures: horizontal, planar, slightly open to closed.

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

1../1

PROPOSED
SOUTH TO WEST RAMP OVER HIGHWAY 417 EB
STRUCTURE #1, OVERPASS
OTTAWA, ONTARIO

W.P. 120-87-04 SITE NO. 3-52-531

DISTRICT 9, EASTERN REGION

1. INTRODUCTION

A field investigation for this project was conducted between September 12 and 15, 1988. Twelve boreholes were drilled to depths between 1.6 and 14.6 m below existing ground surface at the locations shown on Drawing No. W.P.1208704-A.* Eight of these boreholes were advanced at the proposed foundation locations while the remaining four boreholes were located along the approach embankments at the west and east ends of the structure. Details of the field work program are provided in Appendix - A to this report.

The borehole locations were mutually agreed upon and were located in the field by staff of MTO who also provided the ground surface elevations at each borehole location.

2. SITE AND GEOLOGY

The site is located at the west end of Ottawa (near Nepean), in the southwest sector of the intersection of existing Highway 417 and Acres Road.

The site is currently fairly flat farm field with occasional trees along fence lines. Portions of the site are cultivated ground, and were planted with corn.

A review of Map 1335A, Sheet 305, "Southern Ontario", Geological Survey of Ontario, indicates that the site is in a region of variable bedrock geology. It appears that the site is divided by a fault.

The site is underlain by the March Formation(interbedded quartz sandstone and sandy dolostone) west of the fault, and by the Rockcliffe Formation (silty dolostone with shale interbeds) east of the fault.

The Oxford Formation (dolostone) is also present immediately north and south of the site. The Nepean Formation (quartz sandstone) from the Lower Ordovician is also encountered south of the site.

* DWG NO 2 OF THE CONTRACT DWG'S

The site is traversed by a north-south trending fault, which is a geologic structure reportedly common to the area.

A review of 'The Physiography of Southern Ontario' (Chapman & Putnam, 3rd E., 1984) indicates the Ottawa Valley to consist of clay plains interrupted by ridges of rock or sand. The Ottawa area is also known to be seismically active.

Proposed Structure No.1 is a four-span bridge about 180 m in length and about 10 m wide. Earth fill approach embankments will be constructed on the existing native ground to a maximum height of about 7 m.

The proposed structure will cross a proposed new section of Highway 417 as shown on Drawing No. WP1208704-A.* The structure will connect future northbound Highway 416 to the existing westbound lanes of Highway 417. The structure will cross over the proposed eastbound lanes of Highway 417 and exit ramp for Acres Road. The alignment of Structure 1, will not interfere with existing or proposed structures.

3. SUBSURFACE CONDITIONS

Details of the subsurface conditions encountered at the site are summarized below, and are also presented on the accompanying Borehole Logs and Sections on Dwg. No. WP1208704-A. *

Details of the laboratory tests and field tests are summarized on the Borehole Logs and on Figures 1 to 7 inclusive.

It should be noted that the subsurface conditions are confirmed at the borehole locations only, and may vary at other locations.

The boundaries between the various strata as shown on the logs and sections are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of change.

The ground surface along the west half of the proposed bridge alignment is flat and at about elevation 66 m Geodetic. The east half of the proposed alignment rises from about elevation 65 m to elevation 67.5 m Geodetic, in a series of shallow ridges.

The boreholes found a thin topsoil layer at the ground surface. The east half of the bridge and embankment alignment was underlain by 0 to 4.2 m of silty sand to sand (till) overlying dolostone bedrock.

The west half of the alignment was underlain by 5.6 to 8.5 m of firm to stiff silty clay underlain by compact silty sand to sandy silt (till). The till was underlain by sandstone bedrock at depths of 7.3 to 10.1 m.

* DWG NO 2 OF THE CONTRACT DWG'S

October 1988

88311

3.1 Topsoil

At the ground surface in each of the twelve borehole locations, about 150 mm to 200 mm of black, silty topsoil was encountered. This layer and the underlying surface of the native soil were noted to be tilled as the result of use of this property as a cultivated corn field.

3.2 Centre Pier, East Pier, East Abutment, East Embankment

3.2.1 Silty Sand to Sand (Till)

Boreholes 6, 7, 10 and 11 were situated at the east abutment and along the east embankment across a series of small ridges. The boreholes encountered silty sand till directly below the topsoil to depths of 0.9 and 4.2 m, where bedrock was found.

In Boreholes 6 and 11, the till was brown and extended to the bedrock surface at depths of about 0.9 to 1.3 m (elev. 63.8 and 66.2 m).

In Boreholes 7 and 10 the till was brown to a depth of about 1.5 to 2.1 m where the colour changed to grey. Bedrock was encountered at depths of 2.1 to 4.2 m (elev. 64.2 and 62.4 m).

Grain size distribution curves for the silty sand stratum (Till) are presented on Figure 2. The till contained some gravel sizes and trace clay.

The water contents determined on samples obtained from this material, varied between 18 and 42 percent by weight in the upper 0.5 m where some mixing with the topsoil has occurred. Beneath this surficial zone, water contents were about 8 to 20 percent.

The Standard Penetration Test results (N values) ranged between 5 and 14 (blows per 0.3 m) for the upper 0.5 m of the till which have been disturbed by farming. Deeper in the till, the N values ranged between 14 and 37 (blows per 0.3 m) indicating a compact to dense deposit.

October 1988

88311

3.2.1 Bedrock

Massive, fine to medium grained, light to dark grey, crystalline dolostone bedrock was exposed at the ground surface (elev. 65.2 and 65.1 m) at Boreholes 4 and 5 (centre pier and east pier).

In Boreholes 6 and 7 (east abutment) bedrock was encountered beneath the silty sand (till) at depths of about 0.9 and 2.1 m respectively (elev. 63.8 and 64.2 m).

The rock was cored for lengths of 1.3 to 2.1 m. Rock cores obtained at the pier and abutment locations indicated solid core recoveries of 100 percent and RQD's varying between 93 and 100 percent. The recovered rock cores were in a slightly weathered to sound condition.

The rock core examined had frequent calcitic filled vugs and minor sandstone beds.

Boreholes 10 and 11 (east embankment) met refusal to augering at depths of 4.2 and 1.3 m respectively (elev. 62.3 and 66.2 m). Due to the difference in elevation compared to Boreholes 6 and 7, the refusal in Boreholes 10 and 11 may represent the bedrock surface, or a boulder within the till.

3.3 West Pier, West Abutment, West Embankment

3.3.1 Silty Clay

Boreholes 1, 2, 3, 8, 9 and 12 all encountered a silty clay beneath the topsoil layer. The silty clay layer extended to a depth of approximately 1.8 m. The upper 1.0 m was found to be disturbed and/or slightly weathered due to the previous cultivation of the site for corn production and also due to natural disturbance from frost and surface water penetration. The portion of the layer between approximately 1.0 m and 1.8 m was brown changing to grey and found to be stiff to very stiff.

Water contents of the samples varied from about 30 percent to about 52 percent with an average of about 35 percent.

The following range of Atterberg Limits were measured for 3 of the silty clay samples:

	Range	Average
Liquid Limit	28 to 45 percent	39 percent
Plastic Limit	16 to 25 percent	20 percent
Plasticity Index	22 to 26 percent	24 percent

October 1988

88311

The Atterberg Limit results are presented graphically on the Borehole Logs and on Plasticity Charts (Figures 3 and 4). They indicate generally a 'CI' soil, being a clay of intermediate plasticity.

The Standard Penetration Test results within the silty clay stratum varied between 6 and 12 blows per 0.3 m.

3.3.2 Clayey Silt

Boreholes 1, 2, 3, 8, 9 and 12 all encountered a clayey silt beneath the silty clay layer. The clayey silt deposit varied in depth between 3.8 and 6.7 m. The material was grey in colour.

The majority of the borehole sampling in the clayey silt was carried out using thin-walled 75 mm diameter Shelby tubes. The samples were extruded for bulk unit weight, unconfined compressive strength testing, moisture content, Atterberg Limits, and uniaxial consolidation tests.

The clayey silt was found to be frequently interbedded with partings of silty fine sand and thin layers of fine sand and sandy silt typically 20 mm in thickness, with spacings ranging between 150 and 300 mm as observed in the Shelby Tube samples.

Figure 1 presents the results of grain size analyses on 6 samples of the clayey silt. There was about 20 to 50 percent by weight fine sand in the samples tested.

Water contents of the samples varied from about 10 percent in the fine sand layers, to about 52 percent in the clayey silt, with an average of about 34 percent.

The following range of Atterberg Limits were measured for 12 of the clayey silt samples:

	Range	Average
Liquid Limit	23 to 32 percent	28 percent
Plastic Limit	10 to 25 percent	17 percent
Plasticity Index	11 to 19 percent	15 percent

The Atterberg Limit results are presented graphically on the Borehole Logs and on Plasticity Charts (Figures 3 and 4). They indicate generally a 'CL' soil according to the Unified Soil Classification System, which is a clay or clayey silt of low plasticity.

The Standard Penetration Test results within the clayey silt stratum varied between 1 and 8 blows per 0.3 m.

October 1988

88311

In situ vane testing carried out through the clayey silt, indicated variable undrained shear strengths ranging from 45 to more than 155 kPa. The field vane shear strengths were not corrected for plasticity since the correction is small (Bjeerum, 1972) for clays with a Plasticity Index of less than 15.

Tests after remolding indicated a moderate sensitivity, with values ranging typically between 4 and 8. It is likely that the wide range and lack of trend with depth in field vane test results (see Figure 7), are a result of the numerous thin sand layers within the clayey silt.

Unconfined compressive strength tests conducted on selected samples indicated undrained shear strengths varying between 18 and 72 kPa. Much lower strengths were measured from the Shelby tube samples than by the field vane tests. This is attributed to sampling disturbance, and the sand layers which would have a greater effect on unconfined samples.

The bulk unit weights determined on shelby tube samples varied from 24.0 to 20.4 kN/cu.m. These values are relatively high for clayey silt, possibly reflecting the high sand content and high water content.

Consolidation tests were carried out using standard oedometer test methods on specimens obtained from Borehole 9, Sample 4 (2.7 m) and from Borehole 2, Sample 3 (1.9 m). The results of these tests are summarized on the void ratio vs log pressure curves presented on Figures 5 and 6 respectively. The properties are summarized below:

BH	SA	Depth	w%	wp%	wl%		Cv	Cc	Cr	σ'_p	α'
No.	No.	(m)				kN/cu.m	10 ⁻³ cm ³ /s			kPa	kPa
2	3	1.9	40	15	31	22.8	5 to 10	0.32	0.03	150	45
9	4	2.7	50	25	41	23.3	2 to 11	0.55	0.04	385	50

October 1988

88311

3.3.3 Sandy Silt (Glacial Till)

Beneath the clayey silt in Boreholes 1, 2, 3, 8, and 12, a silty sand to sandy silt till was encountered to depths of 7.3 to 9.8 m (elev. 55.2 to 58.8 m). This appears to be the same deposit which was encountered in Boreholes 6, 7, 10 and 11 along the central and eastern portions of site. This sandy till contains some gravel with a trace of clay, and exhibits only minor cohesion. Figure 2 shows the grain size distribution of 2 till samples.

The sandy till was grey in colour and the Standard Penetration Test results (N values) were measured between 4 and 63 blows per 0.3 m. This indicates a loose to very dense condition as was also reflected in the Dynamic Cone Test results shown on the Borehole Logs. The water contents were consistently in the order of 10 percent.

3.3.4 Sand

A uniform fine to medium sand layer was encountered in Borehole 12 from a depth of 8.2 to 10.1 m where grinding auger refusal was met. The measured N value in the sand was 38 blows per 0.3 m, indicating a dense condition. The sand was wet and had a water content of about 15 percent.

3.3.5 Bedrock

A massive, fine to medium grained, light grey, quartz sandstone was encountered in Boreholes 1, 2, and 3 at depths of 8.5 to 9.8 m (elev. 55.2 to 57.6 m). The sandstone was cored for depths of 1.5 to 6.1 m. Rock core recovery varied between 77 and 100 percent and RQD values ranged between 14 and 65 percent. These low RQD values are the result of closely spaced horizontal and vertical fractures in the recovered core. There was little weathering evident on the fracture surfaces. Small interbeds of dolostone occur at typically 10 to 12 cm spacing.

Refusal to augering was met in Boreholes 8, 9, and 12 at depths of 7.3, 8.5, and 10.1 m respectively (elev. 58.8, 57.5, and 55.8 m).

It should be noted that a rock ridge can be observed at the ground surface traversing the proposed structural alignment between Boreholes 3 and 4 and trending north-south. This suggests the presence of a geologic discontinuity such as a fault. This is further supported by the sudden increased depth in overburden and the change in rock type between Boreholes 3 and 4.

3.4 Groundwater

The groundwater levels measured October 1, 1988 are summarized below. In Boreholes 7 and 10, at the east end of the site the levels were at Elev. 64.2 m and Elev. 64.4 m respectively. Boreholes 1, 2, 3, 8, 9 and 12 advanced through the deeper overburden at the west end of site, indicated water levels between Elev. 58.9 and Elev. 64.4 m. At Borehole 1, the water level measured in the bedrock was lower than that in the overlying clayey silt. This indicates

October 1988

88311

downward drainage from the clayey silt to the rock.

The long term static levels should be anticipated to fluctuate, with higher levels expected during wet seasons.

Water levels encountered in the boreholes on the day of drilling are summarized on the Borehole Logs and as follows:

Borehole	Water Depth/Elev.
1	4.6m/61.5m
2	3.8m/62.3m
3	2.4m/63.6m
4	dry
5	dry
6	dry
7	dry
8	3.0m/63.1m
9	4.6m/61.4m
10	3.0m/63.5m
11	dry
12	4.6m/61.3m

Water levels measured in the installed standpipe type piezometers on October 1, 1988 are summarized below.

Borehole	Piezometer	Water Depth/Elev.
1	Sandstone	3.7m/62.4m
1	Clayey Silt	2.4m/63.7m
3	Sandstone	3.4m/62.6m
4	Dolostone	1.4m/63.8m
7	Dolostone	2.1m/64.2m
8	Clayey Silt	2.7m/63.4m
9	Clayey Silt	2.1m/63.9m
10	Sandy Silt (Till)	2.1m/64.4m

October 1988

88311

APPENDIX - A

FIELD PROCEDURE

The field investigation for this project was conducted between September 12 and 15, 1988, when 12 boreholes were advanced to depths of 1.6 to 14.6 m below existing grades, at the locations shown on Drawing WP1208704-A. The drilling was conducted using machinery supplied and operated by Marathon Drilling Company Limited of Ottawa, Ontario. The drilling operations were directed and supervised by Mr. Renato Pasqualoni, B.A.Sc., Terraprobe Limited.

The boreholes were put down in the vicinity of the proposed piers and abutments for the proposed bridge. In addition, 2 boreholes were advanced along the centre alignment of the proposed west and the east approach embankments.

The borings were put down using a truck-mounted CME 55 power auger or truck-mounted diamond drill. Split-spoon samples of the overburden materials were obtained in conjunction with thin walled tube sampling and field vane testing as detailed on the Borehole Logs and Sections. Dynamic Cone Tests were also carried out at the majority of the Boreholes. All samples obtained in this investigation were either sealed in glass jars in the case of split-spoon samples, or sealed in waxed thin-walled Shelby tube samples and transported to our laboratory for detailed inspection and testing.

Standpipe type piezometers were sealed into selected boreholes where overburden was encountered, in order to permit observation of groundwater levels. The standpipes comprised 12 mm I.D. CPVC tubing, which was saw-slotted near the base, and fitted with a sand filter and bentonite seal.

The locations of the borings were determined by measuring relative to the survey stakes placed and marked by Ministry of Transportation, Ontario, representatives. The ground surface elevations at the borehole locations were determined and provided by MTO representatives subsequent to the investigation.

The site was revisited on October 1 and 2, 1988 to measure groundwater levels in the installed piezometers and to provide additional site information.

All of the soil samples obtained in this investigation were examined in detail by the project engineer, and classified according to visual and index properties.

Water content determination was carried out for all samples obtained. In addition, laboratory tests were carried out on selected samples, including grain-size distribution, Atterberg Limits, unit weights, unconfined compressive strength, and Oedometer tests. The results of the testing are presented on the Borehole Logs and on Figures 1 to 7.

October 1988

88311

Based on the information obtained during the field investigation and during the subsequent laboratory testing, engineering analysis was then carried out to study the slope stability characteristics of the proposed embankments and also the settlement behaviour of the proposed embankments.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Terraprobe Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 120-B7-04 LOCATION Co-ordinates N 5 022 540; E 358 146 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Bx Rock Core & Cone Test COMPILED BY KJ
 DATUM Gendetic DATE September 12, 1988 CHECKED BY MT

OFFICE REPORT ON SOIL EXPLORATION

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					
66.1	Ground Level															
65.9	Topsoil		1	SS	6											
0.2	Silty Clay, some sand, very stiff brown becoming grey at approximately 64.6 m		2	TW	PH											
64.3																
1.8	Clayey Silt, with interbedded silty sand and sandy silt layers Firm to stiff Grey		3	TW	PH											
			4	SS	1											
			5	SS	1											
60.0																
6.1	Silty Sand to Sandy Silt, some gravel, occasional cobbles, trace clay Compact to Loose Grey (Glacial Till)		6	SS	20											
			7	SS	7											
57.6																
8.5	Bedrock		8	RC Bx	77% RQD 14%											
	Sandstone, slightly to moderately weathered; very poor to poor Grey and White		9	RC Bx	100% RQD 27%											
			10	RC Bx	100% RQD 31%											
			11	RC Bx	100% RQD 21%											
51.5																
14.6	End of Borehole															

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

RECORD OF BOREHOLE No 2										METRIC				
W P 120-87-04		LOCATION Co-ordinates N 5 022 545; E 358 147				ORIGINATED BY RP								
DIST 9 HWY 417		BOREHOLE TYPE Hollow Stem Auger, Bx Rock Core & Cone Test				COMPILED BY KJ								
DATUM Geodetic		DATE September 13, 1988				CHECKED BY MT								
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					
66.1	Ground Level													
0.0	Topsoil													
0.15	Silty Clay, some sand, occasional sand partings Firm to Stiff Brown, becoming grey at approximately 64.6m		1	SS	7									
			2	SS	10									
64.3			3	TW	PH									
1.8	Clayey Silt, with imbedded silty sand and sandy silt layers firm to stiff Grey		4	SS	4									
			5	TW	PH									
60.7			6	SS	4									
5.4	Silty Sand to Sandy Silt, some gravel, trace clay, Loose to Compact Grey (Glacial Till)		7	SS	13									
			8	SS	15									
57.1			9	RC	82%									
9.1	Bedrock Sandstone, slightly weathered, very poor Grey and White		9	Bx	RQD 18%									
55.5														
10.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity
20
15
10

5 (% STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 530; E 358 180 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Bx Rock Core & Cone Test COMPILED BY KJ
 DATUM Geodetic DATE September 13, 1988 CHECKED BY MT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20	40						60	80	100
66.0	Ground Level																
65.8	Topsoil - 200 mm																
0.2	Silty Clay, some sand, occasional sand partings Firm to Very Stiff Brown		1	SS	11								24.1				
			2	TW	PH												
64.2	Clayey Silt, with interbedded silty sand and sandy silt layers firm to very stiff brown becoming grey at approximately 63.9m		3	TW	PH								23.9	0 17 59 24			
1.8			4	TW	PH								21.2				
60.4	Silty Sand and Gravel trace clay Compact Grey		5	SS	8												
5.6			6	SS	12												
58.6	Silty Sand to Sandy Silt, some gravel, trace clay Very Dense Grey (Glacial Till)		7	SS	63												
			8	SS	43												
55.2	Bedrock		9	RC Bx	100% RQD 65%												
54.6	Sandstone, slightly weathered, fair Grey and White																
11.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 → 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 120-87-04 LOCATION Co-ordinates uN 5 022 509; E 358 233
 DIST 9 HWY 417 BOREHOLE TYPE Nx Rock Core
 DATUM Geodetic DATE September 13, 1988
 ORIGINATED BY RP
 COMPILED BY KJ
 CHECKED BY MT

OFFICE REPORT ON SOIL EXPLORATION


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					
65.2	Ground Level																
0.0	Bedrock																
	Dolostone frequent calcitic vugs light grey.		1	RC Nx	100% RQD 93%												
63.3																	
1.9	End of Borehole																

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

RECORD OF BOREHOLE No 5

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 485; E 358 270 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Nx Rock Core COMPILED BY KJ
 DATUM Geodetic DATE September 13, 1988 CHECKED BY MT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
65.1	Ground Level																
0.0	Bedrock		1	RC Nx	100% RQD 93%	Dry Sept. 13	65										
63.5	Dolostone, frequent calcitic vugs light grey																
1.6	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 470; E 358 302 ORIGINATED BY RP
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Nx Rock Core COMPILED BY KJ
DATUM Geodetic DATE September 13, 1988 CHECKED BY MT

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

ϕ^3, ϕ^5 : Numbers refer to Sensitivity

RECORD OF BOREHOLE No 7

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 462; E 358 295 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Nx Rock Core COMPILED BY KJ
 DATUM Geodetic DATE September 12, 1988 CHECKED BY MT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100										WATER CONTENT (%)		
								SHEAR STRENGTH LP ₀										20 40 60		
66.3	Ground Level																			
0.0	Topsoil																			
0.1	Silty Sand, some gravel, trace clay		1	SS	9								0							
	Compact to Dense		2	SS	37								0							
	Brown becoming grey at 64.8 m (Glacial Till)		3	SS	30								0			8 67 25 0				
64.2																				
2.1	Bedrock																			
	Dolostone, frequent calcitic vugs Light Grey		4	RC Nx	100% RQD 90%															
			5	RC Nx	100% RQD 100%															
61.1																				
5.2	End of Borehole																			

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 553; E 358 080 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY KJ
 DATUM Geodetic DATE September 14, 1988 CHECKED BY MT

OFFICE REPORT ON SOIL EXPLORATION

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					
66.1	Ground Level																
65.9	Topsoil																
0.2	Silty Clay, some sand, occasional sand partings		1	SS	10		Seal							0			
	Firm to Very Stiff Brown becoming grey at approximately 64.7m		2	SS	8		65							0			
64.3	Clayey Silt, with interbedded silty sand and sandy silt layers		3	SS	2									0			
1.8	Firm to Very Stiff grey		4	TW	PH		Water level Oct 1, 88									23.3	0 28 59 13
			5	TW	PH		Sept 14/88										
			6	TW	PH											22.5	
60.0	Sandy Silt, some gravel, trace clay		7	SS	54		60										
	Very Dense Grey																
58.8	(Glacial Till)																
7.3	End of Borehole Auger Refusal on probable bedrock																

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 9										METRIC				
W P 120-87-04		LOCATION Co-ordinates N 5 022 560; E 358 000				ORIGINATED BY RP								
DIST 9 HWY 417		BOREHOLE TYPE Hollow Stem Augers, Cone Test				COMPILED BY KJ								
DATUM Geodetic		DATE September 14, 1988				CHECKED BY MT								
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					
66.0	Ground Level													
65.8	Topsoil													
0.2	Silty Clay, --- some sand, occasional sand partings		1	SS	12									
	Firm to Very Stiff		2	SS	6									
	Brown becoming grey at approximately 64.5m													
64.2			3	SS	1									
1.8	Clayey Silt, with interbedded sandy silt and silty sand layers		4	TW	PH									
	Firm to Very Stiff grey		5	SS	2									
			6	SS	2									
			7	TW	PH									
			8	SS	1									
57.5														
8.5	End of Borehole Auger Refusal on probable bedrock													

OFFICE REPORT ON SOIL EXPLORATION

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

RECORD OF BOREHOLE No 10

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 436; E 358 330 ORIGINATED BY RP
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KJ
DATUM Geodetic DATE September 14, 1988 CHECKED BY MT

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

*3, *5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 11

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 400; E 358 360 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KJ
 DATUM Geodetic DATE September 14, 1988 CHECKED BY HT

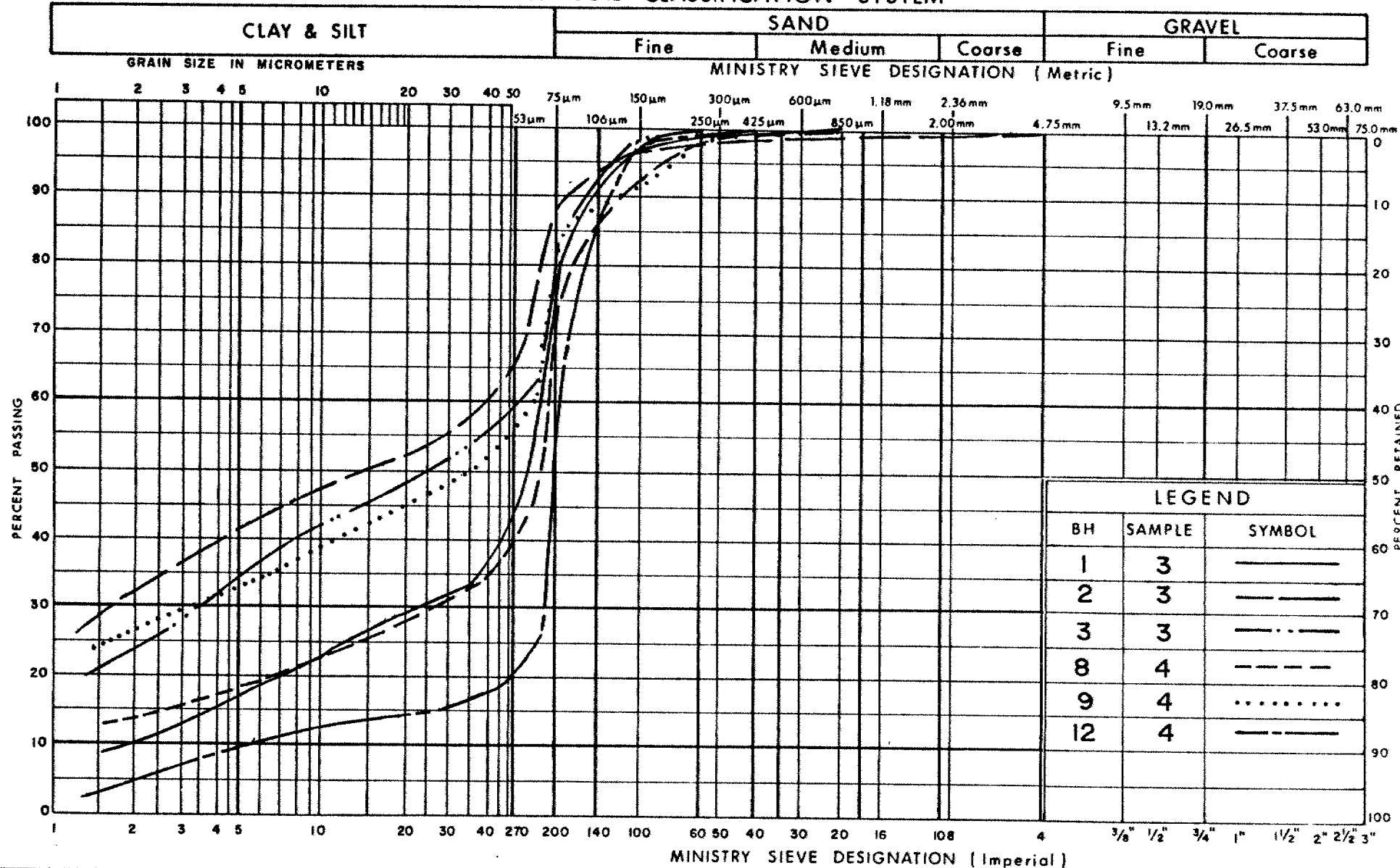
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
67.5	Ground Level																
0.0	Topsoil																
0.15	Sandy Silt, some gravel, trace clay Compact Brown (Glacial Till)		1	SS	6												
66.2			2	SS	15												
1.3	End of Borehole Auger Refusal on probable bedrock																
							65										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 12										METRIC			
W P 120-R7-04		LOCATION Co-ordinates N 5 022 529; E 358 185				ORIGINATED BY RP							
DIST 9 HWY 417		BOREHOLE TYPE Hollow Stem Augers, Cone Test				COMPILED BY KJ							
DATUM Geodetic		DATE September 15, 1988				CHECKED BY MT							
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								
65.9	Ground Level												
65.7	Topsoil		1	SS	12								
0.2	Silty Clay, some sand, occasional sand partings		2	TW	PH								
	Firm to Very Stiff												
64.1	Brown becoming grey at approximately 64.4m		3	TW	PH								
1.8	Clayey Silt, with interbedded silty sand and sandy silt layers												
	firm to very stiff grey		4	TW	PH								
			5	TW	PH								
60.3													
5.6	Silty Sand, trace gravel, occasional cobble		6	SS	17								
	Compact Grey												
58.9													
7.0	Sandy Silt, trace gravel, trace clay		7	SS	24								
	Compact Grey												
57.7	(Glacial Till)												
8.2	Sand, fine to medium		8	SS	38								
	Dense Grey												
55.8													
10.1	End of Borehole Auger Refusal on probable bedrock												

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

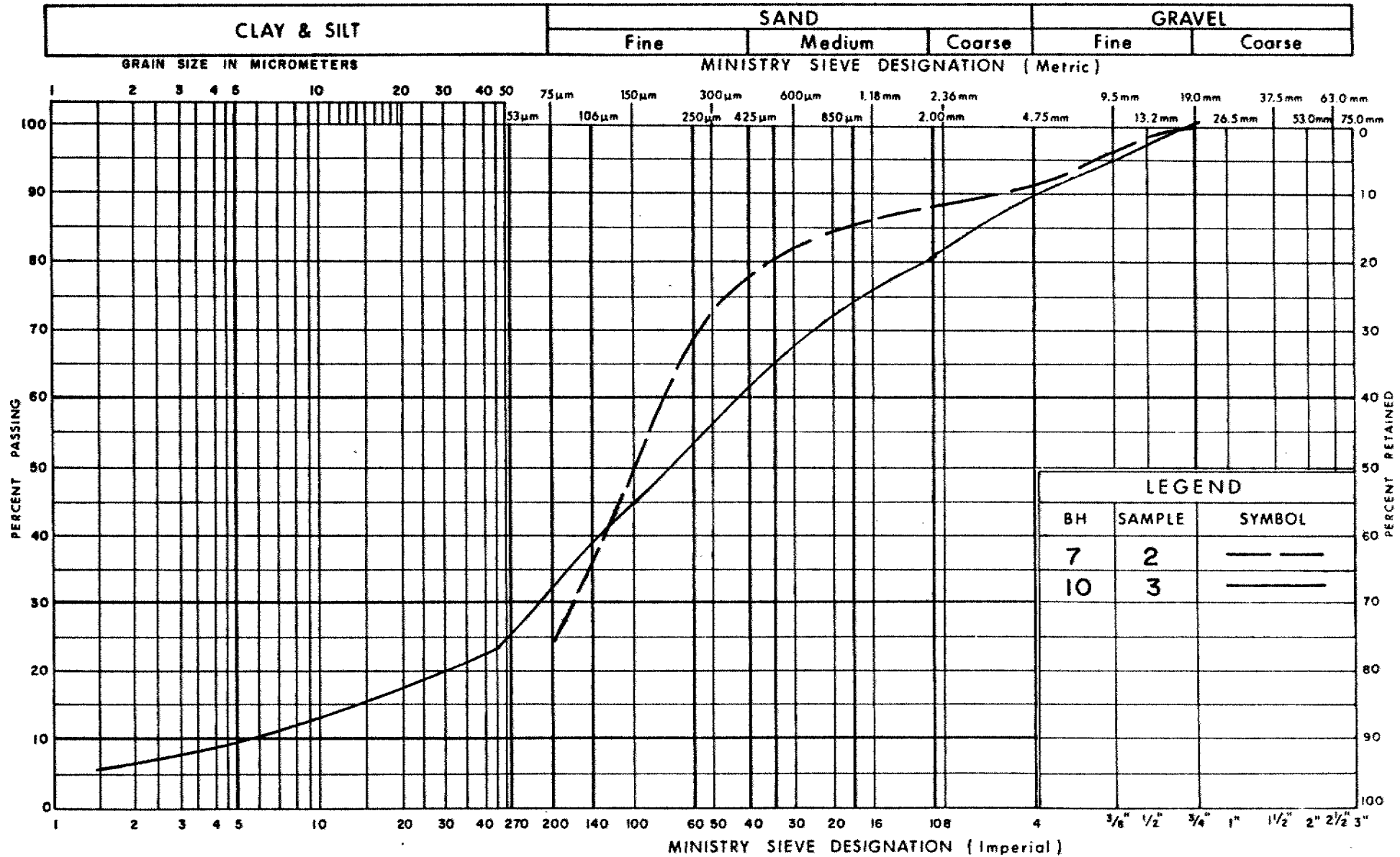
Ontario

GRAIN SIZE DISTRIBUTION
SILTY CLAY, SOME SAND (CL)

FIG No 1

W P 120-87-04

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

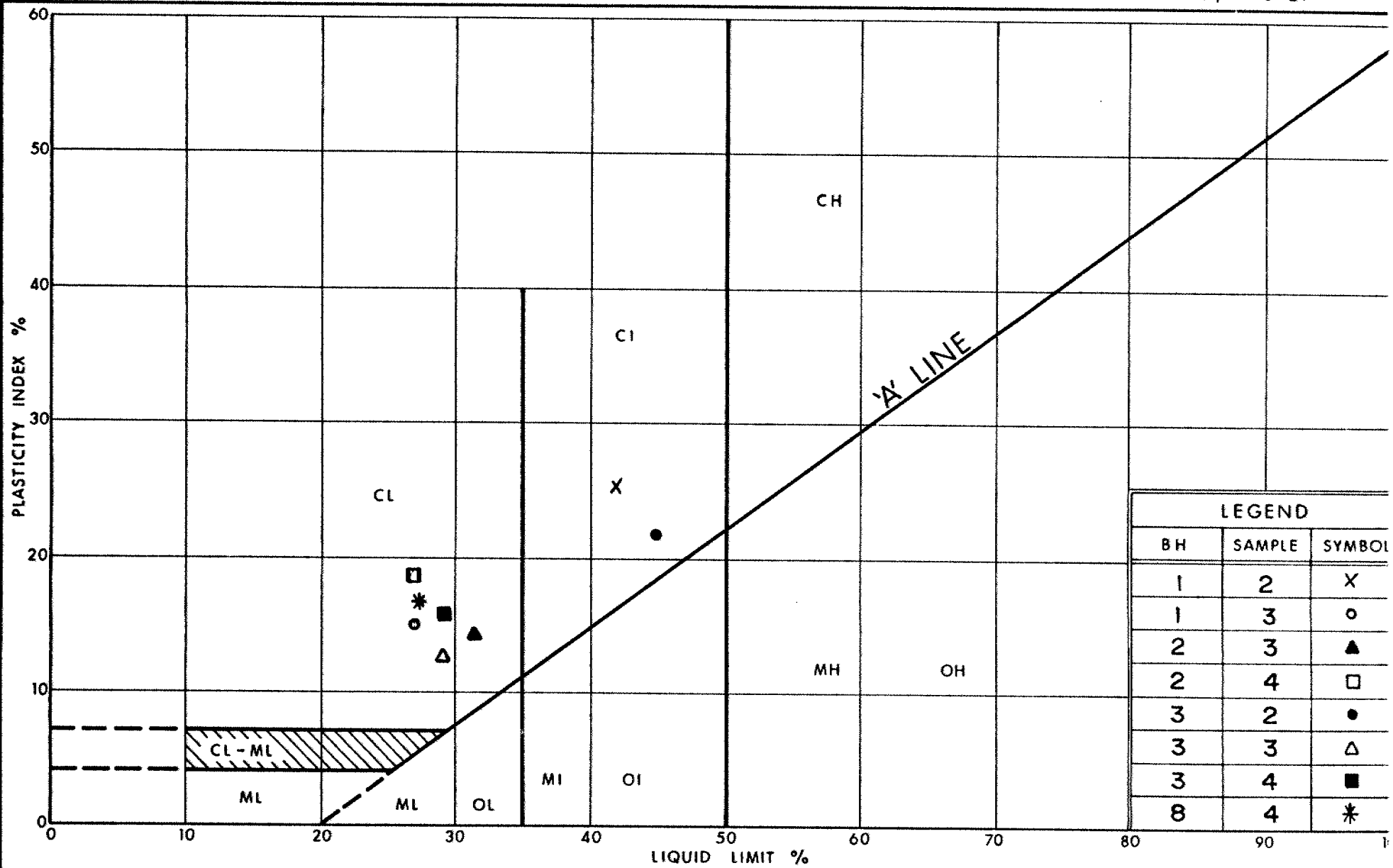
Ontario

GRAIN SIZE DISTRIBUTION
SILTY SAND TILL (SM)

FIG No 2

W P 120-87-04

192



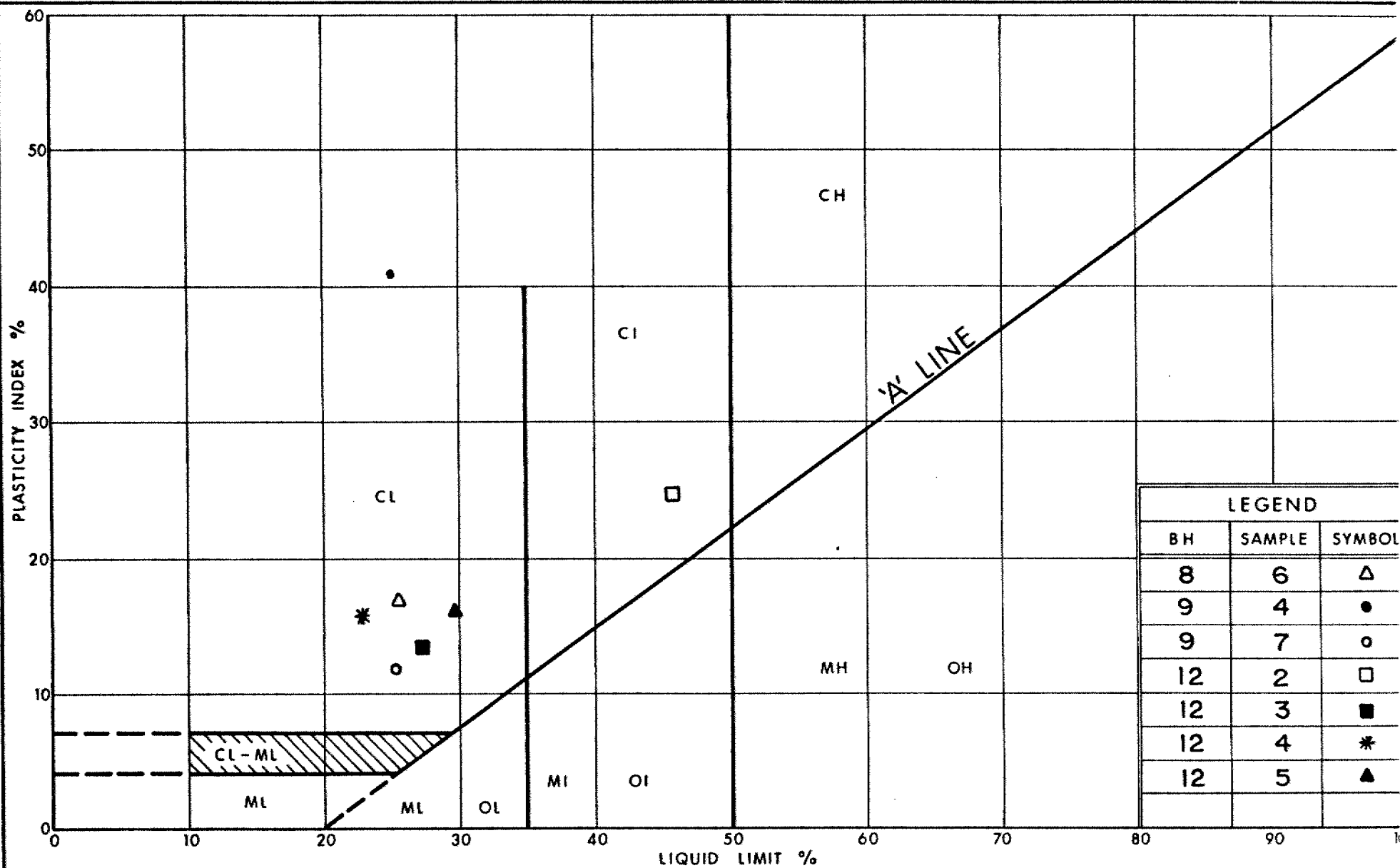
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Ontario

PLASTICITY CHART SILTY CLAY, SOME SAND

FIG No 3

W P 120-87-04



Ontario

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Transportation

PLASTICITY CHART SILTY CLAY, SOME SAND

FIG No 4

W P 120-87-04

194

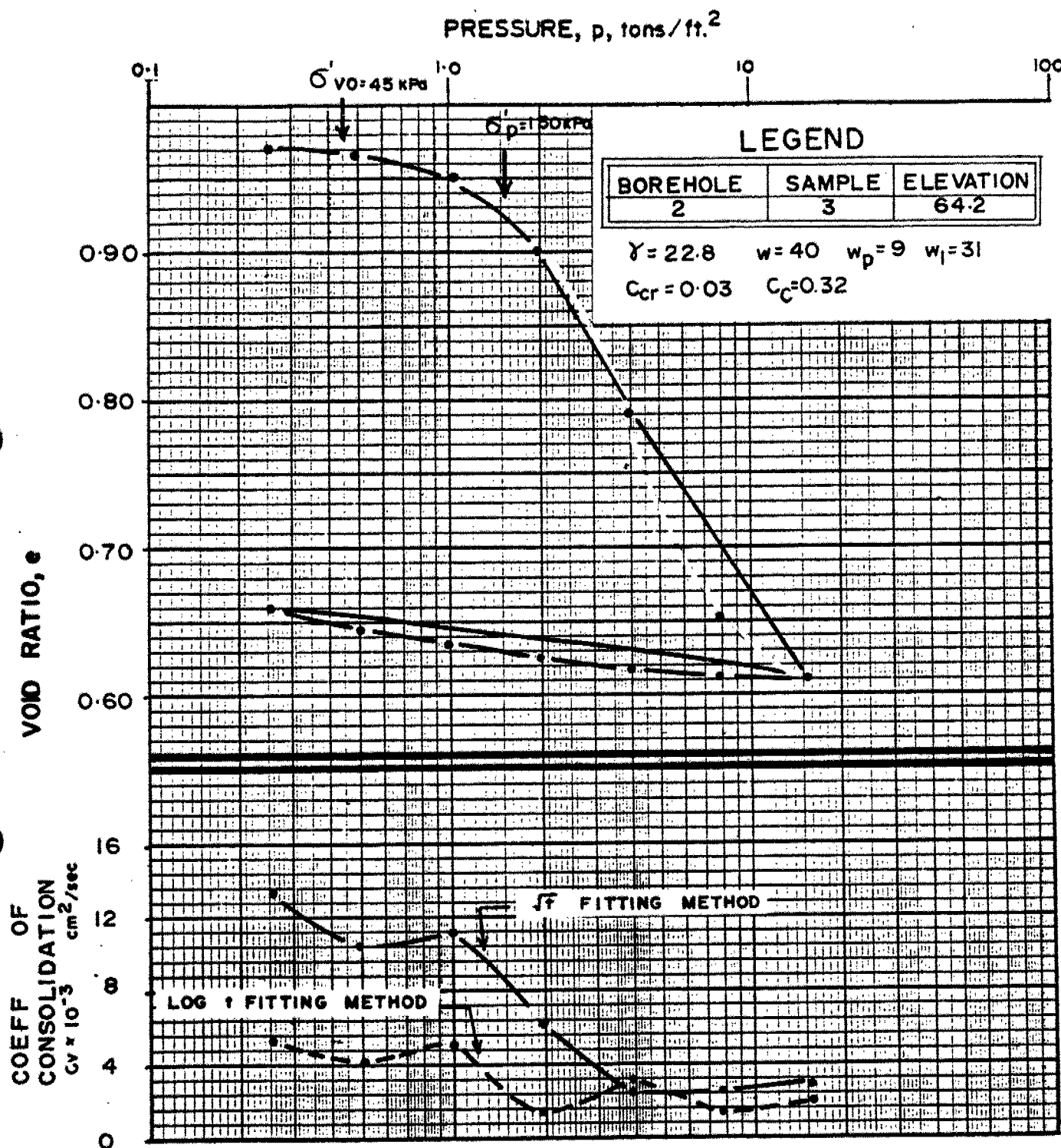
CONSOLIDATION TEST (e -log p)

FIG 5

TESTED BY RC

CALCULATED BY RC

CHECKED BY KJ

DATE OF TESTING SEPT 19 - OCT 3 1988

PROJECT NUMBER 120-87-04

BOREHOLE NUMBER 2

SAMPLE NUMBER 3

DEPTH OF SAMPLE 1.8 m

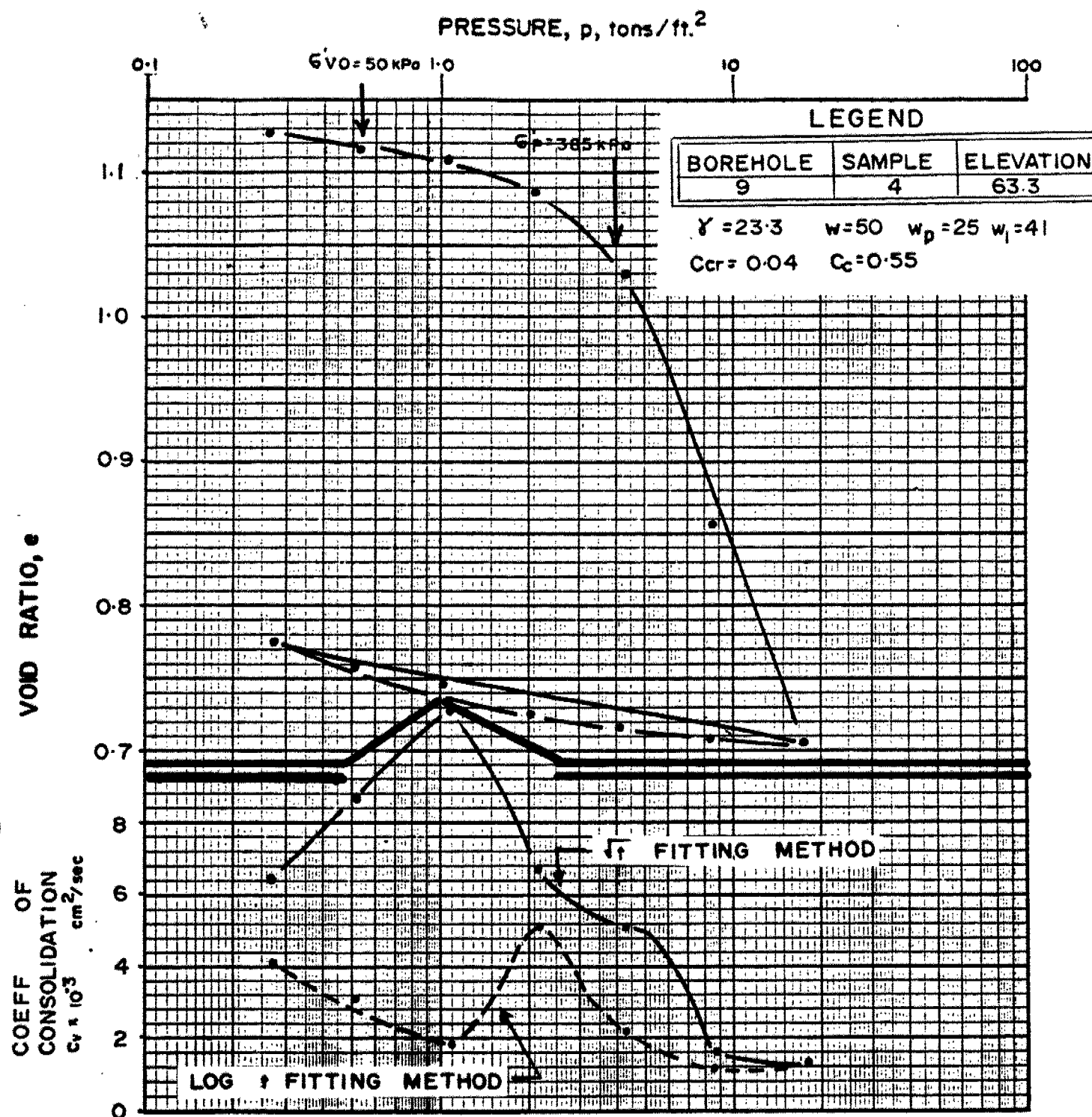
CONSOLIDATION TEST ($e - \log p$)

FIG 6

TESTED BY _____ RC _____

CALCULATED BY _____ RC _____

CHECKED BY _____ KJ _____

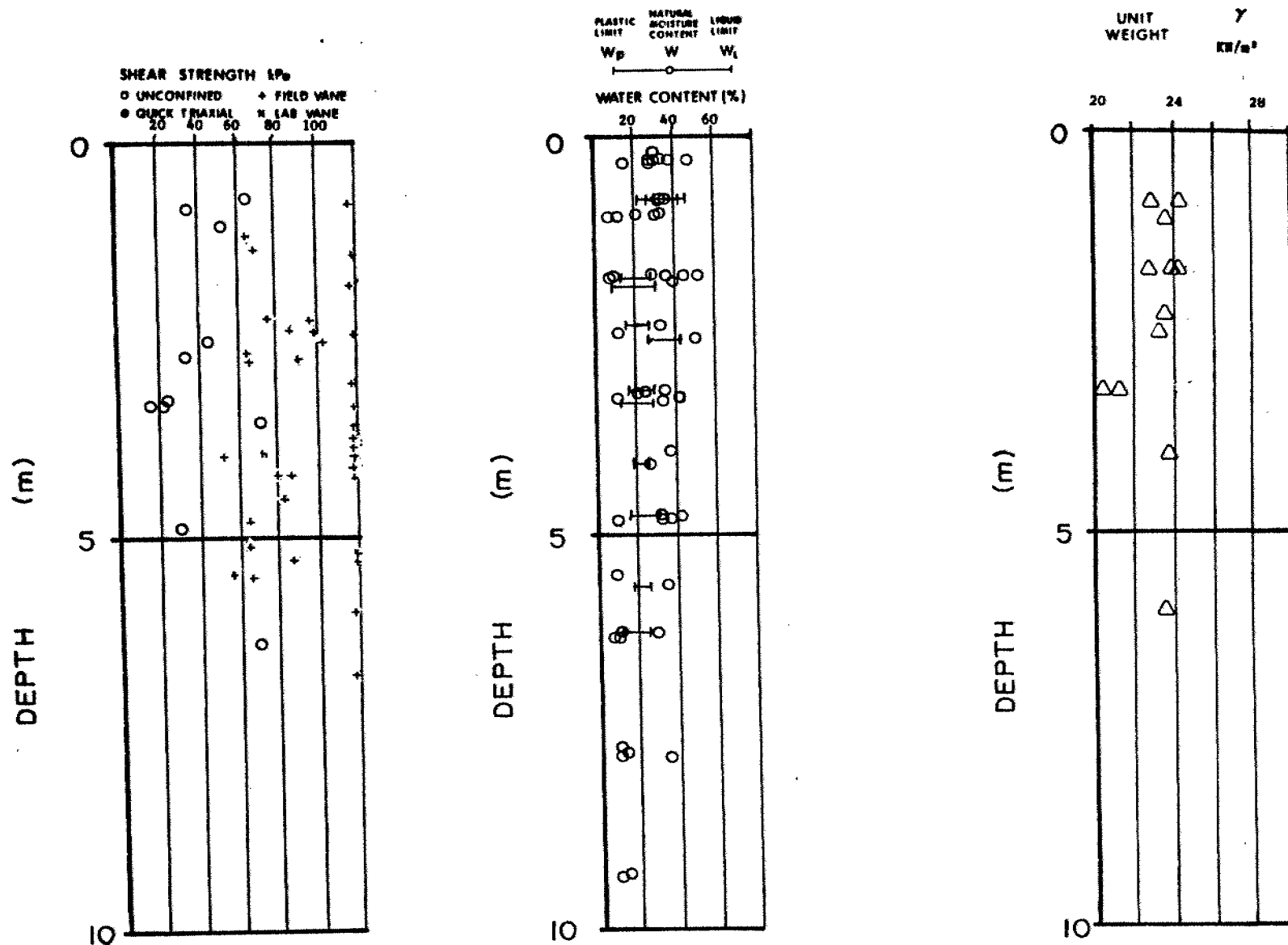
DATE OF TESTING OCT 3 - OCT 16 1988

PROJECT NUMBER 120-87-04

BOREHOLE NUMBER 9

SAMPLE NUMBER 4

DEPTH OF SAMPLE 2.7m



Ministry of
Transportation

Ontario

SOIL PROFILE SUMMARIES

FIG No 7

W P 120-87-04

FOUNDATION INVESTIGATION REPORT

for

E-S Ramp Over Hwy. 417

Hwy. 416/417 Interchange

District 9, Ottawa

W.P. 120-87-05, Site #3-52-532INTRODUCTION

This report summarizes the results of a foundation investigation for the above site.

The fieldwork was carried out from 88 07 25 to 88 08 12 utilizing a continuous flight auger machine equipped with 82 mm I.D. hollow stem augers, solid stem augers, BW casing and BXL rock core barrel. Additional fieldwork was performed from 88 10 25 to 88 10 26.

The investigation consisted of 8 sampled boreholes, and 4 dynamic cone penetration tests. The boreholes ranged in depth from 7 to 39 metres.

Groundwater levels were measured in open boreholes at each borehole location.

SITE DESCRIPTION

The proposed structure site is located immediately south of the existing interchange of highway 417 and Acres Road. The surrounding area is generally flat with slightly rolling corn fields to the south and east of the site. Boreholes were advanced through varying heights of the existing approach fill of the Acres Road overpass and surrounding area.

Approximately 500 m to the west of the site, bedrock outcrops can be seen.

SUBSURFACE CONDITIONS

The subsoil conditions in this area can generally be described as sand and clayey silt fill, overlying a 3.0 m deposit of silty clay, overlying a 6.0 m deposit of clayey silt to silt with interbedded layers of silty sand.

Beneath this cohesive zone lies a thick deposit of silty sand to sand, which in turn overlies a zone of sand, gravel and boulders (Glacial Till) which extends to bedrock.

The boundaries of the subsoil types, laboratory test results and groundwater levels are shown on the Record of Borehole log sheets contained in the Appendix. The locations and elevations of the boreholes along with the stratigraphical profile are shown on Drawing 1208705-A.*

The various soils encountered at this site are described as follows:

Sand, Some Clayey Silt (Fill)

The existing south approach fill to the Acres Road overpass consists of sand with a trace of gravel and pockets of clayey silt.

The top layer consists of granular road bed material with the remainder composed primarily of sand. Some pockets of clayey silt were encountered, particularly at the toes of the approach fill slopes. The thickness of the material corresponds to the height of the approach fill above original ground, ranging up to 4.0 m.

The material is generally non-cohesive and dry. The clayey silt encountered is cohesive and of low plasticity, similar to the natural material located in the area.

Based on 'N' values obtained from the Standard Penetration test, the fill is in a compact to dense state.

Silty Clay, Some Sand

This material was encountered in all boreholes with the exception of borehole 2-4A and 2-4B, where sampling frequencies bypassed this layer. It represents the beginning of the native material for this area.

* DWG NO 2 OF THE CONTRACT DWG'S

The layer consists of brown silty clay with a trace to some sand. It is cohesive, has low plasticity and low moisture content. Based on shear strength data, the material has a firm to very stiff consistency.

Figure 1 illustrates a typical plasticity chart for this material based on representative samples from the site. Figure 2 represents a typical gradation envelope for the material.

Laboratory values are contained on the Record of Borehole log sheets in the Appendix.

Clayey Silt to Silt with Interbedded Layers of Silty Sand

Beneath the silty clay layer lies a deposit of clayey silt to silt. This material is cohesive and ranges from low plasticity to intermediate plasticity. It is characterized by frequent thin seams of silty sand located throughout the deposit.

The material is wet, indicating that the water table is located within this layer. 'N' values from the field investigation indicate very soft conditions throughout this layer, however field vane tests and laboratory shear strength tests indicate that the consistency of the material ranges from soft to firm.

Consolidation tests were performed on this material to investigate its settlement characteristics.

The results of the laboratory test are summarized below:

<u>Atterberg Limits</u>	<u>Range (%)</u>	<u>Average (%)</u>
Water Content (w)	28-43	33.1
Plastic Limit (wp)	12-20	15.1
Liquid Limit (w _L)	19-43	28.9

<u>Undrained Shear Strength (C_u)</u>	<u>Range (kPa)</u>	<u>Sensitivity</u>
Field Vane	38-115	2-12
Laboratory Vane	45-75	3-14
Unconfined Compression Test	27-141	N/A

<u>Consolidation Results</u>	<u>Range</u>
Initial Void Ratio (e_o)	0.969-1.266
Compression Index (C_c)	0.65-1.43
Preconsolidation Pressure (P_c)	383-530

Figure 3 represents a typical plasticity chart for this material while Figure 4 represents a gradation envelope for this material.

Silty Sand to Sand

Underlying the clayey silt to silt layer is a deposit of medium to coarse silty sand, with a trace to some gravel. The deposit ranges in thickness from 2.5 m to 14.2 m.

It is non cohesive, water bearing and is in a very loose to very dense state, based on 'N' values. Cobbles were encountered at varying depths throughout the deposit.

Figure 5 represents a typical grain size distribution envelope for this material.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

This layer is a very dense deposit of sand, gravel and boulders, which lies directly over bedrock.

During the field investigation, augering through this layer was very difficult and time consuming. Rock coring procedures were utilized for sampling due to the high percentage of boulders encountered.

The material is non cohesive and ranges in thickness from 10 m to greater than 16 m. The full vertical extent of the deposit was not determined during the investigation, as the boreholes could not be advanced past elevation 36 m.

Bedrock

Bedrock was encountered in 5 boreholes and cored in 3 boreholes.

On the west side of Acres Road (Boreholes 2-1, 2-2, 2-3 & 2-6) bedrock was encountered at relatively shallow depths.

It is sloped and rises from east to west, from 23 m below ground surface to within 8.5 m. Further west, bedrock outcrops can be seen.

To the east of Acres Road, bedrock was encountered at elevation 35 m, considerably lower than on the west side of Acres Road. There appears to be a fault line or glacial valley running between Boreholes #2-3 and #2-5, as boreholes #2-4A and #2-4B both were advanced to a lower elevation than borehole #2-5 without encountering bedrock (see Drawing 1208705-A). *

Analyses of the recovered core samples indicate that bedrock is composed of sandstone and dolostone. For a complete description of the bedrock, refer to the appendix.

Groundwater

Groundwater was measured in open boreholes at all locations with the exception of Borehole #2-6.

It is located within the clayey silt to silt layer at an estimated elevation of 64.0 m.

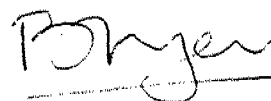
For ground water levels in the vicinity of the structure footings, refer to the Record of Borehole log sheets in the Appendix.

* DWG NO 2 OF THE CONTRACT DWG'S

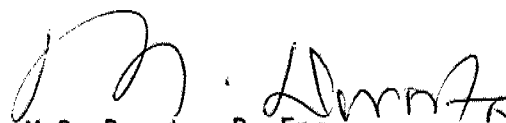
MISCELLANEOUS

The fieldwork was carried out under the supervision of R. Otway, Foundation Engineer, using equipment rented from Marathon Drilling Co. Ltd., Ottawa, and F.E. Johnston Drilling Co. Ltd., Ottawa.

The report was written by R. Otway, Foundation Engineer, and reviewed by M. Devata, Chief Foundations Engineer.



Dr. Balu Iyer, P. Eng.
Senior Foundation Engineer




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

APPENDIX

RECORD OF BOREHOLE No 2-1

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 523.6; E 358 448.7 ORIGINATED BY RO
DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, BW Casing, BXL Rock Core & Cone Test COMPILED BY RO
DATUM Geodetic DATE 88 07 25 CHECKED BY 

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
65.9	Ground Surface											
0.0	Silty Clay Some Sand Firm		1	SS	6							
64.7			2	SS	2							
1.2	Clayey Silt to Silt With Interbedded Layers of Silty Sand Soft to Firm		3	TW	PH							
			4	SS	1							
			5	SS	1							
59.9			6	SS	3							
6.0	Silty Sand to Sand Trace Gravel Occasional Cobbles Very Loose to Loose		7	SS	5							
			8	SS	8							
57.4												
8.5	Sandstone Bedrock Sound		9	BXL RC	REC 92%							
			10	BXL RC	REC 98%							
53.9												
12.0	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2-2


METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 542.6; E 358 463.8 ORIGINATED BY RO
DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, 'B' Casing, BXL Rock Core & Cone Test COMPILED BY RO
DATUM Geodetic DATE 88 07 25 & 88 10 25 to 26 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
66.4	Ground Surface													GR SA SI CL
0.0	Silty Clay		1	SS	12		66							
64.9	Trace of Sand		2	TW	PH									
1.5	Clayey Silt to Silt with Interbedded Layers of Silty Sand		3	SS	2		64	+9						0 64 (36)
	Soft to Firm		4	SS	2			+6						0 29 26 45
			5	SS	1		62	+6						
			6	SS	1			+6						0 9 54 37
			7	SS	1		60	+6						
59.4			8	SS	4									
7.0	Silty Sand to Sand		9	SS	4		58							
	Trace of Gravel		10	SS	80									
	Occasional Cobbles		11	SS	120/25 cm		56							2 94 (4)
	Very Loose to Very Dense		12	SS	100		54							
53.8			13	BXL RC	REC 96%									RQD = 76%
12.6	Bedrock		14	BXL RC	REC 97%									RQD = 50%
	Sandstone, Sound		15	RC	REC 94%		52							RQD = 0%
51.4														
15.0	End of Borehole													

RECORD OF BOREHOLE No 2-3

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 571.5; E 358 475.5 ORIGINATED BY RO
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger - BW Casing & Cone Test COMPILED BY RO
 DATUM Geodetic DATE 88 07 25 to 26 CHECKED BY 

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
67.6	Ground Surface													
0.0	Sand Some Clayey Silt (Fill) Compact		1	SS	11								1 50 28 21	
66.2			2	TW	PH								0 4 46 50	
1.4	Silty Clay Trace of Sand Firm to Very Stiff		3	SS	19								0 4 45 51	
			4	SS	14									
63.2			5	SS	15									
4.4	Clayey Silt to Silt With Interbedded Layers of Silty Sand Soft to Firm		6	SS	1								0 36 44 20	
			7	TW	PH								0 31 30 39	
			8	SS	1									
			9	SS	1									
			10	SS	0									
57.4														
10.2	Silty Sand to Sand Trace of Gravel Occasional Cobbles Compact to Very Dense		11	SS	39								0 93 (7)	
			12	SS	18									
			13	SS	76									
			14	SS	87									
			15	SS	34									
44.7														
22.9	End of Borehole Probable Bedrock													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2-4A

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 604.9; E 358 492.6 ORIGINATED BY RO
 DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, BW Casing, BXL Rock Core COMPILED BY RO
 DATUM Geodetic DATE 88 07 29 to 31 CHECKED BY

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	SHEAR STRENGTH kPa					
69.6	Ground Surface													
0.0	Sand Trace of Clayey Silt Dense (Fill)		1	SS	35									
66.1	Clayey Silt to Silt with Interbedded Layers of Silty Sand		2	SS	22									
3.5	Soft to Firm		3	SS	2									
60.0			4	SS	17									
9.6	Silty Sand to Sand		5	SS	16									
	Some Gravel		6	SS	34									
	Occasional Cobbles		7	SS	32									
	Compact to Very Dense		8	SS	62									
			9	SS	60									
45.8	Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)		10	RC	REC	62%								
23.8	Very Dense		11	RC	REC 1%									
			12	SS	92									
			13	RC	REC 6%									
			14	RC	REC 2%									
39.4														
30.2														

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 2-4A Cont'd METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 604.9; E 358 492.6 ORIGINATED BY RO
 DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, BW Casing, BXL Rock Core COMPILED BY MS
 DATUM Geodetic DATE 88 07 29 to 31 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80	100
								SHEAR STRENGTH kPa								WATER CONTENT (%)	
39.4	Continued																
30.2	Heterogeneous Mixture of Sand Gravel and Boulders (Glacial Till) Very Dense		15	BXL RC	REC 9%												
			16	BXL RC	REC 30%												
			17	RC	REC	47%											
30.6			18	RC	REC	30%											
39.0	End of Borehole																

RECORD OF BOREHOLE No 2-4B

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 613.1; E 358 499.8 ORIGINATED BY MS
DIST 9 HWY 417 BOREHOLE TYPE 'N' Casing, 'B' Casing, BXL Rock Core COMPILED BY RO
DATUM Geodetic DATE 88 08 05 to 12 CHECKED BY SP

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 2-5

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 636.0; E 358 517.7 ORIGINATED BY RO
DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, 'B' Casing - BXL Rock Core & Cone Test COMPILED BY RO
DATUM Geodetic DATE 88 07 25 to 28 CHECKED BY SP.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
66.0	Ground Surface													
0.0	Silty Clay Trace of Sand Stiff		1	SS	12								0 5 53 42	
63.9			2	TW	PH								0 10 54 36	
2.1	Clayey Silt to Silt with Interbedded Layers of Silty Sand Soft to Stiff		3	TW	PH								1 15 45 39	
			4	TW	PH								0 22 61 17	
			5	SS	1									
			6	SS	2								0 29 25 46	
58.7			7	SS	24									
7.3			8	SS	25									
	Silty Sand to Sand Trace of Gravel Occasional Cobbles Compact to Very Dense		9	SS	42								2 80 (18)	
			10	SS	42									
			11	SS	86									
			12	SS	34								10 77 (13)	
45.7			13	RC	REC	71%								
20.3			14	SS	100									
	Heterogeneous Mixture of Sand Gravel and Boulders (Glacial Till) Very Dense		15	RC	REC	14%								
			16	RC	REC	8%								
			17	SS	60									
			18	RC	REC	8%								
			19	RC	REC	8%								
			20	SS	89									
			21	BXL RC	REC 32%									
			22	BXL RC	REC 78%									
35.8														

OFFICE REPORT ON SOIL EXPLORATION


Continued

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 2-5 Cont'd METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 636.0; E 358 517.7 ORIGINATED BY RO
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger 'B' Casing - BXL Rock Core COMPILED BY RO
DATUM Geodetic DATE 88 07 25 to 28 CHECKED BY 

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			20	40	60	80	100					
35.8	Continued															
35.5	(Glacial Till)		22	RC	REC	78%										
30.5	Very Dense		23	RC	REC	94%										
	Bedrock		24	RC	REC	100%										
34.1	Silty Dolostone		25	RC	REC	100%										
31.9	End of Borehole															

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2-6

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 548.1; E 358 453.7 ORIGINATED BY RO
DIST 9 HWY 417 BOREHOLE TYPE Solid Stem Auger COMPILED BY RO
DATUM Geodetic DATE 88 08 02 & 88 10 25 CHECKED BY *RF*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)				
67.4	Ground Surface																
0.0	Sand with Silty Clay Trace Gravel		1	SS	7												
66.2	Loose (Fill)		2	SS	9												
1.2	Silty Clay		3	TW	PH												
65.0	Trace of Sand		4	TW	PM												
2.4	Clayey Silt to Silt With Interbedded Layers of Silty Sand Stiff		5	TW	PH												
59.8			6	TW	PH												
7.6	Silty Sand to Sand Trace of Gravel Occasional Cobbles Loose		7	SS	9												
52.8																	
14.6	End of Borehole Probable Bedrock																

RECORD OF BOREHOLE No 2-7

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 628.1; E 358 526.1 ORIGINATED BY RO
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RO
 DATUM Geodetic DATE 88 10 25 CHECKED BY *ep*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
66.1	Ground Surface																
0.0	Silty Clay Trace of Sand Very Stiff		1	TW	PH												
63.8			2	TW	PH												
2.3	Clayey Silt to Silt With Interbedded Layers of Silty Sand Firm to Very Stiff		3	TW	PH												
			4	TW	PM												
			5	TW	PM												
			6	TW	PM												
59.7	Silty Sand to Sand		7	TW	OW												
6.4	Trace of Gravel																
58.8	Compact		8	SS	22												
7.3	End of Borehole																
	Note: O.W. = Own Weight																

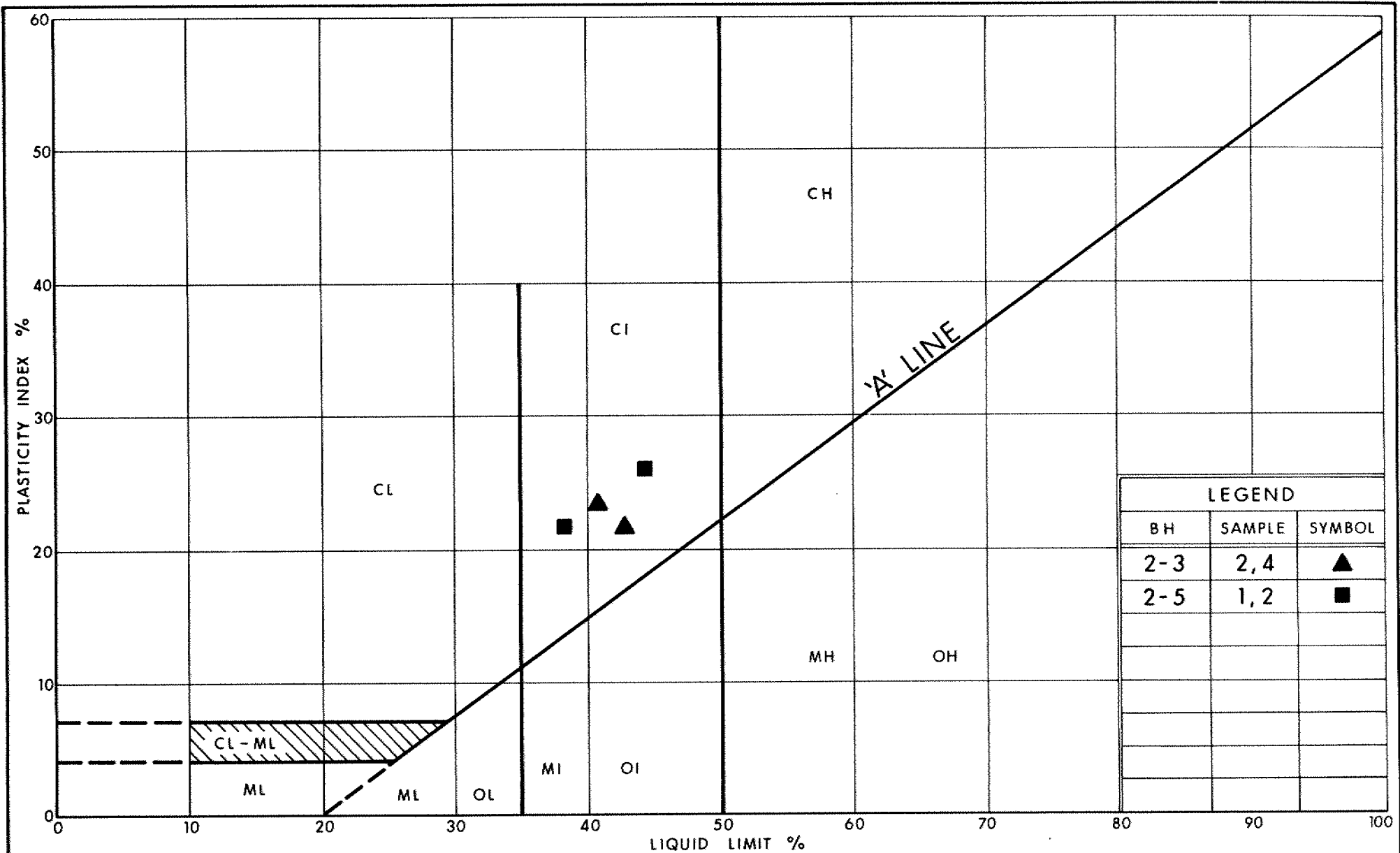


RECORD OF BOREHOLE No 2-8

METRIC

W P 120-87-05 LOCATION Co-ords. N 5 022 642.4; E 358 524.8 ORIGINATED BY RO
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RO
DATUM Geodetic DATE 88 10 25 CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	WL	WATER CONTENT (%)					
66.1	Ground Surface																
0.0	Silty Clay Trace of Sand Very Stiff		1	TW	PH												
			2	TW	PH												
63.8			3	TW	PH												
2.3	Clayey Silt to Silt With Interbedded Layers of Silty Sand Firm to Very Stiff		4	TW	PM												
			5	TW	PH												
			6	TW	PH												
			7	TW	PM												
58.5	Silty Sand to Sand		8	TW	PM												
7.6	Trace of Gravel		9	SS	10												
57.9	Compact																
8.2	End of Borehole																



Ontario

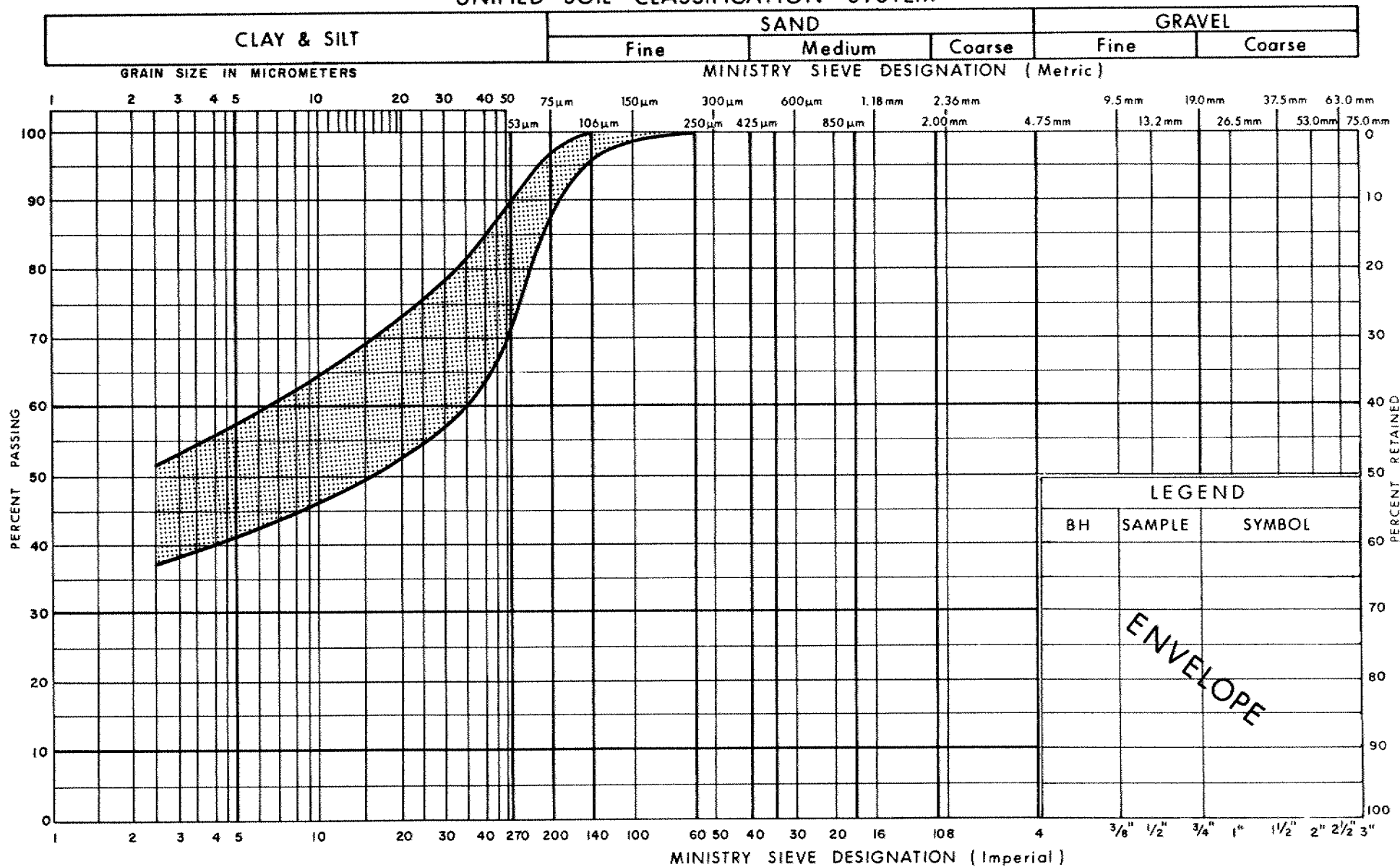
Ministry of
Transportation

PLASTICITY CHART SILTY CLAY, SOME SAND

FIG No 1

W P 120-87-05

UNIFIED SOIL CLASSIFICATION SYSTEM

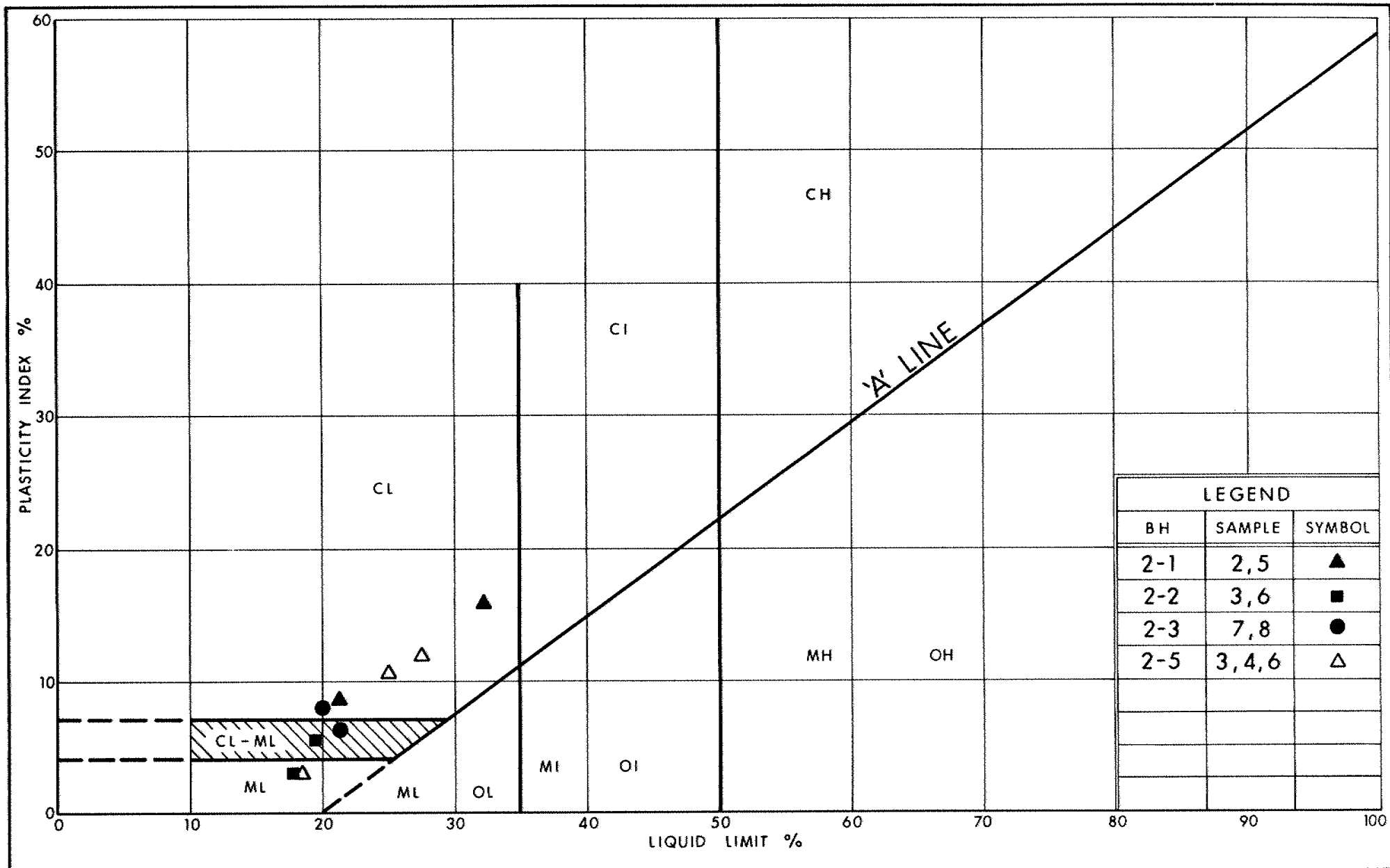


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY, SOME SAND

FIG No 2

W P 120-87-05



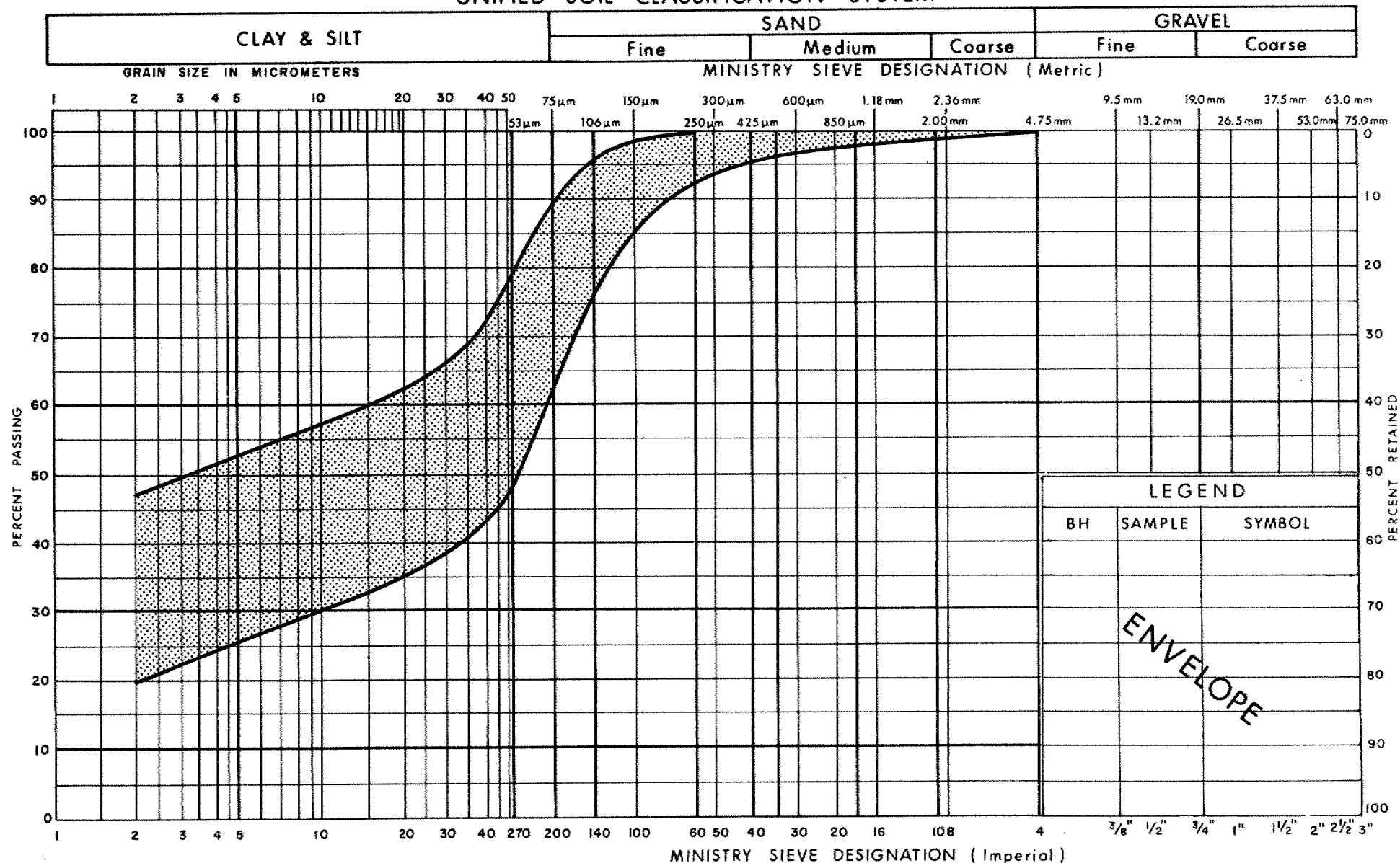
Ministry of
Transportation
Ontario

PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 3

W P 120-87-05

UNIFIED SOIL CLASSIFICATION SYSTEM



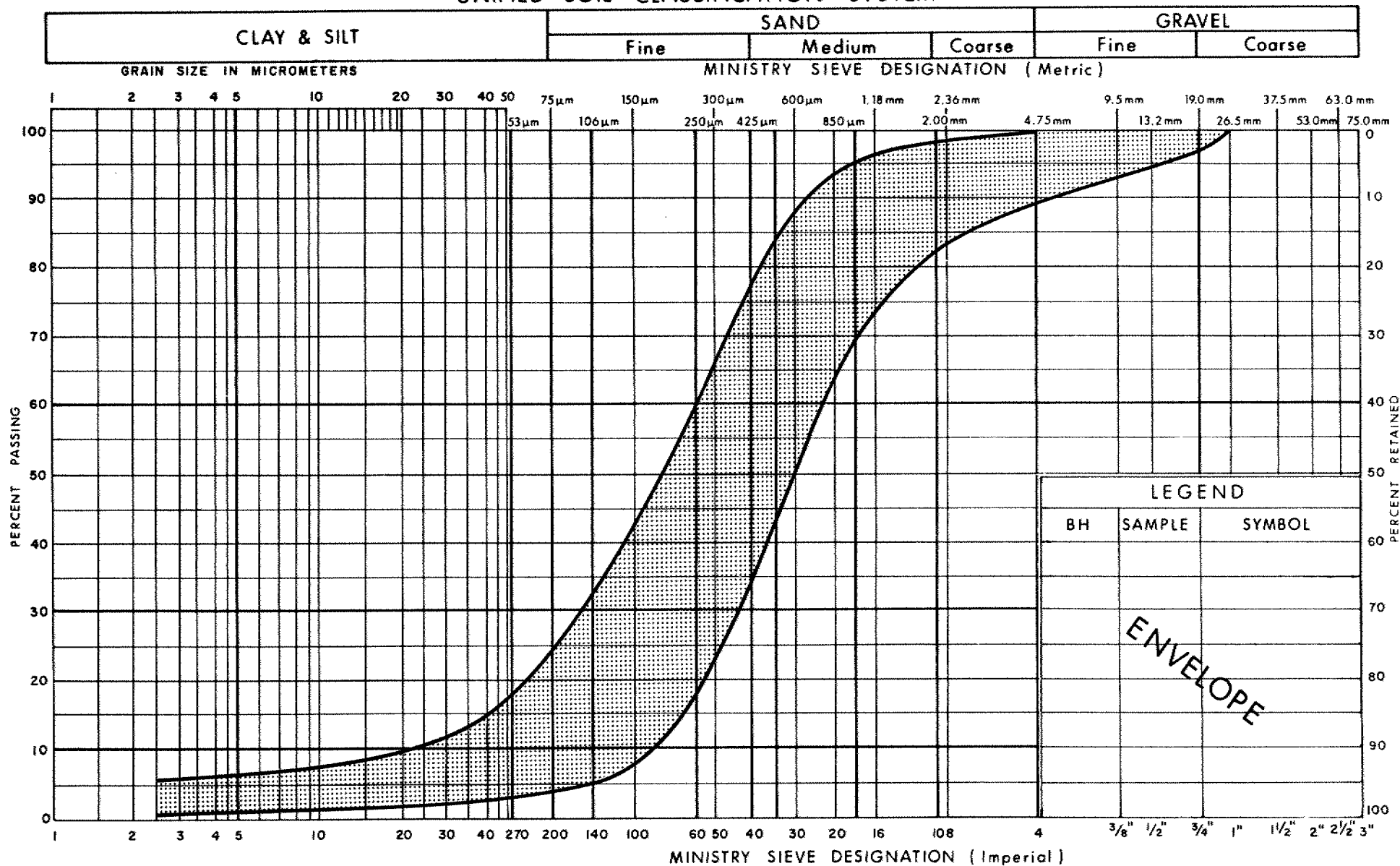
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

FIG No 4

W P 120-87-05

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND, TRACE OF GRAVEL

FIG No 5

W P 120-87-05

DESCRIPTION OF ROCK CORE - WP 120-87-05

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
2-1	8.66-10.39	92	47	8.66-10.21	SANDSTONE , very light grey; medium grained; medium bedded (10-60 cm); well cemented; medium strong rock; slightly weathered to unweathered; moderately close spaced fractures: (1) flat, open, rough, slightly altered; and (2) near vertical, open, calcite filled.
	10.39-11.99	98	75		
				10.21-11.99	SANDSTONE , calcareous; light to medium grey; medium to fine grained; thin to medium bedded (1-40 cm), with very thin argillaceous laminations and thin conglomeratic beds; close spaced fractures: flat, rough, planar, slightly open, slightly altered, clean; intensely fractured zone from 10.06-10.21 m.
2-2	12.62-13.49	96	76	12.62-13.44	SANDSTONE , calcareous; light to medium grey; medium to fine grained; thinly bedded with very thin argillaceous laminations; strong to medium strong rock; moderately close spaced fractures: flat, irregular, rough, open, unaltered, clean.
	13.49-14.48	97	50		
	14.48-14.98	94	0	13.44-14.98	SANDSTONE , very light grey to light brown; fine grained; thick bedded (to 50 cm); strong rock; close spaced fractures: (1) flat, rough, slightly altered, clean; (2) near vertical, planar, open, calcite filled.

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

1../2

DESCRIPTION OF ROCK CORE - WP 120-87-05

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
2-4a	RC10 24.04-25.76	62	-	24.04-39.04	OVERBURDEN , containing foreign and locally derived bedrock material, boulders up to 11 cm. May also contain heavily fractured bedrock (SILTY DOLOSTONE dark grey; fine grained; thinly bedded with minor argillaceous laminations) of very poor drillable quality. -EOH- BEDROCK NOT CONFIRMED BY DRILLING.
	RC11 25.76-26.82				
	26.82-27.03	NOT	CORED		
	RC13 27.03-28.65	6	-		
	28.65-29.13	NOT	CORED		
	RC14 29.13-30.23	2	-		
	RC15 30.23-31.62	9	-		
	31.62-36.27	NOT	CORED		
	RC16 36.27-37.90	30	-		
	RC 17 37.90-38.35	47	-		
	RC18 38.35-39.04	30	-		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

1../2

DESCRIPTION OF ROCK CORE - WP 120-87-05

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
2-4b	RC1 22.86-23.77	38	-	22.86-35.89	OVERBURDEN , containing foreign and locally derived bedrock material. May also contain heavily fractured bedrock (SILTY DOLOSTONE , dark grey; fine grained; thinly bedded with minor argillaceous laminations) of very poor drillable quality.
	23.77-24.99	NOT	CORED		
	RC3 24.99-25.60	25	-	-EOH-	BEDROCK NOT CONFIRMED BY DRILLING.
	25.60-26.52	NOT	CORED		
	RC4 26.52-27.43	19	-		
	27.43-32.89	NOT	CORED		
	RC5 32.89-34.04	18	-		
	34.04-34.32	NOT	CORED		
	RC7 34.32-35.89	35	-		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

2../2

DESCRIPTION OF ROCK CORE - WP 120-87-05

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
2-5	20.27-21.34	71	-	20.27-30.33	OVERBURDEN, containing foreign and locally derived bedrock material, boulders up to 40 cm.
	21.34-22.56	NOT	CORED	30.33-32.08	
	22.56-23.47	14	-	SILTY DOLOSTONE, dark grey; fine grained; thinly bedded with minor argillaceous laminations; medium strong rock; close to very close spaced fractures: (1) flat, irregular, planar, slightly altered, slightly open, clean; (2) near vertical, planar, calcite filled.	
	23.47-24.13	8	-		
	24.13-24.38	NOT	CORED		
	24.38-27.25	8	-		
	27.25-27.74	NOT	CORED		
	27.74-28.96	32	-		
	28.96-30.56	78	0		
	30.56-30.99	94	44		
	30.99-31.47	100	32		
	31.47-32.08	100	56		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

2../2

FOUNDATION INVESTIGATION REPORT
For
Eastbound Highway 417 Overpass Structure
at Acres Road
WP 120-87-06, Site 3-52-533
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of July 6 to July 15, 1988. A two span structure is proposed to carry Hwy. 417 Eastbound over the realigned Acres Road.

Nine boreholes (BH #3-1 to BH #3-9) were advanced and sampled as part of this project by means of hollow stem augers with washboring techniques and using a conventional diamond drill (BX Casing and BX Rock Core barrel) adopted for soil and rock sampling purposes. These boreholes extended down to depths of 15.5 and 28.7 metres below the existing ground surface. The results obtained from the adjacent structure #4 are utilized in this report (BH #4-3, #4-4 and #4-5).

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located in the corn field immediately south of the existing Highway 417 between Richmond Road and the existing Acres Road in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for farming purposes. Residential development exists north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley clay plains founded in the Lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region. The bedrock in the area is of the Rockcliffe and Gull

River formations of the middle Ordovician period. It consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to it's present level.

FIELD INVESTIGATION AND LABORATORY ANALYSES

The fieldwork for the site investigation was carried out between July 6 and July 15, 1988 and consisted of nine (9) sampled boreholes accompanied by dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques with NX or BX Casing were used to advance the boreholes in the overburden. Soil samples were retrieved at selected intervals by a split spoon sampler or Shelby tube in accordance with the Standard Penetration Test (ASTM D1586). In situ vane tests were also carried out to cohesive soil. Samples were identified in the field and then returned to the laboratory for appropriate testing. Bedrock was proven at a number of location minimum 1.5 m using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

To identify the behaviour, gradation, properties and characteristics of the soil, various laboratory testing were performed as follows:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Undrained Unconsolidated Tests (Quick Triaxial)
- 5) Unconfined Compression Test
- 6) Consolidation Tests

Laboratory tests results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The surficial layer consists of a generally soft to very stiff cohesive silty clay to clayey silt which extends to a maximum thickness of 2.7 metres. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of sandy silt. The maximum thickness of this deposit is about 5.3 metres. A deep deposit of silty sand to sand is the subsequent underlying deposit with a maximum thickness of about 22.7 metres and this in turn underlain by a heterogeneous mixture of sand, gravel and boulders (Glacial Till). Approximately 2.1 to 4.8 metres of the till deposit was found before encountering the silty dolostone bedrock.

It should be noted that in the vicinity of east abutment and approach of the Structure No. 3, upper two layers (silty clay to clayey silty layer and clayey silt with interbedded sandy silt layer) are gradually diminished. In stead, fill material was encountered adjacent to the existing Graham Creek. Fill material consists of organic silty sand or clayey silt as shown on Record of borehole (BH #3-9).

A detailed description of the surface conditions encountered is given below.

Fill Material

The fill material was encountered in the vicinity of the northeast portion of the site at three borehole locations (BH #3-7, #3-8 and #3-9). This fill consists of a brown Clayey Silt to Silt with some Sand and trace of Gravel or organic Silty Sand. The thickness of this layer varies from 0.8 metres at BH #3-7 to 1.6 metres at BH #3-8 as shown on Record of boreholes. No Atterberg Limit Tests and Grain Size Distribution Analysis were carried out. However, through visual observation, it is apparent that the fill material is similar to the surficial material which was found adjacent to the site.

Silty Clay to Clayey Silt

This stratum was encountered in most of the boreholes except near the east portion of the site (Boreholes #3-1 to #3-6). This material consists of a silty clay to clayey silt ranging in thickness between 2.0 and 2.7 metres. The material changes in colour from brown to grey at approximately elevation 64.0 metres.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	20.5-44.5
Liquid Limit (w_L)	25.5-47.5
Plastic Limit (w_p)	11.0-16.5
Plasticity Index (I_p)	10.0-32.5
Unit Weight (kN/m^3)	17.5-20.3

From the plasticity chart (see Figure 1) it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in envelope form.

Undrained shear strength of the soil were determined both by in situ vane tests and by laboratory tests, namely undrained unconsolidate (quick triaxials) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength (C_u)</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	36-100	2.6-5.1
Laboratory Results	25-67	-

As shown on the above table, it can be concluded that the laboratory testing provided lower values possibly attributable to disturbance during sampling, transportation and testing. Recommended shear strength for this deposit can be assumed to be within the range of 60 to 70 kPa. Based on this conclusion, the soil has generally a firm to stiff consistency. The sensitivity of the soil is generally low to moderate.

The results (e-log P curves) of two consolidation tests on representative samples obtained in the silty clay to clayey silt deposit are shown on Figure 5. These tests indicated that this cohesive stratum has been preconsolidated in the past to an effective pressure ranging from 340 kPa to 450 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, P_c (kPa)	340-450 kPa
Initial Void Ratio (e_0)	0.863-1.250
Compression Index (C_c)	0.45-0.94

*Test data of similar soil from adjacent investigations (WP 120-87-08) incorporated in results.

Clayey Silt with Interbedded Sandy Silt

Underlying the surficial deposit of silty clay to clayey silt, a layer of grey clayey silt with interbedded sandy silt was encountered. This stratum extends to depths ranging from 2.1 metres to 7.8 metres below the ground surface. The thickness of the stratum varies between 1.9 and 5.3 metres.

The results from the Atterberg Limit Test performed on this material are summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	24.0-43.5
Liquid Limit (w_L)	15.0-30.0
Plastic Limit (w_p)	11.0-15.0
Plasticity Index (I_p)	2.5-16.5
Unit Weight (kN/m^3)	17.9-19.0

From the plasticity chart (Figure 1), it is evident that the layer can be classified as an inorganic clayey silt with interbedded Sandy Silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil were determined both by the in situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	54-80	2.7-6.8
Laboratory Results	17-40	-

Due to the irregular nature of the deposit, that reveals numerous seams and layers of Sandy Silt interbedded within the Clayey Silt, the results provided in the above table are not necessarily indicative of the shear strength of the Clayey Silt portion. In view of this consideration, the consistency of the Clayey Silt portion can be described as soft to stiff. The Sandy Silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 40 kPa can be assumed for this stratum.

The results (e-log P curves) of two consolidation tests on representative samples from the adjacent structure sites (structure 5) are shown on Figure 6. These tests indicated that the Clayey Silt has been preconsolidated in the past to an effective pressure ranging from 190 kPa to 327 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, P_c (kPa)	190-327
Initial Void Ratio (e_0)	0.617-1.111
Compression Index (C_c)	0.078-0.87

*Test data of similar soil from adjacent investigations (WP 120-87-08) incorporated in results.

Silty Sand to Sand

Silty Sand to Sand was encountered below the Clayey Silt with interbedded Sandy Silt layer. The thickness of this layer ranges from 9.9 metres at BH #3-1 to 22.7 metres at BH #3-8.

This deposit contains minor variations in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel (in excess of 40%) was encountered. Grain size distribution analysis indicate that the soil varies between a silty sand to sand. This layer is basically non-plastic. Figure 3 in the Appendix shows the results of grain size distribution tests in an envelope form.

In this stratum, the 'N' values ranged from 2 to over 100 blows/0.3 m indicating a state of compaction described as very loose to very dense.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the silty sand to Sand deposit at a depth ranging from 13.9 to 27.1 metres, a heterogeneous mixture of Sand, Gravel and boulders of glacial origin

was encountered. The thickness of this stratum ranges from about 1.0 m at BH #3-8 to 4.8 metres at BH #3-4. Rock coring techniques were required to penetrate occasional boulders within the stratum. This stratum may be described as a heterogeneous mixture of Sand, Gravel and boulders. Figure 4 shows the result of grain size distribution tests in an envelope form for these materials.

In this stratum, the 'N' values ranged from 44 to over 100 blows/0.3 metres indicating a state of compaction described as dense to very dense.

Bedrock

The glacial till deposit is directly underlain by bedrock of the Rockcliffe and Gull River Formations and was proven at various locations by obtaining up to 2.0 metres of rock core samples. The bedrock consists mainly of a Silty Dolostone. Minor beds of Sandstone and Limestone were also found interbedded in the rock formation. Detailed description of the rock are attached in the Appendix entitled "Description of Rock Core".

Core recoveries and rock quality designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on these results, the rock can be classified as medium strong to strong rock and predominantly unweathered.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater level in the boreholes was found to range between 60.3 metres at BH #3-4 and 61.5 metres at BH #3-1 which corresponds to depths of 5.8 metres to 4.1 metres below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 88 07 06 to 88 07 15 under the supervision of Tae C. Kim, Foundation Engineer. The equipment was owned and operated by Marathon Drilling Co. Ltd., Ottawa and F.E. Johnston Drilling Co. Ltd., Ottawa.

This report was written by Tae C. Kim, Foundation Engineer and reviewed by Murty Devata, Chief Foundation Engineer.



Tae C. Kim
Tae C. Kim, P.Eng.
Foundation Engineer

Murty Devata
Murty Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 3-1

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 619.2; E 358 552.6 ORIGINATED BY JF
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY JF
 DATUM Geodetic DATE 88 07 15 CHECKED BY TCK

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 (%)					
66.3	Ground Level													
0.0	Silty Clay to Clayey Silt, Some Sand	Brown Grey	1	SS	15									
64.2	Soft to Stiff		2	TW	PH									
2.1	Clayey Silt with interbedded Sandy Silt		3	SS	2									
62.3	Soft to Firm		4	SS	4									
4.0	Silty Sand to Sand Some/Trace of Gravel Compact to Dense		5	SS	25									
			6	SS	24									
			7	SS	20									
			8	SS	41									
52.4														
13.9	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) V. Dense		9	SS	55/	15cm								
50.8														
15.5	End of Borehole													

RECORD OF BOREHOLE No 3-2

METRIC

W P 120-87-06 LOCATION CO-ORDS. N 5 022 644.2; E 358 595.9 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 15 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
66.2	Ground Level													
0.0	Silty Clay to Clayey Silt, Trace Sand Soft	Brown Grey	1	TW	PH		66							
63.7			2	SS	2		64		5.1				47.5%	0 9 61 30
2.5	Clayey Silt with interbedded Sandy Silt Soft		3	TW	PH		62		2.7				43.5%	0 20 48 32
60.6			4	TW	PH		60		3.5				18.4	0 31 48 21
5.6	Silty Sand to Sand Trace to some Gravel Compact to Dense		5	SS	13		58							
			6	SS	17		56							2 83 (15)
			7	SS	10		54							
50.5			8	SS	42		52							
15.7	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3-3

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 664.5; E 358 609.9 ORIGINATED BY JF
 DIST 9 HWY 417 BOREHOLE TYPE Washboring, Rock Coring & Cone Test COMPILED BY JF
 DATUM Geodetic DATE 88 07 12 CHECKED BY TCK

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					
66.2	Ground Level													
0.0	Silty Clay to Clayey Silt Trace Sand	Brown Grey	1	SS	17		66						17.5	0 2 47 51
63.7	Soft to Very Stiff		2	TW	PM		64		4.2					
2.5	Clayey Silt with interbedded Sandy Silt Soft to Firm		3	TW	PM		62		6.8				18.7	0 37 40 23
58.4			4	SS	2		60							1 22 51 26
7.8			5	SS	2		58							
	Silty Sand to Sand Some to trace of Gravel Occ. Gravelly Sand Layers Dense to Very Dense		6	SS	31		56							
			7	SS	51		54							43 40 13 4
			8	SS	38		52							
			9	WS	-		50							
			10	SS	75/	8cm	48							
			11	SS	82		46							
43.4			12	WS	-		44							
22.8	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Very Dense		13	SS	112/	20cm	42							
41.3			14	RC	REC 88%		40							RQD = 55%
24.9	Bedrock Silty Dolostone													
39.7														
26.5	End of Borehole													

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3-4

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 656.9; E 358 629.4 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 13 - 14 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			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	W _p	W	W _L		
66.1	Ground Level													
0.0	Silty Clay to Clayey Silt Some Sand Firm	Brown Grey	1	SS	7		66							0 24 45 31
63.6			2	TW	PH		64							
2.5	Clayey Silt with interbedded Sandy Silt Very Soft		3	TW	PH		62							
			4	TW	PH		60							
59.0			5	SS	1		58							
7.1			6	SS	3		56							
	Silty Sand to Sand Trace to some Gravel Very Loose to Dense		7	SS	30		54							8 78 6 8
			8	SS	14		52							
			9	SS	30		50							
			10	SS	44		48							
46.1							46							
20.0	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Dense		11	SS	46		44							27 57 14 2
41.3			12	SS	44		42							
24.8	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3-5

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 681.6; E 358 640.8 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Rock Core & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 11, 12, 13 CHECKED BY TCK

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					
66.0	Ground Level													
0.0	Silty Clay to Clayey Silt with Sand	Brown Grey	1	TW	PH			2.6	σ				20.3	0 33 43 24
	Soft to Firm	Grey	2	TW	PH								20.0	2 35 42 21
63.3														
2.7	Sand with Some Silt, Trace Clay	Brown	3	TW	PH									0 74 20 6
62.0														
4.0	Clayey Silt with interbedded Sandy Silt		4	SS	2/60 cm									
	Very Soft to Firm		5	SS	5									0 42 40 18
58.9														
7.1	Silty Sand to Sand Trace Gravel Occ. Silt Seams Compact to Dense		6	SS	15									
			7	SS	13									
			8	SS	30									
			9	SS	36									
			10	SS	43									1 18 77 4
44.4														
21.6	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Dense		11	SS	45									26 65 (9)
40.7														
25.3	Bedrock Silty Dolostone		12	RC	REC 50%									RQD = 31%
38.7			13	RC	REC 95%									RQD = 27%
27.3	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3-6

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 675.2; E 358 657.1 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 13, 14 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
65.9	Ground Level												
0.0	Silty Clay to Clayey Silt with Sand	Brown Grey	1	SS	3								1 36 38 25
63.9	Soft		2	TW	PH								0 34 46 20
2.0	Sand with some Silt												
62.8	Brown												
3.1	Clayey Silt with interbedded Sandy Silt		3	SS	1								
60.4	V. Soft to Stiff		4	SS	8*								0 53 28 19
5.5			5	SS	9								
	Silty Sand to Sand Trace to some Gravel Loose to Very Dense		6	SS	8								
			7	SS	21								8 86 (6)
			8	SS	36								
			9	SS	66								
			10	SS	59								12 42 40 6
43.6			11	SS	60								27 62 8 3
22.3	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Very Dense												
39.8			12	SS	50	15cm							
26.1	End of Borehole												
	* Spoon Bouncing on Boulder												

RECORD OF BOREHOLE No 3-7

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 700.2; E 358 667.6 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Rock Coring, Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 06, 07 CHECKED BY TCK

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					
66.0	Ground Level													
0.0														
65.2	Clayey Silt (Fill)													
0.8			1	TW	PH					5.7				0 41 43 16
64.4	Silty Sand													
1.6	Clayey Silt		2	TW	PH					8				1 41 29 29
			3	SS	13									
	Silty Sand to Sand													
	Trace to Some Gravel		4	SS	3									20 62 11 7
	Very Loose to Compact		5	SS	14									
			6	SS	10									
			7	SS	14									
			8	SS	30									0 95 (5)
	Brown Grey		9	SS	41									
			10	SS	8									0 9 71 20
			11	SS	57									
			12	SS	59									
42.1			13	SS	57									
23.9	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till)		14	SS	52									36 50 12 2
38.9	Very Dense		15	RC	REC 100%									RQD = 66%
27.1	Bedrock		16	RC	REC 100%									RQD = 100%
37.3	Silty Dolostone													
28.7	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3-8

METRIC

W P 120-87-06 LOCATION Co-Ords N 5 022 692.6; E 358 687.1 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 07 & 08 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
65.5	Ground Level													
0.0	Clayey Silt to Silt		1	TW	PH									
63.9	Soft (Fill)		2	TW	PH									
1.6	Silty Sand to Sand		3	SS	5									
	Trace to Some													
	Gravel		4	SS	5									
	Loose		5	SS	6									
	Brown Grey		6	SS	2									
			7	SS	8									
	Very loose to Dense		8	SS	27									
			9	SS	20									
			10	SS	42									
41.2	Het. Mixture of													
24.3	Sand, Gravel & Boulders													
40.4	Very Dense													
	(Glacial Till)		11	SS	2/	8cm*								
25.1	END OF BOREHOLE													
	*Sampler Bouncing Due to Boulder or Bedrock													

RECORD OF BOREHOLE No 3-9

METRIC

W P 120-87-06 LOCATION Co-Ords N 5 022 704.2; E 358 694.0 ORIGINATED BY TK
DIST 9 HWY 417 BOREHOLE TYPE Hollowstem Auger & Cone Test COMPILED BY TK
DATUM Geodetic DATE 88 07 08,09 CHECKED BY TCK

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					
64.5	Ground Level													
0.0	Organic Silty Sand (Fill)	XXXX	1	SS	5									
63.1	Silty Sand to Sand trace of Gravel		2	SS	7									
1.4	Loose		3	SS	9									
	Brown Grey		4	SS	9									0 92 (8)
			5	SS	8									
			6	SS	25									6 85 (9)
	Loose to very Dense		7	SS	59									0 44 52 4
			8	SS	44									
48.8			9	SS	26									0 98 (2)
15.7	END OF BOREHOLE													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4-3

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 647.3; E 358 647.5 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, 'B' Casing, Washboring, Rock Core, Cone Test
 DATUM Geodetic DATE 88 07 11-13 COMPILED BY JBF
 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
66.1	Ground Level												
0.0	Silty Clay to Clayey Silt		1	SS	11								
			2	TW	PH								
63.6	Soft to Stiff		3	SS	3								0 62 (38)
2.5	Clayey silt with Brown interbedded Sandy Silt		4	SS	2								0 13 57 30
	Soft		5	SS	2								0 21 35 44
59.0			6	SS	34								
7.1	Silty Sand to Sand Trace to Some Gravel occ. Boulders occ. Gravelly Sand Layers Compact to very Dense		7	SS	36								
			8	RC	-								
			9	SS	27								34 54 8 4
			10	RC	-								
			11	SS	63								37 54 8 1
			12	SS	35								
			13	SS	70								
43.2			14	SS	29/								
22.9	Het. Mixture of Sand, Gravel and Boulders Very Dense (Glacial Till)		15	RC	71%								
39.5			16	RC	90%								
26.6	Bedrock		17,18	RC	REC. 56%								
37.9	Silty Dolostone		19	RC	REC. 100%								RQD = 59%
28.2	END OF BOREHOLE * Bouncing on Boulder												

+3, x⁵: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4-4

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 663.6; E 358 668.4 ORIGINATED BY TCK
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, 'B' Casing, Washbore, Rock Core, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 11-13 CHECKED BY TCK

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					
66.1	Ground Level																
0.0	Clayey Silt to Silty Sand (Fill)		1	SS	10		66										
			2	TW	PH		64										
63.6																	
2.5	Clayey Silt with Brown Interbedded Grey Sandy Silt		3	TW	PH		62	2.4								18.9	0 20 43 37
			4	TW	PH		60	3.8								19.0	
59.8	Soft						58										
6.3			5	SS	10		56										
	Silty Sand to Sand		6	SS	18		54										7 75 11 7
	Trace to Some Gravel Occ. Silt seams		7	SS	23		52										
	Compact to Dense		8	SS	31		50										
			9	SS	48		48										0 30 64 6
							46										
44.8			10	SS	37		44										
21.3	Het. Mixture of Sand, Gravel and Boulders Dense (Glacial Till)		11	RC	-		42										41 51 7 1
			12	SS	50		40										
40.3			13	RC	REC	100%											ROD=80%
25.8	Bedrock		14	RC	REC	100%											ROD=52%
	Silty Dolostone		15	RC	REC	100%											ROD=79%
38.6																	
27.5	END OF BOREHOLE																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4-5

METRIC

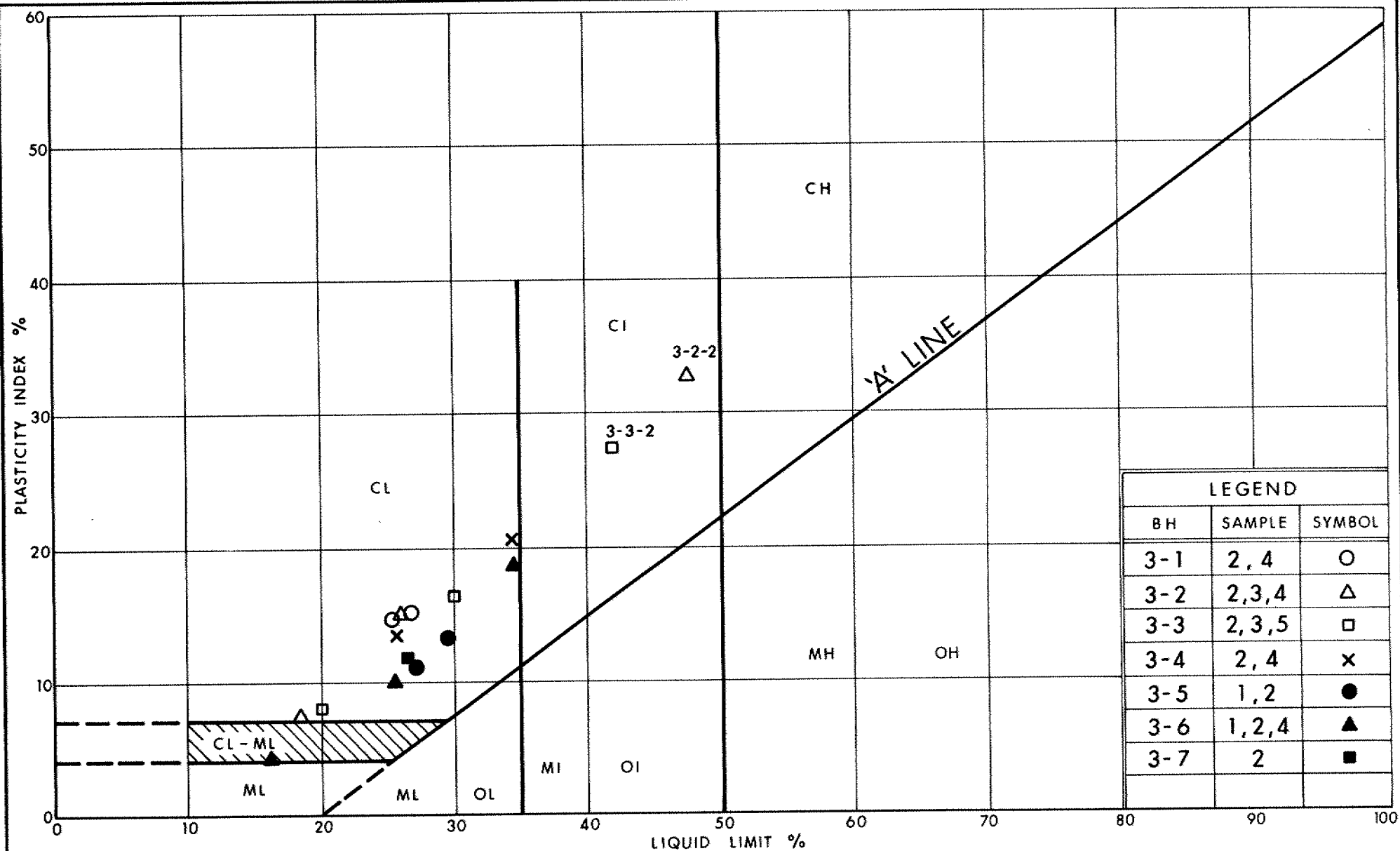
W P 120-87-07 LOCATION Co-Ords N 5 022 687.7; E 358 702.6 ORIGINATED BY BFB/TCK
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washbore, Rock Core, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 09-11 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L			
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				WATER CONTENT (%) 10 20 30		
65.0	Ground Level													GR SA SI CL
0.0	Clayey Silt (Fill)	⊗	1	CS	-									
64.4			2	SS	12		64							0 37 38 25
0.6			3	SS	15									2 63 19 16
			4	SS	5		62							
			5	SS	5		60							
	Silty Sand to		6	SS	2		58							
	Sand													
	Trace of Gravel													
	Occ. Silt Seams		7	SS	4		56							1 95 (4)
	Brown Grey						54							
	Very loose to Very		8	SS	38		52							
	Dense													
			9	SS	31		50							
							48							
			10	SS	34		46							
			11	SS	55		44							
41.9														
23.1	Het. Mixture of Sand,	⊗	12	RC	-		42							
	Gravel and Boulders		13	SS	73/	13cm								58 36 (6)
	Very Dense				REC		40							
	(Glacial Till)		14	RC	29%									
38.7			15	RC	REC									
26.3	Bedrock	⊗	16	RC	REC/	100%								RQD = 35%
37.6	Silty Dolostone	⊗	17	RC	REC/	100%	38							RQD = 94%
27.4	END OF BOREHOLE													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
Transportation

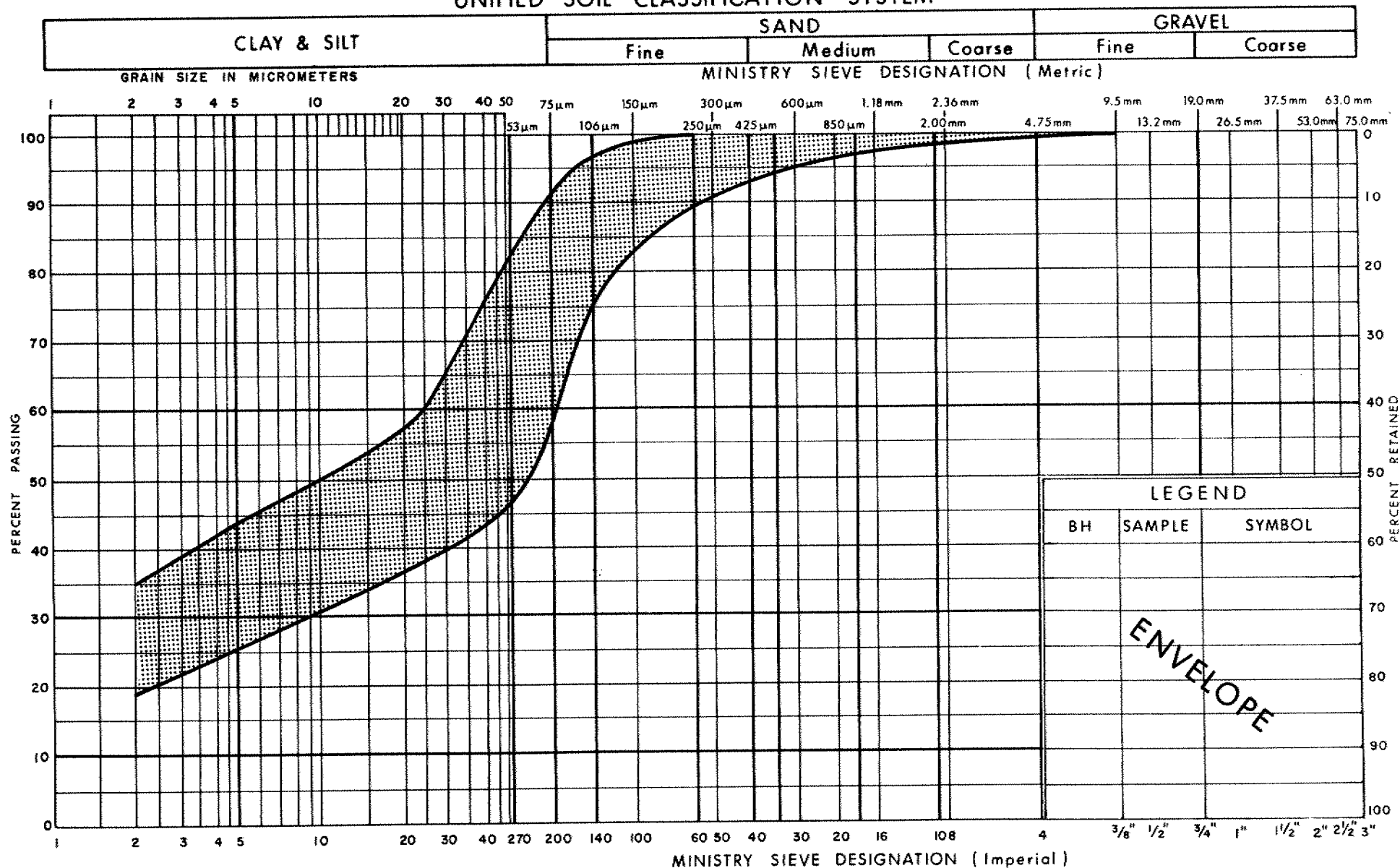
Ontario

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-06

UNIFIED SOIL CLASSIFICATION SYSTEM



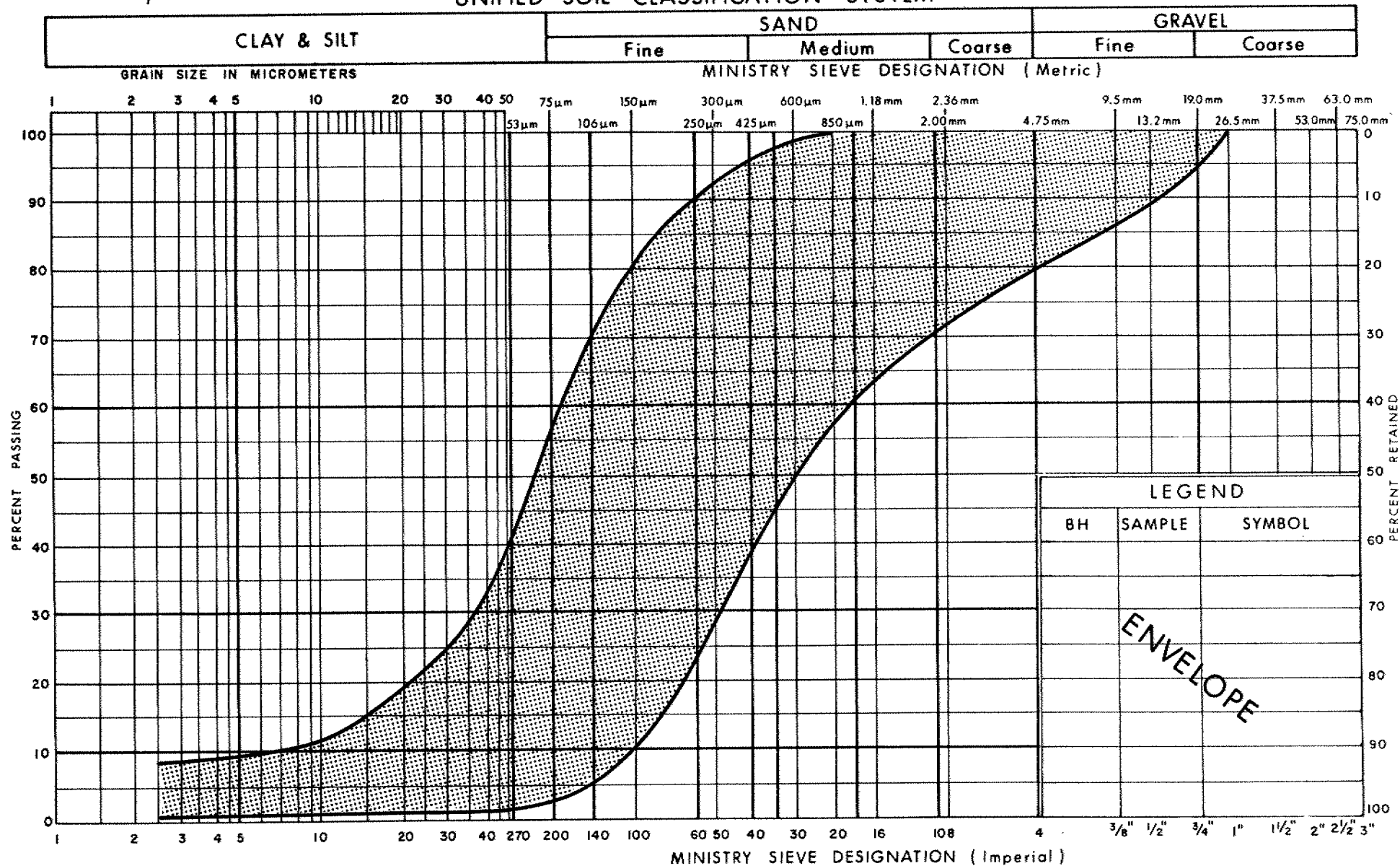
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

FIG No 2

WP 120-87-06

UNIFIED SOIL CLASSIFICATION SYSTEM



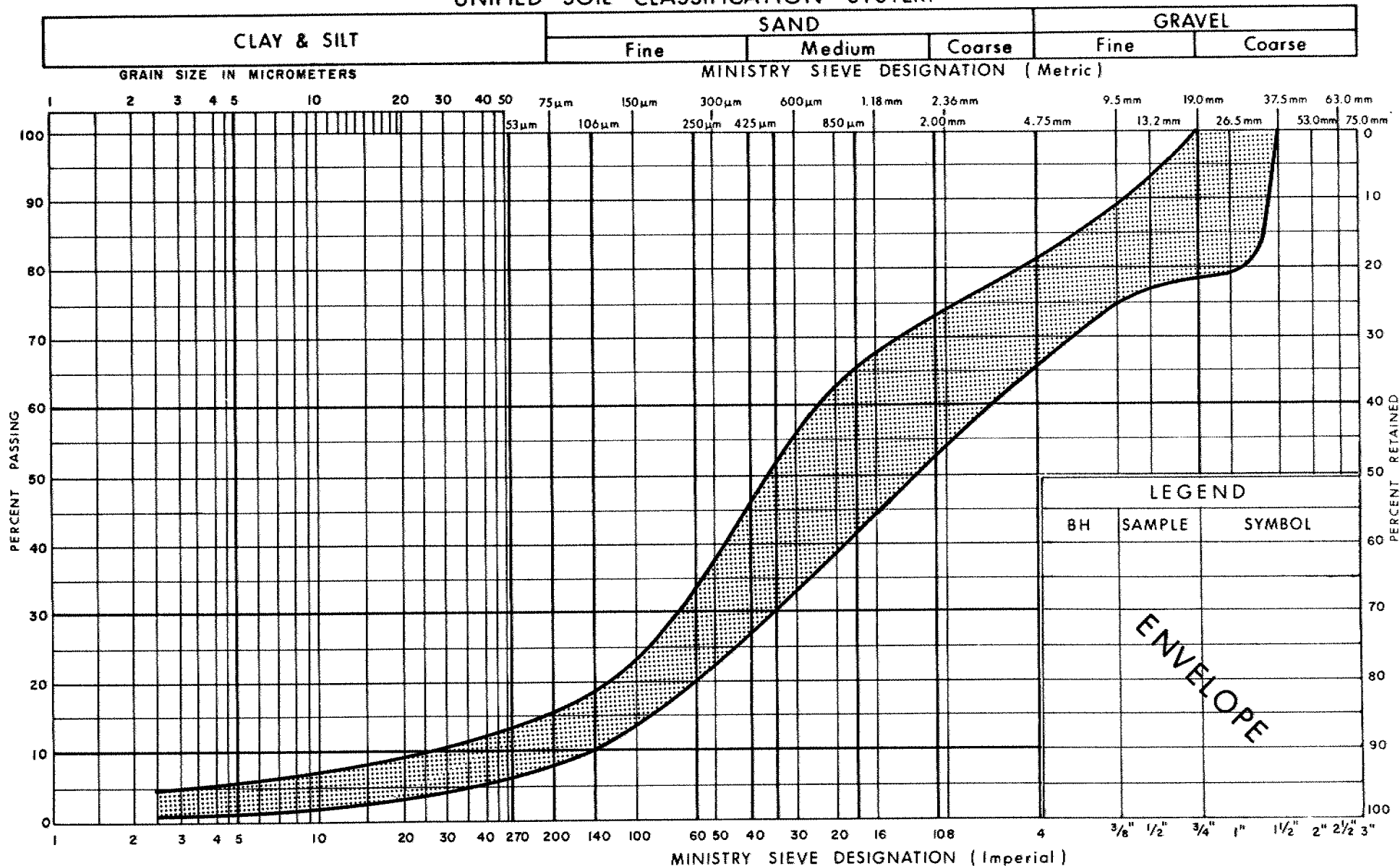
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND, SOME GRAVEL

FIG No 3

W P 120-87-06

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 4

W P 120-87-06

VOID RATIO - PRESSURE CURVES

251

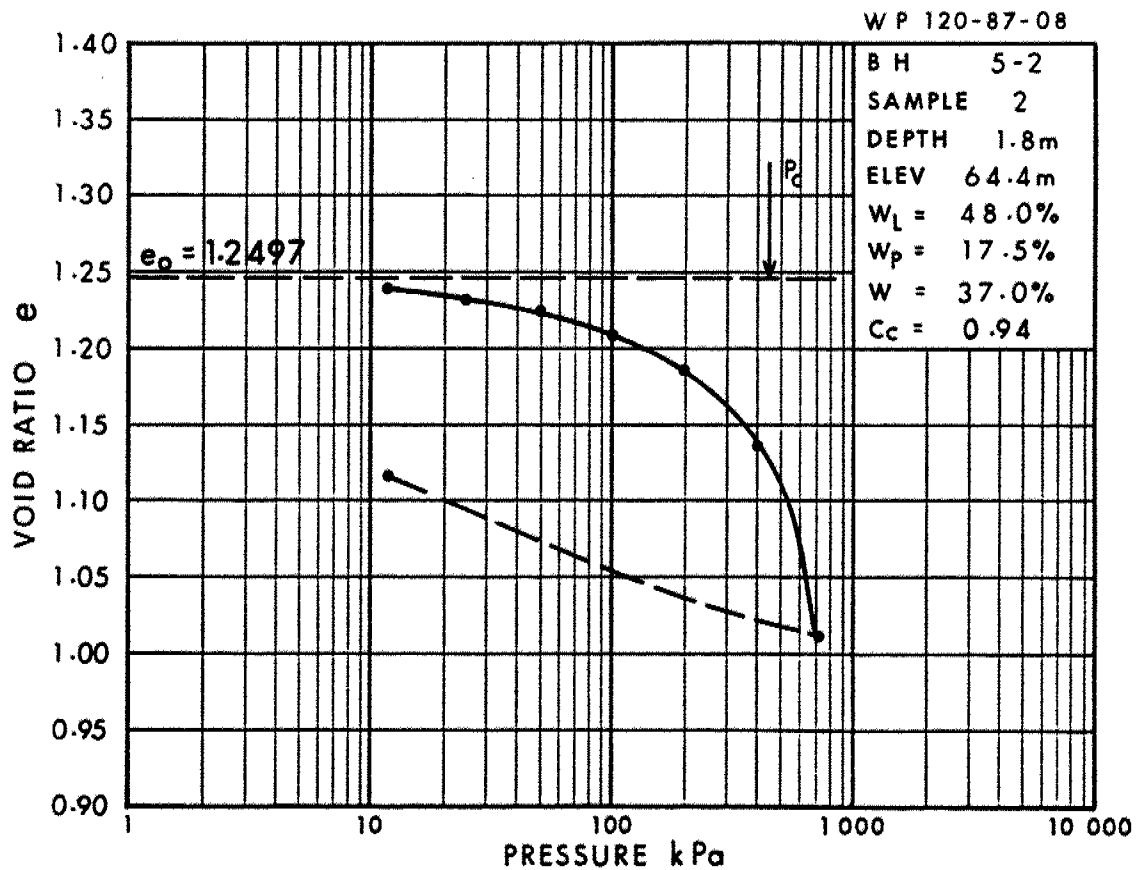
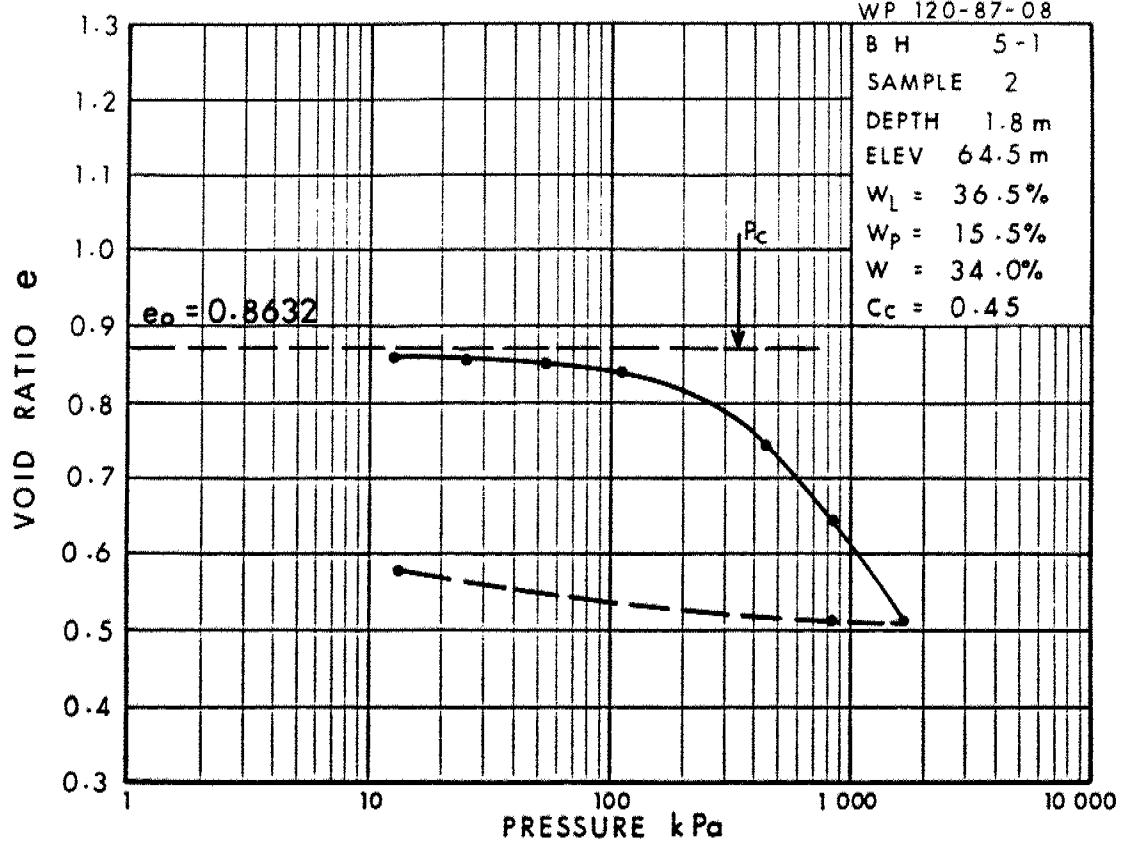


Fig 5

WP 120-87-06

VOID RATIO - PRESSURE CURVES

252

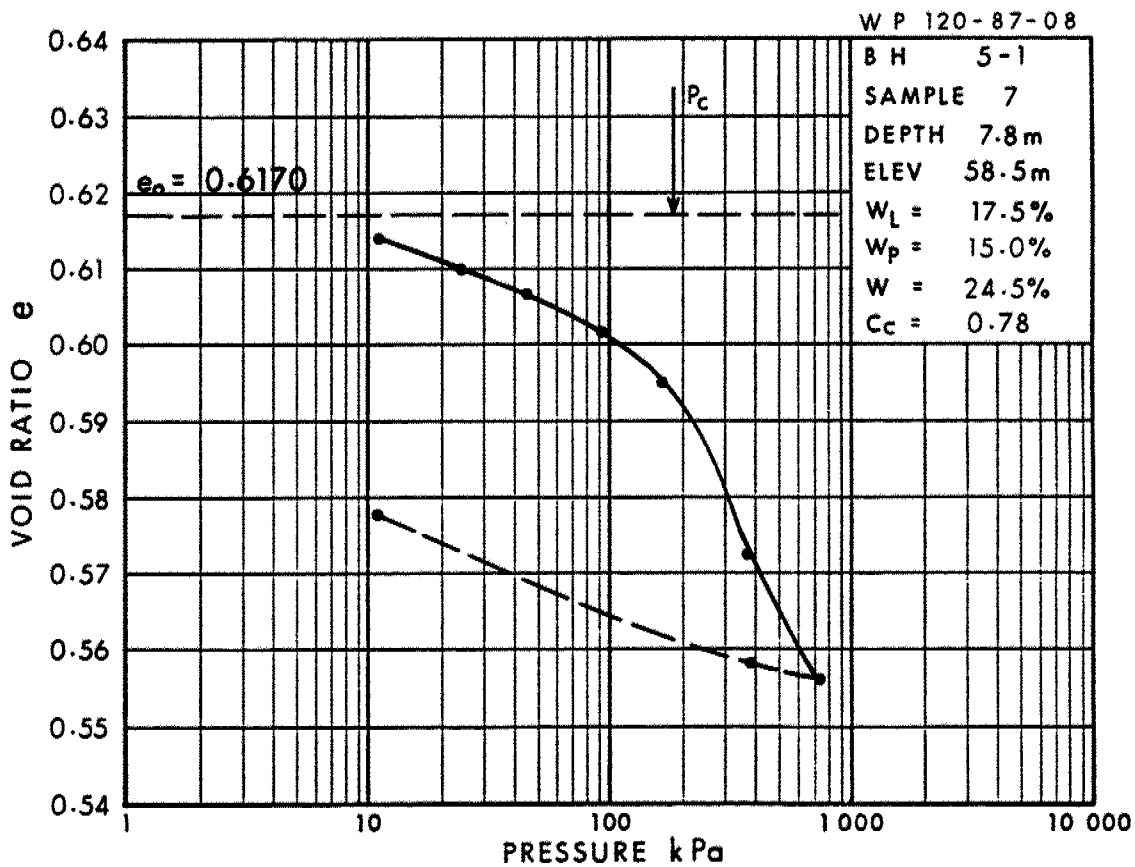
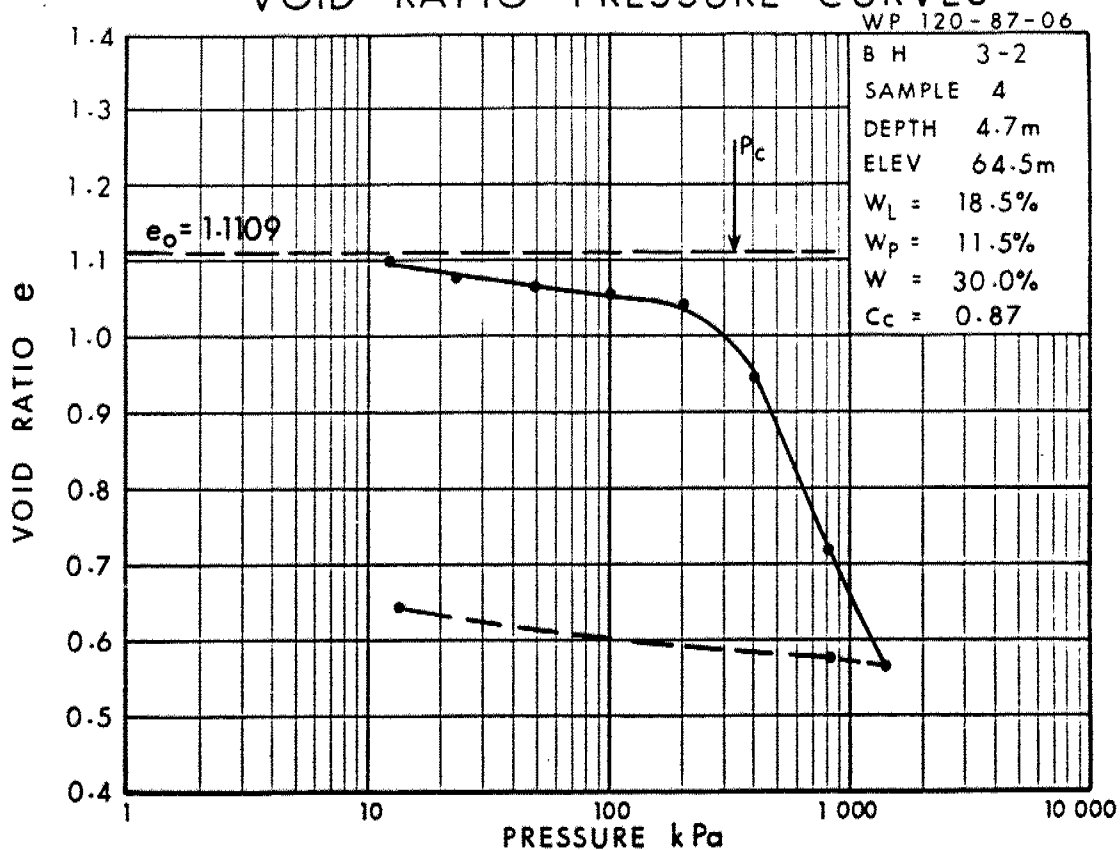


Fig 6

W P 120-87-06

DESCRIPTION OF ROCK CORE - WP 120-87-06

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
3-3	24.94-26.47	88	55	24.94-26.47	SILTY DOLOSTONE, light grey to medium dark grey; fine grained, dense; weak to medium strong rock; unweathered; very close to close spaced fractures: (i) flat, irregular, planar, slightly open, slightly altered; (ii) near vertical, closed, tight, calcite filled.
3-5	25.30-26.21	50	31	25.30-27.25	SILTY DOLOSTONE, light grey to medium dark grey; fine grained, dense; weak to medium strong rock; unweathered; very close to close spaced fractures: flat irregular, planar, slightly open, slightly altered.
	26.21-27.25	95	27		
3-7	27.10-27.89	100	66	27.10-28.65	SILTY DOLOSTONE, medium dark grey; fine grained; thinly bedded, minor argillaceous bands; medium strong rock; unweathered; very close to close spaced fractures: flat rough, planar, slightly open, slightly altered, clean.
	27.89-28.65	100	100		

NOTE: Depths are approximated in zones of poor core recovery.

1../1

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

DESCRIPTION OF ROCK CORE - WP 120-87-07

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
4-3	24.74-25.60	71	-	24.74-26.70	OVERBURDEN , contains foreign and locally derived bedrock material up to 0.35 m diameter.
	25.60-26.34	90	-	26.70-27.53	SILTY DOLOSTONE , medium dark grey; fine grained; thinly bedded; medium strong rock; unweathered to slightly weathered; very close to closely spaced fractures: flat rough, irregular, open, slightly altered.
	26.34-26.44	75	-		
	26.44-26.59	42	-		
	26.59-28.17	100	59	27.53-27.71	SHALE , greyish black to black; very fine grained; dense very thinly bedded; medium strong rock; unweathered; very close to closely spaced fractures: flat, very irregular, slightly open, unaltered, clean.
				27.71-28.17	ARGILLACEOUS DOLOSTONE , medium dark grey to dark grey; thinly bedded with argillaceous material; slightly vuggy; close spaced fractures: rough, planar, closed, clean; interbedded with LIMESTONE , dark grey, weathers to yellow brown; close spaced fractures: irregular, closed.
4-4	25.76-26.14	100	80	25.76-27.46	SILTY DOLOSTONE , medium dark grey; fine to medium grained, dense; medium strong rock; unweathered; very close to closely spaced fractures: rough, flat planar, slightly open, slightly altered; interbedded with LIMESTONE (22%), thinly bedded to 30 cm; undifferentiated from dolostone except for high calcite content.
	26.14-26.75	100	52		
	26.75-27.46	100	79		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

1../2

DESCRIPTION OF ROCK CORE - WP 120-87-07

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
4-5	24.66-25.55	29	-	24.66-26.29	OVERBURDEN, contains foreign and locally derived bedrock material.
	25.55-26.24	11	-	26.29-27.69	SILTY DOLOSTONE, medium dark grey; fine grained thinly bedded; medium strong rock; unweathered; moderately close spaced fractures: (i) flat, rough, planar, slightly altered, slightly open, clean; (ii) near vertical, rough, planar closed to slightly open, calcite filled.
	26.24-26.92	100	35		
	26.92-27.69	100	94		

NOTE: Depths are approximated in zones of poor core recovery.

2../2

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

FOUNDATION INVESTIGATION REPORT
For
South to East Ramp For Hwy. 416/417
Over Acres Road,
WP 120-87-07, Site 3-52-534
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of July 10 to July 15, 1988. A two span structure is proposed to carry South to East Ramp for Hwy. 416/417 over the realigned Acres Road.

Six boreholes (BH #4-1 to BH #4-6) were advanced and sampled as part of this project by means of hollow stem augers with washboring techniques and using a conventional diamond drill (BX Casing and BX Rock Core barrel) adopted for soil and rock sampling purposes. These boreholes extended down to depths of 15.7 and 28.2 metres below the existing ground surface. The results obtained from the adjacent structure #3 are utilized in this report (Boreholes #3-3, #3-4, #3-5, #3-6, #3-7 and #3-8).

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located in the corn field immediately south of the existing Highway 417 between Richmond Road and the existing Acres Road in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for farming purposes. Residential development exists north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley clay plains founded in the Lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region. The bedrock in the area is of the Rockcliffe and Gull

River formations of the middle Ordovician period. It consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to it's present level.

FIELD INVESTIGATION AND LABORATORY ANALYSES

The fieldwork for the site investigation was carried out between July 10 and July 15, 1988 and consisted of six (6) sampled boreholes accompanied by dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques with NX or BX Casing were used to advance the boreholes in the overburden. Soil samples were retrieved at selected intervals by a split spoon sampler or shelby tube in accordance with the Standard Penetration Test (ASTM D1586). In situ vane tests were also carried out to cohesive soil. Samples were identified in the field and then returned to the laboratory for appropriate testing. Bedrock was proven at a number of location minimum 1.5 m using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

To identify the behaviour, gradation, properties and characteristics of the soil, various laboratory testing were performed as follows:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Undrained Unconsolidated Tests (Quick Triaxial)
- 5) Unconfined Compression Test
- 6) Consolidation Tests

Laboratory tests results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The surficial layer consists of a generally soft to very stiff cohesive silty clay to clayey silt which extends to a maximum thickness of 2.5 metres. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of sandy silt. The maximum thickness of this deposit is about 4.6 metres. A deep deposit of silty sand to sand is the subsequent underlying deposit with a maximum thickness of about 22.5 metres and this in turn underlain by a heterogeneous mixture of sand, gravel and boulders (Glacial Till). Approximately 1.8 to 4.5 metres of the till deposit was found before encountering the silty dolostone bedrock.

It should be noted that in the vicinity of east abutment and approach of the Structure No. 4, upper two layers (silty clay to clayey silty layer and clayey silt with interbedded sandy silt layer) are gradually diminished. In stead, fill material was encountered adjacent to the existing Graham Creek. Fill material consists of organic silty sand or clayey silt as shown on Record of boreholes (BH #4-4, #4-5 and #4-6).

A detailed description of the surface conditions encountered is given below.

Fill Material

The fill material was encountered in the vicinity of the northeast portion of the site at three borehole locations (BH #4-4, #4-5 and #4-6). This fill consists of a brown Clayey Silt to Silt with some Sand and trace of Gravel or organic Silty Sand. The thickness of this layer varies from 0.6 metres at BH #4-5 to 4.0 metres at BH #4-6 as shown on Record of boreholes. No Atterberg Limit Tests and Grain Size Distribution Analysis were carried out. However, through visual observation, it is apparent that the fill material is similar to the surficial material which was found adjacent to the site.

Silty Clay to Clayey Silt

This stratum was encountered in most of the boreholes except near the east portion of the site (Boreholes #4-1 to #4-3). This material consists of a silty clay to clayey silt ranging in thickness between 1.4 and 2.5 metres. The material changes in colour from brown to grey at approximately elevation 65.0 metres on the west approach (BH #4-1 and #4-2).

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	20.5-39.0
Liquid Limit (w_L)	25.5-40.0
Plastic Limit (w_p)	11.0-15.0
Plasticity Index (I_p)	11.0-25.0
Unit Weight (kN/m^3)	18.0-18.5

From the plasticity chart (see Figure 1) it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in envelope form.

Undrained shear strength of the soil were determined both by in situ vane tests and by laboratory tests, namely undrained unconsolidate (quick triaxials) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength (C_u)</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	67	6.8
Laboratory Results	48-75	-

As shown on the above table, it can be concluded that the laboratory testing provided lower values possibly attributable to disturbance during sampling, transportation and testing. Recommended shear strength for this deposit can be assumed to be within the range of 60 to 70 kPa. Based on this conclusion, the soil has generally a firm to stiff consistency. The sensitivity of the soil is generally low to moderate.

No consolidation test was carried out on the samples from this site. However, the results (e-log P curves) of two consolidation tests on representative samples obtained from the adjacent structure sites (structures 3 and 5) in the silty clay to clayey silt deposit are shown on Figure 5. These tests indicated that this cohesive stratum has been preconsolidated in the past to an effective pressure ranging from 340 kPa to 450 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, P_c (kPa)	340-450 kPa
Initial Void Ratio (e_0)	0.863-1.250
Compression Index (C_c)	0.45-0.94

*Test data of similar soil from adjacent investigations (WP 120-87-06 and 08) incorporated in results.

Clayey Silt with Interbedded Sandy Silt

Underlying the surficial deposit of silty clay to clayey silt, a layer of grey clayey silt with interbedded sandy silt was encountered. This stratum extends to depths ranging from 2.5 metres to 7.1 metres below the ground surface. The thickness of the stratum varies between 1.1 and 4.6 metres. The material changes in colour from brown to grey at an approximate elevation of 62.7 metres near BH #4-3 and #4-4.

The results from the Atterberg Limit Test performed on this material are summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	30.0-41.0
Liquid Limit (w_L)	16.5-34.0
Plastic Limit (w_p)	13.0-15.0
Plasticity Index (I_p)	3.0-20.5
Unit Weight (kN/m^3)	18.9-19.0

From the plasticity chart (Figure 1), it is evident that the layer can be classified as an inorganic clayey silt with interbedded Sandy Silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil were determined both by the in situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	24-100	2.2-8.4
Laboratory Results	13-21	-

Due to the irregular nature of the deposit, that reveals numerous seams and layers of Sandy Silt interbedded within the Clayey Silt, the results provided in the above table are not necessarily indicative of the shear strength of the Clayey Silt portion. In view of this consideration, the consistency of the Clayey Silt portion can be described as soft to stiff. The Sandy Silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 40 kPa can be assumed for this stratum.

The results (e-log P curves) of two consolidation tests on representative samples from the adjacent structure sites (structure 3 and 5) are shown on Figure 6. These tests indicated that the Clayey Silt has been preconsolidated in the past to an effective pressure ranging from 190 kPa to 327 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, P_c (kPa)	190-327
Initial Void Ratio (e_0)	0.617-1.111
Compression Index (C_c)	0.078-0.87

*Test data of similar soil from adjacent investigations (WP 120-87-06 and 08) incorporated in results.

Silty Sand to Sand

Silty Sand to Sand was encountered below the Clayey Silt with interbedded Sandy Silt layer. The thickness of this layer ranges from 8.3 metres at BH #4-2 to 22.5 metres at BH #4-5.

This deposit contains minor variations in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel (in excess of 40%) was encountered. Grain size distribution analysis indicate that the soil varies between a silty sand to Sand. This layer is basically non-plastic. Figure 3 in the Appendix shows the results of grain size distribution tests in an envelope form.

In this stratum, the 'N' values ranged from 2 to over 70 blows/0.3 m indicating a state of compaction described as very loose to very dense.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the silty sand to Sand deposit at a depth ranging from 13.9 to 26.6 metres, a heterogeneous mixture of Sand, Gravel and boulders of glacial origin

was encountered. The thickness of this stratum ranges from about 3.2 m at BH #4-5 to 4.5 metres at BH #4-4. Rock coring techniques were required to penetrate occasional boulders within the stratum. This stratum may be described as a heterogeneous mixture of Sand, Gravel and boulders. Figure 4 shows the result of grain size distribution tests in an envelope form for these materials.

In this stratum, the 'N' values ranged from 36 to over 100 blows/0.3 metres indicating a state of compaction described as dense to very dense.

Bedrock

The glacial till deposit is directly underlain by bedrock of the Rockcliffe and Gull River Formations and was proven at various locations by obtaining up to 1.7 metres of rock core samples. The bedrock consists mainly of a Silty Dolostone. Minor beds of Sandstone and Limestone were also found interbedded in the rock formation. Detailed description of the rock are attached in the Appendix entitled "Description of Rock Core".

Core recoveries and rock quality designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on these results, the rock can be classified as medium strong to strong rock and predominantly unweathered.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater level in the boreholes was found to range between 60.4 metres at BH #4-5 and 64.8 metres at BH #4-2 which corresponds to depths of 4.6 metres to 1.5 metres below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 88 07 10 to 88 07 15 under the supervision of Tae C. Kim, Foundation Engineer. The equipment was owned and operated by Marathon Drilling Co. Ltd., Ottawa and F.E. Johnston Drilling Co. Ltd., Ottawa.

This report was written by Tae C. Kim, Foundation Engineer and reviewed by Murty Devata, Chief Foundation Engineer.



Tae C. Kim
Tae C. Kim, P.Eng.
Foundation Engineer

Murty Devata
Murty Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 3-3

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 664.5; E 358 609.9 ORIGINATED BY JF
 DIST 9 HWY 417 BOREHOLE TYPE Washboring, Rock Coring & Cone Test COMPILED BY JF
 DATUM Geodetic DATE 88 07 12 CHECKED BY TCK

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					
66.2	Ground Level													
0.0	Silty Clay to Clayey Silt Trace Sand	Brown Grey	1	SS	17		66						17.5	0 2 47 51
63.7	Soft to Very Stiff		2	TW	PM		64	4.2						
2.5	Clayey Silt with interbedded Sandy Silt Soft to Firm		3	TW	PM		62	6.8					18.7	0 37 40 23
			4	SS	2		60							1 22 51 26
			5	SS	2		58							
58.4			6	SS	31		56							
7.8	Silty Sand to Sand Some to trace of Gravel Occ. Gravelly Sand Layers Dense to Very Dense		7	SS	51		54							43 40 13 4
			8	SS	38		52							
			9	WS	-		50							
			10	SS	75/	8cm	48							
			11	SS	82		46							
43.4			12	WS	-		44							
22.8	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Very Dense		13	SS	112/	20cm	42							
41.3	Bedrock		14	RC	REC 88%		40							RQD = 55%
24.9	Silty Dolostone													
39.7														
26.5	End of Borehole													

RECORD OF BOREHOLE No 3-4

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 656.9; E 358 629.4 ORIGINATED BY TK
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring & Cone Test COMPILED BY TK
DATUM Geodetic DATE 88 07 13 - 14 CHECKED BY TCK

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					
66.1	Ground Level													
0.0	Silty Clay to Clayey Silt Some Sand Firm	Brown Grey	1	SS	7									0 24 45 31
63.6			2	TW	PH									
2.5	Clayey Silt with interbedded Sandy Silt Very Soft		3	TW	PH									
			4	TW	PH									
59.0			5	SS	1									
7.1			6	SS	3									
	Silty Sand to Sand Trace to some Gravel Very Loose to Dense		7	SS	30									
			8	SS	14									8 78 6 8
			9	SS	30									
			10	SS	44									
46.1														
20.0	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Dense		11	SS	46									27 57 14 2
41.3			12	SS	44									
24.8	End of Borehole													

RECORD OF BOREHOLE No 3-5

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 681.6; E 358 640.8 ORIGINATED BY TK
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Rock Core & Cone Test COMPILED BY TK
DATUM Geodetic DATE 88 07 11, 12, 13 CHECKED BY TCK

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				
66.0	Ground Level															
0.0	Silty Clay to Clayey Silt with Sand	Brown Grey	1	TW	PH										20.3	0 33 43 24
	Soft to Firm	Grey	2	TW	PH										20.0	2 35 42 21
63.3	Sand with Some Silt, Trace Clay	Brown	3	TW	PH											0 74 20 6
2.7	Clayey Silt with interbedded Sandy Silt		4	SS	2/60 cm											
62.0	Very Soft to Firm		5	SS	5											0 42 40 18
4.0	Silty Sand to Sand Trace Gravel Occ. Silt Seams Compact to Dense		6	SS	15											
58.9			7	SS	13											
7.1			8	SS	30											
			9	SS	36											
			10	SS	43											1 18 77 4
44.4	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Dense		11	SS	45											26 65 (9)
21.6	Bedrock Silty Dolostone		12	RC	REC 50%											RQD = 31%
40.7			13	RC	REC 95%											RQD = 27%
25.3	End of Borehole															
38.7																
27.3																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3-6

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 675.2; E 358 657.1 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 13, 14 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
65.9	Ground Level											
0.0	Silty Clay to Clayey Silt with Sand	Brown Grey	1	SS	3							1 36 38 25
63.9	Soft		2	TW	PH							0 34 46 20
2.0	Sand with some Silt	Brown										
62.8												
3.1	Clayey Silt with interbedded Sandy Silt		3	SS	1							
	V. Soft to Stiff		4	SS	8*							0 53 28 19
60.4												
5.5			5	SS	9							
	Silty Sand to Sand Trace to some Gravel Loose to Very Dense		6	SS	8							
			7	SS	21							8 86 (6)
			8	SS	36							
			9	SS	66							
			10	SS	59							12 42 40 6
43.6												
22.3	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Very Dense		11	SS	60							27 62 8 3
39.8			12	SS	50/	15cm						
26.1	End of Borehole											
	* Spoon Bouncing on Boulder											

METRIC

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			
66.0	Ground Level								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	WATER CONTENT (%) 10 20 30		GR SA SI CL

[illegible]

+3, x5. Numbers refer to
Series 14

20
15 σ E (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3-8

METRIC

W P 120-87-06 LOCATION Co-Ords N 5 022 692.6; E 358 687.1 ORIGINATED BY TK
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Cone Test COMPILED BY TK
DATUM Geodetic DATE 88 07 07 & 08 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)		
65.5	Ground Level													GR SA SI CL
0.0	Clayey Silt to Silt		1	TW	PH									
63.9	Soft (Fill)		2	TW	PH									
1.6	Silty Sand to Sand		3	SS	5									3 80 (17)
	Trace to Some		4	SS	5									0 94 (6)
	Gravel		5	SS	6									
	Loose		6	SS	2									
	Brown Grey		7	SS	8									
	Very loose to Dense		8	SS	27									
			9	SS	20									
			10	SS	42									0 94 (6)
41.2	Het. Mixture of													
24.3	Sand, Gravel & Boulders													
40.4	Very Dense (Glacial Till)		11	SS	2/	8cm*								
25.1	END OF BOREHOLE													
	*Sampler Bouncing Due to Boulder or Bedrock													

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4-1

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 563.6; E 358 565.5 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washboring, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 14-15 CHECKED BY TCK

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 (%)
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 (%)		
66.3	Ground Level												
0.0	Silty Clay to Clayey Silt						66						
64.9	Very Stiff Brown		1	SS	17		64					19.0	0 43 38 19
1.4	Clayey Silt Grey		2	TW	PH								0 32 34 34
63.8	with interbedded Sandy Silt												
2.5			3	SS	25								
	Brown Grey												
	Silty Sand to Sand, Some to trace of Gravel		4	SS	16								
	Loose to compact		5	SS	8								24 59 11 6
			6	SS	8								
			7	SS	13								
52.4													
13.9	Het Mixture of Sand Gravel and Boulders Very Dense (Glacial Till)		8	SS	72								29 59 7 5
50.6													
15.7	END OF BOREHOLE												

RECORD OF BOREHOLE No 4-2

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 603.6; E 358 595.4 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washboring, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 14-15 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
66.3	Ground Level												kN/m ³	GR SA SI CL
0.0	Silty Clay to Clayey Silt		1	SS	13		66							0 19 23 58
	Some Sand <i>Brown</i>		2	TW	PH		64						18.4	
	Soft to Stiff <i>Grey</i>													
63.8														
2.5	Clayey Silt with interbedded sandy silt		3	SS	2		62							0 22 31 47
			4	TW	PH		60							
60.7	Soft to Firm						58							0 18 46 36
5.6			5	SS	*		56							
	Silty Sand to Sand some to trace of Gravel		6	SS	10		54							6 69 17 8
	Very loose to Dense		7	SS	19		52							
			8	SS	35									
52.4														
13.9	Het mixture of Sand, Gravel and Boulders													
50.6	Dense (Glacial Till)		9	SS	36									
15.7	END OF BOREHOLE													
	* Weight of Rods													

RECORD OF BOREHOLE No 4-3

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 647.3; E 358 647.5 ORIGINATED BY JBF
DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, 'B' Casing, Washboring, Rock Core, Cone Test COMPILED BY JBF
DATUM Geodetic DATE 88 07 11-13 CHECKED BY TCK

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	SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	10 20 30						GR SA SI CL			
66.1	Ground Level																		
0.0	Silty Clay to Clayey Silt		1	SS	11		66												
			2	TW	PH		64							0 62 (38)					
63.6	Soft to Stiff		3	SS	3		62							0 13 57 30					
2.5	Clayey silt with <u>Brown</u> interbedded Sandy <u>Grey</u> Silt		4	SS	2		60							0 21 35 44					
	Soft		5	SS	2		58												
59.0			6	SS	34		56												
7.1	Silty Sand to Sand Trace to Some Gravel occ. Boulders occ. Gravelly Sand Layers Compact to very Dense		7	SS	36		54							34 54 8 4					
			8	RC	-		52												
			9	SS	27		50							37 54 8 1					
			10	RC	-		48												
			11	SS	63		46												
			12	SS	35		44												
			13	SS	70		42												
43.2			14	SS	29/ REC.		40												
22.9	Het. Mixture of Sand, Gravel and Boulders Very Dense (Glacial Till)		15	RC	71% REC		38												
39.5			16	RC	90% REC														
26.6	Bedrock		17,18	RC	56% REC.														
37.9	Silty Dolostone		19	RC	100% REC.									RQD = 59%					
28.2	END OF BOREHOLE																		
	* Bouncing on Boulder																		

* 3, x 5: Numbers refer to 20
Sensitivity 15 5 (% STRAIN AT FAILURE

RECORD OF BOREHOLE No 4-4

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 663.6: E 358 668.4 ORIGINATED BY TCK
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, 'B' Casing, Washbore, Rock Core, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 11-13 CHECKED BY TCK

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					
66.1	Ground Level													
0.0	Clayey Silt to Silty Sand (Fill)		1	SS	10		66							
63.6			2	TW	PH		64							
2.5	Clayey Silt with Brown Interbedded Grey Sandy Silt		3	TW	PH		62	2.4					18.9	0 20 43 37
			4	TW	PH		60	3.8					19.0	
59.8	Soft						58							
6.3			5	SS	10		56							
	Silty Sand to Sand		6	SS	18		54							7 75 11 7
	Trace to Some Gravel Occ. Silt seams		7	SS	23		52							
	Compact to Dense		8	SS	31		50							
			9	SS	48		48							0 30 64 6
44.8			10	SS	37		46							
21.3	Het. Mixture of Sand, Gravel and Boulders Dense (Glacial Till)		11	RC	-		44							
			12	SS	50		42							41 51 7 1
40.3			13	RC	REC	100%	40							RQD=80%
25.8	Bedrock		14	RC	REC	100%								RQD=52%
	Silty Dolostone		15	RC	REC	100%								RQD=79%
38.6														
27.5	END OF BOREHOLE													

+3, x5: Numbers refer to
Sensitivity

20
15 x 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4-5

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 687.7; E 358 702.6 ORIGINATED BY JBF/TCK
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washbore, Rock Core, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 09-11 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	10 20 30		
65.0	Ground Level													
0.0	Clayey Silt (Fill)		1	CS	-									
64.4			2	SS	12									0 37 38 25
0.6			3	SS	15									2 63 19 16
			4	SS	5									
			5	SS	5									
	Silty Sand to		6	SS	2									
	Sand													
	Trace of Gravel													
	Occ. Silt Seams		7	SS	4									1 95 (4)
	Brown Grey													
	Very loose to Very		8	SS	38									
	Dense													
			9	SS	31									
			10	SS	34									
			11	SS	55									
41.9														
23.1	Het. Mixture of Sand,		12	RC	-									
	Gravel and Boulders		13	SS	73/	13cm								58 36 (6)
	Very Dense				REC									
	(Glacial Till)		14	RC	29%									
38.7			15	RC	REC									
26.3	Bedrock		16	RC	REC/	100%								RQD = 35%
37.6	Silty Dolostone		17	RC	REC/	100%								RQD = 94%
27.4	END OF BOREHOLE													

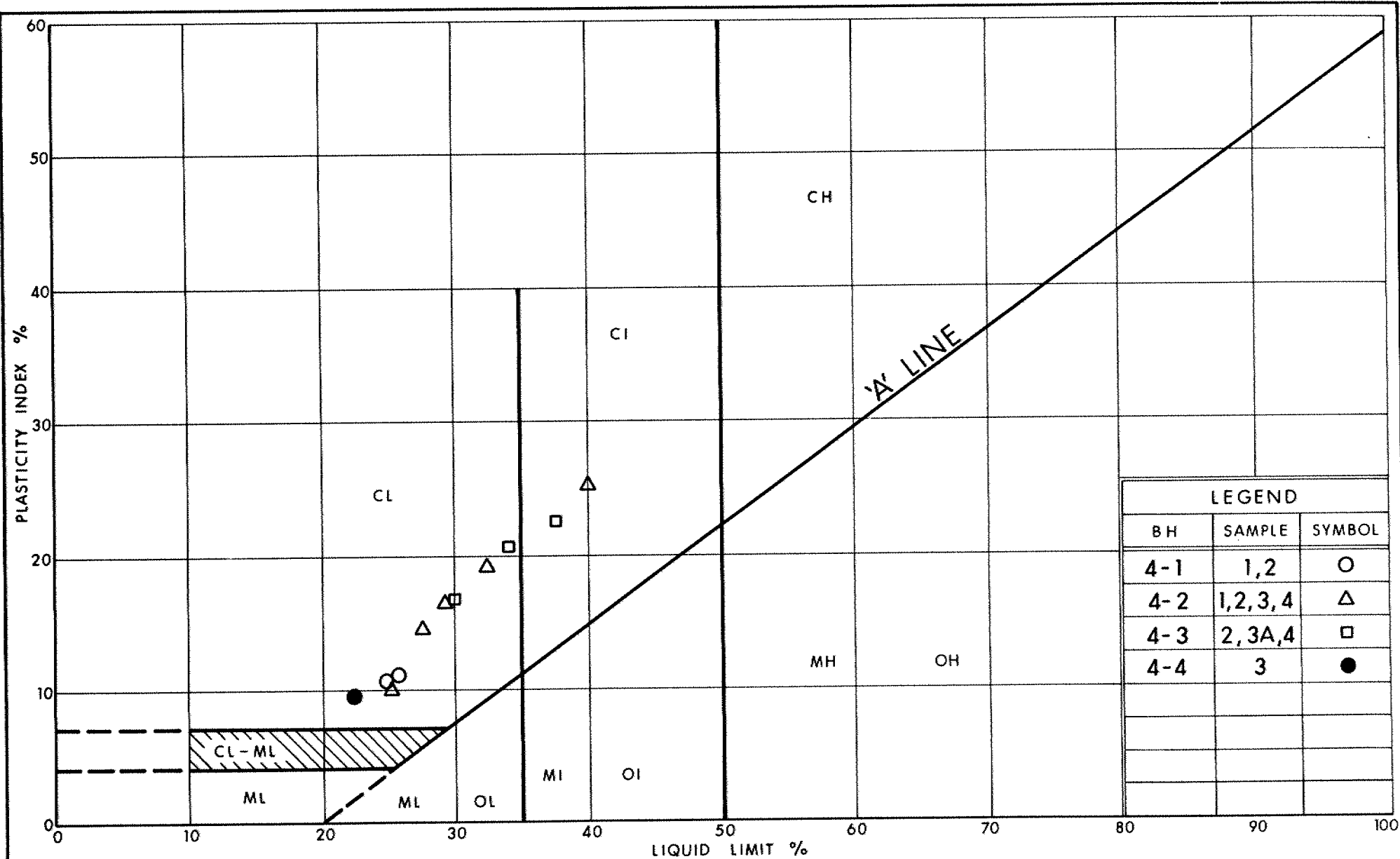
RECORD OF BOREHOLE No 4-6

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 699.6; E 358 709.8 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washbore, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 09-10 CHECKED BY TCK

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
64.7 0.0	Ground Level											
	Organic Silty Sand (Fill)		1	SS	6							
			2	SS	4							
			3	SS	4							
			4	SS	2							
60.7 4.0												1 57 33 9
	Silty Sand to Sand		5	SS	9							
			6	SS	8							
												0 99 (1)
	Loose to Dense		7	SS	17							
	Brown Grey		8	SS	30							
49.0 15.7			9	SS	44							0 94 (6)
	END OF BOREHOLE											

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
Transportation

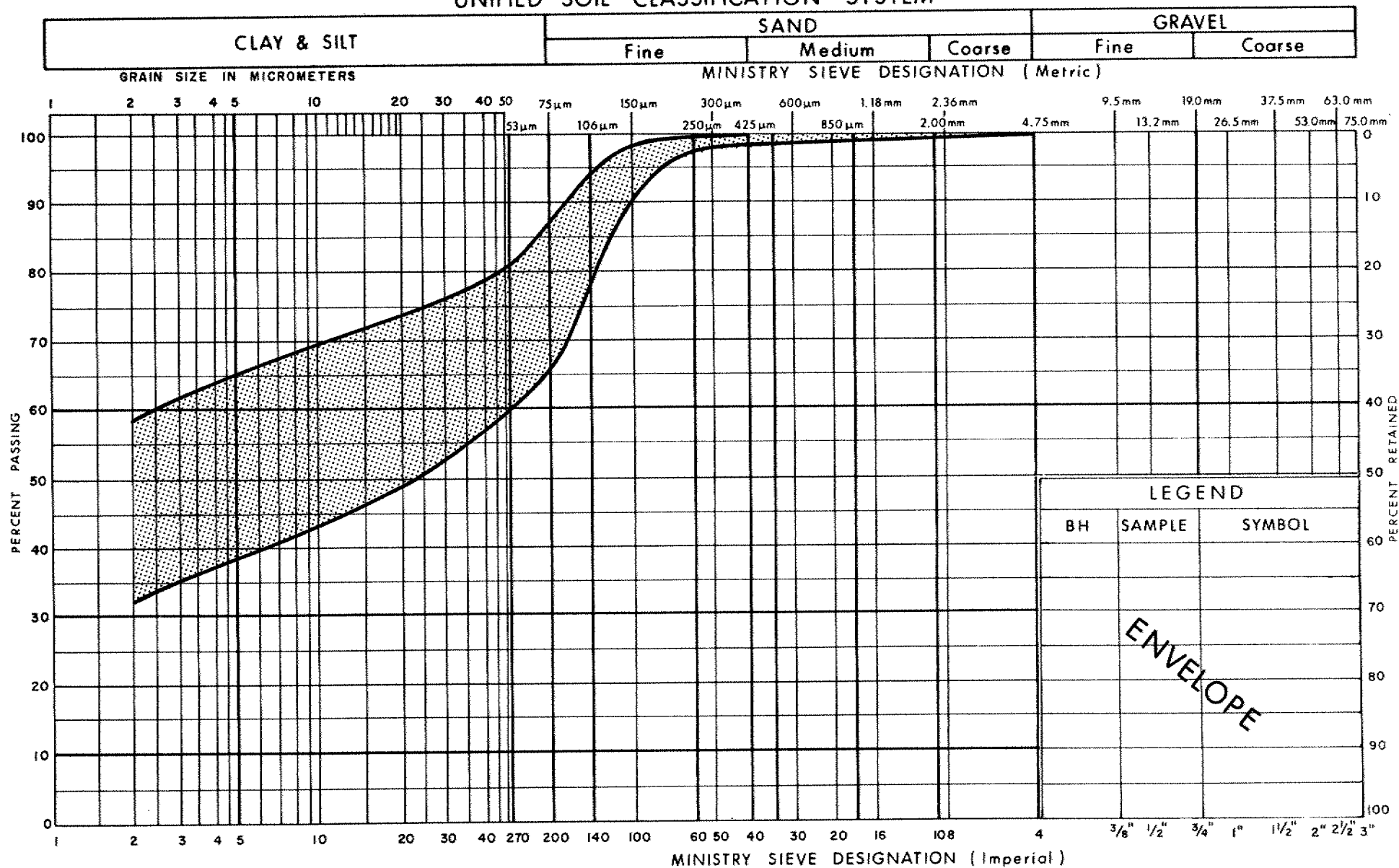
Ontario

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-07

UNIFIED SOIL CLASSIFICATION SYSTEM



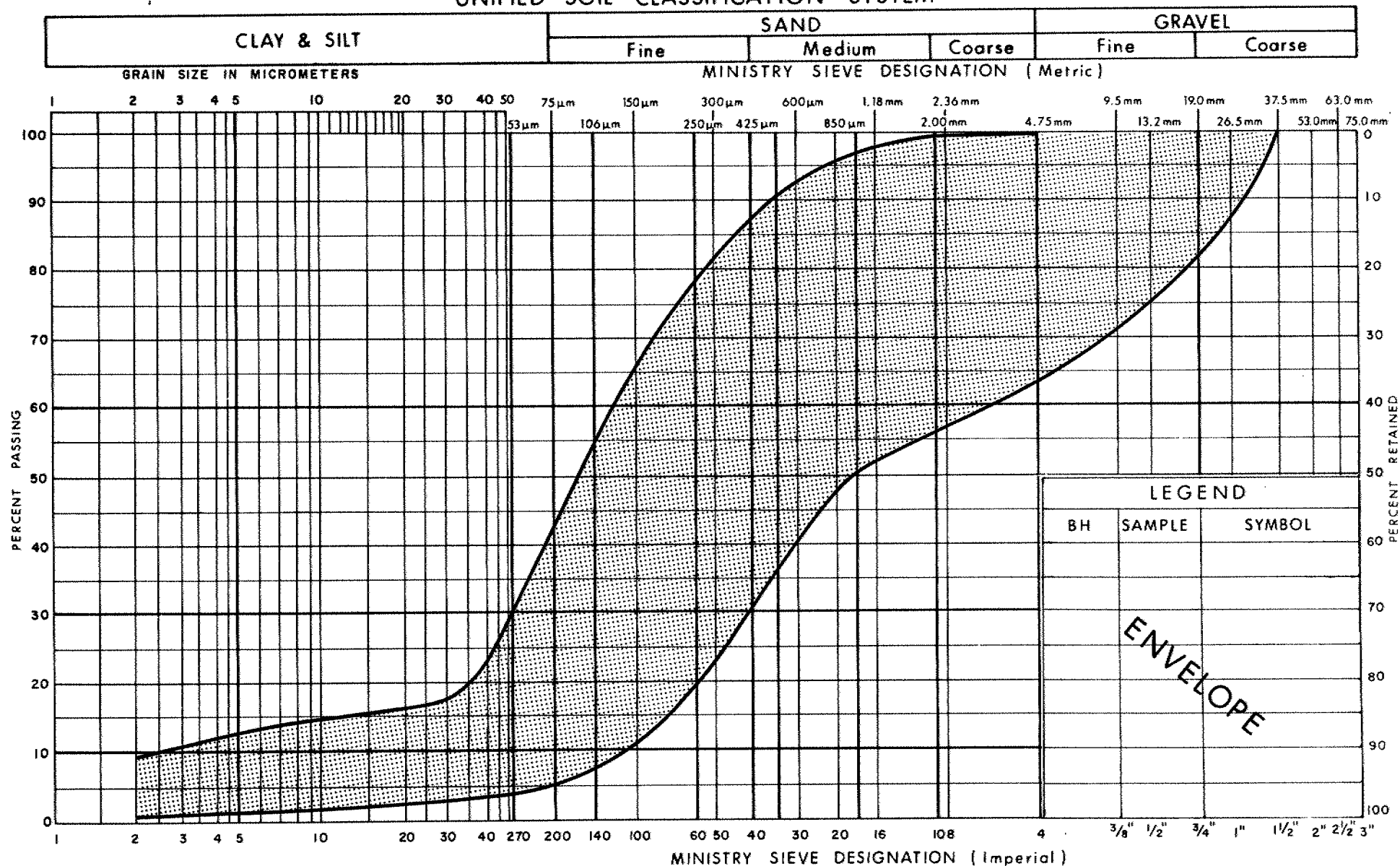
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

FIG No 2

W P 120-87-07

UNIFIED SOIL CLASSIFICATION SYSTEM



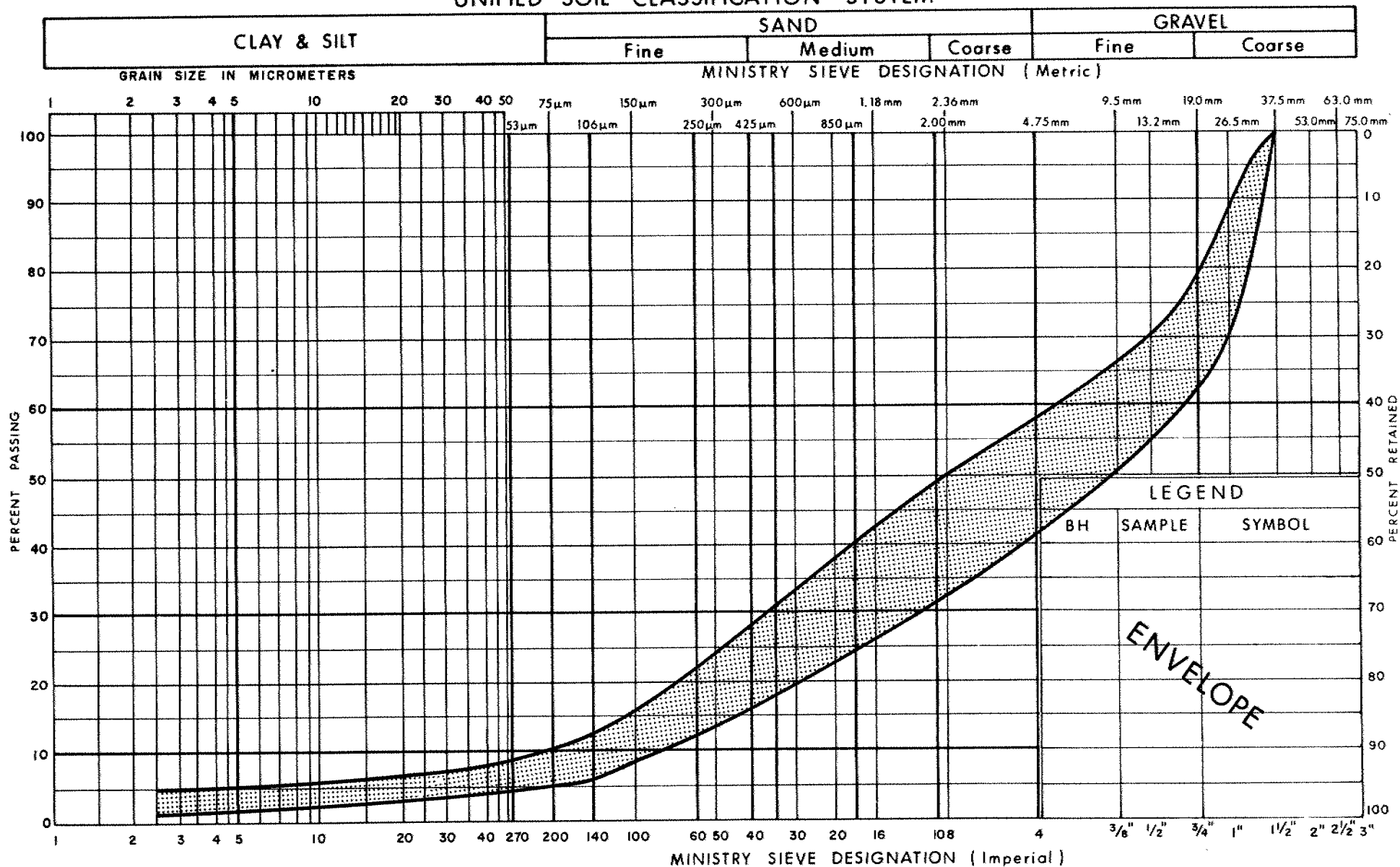
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND, SOME GRAVEL

FIG No 3

W P 120-87-07

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 4

W P 120-87-07

VOID RATIO - PRESSURE CURVES

282

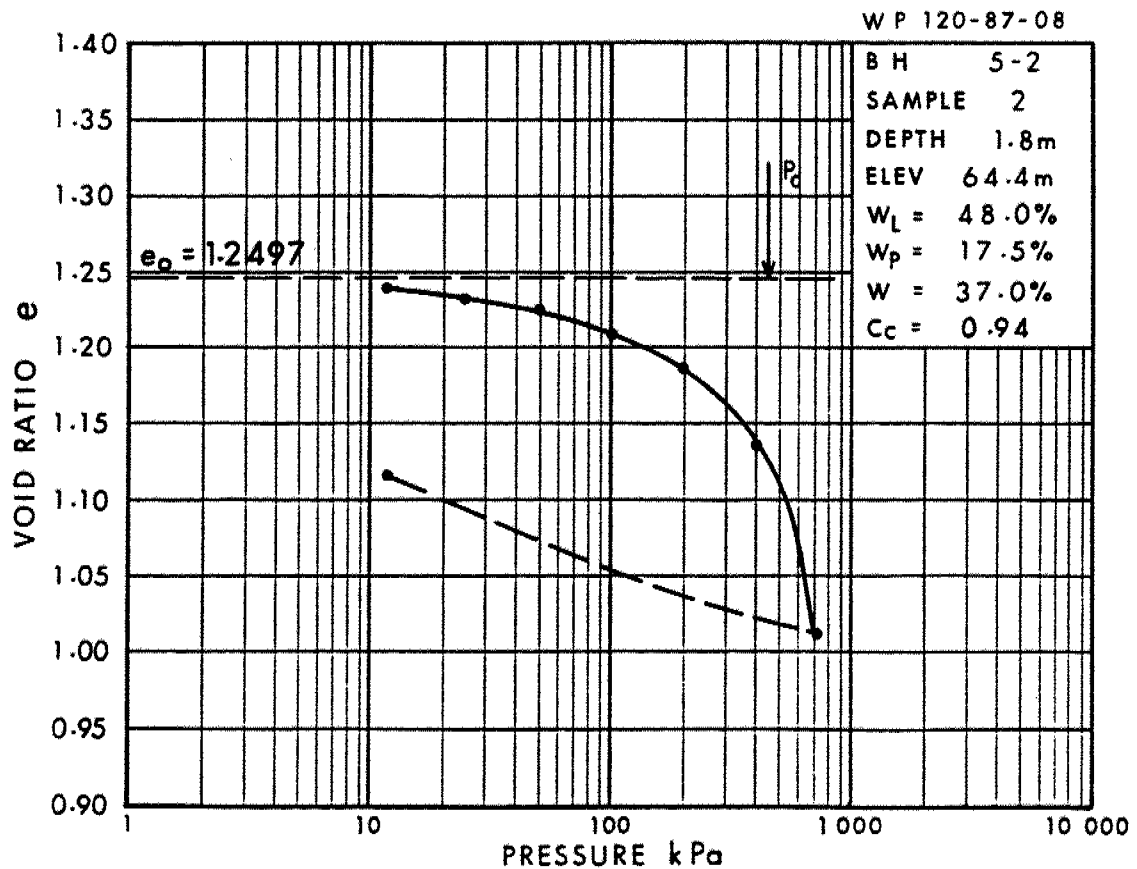
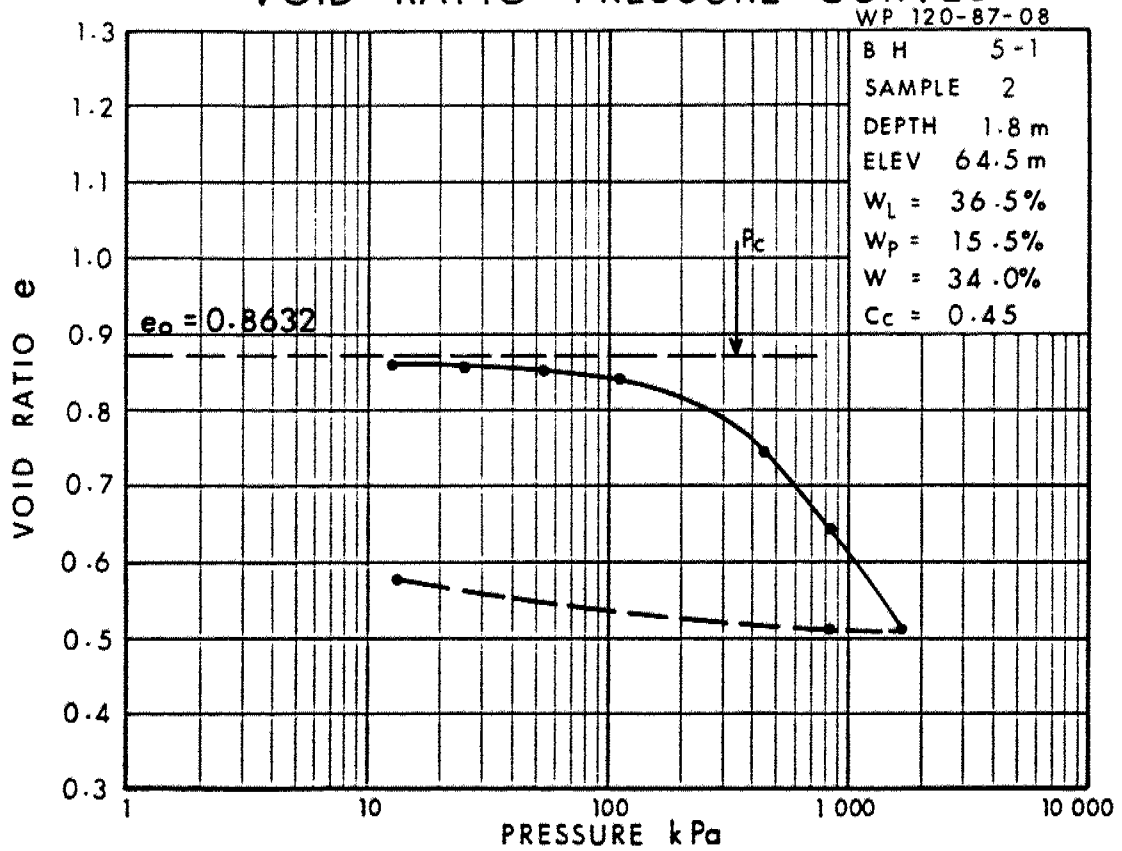


Fig 5

WP 120-87-07

VOID RATIO - PRESSURE CURVES

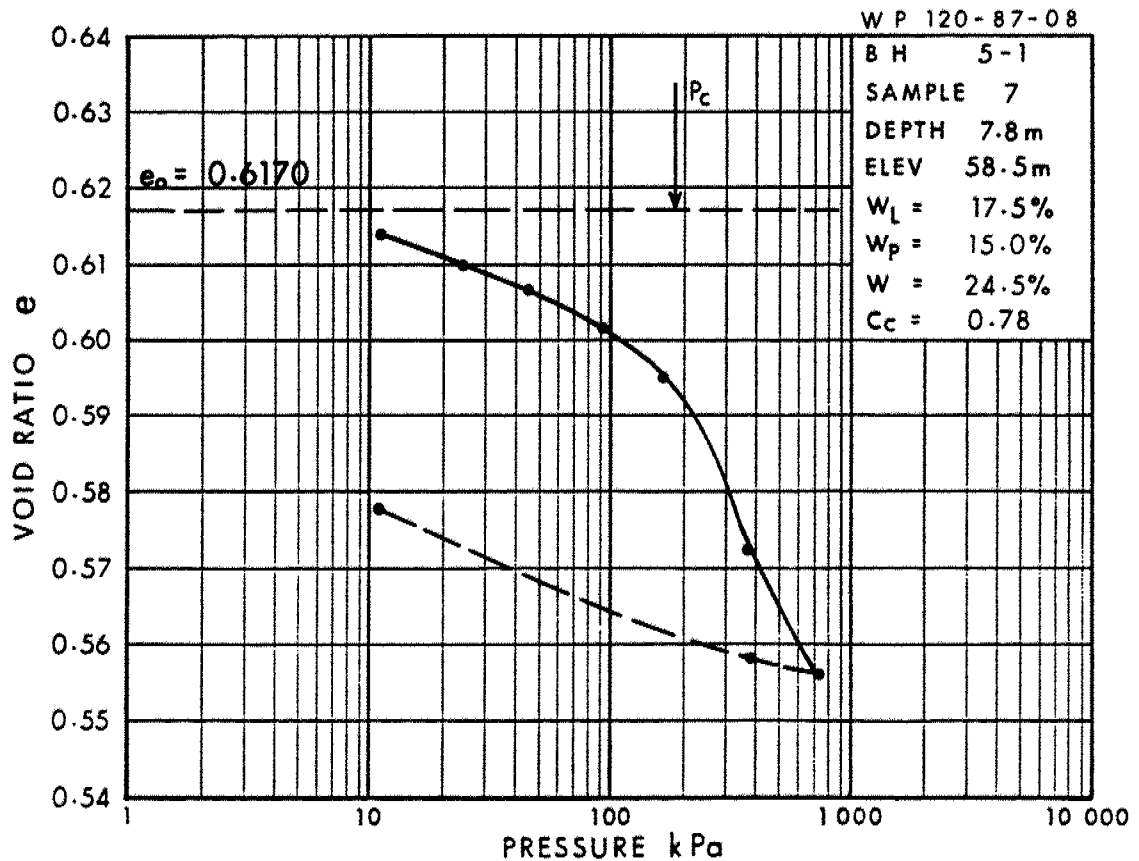
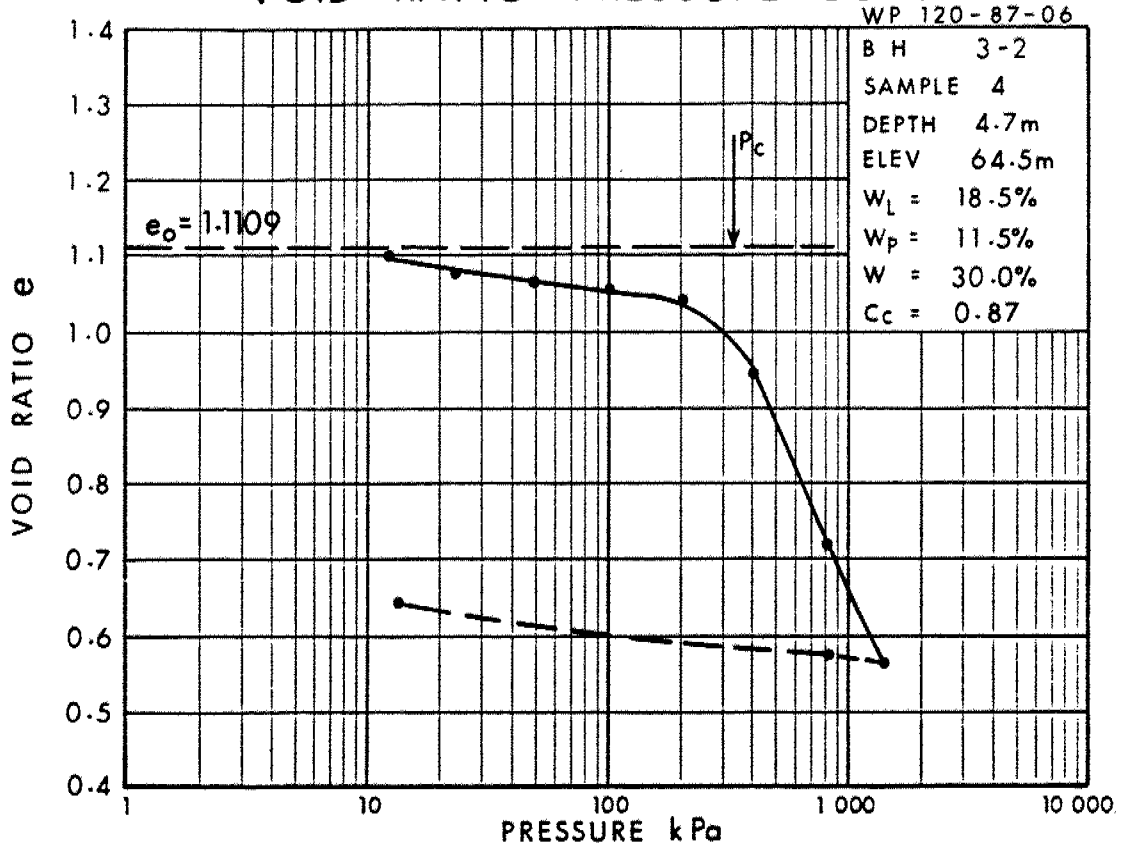


Fig 6

WP 120-87-07

DESCRIPTION OF ROCK CORE - WP 120-87-06

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
3-3	24.94-26.47	88	55	24.94-26.47	SILTY DOLOSTONE, light grey to medium dark grey; fine grained, dense; weak to medium strong rock; unweathered; very close to close spaced fractures: (i) flat, irregular, planar, slightly open, slightly altered; (ii) near vertical, closed, tight, calcite filled.
3-5	25.30-26.21	50	31	25.30-27.25	SILTY DOLOSTONE, light grey to medium dark grey; fine grained, dense; weak to medium strong rock; unweathered; very close to close spaced fractures: flat irregular, planar, slightly open, slightly altered.
	26.21-27.25	95	27		
3-7	27.10-27.89	100	66	27.10-28.65	SILTY DOLOSTONE, medium dark grey; fine grained; thinly bedded, minor argillaceous bands; medium strong rock; unweathered; very close to close spaced fractures: flat rough, planar, slightly open, slightly altered, clean.
	27.89-28.65	100	100		

NOTE: Depths are approximated in zones of poor core recovery.

1../1

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

DESCRIPTION OF ROCK CORE - WP 120-87-07

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
4-3	24.74-25.60	71	-	24.74-26.70	OVERBURDEN , contains foreign and locally derived bedrock material up to 0.35 m diameter.
	25.60-26.34	90	-	26.70-27.53	SILTY DOLOSTONE , medium dark grey; fine grained; thinly bedded; medium strong rock; unweathered to slightly weathered; very close to closely spaced fractures: flat rough, irregular, open, slightly altered.
	26.34-26.44	75	-		
	26.44-26.59	42	-		
	26.59-28.17	100	59	27.53-27.71	SHALE , greyish black to black; very fine grained; dense very thinly bedded; medium strong rock; unweathered; very close to closely spaced fractures: flat, very irregular, slightly open, unaltered, clean.
				27.71-28.17	ARGILLACEOUS DOLOSTONE , medium dark grey to dark grey; thinly bedded with argillaceous material; slightly vuggy; close spaced fractures: rough, planar, closed, clean; interbedded with LIMESTONE , dark grey, weathers to yellow brown; close spaced fractures: irregular, closed.
4-4	25.76-26.14	100	80	25.76-27.46	SILTY DOLOSTONE , medium dark grey; fine to medium grained, dense; medium strong rock; unweathered; very close to closely spaced fractures: rough, flat planar, slightly open, slightly altered; interbedded with LIMESTONE (22%), thinly bedded to 30 cm; undifferentiated from dolostone except for high calcite content.
	26.14-26.75	100	52		
	26.75-27.46	100	79		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

1../2

DESCRIPTION OF ROCK CORE - WP 120-87-07

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
4-5	24.66-25.55	29	-	24.66-26.29	OVERBURDEN, contains foreign and locally derived bedrock material.
	25.55-26.24	11	-	26.29-27.69	SILTY DOLOSTONE, medium dark grey; fine grained thinly bedded; medium strong rock; unweathered; moderately close spaced fractures: (i) flat, rough, planar, slightly altered, slightly open, clean; (ii) near vertical, rough, planar closed to slightly open, calcite filled.
	26.24-26.92	100	35		
	26.92-27.69	100	94		

NOTE: Depths are approximated in zones of poor core recovery.

2../2

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

FOUNDATION INVESTIGATION REPORT
For
East to South Ramp For Hwy. 416/417
Over Acres Road
WP 120-87-08, Site 3-52-535
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above-mentioned site during the period of July 5 to July 14, 1988. A two span structure is proposed to carry East to South Ramp for Hwy. 416/417 over the realigned Acres Road.

Five boreholes (BH #5-1 to BH #5-5) were advanced and sampled as part of this project by means of hollow stem augers with washboring techniques and using a conventional diamond drill (BX Casing and BX Rock Core barrel) adopted for soil and rock sampling purposes. These boreholes extended down to depths of 15.7 and 28.6 metres below the existing ground surface.

SITE DESCRIPTION AND GEOLOGY

The proposed structure site is located immediately south of the existing Highway 417 between Richmond Road and the existing Acres Road in the City of Nepean, Ottawa-Carleton Municipality. The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for farming purposes. Residential development exists north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley clay plains founded in the Lowlands of the St. Lawrence. The subsoil consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region. The bedrock in the area is of the Rockcliffe and Gull

River formations of the middle Ordovician period. It consists of interbedded fine grained quartz sandstone, silty dolostone, and limestone. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to it's present level.

FIELD INVESTIGATION AND LABORATORY ANALYSES

The fieldwork for the site investigation was carried out between July 5 and July 14, 1988 and consisted of five (5) sampled boreholes accompanied by dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques with NX or BX Casing were used to advance the boreholes in the overburden. Soil samples were retrieved at selected intervals by a split spoon sampler or shelby tube in accordance with the Standard Penetration Test (ASTM D1586). In situ vane tests were also carried out to cohesive soil. Samples were identified in the field and then returned to the laboratory for appropriate testing. Bedrock was proven at a number of location minimum 1.8 m using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

To identify the behaviour, gradation, properties and characteristics of the soil, various laboratory testing were performed as follows:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Undrained Unconsolidated Tests (Quick Triaxial)
- 5) Unconfined Compression Test
- 6) Consolidation Tests

Laboratory tests results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The surficial layer consists of a generally soft to very stiff cohesive silty clay to clayey silt which extends to a maximum thickness of 2.5 metres. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of sandy silt. The maximum thickness of this deposit is about 7.6 metres. A deep deposit of silty sand to sand is the subsequent underlying deposit with a maximum thickness of about 19.1 metres and this in turn underlain by a heterogeneous mixture of sand, gravel and boulders (Glacial Till). Approximately 3.1 to 5.7 metres of the till deposit was found before encountering the silty dolostone bedrock.

It should be noted that in the vicinity of east abutment and approach of the Structure No. 5, upper two layers (silty clay to clayey silt layer and clayey silt with interbedded sandy silt layer) are gradually diminished. In stead, fill material was encountered adjacent to the existing Graham Creek. Fill material consists of sandy silt or clayey silt to silt as shown on Record of boreholes (BH #5-4 and #5-5).

A detailed description of the surface conditions encountered is given below.

Fill Material

The fill material was encountered in the vicinity of the northeast portion of the site at two borehole locations (BH #5-4, #5-5). This fill consists of a brown Sandy Silt or Clayey Silt to Silt. The thickness of this layer varies from 0.8 metres at BH #5-4 to 1.3 metres at BH #5-5 as shown on Record of boreholes. No Atterberg Limit Tests and Grain Size Distribution Analysis were carried out. However, through visual observation, it is apparent that the fill material is similar to the surficial material which was found adjacent to the site.

Silty Clay to Clayey Silt

This stratum was encountered in most of the boreholes except near the east portion of the site (Boreholes #5-1, #5-2 and #5-3). This material consists of a silty clay to clayey silt with an average thickness up to 2.5 metres. The material changes in colour from brown to grey at approximately elevation 64.9 metres at Boreholes #5-1, #5-2 and #5-3.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	23.5-42.0
Liquid Limit (w_L)	22.0-57.0
Plastic Limit (w_p)	12.5-36.0
Plasticity Index (I_p)	16.0-29.0
Unit Weight (kN/m^3)	17.6-19.3

From the plasticity chart (see Figure 1) it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in envelope form.

Undrained shear strength of the soil were determined both by in situ vane tests and by laboratory tests, namely undrained unconsolidate (quick triaxials) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength (C_u)</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	48-126	3.0-5.7
Laboratory Results	30-72	-

As shown on the above table, it can be concluded that the laboratory testing provided lower values possibly attributable to disturbance during sampling, transportation and testing. Recommended shear strength for this deposit can be assumed to be within the range of 60 to 70 kPa. Based on this conclusion, the soil has generally a firm to very stiff consistency. The sensitivity of the soil is generally low to moderate.

The results (e-log P curves) of two consolidation tests on representative samples obtained in the silty clay to clayey silt deposit are shown on Figure 5. These tests indicated that this cohesive stratum has been preconsolidated in the past to an effective pressure ranging from 340 kPa to 450 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, P_c (kPa)	340-450 kPa
Initial Void Ratio (e_0)	0.863-1.250
Compression Index (C_c)	0.45-0.94

*Test data of similar soil from adjacent investigations (WP 120-87-06) incorporated in results.

Clayey Silt with Interbedded Sandy Silt

Underlying the surficial deposit of silty clay to clayey silt, a layer of grey clayey silt with interbedded sandy silt was encountered. This stratum extends to depths ranging from 0.8 metres to 10.1 metres below the ground surface. The thickness of the stratum varies between 1.7 and 7.6 metres.

The results from the Atterberg Limit Test performed on this material are summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	23.0-42.0
Liquid Limit (w_L)	16.0-34.5
Plastic Limit (w_p)	12.0-15.0
Plasticity Index (I_p)	2.0-21.0
Unit Weight (kN/m^3)	19.3-19.9

From the plasticity chart (Figure 1), it is evident that the layer can be classified as an inorganic clayey silt with interbedded Sandy Silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil were determined both by the in situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	51-104	2.7-4.0
Laboratory Results	17-55	-

Due to the irregular nature of the deposit, that reveals numerous seams and layers of Sandy Silt interbedded within the Clayey Silt, the results provided in the above table are not necessarily indicative of the shear strength of the Clayey Silt portion. In view of this consideration, the consistency of the Clayey Silt portion can be described as soft to very stiff. The Sandy Silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 40 kPa can be assumed for this stratum.

The results (e-log P curves) of two consolidation tests on representative samples are shown on Figure 6. These tests indicated that the Clayey Silt has been preconsolidated in the past to an effective pressure ranging from 190 kPa to 327 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, P_c (kPa)	190-327
Initial Void Ratio (e_0)	0.617-1.111
Compression Index (C_c)	0.078-0.87

*Test data of similar soil from adjacent investigations (WP 120-87-06) incorporated in results.

Silty Sand to Sand

Silty Sand to Sand was encountered below the Clayey Silt with interbedded Sandy Silt layer. The thickness of this layer ranges from 11.2 metres at BH #5-2 to 19.1 metres at BH #5-4. The material changes in colour from brown to grey at an approximate elevation of 57 metres on the east portion of the site (BH #5-5).

This deposit contains minor variations in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel (in excess of 40%) was encountered. Grain size distribution analysis indicate that the soil varies between a silty sand to Sand. This layer is basically non-plastic. Figure 3 in the Appendix shows the results of grain size distribution tests in an envelope form.

In this stratum, the 'N' values ranged from 4 to over 70 blows/0.3 m indicating a state of compaction described as loose to very dense.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the silty sand to Sand deposit at a depth ranging from 21.3 to 27.3 metres, a heterogeneous mixture of Sand, Gravel and boulders of glacial origin

was encountered. The thickness of this stratum ranges from about 3.1 m at BH #5-2 to 5.7 metres at BH #5-4. Rock coring techniques were required to penetrate occasional boulders within the stratum. This stratum may be described as a heterogeneous mixture of Sand, Gravel and boulders. Figure 4 shows the result of grain size distribution tests in an envelope form for these materials.

In this stratum, the 'N' values ranged from 28 to over 100 blows/0.3 metres indicating a state of compaction described as compact to very dense.

Bedrock

The glacial till deposit is directly underlain by bedrock of the Rockcliffe and Gull River Formations and was proven at various locations by obtaining up to 1.8 metres of rock core samples. The bedrock consists mainly of a Silty Dolostone. Minor beds of Sandstone and Limestone were also found interbedded in the rock formation. Detailed description of the rock are attached in the Appendix entitled "Description of Rock Core".

Core recoveries and rock quality designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on these results, the rock can be classified as medium strong to strong rock and predominantly unweathered.

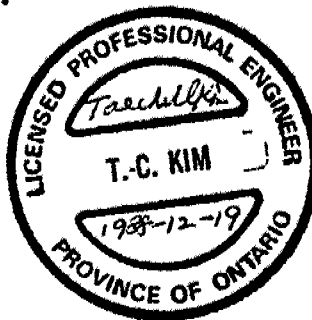
GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater level in the boreholes was found to range between 60.9 metres at BH #5-2 and 64.9 metres at BH #5-1 which corresponds to depths of 5.3 metres to 1.4 metres below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 88 07 05 to 88 07 14 under the supervision of Tae C. Kim, Foundation Engineer. The equipment was owned and operated by Marathon Drilling Co. Ltd., Ottawa and F.E. Johnston Drilling Co. Ltd., Ottawa.

This report was written by Tae C. Kim, Foundation Engineer and reviewed by Murty Devata, Chief Foundation Engineer.



Tae C. Kim
Tae C. Kim, P.Eng.
Foundation Engineer

Murty Devata
Murty Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 5-1

METRIC

W P 120-87-08 LOCATION Co-Ords N 5 022 651.6; E 358 543.0 ORIGINATED BY JF
DIST 9 HWY 417 BOREHOLE TYPE Hollowstem Auger, Cone Test COMPILED BY JF
DATUM Geodetic DATE 88 07 08 CHECKED BY TCR

OFFICE REPORT ON SOIL EXPLORATION

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					
66.3	Ground Level													
0.0	Silty Clay to Clayey		1	SS	12		66						49	0 2 52 46
	Silt, some to trace sand	Brown Grey	2	TW	PH		64		126				18.6	0 12 58 30
63.8	Stiff													
2.5	Clayey Silt with interbedded Sandy Silt		3	SS	1		62		3.6					0 31 40 29
	Occ. Silt Layers		4	SS	2		60		3.3					0 26 42 32
	Very soft to soft		5	SS	1		58							0 29 50 21
57.7			6	SS	1		56							
8.6	Silty Sand to Sand		8	SS	16		54							1 84 (15)
	Trace of Gravel						52							
	Compact		9	SS	24									
50.6			10	SS	*									
15.7	END OF BOREHOLE													
	* Not representative due to Sand blow back in Aguers													

RECORD OF BOREHOLE No 5-2

METRIC

W P 120-87-08 LOCATION Co-Ords N 5 022 676.9; E 358 562.9 ORIGINATED BY JF
DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, Washboring, Rock Coring & Cone Test COMPILED BY JF
DATUM Geodetic DATE 88 07 05 - 14 CHECKED BY TCK

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					
66.2	Ground Level													
0.0	Silty Clay to Clayey Silt Occ. Clay Layers Brown Grey		1	SS	9		66							
			2	TW	PH		64	3.6					48 18.2	0 5 46 49
63.7	Stiff							3.1					57 17.6	0 2 45 53
2.5	Clayey Silt with interbedded Sandy silt Occ. Silt Layers Very soft to soft		3	TW	PH		62							0 32 39 29
			4	SS	1		60							
			5	SS	2		58							0 31 44 25
			6	SS	1		56							
			7	SS	2		54							
			8	SS	1		52							
			9	SS	2		50							
56.1							48							
10.1			10	SS	29		46							
	Silty Sand to Sand trace to some Gravel		11	SS	32		44							23 59 9 9
			12	SS	43		42							
	Compact to Dense		13	SS	44		40							
44.9							38							
21.3	Het. Mixture of Sand, Gravel and Boulders Compact to very Dense (Glacial Till)		17	SS	28		36							30 62 (8)
41.8			18	RC	REC		34							
24.4	Bedrock		19	RC	REC	63%	32							RQD = 11%
	Silty Dolostone						30							RQD = 55%
40.0			20	RC	REC		28							
26.2	END OF BOREHOLE						26							

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5-3										METRIC				
W P 120-87-08		LOCATION Co-Ords N 5 022 692.9; E 358 607.4				ORIGINATED BY TK								
DIST 9 HWY 417		BOREHOLE TYPE H-S Auger, Washboring, Rock Coring & Cone Test				COMPILED BY TK								
DATUM Geodetic		DATE 88 07 05 - 07				CHECKED BY TCK								
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					
66.0	Ground Level													
0.0	Silty Clay to Clayey Silt	Brown Grey	1	SS	6								8 17 46 29	
	Some Sand		2	TW	PH									
63.5	Trace Gravel													
2.5	Firm													
	Clayey Silt with interbedded Sandy Silt		3	TW	PH									
			4	SS	1									
			5	SS	1									
			6	SS	1									
	Very Soft													
58.1			7	SS	30								0 36 47 17	
7.9														
	Silty Sand to Sand		8	SS	15									
	Trace of Gravel		9	SS	18									
	Occ. Gravelly Sand Layers		10	SS	4									
			12	SS	9									
	Occ. Clayey Silt Seams		13	SS	70									
	Loose to very Dense		14	SS	45									
			15	SS	59									
	Clayey Silt		16	SS	73									
			17	SS	51									
43.7														
22.3	Het. Mixture of Sand, Gravel and Boulders		18	SS	83									
	Very Dense		19	SS	67									
	(Glacial Till)		20	RC	REC 50%									
39.4			22	SS	*									
26.6	Bedrock													
	Silty Dolostone		23	RC	REC 98%									
38.0														
28.0	END OF BOREHOLE													
	* Not Representative													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5-4

METRIC

W P 120-87-08 LOCATION Co-Ords N 5 022 719.6; E 358 627.5 ORIGINATED BY TK
 DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, Washhoring, Rock Coring & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 88 07 05 - 97 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
65.3	Ground Level													
0.0	Sandy Silt (Fill)													
64.5														
0.8	Clayey Silt with Interbedded Sandy Silt Soft		1	SS	2									0 25 46 29
62.8			2	TW	PH									
2.5			3	SS	22									
			4	SS	14									14 80 (6)
	Silty Sand to Sand		5	SS	14									
	Some Gravel	Grey Brown	6	SS	25									43 49 6 2
	Occ.Gravelly Sand Layers		7	SS	18									
		Brown Grey	8	SS	14									12 79 (9)
	Compact to Dense		9	SS	29									
			10	SS	36									
			11	SS	33									
			12	SS	40									
43.7														
21.6	Het. Mixture of Sand, Gravel and Boulders Dense to Very Dense (Glacial Till)		13	SS	38									
			14	RC	REC 63%									
			15	SS	49									41 48 9 2
			16	RC	REC 83%									
			17	RC	REC 33%									
38.0			18	SS	37	10cm								
27.3	Bedrock		19	RC	REC 96%									
36.7	Silty Dolostone													ROD = 43%
28.6	END OF BOREHOLE													

OFFICE REPORT ON SOIL EXPLORATION

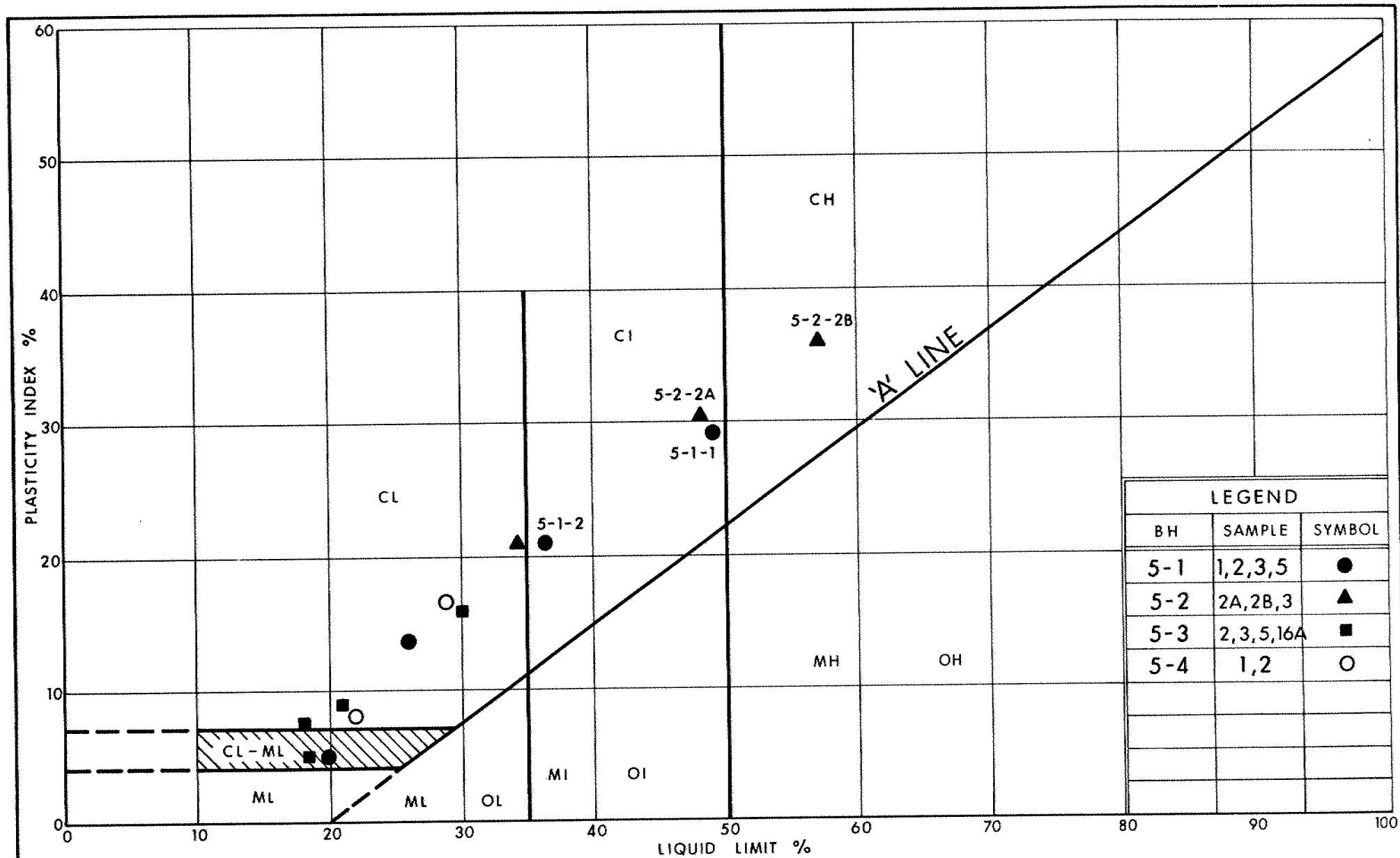
RECORD OF BOREHOLE No 5-5

METRIC

W P 120-87-08 LOCATION Co-Ords N 5 022 728.2; E 358 659.4 ORIGINATED BY TK
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Wash Boring, Cone Test COMPILED BY TK
DATUM Geodetic DATE 88 07 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
65.8	Ground Level													
0.0	Clayey Silt to Silt (Fill)		1	TW	PH									
64.5			2	SS	18									
1.3			3	SS	5									
			4	SS	5									
			5	SS	8									
			6	SS	11									
			7	SS	8									
	Silty Sand to Sand													
	Trace to some Gravel													
			8	WS	4									
	Loose to	Brown Grey												
	Very Dense		9	SS	17									
			10	SS	38									
			11	SS	32									
			12	SS	52									
50.1			13	SS	41									
15.7	END OF BOREHOLE													
47.5														
18.3	END OF CONE TEST													

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
Transportation

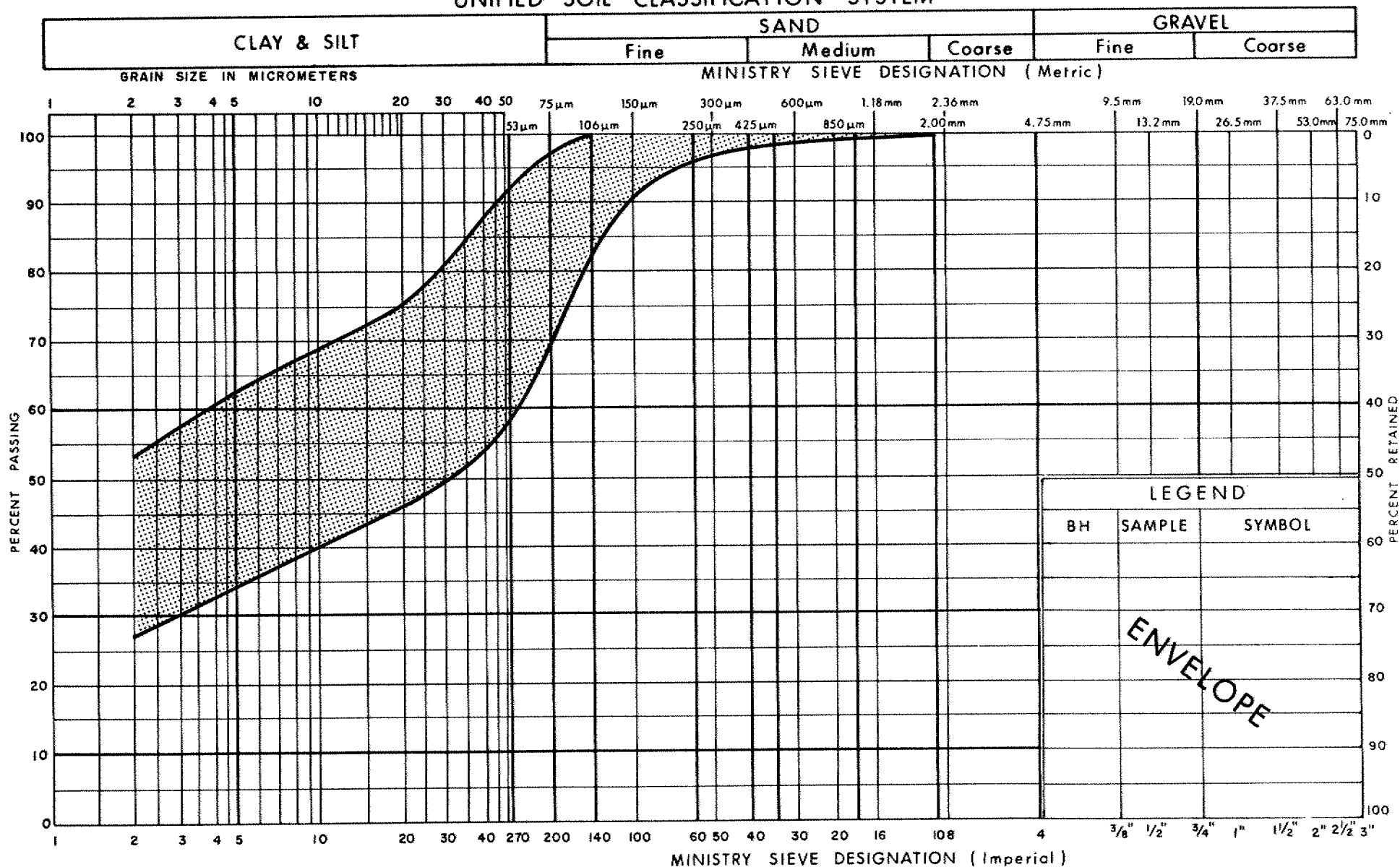
Ontario

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-08

UNIFIED SOIL CLASSIFICATION SYSTEM



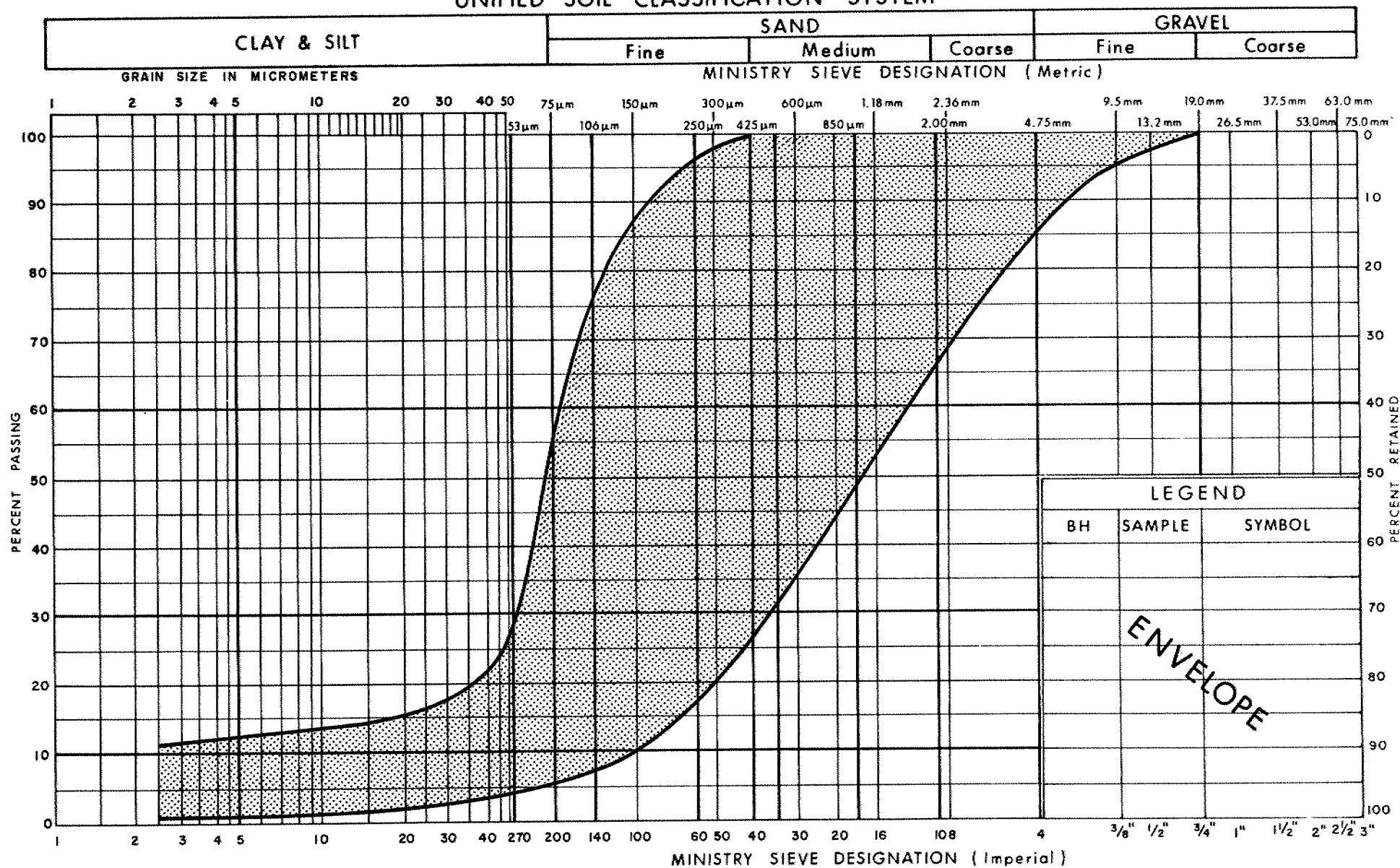
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

FIG No 2

W P 120-87-08

UNIFIED SOIL CLASSIFICATION SYSTEM



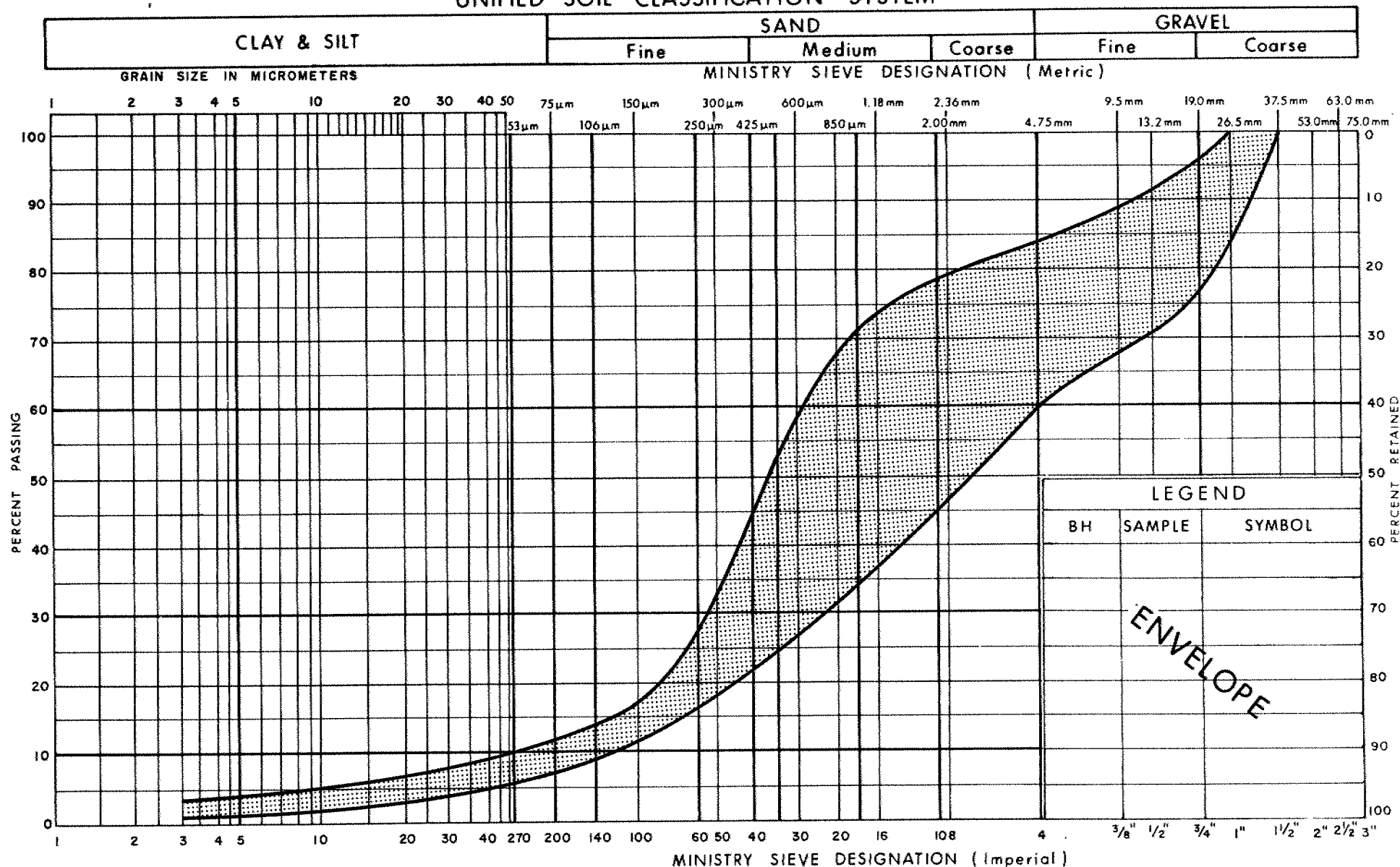
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND, TRACE GRAVEL

FIG No 3

W P 120-87-08

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 4

W P 120-87-08

VOID RATIO - PRESSURE CURVES

WP 120-87-08

306

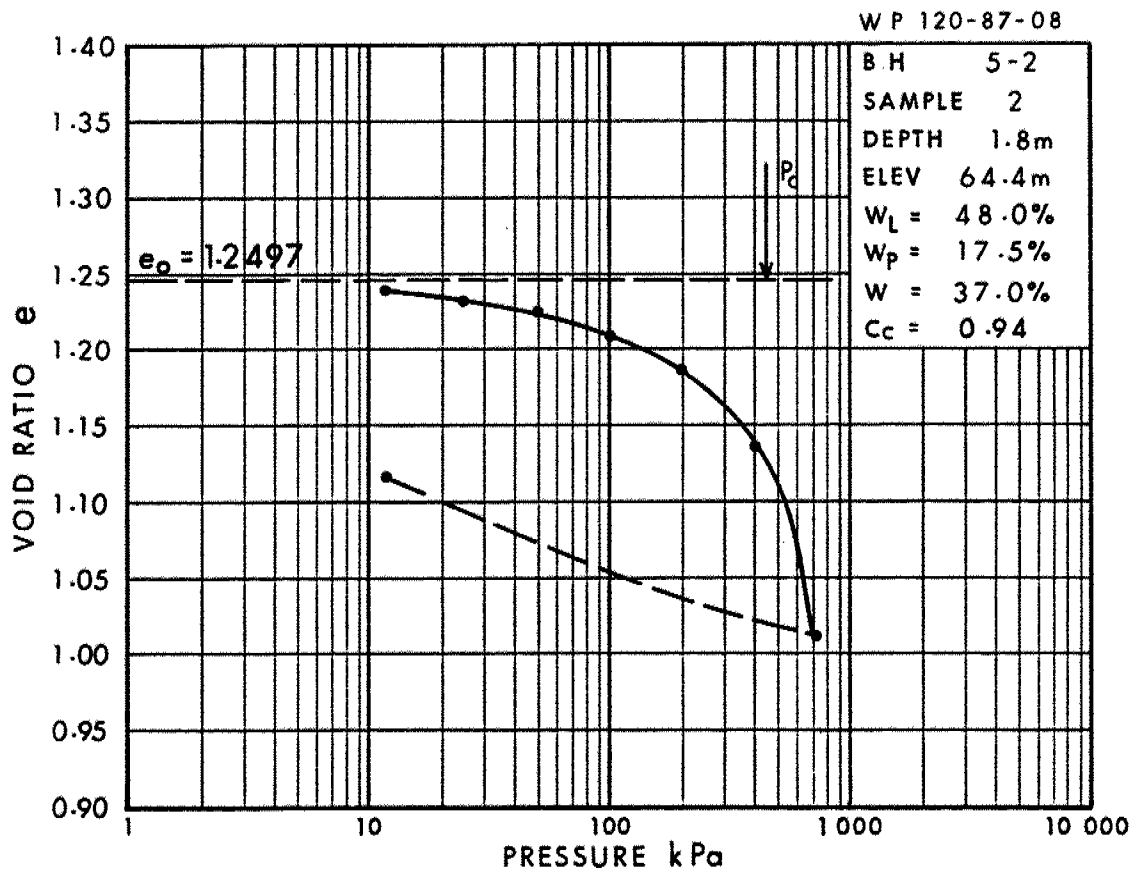
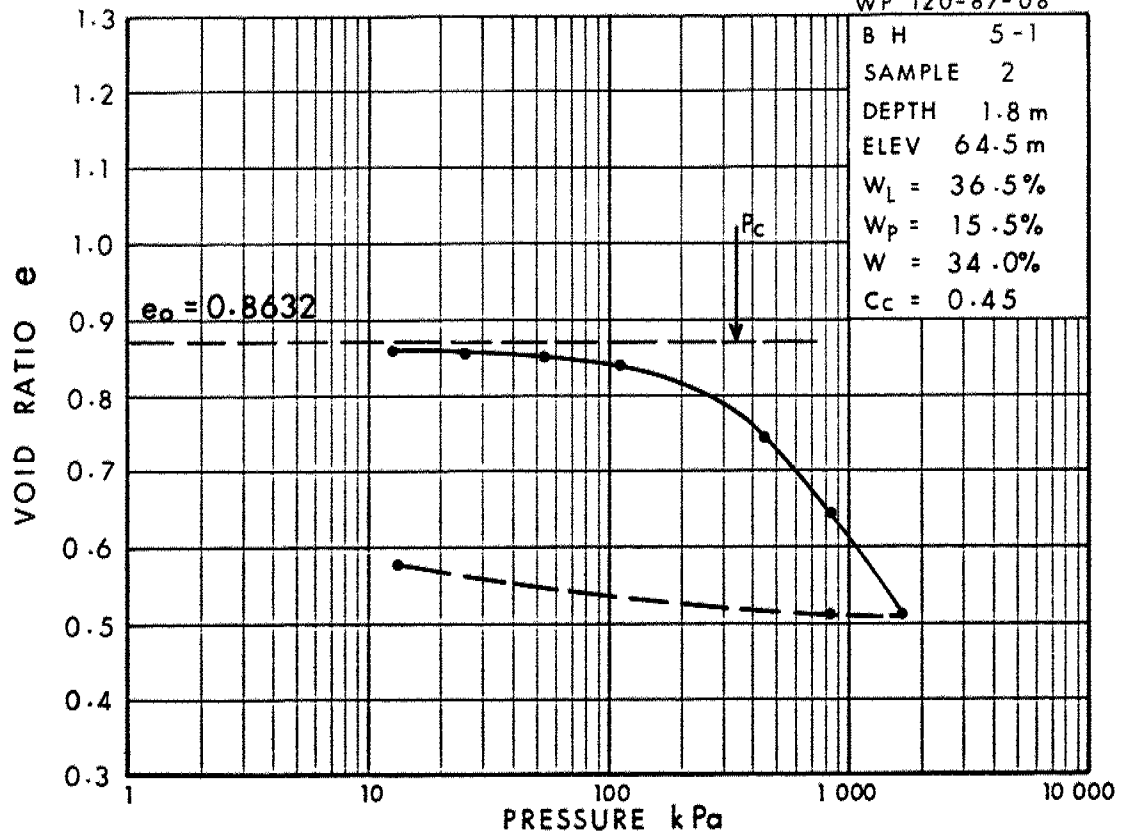


Fig 5

WP 120-87-08

VOID RATIO - PRESSURE CURVES

WP 120-87-06

307

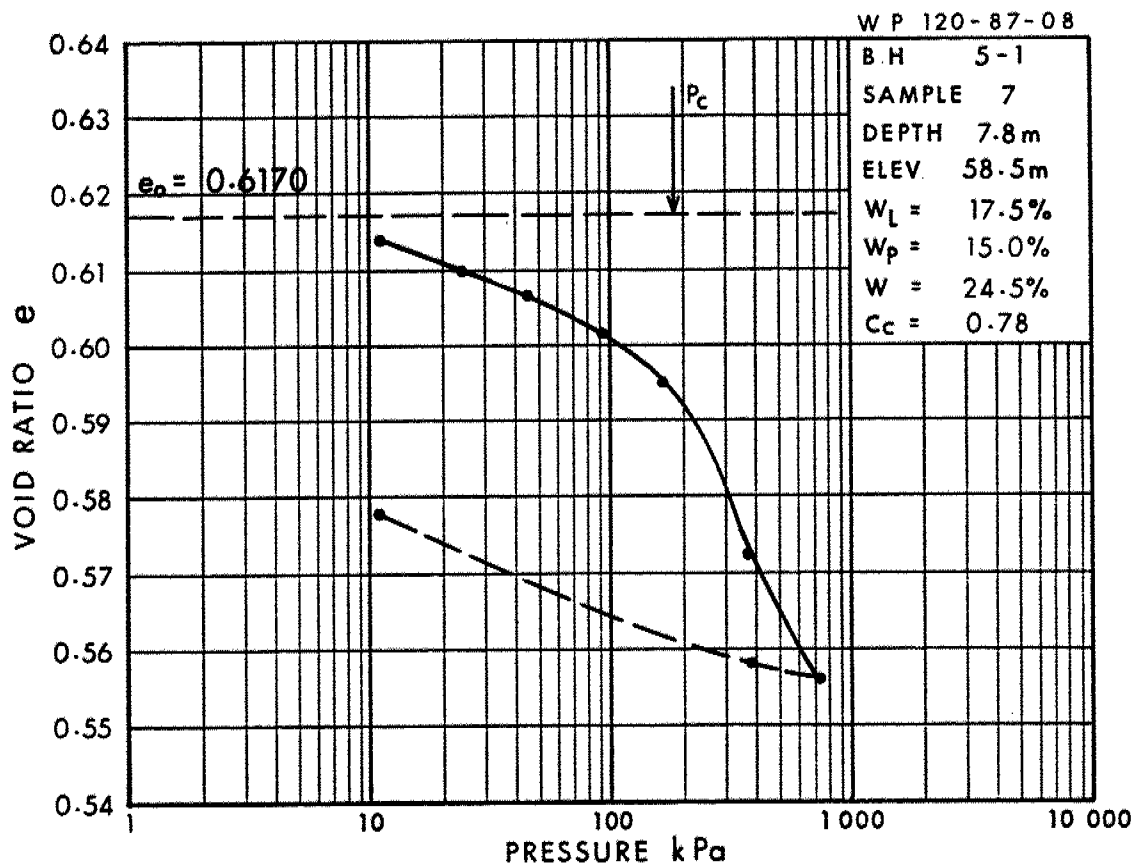
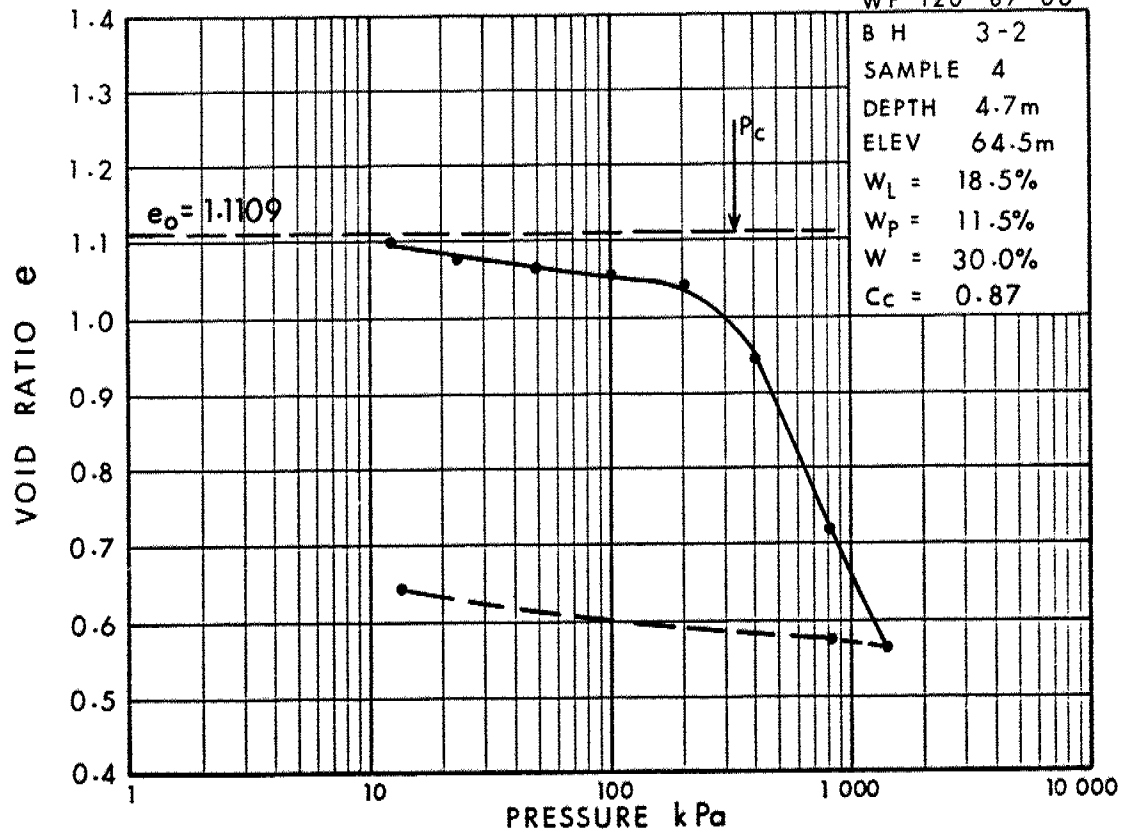


Fig 6

WP 120-87-08

DESCRIPTION OF ROCK CORE - WP 120-87-08

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
5-2	24.38-24.49	63	-	24.38-26.21	SILTY DOLOSTONE, medium dark grey; fine grained, thinly bedded with minor argillaceous bands; medium strong rock; unweathered; intensely fractured zone from 25.30 - 25.75 m, and from 26.00 - 26.21 m.
	24.49-25.60	57	11		
	25.60-26.21	94	55		
5-3	25.73-26.01	50	-	25.73-26.63	OVERBURDEN, containing foreign and locally derived bedrock material up to 6 cm diameter.
	26.01-26.14	50	-	26.63-28.04	SILTY DOLOSTONE, medium dark grey; fine grained, thinly bedded with minor argillaceous bands and LIMESTONE beds; medium strong rock; unweathered; moderately close spaced fractures: flat, rough, open, slightly altered, clean.
	26.14-26.52	NOT CORED			
	26.52-28.04	98	91		
5-4	23.47-23.77	63	-	23.47-27.25	OVERBURDEN, containing foreign and locally derived bedrock material up to 12 cm diameter.
	23.77-24.38	NOT CORED		27.25-28.58	SILTY DOLOSTONE, medium dark grey; fine grained, thinly bedded; medium strong rock; unweathered; moderately spaced fractures: flat, rough, open, slightly altered, clean.
	24.38-25.43	10	-		
	25.43-25.73	83	-		
	25.73-26.87	33	-		
	26.87-27.20	0	0		
	27.20-28.58	96	43		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

FOUNDATION INVESTIGATION REPORT
For
Hwy. 417 W.B. Overpass Structure
at Acres Road and Associated Ramps

WP 120-87-10, Site No. 3-536

Hwy. 417, District 9, Ottawa

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation implemented at the aforementioned site. A two span structure is proposed to carry Hwy. 417 WB and the Richmond Road to Hwy. 417 WB ramp over the realigned Acres Road.

SITE DESCRIPTION AND GEOLOGY

The site of the proposed structure is located immediately south of the existing Hwy. 417 WB and bisected by the existing Hwy. 417 EB in the City of Nepean, Ottawa-Carleton Municipality. It is located immediately east and adjacent to the existing Acres Road overpass. The median between Hwy. 417 WB and Hwy. 417 EB exists within the site and consists of grassland and contains a storm sewer that is aligned parallel to the existing Hwy. 417.

The terrain surrounding the site is generally flat to gently undulating. Immediately south of the proposed structure, the land is used primarily for agriculture. Residential developments exist north of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay Plains founded in the Lowlands of the St. Lawrence. The deposit consists of clay plains interrupted by ridges of rock or sand. Fault scarps are also evident within the area, an illustration of the numerous normal faults that dominate the region.

The bedrock in the area is of the Gull River Formation of the Middle Ordovician Period. It consists of interbedded silty dolostone, shaley limestone and fine grained quartz sandstone. The overburden was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the Champlain Sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 88 07 18 and 88 07 23 and consisted of 10 sampled boreholes accompanied by dynamic cone penetration tests. Continuous flight hollow stem auger equipment and washboring techniques were used to advance the boreholes in the overburden. Subsoil samples were retrieved at selected intervals by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586) and by Shelby tubes, manually or hydraulically advanced. Samples were identified in the field and then returned to the laboratory for applicable testing. Bedrock was proven at a number of locations using conventional rock coring methods.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

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

LABORATORY ANALYSIS

To identify the behaviour, gradation, properties and characteristics of the soil, various laboratory testing were performed. Tests included:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents
- 4) Undrained Unconsolidated Tests (Quick Triaxial)
- 5) Unconfined Compression Tests
- 6) Consolidation Tests

Laboratory test results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

Subsoil conditions are generally uniform across the site. The surficial layer consists of a generally firm to stiff cohesive silty clay to clay and extends to a maximum thickness of 3.8 metres. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of silty sand. The maximum thickness of this deposit is 7.7 metres. A deep deposit (maximum 19.8 m) of sand to silty sand is the subsequent underlying deposit and this in turn is underlain by a heterogeneous mixture of sand, gravel and boulders (glacial till). Approximately 1.5 to 4 metres of the till deposit was penetrated before encountering the silty dolostone bedrock.

Two isolated areas of fill material were also discovered in the investigation. A mixture of clayey silt, sand and gravel was encountered at the location of the existing Acres Road Overpass south approach. Fill material consisting of sand and gravel was encountered adjacent to the existing Graham Creek Culvert.

The boundaries between the various soil types, in situ and laboratory test results as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are also provided on Dwg. 1208710-A & 1208710-B. *

A detailed description of the subsurface conditions encountered is given below.

Fill Material

As mentioned above, fill material was encountered at two areas of the site and its composition varied at either location. A cohesive mixture of clayey silt, sand and gravel was sampled adjacent to the existing Acres Road Overpass (BH 7-3) which is the location of the proposed structure's west approach. Approximately 2.1 metres of stiff to very stiff fill material was encountered. Cohesionless sand and gravel fill material underlying a thin crust of clayey

* DWG NO 2 & 2 A OF THE CONTRACT DWG'S

silt, sand and gravel fill was encountered in the area of the existing Graham Creek culvert. This area is within the proposed structure's east approach. The fill penetrates to a depth of 6.6 metres.

Grain Size Distribution curves for the varying fill materials are provided in Figure 1 in the Appendix.

Silty Clay to Clay

The native surficial deposit spread across the site consists of a cohesive silty clay to clay ranging in thickness from 1.7 metres to 3.8 metres.

Atterberg Limit were obtained to evaluate the behaviour of this cohesive deposit and the results are plotted in Figure 2. A summary of the indices is provided in Table 1 & 2 below. Unit weights are also included:

Table 1 - Clay

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	32-48	40
Liquid Limit (w_L %)	51-65	57
Plastic Limit (I_p %)	30-45	37
Unit Weight (kN/m^3)	17.4-18.8	18.3

Table 2 - Silty Clay

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	35-48	40
Liquid Limit (w_L %)	35-45	40
Plastic Limit (w_p %)	19-29	25
Unit Weight (kN/m^3)	17.7-19.9	18.6

The test results reveal that the deposit varies randomly in plasticity ranging from intermediate (silty clay) to high (clay).

A grain size distribution envelope for this deposit as determined by mechanical analysis is given in Figure 3.

Undrained shear strengths of the soil were determined both by in situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of Boreholes in the Appendix and summarized in Table 3 below:

Table 3

Test Method	*Undrained Shear Strength (C _u) (kPa)	Sensitivity (S _e)
	Range	Range
Field Vane	70->120	2-5
Unconfined Compression	20-60	-
Undrained Unconsolidated	25-70	-

*Test data of similar soil from adjacent investigations (WP 120-87-06, 07, 08) incorporated in results.

Results reveal that the soil has a generally firm to stiff consistency and is of low to moderate sensitivity. It can be concluded from the results that the laboratory testing produced lower values attributable to disturbance induced during sampling and transportation. Consequently, shear strength values for design purposes can be safely assumed to be within the range of 60 to 70 kPa.

The results (e-log p curves) of two consolidation tests on representative samples obtained in the silty clay to clay deposit are shown in Figure 4. These tests indicated that this cohesive stratum has been preconsolidated in the past to an effective pressure ranging from 130 kPa to 220 kPa in excess of the existing effective overburden pressure.

Clayey Silt interbedded with Silty Sand

Underlying the native surficial deposit of silty clay to clay there exists a deposit of clayey silt interbedded with silty sand. This stratum extends to depths ranging from 4.6 metres to 10.7 metres below ground surface. The thickness of the stratum varies from 1.7 metres to 7.7 metres.

The major portion of the deposit may be described as cohesive clayey silt. Atterberg Limits were obtained to evaluate the soil's behaviour and the results are plotted in Figure 5. A summary of the indices is provided in Table 4 below. Unit weights are also included:

Table 4

	<u>Range</u>	<u>Avg.</u>
Water Content (w%)	25-45	32
Liquid Limit (w _L %)	21-34	27
Plastic Index (I _p %)	8-18	13
Liquid Index (I _L)	1.1-2.9	1.7
Unit Weight (kN/m ³)	16.6-18.4	17.8

The results reveal that the cohesive portion of the deposit is of low plasticity. In addition, the in-situ moisture contents generally exceed the liquid limit of the cohesive soil revealing that the soil is generally, very soft and of low shear strength.

A grain size distribution envelope for this deposit as determined by mechanical analyses is given in Figure 6.

Undrained shear strength measurements were determined both by in-situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of Boreholes in the Appendix and summarized in Table 5 below:

Table 5

Test Method	Undrained Shear Strength	Sensitivity
	(C _u) (kPa)	(S _t)
	Range	Range
Field Vane	44-100	3-7.5
Unconfined Compression	20-30	-
Undrained Unconsolidated	30-60	-

Due to the irregular nature of the deposit, that reveals numerous seams and layers of silty sand ranging in thickness from a few millimetres to 100 millimetres, interbedded within the clayey silt, the results provided in Table 5 are not necessary indicative of the shear strength of the clayey silt portion. In view of this consideration, the consistency of the clayey silt portion can be described as very soft to firm. The silty sand portion was generally very loose in relative density. For design purposes, an undrained shear strength of 40 kPa can be assumed for this stratum.

The results (e-log p curve) of a consolidation test on a representative sample of the clayey silt portion is shown in Figure 7. These tests indicted that the clayey silt has been preconsolidated in the past to an effective pressure some 230 kPa in excess of the existing effective overburden pressure.

Sand

Underlying the clayey silt with interbedded silty sand stratum is a deep deposit of cohesionless sand with traces of silt. The deposit ranges in thickness from 12.2 m to 20.2 m and contains minor variations in gravel content throughout its thickness. Generally, the deposit contains traces of gravel but at some locations, considerable gravel (in excess of 40%) was encountered. A grain size distribution envelope for this deposit is provided in Figure 8 in the Appendix.

The relative density of the cohesionless deposit varies from loose to very dense with 'N' values obtained from the Standard Penetration Test ranging from 2 blows/0.3 m to 104 blows/.15 m. Generally, the deposit is in a loose to compact state of condition in the upper portions and becomes increasing dense with depth.

Heterogeneous Mixture of Sand, Gravel and Boulders (Glacial Till)

Underlying the sand deposit at a depth ranging from 21.3 m to 24.8 m a heterogeneous mixture of sand, gravel and boulders of glacial origin is present. The thickness of this deposit ranges from 1.6 m to 4.0 m and rock coring techniques were required to penetrate this stratum.

The glacial till deposit is directly underlain by bedrock of the Gull River Formation and was proven at various locations by obtaining up to 2.6 metres of rock core samples. The bedrock consists of a silty dolostone which is a clastic sedimentary rock. Minor beds of sandstone and limestone were also found interbedded in the rock formation. Detailed descriptions of the rock are attached in the Appendix entitled "Description of Rock Core".

Core recoveries and rock quality designation (RQD) were determined in-situ and also in the laboratory to evaluate the competence and integrity of the rock. Rock recoveries varred between 38 and 100% while RQD's varied between 11 and 100%. Based on the results, the rock can be classified as medium strong to strong rock and predominantly unweathered.

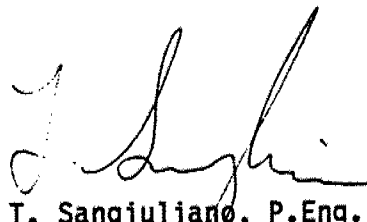
Groundwater Conditions

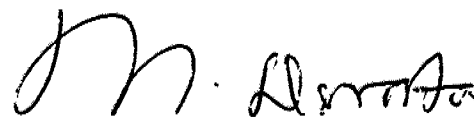
Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 60.5 m to 64.0 m which corresponds to depths of 1.8 m to 5.5 m below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of J. Fellenius, Student Engineer and T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Marathon Drilling and Johnston Drilling. The description of bedrock core samples was carried out by S. Senior, Geologist. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer.




T. Sangiuliano, P.Eng.
Foundation Engineer


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

APPENDIX

RECORD OF BOREHOLE No 7-2

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 636.1; E 358 305.4 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, B Casing Washbore & Cone Test COMPILED BY JBF/TS
 DATUM Geodetic DATE 88 07 20 - 21 CHECKED BY

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					
65.7	Ground Surface													
0.0	8cm Topsoil													
	Silty Clay to Clay		1	SS	19								18.8	0 3 42 55
	Soft to Hard		2	TW	PH								17.7	
	Grey													
			3	TW	PH								18.2	
61.7														
4.0	Clayey Silt		4	SS	3								18.4	0 0 55 45
	with interbedded													
	Silty Sand		5	SS	2								16.6	0 26 51 23
	V. Soft to Soft													
			6	SS	1									
55.0														
10.7	Sand with Gravel		7	SS	37									35 56 (9)
	V. Dense													
51.5			8	SS	51									
14.2	End of Borehole													
46.8														
18.9	End of Cone Test													

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-3

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 648.1; E 358 394.8 ORIGINATED BY JBF/TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Augers, Washbore & Cone Test COMPILED BY JBF/TS
 DATUM Geodetic DATE 88 07 20 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)			
66.6	Ground Surface													
0.0	Mix. of Clayey Silt Sand and Gravel Grey Stiff to Very Stiff (Fill)		1	SS	25		66							
64.5			2	SS	10									
2.1	Silty Clay to Clay Grey Very Soft to Stiff		3	TW	PH		64							
62.6			4	SS	3									
4.0	Clayey Silt with interbedded Silty Sand Soft to Stiff		5	TW	PH		62					19.0		
			6	SS	3		60							0 40 48 12
			7	SS	2		58							1 22 56 21
58.0			8	SS	20		56							8 74 (18)
8.6	Sand Trace of Silt Trace of Gravel Loose to Dense		9	SS	6		54							
			10	SS	23		52							
							50							
47.7	Some Gravel		11	SS	30		48							17 75 (8)
18.9	Het. Mixt. of Sand Gravel and Boulders (Glacial Till)		12	SS	90									44 52 (4)
46.3														
20.3	End of Borehole													

RECORD OF BOREHOLE No 7-9

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 765.3; E 358 681.4 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.7	Ground Surface										
0.0	Mixt. of Clayey Silt Sand and Gravel Grey					*					
63.7	Very Stiff		1	SS	17		64				3 49 30 18
2.0	Sand Some Gravel Brown Compact (Fill)		2	SS	10		62				
			3	SS	10		60				28 64 (8)
59.1			4	SS	14		58				
6.6	Sand Trace Silt Grey		5	SS	9		56				0 98 (2)
	Loose		6	SS	7		54				
	Compact to Dense		7	SS	45		52				0 96 (4)
			8	SS	20		50				
50.0			9	SS	15		48				
15.7	End of Borehole						46				
							44				
							42				
							40				
38.6											
27.1	End of Cone Test										
	* Water Level not Established										

*³, *⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7-10

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 771.4; E 358 729.2 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 22 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.9	Ground Surface										
0.0	Sand, Tr. Gravel					*					
65.0	Brown, Compact (Fill)										
0.9	Clayey Silt, Tr. Sand										
63.9	Brown, Stiff		1	SS	10		64				0 32 41 27
2.0	Sand		2	SS	15		62				5 66 17 12
	Trace of Silt		3	SS	60		60				28 61 (11)
	Trace of Gravel		4	SS	38		58				7 83 (10)
	Occ. Gravelly Zones		5	SS	30		56				1 91 (8)
	Compact to Very Dense		6	SS	30		54				
			7	SS	40						
53.2			8	SS	31						
12.7	End of Borehole										
	* Water Level not Established										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-11

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 711.9; E 358 484.4 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 18 CHECKED BY

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								WATER CONTENT (%)	GR SA SI CL		
								SHEAR STRENGTH kPa											
65.9	Ground Surface																		
0.0	Silty Caly Grey Firm to Stiff		1	SS	8								19.9	0 4 48 48					
			2	SS	3														
63.0			3	TW	PH								17.9	0 5 51 44					
2.9	Clayey Silt with interbedded Silty Sand		4	SS	3									0 11 53 36					
61.3	Soft		5	SS	2														
4.6			6	SS	2									0 42 37 21					
			7	SS	6														
	Sand		8	SS	4														
	Trace of Silt		9	SS	6									2 76 (22)					
	Trace of Gravel		10	SS	22														
	Loose to Compact		11	SS	85									0 90 (10)					
	Dense to V. Dense																		
			12	SS	50														
			13	SS	36									0 93 (7)					
41.5																			
24.4	Het. Mixt. of Sand, Gravel, Boulders (Glacial Till)		14	RC	REC	94%								ROD = 0					
			15	RC	REC	28%								RQD = 0					
39.4																			
26.5	Bedrock Silty Dolostone		16	RC	REC	38%								RQD = 11%					
			17	RC	REC	90%								RQD = 63%					
37.2																			
28.7	End of Borehole																		

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7-12

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 725.2; E 358 531.7 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 18 - 20 CHECKED BY

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					
65.8	Ground Surface													
0.0	Clayey Silt to Silty Clay		1	SS	6								19.0	
	Soft to Stiff		2	SS	4								18.0	0 8 61 31
	Grey		3	TW	PH			4.0						0 1 52 47
62.0			4	TW	PH									0 17 56 27
3.8	Clayey Silt with interbedded Silty Sand		5	SS	2			7.5						0 31 48 21
	V. Soft to Firm		6	SS	1									
56.7			7	SS	11									13 69 (18)
9.1	Sand		8	SS	64									0 97 (3)
	Trace of Silt		9	SS	13									
	Trace to some Gravel		10	SS	43									5 90 (5)
	Compact to V. Dense		11	SS	80									0 96 (4)
44.5			12	SS	56									
21.3	Het. Mixt. of Sand Gravel & Boulders (Glacial Till)		13	RC	REC 67%									RQD = 0
			14	RC	REC 37%									RQD = 0
			15	RC	REC 39%									RQD = 0
40.5			16	RC	REC 100%									RQD = 85%
25.3	Bedrock Silty dolostone													
39.0														
26.8	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-13

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 737.6; E 358 578.6 ORIGINATED BY TS
DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core, & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 07 20 -21 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	20 40 60	GR SA SI CL			
66.1	Ground Surface													
0.0	Topsoil						66						17.4	0 12 43 45
	Silty Clay to Clay		1	SS	5		64							0 5 55 40
	Firm to Stiff		2	TW	PH									
63.0														
3.1	Clayey Silt with interbedded Silty Sand		3	TW	PH		62	5.2						
	Soft to Firm		4	SS	2		60							
			5	SS	2									
58.5							58							
7.6			6	SS	60/7cm		56							3 80 (17)
	Sand		7	SS	13		54							
	Trace of Silt						52							
	Trace of Gravel						50							
	Occ. Gravel Zones		8	SS	20		48							
	Compact						46							
			9	SS	27		44							
							42							
41.7							40							
24.4	Het. Mixt. of Sand, Gravel & Boulders (Glacial Till)		12	SS	93									
40.1														
26.0	Bedrock		13	RC	REC 72%									RQD = 40%
38.6	Silty Dolostone		14	RC	REC 100%									RQD = 100%
27.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7-14

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 721.1; E 358 611.8 ORIGINATED BY JFB
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore & Cone Test COMPILED BY JFB
 DATUM Geodetic DATE 88 07 18 - 19 CHECKED BY

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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
66.0	Ground Surface												
0.0	Silty Clay		1	SS	8							19.7	0 11 44 45
64.3	Grey Firm		2	TW	PH								
1.7	Clayey Silt with interbedded Silty Sand		3	SS	2								0 20 55 25
61.4	Soft		4	SS	2								
4.6			5	SS	2								22 57 13 8
	Sand		6	SS	25								
	Trace of Silt		7	SS	29								21 73 (6)
	Trace to Some Gravel		8	SS	29								
	Compact to V. Dense		9	SS	51								0 99 (1)
			10	SS	24								28 64 (8)
			11	SS	57								
			12	SS	100								
			13	SS	80/10cm								0 99 (1)
41.2			14	SS	91								28 66 (6)
24.8	Het. Mixt. of Sand, Gravel & Boulders (Glacial Till)		15	RC	REC 44%								RQD = 0%
38.7	Bedrock		16	RC	REC 100%								RQD = 38%
27.3	Limestone Silty Dolostone		17	RC	REC 88%								RQD = 85%
36.1													
29.9	End of Borehole												

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

RECORD OF BOREHOLE No 7-15

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 706.4; E 358 575.0 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 18 ~ 19 CHECKED BY

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					
65.2	Ground Surface													
0.0	Silty Clay to Clay Soft to Firm Grey		1	SS	2		64						19.0	0 7 50 43
63.2			2	TW	PH								17.8	
2.0	Clayey Silt with interbedded Silty Sand Soft		3	SS	6		62							0 32 48 20
			4	SS	1									
			5	SS	1		60							
			6	SS	2									
			7	SS	1		58							0 54 28 18
56.1			8	SS	14		56							30 65 (5)
9.1	Sand Trace of Silt Trace to some Gravel Loose to Compact		9	SS	6		54							1 94 (5)
			10	RC	-		52							
			11	SS	18		50							
			12	SS	18		48							14 77 (9)
			13	SS	9		46							
41.7			14	RC	REC		44							
23.5	Het. Mixt. of Sand Gravel & Boulders (Glacial Till)		15	RC	REC	29%	42							RQD = 0
			16	RC	REC	58%	40							RQD = 0
39.0			17	RC	REC	100%								RQD = 0
26.2	Bedrock Silty Dolostone		18	RC	REC	78%	38							RQD = 70%
37.7														
27.5	End of Borehole													

+3, x⁵: Numbers refer to 20
Sensitivity 15-5 (%) STRAIN AT FAILURE
1C

RECORD OF BOREHOLE No 7-16

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 691.2; E 358 532.7 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE N-Casing, E-Casing, HS Auger, Washbore, Rock Core and Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 18 - 21 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							W _p W W _L		
								SHEAR STRENGTH kPa							WATER CONTENT (%)		
66.0	Ground Surface																
0.0	Silty Clay to Clay Grey Firm to Stiff		1	SS	15								18.4				
			2	SS	5									18.7	0 4 52 44		
63.0	Clayey Silt with Interbedded Silty Sand Very Soft to Firm		3	TW	PH												
3.0			4	TW	PH												
			5	TW	2										0 34 50 16		
			6	SS	2										0 37 46 17		
55.3	Sand Trace of Silt Some Gravel Dense to Very Dense		7	SS	40									28 58 (14)			
10.7			8	SS	52												
			9	SS	50										16 81 (3)		
			10	SS	104	15 cm									0 100 (0)		
			11	SS	59												
43.1	Het. Mixture of Sand, Gravel and Boulders (Glacial Till)		12	RC	REC	19%								RQD = 0%			
22.9			13	RC	REC	48%									RQD = 0%		
			14	RC	REC	86%									RQD = 0%		
			15	RC	REC	32%									RQD = 0%		
40.1	Bedrock Silty Dolostone		16	RC	REC	66%								RQD = 14%			
25.9			17	RC	REC	60%									RQD = 0%		
			18	RC	REC	100%									RQD = 7%		
37.8	End of Borehole																
28.2																	

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

OFFICE REPORT ON SOIL EXPLORATION

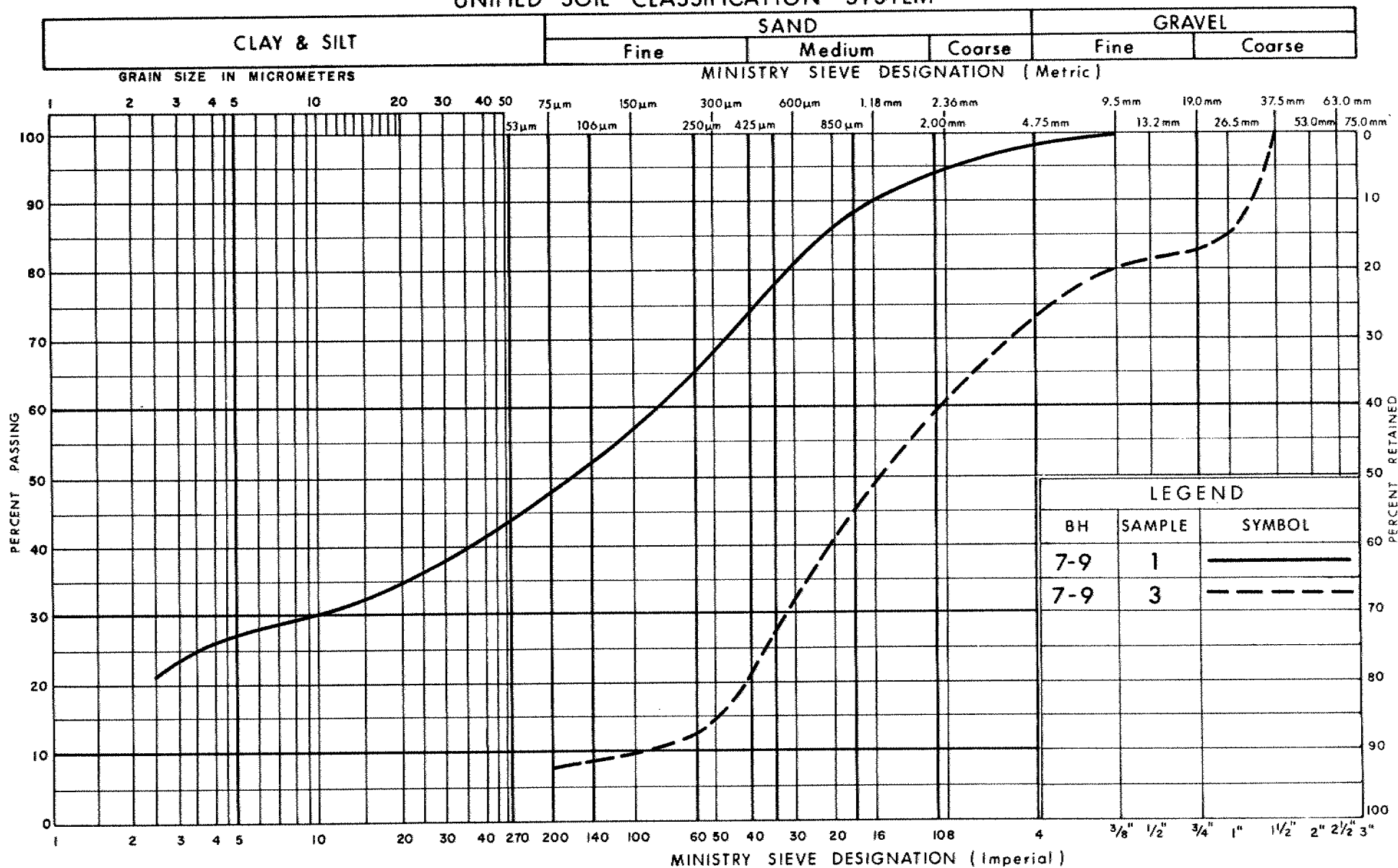
RECORD OF BOREHOLE No 14-2

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 758.9; E 358 645.1 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE Cone Test, H-S Auger, B-Casing, Washbore COMPILED BY TS
 DATUM Geodetic DATE 88 07 22-23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
65.6	Ground Surface										
0.0	Mixture of Clayey Silt, Sand and Gravel (Fill) Brown Compact		1	SS	18		64				2 72 19 7
			2	SS	15		62				6 70 20 4
60.6			3	SS	21		60				5 88 (7)
5.0			4	SS	5		58				4 90 (6)
			5	SS	12		56				1 90 (9)
			6	SS	23		54				1 90 (9)
			7	SS	25		52				0 91 (9)
			8	SS	19		50				
			9	SS	30		48				
			10	SS	55		46				
			11	SS	38		44				13 78 (9)
			12	SS	33		42				
			13	SS	32		40				
			14	SS	36		38				
			15	SS	97						
41.2			16	SS	54						
24.4	Het. Mixture of Sand, Gravel and Boulders (Glacial Till)		17	RC	REC	100%					RQD = 41%
39.1			18	RC	REC	95%					RQD = 64%
26.5	Bedrock Dolostone Unweathered										
37.9											
27.7	End of Borehole * Water Level Not Established Hole caved in at 2.1 m depth										

UNIFIED SOIL CLASSIFICATION SYSTEM

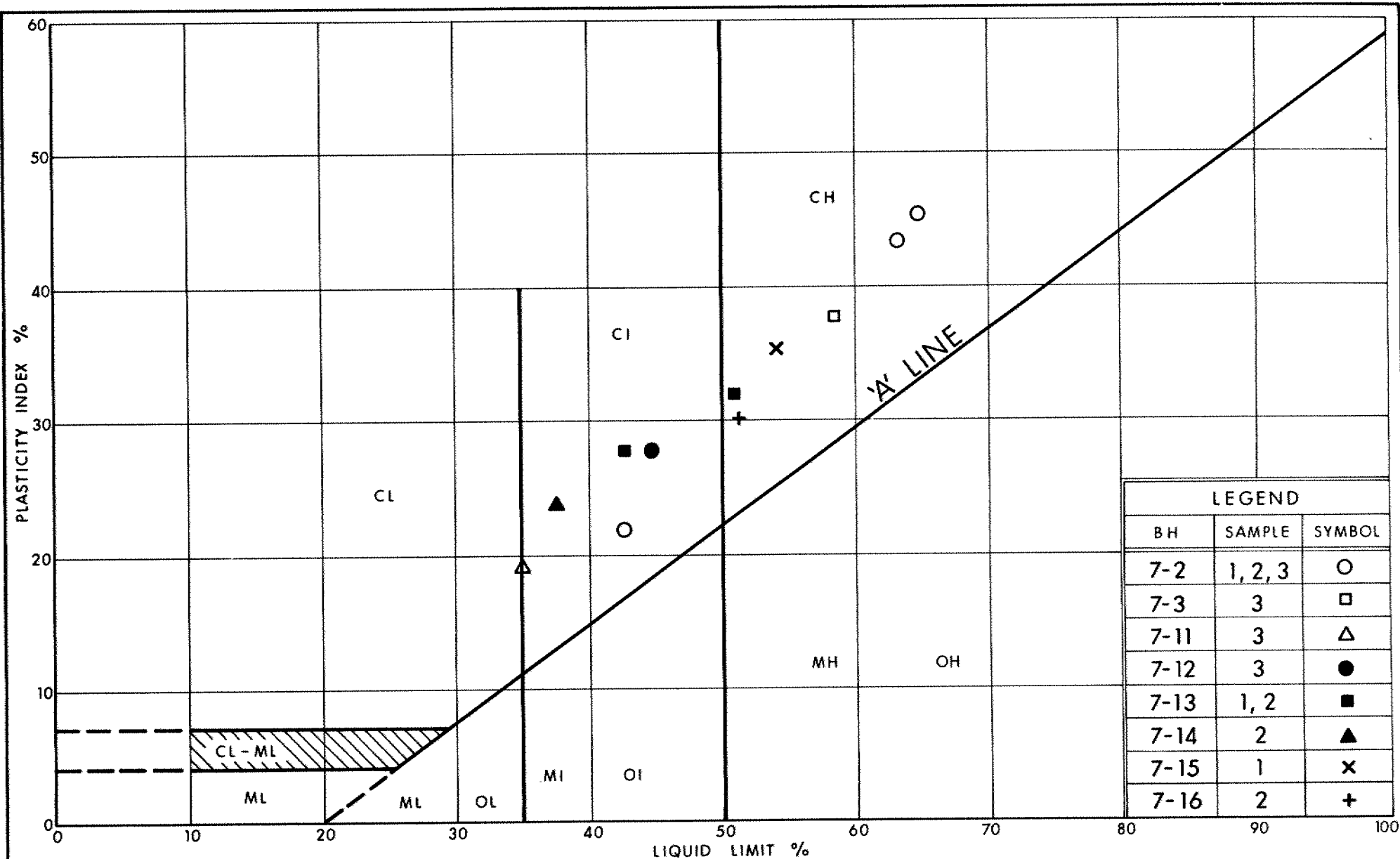


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Transportation

GRAIN SIZE DISTRIBUTION
MIXTURE OF CLAYEY SILT, SAND & GRAVEL /
SAND, SOME GRAVEL (Fill)

FIG No 1

W P 120-87-10



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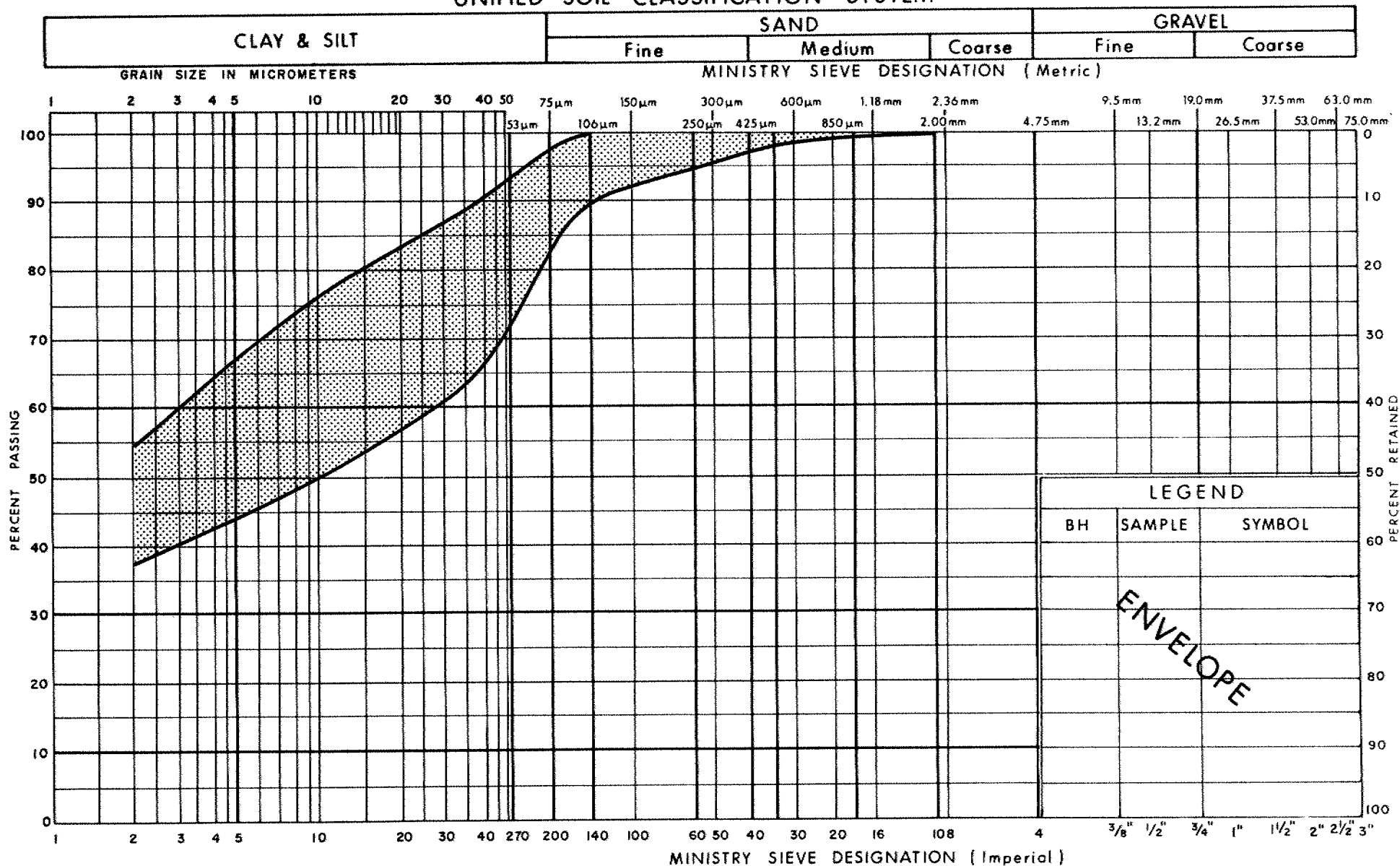
Ontario

PLASTICITY CHART SILTY CLAY TO CLAY

FIG No 2

W P 120-87-10

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY

FIG No 3

W P 120-87-10

VOID RATIO - PRESSURE CURVES

332

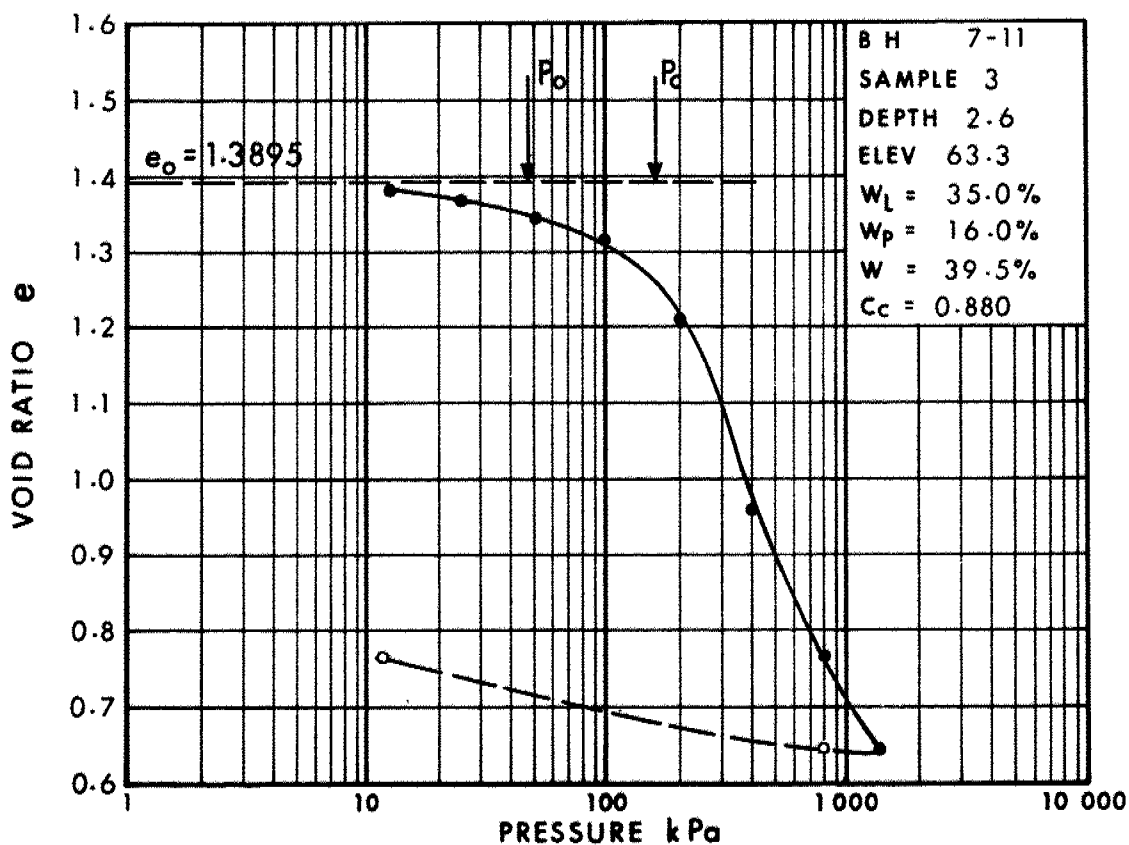
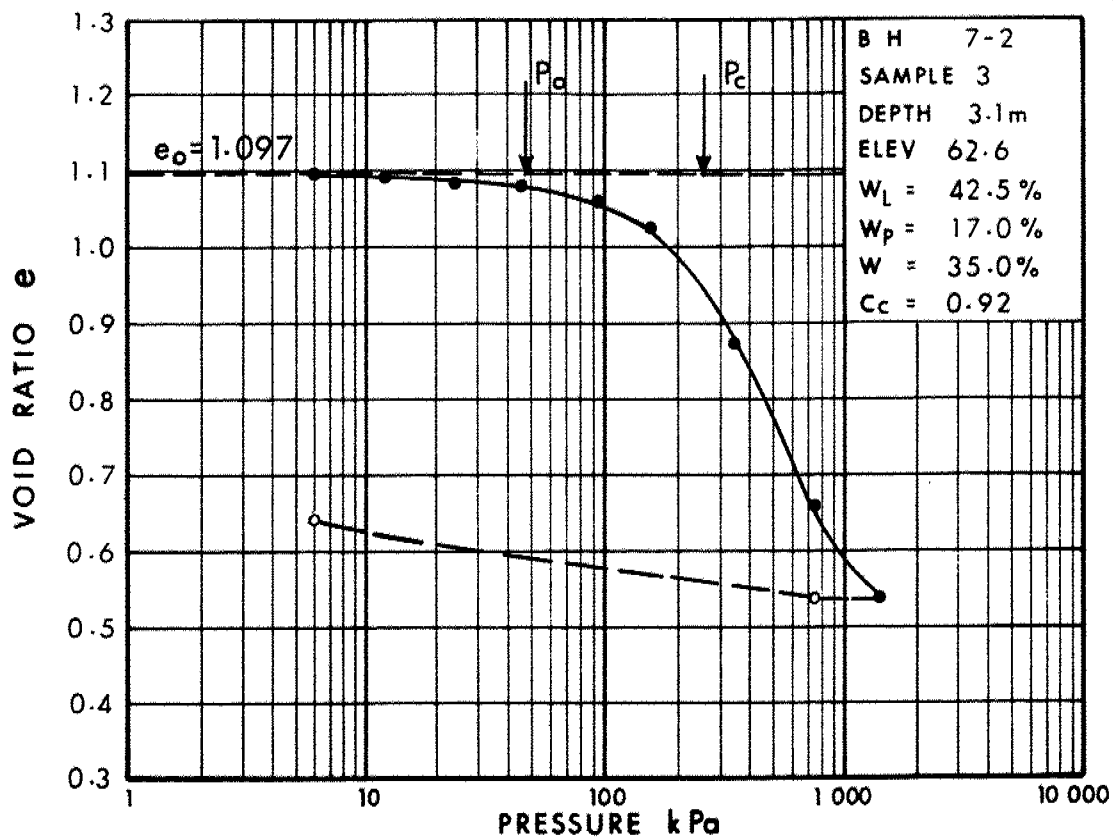
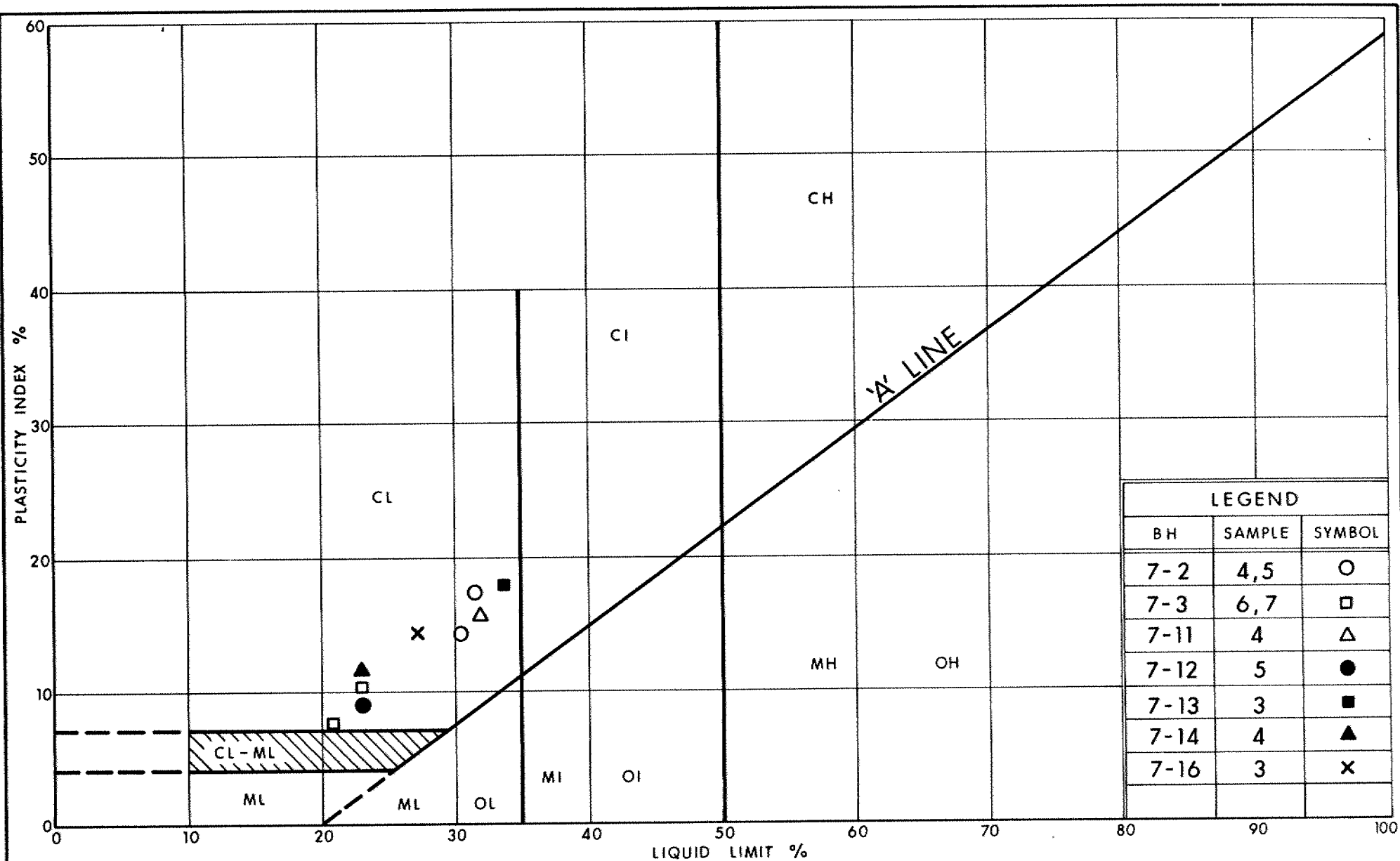


Fig 4

W P 120-87-10



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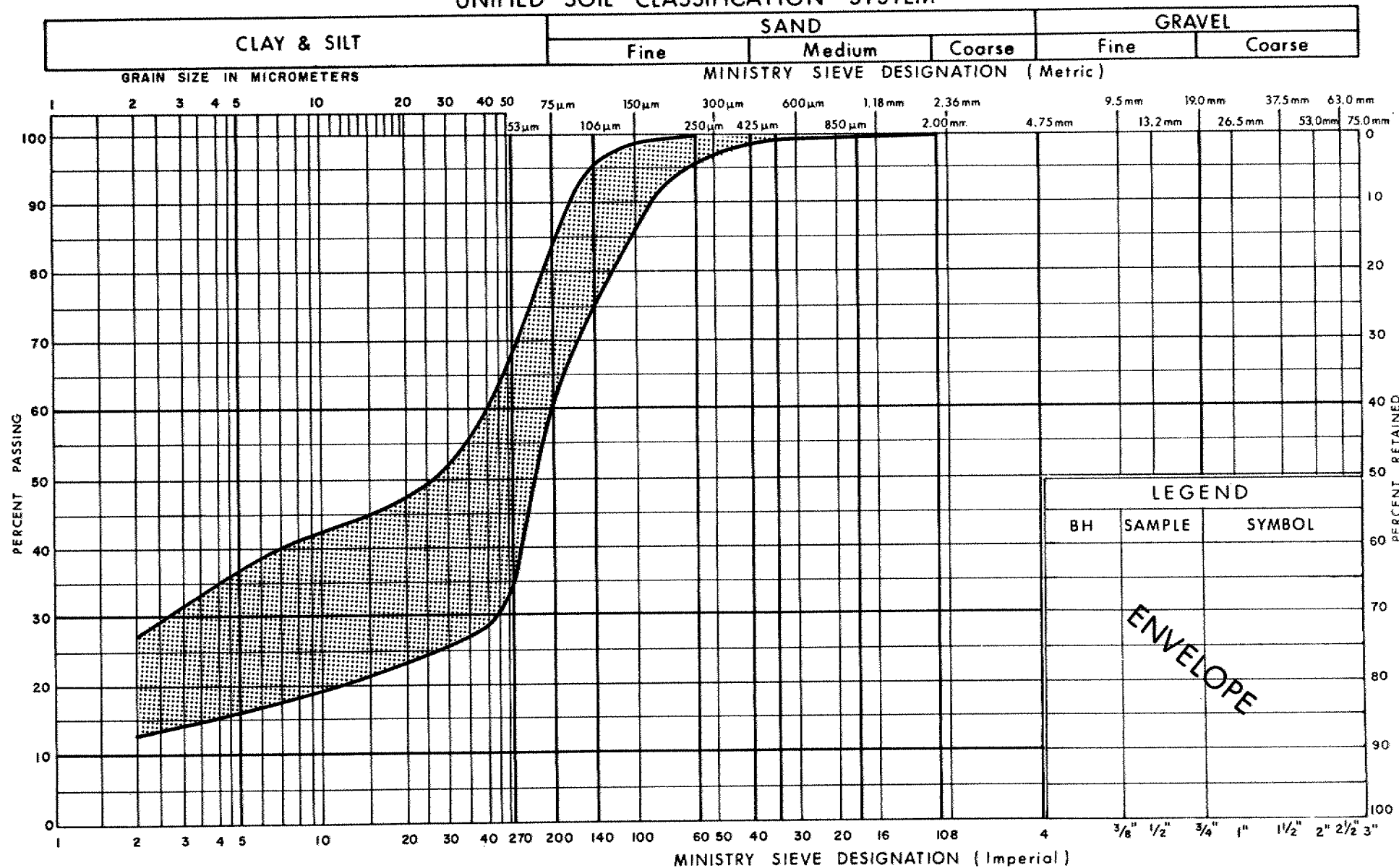
Ontario

PLASTICITY CHART CLAYEY SILT WITH INTERBEDDED SILTY SAND

FIG No 5

W P 120-87-10

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH INTERBEDDED SILTY SAND

FIG No 6

W P 120-87-10

VOID RATIO - PRESSURE CURVES

335

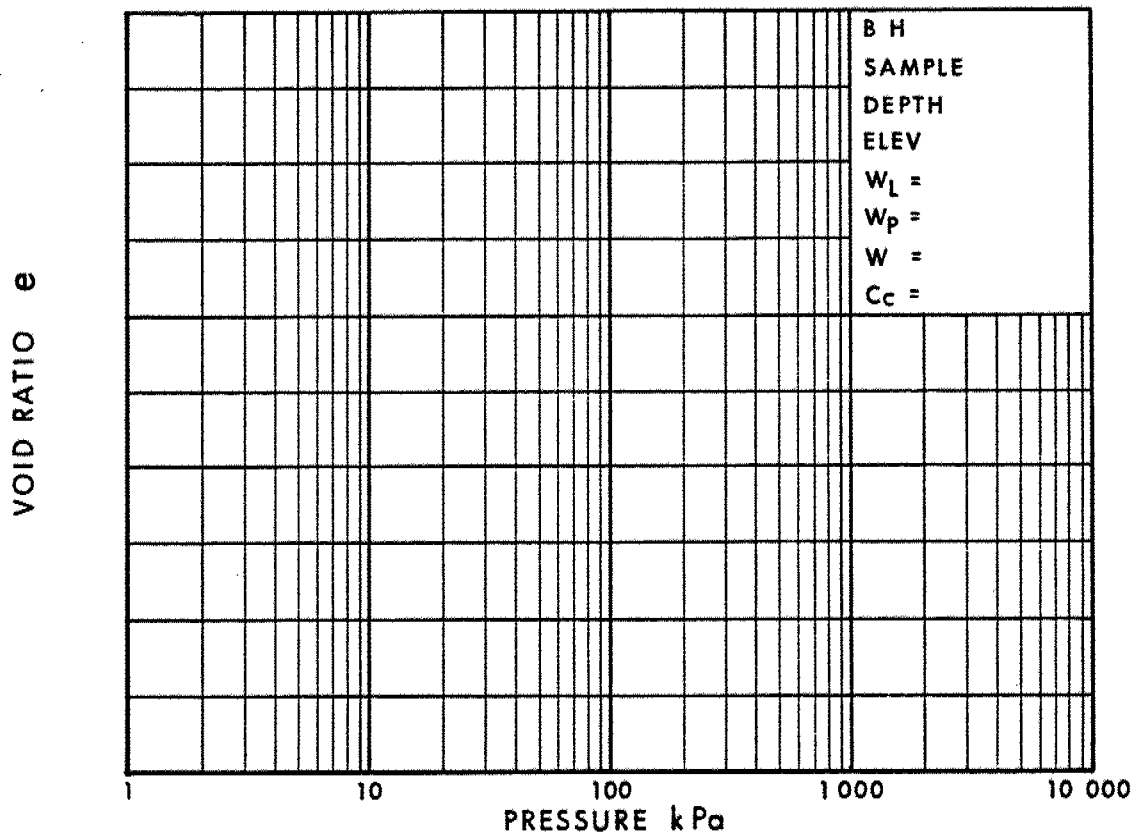
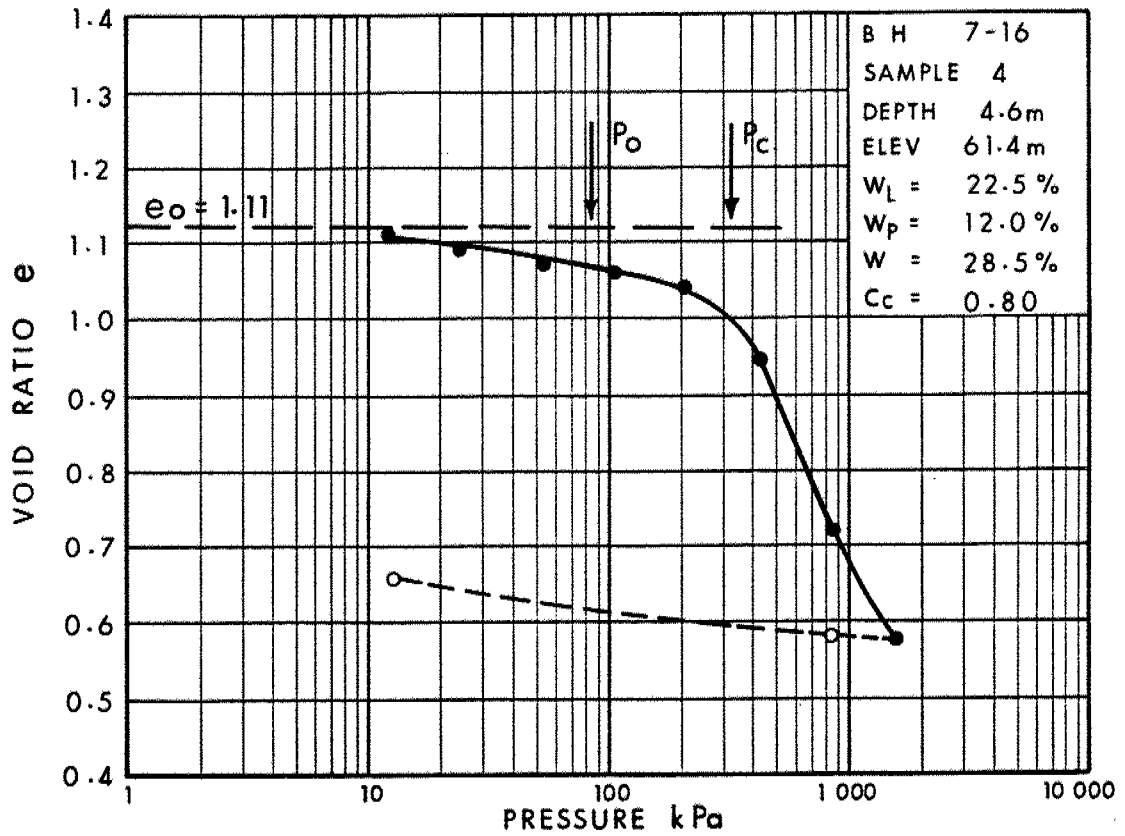
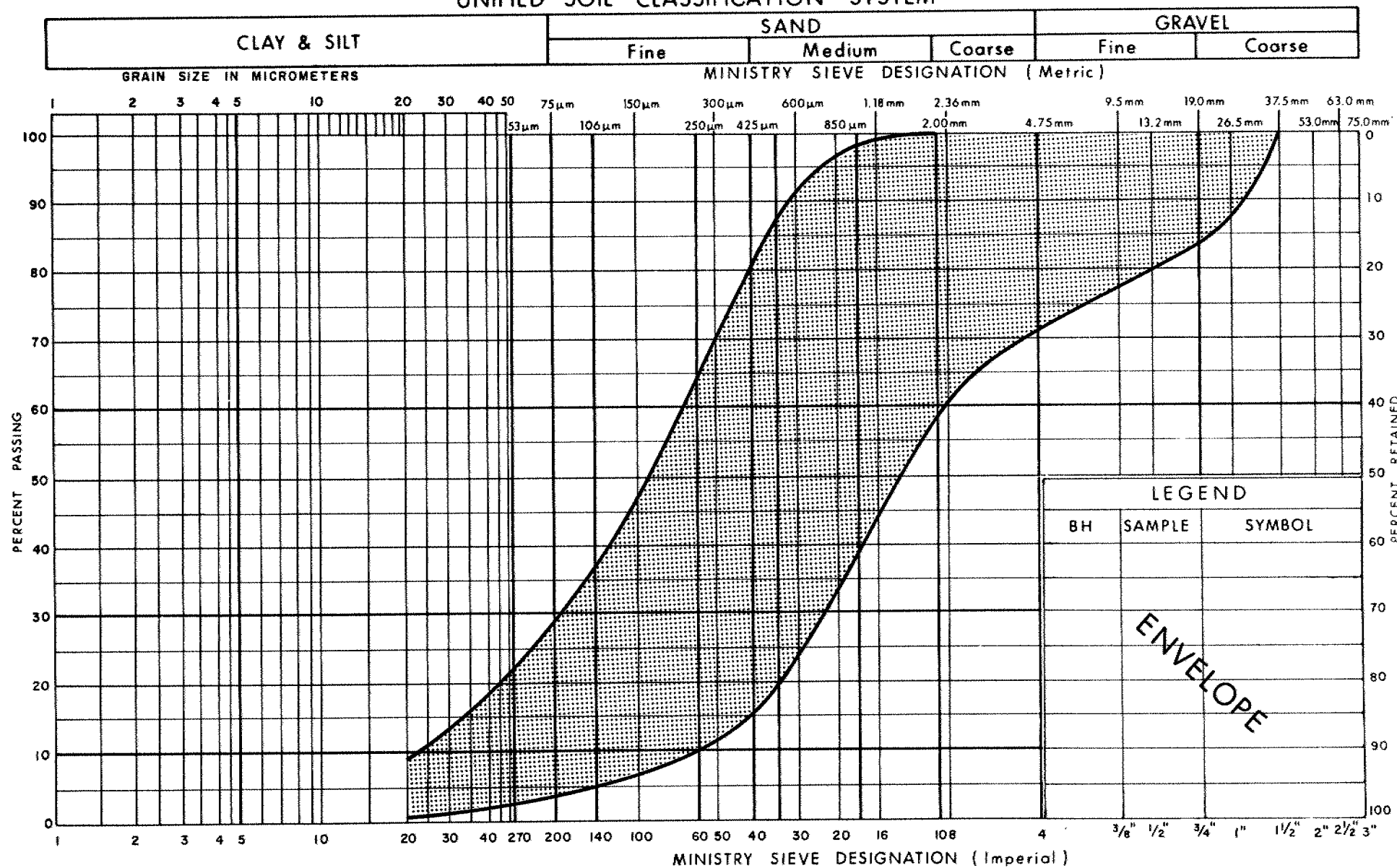


Fig 7

W P 120-87-10

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND, SOME GRAVEL

FIG No 8

W P 120-87-10



Ministry of
Transportation

Ontario

DESCRIPTION OF ROCK CORE - WP 120-87-10

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
7-11	24.38-24.84	94	-	24.38-26.50	OVERBURDEN, containing local and foreign rock material.
	28.84-26.16	28	-	26.50-26.67	LITHOGRAPHIC LIMESTONE, tan, medium light grey; extremely fine grained; very dense; strong to very strong rock; slightly weathered to unweathered; very closely spaced fractures: flat irregular.
	26.16-27.69	38	11		
	27.69-28.70	98	33	26.67-28.70	SILTY DOLOSTONE, medium dark grey, fine grained; medium strong to strong rock; slightly weathered to unweathered; very close to close spaced fractures: (i) flat, rough, slightly open; (ii) near vertical irregular, undulating, calcite filled, continuous; interbedded with SHALE (11%), greyish black; very fine grained; medium strong rock; slightly to moderately weathered. <u>NOTE</u> : Interbedded shale accounts for high core loss in this section.
7-12	22.23-22.91	67	-	22.23-25.30	OVERBURDEN, containing local and foreign rock material. Boulders up to 0.61 m diameter.
	22.91-23.88	37	-	25.30-26.82	SILTY DOLOSTONE, medium dark grey, fine grained; thinly bedded; medium strong to strong rock; slightly weathered to unweathered; close to moderately close spaced fractures: flat, rough, irregular; interbedded with SHALE (8%) up to 10 cm beds; minor SANDSTONE bed (2 cm) at 26.19 m.
	23.88-25.30	39	-		
	25.30-26.82	100	85		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

1../3

DESCRIPTION OF ROCK CORE - WP 120-87-10

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
7-13	25.60-26.72	72	40	25.60-26.04	OVERBURDEN, foreign and local rock material up to 5 cm diameter.
	26.72-27.50	100	100	26.04-27.50	SILTY DOLOSTONE, medium dark grey, fine grained; thinly bedded; medium strong to strong rock; slightly weathered to unweathered; close to moderately close spaced fractures: flat, rough, irregular; interbedded with SHALE (11%); minor SANDSTONE bed (2 cm) at 26.75 m (Correlates with BH 7-12).
7-14	26.06-27.74	44	-	26.06-27.33	OVERBURDEN, foreign (igneous and metamorphic) and local (carbonate) rock material.
	27.74-28.40	100	38	27.33-28.50	LIMESTONE, dark grey to greyish black; crystalline; medium strong rock; slightly weathered to unweathered; close to very close spaced fractures: flat, rough, closed, slightly altered, clay free.
	28.40-29.92	88	85	28.50-29.92	SILTY DOLOSTONE, medium dark grey, fine grained; thinly bedded; medium strong to strong rock; slightly weathered to unweathered; moderately close spaced fractures: flat, rough, slightly open, slightly altered clay free.

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

2../3

DESCRIPTION OF ROCK CORE - WP 120-87-10

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
7-15	23.47-24.49	50	-	23.47-26.15	OVERBURDEN , contains foreign and local rock material. Dolostone boulder up to 0.40 m diameter. Sand and gravel encountered in borehole from 25.65 - 26.15 m.
	24.49-24.84	29	-		
	24.84-25.45	58	-	26.15-27.48	SILTY DOLOSTONE , medium grey to medium light grey, spotted pink (dolomite), streaked white (calcite); medium to fine grained; medium strong rock; slightly weathered to unweathered; moderately close spaced fractures: flat, rough, open, slightly altered, clay free.
	25.45-25.65	100	-		
	25.65-27.48	78	70		
7-16	22.86-23.47	19	-	22.86-25.88	OVERBURDEN , contains foreign an locally derived bedrock material, up to 12 cm diameter.
	23.47-24.38	48	-		
	23.38-24.66	86	-	25.88-28.17	SILTY DOLOSTONE , medium grey; medium grained; medium strong rock; moderately weathered to unweathered, very close to close spaced fractures: flat (bedding joints), rough, undulating, slightly open, slightly altered, clay free, minor calcite mineralization.
	24.66-24.94	32	-		
	24.94-26.52	66	14		
	26.52-26.77	60	0		
	26.77-28.17	100	7		

NOTE: Depths are approximated in zones of poor core recovery.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

3../3

CONT. 90-36

MINISTRY OF TRANSPORTATION OF ONTARIO

GEOTECHNICAL INVESTIGATION

HWY 417/416 INTERCHANGE
HIGH MAST LIGHTING (HML)

WP 120-87-00

DIST 9

JACQUES, WHITFORD LIMITED

AUGUST 22, 1989

PROJECT NO. O-19350



Report

to

Ministry of Transportation of Ontario

on

Geotechnical Investigation

HWY 417/416 Interchange
High Mast Lighting (HML)

WP 120-87-00

DIST 9

Jacques, Whitford Limited

August 22, 1989

Project No. O-19350



MINISTRY OF TRANSPORTATION OF ONTARIO

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TABLE OF CONTENTS

	Page No.
1.0 INTRODUCTION	1
2.0 PROPOSED DEVELOPMENT	2
3.0 SCOPE OF WORK	2
4.0 PROCEDURE	3
4.1 Review of Existing Information.	3
4.2 Field Investigation	4
4.3 Survey.	5
4.4 Laboratory Testing.	6
5.0 RESULTS OF THE INVESTIGATION	7
5.1 Surface Conditions.	7
5.2 Subsurface Profile	7
5.3 Groundwater	11
6.0 DISCUSSION AND RECOMMENDATIONS	12
6.1 General	12
6.2 Soil and Bedrock Design Parameters.	12
6.3 Frost Effects	13
6.4 Soil Chemistry.	13
6.5 Presence of Bedrock	14
6.6 Construction Recommendations.	14
7.0 CLOSURE	15

APPENDIX 1

Explanation of Terms Used in Report

Record of Boreholes

Table 1 - Recommended Design Parameters at Proposed HML
Locations

APPENDIX 2

Selected Previous MTO Borehole Records

APPENDIX 3

Drawings 1208700 A, B, and C - Bore Hole Locations



1.0 INTRODUCTION

This report presents the results of a geotechnical investigation for the High Mast Lighting (HML) to be constructed at the proposed Highway 417 interchange at Highway 416. The proposed interchange is to be located in Nepean, Ontario at the existing Highway 417 between Richmond Road and Moodie Drive. The investigation was carried out in accordance with our proposal dated June 28, 1989. Authorization to carry out the work was provided by Mr. Murty Devata, P.Eng. of the Ministry of Transportation of Ontario (MTO) on July 7, 1989.

Two copies of the draft version of this report, dated August 3, 1989, were submitted for review to the MTO. The comments to the draft report were discussed during a meeting held at the MTO office on August 17, 1989. This report incorporates these comments and additional work carried out subsequent to the meeting.

This report has been prepared specifically and solely for the proposed High Mast Lighting project described herein. It contains all of our findings and includes geotechnical recommendations for the design and construction of the HML foundations.



2.0 PROPOSED DEVELOPMENT

The site is located at the intersection of Highway 417 and the proposed Highway 416 in the City of Nepean. It is understood that it is proposed to construct 34 High Mast Lights (HMLs C-1 to C-34, inclusive) at this intersection. The lights will be located along Highway 417 between Richmond Road and Moodie Drive and for a short distance south of Highway 417 along Highway 416.

The HML structures are understood to be about 30 metres high. Foundations for these structures will need to be designed to resist the overturning moments caused by wind loading on the structure. It is understood that depending upon the site subsurface conditions, the foundations typically consists of a single cast-in-place concrete pile or caisson.

3.0 SCOPE OF WORK

The scope of work for this investigation, as outlined in our June 28, 1989 letter of proposal, is as follows:

- To carry out a field drilling investigation to identify the subsurface soil and groundwater conditions at the proposed HML locations.
- To provide a comprehensive engineering report summarizing the results of the investigation and presenting the necessary soil parameters for the design of the foundations. It is understood that the actual foundation designs will be carried out by others.
- To provide recommendations for the construction of the foundations in light of the observed subsurface conditions.



4.0 PROCEDURE

4.1 Review of Existing Information

Prior to the onset of the field investigation, all known existing geological and geotechnical information was collected and reviewed. The following existing geotechnical profiles, illustrating borehole information, were obtained from the MTO Downsview office and reviewed:

- Dwg 1248701-A
- Dwg 1248703-A
- Dwg 1248705-A
- Dwg 1208706-A and -B
- Dwg 1208707-A
- Dwg 1208708-A
- Dwg 1208709-A
- Dwg 1208710-A and -B
- Profiles prepared for W.P. 120-87-04

The existing geotechnical/geological information suggests that the subsurface conditions at the proposed HML locations are not uniform. The overburden soils are generally Champlain Sea deltaic and marine deposits that consist of interbedded clays, silts and sands that overlie sand. The thickness of these materials are expected to range from zero metres to more than 30 metres. A layer of glacial till, likely of the Wisconsin age, is also noted at some locations. Bedrock is lower Ordovician in age and varies from the Nepean Formation sandstone at the western section of the site, to the sandstone and dolostone of the March Formation near the central sections to the shaly limestone of the Ottawa Formation at the eastern section.

Although the subsurface soils are not uniform, it was not necessary to drill a borehole at all HML locations. Existing information was used to provide an assessment of nearby HML locations not drilled. Furthermore, the proposed HML locations are sufficiently close to each other that some locations were skipped where the soil conditions between boreholes were found to be relatively uniform.



4.2 Field Investigation

Prior to the onset of the drilling investigation, the borehole locations were identified in the field. The necessary utility check clearances were obtained by members of our site personnel. Only one borehole (Borehole 89-12, located at HML C-17) needed to be relocated due to the presence of underground utilities. This borehole was shifted about 16 metres north of the actual location in order to avoid the newly constructed Watts Creek Sewage Pumping Station force main.

The field work for this investigation was carried out between July 11, and 15, 1989 under the full-time direction of Mr. R. Haché, P.Eng. of Jacques, Whitford Limited. A total of 20 boreholes, (numbered 89-1 to 89-13, 89-15, 89-16, 89-18 to 89-20, 89-22 and 89-24) and four (4) Dynamic Cone Penetration Holes (numbered 89-14, 89-17, 89-21 and 89-23) were put down at or near the proposed HML locations.

The test locations and all proposed HML sites are indicated on Drawings No. 1208700 A, B, and C, provided in Appendix 3. The corresponding HML number is plotted beside each test location where boreholes or Penetration Tests were carried out. In addition, the drawings show the locations of selected previous MTO boreholes that were used to infer the soil stratigraphy at HML locations not tested. Although other boreholes were drilled within the limits of this site, only those referenced in this report are shown on the drawings. These other Borehole Records are available at the MTO office.

The boreholes and cone tests were put down to depths ranging from 3.8 to 12.5 metres beneath the existing ground surface using both truck mounted and track mounted CME power auger drills suitably equipped for soil and bedrock sampling and testing. The boreholes were advanced in soil using hollow-stem augers and in bedrock using BX core equipment. Boreholes and cone tests were extended at least 10 m into overburden or to bedrock. Bedrock was proven by coring in the boreholes and inferred by refusal at the cone test locations.



The soils were sampled in most boreholes at nominal one metre spacings by conducting Standard Penetration Tests. Three (3) open-ended Shelby tube samples were also obtained to further define the soil stratigraphy at critical locations. An estimate of the shearing strength of cohesive soil deposits was obtained by conducting pocket penetrometer tests on all cohesive samples and by conducting insitu vane shear tests at selected depths in Boreholes 89-6, 89-9, 89-10, 89-11, 89-13, 89-15, 89-16, 89-19, 89-20, 89-22 and 89-24.

Bedrock was proven by coring in Boreholes 89-1, 89-3, 89-15, 89-16, 89-18 to 89-20 and 89-22. The retrieved core was immediately logged in the field by our experienced site personnel and stored in core boxes.

All soil samples recovered were stored in moisture-proof bags and were sent to our laboratory with the bedrock samples for detailed classification and testing.

Standpipe piezometers were installed in all boreholes prior to backfilling. All boreholes were carefully backfilled to the ground surface using soil cuttings. Imported granular materials were also used for backfilling the boreholes where the soil cuttings were insufficient.

Dynamic Cone Penetration Tests were carried out without augering and sampling at the four test locations noted above. Dynamic Cone Penetration Tests were also performed within (or adjacent to) selected auger borehole locations to further define the overburden characteristics or to determine the depth to inferred bedrock.

4.3 Survey

The proposed HML locations were surveyed in plan and elevation by MTO staff prior to the onset of the field investigation. Any boreholes not put down at the exact HML locations were surveyed by our field personnel.



4.4 Laboratory Testing

To identify the behaviour and properties of the soil and bedrock samples collected during the field investigation, the following laboratory testing was carried out:

1. Detailed visual description.
2. Natural moisture content testing.
3. Gradation sieve and hydrometer testing.
4. Atterberg Limit testing.
5. Specific gravity testing.
6. Volumetric unit weight testing of soil and bedrock.
7. Point load testing of bedrock.

Samples remaining after testing will be stored for a period of three months after issuance of this report. They will then be discarded unless we are directed otherwise.



5.0 RESULTS OF THE INVESTIGATION

5.1 Surface Conditions

The topography of the area is generally flat to undulating at the proposed HML locations. The maximum change in ground surface between all boreholes drilled was 4.7 metres.

Most of the HML locations are located within the grassed median between the existing Highway 417 eastbound and westbound lanes. The remaining boreholes are located on either side of the Highway 417 lanes in grassed or treed areas. Some of the HMLs are located outside of the existing highway right-of-way in open or farmed fields.

Drainage of the site is generally provided by the highway ditches that are connected to the existing creeks. It is noted that some of the proposed HMLs are located within or adjacent to these ditches.

5.2 Subsurface Profile

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records provided in Appendix 1. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix 1.

A layer of rootmat, consisting of grass, topsoil and rootlets was observed immediately beneath the ground surface at all borehole locations. The thickness of the rootmat was observed to range from between 100 and 300 mm at the borehole locations.

As previously mentioned, the subsurface soil conditions at this site are not uniform and are therefore difficult to generalize. A brief discussion of the observed subsurface conditions is provided below. However, the Borehole Records should be used to determine the soil conditions at a particular location.



5.2.1 Fill

Fill materials were observed at some borehole locations. The fill characteristics vary depending upon location and proximity to existing roadways.

At Boreholes 89-1, 89-3 and 89-4, the fill was observed to consist mostly of very loose to compact, sand and silt to clayey sand. The thickness of this fill ranges from 1.4 to 5.5 metres. Organics were observed in some locations of this fill.

At Borehole 89-7, a loose sand and clay fill material of 0.7 metres in thickness was observed.

Firm to very stiff clay fill is present in several of the boreholes drilled within the grassed median at the west end of the site (Boreholes 89-16, 89-18, and 89-22). Where observed, the thickness of this clay fill varies from 1.1 to 2.2 metres. Roots and cobbles were noted at some locations within the clay fill.

5.2.2 Silty Clay

The most predominate overburden stratum observed in the boreholes drilled during this investigation is a silty clay material that contains interbedded layers, lenses and seams of silt and sand. This material was noted in all boreholes except Boreholes 89-1, 89-2, 89-3, 89-5 and 89-18.

This material has been defined as a silty clay due to its cohesive nature. However, it is noted that the silty clay has frequent interbedded sand and silt layers, particularly in the upper portion of the soils that were drilled at the eastern section of the site. It also becomes quite silty with depth. Grain size tests carried out on the silty clay indicate that there is no gravel in this material and the sand content varies from 2% to 43%.

The thickness of the silty clay ranges from 1.3 metres to 11 metres at the borehole locations. At most locations, the upper two (2) to three (3) metres of this material is weathered and relatively stiffer than the underlying material.



The results of laboratory testing of the silty clay are provided on the Borehole Records and are summarized below:

<u>Property</u>	<u>Range</u>	<u>#Tests</u>	<u>Average</u>
Moisture Content (%)	18 - 59	49	33
Liquid Limit (%)	23 - 34	4	28
Plastic Limit (%)	9 - 19	4	15
Plasticity Index (%)	12 - 15	4	14
Specific Gravity	2.77 - 2.78	2	2.78
Unit Weight (kN/m ³)	17.5 - 18.0	3	17.7
C _u - Field Vane (kPa)	32 - 92	19	68
Sensitivity	2 - 16	15	7

Based on the above testing and visual identification, this material can generally be classified as an inorganic, silty clay with intermediate to low plasticity. The soil has generally a firm to stiff consistency with a low to high sensitivity.

5.2.3 Sand/Silty Sand

A sand layer was noted at Boreholes 89-1, 89-2, and Boreholes 89-4 to 89-12 inclusive, and Borehole 89-14. This sand material was observed to underlie the silty clay material described above where the silty clay was noted. Otherwise the sand was overlain by rootmat or fill. With the exception of Borehole 89-10, where the thickness of the sand is only one (1) metre, the above noted boreholes were terminated in the sand.

This deposit can generally be described as a medium to coarse sand with a trace to some silt and gravel. Cobbles were encountered within the sand at some locations. The sand is a non-cohesive material. The density of the sand varies from loose to dense based on "N" values, and is typically compact.

5.2.4 Glacial Till

A layer of glacial till was encountered beneath the silty clay at Boreholes 89-15 to 89-17, and Boreholes 89-20 to 89-23 inclusive. The deposit ranges in thickness from 0.6 to 1.7 metres at the borehole locations.



The till consists of a clayey sand with some gravel. No boulders were encountered in the till at these test locations. The behaviour of the till is expected to be that of a non-cohesive nature. The density of the till is compact on the basis of "N" values.

5.2.5 Bedrock

Bedrock was confirmed by coring in Boreholes 89-1, 89-3, 89-15, 89-16, 89-18, 89-19, 89-20 and 89-22. The depth to bedrock from the existing ground surface ranges from 1.2 to 7.9 metres in these boreholes. Inferred bedrock was encountered by augering and/or penetration testing at depths of between 3.8 and 11.0 metres at Boreholes 89-10, 89-14, 89-17, 89-21, 89-23, and 89-24.

Detailed visual identification of the bedrock cores suggests they consist of shale with lenses of sandstone, likely of the Ottawa Formation at Boreholes 89-1 and 89-3, and consist of sandstone and dolostone, probably of the March Formation at Borehole 89-15. The bedrock encountered at Borehole 89-16 and west of this point consists of sandstone, likely of the Nepean Formation.

The results of point load strength tests carried out on selected core samples are summarized on the Borehole Records. The point load tests were carried out diametrically on BX size rock cores. Due to the horizontal bedding present in the shale and in the sandstone/sandy dolomite encountered, the point load test results are likely to be affected by horizontal planes of weakness. The more homogeneous sandstone encountered in Boreholes 89-16 to 89-22 are less likely to be influenced by planes of weakness. Due to the nature of the test, the results are considered to be a lower bound. The results suggest that the uniaxial compressive strength of the bedrock (q_u) ranges between 26 and 153 MPa.

Core recoveries varied from between 70% and 100% with an average of 96%. Rock Quality Designations (RQD) varied from 0% to 100% with an average value of 68%. Lower RQD values were generally noted in the upper one (1) metre of the bedrock.



5.3 Groundwater

Groundwater level observations within standpipes were read several days after installation on July 22, 1989. These readings are provided on the Borehole Records.

Groundwater was observed in every standpipe at a depth below existing ground surface that varied between 1.1 and 5.5 metres. The elevation of the groundwater level ranged from 60.9 to 65.8 metres Geodetic.

Fluctuations in the groundwater levels due to seasonal variations or in response to a particular precipitation event should be anticipated.



6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

The design of the foundations for the proposed HML structures at this site will need to take into account the variable soil and bedrock conditions as discussed in Section 5 above. As previously mentioned, the foundation for these structures typically consists of a single cast-in-place concrete pile or caisson depending upon the site subsurface conditions.

Recommendations for the soil parameters to be used for design of the foundations are discussed in Section 6.2. Further discussions to be considered during the design of the foundations are provided in Sections 6.3 to 6.5. Recommendations for the construction of the foundations in light of the observed subsurface conditions are provided in Section 6.6.

6.2 Soil and Bedrock Design Parameters

The results of the field and laboratory investigation described herein have been utilized to designate soil parameters to be used in the design of the HML foundations. These parameters are provided on Table 1 in Appendix 1.

Overburden soils at this site have been characterized as cohesive or non-cohesive in nature and have been assigned an appropriate unconfined compressive strength, (q_u), or angle of internal friction (ϕ), respectively. Uniaxial compressive strength values (q_u), have been determined for the bedrock materials. Unit weight values for both the overburden and the bedrock materials have also been identified.

Due to the variability of the subsurface conditions, Table 1 has been prepared which summarizes the recommended parameters for each individual HML location. This table has been prepared based on the borehole information obtained from both this investigation and previous investigations. When using this table, the following should be considered:

1. The recommended parameters have been provided for design purposes only. Actual soil conditions at locations where the soil stratigraphy has been inferred from previous investigations may differ from what has been assumed.

2. The unit weights provided on Table 1 are saturated bulk unit weights and should be reduced by 9.81 kN/m^3 below the groundwater table. Groundwater levels provided on the Borehole Records may be used as a preliminary estimate of the groundwater table. However, it is recommended that the standpipes installed during this investigation continue to be monitored to identify the groundwater seasonal fluctuations.
3. The soil and bedrock parameters provided on Table 1 represent ultimate values and will need to be factored during design in accordance with the O.H.B.D.C..

6.3 Frost Effects

A frost penetration depth of 1.8 metres should be used for the foundation design of the HML structures.

6.4 Soil Chemistry

A selected number of soil samples were submitted to Bondar-Clegg Laboratories in Ottawa for soluble sulphate and chloride testing. The results of these tests are summarized below:

<u>Borehole</u>	<u>HML</u>	<u>Depth (m)</u>	<u>Soluble Sulphates (ppm)</u>	<u>Chlorides (ppm)</u>	<u>Degree of Attack</u>
89-2	C-3	3.2	230	61	Negligible
89-8	C-11	5.0	313	89	Negligible
89-10	C-14	6.4	214	64	Negligible
89-11	C-16	4.9	444	39	Negligible
89-15	C-23	1.7	683	116	Negligible
89-19	C-29	3.2	444	30	Negligible

These results suggest that although these chemicals are present, no special precautions are necessary in the type of cement chosen or in the protection of the reinforcing bars.



6.5 Presence of Bedrock

As previously mentioned in Section 5.2.5, bedrock was encountered at some boreholes at depths as shallow as 1.2 metres from the ground surface. It is therefore possible that caisson foundations may not be practical at some locations where bedrock is too close to the ground surface.

The use of grouted anchors may be an alternate foundation solution at these locations. For anchor design, it is recommended that at least the upper one (1) metre of the bedrock surface be neglected when calculating pull-out resistance due to the fractured nature of the upper weathered bedrock.

A preliminary estimate of the bond resistance of anchors grouted in bedrock can be obtained by using the recommended q_u values provided in Table 1 and typical correlations provided in the literature. Our firm would be pleased to provide assistance with the design of the anchors if it is desired.

6.6 Construction Recommendations

Open holes drilled within both the sand and the clay overburden materials at this site are not expected to remain open for any period of time, particularly for the sections drilled beneath the groundwater table. Consequently, the use of casing or slurry stabilization techniques would likely be required if cast-in-place concrete caissons are used for this project.

Concrete placement below the groundwater table will likely need to be placed by tremie techniques to avoid concrete segregation and cement washout.

Upon completion of the foundation installation, it is recommended that the ground surface surrounding the HML structure be graded so to prevent surface water from ponding at the structure.



7.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when your drawings and specifications are complete. We would be very pleased to assist you with the preparation of the tender package or any design aspects if it is required.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

We trust the above information meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

We thank you for the opportunity to be of service to you.

Yours very truly,

JACQUES, WHITFORD LIMITED



A handwritten signature in black ink, appearing to read "J.G.A. Raymond Haché".

J.G.A. Raymond Haché, M.Sc.Eng.



A handwritten signature in black ink, appearing to read "Gordon J. Kack".

Gordon J. Kack, M.E.Sc., P.Eng.



APPENDIX 1

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'_{v0}	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_f	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 89-1

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,910.0; E 359,479.0 (HML C-1) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							SHEAR STRENGTH kPa	WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
68.0	Ground Surface													GR SA SI CL		
0.0	Fill, Sand and Silt trace organics: Brownish grey		1	SS	5		67						25.1	31 28(41)		
66.6	Loose															
1.4	Sandy, Gravelly, Silt to Sand, traces of silt and gravel. Light grey		2	SS	9		66									
	Loose to dense		3	SS	40		65									
63.2		4	SS	20/15cm		64										
4.8	Bedrock Shale with lenses of Sandstone. Grey to light grey Very poor to good	5	RC BX	REC 94%		63										
		6	RC BX	REC 100%		62										
		7	RC BX	REC 96%		61										
60.2														RQD=54%		
7.8	End of Borehole *q _u (MPa) obtained from point load test.															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-2

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,818.0; E 359,232.0 (HML C-3) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
66.0	Ground Surface												
0.0	Sandy, Clayey, Silt												
	Brownish grey												
	Compact		1	SS	10								
64.5													
1.5	Sand, trace silt.												
	Grey												
	Loose		2	SS	6								
			3	SS	5								
			4	SS	5								
			5	SS	7								
			6	SS	8								
			7	SS	6								
56.2													
9.8	End of Borehole												
	Inferred Sand												
54.6													
11.4	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-3

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,023,067.0; E 359,363.0 (HML C-4) ORIGINATED BY R.H.
 DIST 9 HWY 417 3 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100						SHEAR STRENGTH kPa
70.2	Ground Surface													
0.0	Fill, Clayey Sand, trace gravel. Brownish grey Very loose to compact		1	SS	10									
			2	SS	7									
			3	SS	3									
			4	SS	17									
64.7	Bedrock Shale with lenses of Sandstone. Grey to light grey Fair		5	RC REC BX 100%									RQD=51%	
5.5			6	RC REC BX 96%									* (69) RQD=72%	
62.1	8.1 End of Borehole													
	*q _u (MPa) obtained from point load test.													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-4

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,890.0; E 359,174.0 (HML C-5) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
67.6	Ground Surface																
0.0	Silty Sand, some gravel; FILL.																
	Dark grey		1	SS	26		67										
	Very loose to Compact		2	SS	2		66										
64.9							65										
2.7	Silty Clay, some sand.		3	SS	4		64										
	Grey stiff																
63.6																	
4.0	Sand, trace silt, trace to some gravel.		4	SS	11		63										
	Grey to greyish brown						62										
	Loose to compact						61										
	-cobble 4.0m to 4.6m		5	SS	14		60										
	5.0m to 6.1m						59										
	-Clayey silt zone at 7.8m		6	SS	5		58										
			7	SS	11												
57.8																	
9.8	End of Borehole																



METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,797.0; E 359,092.0 (HML C-6) ORIGINATED BY R.H.
DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 89-6

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,658.0; E 359,071.0 (HML C-7) ORIGINATED BY R.H.
 DIST 9 HWY417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 12, 1989 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	1					
66.4	Ground Surface												
0.0													
	Sand and Clay. Brown Very stiff		1	SS	16								
			2	SS	4								
			3	SS	6								
62.3													
4.1	Silty Clay, interbedded with sandy silt. Grey Firm to Stiff		4	SS	1								
			5	SS	1								
59.1													
7.3	Sand, trace silt and gravel. Grey Dense		6	SS	32								
			7	SS	55								
56.7													
9.7	End of Borehole Inferred Sand												
55.7													
10.7	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-7

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,737.0; E 358,823.0 (HML C-9) ORIGINATED BY R.H.
DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

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					
66.4	Ground Surface													
0.0	Fill, Sand and Clay.													
65.7	Brown Loose													
0.7			1	SS	11									
	Brown --- Grey		2	SS	4									
			3	SS	2									
	Silty Clay, interbedded sandy silt.		4	SS	2									
	Firm to stiff		5	SS	2									
			6	SS	2									
56.8			7	SS	5									
56.6	*													
9.8	End of Borehole													
	Inferred Sand													
53.9														
12.5	End of Cone Test													
	*Sand, trace gravel													
	Grey													
	Loose													

RECORD OF BOREHOLE No 89-8

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,793.0; E 358,653.0 (HML C-11) ORIGINATED BY R.H.
 DIST 9 HWY 417 3 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 12, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
65.9	Ground Surface																
0.0	Silty Clay, some to trace sand.																
	Greyish brown		1	SS	11												
64.5	Stiff																
1.4			2	SS	11												
			3	SS	6												
	Sand, trace silt and gravel.																
	Loose to dense																
			4	SS	23												
			5	SS	24												
	Brown																
	Grey		6	SS	38												
			7	SS	47												
56.1																	
9.8	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-9

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,685.0; E 358,328.0 (HML C-13) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								20 40 60 80 100							20 40 60				
65.5	Ground Surface							20 40 60 80 100	20 40 60										
0.0																			
			1	SS	4														
	Greyish brown																		
	Grey																		
	Silty Clay, interbedded with sandy silt.		2	SS	2									0 4 33 43					
	Stiff																		
			3	SS	2														
			4	SS	1									0 43(57)					
			5	SS	3														
			6	SS	5														
55.7	End of Borehole																		
9.8	Inferred Silty Clay																		
54.5																			
11.0	Inferred Sand																		
53.5																			
12.0	End of Cone Test																		

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-10

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,641.0; E 358,176.0 (HML C-14) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

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					
65.8	Ground Surface													
0.0														
	Clayey Silt, interbedded with sandy silt.		1	SS	2									
	Grey													
	Stiff		2	TW	PH									
			3	SS	4									
			4	SS	2									
			5	SS	5									
57.7														
8.1	Silty Sand, trace gravel.													
	Grey													
56.7	Compact		6	SS	50/0cm									
9.1	End of Borehole (Split spoon refusal on possible bedrock)													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 89-11

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,525.0; E 358,637.0 (HML C-16) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
66.5	Ground Surface														
0.0	Silty Clay, interbedded with sandy silt. Greyish brown Very stiff		1	SS	8		66								
			2	SS	4		65								
							64								
			3	SS	1		63								
	Silty Clay, interbedded with sandy silt. Grey Firm to stiff		4	SS	1		62								
							61								
			5	SS	1		60								
59.2							59								
7.3	Sand, trace to some silt, trace gravel. Grey Compact		6	SS	22		58								
							57								
56.7			7	SS	16										
9.8	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-12

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,536.0; E 358,476.5 (HML C-17) ORIGINATED BY R.H.
DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L	WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
66.3	Ground Surface												GR SA SI CL
0.0	Silty Clay, interbedded with sandy silt.						66						
	Greyish brown		1	SS	15		65						
	Very stiff to stiff		2	SS	4								
							64						
	Silty Clay, interbedded with sandy silt.						63						
	Grey		3	SS	1		62						
	Firm						61						
61.1			4	SS	1		60						
5.2	Sand, trace silt.						59						
	Grey						58						
	Compact to dense		5	SS	15		57						
	-cobbles and gravel from 5.5m to 5.8m		6	SS	14								
			7	SS	50								
56.5													
9.8	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-13

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,537.0; E 357,805.0 (HML C-21) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
66.7	Ground Surface													
0.0	Silty Clay, interbedded with sandy silt. Grey Stiff		1	SS	5									
			2	SS	2									
			3	SS	2									
			4	SS	2									
			5	SS	2									
			6	SS	3									
56.9	End of Borehole													
9.8														

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-14

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,507.0; E 357,656.0 (HML C-22) ORIGINATED BY R.H.
DIST 9 HWY 417 @ 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
66.2	Ground Surface												
0.0	Inferred Silty clay.												
60.3													
5.9	Inferred Sand												
59.0													
7.2	End of Dynamic Cone Penetration Test (Cone Refusal on inferred Bedrock)							100/0 cm					

OFFICE REPORT ON SOIL EXPLORATION



METRIC

W P 120-87-00 LOCATION Co-Ords. N 5,022,471.0; E 357,512.0 (HML C-23) ORIGINATED BY K.C.
DIST 9 HWY 417 Q 416 BOREHOLE TYPE Hollow Stem Augers, BX Rock Core COMPILED BY R.H.
DATUM Geodetic DATE July 12, 1989 CHECKED BY G.J.K.

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 89-16

METRIC

W P 120-87-00 LOCATION Co-ords. N 5,022,387.0; E 357,225.0 (HML C-25) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 11, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W _p W W _L	20 40 60	20 40 60		
66.8	Ground Surface												
0.0	Fill, Clay, trace debris. Brown Firm		1	SS	17								
65.7													
1.1	Silty Clay, interbedded with sandy silt. Grey Stiff		2	SS	10								0 2 (98)
63.4			3	SS	13								8 48 (44)
3.4	Clayey Sand, some gravel; Till. Grey Compact		4	SS	20								
61.8													
5.0	Bedrock Sandstone Light grey Fair to excellent		5	RC BX	REC 97%								RQD=64%
			6	RC BX	REC 100%								RQD=100%
			7	RC BX	REC 100%								RQD=100% *(153)
59.0													
7.8	End of Borehole *q _u (MPa) obtained from point load test.												

+³, x⁵: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 89-17

METRIC

W P 120-87-00 LOCATION Co-Ords. N 5,022,345.0; E 357,082.0 (HML C-26) ORIGINATED BY R.H.
DIST 9 HWY 417 G 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
66.4	Ground Surface										
0.0	Inferred Silty Clay.						66				
63.1							65				
3.3	Inferred Till						64				
62.6							63				
3.8	End of Dynamic Cone Penetration Test (Refusal on inferred Bedrock)										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-18

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,305.0; E 356,938.0 (HML C-27) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

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					
66.1	Ground Surface												
0.0	Fill, Silty Clay. Brown												
64.9	Firm												
1.2	Bedrock												
	Sandstone		1	RC	REC								RQD=80%
	Light grey			BX	89%								
	Good to excellent.		2	RC	REC								RQD=100%
				BX	100%								
			3	RC	REC								RQD=100%
				BX	100%								*(83)
61.8													
4.3	End of Borehole												
	*qu(MPa) obtained from point load test.												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-19

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,215.0; E 356,693.0 (HML C-29) ORIGINATED BY K.C.
DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
65.7	Ground Surface									
0.0	Silty Clay, interbedded with sandy silt.		1	SS	3					
	Grey		2	SS	2					
	Stiff		3	SS	37					
61.9										
3.8	Bedrock		4	RC BX	REC 94%					RQD=65 %
	Sandstone									
	Light grey		5	RC BX	REC 91%					RQD=83 %
	Fair to good									
59.1										
6.6	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-20

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,142.0; E 356,566.0 (HML C-30) ORIGINATED BY K.C.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 13, 1989 CHECKED BY G.J.K.

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									
								20 40 60 80 100									
66.2	Ground Surface																
0.0	Silty Clay, interbedded with Sandy Silt.		1	SS	3												
			2	SS	2												
			3	TW	PH												
			4	SS	2												
60.0	Till, Clayey Sand, some gravel. Grey compact		5	SS	9												
6.2			6	SS	12/7												
58.3	Bedrock Sandstone Light grey		7	RC REC BX 100%													
7.9			8	RC REC BX 90%													
56.4	Poor to Fair																
9.8	End of Borehole																
	*q _u (MPa) obtained from point load test.																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-21

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,249.0; E 356,534.0 (HML C-31) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
66.7	Ground Surface													
0.0														
	Inferred Silty Clay.													
60.6														
6.1	Inferred Till.													
59.7														
7.0	End of Cone Test (Cone Penetration Test refusal on inferred Bedrock)													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 89-22

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,022,252.0; E 356,405.0 (HML C-32) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger, BX Rock Core COMPILED BY R.H.
 DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80					
68.2	Ground Surface															
0.0	Fill, silty clay, trace roots, to silt and sand, occasional cobbles		1	SS	11											
	Brown to dark grey															
	Very stiff		2	SS	15											
66.0																
2.2	Silty Clay, interbedded with sandy silt.		3	SS	2											
	Grey															
	Firm to stiff		4	SS	3											
62.4																
5.8	Clayey sand; some gravel; Till		5	SS	17											
	Grey Compact															
61.4																
6.8	Bedrock		6	RC BX	REC 85%											
	Sandstone															
	Light grey															
	Fair to good		7	RC BX	REC 100%											
58.4																
9.8	End of Borehole															
	*q _u (MPa) obtained from point load test.															

+3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 89-23

METRIC

W P 120-87-00 LOCATION Co-ords N 5,022,031.0; E 356,466.1 (HML C-33) ORIGINATED BY R.H.
 DIST 9 HWY 417 @ 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY R.H.
 DATUM Geodetic DATE July 15, 1989 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
69.0 0.0	Ground Surface											
	Inferred Silty Clay.											
59.8 9.2	Inferred Till											
59.0 10.0	End of Dynamic Cone Penetration Test (Refusal on inferred Bedrock)						(100/0 cm)					

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 89-24

METRIC

W P 120-87-00 LOCATION Co-Ords N 5,021,883.1; E 356,479.0 (HML C-34) ORIGINATED BY R.H.
DIST 9 HWY 417 @ 416 BOREHOLE TYPE Hollow Stem Auger; Dynamic Cone COMPILED BY R.H.
DATUM Geodetic DATE July 14, 1989 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT Wl WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES							
68.0	Ground Surface											
0.0												
	Silty Clay, interbedded with sandy silt.		1	SS	10		67					
			2	SS	4		66					
	Greyish brown Grey		3	SS	1		65					
			4	SS	1		64					
			5	SS	1		63					
			6	SS	1		62					
			7	SS	1		61					
58.2	End of Borehole						60					
9.8	Inferred Silty Clay						59					
57.0							58					
11.0	End of Cone Test											
	(Dynamic Cone refusal on inferred Bedrock)											

Table 1

**RECOMMENDED DESIGN PARAMETERS AT PROPOSED
HML LOCATIONS**

(Refer to report for notes regarding use of this table)

HML	Nearest Borehole	Geodetic Elevation (m)	w^* (kN/m ³)	<u>Overburden</u>		<u>Bed- Rock</u> q_u (MPa)
				q_u (kPa)	ϕ	
C-1	89-1	68.0 - 66.6	19.0	0	30	30
		66.6 - 63.2	20.0	0	32	
		63.2 - 60.2	25.1			
C-2	MTO 6B/89-3	67.1 - 65	19.5	0	30	50
		below 65	25.1			
C-3	89-2	66.0 - 54.6	19.5	0	30	30
C-4	89-3	70.2 - 64.7	19.5	0	30	
		64.7 - 62.1	25.1			
C-5	89-4	67.6 - 64.9	19.0	0	30	
		64.9 - 63.6	18.0	120	0	
		63.6 - 57.8	19.5	0	30	
C-6	89-5	65.8 - 63.0	19.5	0	30	
		63.0 - 56.0	20.0	0	31	
C-7	89-6	66.4 - 62.3	19.5	200	0	
		62.3 - 59.1	17.0	100	0	
		59.1 - 55.7	20.0	0	35	
C-8	89-5/7	66.6 - 62	18.0	100	0	
		below 62	19.5	0	31	
C-9	89-7	66.4 - 56.8	18.0	100	0	
		56.8 - 53.9	19.5	0	31	
C-10	MTO 4-5	65.1 - 54	19.5	0	30	
		below 54	20.0	0	35	
C-11	89-8	65.9 - 64.5	18.5	120	0	
		64.5 - 61.0	19.5	0	29	
		61.0 - 56.1	20.0	0	33	

* w is the saturated unit weight



Table 1 (continued)

(Refer to report for notes regarding use of this table)

HML	Nearest Borehole	Geodetic Elevation (m)	w (kN/m ³)	Overburden		Bed-Rock qu (MPa)
				qu (kPa)	Ø	
C-12	MTO 7-11	65.4 - 61	18.0	100	0	
		61 - 50.5	19.5	0	30	
		below 50.5	20.0	0	35	
C-13	89-9	65.5 - 54.5	18.0	120	0	
		54.5 - 53.5	20.0	0	32	
C-14	89-10	65.8 - 57.7	17.5	150	0	
		57.7 - 56.7	20.0	0	32	
C-15	MTO 3-1/4-2	66.3 - 61	17.5	100	0	
		61 - 50.7	20.0	0	32	
C-16	89-11	66.5 - 64.0	19.0	200	0	
		64.0 - 59.2	18.0	150	0	
		59.2 - 56.7	20.0	0	32	
C-17	89-12	65.9 - 64	19.0	200	0	
		64 - 61	17.5	100	0	
		61 - 56.5	19.5	0	31	
C-18	MTO 5	64.7 - 64 below 64	18.0 25.1	150	0	50
C-19	MTO 8	66.1 - 60	18.5	100	0	
		60 - 58.5	20.0	0	38	
		below 58.8	25.1			50
C-20	MTO 9	66.0 - 57.5 below 57.5	18.0 25.1	120	0	50
C-21	89-13	66.7 - 56.9	18.0	130	0	
C-22	89-14	66.2 - 60.3	18.0	100	0	
		60.3 - 59.0	19.5	0	30	
		below 59.0	25.1			50
C-23	89-15	66.6 - 62.2	18.0	90	0	
		62.2 - 61.6	20.0	0	35	
		below 61.6	23.7			50



Table 1 (continued)

(Refer to report for notes regarding use of this table)

HML	Nearest Borehole	Geodetic Elevation (m)	w (kN/m ³)	<u>Overburden</u>		<u>Bed-Rock</u> Qu (MPa)
				Qu (kPa)	Ø	
C-24	89-15/16	66.5 - 62.5	18.0	90	0	50
		62.5 - 61.5	19.5	0	35	
		below 61.5	25.0			
C-25	89-16	66.8 - 63.4	18.0	120	0	50
		63.4 - 61.8	19.5	0	35	
		below 61.8	25.4			
C-26	89-17	66.4 - 63.1	18.0	100	0	50
		63.1 - 62.6	19.5	0	35	
		below 62.6	25.3			
C-27	89-18	66.1 - 64.9	18.0	100	0	50
		below 64.9	25.2			
C-28	89-18/19	65.6 - 63	18.0	100	0	50
		below 63	25.2			
C-29	89-19	65.7 - 61.9	18.0	120	0	50
		below 61.9	25.2			
C-30	89-20	66.2 - 60.0	18.0	80	0	50
		60.0 - 58.3	20.0	0	35	
		below 58.3	24.7			
C-31	89-21	66.7 - 60.6	18.0	80	0	50
		60.6 - 59.7	20.0	0	35	
		below 59.7	25.2			
C-32	89-22	68.2 - 66.0	19.0	200	0	50
		66.0 - 62.4	18.0	80	0	
		62.4 - 61.4	20.0	0	35	
		below 61.4	25.4			
C-33	89-23	69.0 - 59.8	18.0	100	0	50
		59.8 - 59.0	20.0		35	
		below 59.0	25.4			
C-34	89-24	68.0 - 57.0	18.0	120	0	50
		below 57.0	25.4			



APPENDIX 2

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No 68

METRIC

W P 124-87-01 LOCATION Co-Ords N 5022 887.8; E 359235.6 ORIGINATED BY MS
 DIST 9 HWY 417 BOREHOLE TYPE H-S Auger, BX Rock Core COMPILED BY MS
 DATUM Geodetic DATE 88 08 05 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
67.8	Ground Surface																
0.0	Sand and Gravel (Fill)					*											
66.6																	
1.2	Bedrock		1	RC	REC	76%	66									RQD = 0%	
65.4	Sandstone		2	RC	REC	65%										RQD = 0%	
2.4	END OF BOREHOLE																
	* Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4-5

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 687.7; E 358 702.6 ORIGINATED BY BJBF/TCK
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washbore, Rock Core, Cone Test COMPILED BY JB
 DATUM Geodetic DATE 88 07 09-11 CHECKED BY TCK

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
65.0	Ground Level									
0.0	Clayey Silt (Fill)	⊗	1	CS	-					
64.4			2	SS	12					0 37 38 25
0.6			3	SS	15					2 63 19 16
			4	SS	5					
			5	SS	5					
	Silty Sand to									
	Sand		6	SS	2					
	Trace of Gravel									
	Occ. Silt Seams		7	SS	4					1 95 (4)
	Brown Grey									
	Very loose to Very		8	SS	38					
	Dense									
			9	SS	31					
			10	SS	34					
			11	SS	55					
41.9										
23.1	Het. Mixture of Sand,	⊗	12	RC	-					
	Gravel and Boulders		13	SS	73/	13cm				58 36 (6)
	Very Dense		14	RC	29%					
	(Glacial Till)		15	RC	11%					
38.7										
26.3	Bedrock	⊗	16	RC	REC/	100%				RQD = 35%
37.6	Silty Dolostone	⊗	17	RC	REC/	100%				RQD = 94%
27.4	END OF BOREHOLE									

RECORD OF BOREHOLE No 4-2

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 603.6; E 358 595.4 ORIGINATED BY JBF
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washboring, Cone Test COMPILED BY JBF
 DATUM Geodetic DATE 88 07 14-15 CHECKED BY TCK

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y 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					
66.3	Ground Level												
0.0	Silty Clay to Clayey Silt Some Sand <u>Brown</u> Soft to Stiff <u>Grey</u>		1	SS	13							18.4	0 19 23 58
63.8			2	TW	PH								
2.5	Clayey Silt with interbedded sandy silt		3	SS	2								0 22 31 47
60.7			4	TW	PH								0 18 46 36
5.6	Soft to Firm												
	Silty Sand to Sand some to trace of Gravel		5	SS	*								
			6	SS	10								
	Very loose to Dense		7	SS	19								
			8	SS	35								6 69 17 8
52.4													
13.9	Het mixture of Sand, Gravel and Boulders												
50.6	Dense (Glacial Till)		9	SS	36								
15.7	END OF BOREHOLE												
	* Weight of Rods												

RECORD OF BOREHOLE No 3-1

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 619.2; E 358 552.6 ORIGINATED BY JF
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY JF
 DATUM Geodetic DATE 88 07 15 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
66.3	Ground Level											
0.0	Silty Clay to Clayey Silt, Some Sand	Brown Grey	1	SS	15		66					
64.2	Soft to Stiff		2	TW	PH		64				17.9	0 22 43 35
2.1	Clayey Silt with interbedded Sandy Silt		3	SS	2							
62.3	Soft to Firm		4	SS	4		62					0 34 48 18
4.0			5	SS	25		60					
	Silty Sand to Sand Some/Trace of Gravel Compact to Dense		6	SS	24		58					16 81 3 0
			7	SS	20		56					
			8	SS	41		54					
52.4							52					
13.9	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) V. Dense		9	SS	55/15cm							30 57 (13)
50.8												
15.5	End of Borehole											

RECORD OF BOREHOLE No 7-11

METRIC

W P 120-87-10 LOCATION Co-ords. N 5 022 711.9; E 358 484.4 ORIGINATED BY TS
 DIST 9 HWY 416/417 BOREHOLE TYPE H.S. Auger, B-Casing, Washbore, Rock Core & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 07 18 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

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			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								UNCONFINED								FIELD VANE		QUICK TRIAXIAL	
							20	40	60	80	100	20	40	60	GR	SA	SI	CL	
65.9	Ground Surface																		
0.0	Silty Caly Grey Firm to Stiff		1	SS	8								19.9	0 4 48 48					
			2	SS	3														
63.0			3	TW	PH								17.9	0 5 51 44					
2.9	Clayey Silt with interbedded Silty Sand		4	SS	3									0 11 53 36					
61.3	Soft		5	SS	2														
4.6	Sand Trace of Silt Trace of Gravel		6	SS	2									0 42 37 21					
			7	SS	6														
			8	SS	4														
			9	SS	6									2 76 (22)					
			10	SS	22														
	Loose to Compact Dense to V. Dense		11	SS	85									0 90 (10)					
			12	SS	50														
			13	SS	36									0 93 (7)					
41.5																			
24.4	Het. Mixt. of Sand, Gravel, Boulders (Glacial Till)		14	RC	REC	94%												ROD = 0	
			15	RC	REC	28%												RQD = 0	
39.4	Bedrock Silty Dolostone		16	RC	REC	38%												RQD = 11%	
26.5			17	RC	REC	90%												RQD = 63%	
37.2																			
28.7	End of Borehole																		

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 485; E 358 270 ORIGINATED BY RP
DIST 9 HWY 417 BOREHOLE TYPE Nx Rock Core COMPILED BY KJ
DATUM Geodetic DATE September 13, 1988 CHECKED BY MT

[illegible]

+3, x5: Numbers refer to Sensitivity

15 ϕ 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 553; E 358 080 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY KJ
 DATUM Geodetic DATE September 14, 1988 CHECKED BY MT

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			SHEAR STRENGTH kPa							WATER CONTENT (%)					
								20	40						60	80	100	20	40	60
66.1	Ground Level																			
65.9	Topsoil		1	SS	10															
0.2	Silty Clay, some sand, occasional sand partings		2	SS	8															
	Firm to Very Stiff Brown becoming grey at approximately 64.7m		3	SS	2															
64.3	Clayey Silt, with interbedded silty sand and sandy silt layers																			
1.8	Firm to Very Stiff grey		4	TW	PH															
			5	TW	PH															
			6	TW	PH															
60.0	Sandy Silt, some gravel, trace clay		7	SS	54															
6.1	Very Dense Grey																			
58.8	(Glacial Till)																			
7.3	End of Borehole Auger Refusal on probable bedrock																			

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 120-87-04 LOCATION Co-ordinates N 5 022 560; E 358 000 ORIGINATED BY RP
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Augers, Cone Test COMPILED BY KJ
 DATUM Geodetic DATE September 14, 1988 CHECKED BY MT

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					
66.0	Ground Level																
65.8	Topsoil																
0.2	Silty Clay, ---: some sand, occasional sand partings		1	SS	12		Seal							0			
	Firm to Very Stiff		2	SS	6		65							0			
64.2	Brown becoming grey at approximately 64.5m		3	SS	1									0			
1.8	Clayey Silt, with interbedded sandy silt and silty sand layers		4	TW	PH									0		23.3	0 20 53 27
	Firm to Very Stiff grey		5	SS	2									0			
			6	SS	2		Sept 14/88							0			
			7	TW	PH									0		23.5	
			8	SS	1		Water level Oct 1/88							0			
57.5																	
8.5	End of Borehole Auger Refusal on probable bedrock																

OFFICE REPORT ON SOIL EXPLORATION

APPENDIX 3

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

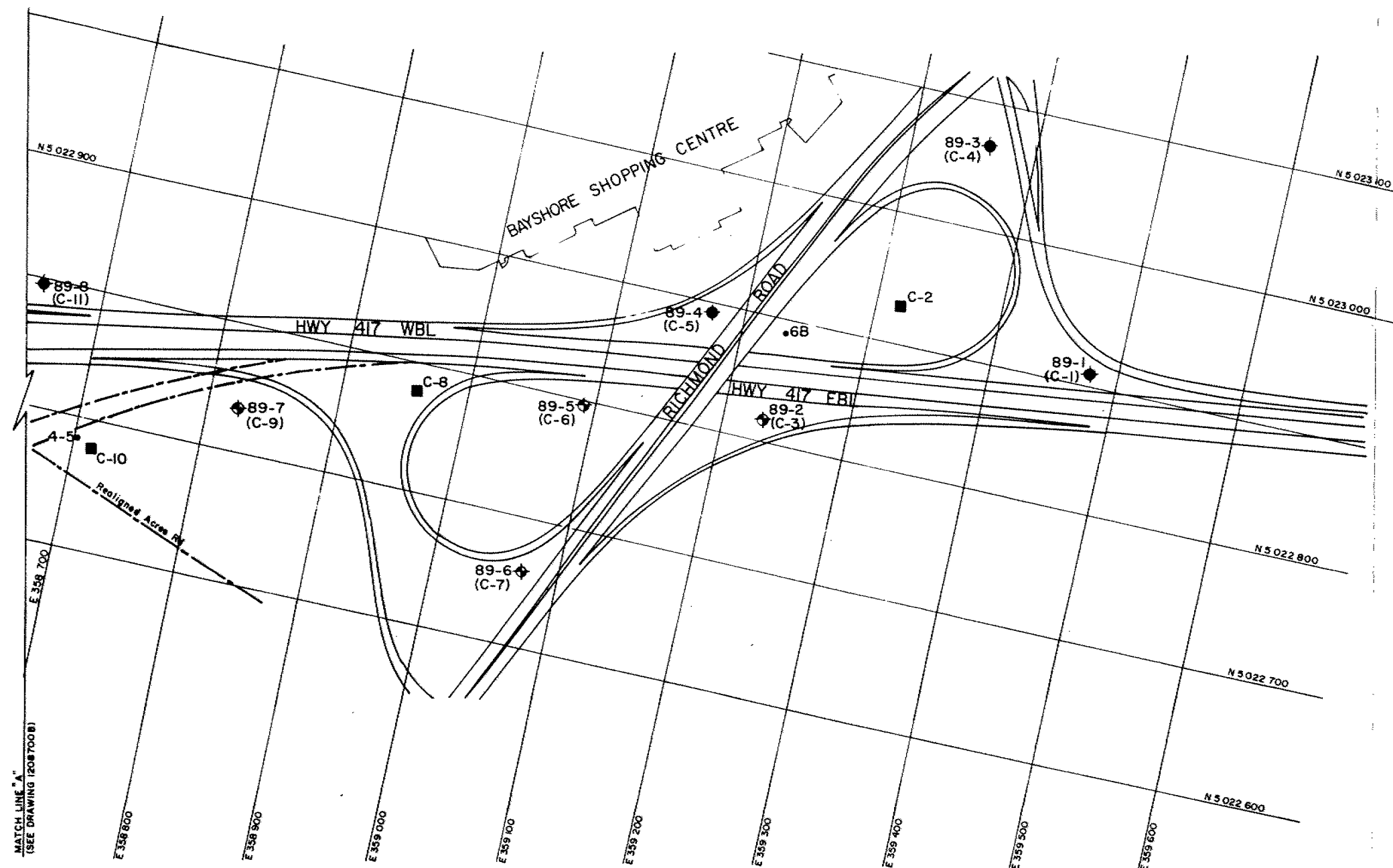
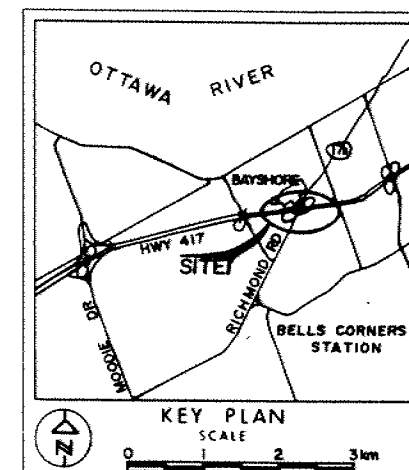
CONT No
WP No 120-87-00



HWY 417/416 INTERCHANGE
HIGH MAST LIGHTING
BORE HOLE LOCATIONS

SHEET

JACQUES, WHITFORD LIMITED



PLAN

SCALE



NOTE

For Subsurface information refer to
Record of Borehole Sheets.

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
- HML Location not drilled
- Location of other MTO Bore Hole near proposed HML location

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
89-1	66.0	5 022 910.0	359 479.0
89-2	66.0	5 022 818.0	359 232.0
89-3	70.2	5 023 067.0	359 363.0
89-4	67.6	5 022 890.0	359 174.0
89-5	65.8	5 022 797.0	358 092.0
89-6	66.4	5 022 658.0	359 071.0
89-7	66.4	5 022 737.0	358 823.0
89-8	65.9	5 022 793.0	358 653.0
68	67.8	5 022 887.8	359 235.6
4-5	65.0	5 022 687.7	358 702.6

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 included in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION
1			

Geocres No 3165-163

HWY No 417/416 Interchange	DIST 9
SUBM'D R.M. CHECKED R.M. DATE 31-07-89	SITE
DRAWN C.B. CHECKED G.K. APPROVED G.H.	DWG 120 87 00 A

METRIC

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

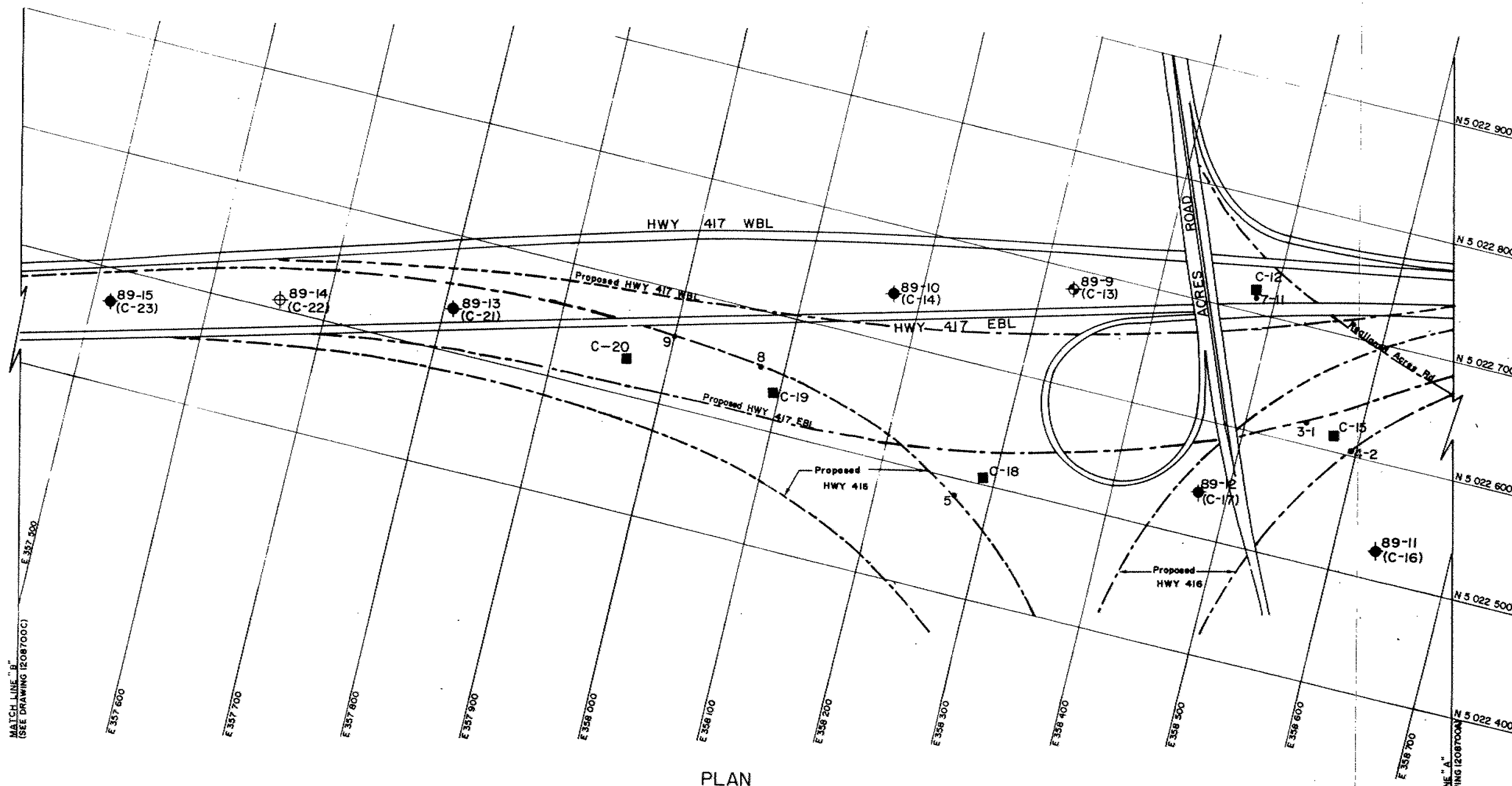
CONT No
WP No 120-87-00

HWY 417/416 INTERCHANGE
HIGH MAST LIGHTING
BORE HOLE LOCATIONS

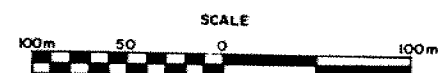


SHEET

JACQUES, WHITFORD LIMITED



PLAN



NOTE

For Subsurface information refer to
Record of Borehole Sheets.

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
- HML Location not drilled
- Location of other MTO Bore Hole near proposed HML location

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
89-9	65.5	5 022 685.0	358 328.0
89-10	65.8	5 022 641.0	358 178.0
89-11	66.5	5 022 525.0	358 637.0
89-12	66.3	5 022 536.0	358 476.5
89-13	66.7	5 022 537.0	357 806.0
89-14	66.2	5 022 507.0	357 856.0
89-15	66.6	5 022 471.0	357 512.0
5	65.1	5 022 485.0	358 270.0
8	66.1	5 022 553.0	358 080.0
9	66.0	5 022 560.0	358 000.0
3-1	66.3	5 022 619.2	358 552.6
4-2	66.3	5 022 603.6	358 595.4
7-11	65.9	5 022 711.9	358 484.4

NOTE

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REV	DATE	BY	DESCRIPTION
Geocres No 3165-163			
HWY No 417/416 Interchange			DIST 9
SUBM'D R/L CHECKED R/L DATE 31-07-88			SITE
DRAWN C.E. CHECKED G.R. APPROVED K.H.			DWG 12087008

METRIC

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

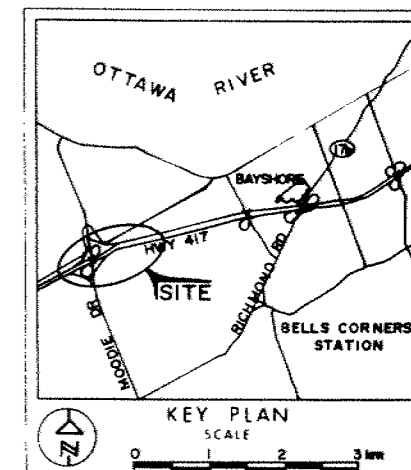
CONT No
WP No 120-87-00

HWY 417/416 INTERCHANGE
HIGH MAST LIGHTING
BORE HOLE LOCATIONS



SHEET

JACQUES, WHITFORD LIMITED



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
- HML Location not drilled

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
89-16	66.8	5 022 387.0	357 225.0
89-17	66.4	5 022 345.0	357 082.0
89-18	66.1	5 022 305.0	356 938.0
89-19	65.7	5 022 215.0	356 693.0
89-20	66.2	5 022 142.0	356 566.0
89-21	66.7	5 022 249.0	356 534.0
89-22	68.2	5 022 252.0	356 405.0
89-23	69.0	5 022 031.0	356 466.1
89-24	68.0	5 021 883.1	356 479.0

MATCH LINE "B"
(SEE DRAWING 1208700B)

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.

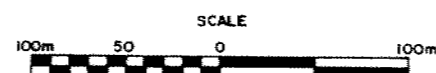
REV.	DATE	BY	DESCRIPTION

Geocres No 3165-163

HWY No 417/416 Interchange	DIST 2
SUBMITTAL R.H. CHECKED R.H. DATE 31-07-88	SITE
DRAWN C.B. CHECKED G.K. APPROVED K.H.	DWG 1208700.C



PLAN



NOTE

For Subsurface information refer to
Record of Borehole Sheets.