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GEOPRES No:
30M16-29

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 2001- 4006

**FOUNDATION INVESTIGATION REPORT
PROPOSED BURNHAM STREET BRIDGE
OVER HIGHWAY 401
COBOURG, ONTARIO
W.P. 678-90-00
SITE: 21-243**

Prepared For:

McCORMICK RANKIN CORPORATION

No Geocres

Prepared by:

SHAHEEN & PEAKER LIMITED

**Project: SPT1018
April 20, 2001
Geocres No. 30M16-35**

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**FOUNDATION INVESTIGATION REPORT
PROPOSED BURNHAM STREET BRIDGE OVER HIGHWAY 401
COBOURG, ONTARIO
W.P. 678-90-00**

1. INTRODUCTION

As part of the planned widening of Highway 401 from four to six lanes, the Highway 401 underpass structure at Burnham Street in Cobourg will be replaced with a longer and wider structure.

The existing Burnham Street bridge over Highway 401 (Interchange #472) consists of a single span, two lane, reinforced Tee beam concrete rigid frame, closed abutment structure which spans the existing four lane Highway 401.

Shaheen & Peaker Limited (S&P) was retained by McCormick Rankin Corporation to carry out a foundation investigation for the proposed new bridge. The site is located at the intersection of Highway 401 and Burnham Street (County Road 18) about 3 km north of the Town of Cobourg in the Township of Hamilton, County of Northumberland.

An investigation was carried out in 1958 by MTO for the existing bridge and also in 1993 for the then proposed widening of the existing bridge. Subsequently, it was decided to replace the existing structure with a longer span structure to accommodate the proposed six laning of Highway 401. The purpose of the present investigation was to obtain additional information at the site by means of boreholes.

The findings of the investigation are presented in this report.

2. SITE DESCRIPTION AND GEOLOGY

The site is located at the intersection of Highway 401 and Burnham Street in Cobourg about four km north of Lake Ontario.

Burnham Street is a two-lane roadway at and north of the interchange and a recently upgraded 4-lane roadway immediately south of the interchange.

The interchange is located on the boundary of the Town of Cobourg and the Township of Hamilton in the County of Northumberland. This is one of the two interchanges providing access to the Town of Cobourg from Highway 401.

Burnham Street structure over Highway 401 was constructed in 1960 and is a 31.1 m long, single span structure and accommodates two lanes of traffic. The bridge is 11.2 m wide with steel handrails.

The study area is located in the physiographic region known as the "Iroquois Plain." The plain consists of drumlins and sand plains (Ref: Chapman and Putnam, 1984).

The lowermost bedrock in the general area (i.e. Northumberland County) consists of Precambrian rock, with upper layers of limestone. These limestone layers are made up of the Trenton Group bedrock formations and were deposited during the Middle Ordovician Period, during the Paleozoic seas, some 480 millions years ago.

Glacio-lacustrine lake plain deposits of silt and clay with gently rolling terrain characterize the soils of the area.

The majority of the interchange is located on Schomberg soils. At the interchange site the soil is Smithfield, a silty clay loam of the Gray Brown Podzolic Group. Characteristics of this soil type are imperfect drainage, smooth to gently sloping topography, free of stones.

Cobourg Creek is located about 200 m east of the Burnham Street Bridge and the grade at the site drops from west to east towards the creek valley. The watercourse flows northeast to southwest towards Lake Ontario and crosses under Highway 401 via an existing 12.2 m concrete arch culvert, 65.5 m in length.

Highway 401 has a median storm sewer system which outlets to a detention pond, with a sediment forebay, immediately adjacent to the creek.

3. INVESTIGATION PROCEDURES

Because of the weather conditions and traffic requirements for safety, the fieldwork for this project had to be carried over a period of time spanning from December 5, 2000 to January 10, 2001 and consisted of drilling and sampling eight boreholes (Boreholes 101, 102, 103A, 103B, 104, 104A, 105 and 106). The plan locations of the boreholes, along with the stratigraphic sections, are shown on Drawing No. 1.

The boreholes were advanced using solid stem continuous flight augers with track and truck mounted drilling rigs owned and operated by Groundworks Drilling Inc., under the full time supervision of geotechnical personnel from S&P.

The depths of the boreholes ranged from 8.1 to 26.9 m. Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter O.D. split barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Where the consistency of the soil permitted, the undrained shear strength of the soil was measured in-situ by means of field vane tests using an MTO type field vane tester and several relatively undisturbed samples were taken by means of thin walled Shelby tube samplers.

The borehole locations were established in the field by our engineering staff, in relation to the existing features. The borehole geodetic elevations and coordinates were later taken by surveyors from David Harwood Limited, who provided us with the results.

Water level observations in the open boreholes were made during the drilling and at the completion of each borehole and, wherever possible, thereafter. To enable us to monitor groundwater levels over a prolonged period of time without interference from surface water piezometers were installed in two of the boreholes and the water levels in these piezometers were monitored during subsequent site visits.

The results of drilling, in-situ testing and water level measurements are summarized on the Record of Borehole Sheets in Appendix A.

Upon their completion, the boreholes were backfilled to about 8 m below the ground surface with soils brought up by augering (i.e. augering cuttings). The upper 8 m of the open boreholes was then grouted using a cement/bentonite mixture.

A laboratory testing programme consisting of natural moisture content, bulk unit weight, Atterberg Limits tests and grain-size analyses, was performed on selected soil samples. The results of the laboratory tests are presented on the appropriate Borehole Log Sheets and also in Appendix C.

4. SUBSURFACE CONDITIONS

Beneath some fill, the site is underlain by surficial silty clay and silty clay till. These deposits attain a somewhat coarser glacial till texture (i.e. heterogeneous mixture of clayey silt with sand and some gravel) with increasing depth. This upper till sheet extends to an average elevation of about 94-95 m and is underlain by a clayey silt to silty clay deposit. This deposit is generally 3 to 5 m thick and is underlain by a lower till sheet. The lower till sheet is coarser in texture in comparison with the upper till deposit and consists of a heterogeneous mixture of silt and sand size particles with gravel and traces to some clay. This deposit was encountered at about Elevation 90 m and extended to the full limit of the explorations.

It should be pointed out that MTO Boreholes 1, 2, 3 and 4 were drilled before the construction of the existing bridge and, therefore, do not represent post-construction conditions.

Details of the subsurface conditions encountered in boreholes drilled for this investigation are presented on the Borehole Log Sheets, Appendix A. The logs of boreholes previously drilled by MTO in 1958 and 1993 are presented in Appendix B. The individual soil strata encountered in the boreholes drilled for the present investigation are briefly described, as follows.

4.1 FILL

4.1.1 GRAVELLY SAND (GRANULAR FILL)

Boreholes 101 and 102 were drilled from the paved Burnham Street surface and encountered 150 mm of asphaltic concrete, underlain by granular road fill to 0.9 m and 2.1 m, respectively.

In Boreholes 103A and 103B, which were drilled from the central median of Highway 401, a 150 mm thick layer of asphaltic concrete was followed by a 400 to 450 mm of granular base course. In Borehole 103B, a 300 mm of sand fill was contacted underlying the base coarse.

4.1.2 SILTY CLAY FILL (EMBANKMENT FILL)

Fill materials making up the road embankment were encountered in boreholes drilled from the top of Burnham Street embankment (i.e. Boreholes 101, 102, 104 and 105). In these boreholes, the depth of the embankment fill ranged from 2.1 m (BH105) to 5.5 m (BH101) or to Elevations ranging from 105.0 to 103.3 m.

In Boreholes 101 and 102, which were drilled on the southeast side of the existing bridge structure, an approximately 0.4 m thick buried topsoil layer was encountered immediately below the fill (i.e. probably the original topsoil) while in Boreholes 104 and 105, drilled on the northeast side, the thickness of the buried topsoil was about 0.1 m. The embankment fill generally consisted of silty clay, mixed with some topsoil and traces of gravel. These fill materials are expected to behave as cohesive soils.

N-values recorded in these fill materials range from 13 to 35 blows/0.3 m (generally 14-25 blows/0.3 m), indicating that the embankment fills received some degree of systematic compaction when the embankment was built.

4.2 SURFICIAL SILTY CLAY

Boreholes 104 and 105, which were drilled on the north side of the existing bridge contacted beneath the embankment fill, a 2.3 to 3.0 m thick silty clay layer. The grain size distribution of a sample from this deposit is given in Figure 3, Appendix C.

Standard Penetration tests performed in this cohesive material ranged from 39 to 65 blows/0.3 m and, based on this, the consistency of the deposit is described as hard.

4.3 SURFICIAL SILTY CLAY TILL

In Boreholes 101, 102 and 106, drilled on the south side of the existing bridge, a surficial silty clay till deposit was contacted immediately below the fill and topsoil below Elevations ranging from 103.4 m (Boreholes 101 and 102) and 102.5 m (Borehole 106). The thickness of this cohesive deposit ranged from 0.6 to 2.3 m and it extended to Elevations ranging from 102.8 to 101.1 m.

An Atterberg Limits test performed on a sample from the deposit yielded the following index values, as shown on the Plasticity Chart in Figure 4, Appendix C.

Liquid Limit = 25%

Plastic Limit = 16%

Plasticity Index = 9%

Natural Moisture Content = 21%

These results are characteristic of clayey soils of low plasticity.

Based on recorded N-values ranging from 12 to 48 blows/0.3 m, the consistency of the deposit is described as stiff to hard, but generally very stiff to hard.

4.4 CLAYEY SILT WITH SAND AND SOME GRAVEL (GLACIAL TILL)

Underlying the granular pavement fill in Boreholes 103A and 103B (drilled from Highway 401) and surficial clayey deposit encountered in the remaining boreholes, as described in the preceding paragraphs, all boreholes contacted an upper glacial till sheet consisting of a heterogeneous unsorted mixture of clayey silt with sand and some gravel. In Boreholes 101 and 105, the exploration was terminated in this deposit while in others the deposit was found to be 7.1 m (Borehole 106) to 9.1 m (Borehole 103B) thick and extended to elevations ranging from 94.0 to 92.0 m, respectively, showing a variation (difference) of about 2 m in thickness and base elevation. In Boreholes previously drilled by MTO, the minimum thickness was about 4.4 m.

The results of grain-size distribution analyses carried out on selected samples are given Appendix C; the results of tests previously carried out by MTO are shown in Figure 1 of Appendix D.

The results indicate 0-14% gravel, 8-38% sand, 31-68% silt and 7-36% clay size particles, showing a large variation. From the observed resistance to augering (i.e. grinding), the presence of coarse gravel and cobbles can be inferred. It should also be pointed out that cobbles and boulders are characteristic components of glacial till deposits.

This deposit is classified as a cohesive material and Atterberg Limits test performed on the fine fraction gave the following range of values:

Liquid Limit	=	12-43%
Plastic Limit	=	8-20%
Plasticity Index	=	3-23%
Natural Moisture Content	=	6-26%

As shown on the plasticity charts in Appendix C and D, the material can be classified as a clayey silt to silty clay of low plasticity. In general, the deposit has a higher clay content and higher plasticity in the upper zones.

Standard Penetration tests performed in this deposit show N-values with considerable variations from borehole to borehole. The recorded values range from 9 to in excess of 50 blows/0.3 m which indicate a stiff to hard consistency but

Foundation Investigation Report, Highway 401-Burnham Street Bridge, Cobourg, Ontario
McCormick Rankin Corporation

generally very stiff to hard. There is evidence that the material is somewhat more competent on the south side of the site when compared with the north side.

4.5 CLAYEY SILT

Sandwiched between the upper and lower till sheets is a clayey silt deposit with a measured thickness of between about 2 and 6 m. This unit was encountered below elevations ranging between 96.7 m and 92.0 m and extended to between 90.7 and 88.8 m.

The results of grain-size distribution tests from this deposit are shown in Appendix C and Appendix D. The results indicate 0-1% sand, 65-70% silt and 29-35% clay size particles.

Atterberg Limits tests performed in the laboratory on selected samples gave the following index values:

Liquid Limit	=	12-29%
Plastic Limit	=	8-17%
Plasticity Index	=	4-14%
Natural Moisture Content	=	7-25%

These results are indicative of clayey soils of low plasticity. An unusual feature of these results is that with most soils, the measured clay size percentages are normally associated with higher plasticity index values than reported above. Another unusual feature was that the samples of the material obtained from the boreholes showed a much higher degree of dilatancy than would be expected from soil containing a relatively high percentage of clay sizes as measured. This rather unusual property can perhaps be caused by clay size particles being rather inactive. Chapman and Putnam observed this behaviour many years ago and offered the following hypotheses on similar soils as an explanation, "...Mechanical analyses indicate about 50% clay and 40% silt, but its behaviour is more like that of silt than clay. It is very slippery when wet and inclined to be mealy when dry. It is probably composed of freshly ground rock flour rather than weathered clay materials."

N-values recorded in this deposit ranged from 5 to 28 blows/0.3 m. Field vane tests gave undrained shear strength values ranging from 20 to in excess of 100 kPa. Based on these results, together with a visual and tactile examination of the soil samples, the consistency of this cohesive deposit is described as firm to stiff with occasional soft and very stiff zones. It should also be added that the consistency of the deposit was found to be quite variable from borehole to borehole but is considered somewhat weaker and more compressive towards the north side compared with the south abutment location.

4.6 HETEROGENEOUS MIXTURE OF SILT, SAND AND GRAVEL, SOME CLAY (GLACIAL TILL)

Beneath the weak clayey silt to silty clay layer, the site is underlain by a lower till sheet, consisting of a heterogeneous unsorted mixture of silt and sand with gravel and traces to some clay size particles. The results of grain size distribution tests carried out on selected samples from the deposit are presented in Appendices C and D. They indicate 10-28% gravel, 37-46% sand and 34-44% soil fines (i.e. silt and clay size particles). There is some indication that the deposit contains a greater percentage of gravel and cobbles, than exhibited by the grain size distribution curves. The presence of cobbles and boulders should always be expected in the glacial till deposits, due to their mode of deposition.

The soil samples recovered were generally moist to wet and the deposit is considered to be water bearing. Standard penetration tests carried out in this basically granular (i.e. non-cohesive) material yielded N-values ranging from 6 to in excess of 100 blows/0.3 m. The lower N-values are near the surface of this unit at the interface with the overlying clayey silt layer. In this upper portion, the presence of clayey silt and silty clay seams/lenses was also noted. Below this upper zone, at about 1 to 4 m below the interface or below about Elevation 86 m, the recorded N-values are consistently in excess of 50 blows/0.3 m.

Boreholes which were extended into this lower till sheet were terminated after penetrating the deposit about 1 to 8 m or to elevations ranging from about 91 m (Borehole 106) to 81 m (Borehole 104A).

4.7 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes were observed while drilling and at the completion of each borehole. In addition, piezometers were installed in two of the boreholes (i.e. Boreholes 104A and 106) to enable prolonged groundwater level measurements, without interference from surface water. The observations and recorded values are shown on individual borehole log sheets.

Water levels in the piezometers were measured at elevations ranging between 102.4 and 96.5 m. Based on these values and the change of the colour of the soil from brown to grey, which is generally at Elevations 101-98 m, the permanent groundwater table at the site can be expected between Elevations 101 and 97 m. On the east side, the groundwater level can to a certain extent be expected to be regulated by the water level in the existing storm water detention pond, elevation of approximately 98.5 m.

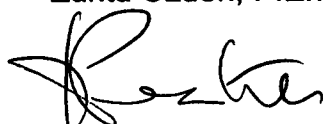
It should also be pointed out that the groundwater is subject to seasonal fluctuations and fluctuations in response to major weather events.

Yours truly

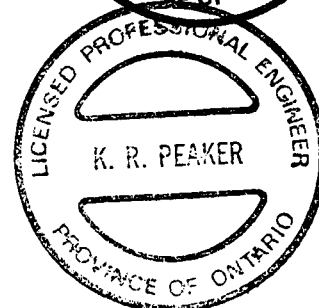
SHAHEEN & PEAKER LIMITED



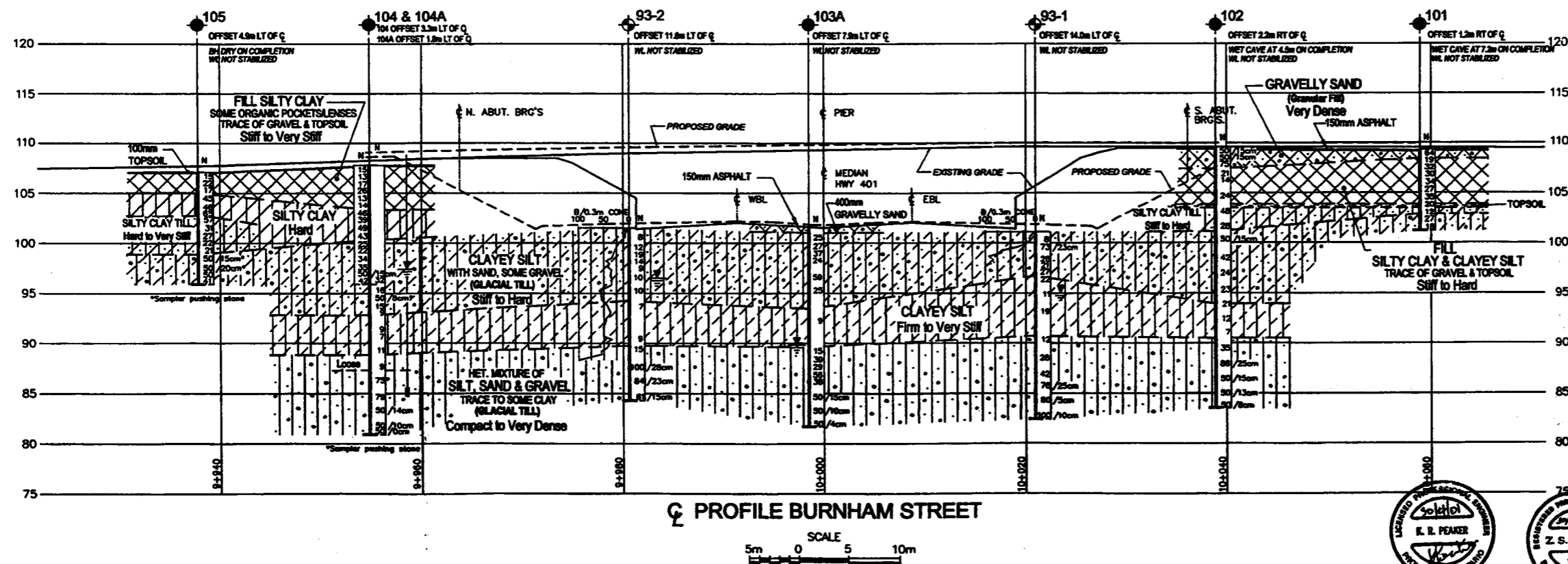
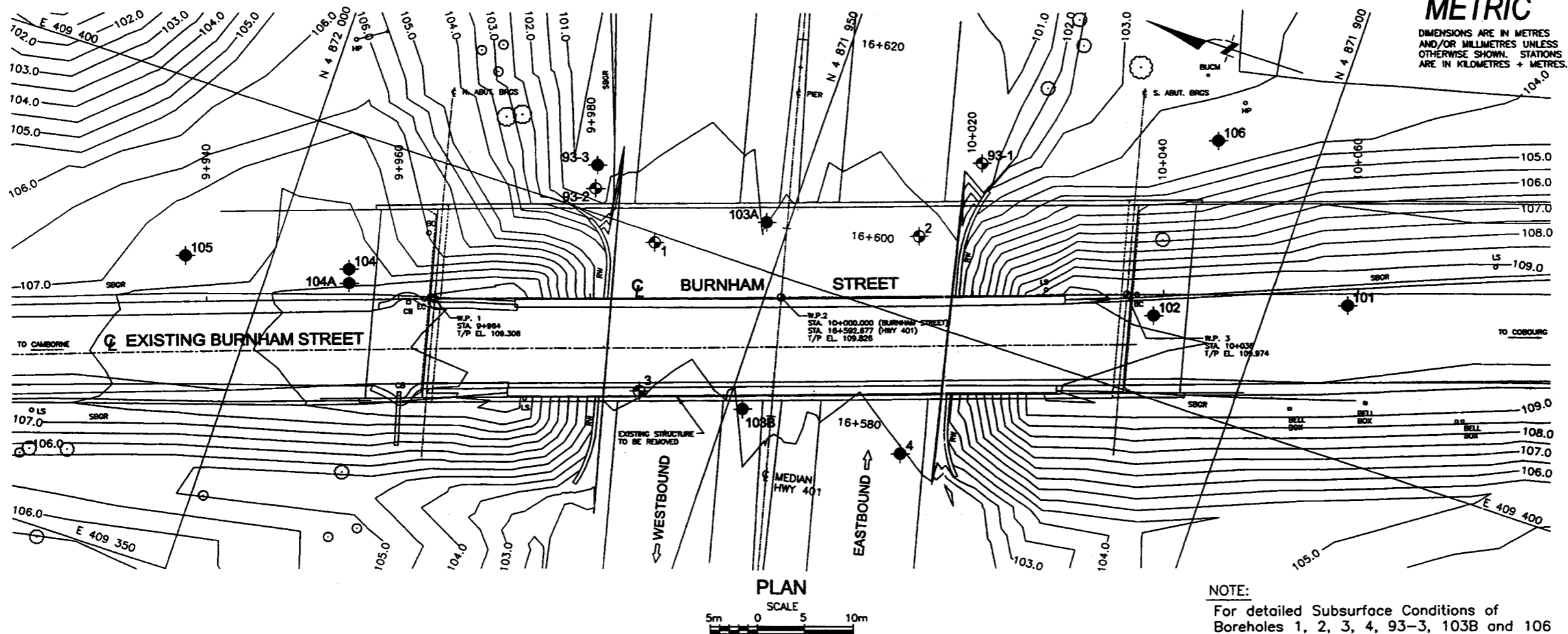
Zuhtu Ozden, P.Eng.



K. R. Peaker, Ph.D., P.Eng.



DRAWINGS









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

HWY 401 - BURNHAM ST.
UNDERPASS
BORE HOLE LOCATIONS & SOIL STRATA



Shaheen & Peaker 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 Aug. 1993 and Jan. 2001		
	W L in Piezometer		
	Piezometer		
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	104.5	4 871 962.8	409 399.
2	103.6	4 871 936.8	409 408.
3	104.1	4 871 959.3	409 383.
4	103.9	4 871 931.3	409 386.
93-1	101.1	4 871 933.0	409 418.
93-2	101.5	4 871 970.4	409 402.
93-3	101.5	4 871 971.0	409 404.
101	109.3	4 871 892.2	409 415.
102	109.5	4 871 910.8	409 408.
103A	101.6	4 871 952.3	409 404.
103B	102.0	4 871 948.4	409 385.
104	107.8	4 871 992.0	409 386.
104A	107.8	4 871 991.6	409 384.
105	107.1	4 872 008.6	409 382.
106	103.6	4 871 910.3	409 428.

=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, Downview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

REV.				
	DATE	BY	DESCRIPTION	
Geocres No. 30M16-35				
SNRY No	401			DIST 21
SURFNO	checked ZO	DATE	Apr., 2001	SITE 21-243
DESIGN	checked ID	APPROVED		DWG 2

APPENDIX A

Records of Boreholes by Shaheen & Peaker Limited

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 892.2; E 409 415.9 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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		
109.3	Ground surface													
0.0	150 mm Asphalt		1	SS	64		109							GR SA SI CL
108.4	Gravelly Sand (Granular Fill) brown, very dense													
0.9			2	SS	19		108						20.4	
	FILL: Silty Clay and Clayey Silt, trace gravel, some topsoil pockets, very stiff to hard, brown, damp		3	SS	32		107						19.8	
			4	SS	30		106						19.5	
	----- high topsoil content black, moist -----		5	SS	34		105						19.7	
			6	SS	27		104						19.2	
103.8			7	SS	35		103						19.4	
5.5	TOPSOIL, black		8	SS	20		102						20.8	
103.4														
5.9	SILTY CLAY TILL, stiff, greyish brown		9	SS	12								20.8	
102.8														
6.5	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to very stiff, brown		10	SS	27								22.6	
101.2			11	SS	16								21.0	
8.1	End of borehole • Wet cave at 7.2 m on completion. Water level not stabilized Borehole drilled to 5.0 m on Dec.5/2000. Abandon borehole due to snow storm re-drilled on Jan.10/2001													

RECORD OF BOREHOLE No 102

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
109.5	Ground surface											
0.0			1	SS	50/15		109					
	150 mm Asphalt		2	SS	50/15							
	Gravelly Sand											
	(Granular FILL)											
	brown, very dense		3	SS	75/30		108					
107.4												
2.1			4	SS	21		107					
	FILL:											
	Silty Clay, trace of		5	SS	14							
	gravel and topsoil,											
	stiff to very stiff, brown						106					
			6	SS	24		105					
103.8												
5.7	TOPSOIL, black						104					
103.4												
6.1	some organics		7	SS	48		103					
	SILTY CLAY TILL											
	greyish brown, very stiff		8	SS	28		102					
	to hard											
101.1							101					
8.4			9	SS	50/15		100					
	Clayey Silt with Sand,						99					
	some gravel		10	SS	42		98					
	(GLACIAL TILL)											
	hard to very stiff, brown											
	to 10 m, grey below		11	SS	24		97					
			12	SS	23		96					
							95					

Continued Next Page

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

RECORD OF BOREHOLE No 102

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
94.5												
15.0	Clayey Silt with Sand, some gravel (GLACIAL TILL)		13	SS	21		94				22.6	
93.9	grey, very stiff											
15.6												
	CLAYEY SILT firm to very stiff, grey		14	SS	12		93				20.1	
							92					
			15	SS	7		91				21.3	
90.5							90					
19.0	Heterogeneous mixture of Silt, Sand and Gravel, some clay (GLACIAL TILL)		16	SS	35		89				23.6	
	dense to 21 m, very dense below, grey						88				22.9	
			17	SS	88/25		87					
							86				23.1	
	more sandy with Sand layers below 24 m		18	SS	50/15		85				22.8	
							84					
83.5			19	SS	50/13							
											22.1	
26.0	End of borehole * Wet cave at 4.5 m on completion. Water level not stabilized Borehole drilled to 6.6 m on Dec. 5/2000. Borehole had to be abandoned due to snow storm. Borehole re-drilled on Jan. 10-11/2001		20	SS	50/8							

+ 3, x 3: Numbers refer to
Sensitivity

20
15-5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 103A

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 952.3; E 409 404.9 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 09.01.01 CHECKED BY ZO

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		
101.6	Ground surface													
0.0	150 mm Asphalt		1	AS			101							33 54 (13)
101.0	400 mm Gravelly Sand (Granular Fill)		2	SS	25								21.9	
0.6			3	SS	27		100							
			4	SS	37		99						22.5	
	Clayey Silt with Sand and Gravel (GLACIAL TILL) very stiff to hard, brown to 3.2 m, grey below		5	SS	24		98						22.0	
			6	SS	59		97							
			7	SS	25		96						22.1	
93.4							95							
8.2							94							
	CLAYEY SILT grey, stiff		8	SS	9		93						20.1	
							92							
							91							
89.6							90							
12.0			9	SS	15		89						22.6	
	Heterogeneous mixture of Silt, Sand and Gravel, some clay (GLACIAL TILL) compact to very dense, grey, moist to wet		10	SS	39		88						23.0	
			11	SS	29								23.3	
			12	SS	56		87						23.1	

Continued Next Page

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

RECORD OF BOREHOLE No 103A

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 952.3; E 409 404.9 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 09.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								20 40 60 80 100								
86.6 15.0	Heterogeneous mixture of Silt, Sand and Gravel, trace to some clay (GLACIAL TILL) dense to 16 m, very dense below, grey, moist to wet Sand seam/lense at 18.3 m		13	SS	38									23.4	28 38 29 5	
			14	SS	50/15									22.5		
			15	SS	50/10											

+³, x³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 103B

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 948.4; E 409 385.3 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 09.01.01 CHECKED BY ZO

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			SHEAR STRENGTH kPa				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	WATER CONTENT (%)		
102.0	Ground surface					20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		GR SA SI CL	
0.0	150 mm Asphalt		1	SS	50/8							
101.4	Gravelly Sand (Granular Fill)											
0.6												
101.1	Sand, some gravel and silt, brown, compact (FILL)		2	SS	10							
0.9	stiff											
			3	SS	10						20.1	
			4	SS	17						20.3	0 3 61 36
			5	SS	17						21.1	
	Clayey Silt with Sand and Gravel (GLACIAL TILL) very stiff to hard, brown to 3.3 m, grey below		6	SS	38						22.8	
			7	SS	34						22.6	
			8	SS	48						22.9	
			9	SS	34						22.7	
			10	SS	30						21.8	
			11	SS	15						21.7	
92.0	stiff		12	SS	7						19.7	
10.0			13	TW	PH							
	CLAYEY SILT firm to stiff		14	SS	10						20.2	0 1 65 34
			15	TW	PH							
89.0												
13.0	Heterogeneous mixture of Silt, Sand and Gravel, some clay, (GLACIAL TILL) loose to compact, grey, wet		16	SS	6						22.2	

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 103B

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 948.4; E 409 385.3 ORIGINATED BY GI
 DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
 DATUM Geodetic DATE 09.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100							

RECORD OF BOREHOLE No 104

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 992.0; E 409 386.2 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 CHECKED BY ZO

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		
107.8	Ground surface													
0.0	100 mm Topsoil		1	SS	15	*	107						19.5	
	FILL: Silty Clay, trace of gravel, some organic, pockets/lenses, stiff to very stiff, brown		2	SS	13		106						19.8	
			3	SS	17		105						18.7	
			4	SS	26		104						18.6	
			5	SS	13		103						18.4	
			6	SS	14		102						19.7	
103.3			7	SS	46		101						20.2	0 5 65 30
4.5	SILTY CLAY hard, brown		8	SS	39		100						19.5	
			9	SS	49		99						20.2	
			10	SS	43		98						20.6	
100.3			11	SS	25		97						21.4	
7.5	Clayey Silt with Sand, some gravel (GLACIAL TILL) very stiff to hard, grey		12	SS	22		96						22.4	
			13	SS	34									
			14	SS	35									
			15	SS	50/15									
			16	SS	42									
95.9														
11.9	End of borehole Borehole moved 1.5 m to the West and re-drilled without sampling to 7.6 m; See BH104A for continuation * Water Level not Established													

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 104A

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 991.6; E 409 384.7 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 20.12.00 CHECKED BY ZO

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		
92.8	CLAYEY SILT grey, firm to stiff		8	TW	PH		92	1.1						
15.0			9	SS	9		91	1.7					20.7	
			10	SS	7		90	1.1					20.2	
			11	TW	PH		89						18.8	
			12	SS	11		88						22.5	
88.8							87						22.7	
19.0	Heterogeneous mixture of Silt, Sand and Gravel, trace to some clay (GLACIAL TILL) loose to 20.5 m, very dense below, grey, wet to moist		13	SS	9		86						22.7	10 46 36 8
			14	SS	75		85						23.4	
			15	SS	79		84						23.2	
			16	SS	50/14		83						22.7	
			17	SS	50/10		82							
			18	AS	50/0		81							
80.9	End of borehole Auger refusal at 26.9 m probably on a boulder. Piezometer installed at 23 m upon completion Water level in piezometer at: Dec.21/2000 - 20.3 m Jan. 04/2001 - 10.7 m Jan. 09/2001 - 10.4 m Jan. 10/2001 - 10.5 m Jan. 11/2001 - 10.4 m Jan. 17/2001 - 10.3 m													
26.9														

Continued Next Page

+ 3 . x 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 872 008.6; E 409 382.1 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
107.1	Ground surface						20 40 60 80 100					
0.0	100 mm Topsoil		1	SS	15	*					17.9	
	FILL: Silty Clay, some topsoil and trace of gravel, brown, grey, dark/brown, black		2	SS	22						19.7	
105.0			3	SS	17						18.9	
2.1	SILTY CLAY hard, brown		4	SS	45						20.0	
			5	SS	46						20.4	
102.7			6	SS	65						20.4	
4.4	SILTY CLAY TILL brown and hard to 5.2 m, grey and very stiff below		7	SS	57						20.9	
			8	SS	31						20.3	
			9	SS	27						21.1	
			10	SS	22						20.7	* Sampler pushing stone
98.9			11	SS	21						23.4	
8.2	Clayey Silt with Sand, some gravel (GLACIAL TILL) hard, grey		12	SS	50/15	*					23.2	
			13	SS	50/20	*						
			14	SS	50							
95.9			15	SS	41							
11.2	End of borehole **Borehole dry on completion (not stabilized)											

+ 3 . x 3 : Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 106

2 OF 2

METRIC

W.P. 678-90-00

LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 781 910.3; E 409 428.2

ORIGINATED BY GI

DIST 21 HWY 401

BOREHOLE TYPE Solid Stem Augers

COMPILED BY GT

DATUM Geodetic

DATE 21.12.00 04.01.01

CHECKED BY **ZO**

[illegible]

APPENDIX B

Records of Previous Boreholes by MTO

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 962.8 E 409 399.1. ORIGINATED BY H.S

DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY A.L

DATUM Geodetic DATE April 22, 1958 CHECKED BY T.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 × LAB VANE 20 40 60 80 100	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									
104.5	Ground Surface													
0.0	--- Topsoil --- Brown --- Grey Clayey Silt With Sand, Some Gravel, Stiff to Hard (Glacial Till)		1	SS	14		104							
			2	SS	27		102							
			3	SS	24		100							
			4	SS	24		98							
			5	SS	41		96							
95.4														
9.1	Clayey Silt, Firm to Stiff		6	SS	5		94							
93.2			7	SS	8									
11.3	End of Borehole • WL Not Established													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 936.8, E 409 408.6 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY A.L.
 DATUM Geodetic DATE April 30, 1958 CHECKED BY T.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	20 40 60 80 100					
103.6	Ground Surface												
0.0	Topsoil												
	Clayey Silt With Sand, Some Gravel, Very Stiff to Hard (Glacial Till)		1	SS	16								
			2	SS	40								
			3	SS	70								
			4	SS	88								
			4A	SS	74								
			5	SS	40								
94.8													
8.8	Clayey Silt, Very Stiff		6	SS	28								
			7	SS	20								
			8	SS	16								
			9	SS	18								
90.2													
13.4	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense to Very Dense (Glacial Till)		10	SS	40								
			11	SS	75								
			12	SS	69								
85.0													
18.6	End of Borehole												
	• WL Not Established												

METRIC

DATUM Geodetic DATE May 12, 1958 CHECKED BY T.K.

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 931.3, E 409 386.1 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring COMPILED BY AL
 DATUM Geodetic DATE May 14, 1958 CHECKED BY T.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							WATER CONTENT (%)			
								20 40 60 80 100										
103.9	Ground Surface																	
0.0	Topsoil		1	SS	22		102											
	Clayey Silt, Some Sand, Some Gravel, Stiff to Hard (Glacial Till)		2	SS	33		100											
			3	SS	30		98											
			4	SS	53		96											
94.8			5	SS	26		94											
9.1	Clayey Silt, Stiff to Very Stiff		6	SS	20		92											
			7	SS	9		90											
89.3			8	SS	9													
14.6	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense (Glacial Till)		9	SS	37													
88.2																		
15.7	End of Borehole																	

RECORD OF BOREHOLE No 93-1

1 OF 1

METRIC

W.P. 678-90-01

LOCATION Co-ords: N 4 871 933.0, E 409 418.0

ORIGINATED BY D.S.

DIST 7 HWY 401



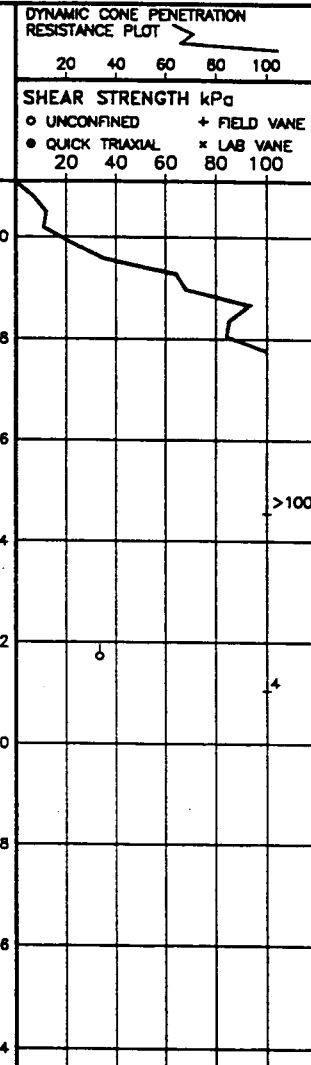

BOREHOLE TYPE Hollow Stem Auger and Cone Test

COMPILED BY D.S.

DATUM Geodetic

DATE Aug. 9, 1993

CHECKED BY T.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 (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
101.1	Ground Surface														
0.0	Clayey Silt With Sand, Some Gravel, Very Stiff Brown (Glacial Till) Grey		1	SS	8	 /23cm	100						20.8	14 33 31 22	
96.7			2	SS	7.5		98								
4.4			3	SS	28										
			4	SS	21										
			5	SS	27										
	6	SS	22												
	7	SS	11												
	8	SS	19												
	9	TW	PH												
90.7			10	SS	12										
10.4	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay Compact to Very Dense (Glacial Till)		11	SS	28										
			12	SS	42										
			13	SS	76										
			14	SS	80										
			15	SS	100										
82.4															
18.7	End of Borehole • WL Not Stabilized														

1 OF 1

W.P. 678-90-01

LOCATION Co-ords: N 4 871 970.4 E 409 402.5

ORIGINATED BY D.S

DIST 7 HWY 401

BOREHOLE TYPE Hollow Stem Auger and Cone Test

COMPILED BY D.S.

DATUM Geodetic

DATE Aug. 9 and Aug. 10, 1993

CHECKED BY **T.K.**

+3, x5: Numbers refer to $\frac{20}{15-5}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 93-3 1 OF 1 METRIC

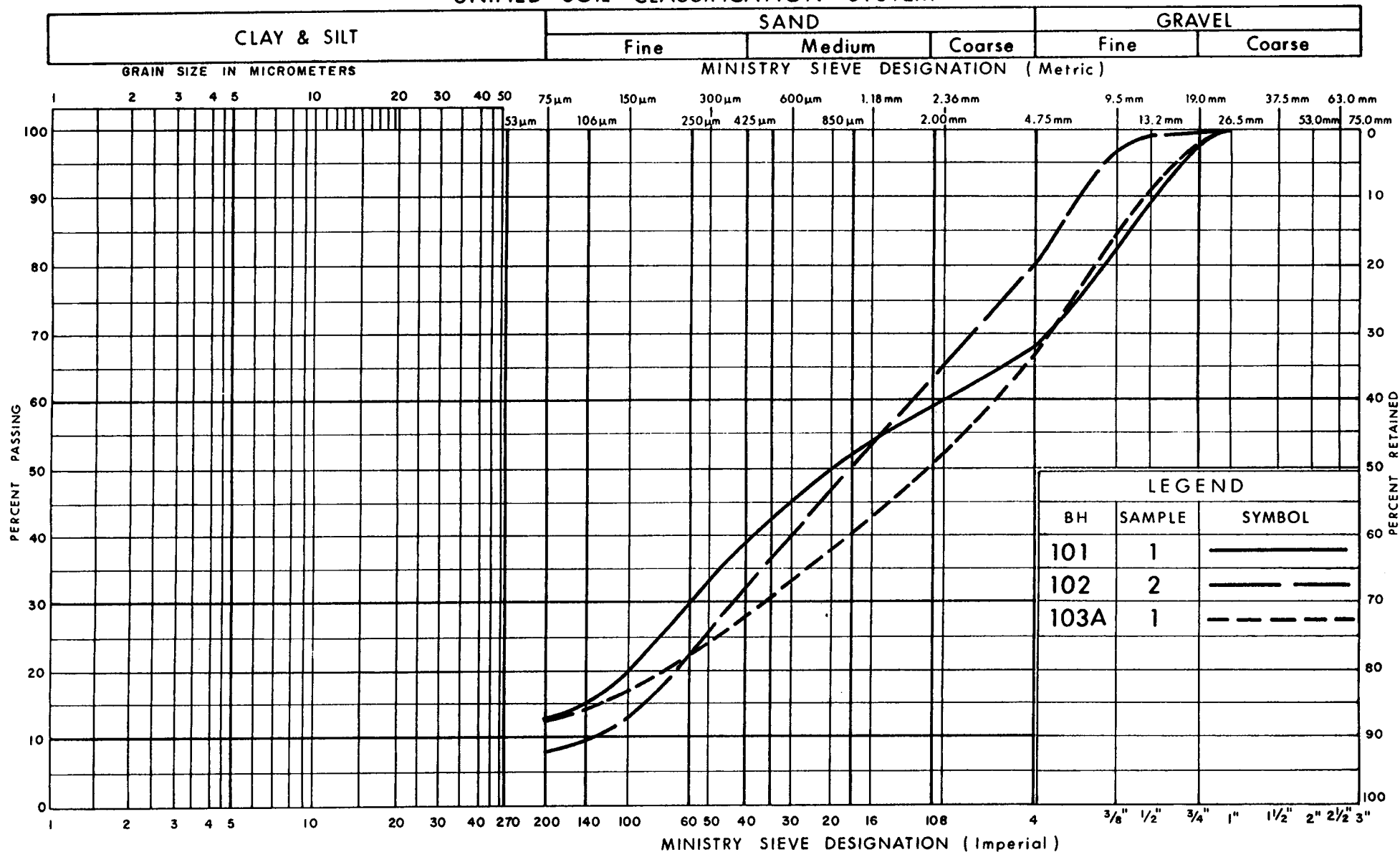
W.P. 678-90-01 LOCATION Co-ords: N 4 871 971.0. E 409 404.9 ORIGINATED BY D.S.
 DIST 7 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY D.S.
 DATUM Geodetic DATE Aug. 13, 1993 CHECKED BY T.K.

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	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _P W W _L	WATER CONTENT (%)				
101.5	Ground Surface														
0.0	Brown Grey Clayey Silt With Sand, Some Gravel, Stiff to Very Stiff (Glacial Till)	1	SS	14											
		2	SS	10											
		3	SS	14											
		4	SS	11											
		5	SS	14											
		6	SS	10											
94.4	Clayey Silt, Firm to Stiff	7	SS	8											
7.1		8	SS	5											
		9	TW	PH											
		10	SS	11											
89.9	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense to Very Dense, (Glacial Till)	11	SS	32											
11.6		12	SS	73											
87.3															
14.2	End of Borehole														
93 08 30 * GROUND WATER CONDITIONS															
PIEZO. NO.		GROUND WATER ELEVATION (Metres)													
1		96.5													

APPENDIX C

Laboratory Test Results by Shaheen & Peaker Limited

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

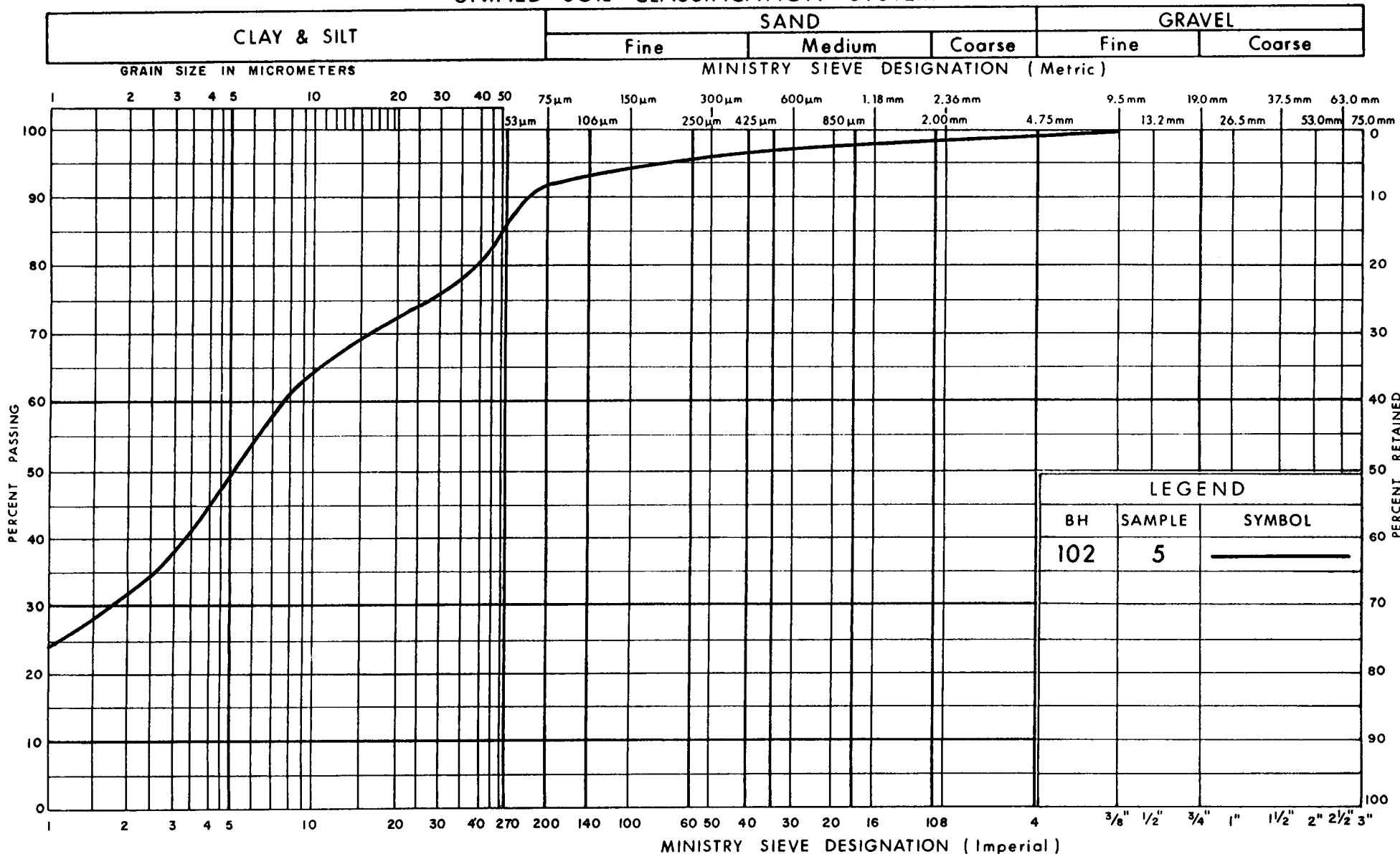
GRAIN SIZE DISTRIBUTION GRAVELLY SAND (Granular Fill)

FIG No 1

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

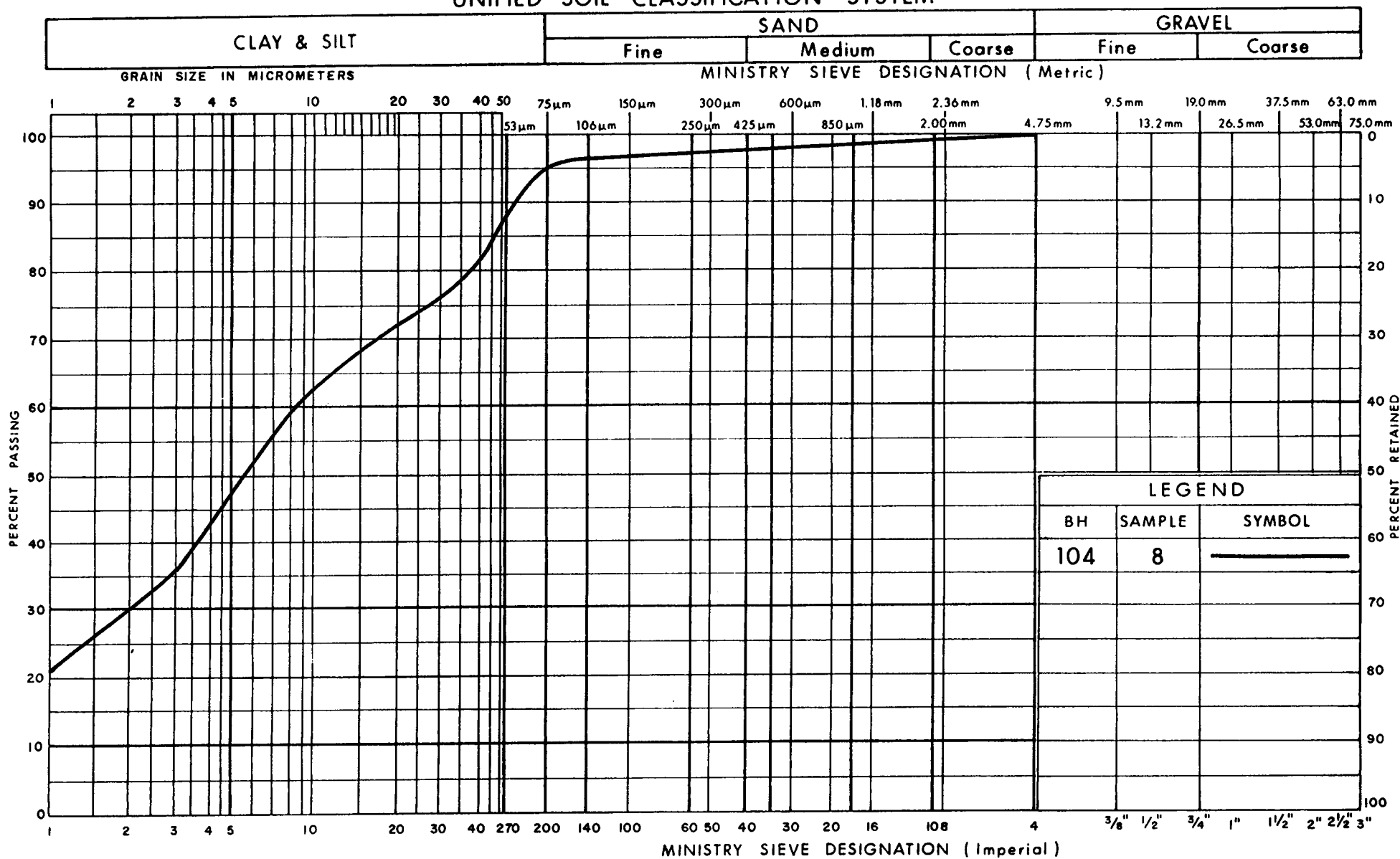
GRAIN SIZE DISTRIBUTION
FILL: SILTY CLAY

FIG No 2

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



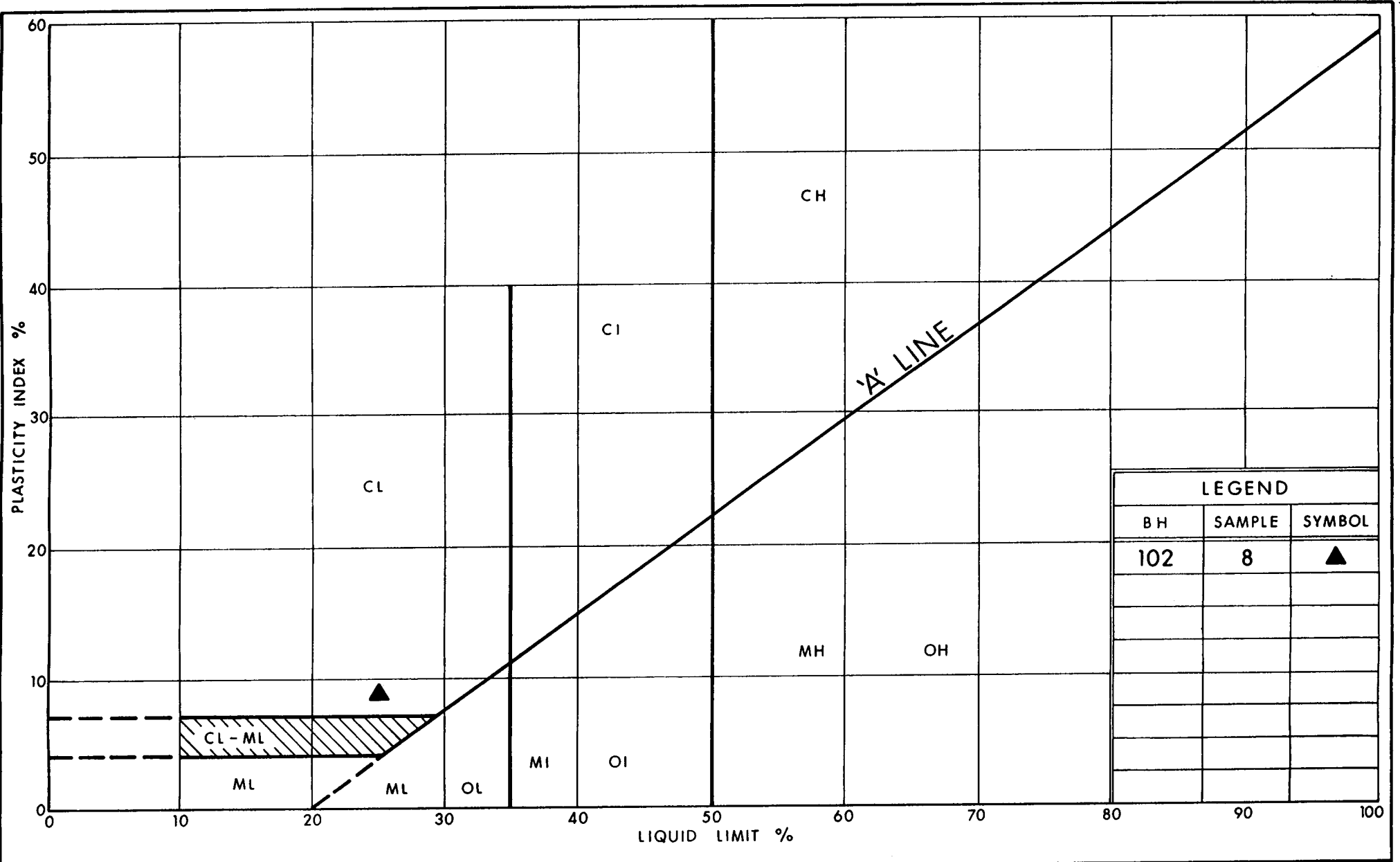
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SILTY CLAY

FIG No 3

W P 678-90-00

SPT 1018



Ministry of
Transportation
Ontario

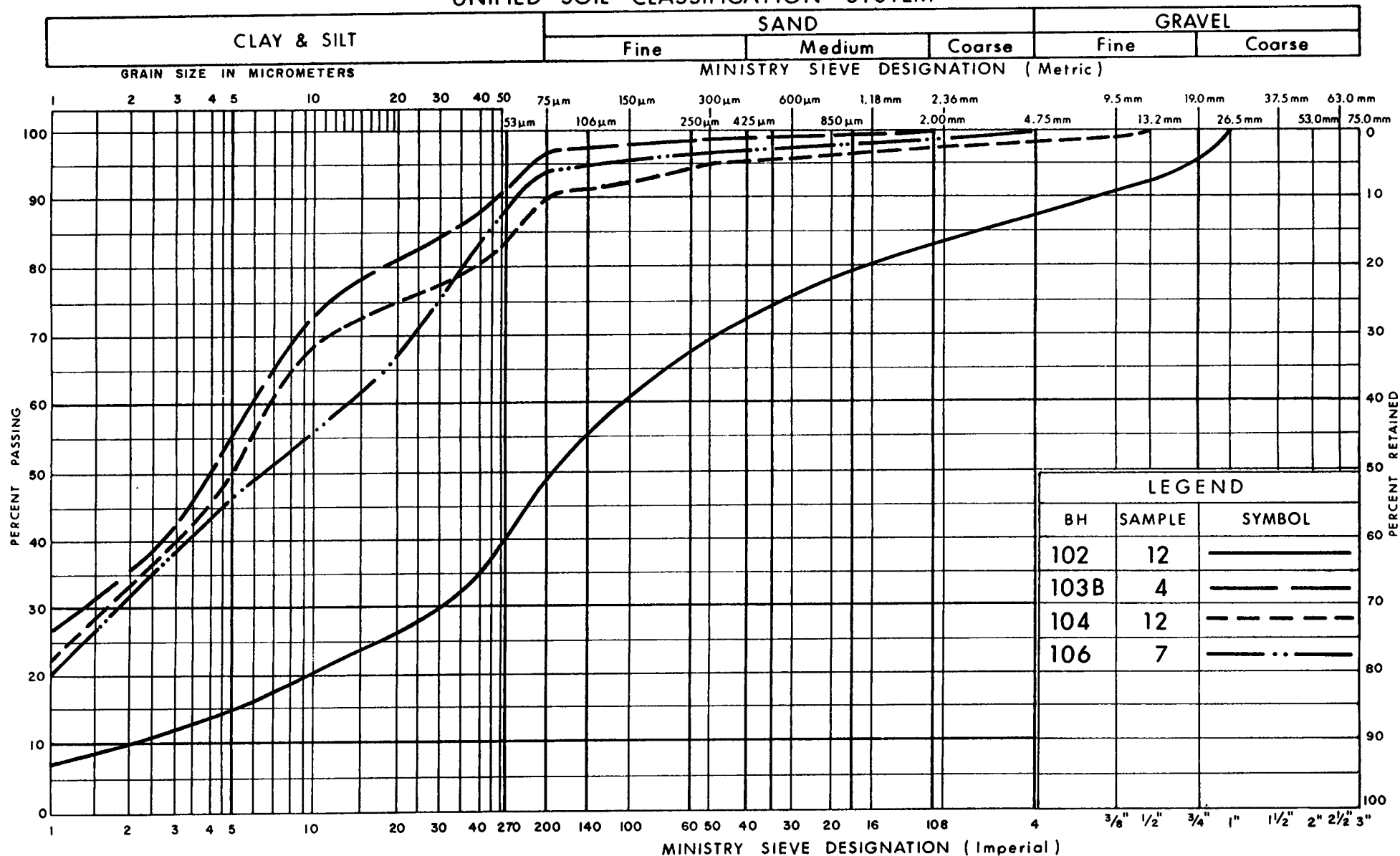
PLASTICITY CHART SILTY CLAY TILL

FIG No 4

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



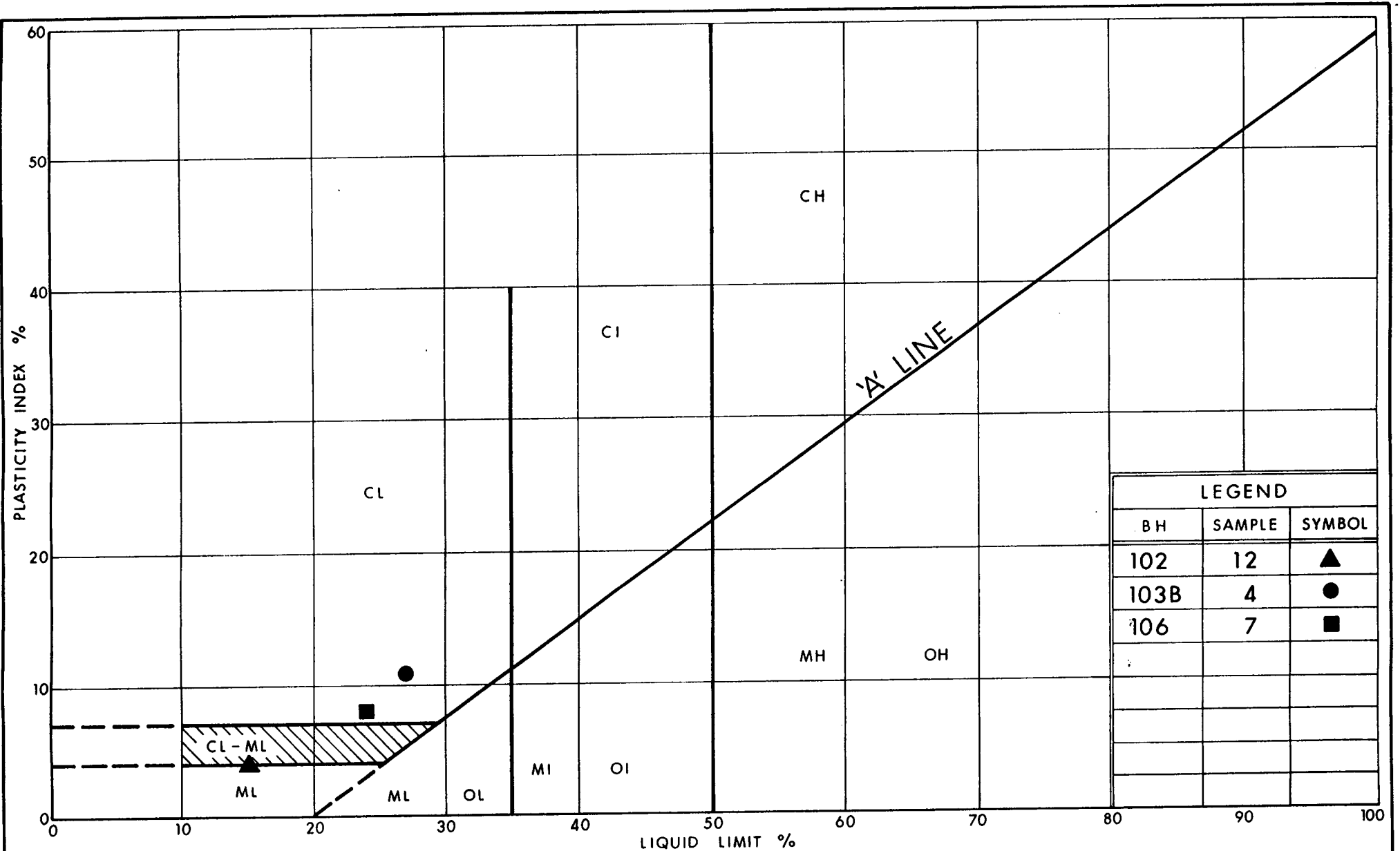
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH SAND, SOME GRAVEL
(Glacial Till)

FIG No 5

W P 678-90-00

SPT 1018



Ministry of
Transportation

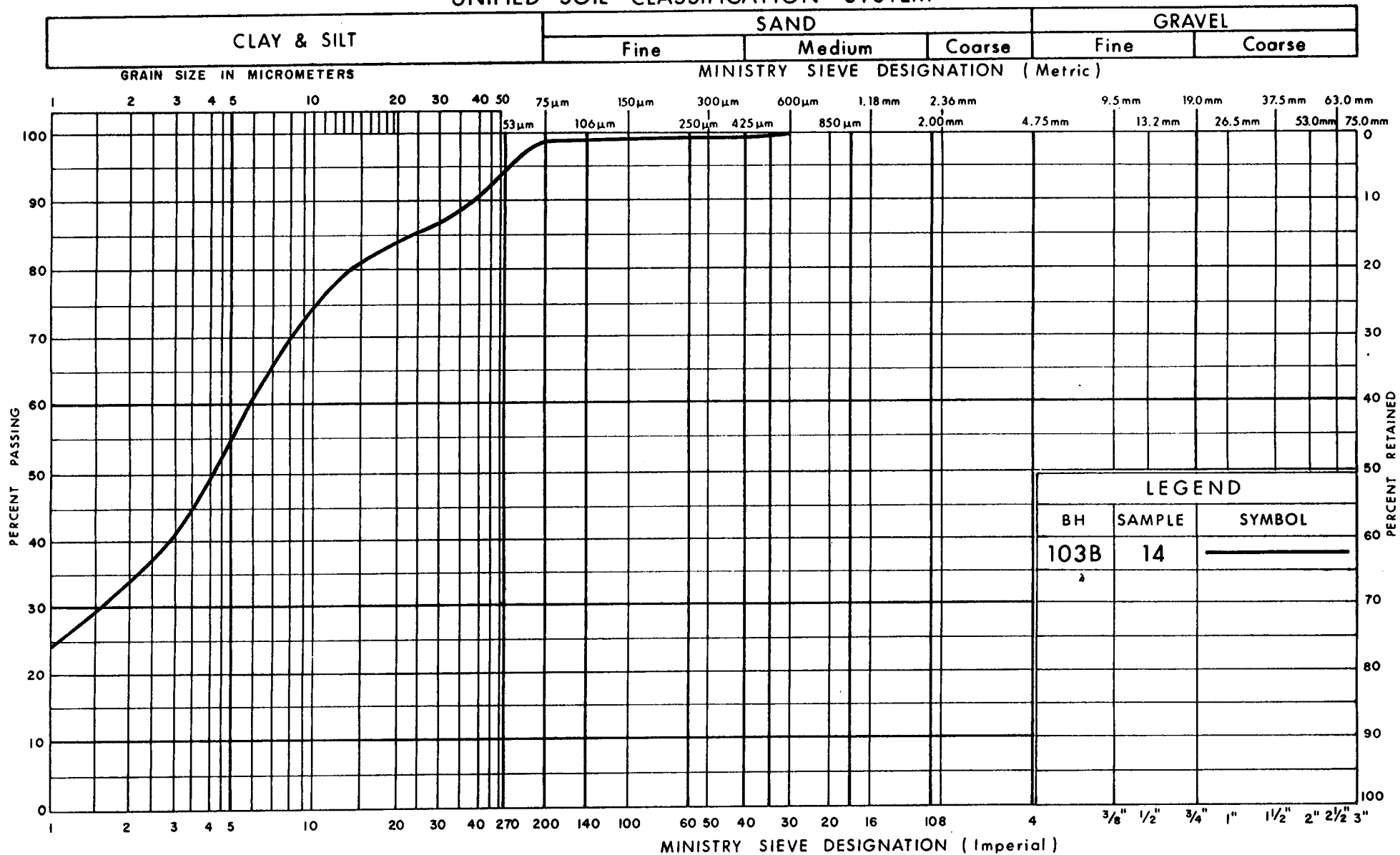
PLASTICITY CHART CLAYEY SILT WITH SAND, SOME GRAVEL (Glacial Till)

FIG No 6

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



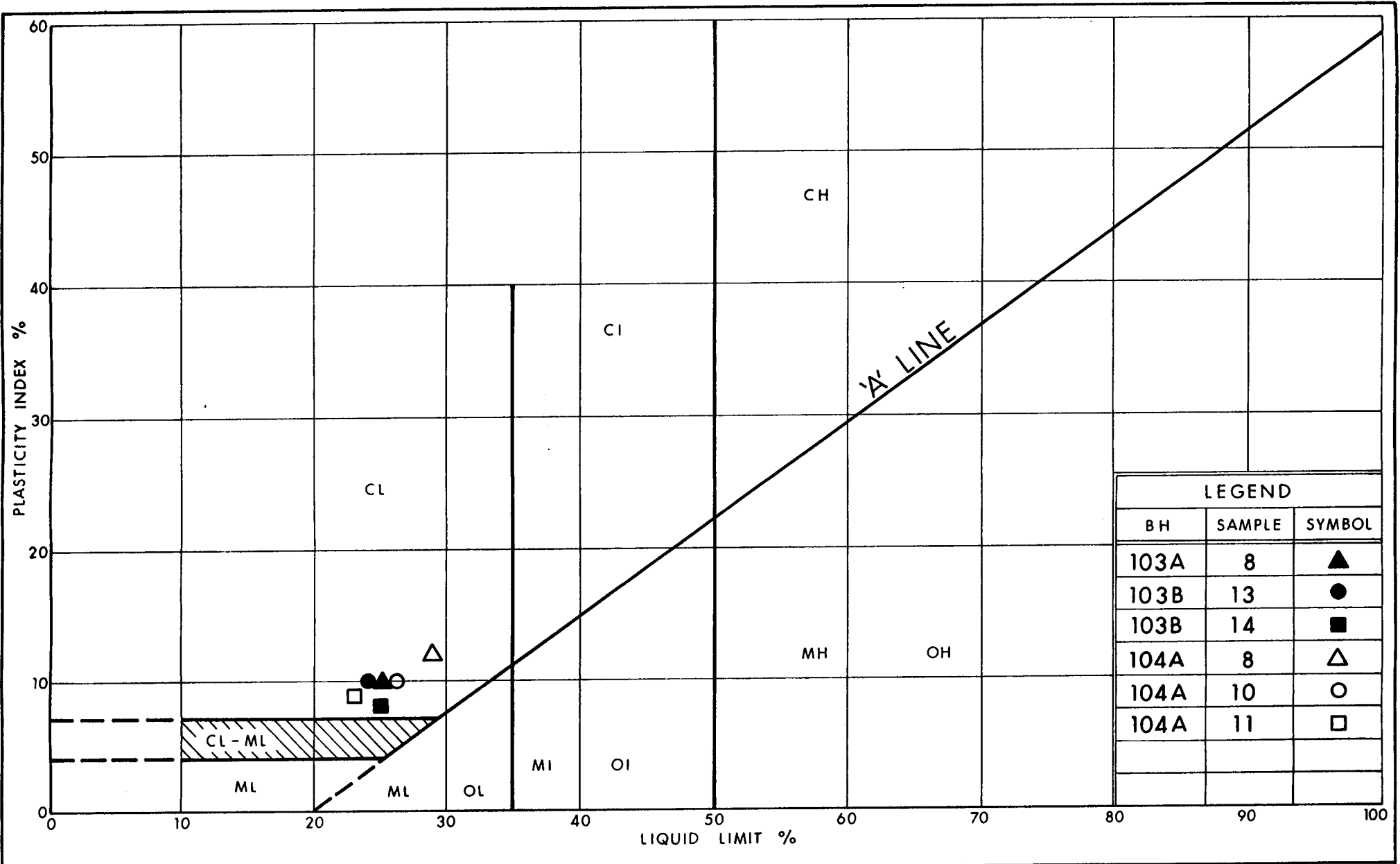
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION CLAYEY SILT

FIG No 7

W P 678-90-00

SPT 1018



Ministry of
Transportation
Ontario

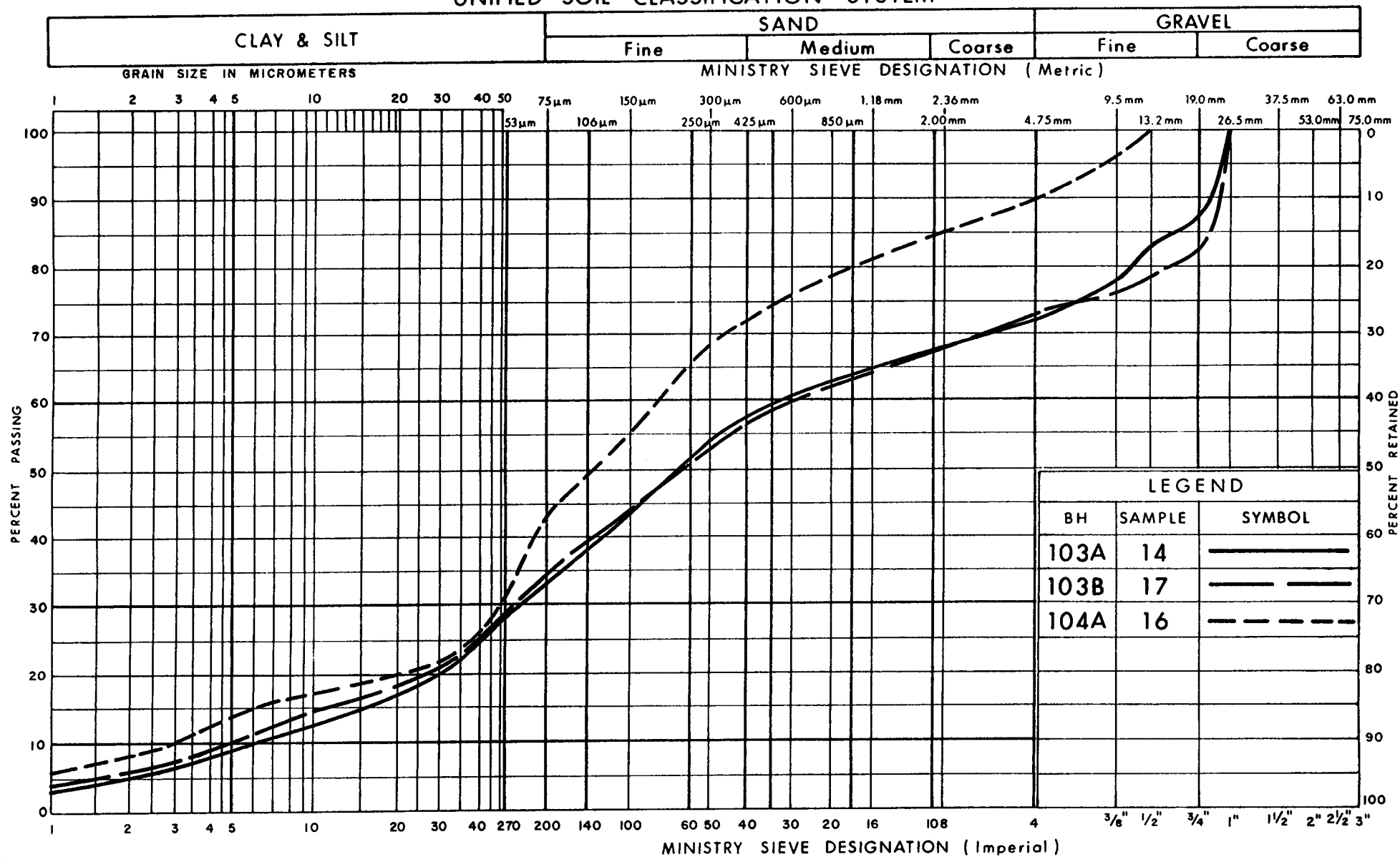
PLASTICITY CHART CLAYEY SILT

FIG No 8

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET. MIXTURE OF SILT, SAND & GRAVEL TRACE TO SOME CLAY
(Glacial Till)

FIG No 9

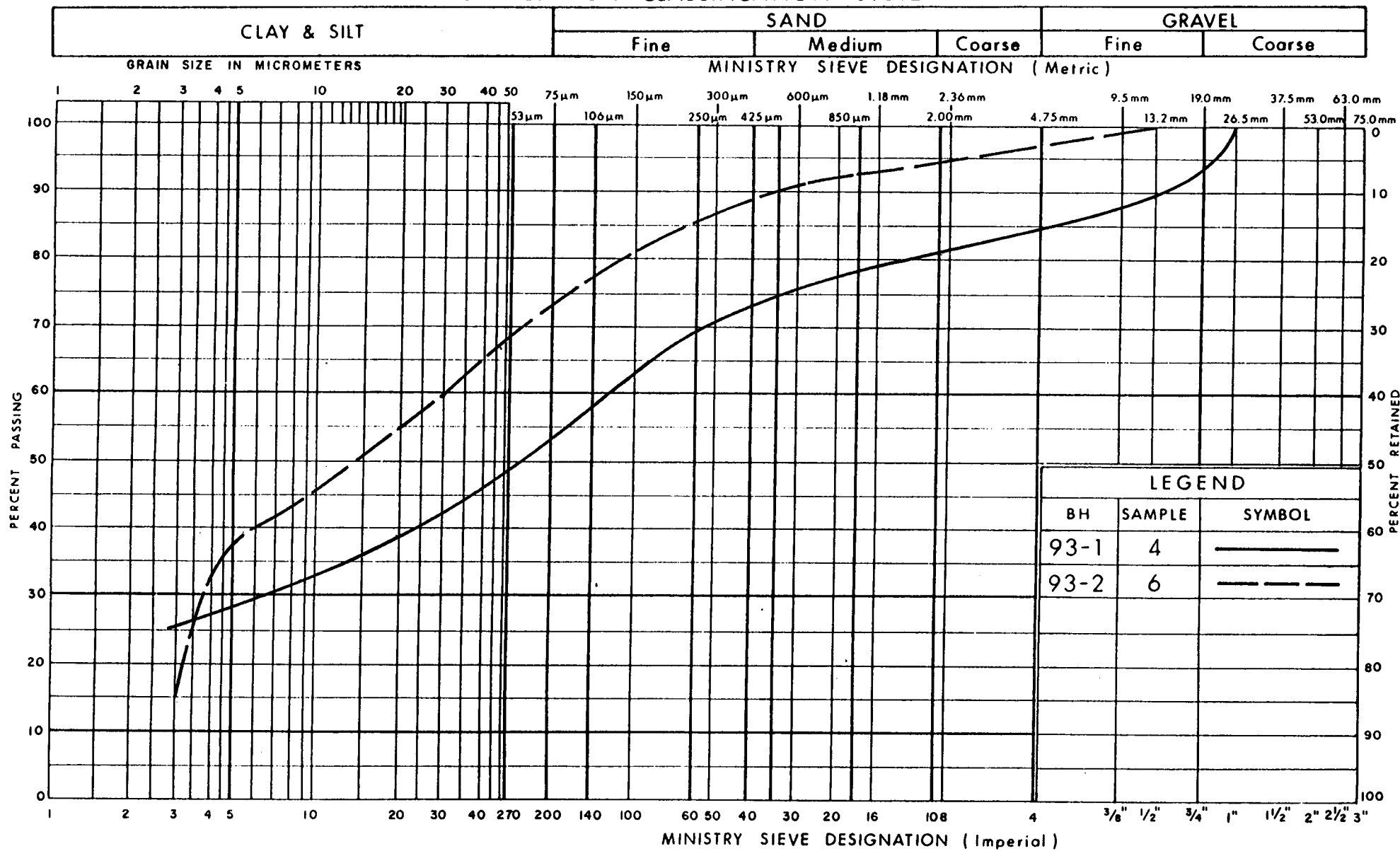
W P 678-90-00

SPT 1018

APPENDIX D

Previous Laboratory Test Results by MTO

UNIFIED SOIL CLASSIFICATION SYSTEM

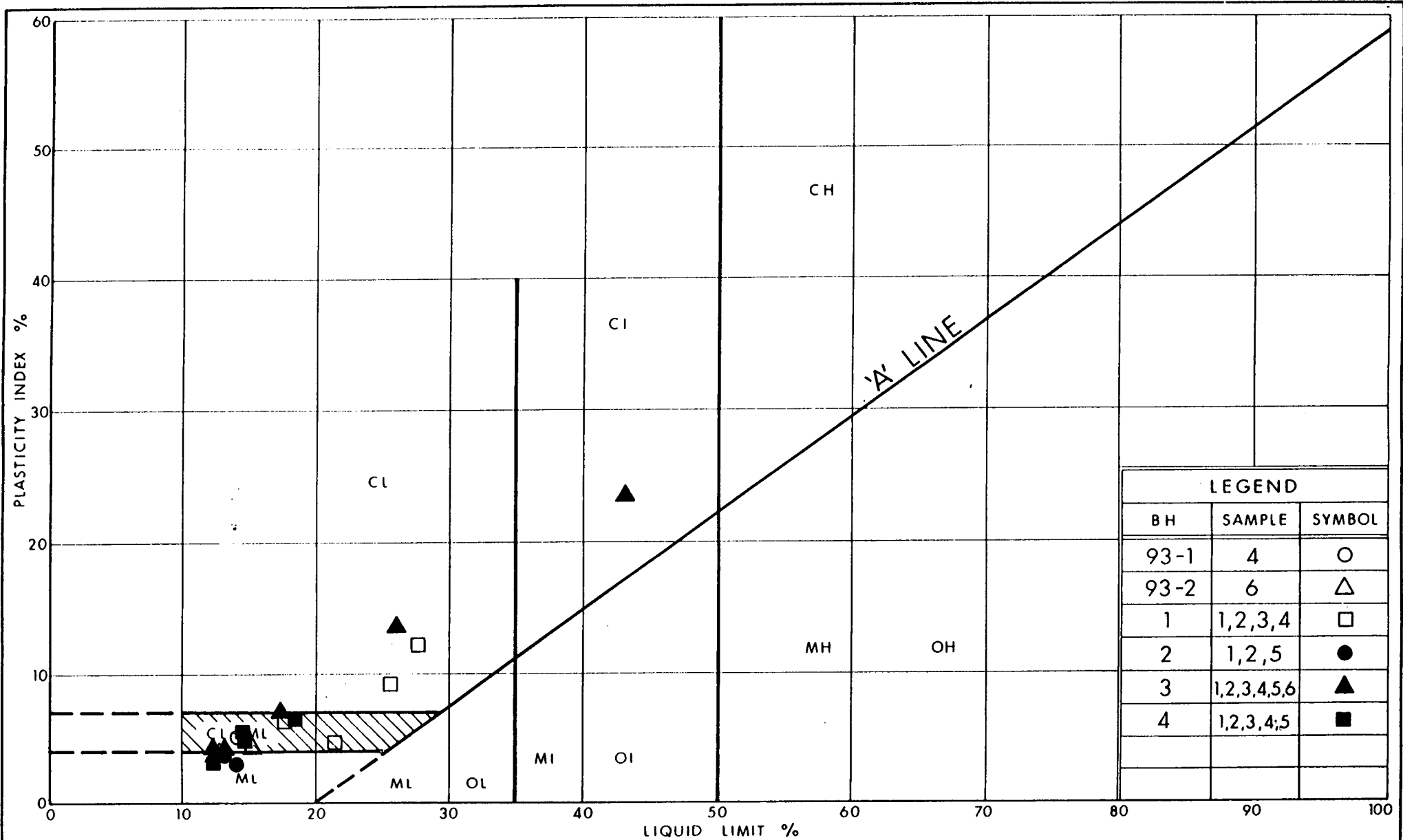


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, WITH SAND & SOME GRAVEL
(GLACIAL TILL)

FIG No 1

W P 678-90-01



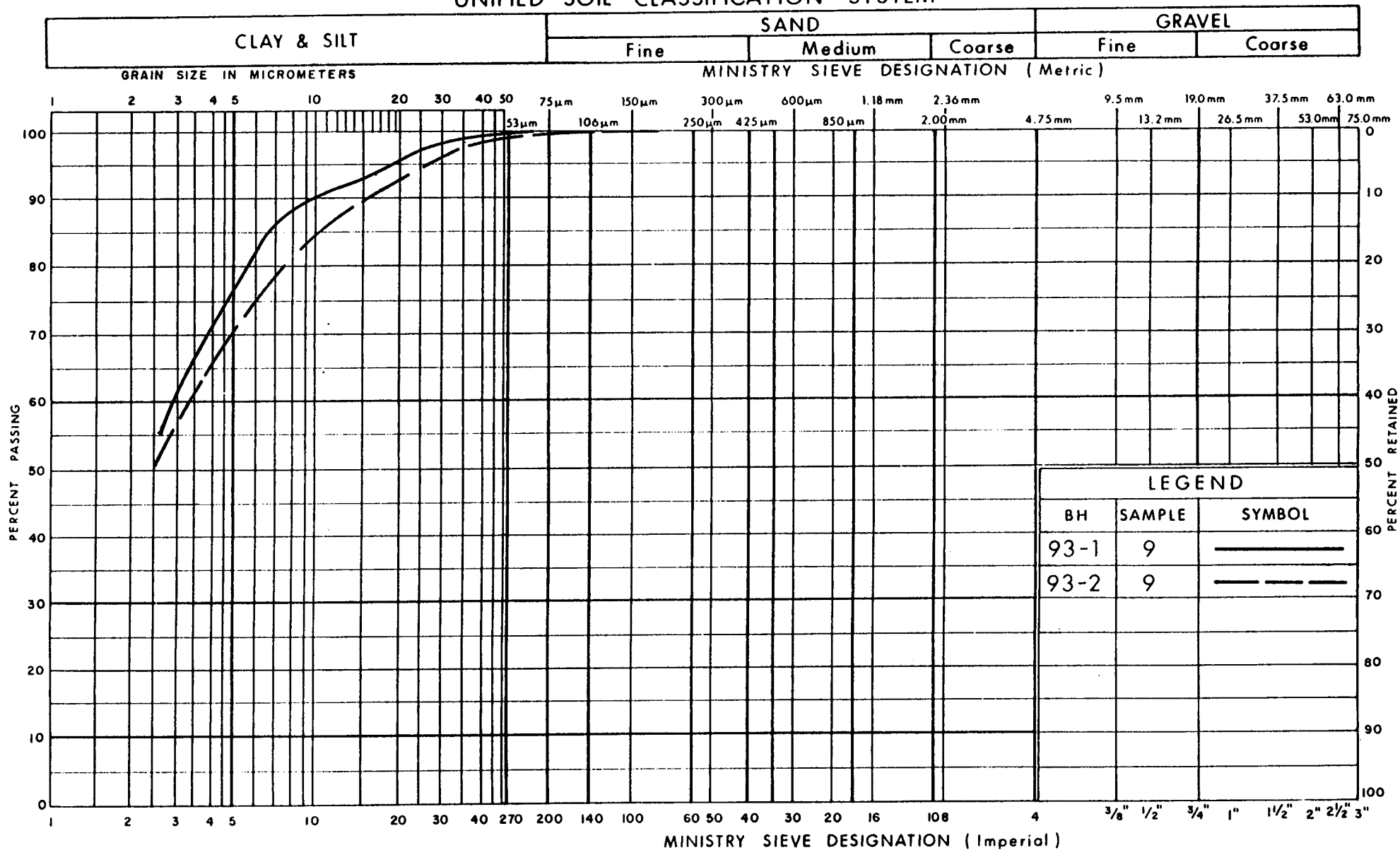
Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT, WITH SAND & SOME GRAVEL (GLACIAL TILL)

FIG No 2

W P 678-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

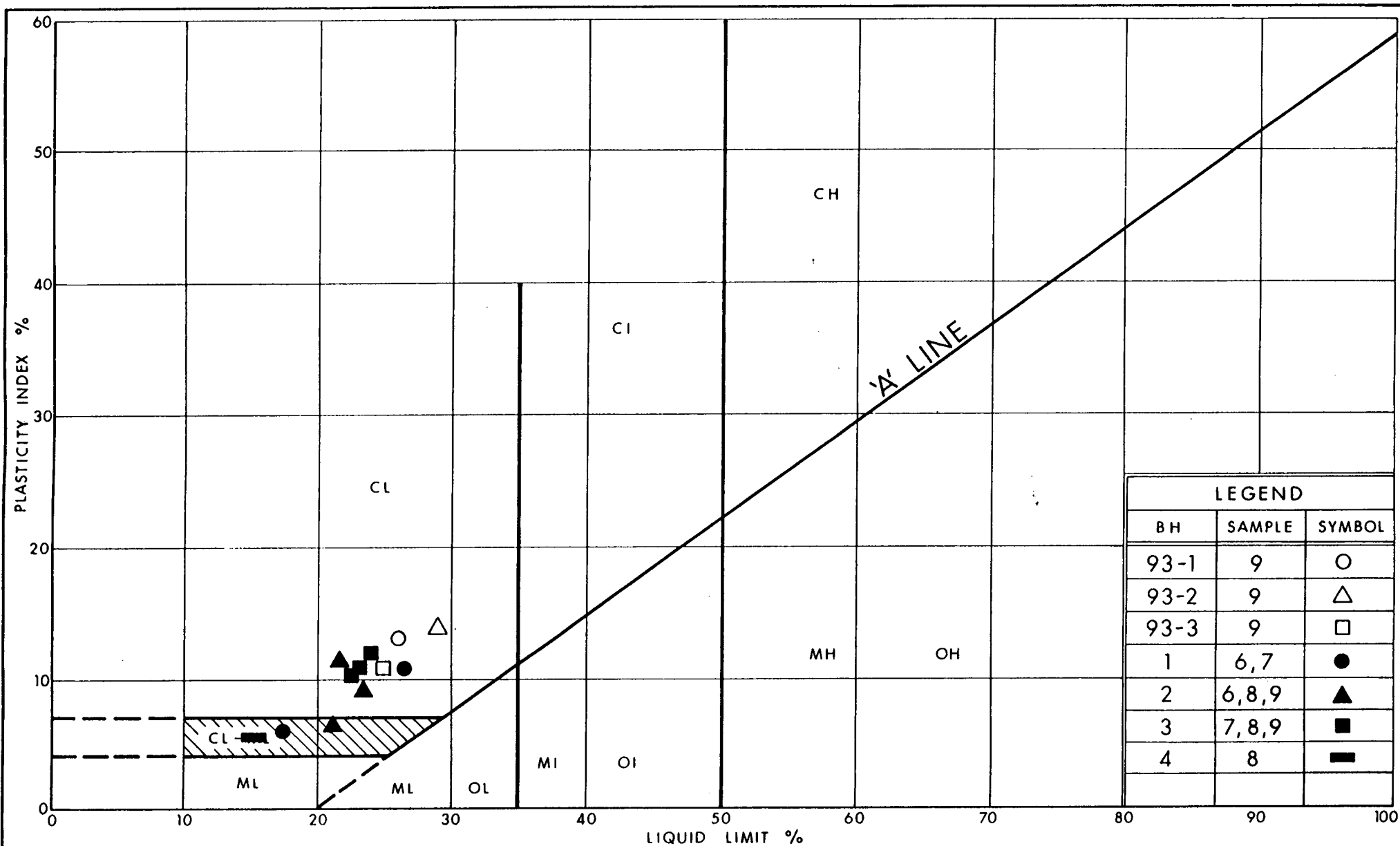


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 3

W P 678 -90-01



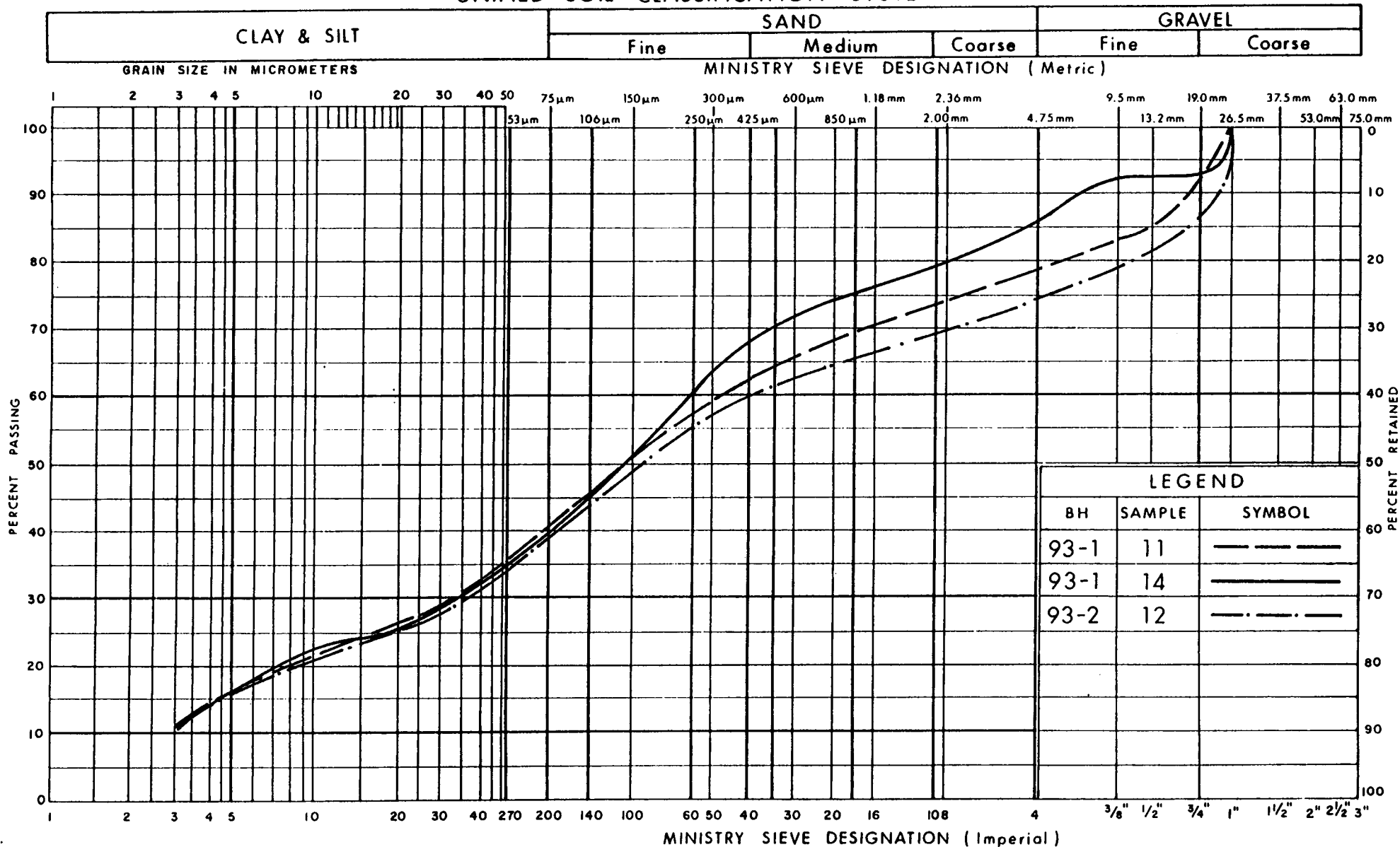
Ministry of
Transportation

PLASTICITY CHART
CLAYEY SILT

FIG No 4

W P 678-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF SILT, SAND & GRAVEL SOME CLAY
(GLACIAL TILL)

FIG No 5

W P 678-90-01

APPENDIX E

Explanation of Terms Used in Report

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

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 = $\frac{c_u}{\tau_r}$

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

**FOUNDATION INVESTIGATION REPORT
RETAINING WALL FOR PROPOSED WIDENING OF
SOUTH EMBANKMENT OF BURNHAM STREET BRIDGE
OVER HIGHWAY 401, COBOURG, ONTARIO
W.P. 678-90-00
SITE: 21-243**

Prepared For:

McCORMICK RANKIN CORPORATION

Prepared by:

SHAHEEN & PEAKER LIMITED

**Project: SPT1018A
September 6, 2001
Geocres No. 30M16-35**

**250 Galaxy Boulevard
Etobicoke, Ontario
M9W 5R8
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DRAWINGS

DRAWING NO.

BOREHOLE LOCATION PLAN & STRATIGRAPHIC SECTION

1

APPENDICES

RECORD OF BOREHOLE SHEETS

APPENDIX A

LABORATORY TEST RESULTS

APPENDIX B

EXPLANATION OF TERMS USED IN REPORT

APPENDIX C

**FOUNDATION INVESTIGATION REPORT
RETAINING WALL FOR PROPOSED WIDENING OF
SOUTH EMBANKMENT OF BURNHAM STREET BRIDGE
OVER HIGHWAY 401, COBOURG, ONTARIO
W.P. 678-90-00
SITE: 21-243**

1. INTRODUCTION

As part of the Highway 401 – Burnham Street Bridge replacement in Cobourg, a new retaining wall may be constructed to support the east side of south approach fill embankment. Shaheen & Peaker Limited (S&P) was retained by McCormick Rankin Corporation to carry out a foundation investigation for the proposed retaining wall structure.

The site is located at the intersection of Highway 401 and Burnham Street (County Road 18) interchange (Interchange #472), about three km north of the Town of Cobourg in the Township of Hamilton, County of Northumberland.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes.

The findings of the investigation are presented in this report.

2. SITE DESCRIPTION AND GEOLOGY

The site is located at the south-east quadrant of the intersection of Highway 401 and Burnham Street in Cobourg, about four km north of Lake Ontario.

Burnham Street is a two-lane roadway at and north of the interchange and a recently upgraded four-lane roadway immediately south of the interchange.

The interchange is located on the boundary of the Town of Cobourg and the Township of Hamilton in the County of Northumberland. This is one of the two interchanges providing access to the Town of Cobourg from Highway 401.

Burnham Street structure over Highway 401 was constructed in 1960 and is a 31.1 m long, 11.2 m wide single span structure and accommodates two lanes of traffic.

The study area is located in the physiographic region known as the "Iroquois Plain." The plain consists of drumlins and sand plains (Ref: Chapman and Putnam, 1984).

The lowest bedrock in the general area (i.e. Northumberland County) consists of Precambrian rock, with upper layers of limestone. These limestone layers are made up of the Trenton Group bedrock formations and were deposited during the Middle Ordovician Period, during the Paleozoic seas, some 480 million years ago.

Glacio-lacustrine lake plain deposits of silt and clay with gently rolling terrain characterize the soils of the area.

The majority of the interchange is located on Schomberg soils. At the interchange site the soil is Smithfield, a silty clay loam of the Gray Brown Podzolic Group. Characteristics of this soil type are imperfect drainage, smooth to gently sloping topography, free of stones.

Cobourg Creek is located about 200 m east of the Burnham Street Bridge and the grade at the site drops from west to east towards the creek valley. The watercourse flows northeast to southwest towards Lake Ontario and crosses under Highway 401 via an existing concrete arch culvert, 65.5 m in length. Highway 401 has a median storm sewer system which outlets to a detention pond, with a sediment forebay immediately adjacent to the creek, in the north-east quadrant of the interchange.

3. INVESTIGATION PROCEDURE

The fieldwork for this investigation consisted of drilling and sampling five boreholes (i.e. Boreholes 101, 102, 106, 107 and 108) at the positions shown on the Borehole Location Plan, Drawing No. 1. The depth of the boreholes ranged between 7.9 and 26.0 m.

The boreholes were advanced using solid stem continuous flight augers with track and truck mounted drilling rigs owned and operated by Groundworks Drilling Inc. under the full-time supervision of our technical personnel. The field work was performed in conjunction with the investigation for the proposed bridge and because of traffic safety requirements in inclement weather conditions

(i.e. snow storms), the field work had to be performed in increments of time (weather permitting) between December 21, 2000 and January 10, 2001.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter O.D. split barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Where the consistency of the soil permitted, the undrained shear strength of the clayey soils was measured in-situ by means of field vane tests using an MTO type field vane tester and a relatively undisturbed sample was taken by means of a thin-walled Shelby tube sampler.

The borehole locations were established in the field by our engineering staff, in relation to the existing features. The borehole geodetic elevations and coordinates were later taken by surveyors from David Harwood Limited, who provided us with the coordinates and elevations.

In the boreholes, water level observations were made during the drilling and at the completion of each borehole. In Boreholes 106 and 107, piezometers were installed to monitor groundwater levels over a prolonged period of time without interference from surface water. Water levels in the piezometers were recorded at regular intervals of time after their installation.

The results of drilling, in-situ testing and water level measurements are summarized on the Record of Borehole sheets in Appendix A.

Upon their completion, the boreholes were backfilled to about 6 to 8 m below the ground surface with soils brought up from the boreholes by the augers (i.e. by auger cuttings). The upper 6 to 8 m of the boreholes were grouted using a cement/bentonite mixture.

A laboratory testing programme, consisting of natural moisture content, bulk unit weight and Atterberg Limits tests and grain size analyses, was performed

on selected soil samples. The results of the laboratory tests are presented on the Borehole Log Sheets and also in Appendix B.

If deemed necessary, additional information from boreholes drilled in the general area and laboratory test data can be obtained by referring to the investigations carried out in 1958 for the existing bridge, proposed widening of the existing bridge in 1993 and for the replacement of the existing bridge (in conjunction with this present investigation in 2000-2001, Ref No. SPT1018).

4. SUBSURFACE CONDITIONS

Boreholes 101, 102, 106, 107 and 108 show that, in general, beneath some fill and topsoil, the site is underlain by a surficial silty clay till deposit becoming somewhat coarser clayey silt till with increasing depth. This upper till sheet extends to Elevations ranging between 97 and 94 m and is underlain by a weak and compressible clayey silt/silty clay layer. This unit is 2.4 to 3.4 m thick and is underlain by a lower till sheet. The lower till sheet is a basically granular material (i.e. heterogeneous mixture of silt and sand with gravel and some clay) and was encountered at Elevations 90.5 and 91.6 m in Boreholes 102 and 106, respectively.

Details of the subsurface conditions encountered in the boreholes are given on the Borehole Log Sheets in Appendix A. The individual soil strata encountered in the boreholes are briefly described in the following paragraphs.

4.1 TOPSOIL

Boreholes 101 and 102, which were drilled from the top of the Burnham Street embankment, contacted fill to depths of 5.5 to 5.7 m or to Elevation 103.8 m. An approximately 400 mm thick layer of topsoil was contacted underlying the fill. This probably represents the original topsoil which was left in place when constructing the existing embankment fill.

Boreholes 106, 107 and 108, which were drilled from near the toe of the Burnham Street embankment (ground Elevations 103.6, 104.4 and 105.4 m, respectively), contacted an approximately 300 mm thick topsoil layer. In Boreholes 106 and 108, the topsoil is underlain by a surficial fill layer, extending to 0.9 m below the ground surface, underlain by a 200 mm thick topsoil layer.

4.2 FILL

4.2.1 GRANULAR FILL

Boreholes 101 and 102 were drilled from the top of Burnham Street embankment and these boreholes encountered below a 150 mm thick asphaltic concrete, a granular pavement fill extending to depths of 0.9 and 2.1 m, respectively.

The grain size distribution of two samples from the granular fill is given in Appendix B.

4.2.2 COHESIVE FILL

The granular fill in Boreholes 101 and 102 is underlain by a silty clay to clayey silt embankment fill which extends to depths of 5.5 m (Elevation 103.8 m) and 5.7 m (Elevation 103.8 m), respectively. This is a basically cohesive soil and was found to be mixed with some topsoil and gravel. The grain-size distribution of a sample from the embankment fill is given in Appendix B. N-values recorded in this fill ranged from 14 to 35 blows/0.3 m, indicating that the fill has received some degree of systemic compaction when the embankment was first built.

Boreholes 106 and 108, drilled from the bottom of the embankment, encountered a surficial cohesive (0.6 m thick) fill consisting of silty clay to clayey silt with traces to some gravel and topsoil.

4.3 SURFICIAL SILTY CLAY

Underlying the topsoil in Borehole 107 and the fill and topsoil in Borehole 108, a surficial silty clay layer was contacted at depths of 0.3 m and 1.1 m. The thickness of this deposit was 1.1 m and 0.2 m and it extended to Elevations 103.0 and 104.1 m in Boreholes 107 and 108, respectively.

The silty clay is a cohesive soil and contains traces of topsoil. Based on recorded N-values of 29 to 37 blows/0.3 m, together with a visual and tactile examination of the recovered soil samples from the deposit, its consistency is described as stiff to hard.

4.4 SILTY CLAY TILL

Underlying the surficial silty clay layer in Boreholes 107 and 108 and the fill and topsoil in the remaining boreholes, the site is underlain by a 0.6 to 2.3 m thick silty clay till deposit. This unit was contacted below Elevations ranging from 104.1 to 102.5 m and extended to Elevations 103.3-101.1 m.

This is a cohesive material is considered to have a low permeability. The results of an Atterberg Limits test performed on a sample from the deposit are given in Figure 3, Appendix B.

Standard Penetration tests performed in this deposit yielded N-values ranging from 12 to 48 blows/0.3 m, indicating a stiff to hard consistency.

4.5 CLAYEY SILT WITH SAND AND SOME GRAVEL (GLACIAL TILL)

The silty clay till described in the preceding section attains with increasing depth, a coarser texture and becomes a clayey silt till (i.e. heterogeneous, unsorted mixture of clayey silt with sand and some gravel). Boreholes 101 and 108 were terminated in this deposit at a depth of about 8 m below the ground surface or at Elevations of 101.2 and 97.5 m, respectively. In the remaining boreholes, this deposit was found to be underlain by a clayey silt layer at depths of 15.6 m (Elevation 93.9 m) in Borehole 102; 9.6 m (Elevation 94.0 m) in Borehole 106 and 7.5 m (Elevation 96.9 m) in Borehole 107.

The results of a grain-size distribution analyses carried out on selected samples from this unit is given in Appendix B. They indicate 0-13% gravel, 6-39% sand, 38-61% silt and 9-33% clay size particles. From the observed resistance to augering (i.e. grinding) during the fieldwork, the presence of coarse gravel, cobbles and boulders in the deposit can be inferred. Boulders and cobbles are characteristic components of glacial till deposits.

Atterberg limits tests performed on samples from the deposit yielded the following index values:

Liquid Limit	=	15-24%
Plastic Limit	=	11-16%
Plasticity Index	=	4 – 8 %

These results are representative of clayey soils of low plasticity (as shown on the Plasticity Chart Figure in Appendix B). The measured natural moisture contents generally range from 8 to 20%.

N-values recorded in the deposit ranged from 12 to in excess of 50 blows/0.3 m which indicate a stiff to hard consistency, but generally very stiff to hard.

4.6 CLAYEY SILT

The boreholes show the presence of a clayey silt/silty clay layer, sandwiched between the upper and lower till sheets. This deposit was contacted in the deeper boreholes (i.e. Boreholes 102, 106 and 107) at about elevations ranging from 97 to 94 m. Borehole 107 was terminated in this material at Elevation 94.4 m, after penetrating it for a distance of 2.5 m, while in Boreholes 102 and 106 it extended to Elevation 90.5 and 91.6 m, respectively (i.e. 2.4 to 3.4 m thick). In the boreholes drilled in the general area for the existing bridge and for the proposed bridge structure, the thickness of this unit was found to range from about 2 to 6 m.

Laboratory tests carried out in the boreholes drilled in the general area indicate 0-1% sand, 65-70% silt and 29-35% clay size particles and Atterberg limits tests gave the following results:

Liquid Limit	=	12-29%
Plastic Limit	=	8-17%
Plasticity Index	=	4-14%
Natural Moisture Content	=	7-25%

These results are indicative of clayey soils of low plasticity. An unusual feature of these results is that with most soils, the measured clay size percentages are normally associated with higher plasticity index values than reported. Another unusual feature was that the samples of the material obtained from the boreholes showed a much higher degree of dilatancy than would be expected from soil containing a relatively high percentage of clay sizes as measured. This rather unusual property can perhaps be caused by clay size particles being rather inactive. Chapman and Putnam observed this behaviour many years ago and offered the following hypothesis on similar soils as an explanation, "....Mechanical analyses indicate about 50% clay and 40% silt, but its behaviour is more like that of silt than

clay. It is very slippery when wet and inclined to be mealy when dry. It is probably composed of freshly ground rock flour rather than weathered clay materials."

N-values recorded in this deposit ranged from 7 to 13 blows/0.3 m and field vane tests gave undrained in-situ shear strength values ranging from 72 to in excess of 100 kPa. Based on these results, the consistency of this cohesive deposit is described as firm to very stiff, but generally stiff. It should be pointed out that in boreholes previously drilled further north for the existing bridge and subsequently for the proposed bridge, field vane tests gave undrained shear strength values as low as 20 kPa.

4.7 HETEROGENEOUS MIXTURE OF SILT, SAND AND GRAVEL, SOME CLAY (GLACIAL TILL)

Boreholes 102 and 106 (i.e. the deeper boreholes) contacted, underlying the clayey silt/silty clay layer (described in the preceding section), a lower till sheet at Elevation 90.5 and 91.6 m, respectively. Both boreholes were terminated in this deposit after penetrating it 7.0 m and 0.7 m, respectively. This lower till sheet was encountered in boreholes drilled further north for the bridge as well and was penetrated for a maximum depth of 8 m or to Elevation of about 81 m. It consists of heterogeneous mixture of silt and sand with gravel and traces to some clay size particles. Grain size distribution analysis on samples from the boreholes drilled in the median of Highway 401 to the north of the proposed retaining wall site gave the following results:

10-28%	gravel
37-46%	sand
33-44%	soil fines (silt & clay size particles)

The presence of cobbles and boulders can always be expected in the glacial till deposits, due to their mode deposition. There is some indication that the deposit contains a greater percentage of gravel and cobbles than exhibited by the samples tested, especially on the south side of the existing bridge.

Standard Penetration tests performed in this deposit in Boreholes 102 and 106 gave N-values ranging from 17 to in excess of 86 blows/0.3 m, indicating a compact to generally very dense condition.

4.8 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes were observed while drilling and at the completion of each borehole. In addition, piezometers were installed in Boreholes 106 and 107 to monitor the groundwater levels over a prolonged period of time without interference from surface water. The observations and the recorded water levels are given on the individual borehole log sheets.

Water levels in the piezometers installed in Boreholes 106 and 107 were measured 1.2 and 2.3 m below the ground surface or at Elevations 102.4 and 102.1 m, respectively.

It should be pointed out that the groundwater level can be expected to fluctuate seasonally and in response to major weather events.

Yours very truly,

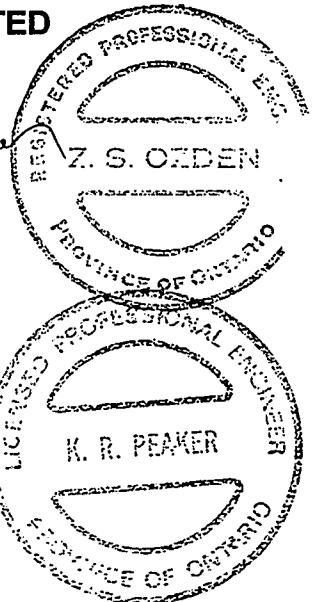
SHAHEEN & PEAKER LIMITED



Zuhtu S. Ozden, P.Eng.



K.R. Peaker, Ph.D., P.Eng.

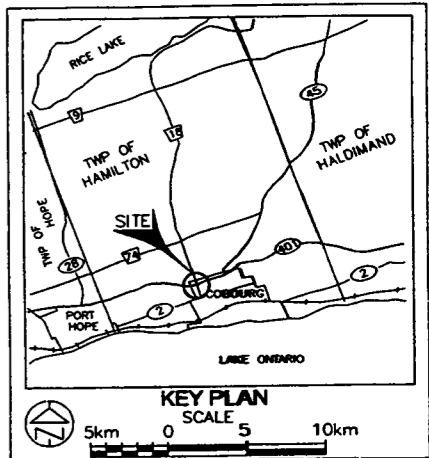


Drawings



HWY 401 - BURNHAM ST.
PROPOSED RETAINING WALL
BORE HOLE LOCATIONS & SOIL STRATA

Shaheen & Peaker 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 Jan. 2001
- W L in Piezometer
- Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
101	109.3	4 871 892.2	409 415.9
102	109.5	4 871 910.8	409 408.5
106	103.6	4 871 910.3	409 428.2
107	104.4	4 871 869.6	409 442.2
108	105.4	4 871 837.8	409 450.8

NOTE

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

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

REV.	DATE	BY	DESCRIPTION

Geocres No. _____

HWY No 401

SUBM'D ZO _____

DRWN JTW

CHECKED ZO _____

CHECKED JP _____

DATE Aug., 2001

SITE _____

DATE _____

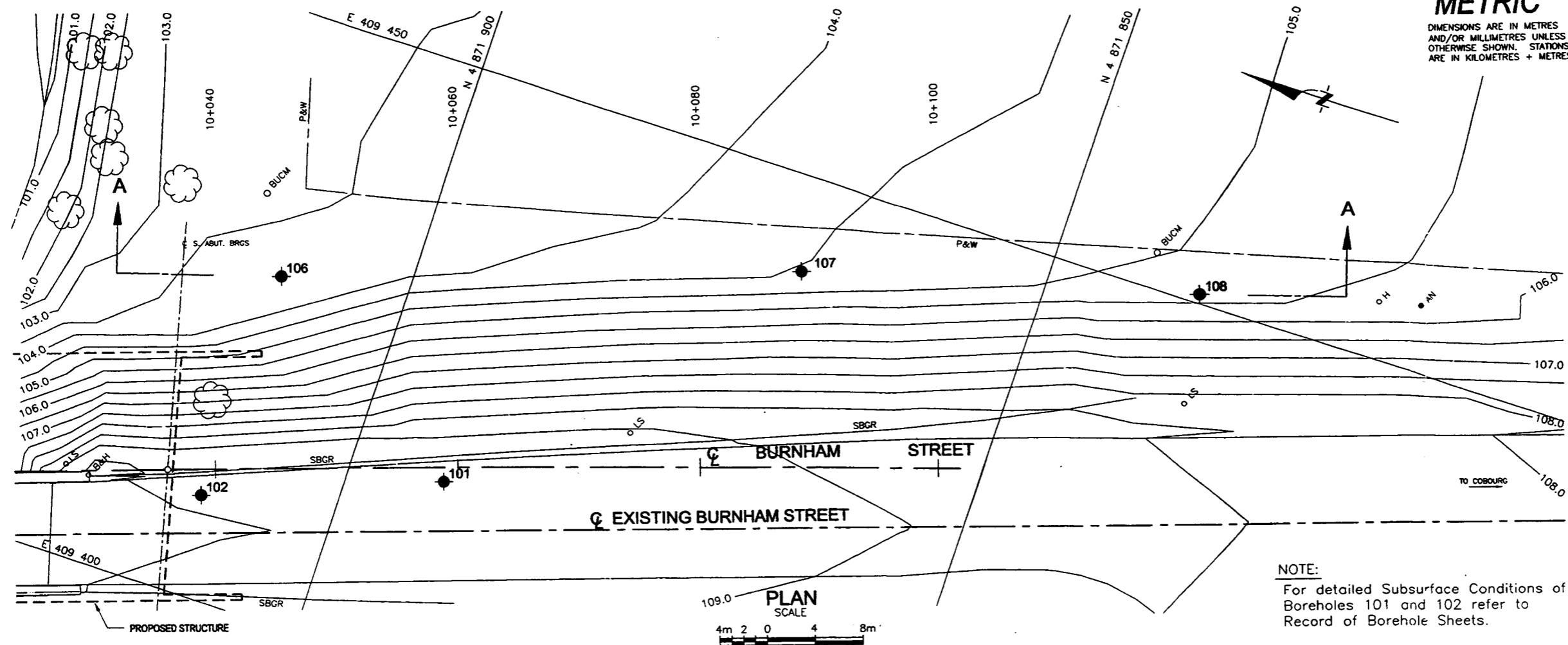
DESIGNER _____

DATE _____

SCALE 1

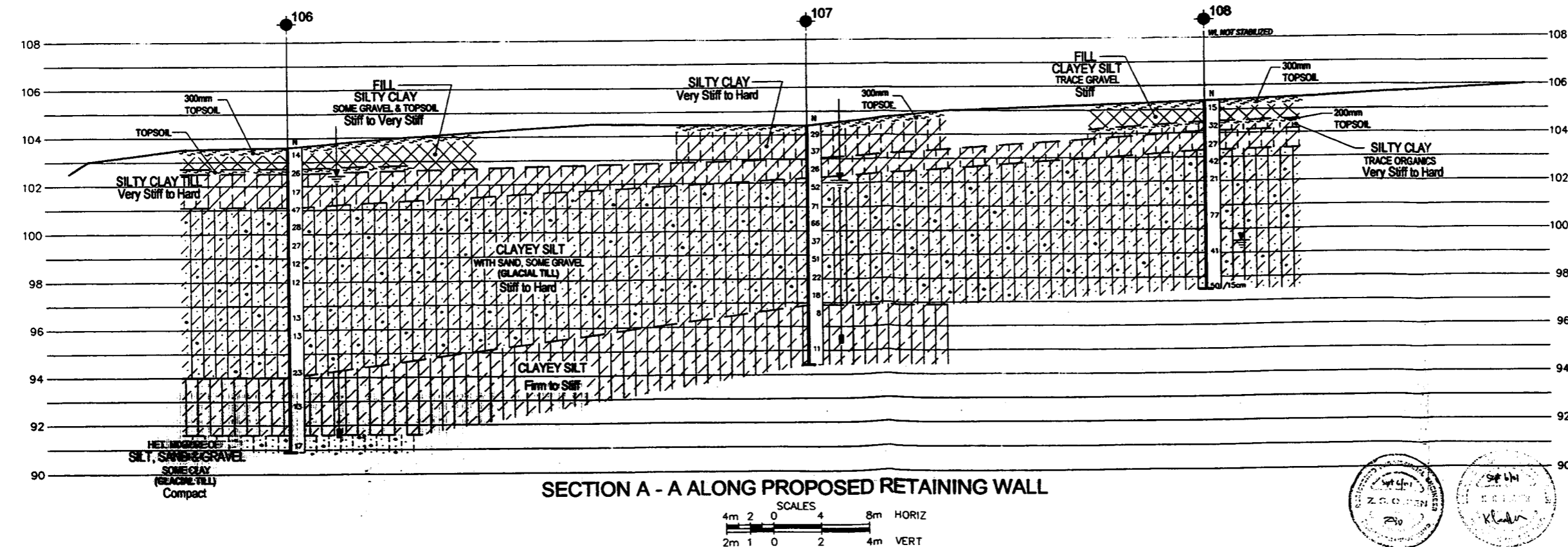
METRIC

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



NOTE:

For detailed Subsurface Conditions of Boreholes 101 and 102 refer to Record of Borehole Sheets.



SECTION A - A ALONG PROPOSED RETAINING WALL



Appendix A

Records of Boreholes

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 892.2; E 409 415.9 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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		
109.3	Ground surface													
0.0	150 mm Asphalt		1	SS	64		109							32 55 (13)
108.4	Gravelly Sand (Granular Fill) brown, very dense													
0.9			2	SS	19		108						20.4	
	FILL: Silty Clay and Clayey Silt, trace gravel, some topsoil pockets, very stiff to hard, brown, damp		3	SS	32								19.8	
			4	SS	30		107						19.5	
	----- high topsoil content black, moist -----		5	SS	34		106						19.7	
			6	SS	27		105						19.2	
			7	SS	35		104						19.4	
103.8														
5.5	TOPSOIL, black		8	SS	20		103						20.8	
103.4														
5.9	SILTY CLAY TILL, stiff, greyish brown		9	SS	12		102						20.8	
102.8														
6.5	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to very stiff, brown		10	SS	27								22.6	
			11	SS	16								21.0	
101.2														
8.1	End of borehole • Wet cave at 7.2 m on completion. Water level not stabilized Borehole drilled to 5.0 m on Dec.5/2000. Abandon borehole due to snow storm re-drilled on Jan.10/2001													

RECORD OF BOREHOLE No 102

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
109.5	Ground surface		1	SS	50/15		109					
0.0	150 mm Asphalt Gravelly Sand (Granular FILL) brown, very dense		2	SS	50/15		108					20 72 (8)
107.4			3	SS	75/30		107					
2.1	FILL: Silty Clay, trace of gravel and topsoil, stiff to very stiff, brown		4	SS	21		106					20.0
			5	SS	14		105					20.5
			6	SS	24		104					
103.8							103					
5.7	TOPSOIL, black		7	SS	48		102					
103.4	some organics		8	SS	28		101					
6.1	SILTY CLAY TILL greyish brown, very stiff to hard		9	SS	50/15		100					20.3
101.1			10	SS	42		99					23.2
8.4	Clayey Silt with Sand, some gravel (GLACIAL TILL) hard to very stiff, brown to 10 m, grey below		11	SS	24		98					22.9
			12	SS	23		97					23.9
							96					13 38 39 10
							95					

Continued Next Page

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

RECORD OF BOREHOLE No 102

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
94.5														
15.0	Clayey Silt with Sand, some gravel (GLACIAL TILL)		13	SS	21								22.6	
93.9	grey, very stiff													
15.6														
	CLAYEY SILT firm to very stiff, grey		14	SS	12								20.1	
			15	SS	7								21.3	
90.5														
19.0	Heterogeneous mixture of Silt, Sand and Gravel, some clay (GLACIAL TILL) dense to 21 m, very dense below, grey		16	SS	35								23.6	
			17	SS	86/25								22.9	
	more sandy with Sand layers below 24 m		18	SS	50/15								23.1	
			19	SS	50/13								22.6	
83.5														
26.0	End of borehole * Wet cave at 4.5 m on completion. Water level not stabilized Borehole drilled to 6.6 m on Dec.5/2000. Borehole had to be abandoned due to snow storm. Borehole re-drilled on Jan.10-11/2001		20	SS	50/8								22.1	

RECORD OF BOREHOLE No 106

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.3; E 409 428.2 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 21.12.00 04.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
103.6	Ground surface													
0.0	300 mm Topsoil		1	SS	14							21.7		
102.7	FILL: Silty Clay, some gravel and topsoil, brown, stiff to very stiff		2	SS	26							20.6		
102.5	TOPSOIL, black													
1.1	SILTY CLAY TILL very stiff to hard, brown		3	SS	17							19.7		
101.1			4	SS	47							21.3		
2.5			5	SS	28							21.8		
	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to hard, brown to 4.4 m, grey below		6	SS	27							21.2		
			7	SS	12							20.1	0 6 61 33	
			8	SS	12							20.8		
			9	TW	PH									
			10	SS	13									
			11	SS	13									
94.0			12	SS	23									
9.6	CLAYEY SILT stiff, grey		13	SS	13							22.0		
91.6			14	TW	PH									
12.0	Heterogeneous mixture of Silt, Sand and Gravel, some clay, (GLACIAL TILL) compact, grey, wet		15	SS	17							23.2		
90.9														
12.7	End of borehole Borehole drilled to 6.6 m on Dec.21/2000 and re-drilled on Jan.04/2001 Borehole dry and open to 11.1 m on completion													

Continued Next Page

+ 3 . x 3. Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 106

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.3; E 409 428.2 ORIGINATED BY GI
 DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
 DATUM Geodetic DATE 21.12.00 04.01.01 CHECKED BY ZO

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									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
	Piezometer installed to 12.1 m Water level in piezometer: Jan.04/2001 - 5.5 m Jan.09/2001 - 1.1 m Jan.10/2001 - 1.0 m Jan.11/2001 - 1.2 m																

RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 869.6; E 409 442.2 ORIGINATED BY GI
 DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
 DATUM Geodetic DATE 04.01.01 CHECKED BY ZO

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							
104.4	Ground surface							20 40 60 80 100							
0.0	300 mm Topsoil Silty Clay very stiff to hard, dark brown and organic stained to 0.8 m, brown below		1	SS	29		104					○		18.1	
			2	SS	37							○		19.1	
103.0							103								
1.4	SILTY CLAY TILL very stiff, brown		3	SS	26							○		21.5	
102.2							102					○		22.1	
2.2			4	SS	52							○		22.3	
			5	SS	71		101					○		21.7	
	Clayey Silt with Sand, some Gravel (GLACIAL TILL) hard to 5.8 m, very stiff below, brown to 4.8 m, grey below		6	SS	66		100					○		21.6	
			7	SS	37							○		21.6	
			8	SS	51		99					○ H		22.4	
			9	SS	22		98					○		22.7	
			10	SS	18							○		22.0	
96.9							97								
7.5	CLAYEY SILT firm to stiff, grey		11	SS	8							○		19.3	
							96								
			12	SS	11		95					○		20.1	
94.4															
10.0	End of borehole Water level at 5.5 m upon completion Piezometer installed to 9.1 m Water level in piezometer: Jan.04/2001 - 5.3 m Jan.09/2001 - 2.0 m Jan.10/2001 - 2.2 m Jan.11/2001 - 2.3 m														

+ 3 . x 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 837.8; E 409 450.8 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 05.01.01 CHECKED BY ZO

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		
105.4	Ground surface													
0.0	300 mm Topsoil FILL:		1	SS	15		105						17.6	
104.5	Clayey Silt, trace gravel, stiff, brown		2	SS	32								19.3	
0.9	200 mm TOPSOIL													
104.1	SILTY CLAY: trace organics, very stiff to hard, brown		3	SS	27		104						20.0	
1.3	SILTY CLAY TILL very stiff, brown													
103.3			4	SS	42		103						21.3	
2.1			5	SS	21		102						21.9	12 36 43 9
	Clayey Silt with Sand, some Gravel (GLACIAL TILL) very stiff to hard brown to 5.5 m, grey below		6	SS			101						22.4	
			7	SS	41		100							
							99						22.4	
97.5			8	SS	50/15		98							
7.9	End of borehole *Water level at 5.9 m upon completion (not stabilized)													

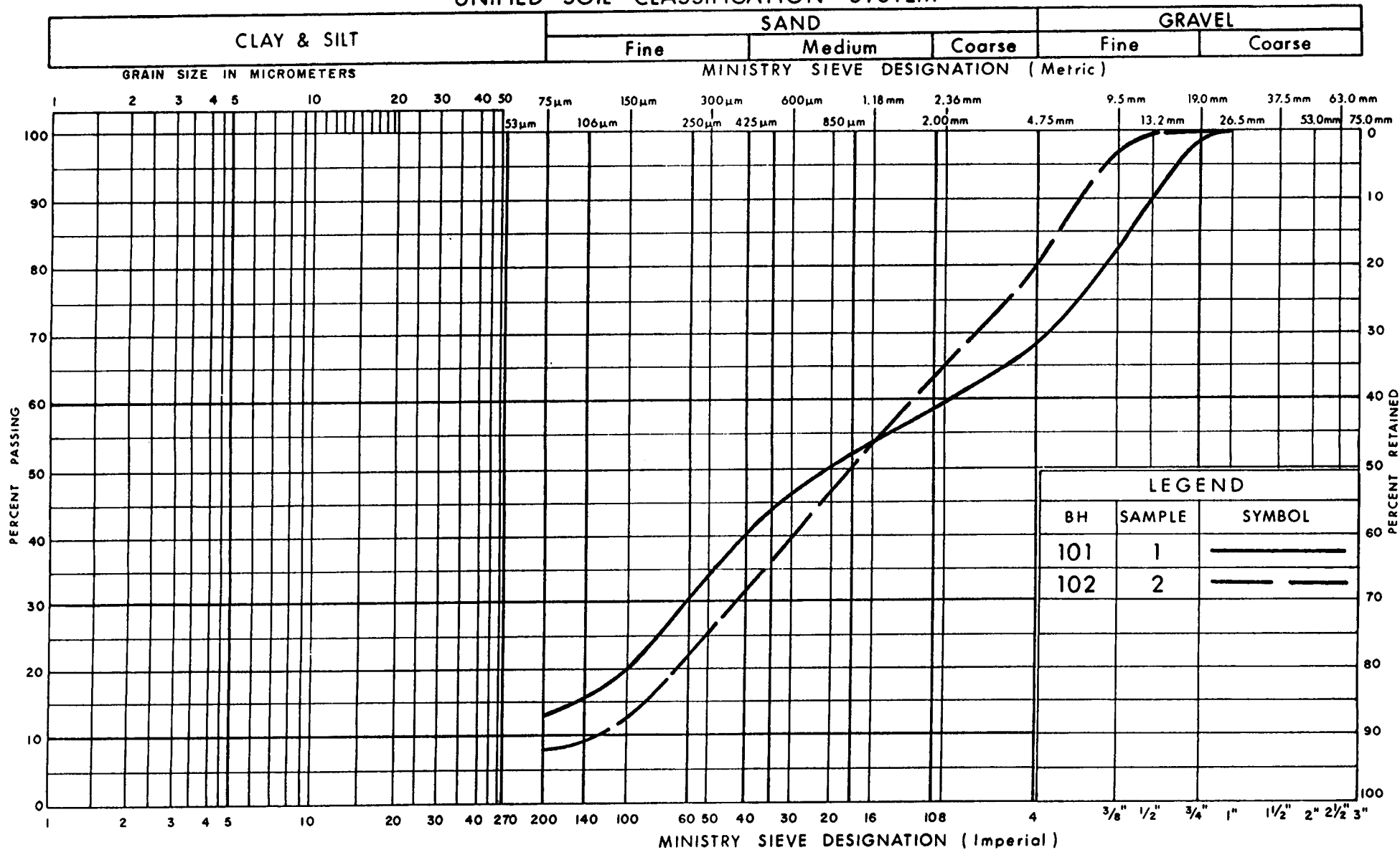
+ 3 . x 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

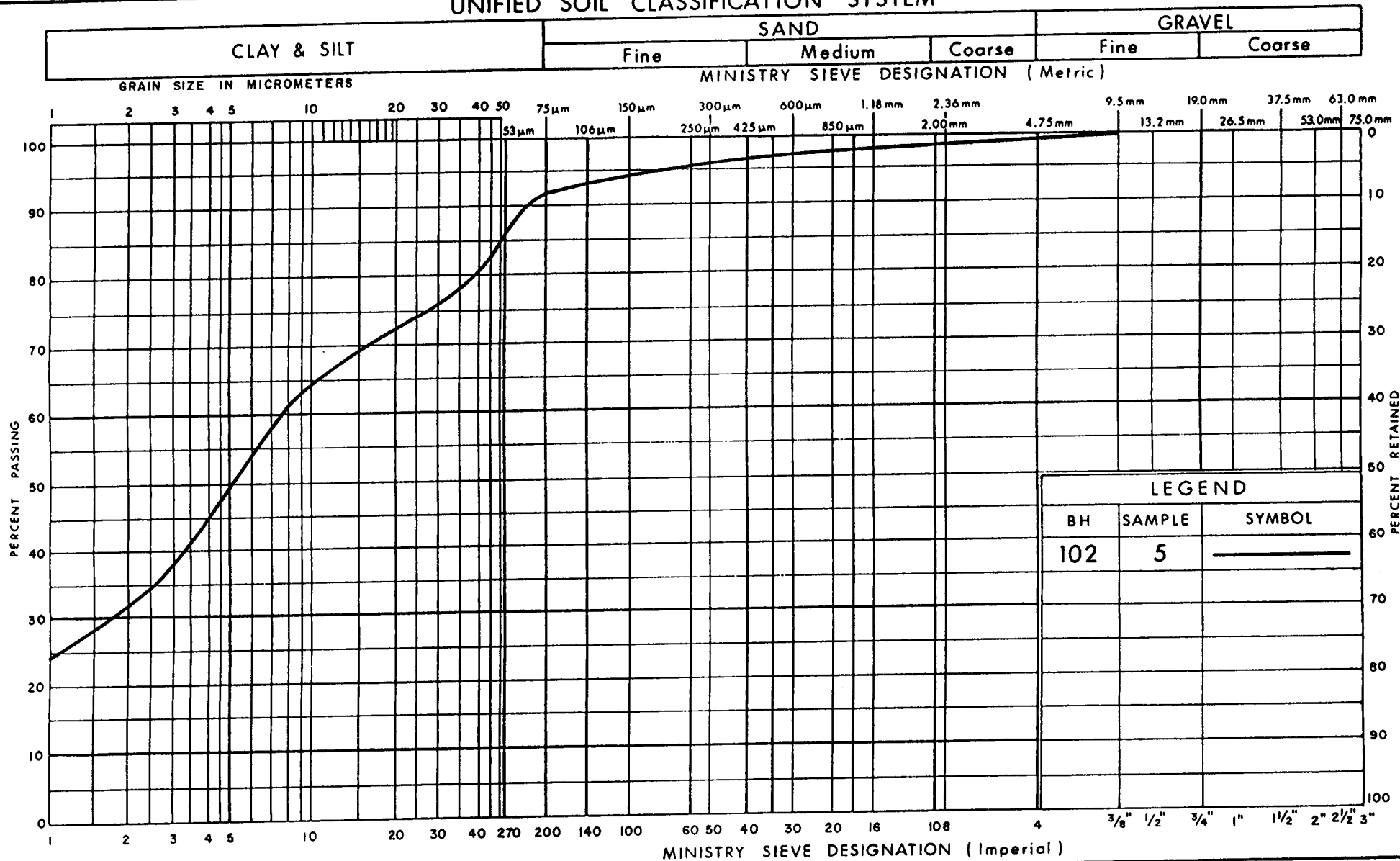
GRAVELLY SAND (Granular Fill)

FIG No 1

W P 678-90-00

SPT 1018A

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
FILL: SILTY CLAY

FIG No 2

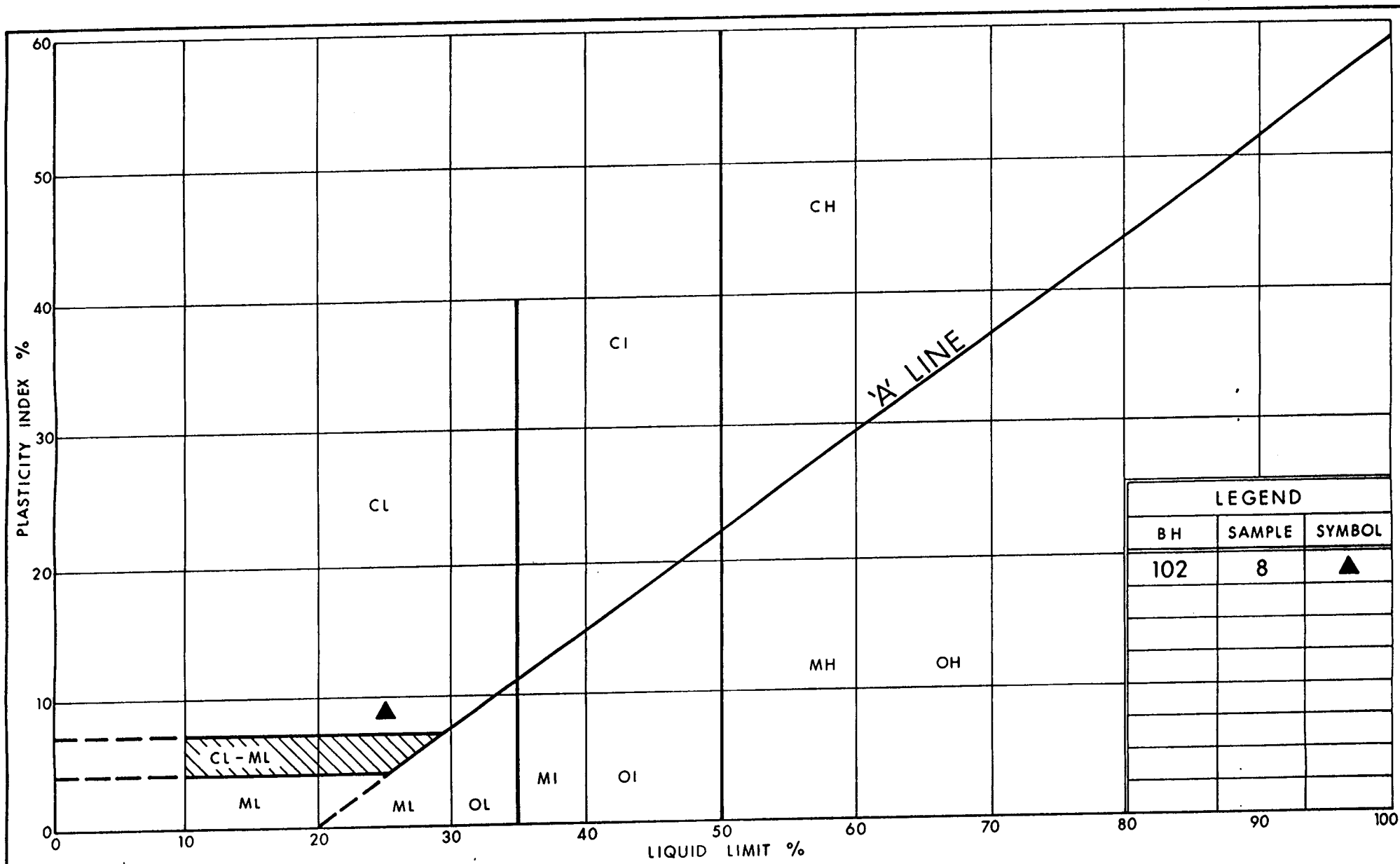
W P 678-90-00

SPT 1018A



Ontario

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Transportation



LEGEND		
BH	SAMPLE	SYMBOL
102	8	▲

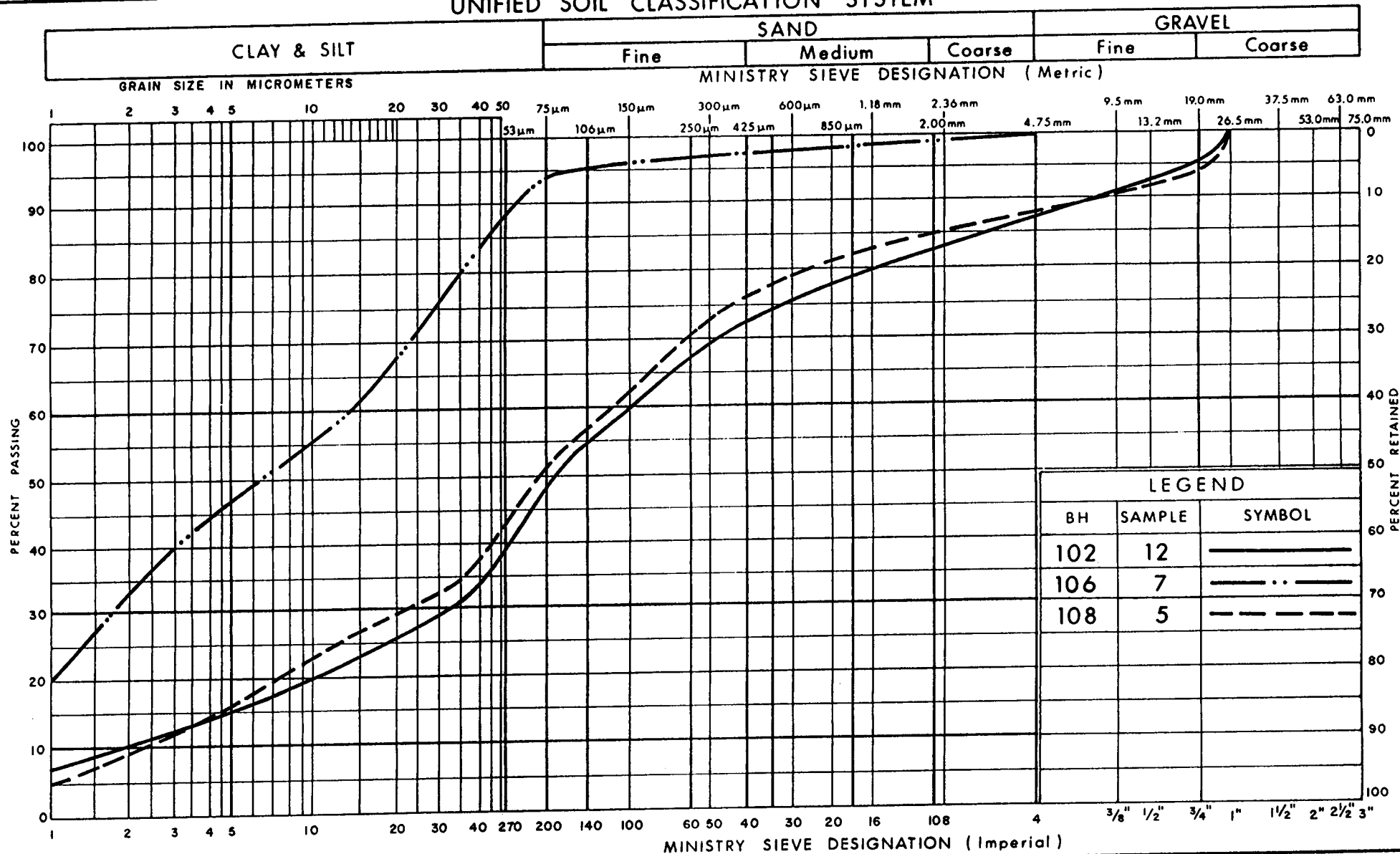


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Transportation

PLASTICITY CHART SILTY CLAY TILL

FIG No 3
W P 678-90-00
SPT 1018A

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH SAND, SOME GRAVEL
(Glacial Till)

FIG No 4

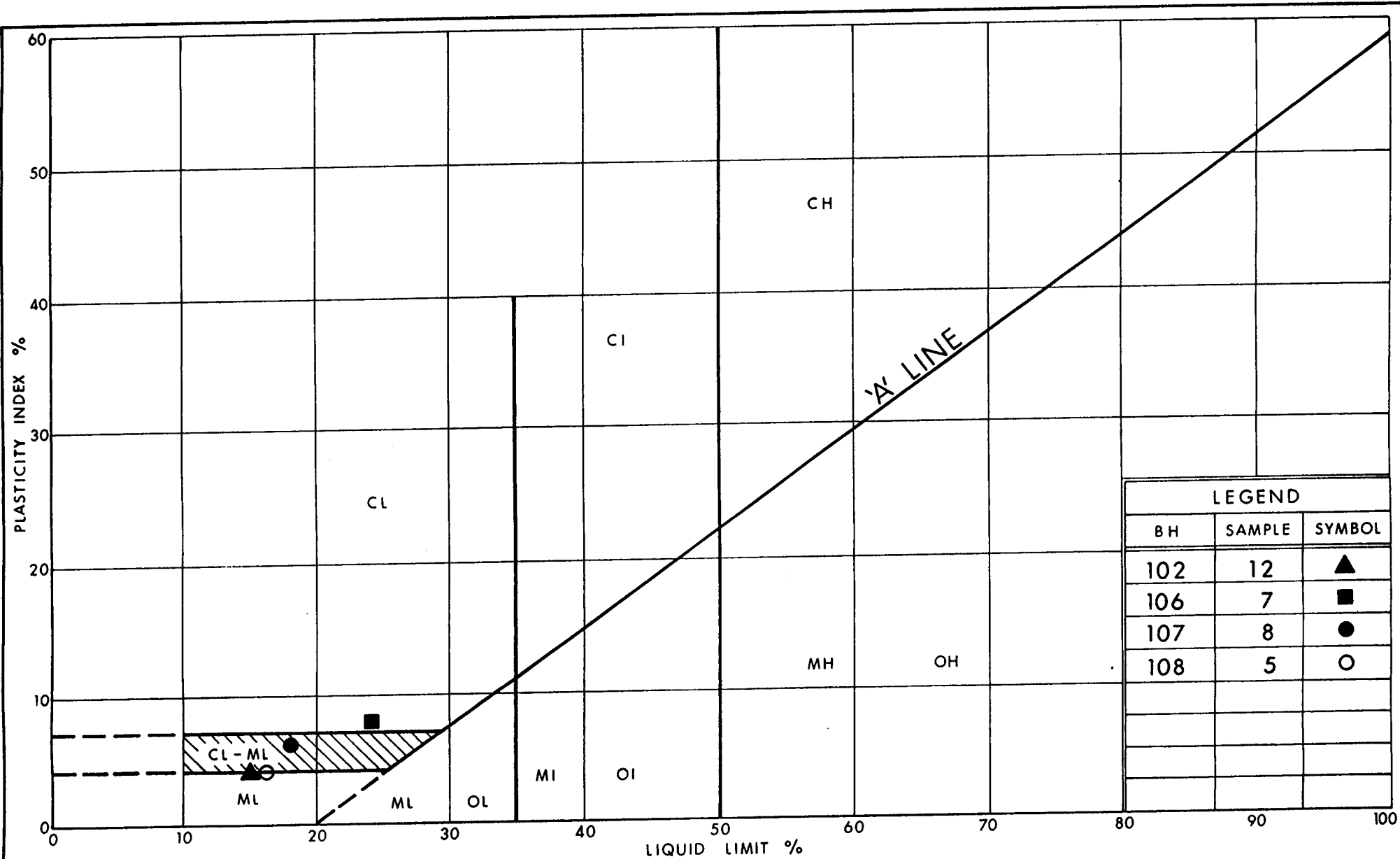
W P 678-90-00

SPT 1018A



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PLASTICITY CHART
CLAYEY SILT WITH SAND, SOME GRAVEL
(Glacial Till)

FIG No 5

W P 678-90-00

SPT 1018A



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Ontario

Appendix C

Explanation of Terms Used in Report

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
WS	WASH SAMPLE	OS	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

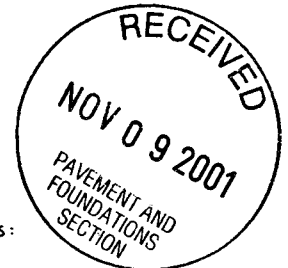
u_w	kPa	PORE WATER PRESSURE
u	l	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	l	COMPRESSION INDEX
C_s	l	SWELLING INDEX
C_α	l	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	l	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_l	l	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	l, %	VOID RATIO	e_{min}	l, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	l, %	POROSITY	I_D	l	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	l, %	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	l	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	l	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	l	HYDRAULIC GRADIENT
γ_{sat}	kn/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	l	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	l, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



7009



**FOUNDATION INVESTIGATION REPORT
PROPOSED BURNHAM STREET BRIDGE
OVER HIGHWAY 401
COBOURG, ONTARIO
W.P. 678-90-00
SITE: 21-243**

Prepared For:

McCORMICK RANKIN CORPORATION

Prepared by:

SHAHEEN & PEAKER LIMITED

**Project: SPT1018
April 20, 2001
Geocres No. 30M16-35**

**250 Galaxy Boulevard
Etobicoke, Ontario
M9W 5R8
Tel: (416) 213-1255
Fax: (416) 213-1260**

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PREVIOUS LABORATORY TEST RESULTS BY MTO	APPENDIX D
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**FOUNDATION INVESTIGATION REPORT
PROPOSED BURNHAM STREET BRIDGE OVER HIGHWAY 401
COBOURG, ONTARIO
W.P. 678-90-00**

1. INTRODUCTION

As part of the planned widening of Highway 401 from four to six lanes, the Highway 401 underpass structure at Burnham Street in Cobourg will be replaced with a longer and wider structure.

The existing Burnham Street bridge over Highway 401 (Interchange #472) consists of a single span, two lane, reinforced Tee beam concrete rigid frame, closed abutment structure which spans the existing four lane Highway 401.

Shaheen & Peaker Limited (S&P) was retained by McCormick Rankin Corporation to carry out a foundation investigation for the proposed new bridge. The site is located at the intersection of Highway 401 and Burnham Street (County Road 18) about 3 km north of the Town of Cobourg in the Township of Hamilton, County of Northumberland.

An investigation was carried out in 1958 by MTO for the existing bridge and also in 1993 for the then proposed widening of the existing bridge. Subsequently, it was decided to replace the existing structure with a longer span structure to accommodate the proposed six laning of Highway 401. The purpose of the present investigation was to obtain additional information at the site by means of boreholes.

The findings of the investigation are presented in this report.

2. SITE DESCRIPTION AND GEOLOGY

The site is located at the intersection of Highway 401 and Burnham Street in Cobourg about four km north of Lake Ontario.

Burnham Street is a two-lane roadway at and north of the interchange and a recently upgraded 4-lane roadway immediately south of the interchange.

The interchange is located on the boundary of the Town of Cobourg and the Township of Hamilton in the County of Northumberland. This is one of the two interchanges providing access to the Town of Cobourg from Highway 401.

Burnham Street structure over Highway 401 was constructed in 1960 and is a 31.1 m long, single span structure and accommodates two lanes of traffic. The bridge is 11.2 m wide with steel handrails.

The study area is located in the physiographic region known as the "Iroquois Plain." The plain consists of drumlins and sand plains (Ref: Chapman and Putnam, 1984).

The lowermost bedrock in the general area (i.e. Northumberland County) consists of Precambrian rock, with upper layers of limestone. These limestone layers are made up of the Trenton Group bedrock formations and were deposited during the Middle Ordovician Period, during the Paleozoic seas, some 480 millions years ago.

Glacio-lacustrine lake plain deposits of silt and clay with gently rolling terrain characterize the soils of the area.

The majority of the interchange is located on Schomberg soils. At the interchange site the soil is Smithfield, a silty clay loam of the Gray Brown Podzolic Group. Characteristics of this soil type are imperfect drainage, smooth to gently sloping topography, free of stones.

Cobourg Creek is located about 200 m east of the Burnham Street Bridge and the grade at the site drops from west to east towards the creek valley. The watercourse flows northeast to southwest towards Lake Ontario and crosses under Highway 401 via an existing 12.2 m concrete arch culvert, 65.5 m in length.

Highway 401 has a median storm sewer system which outlets to a detention pond, with a sediment forebay, immediately adjacent to the creek.

3. INVESTIGATION PROCEDURES

Because of the weather conditions and traffic requirements for safety, the fieldwork for this project had to be carried over a period of time spanning from December 5, 2000 to January 10, 2001 and consisted of drilling and sampling eight boreholes (Boreholes 101, 102, 103A, 103B, 104, 104A, 105 and 106). The plan locations of the boreholes, along with the stratigraphic sections, are shown on Drawing No. 1.

The boreholes were advanced using solid stem continuous flight augers with track and truck mounted drilling rigs owned and operated by Groundworks Drilling Inc., under the full time supervision of geotechnical personnel from S&P.

The depths of the boreholes ranged from 8.1 to 26.9 m. Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter O.D. split barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Where the consistency of the soil permitted, the undrained shear strength of the soil was measured in-situ by means of field vane tests using an MTO type field vane tester and several relatively undisturbed samples were taken by means of thin walled Shelby tube samplers.

The borehole locations were established in the field by our engineering staff, in relation to the existing features. The borehole geodetic elevations and coordinates were later taken by surveyors from David Harwood Limited, who provided us with the results.

Water level observations in the open boreholes were made during the drilling and at the completion of each borehole and, wherever possible, thereafter. To enable us to monitor groundwater levels over a prolonged period of time without interference from surface water piezometers were installed in two of the boreholes and the water levels in these piezometers were monitored during subsequent site visits.

The results of drilling, in-situ testing and water level measurements are summarized on the Record of Borehole Sheets in Appendix A.

Upon their completion, the boreholes were backfilled to about 8 m below the ground surface with soils brought up by augering (i.e. augering cuttings). The upper 8 m of the open boreholes was then grouted using a cement/bentonite mixture.

A laboratory testing programme consisting of natural moisture content, bulk unit weight, Atterberg Limits tests and grain-size analyses, was performed on selected soil samples. The results of the laboratory tests are presented on the appropriate Borehole Log Sheets and also in Appendix C.

4. SUBSURFACE CONDITIONS

Beneath some fill, the site is underlain by surficial silty clay and silty clay till. These deposits attain a somewhat coarser glacial till texture (i.e. heterogeneous mixture of clayey silt with sand and some gravel) with increasing depth. This upper till sheet extends to an average elevation of about 94-95 m and is underlain by a clayey silt to silty clay deposit. This deposit is generally 3 to 5 m thick and is underlain by a lower till sheet. The lower till sheet is coarser in texture in comparison with the upper till deposit and consists of a heterogeneous mixture of silt and sand size particles with gravel and traces to some clay. This deposit was encountered at about Elevation 90 m and extended to the full limit of the explorations.

It should be pointed out that MTO Boreholes 1, 2, 3 and 4 were drilled before the construction of the existing bridge and, therefore, do not represent post-construction conditions.

Details of the subsurface conditions encountered in boreholes drilled for this investigation are presented on the Borehole Log Sheets, Appendix A. The logs of boreholes previously drilled by MTO in 1958 and 1993 are presented in Appendix B. The individual soil strata encountered in the boreholes drilled for the present investigation are briefly described, as follows.

4.1 FILL

4.1.1 GRAVELLY SAND (GRANULAR FILL)

Boreholes 101 and 102 were drilled from the paved Burnham Street surface and encountered 150 mm of asphaltic concrete, underlain by granular road fill to 0.9 m and 2.1 m, respectively.

In Boreholes 103A and 103B, which were drilled from the central median of Highway 401, a 150 mm thick layer of asphaltic concrete was followed by a 400 to 450 mm of granular base course. In Borehole 103B, a 300 mm of sand fill was contacted underlying the base coarse.

4.1.2 SILTY CLAY FILL (EMBANKMENT FILL)

Fill materials making up the road embankment were encountered in boreholes drilled from the top of Burnham Street embankment (i.e. Boreholes 101, 102, 104 and 105). In these boreholes, the depth of the embankment fill ranged from 2.1 m (BH105) to 5.5 m (BH101) or to Elevations ranging from 105.0 to 103.3 m.

In Boreholes 101 and 102, which were drilled on the southeast side of the existing bridge structure, an approximately 0.4 m thick buried topsoil layer was encountered immediately below the fill (i.e. probably the original topsoil) while in Boreholes 104 and 105, drilled on the northeast side, the thickness of the buried topsoil was about 0.1 m. The embankment fill generally consisted of silty clay, mixed with some topsoil and traces of gravel. These fill materials are expected to behave as cohesive soils.

N-values recorded in these fill materials range from 13 to 35 blows/0.3 m (generally 14-25 blows/0.3 m), indicating that the embankment fills received some degree of systematic compaction when the embankment was built.

4.2 SURFICIAL SILTY CLAY

Boreholes 104 and 105, which were drilled on the north side of the existing bridge contacted beneath the embankment fill, a 2.3 to 3.0 m thick silty clay layer. The grain size distribution of a sample from this deposit is given in Figure 3, Appendix C.

Standard Penetration tests performed in this cohesive material ranged from 39 to 65 blows/0.3 m and, based on this, the consistency of the deposit is described as hard.

4.3 SURFICIAL SILTY CLAY TILL

In Boreholes 101, 102 and 106, drilled on the south side of the existing bridge, a surficial silty clay till deposit was contacted immediately below the fill and topsoil below Elevations ranging from 103.4 m (Boreholes 101 and 102) and 102.5 m (Borehole 106). The thickness of this cohesive deposit ranged from 0.6 to 2.3 m and it extended to Elevations ranging from 102.8 to 101.1 m.

An Atterberg Limits test performed on a sample from the deposit yielded the following index values, as shown on the Plasticity Chart in Figure 4, Appendix C.

Liquid Limit = 25%

Plastic Limit = 16%

Plasticity Index = 9%

Natural Moisture Content = 21%

These results are characteristic of clayey soils of low plasticity.

Based on recorded N-values ranging from 12 to 48 blows/0.3 m, the consistency of the deposit is described as stiff to hard, but generally very stiff to hard.

4.4 CLAYEY SILT WITH SAND AND SOME GRAVEL (GLACIAL TILL)

Underlying the granular pavement fill in Boreholes 103A and 103B (drilled from Highway 401) and surficial clayey deposit encountered in the remaining boreholes, as described in the preceding paragraphs, all boreholes contacted an upper glacial till sheet consisting of a heterogeneous unsorted mixture of clayey silt with sand and some gravel. In Boreholes 101 and 105, the exploration was terminated in this deposit while in others the deposit was found to be 7.1 m (Borehole 106) to 9.1 m (Borehole 103B) thick and extended to elevations ranging from 94.0 to 92.0 m, respectively, showing a variation (difference) of about 2 m in thickness and base elevation. In Boreholes previously drilled by MTO, the minimum thickness was about 4.4 m.

The results of grain-size distribution analyses carried out on selected samples are given Appendix C; the results of tests previously carried out by MTO are shown in Figure 1 of Appendix D.

The results indicate 0-14% gravel, 8-38% sand, 31-68% silt and 7-36% clay size particles, showing a large variation. From the observed resistance to augering (i.e. grinding), the presence of coarse gravel and cobbles can be inferred. It should also be pointed out that cobbles and boulders are characteristic components of glacial till deposits.

This deposit is classified as a cohesive material and Atterberg Limits test performed on the fine fraction gave the following range of values:

Liquid Limit	=	12-43%
Plastic Limit	=	8-20%
Plasticity Index	=	3-23%
Natural Moisture Content	=	6-26%

As shown on the plasticity charts in Appendix C and D, the material can be classified as a clayey silt to silty clay of low plasticity. In general, the deposit has a higher clay content and higher plasticity in the upper zones.

Standard Penetration tests performed in this deposit show N-values with considerable variations from borehole to borehole. The recorded values range from 9 to in excess of 50 blows/0.3 m which indicate a stiff to hard consistency but

Foundation Investigation Report, Highway 401-Burnham Street Bridge, Cobourg, Ontario
McCormick Rankin Corporation

generally very stiff to hard. There is evidence that the material is somewhat more competent on the south side of the site when compared with the north side.

4.5 CLAYEY SILT

Sandwiched between the upper and lower till sheets is a clayey silt deposit with a measured thickness of between about 2 and 6 m. This unit was encountered below elevations ranging between 96.7 m and 92.0 m and extended to between 90.7 and 88.8 m.

The results of grain-size distribution tests from this deposit are shown in Appendix C and Appendix D. The results indicate 0-1% sand, 65-70% silt and 29-35% clay size particles.

Atterberg Limits tests performed in the laboratory on selected samples gave the following index values:

Liquid Limit	=	12-29%
Plastic Limit	=	8-17%
Plasticity Index	=	4-14%
Natural Moisture Content	=	7-25%

These results are indicative of clayey soils of low plasticity. An unusual feature of these results is that with most soils, the measured clay size percentages are normally associated with higher plasticity index values than reported above. Another unusual feature was that the samples of the material obtained from the boreholes showed a much higher degree of dilatancy than would be expected from soil containing a relatively high percentage of clay sizes as measured. This rather unusual property can perhaps be caused by clay size particles being rather inactive. Chapman and Putnam observed this behaviour many years ago and offered the following hypotheses on similar soils as an explanation, "...Mechanical analyses indicate about 50% clay and 40% silt, but its behaviour is more like that of silt than clay. It is very slippery when wet and inclined to be mealy when dry. It is probably composed of freshly ground rock flour rather than weathered clay materials."

N-values recorded in this deposit ranged from 5 to 28 blows/0.3 m. Field vane tests gave undrained shear strength values ranging from 20 to in excess of 100 kPa. Based on these results, together with a visual and tactile examination of the soil samples, the consistency of this cohesive deposit is described as firm to stiff with occasional soft and very stiff zones. It should also be added that the consistency of the deposit was found to be quite variable from borehole to borehole but is considered somewhat weaker and more compressive towards the north side compared with the south abutment location.

4.6 HETEROGENEOUS MIXTURE OF SILT, SAND AND GRAVEL, SOME CLAY (GLACIAL TILL)

Beneath the weak clayey silt to silty clay layer, the site is underlain by a lower till sheet, consisting of a heterogeneous unsorted mixture of silt and sand with gravel and traces to some clay size particles. The results of grain size distribution tests carried out on selected samples from the deposit are presented in Appendices C and D. They indicate 10-28% gravel, 37-46% sand and 34-44% soil fines (i.e. silt and clay size particles). There is some indication that the deposit contains a greater percentage of gravel and cobbles, than exhibited by the grain size distribution curves. The presence of cobbles and boulders should always be expected in the glacial till deposits, due to their mode of deposition.

The soil samples recovered were generally moist to wet and the deposit is considered to be water bearing. Standard penetration tests carried out in this basically granular (i.e. non-cohesive) material yielded N-values ranging from 6 to in excess of 100 blows/0.3 m. The lower N-values are near the surface of this unit at the interface with the overlying clayey silt layer. In this upper portion, the presence of clayey silt and silty clay seams/lenses was also noted. Below this upper zone, at about 1 to 4 m below the interface or below about Elevation 86 m, the recorded N-values are consistently in excess of 50 blows/0.3 m.

Boreholes which were extended into this lower till sheet were terminated after penetrating the deposit about 1 to 8 m or to elevations ranging from about 91 m (Borehole 106) to 81 m (Borehole 104A).

4.7 GROUNDWATER CONDITIONS

Groundwater conditions in the open boreholes were observed while drilling and at the completion of each borehole. In addition, piezometers were installed in two of the boreholes (i.e. Boreholes 104A and 106) to enable prolonged groundwater level measurements, without interference from surface water. The observations and recorded values are shown on individual borehole log sheets.

Water levels in the piezometers were measured at elevations ranging between 102.4 and 96.5 m. Based on these values and the change of the colour of the soil from brown to grey, which is generally at Elevations 101-98 m, the permanent groundwater table at the site can be expected between Elevations 101 and 97 m. On the east side, the groundwater level can to a certain extent be expected to be regulated by the water level in the existing storm water detention pond, elevation of approximately 98.5 m.

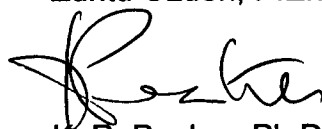
It should also be pointed out that the groundwater is subject to seasonal fluctuations and fluctuations in response to major weather events.

Yours truly

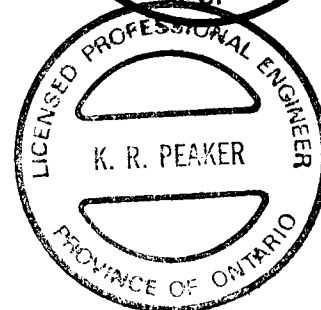
SHAHEEN & PEAKER LIMITED



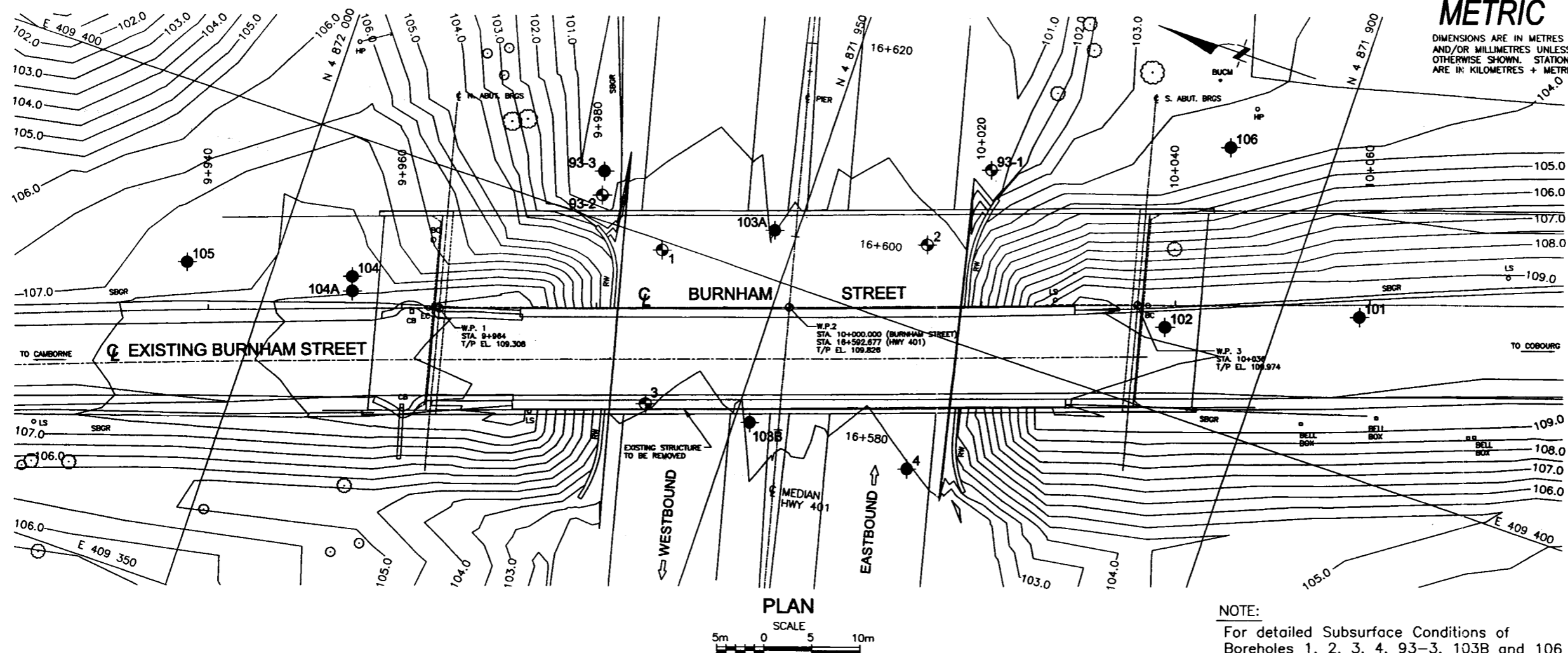
Zuhtu Ozden, P.Eng.



K. R. Peaker, Ph.D., P.Eng.

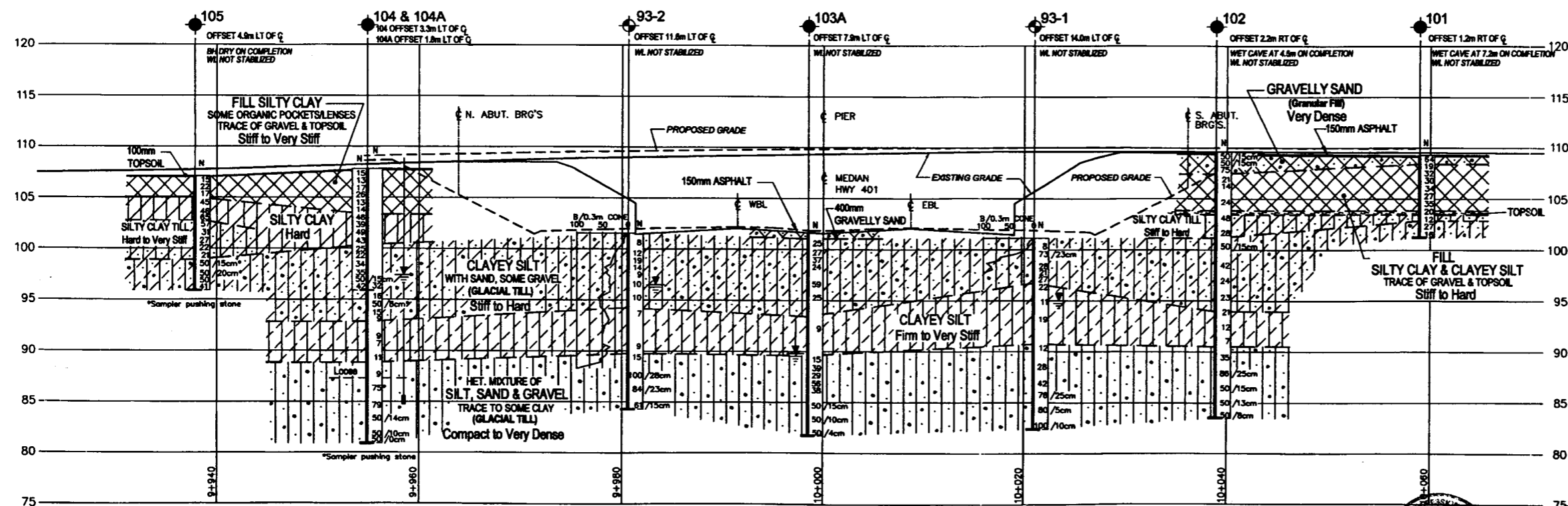


DRAWINGS

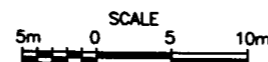


NOTE:

For detailed Subsurface Conditions of Boreholes 1, 2, 3, 4, 93-3, 103B and 106 refer to Record of Borehole Sheets.



Q PROFILE BURNHAM STREET

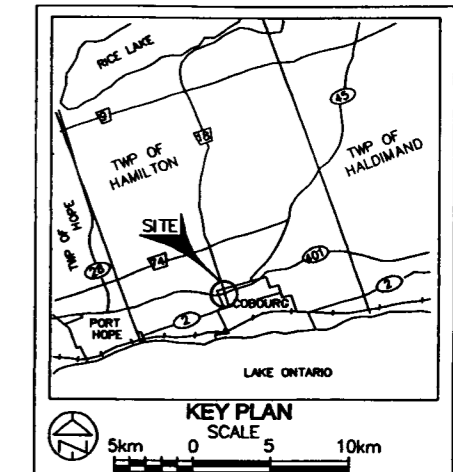


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WP No 678-90-00






HWY 401 - BURNHAM ST.
UNDERPASS
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

Shaheen & Peaker 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
 Aug. 1993 and Jan. 2001
 W L in Piezometer
 Piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	104.5	4 871 962.8	409 399.1
2	103.6	4 871 936.8	409 408.6
3	104.1	4 871 959.3	409 383.6
4	103.9	4 871 931.3	409 386.1
93-1	101.1	4 871 933.0	409 418.0
93-2	101.5	4 871 970.4	409 402.5
93-3	101.5	4 871 971.0	409 404.9
101	109.3	4 871 892.2	409 415.9
102	109.5	4 871 910.8	409 408.5
103A	101.6	4 871 952.3	409 404.9
103B	102.0	4 871 948.4	409 385.3
104	107.8	4 871 992.0	409 386.2
104A	107.8	4 871 991.6	409 384.7
105	107.1	4 872 008.6	409 382.1
106	103.6	4 871 910.3	409 428.2

NOTE

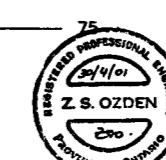
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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

REV.			
	DATE	BY	DESCRIPTION

Geocres No. 30M16-35

HWY No 401		DIST 21	
SUBM'D ZO	CHECKED ZO	DATE Apr., 2001	SITE 21-243
DRAWN JTW	CHECKED JP	APPROVED	DRWG 2



APPENDIX A

Records of Boreholes by Shaheen & Peaker Limited

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 892.2, E 408 415.9
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers
DATUM Geodetic DATE 05.12.00 10.01.01

ORIGINATED BY GI

COMPILED BY GT

CHECKED BY ZO

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			20	40	60	80	100		
109.3	Ground surface												
0.0	150 mm Asphalt		1	SS		109							32 55 (13)
	Gravelly Sand (Granular Fill)												
108.4	brown, very dense		2	SS		108						20.4	
0.9	FILL: Silty Clay and Clayey Silt, trace gravel, some topsoil pockets, very stiff to hard, brown, damp ----- high topsoil content black, moist -----		3	SS		108						19.8	
			4	SS		107						19.5	
			5	SS		106						19.7	
			6	SS		105						19.2	
			7	SS		104						19.4	
103.8			8	SS		103						20.8	
5.5			9	SS		102						20.8	
103.4	TOPSOIL, black												
5.9	SILTY CLAY TILL, stiff, greyish brown		10	SS									
102.8	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to very stiff, brown		11	SS								22.6	
6.5													
101.2	End of borehole											21.0	
8.1	Wet cave at 7.2 m on completion. Water level not stabilized Borehole drilled to 5.0 m on Dec.5/2000. Abandon borehole due to snow storm re-drilled on Jan.10/2001												

RECORD OF BOREHOLE No 102

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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							
109.5	Ground surface							20 40 60 80 100							
0.0			1	SS	50/15		109								
	150 mm Asphalt Gravelly Sand (Granular FILL) brown, very dense		2	SS	50/15		108								20 72 (8)
107.4			3	SS	75/30		107								
2.1			4	SS	21		106							20.0	
	FILL: Silty Clay, trace of gravel and topsoil, stiff to very stiff, brown		5	SS	14		105							20.5	1 7 60 32
103.8			6	SS	24		104								
5.7	TOPSOIL, black						103								
103.4			7	SS	48		102								
6.1	some organics		8	SS	28		101								
	SILTY CLAY TILL greyish brown, very stiff to hard						100							20.3	
101.1			9	SS	50/15		99								
8.4			10	SS	42		98							23.2	
	Clayey Silt with Sand, some gravel (GLACIAL TILL) hard to very stiff, brown to 10 m, grey below		11	SS	24		97							22.9	
			12	SS	23		96							23.9	13 38 39 10
							95								

Continued Next Page

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

RECORD OF BOREHOLE No 102

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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		
94.5														
15.0	Clayey Silt with Sand, some gravel (GLACIAL TILL) grey, very stiff		13	SS	21		94						22.6	
93.9							93							
15.6							92						20.1	
	CLAYEY SILT firm to very stiff, grey		14	SS	12		91						21.3	
90.5			15	SS	7		90							
19.0							89						23.6	
	Heterogeneous mixture of Silt, Sand and Gravel, some clay (GLACIAL TILL) dense to 21 m, very dense below, grey		16	SS	35		88						22.9	
			17	SS	86/25		87							
							86						23.1	
	more sandy with Sand layers below 24 m		18	SS	50/15		85						22.6	
			19	SS	50/13		84							
83.5														
26.0	End of borehole * Wet cave at 4.5 m on completion. Water level not stabilized Borehole drilled to 6.6 m on Dec.5/2000. Borehole had to be abandoned due to snow storm. Borehole re-drilled on Jan.10-11/2001		20	SS	50/8								22.1	

RECORD OF BOREHOLE No 103A

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 952.3; E 409 404.9 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 09.01.01 CHECKED BY ZO

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					
101.6	Ground surface															
0.0	150 mm Asphalt		1	AS												
101.0	400 mm Gravelly Sand (Granular Fill)		2	SS	25										21.9	33 54 (13)
0.6			3	SS	27											
			4	SS	37										22.5	
	Clayey Silt with Sand and Gravel (GLACIAL TILL) very stiff to hard, brown to 3.2 m, grey below		5	SS	24										22.0	
			6	SS	59											
			7	SS	25										22.1	
93.4			8	SS	9										20.1	
8.2	CLAYEY SILT grey, stiff		9	SS	15										22.6	
			10	SS	39										23.0	
89.6			11	SS	29										23.3	
12.0	Heterogeneous mixture of Silt, Sand and Gravel, some clay (GLACIAL TILL) compact to very dense, grey, moist to wet		12	SS	56										23.1	

Continued Next Page

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

RECORD OF BOREHOLE No 103A

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 952.3; E 409 404.9 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 08.01.01 CHECKED BY ZO

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 (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
86.6 15.0	Heterogeneous mixture of Silt, Sand and Gravel, trace to some clay (GLACIAL TILL) dense to 16 m, very dense below, grey, moist to wet Sand seam/lense at 18.3 m		13	SS	38										23.4	28 38 29 5				
			14	SS	50/15												22.5			
			15	SS	50/10															
81.7	End of borehole • Water level at 11.8 m (not stabilized) and hole open to 12.5 m on completion		16	SS	50/4										22.2					
19.9																				

METRIC

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
						SHEAR STRENGTH kPa					WATER CONTENT (%)						
	Heterogeneous mixture of Silt, Sand and Gravel, trace to some clay (GLACIAL TILL) very dense, moist to wet		17	SS	74/29										23.4	27 38 29	
85.1			18	SS	50/14										22.5		
16.9	End of borehole • Water level at 12.1 m (not stabilized) and hole open to 13.4 m on completion																

RECORD OF BOREHOLE No 104

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 992.0; E 409 386.2 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 CHECKED BY ZO

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	20 40 60 80 100		
107.8 0.0	Ground surface 100 mm Topsoil FILL: Silty Clay, trace of gravel, some organic, pockets/lenses, stiff to very stiff, brown		1	SS	15	*	107						19.5	
			2	SS	13		106						19.8	
			3	SS	17		105						18.7	
			4	SS	26		104						18.6	
			5	SS	13		103						18.4	
			6	SS	14		102						19.7	
103.3 4.5	SILTY CLAY hard, brown		7	SS	46		101						20.2	0 5 65 30
			8	SS	39		100						19.5	
			9	SS	49		99						20.2	
			10	SS	43		98						21.7	
100.3 7.5	Clayey Silt with Sand, some gravel (GLACIAL TILL) very stiff to hard, grey		11	SS	25		97						20.1	2 8 56 34
			12	SS	22		96						20.6	
			13	SS	34								20.6	
			14	SS	35								21.4	
			15	SS	50/15								22.4	
95.9			16	SS	42									
11.9	End of borehole Borehole moved 1.5 m to the West and re-drilled without sampling to 7.6 m; See BH104A for continuation * Water Level not Established													

Continued Next Page

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

RECORD OF BOREHOLE No 104A

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 991.6; E 409 384.7 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 20.12.00 CHECKED BY ZO

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					
107.8 0.0	Ground surface													
	No sampling to 7.6 m See borehole # 104													
100.2 7.6	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to hard, grey		1	TW	PH									
			2	TW	PH									
			3	SS	32									
			4	SS	16								22.5	
			5	SS	50/8								21.7	* Sampler pushing stone
			6	SS	15								22.3	
			7	SS	9								19.3	

Continued Next Page

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

RECORD OF BOREHOLE No 104A

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 991.6; E 409 384.7 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI
DATUM Geodetic DATE 20.12.00 CHECKED BY ZO

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		
92.8 15.0	CLAYEY SILT grey, firm to stiff		8	TW	PH								
			9	SS	9							20.7	
			10	SS	7							20.2	
			11	TW	PH								
			12	SS	11							18.8	
88.8													
19.0	Heterogeneous mixture of Silt, Sand and Gravel, trace to some clay (GLACIAL TILL) loose to 20.5 m, very dense below, grey, wet to moist		13	SS	9							22.5	
			14	SS	75							22.7	
			15	SS	79							22.7	
			16	SS	50/14							23.4	10 46 36 8
			17	SS	50/10							23.2	
			18	AS	50/0							22.7	
80.9													
26.9													
	End of borehole Auger refusal at 26.9 m probably on a boulder. Piezometer installed at 23 m upon completion Water level in piezometer at: Dec. 21/2000 - 20.3 m Jan. 04/2001 - 10.7 m Jan. 09/2001 - 10.4 m Jan. 10/2001 - 10.5 m Jan. 11/2001 - 10.4 m Jan. 17/2001 - 10.3 m												

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 872 008.6; E 408 382.1 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 05.12.00 CHECKED BY ZO

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										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
107.1	Ground surface																	
0.0	100 mm Topsoil		1	SS	15	:	107							17.9				
	FILL: Silty Clay, some topsoil and trace of gravel, brown, grey, dark/brown, black		2	SS	22		106							19.7				
			3	SS	17		105							18.9				
105.0			4	SS	45		105							20.0				
2.1	SILTY CLAY hard, brown		5	SS	46		104							20.4				
			6	SS	65		103							20.4				
102.7			7	SS	57		102							20.9				
4.4	SILTY CLAY TILL brown and hard to 5.2 m, grey and very stiff below		8	SS	31		101							20.3				
			9	SS	27		100							21.1				
			10	SS	22		99							20.7	* Sampler pushing stone			
98.9			11	SS	21		98							23.4				
8.2	Clayey Silt with Sand, some gravel (GLACIAL TILL) hard, grey		12	SS	50/15	*	97							23.2				
			13	SS	50/20	*												
			14	SS	50													
			15	SS	41													
95.9							96											
11.2	End of borehole **Borehole dry on completion (not stabilized)																	

RECORD OF BOREHOLE No 106

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 781 910.3; E 409 428.2 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 21.12.00 04.01.01 CHECKED BY ZO

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	20 40 60 80 100					
103.6	Ground surface														
0.0	300 mm Topsoil		1	SS	14		103							21.7	
102.7	FILL: Silty Clay, some gravel and topsoil, brown, stiff to very stiff														
102.5	TOPSOIL, black		2	SS	26									20.6	
1.1	SILTY CLAY TILL		3	SS	17		102							19.7	
	very stiff to hard, brown														
101.1			4	SS	47		101							21.3	
2.5			5	SS	28									21.8	
	Clayey Silt with		6	SS	27		100							21.2	
	Sand, some gravel		7	SS	12		99							20.1	0 6 61 33
	(GLACIAL TILL)		8	SS	12		98							20.8	
	stiff to hard,		9	TW	PH		97								
	brown to 4.4 m,		10	SS	13		96								
	grey below		11	SS	13		95								
94.0			12	SS	23		94								
9.6	CLAYEY SILT						93							22.0	
	stiff, grey		13	SS	13		92								
91.6			14	TW	PH		91							23.2	
12.0	Heterogeneous mixture of														
90.9	Silty Sand and Gravel,		15	SS	17										
12.7	some clay,														
	(GLACIAL TILL)														
	compact, grey, wet														
	End of borehole														
	Borehole drilled to 6.6 m on														
	Dec.21/2000 and re-drilled on														
	Jan.04/2001														
	Borehole dry and open to 11.1 m														
	on completion														

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 106

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 781 910.3; E 409 428.2 ORIGINATED BY GI
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT
DATUM Geodetic DATE 21.12.00 04.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
	Piezometer installed to 12.1 m Water level in piezometer: Jan.04/2001 - 5.5 m Jan.09/2001 - 1.1 m Jan.10/2001 - 1.0 m Jan.11/2001 - 1.2 m																

APPENDIX B

Records of Previous Boreholes by MTO

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 962.8, E 409 399.1. ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY A.L.
 DATUM Geodetic DATE April 22, 1958 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20 40 60 80 100							10 20 30		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
104.5	Ground Surface																
0.0	--- Topsoil --- Brown Grey Clayey Silt With Sand, Some Gravel, Stiff to Hard (Glacial Till)		1	SS	14		104										
			2	SS	27		102										
			3	SS	24		100										
			4	SS	24		98										
			5	SS	41		96										
95.4							94										
9.1	Clayey Silt, Firm to Stiff		6	SS	5												
93.2			7	SS	8												
11.3	End of Borehole • WL Not Established																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 936.8, E 409 408.6 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY AL
 DATUM Geodetic DATE April 30, 1958 CHECKED BY T.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			20 40 60 80 100	20 40 60 80 100					
103.6	Ground Surface													
0.0	Topsoil		1	SS	16	*	102							
	Clayey Silt With Sand, Some Gravel, Very Stiff to Hard (Glacial Till)		2	SS	40		100							
			3	SS	70		98							
			4	SS	88		96							
			4A	SS	74		94							
94.8			5	SS	40		92							
8.8	Clayey Silt, Very Stiff		6	SS	28		90							
			7	SS	20		88							
			8	SS	16		86							
90.2			9	SS	18									
13.4	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense to Very Dense (Glacial Till)		10	SS	40									
			11	SS	75									
			12	SS	69									
85.0														
18.6	End of Borehole													
	• WL Not Established													

RECORD OF BOREHOLE No 4

1 OF 1 METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 931.3, E 409 386.1 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring COMPILED BY A.L.
 DATUM Geodetic DATE May 14, 1958 CHECKED BY T.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								
								20 40 60 80 100								
				• UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE				WATER CONTENT (%)								
103.9	Ground Surface															
0.0	Topsoil															
	Clayey Silt, Some Sand, Some Gravel, Stiff to Hard (Glacial Till)		1	SS	22											
			2	SS	33											
			3	SS	30											
			4	SS	53											
94.8																
9.1	Clayey Silt, Stiff to Very Stiff		5	SS	26											
			6	SS	20											
			7	SS	9											
			8	SS	9											
89.3																
14.6	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense (Glacial Till)															
88.2			9	SS	37											
15.7	End of Borehole															

RECORD OF BOREHOLE No 93-1

1 of 1

METRIC

W.P. 678-90-01 LOCATION Co-ords: N 4 871 933.0, E 409 418.0 ORIGINATED BY D.S.
 DIST 7 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY D.S.
 DATUM Geodetic DATE Aug. 9, 1993 CHECKED BY T.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			20 40 60 80 100	20 40 60 80 100					
101.1	Ground Surface													
0.0	Clayey Silt With Sand, Some Gravel, Very Stiff (Glacial Till)		1	SS	8		100						20.8	14 33 31 22
			2	SS	7.3		98							
			3	SS	28									
			4	SS	21									
96.7			5	SS	27									
4.4			6	SS	22		96							
	Clayey Silt, Stiff to Very Stiff		7	SS	11		94							
			8	SS	19		92							
			9	TW	PH		90							
90.7			10	SS	12		88							
10.4			11	SS	28		86							
	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay Compact to Very Dense (Glacial Till)		12	SS	42		84							
			13	SS	76									
			14	SS	80									
82.4			15	SS	100									
18.7	End of Borehole • WL Not Stabilized													

RECORD OF BOREHOLE No 93-2 1 OF 1 METRIC

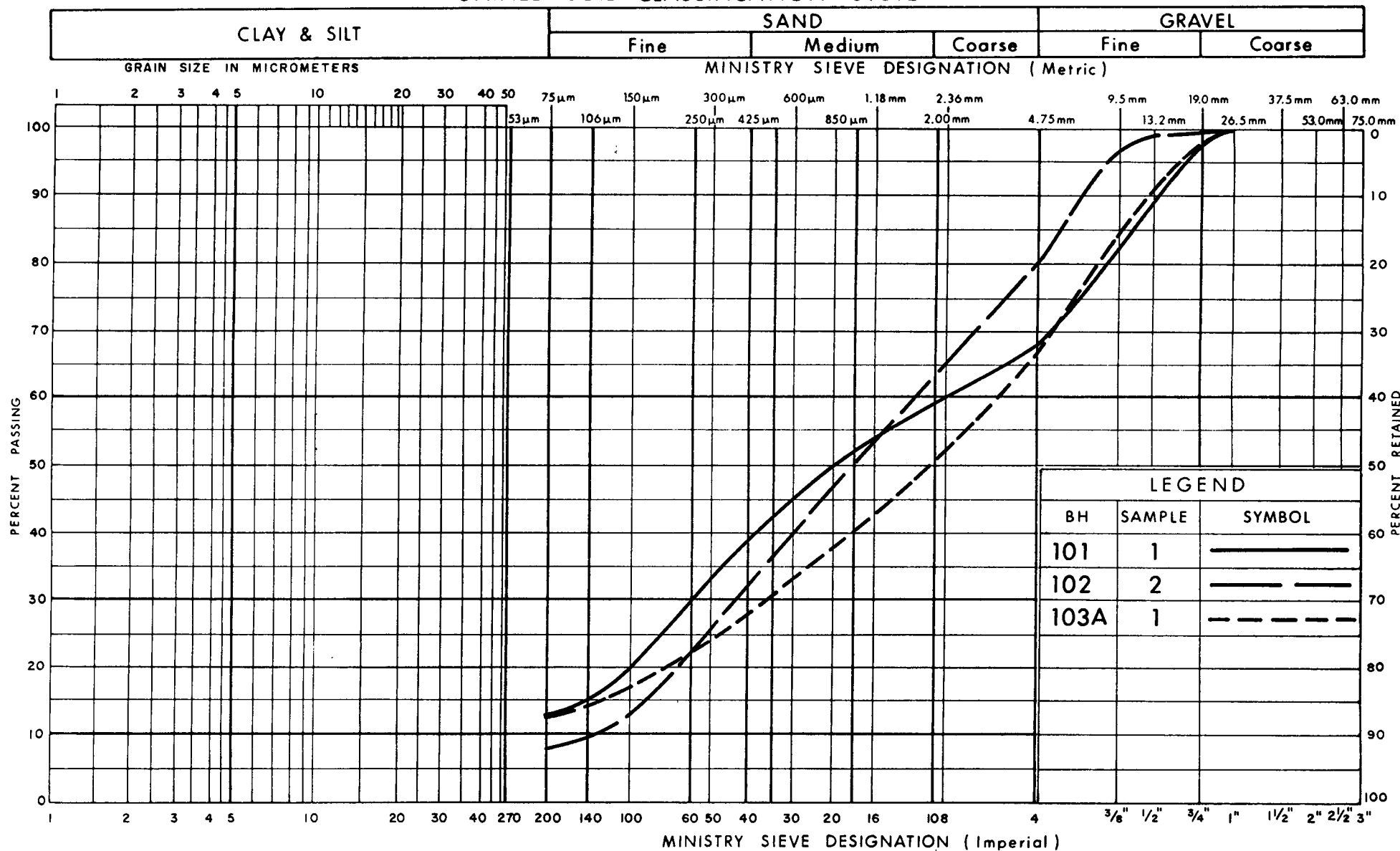
W.P. 678-90-01 LOCATION Co-ords: N 4 871 970.4, E 409 402.5 ORIGINATED BY D.S.
 DIST 7 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY D.S.
 DATUM Geodetic DATE Aug. 9 and Aug. 10, 1993 CHECKED BY T.K.

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							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
101.5	Ground Surface							20 40 60 80 100	10 20 30						
0.0	Clayey Silt With Sand, Some Gravel, Stiff to very Stiff (Glacial Till)	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div> <div>Brown Grey</div>	1	SS	8										
			2	SS	12										
			3	SS	19										
			4	SS	14										
			5	SS	9										
			6	SS	10										
			7	SS	10										
94.2	Clayey Silt, Firm to Stiff	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>	8	SS	7										
7.3			9	TW	PH										
			10	SS	9										
89.8	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Compact to Very Dense (Glacial Till)	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div></div>	11	SS	15										
11.7			12	SS	100	/28cm									
			13	SS	84	/23cm									
			14	SS	61	/15cm									
84.3	End of Borehole • WL Not Stabilized														
17.2															

APPENDIX C

Laboratory Test Results by Shaheen & Peaker Limited

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

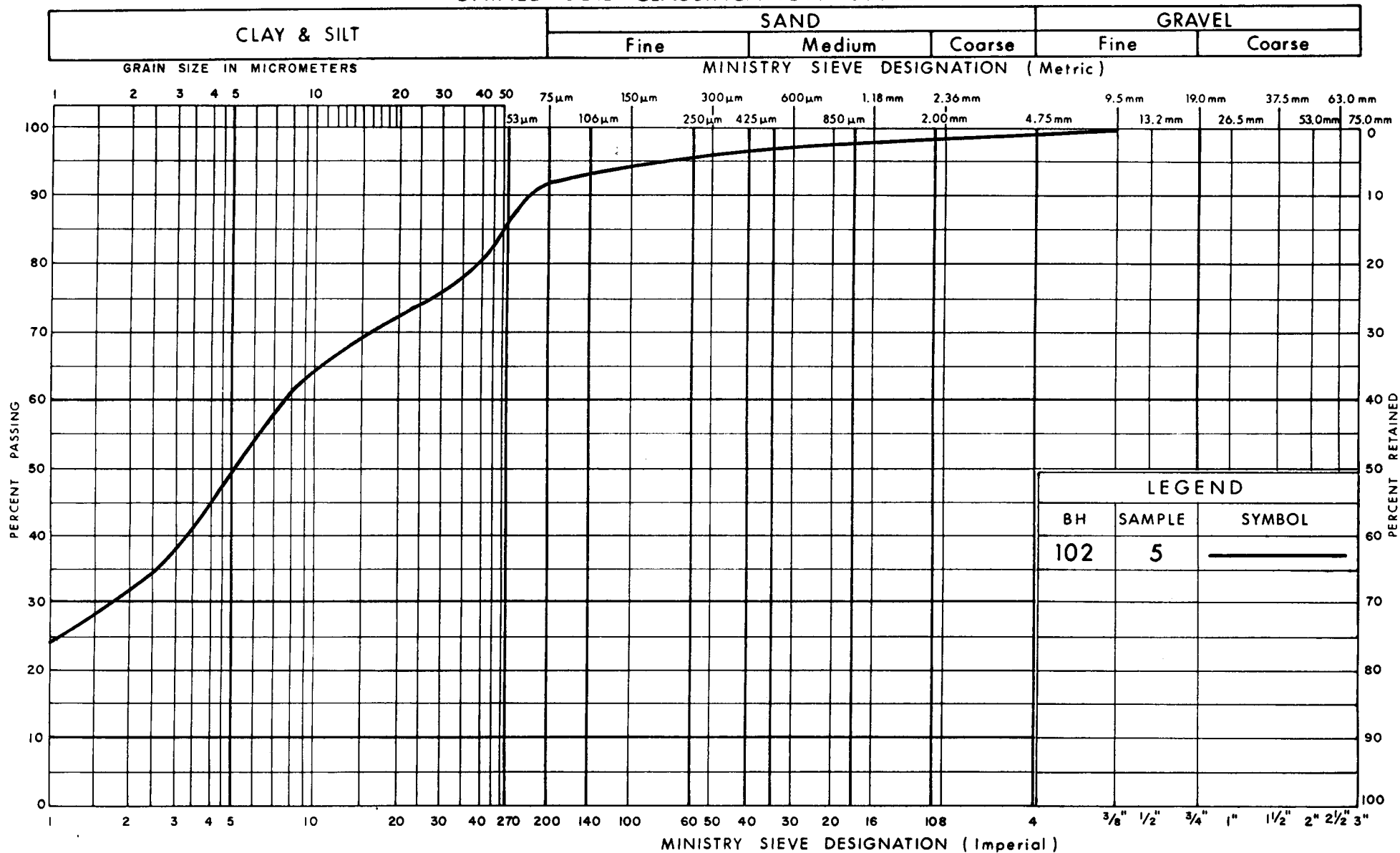
GRAIN SIZE DISTRIBUTION
GRAVELLY SAND (Granular Fill)

FIG No 1

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

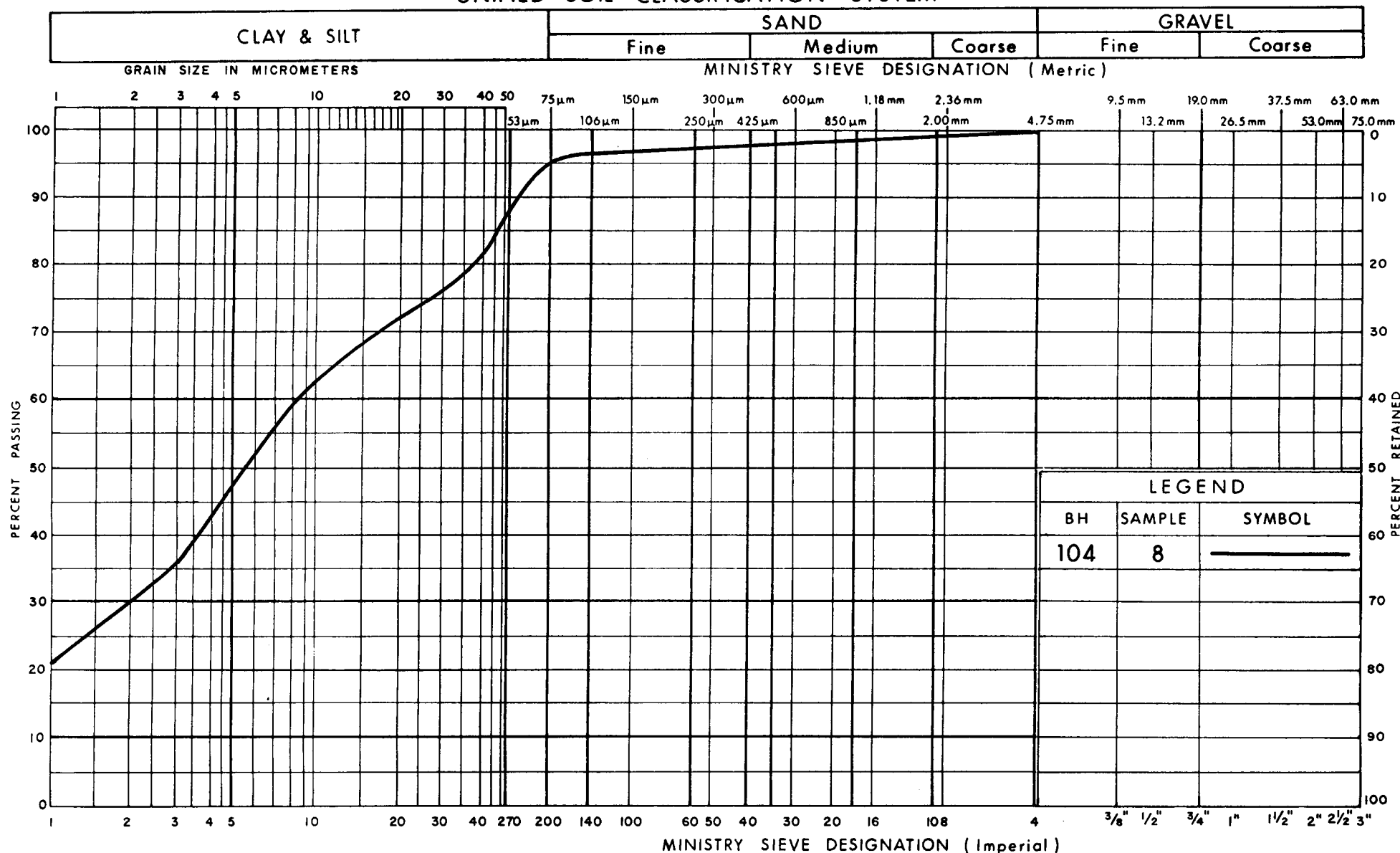
FILL: SILTY CLAY

FIG No 2

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



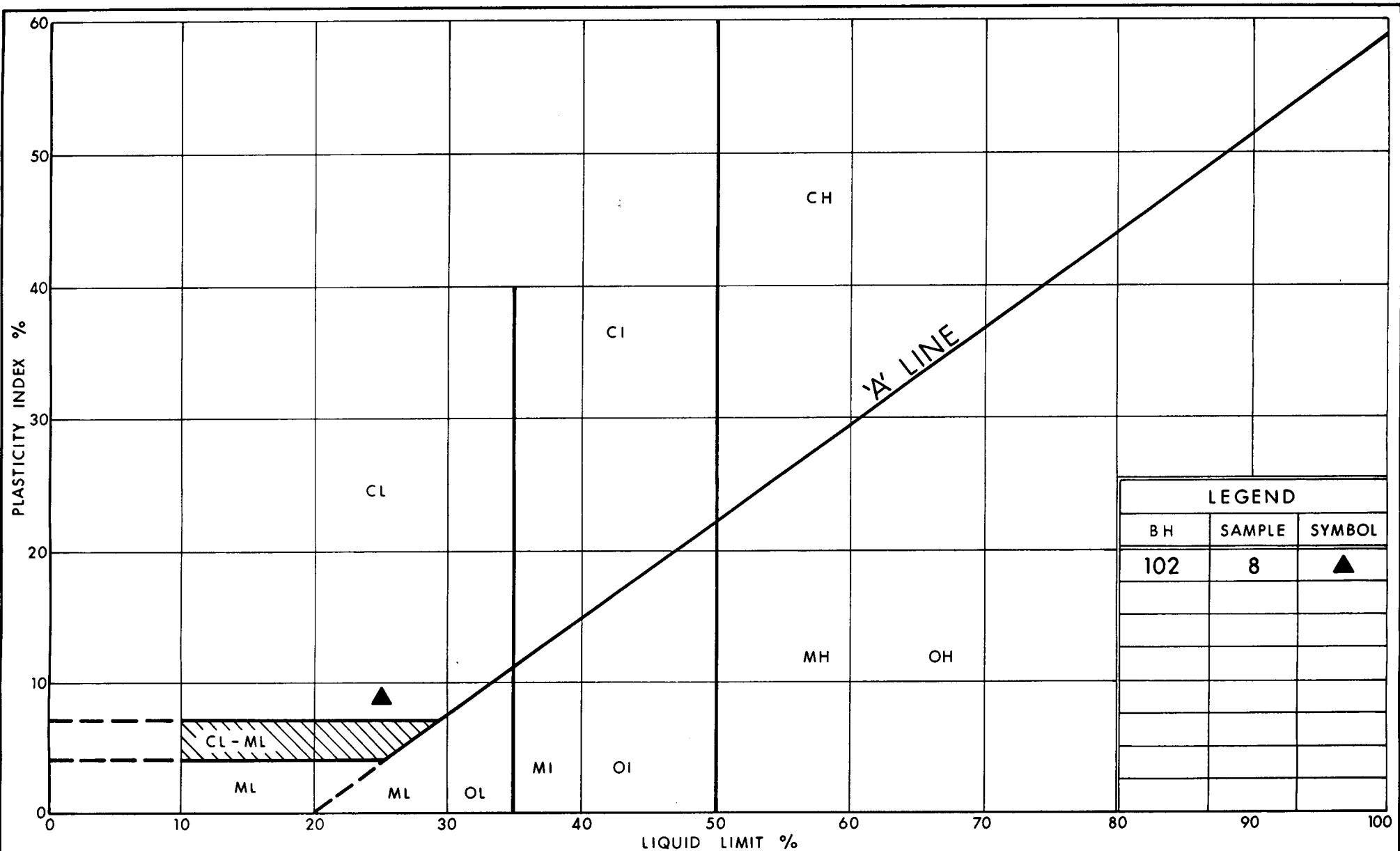
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 3

W P 678-90-00

SPT 1018



Ministry of
Transportation

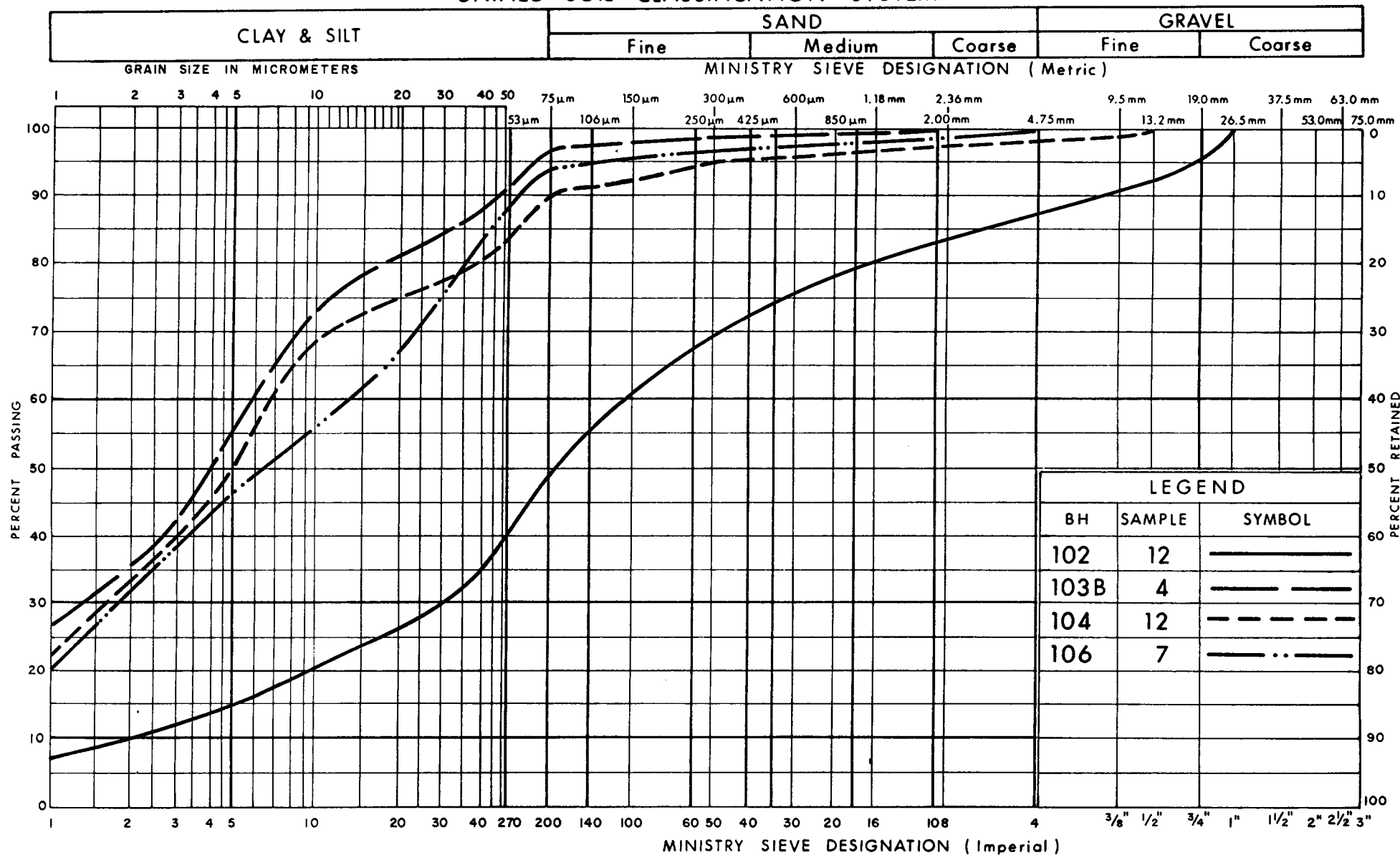
PLASTICITY CHART SILTY CLAY TILL

FIG No 4

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



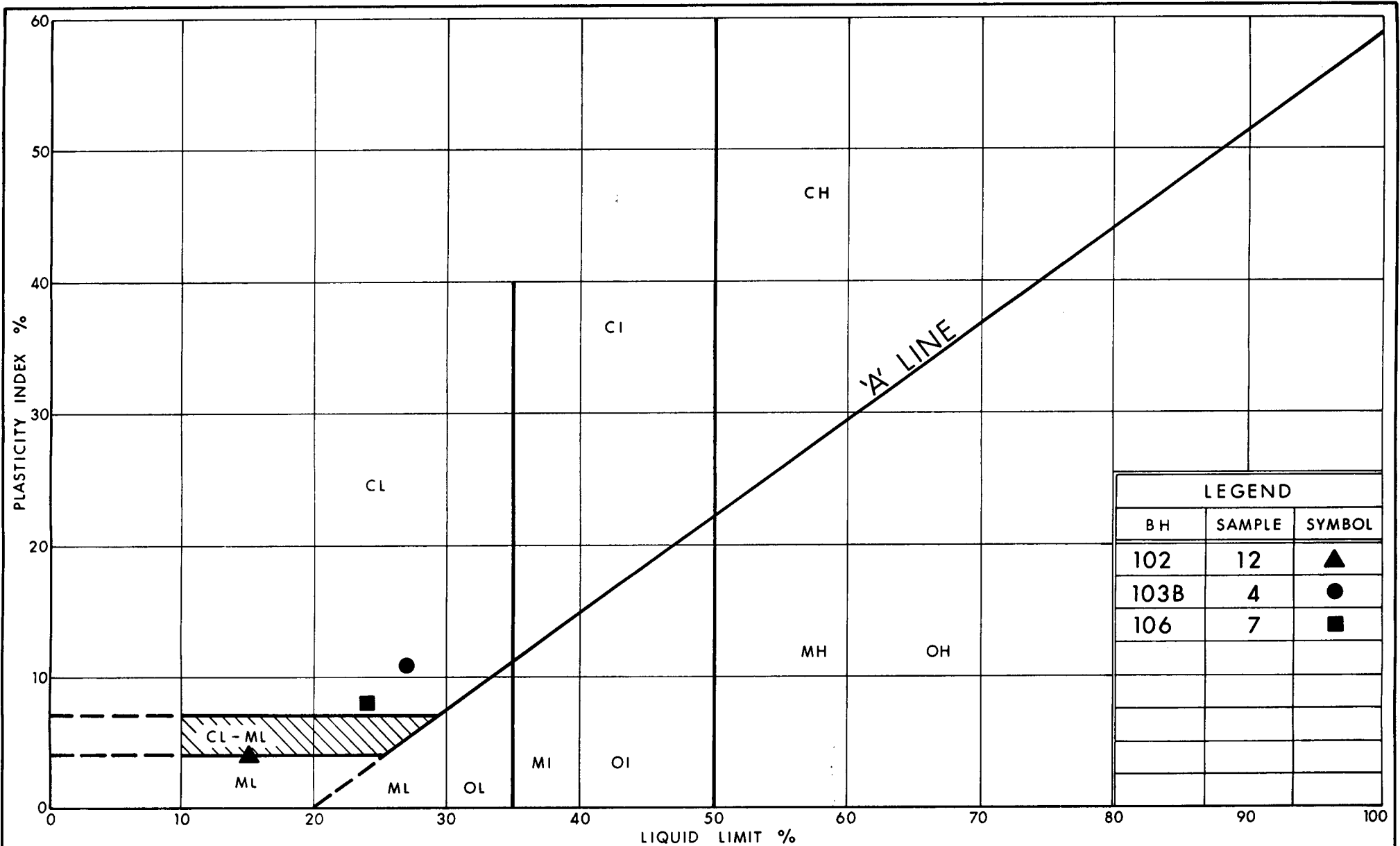
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH SAND, SOME GRAVEL
(Glacial Till)

FIG No 5

W P 678-90-00

SPT 1018



Ministry of
Transportation

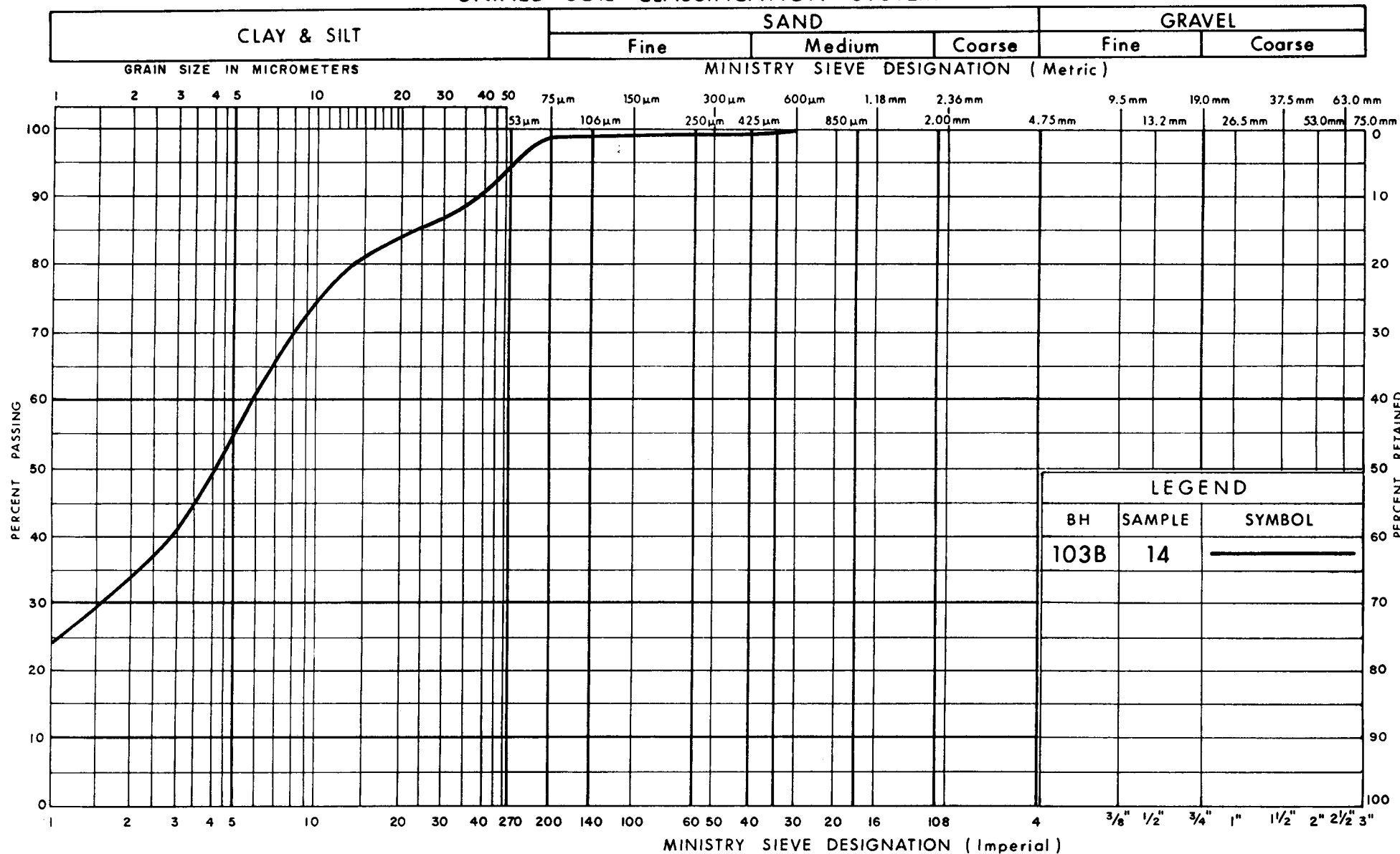
PLASTICITY CHART
CLAYEY SILT WITH SAND, SOME GRAVEL
(Glacial Till)

FIG No 6

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



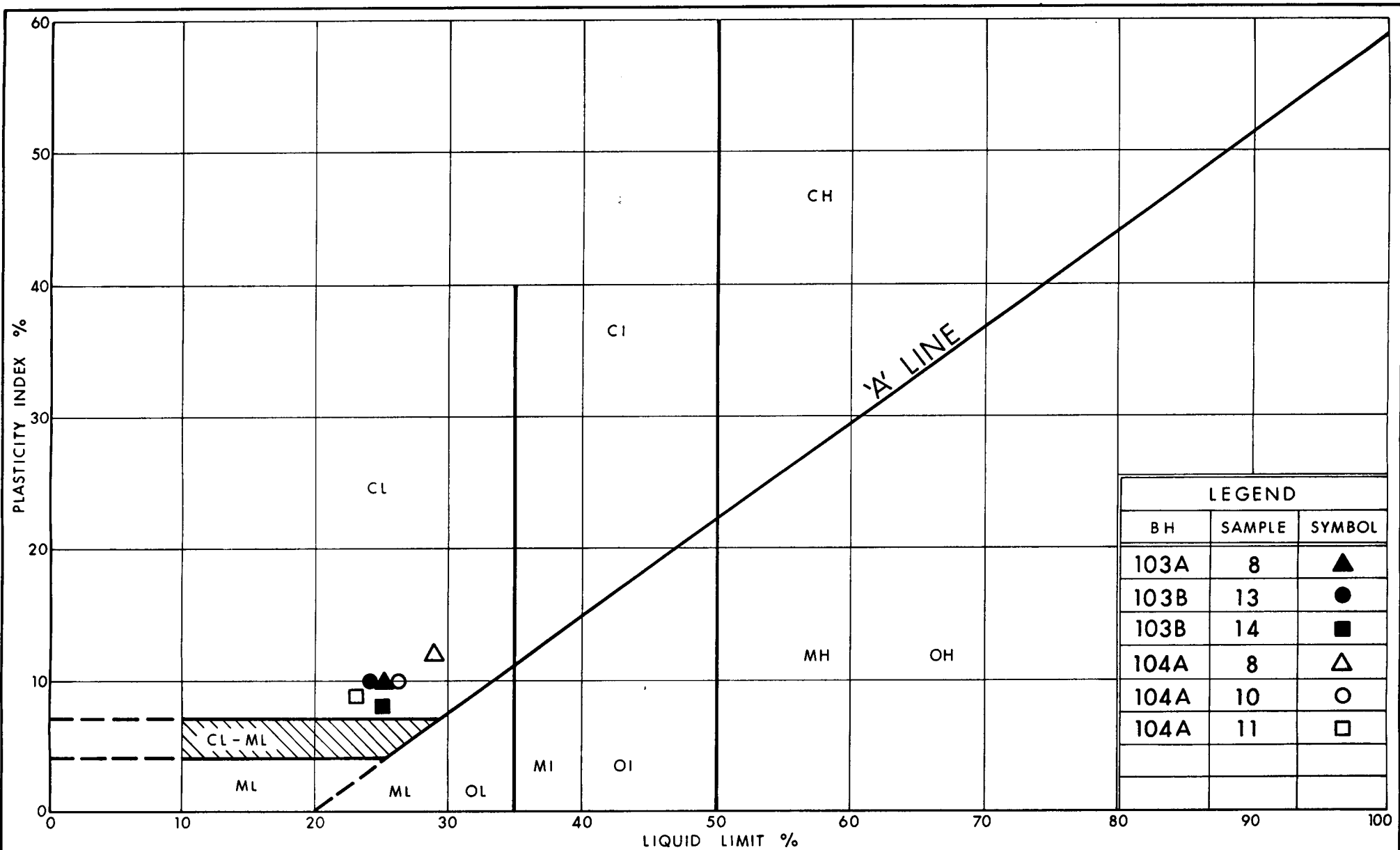
Ontario

Ministry of
TransportationGRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 7

W P 678-90-00

SPT 1018



Ministry of
Transportation

Ontario

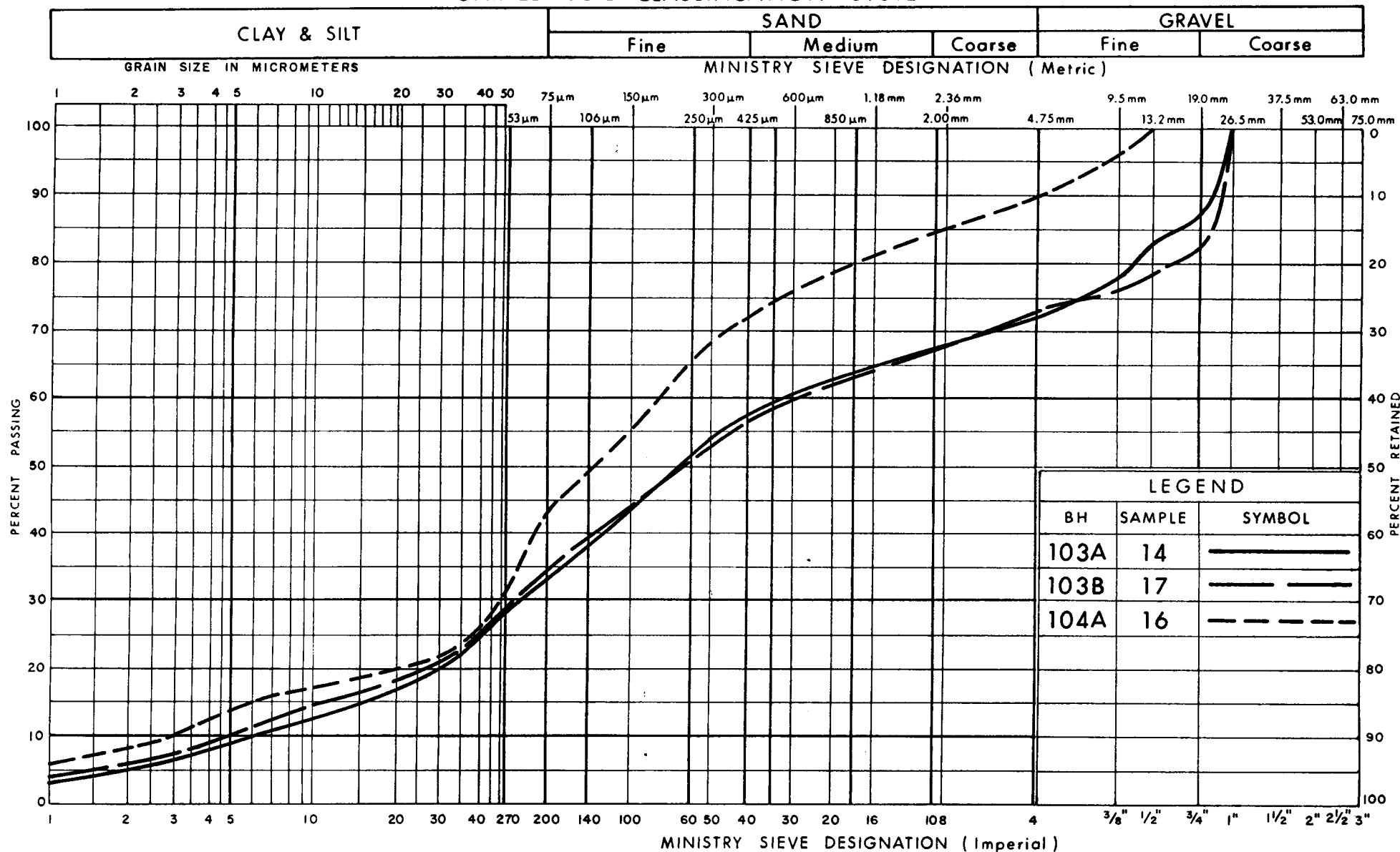
PLASTICITY CHART CLAYEY SILT

FIG No 8

W P 678-90-00

SPT 1018

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET. MIXTURE OF SILT, SAND & GRAVEL TRACE TO SOME CLAY
(Glacial Till)

FIG No 9

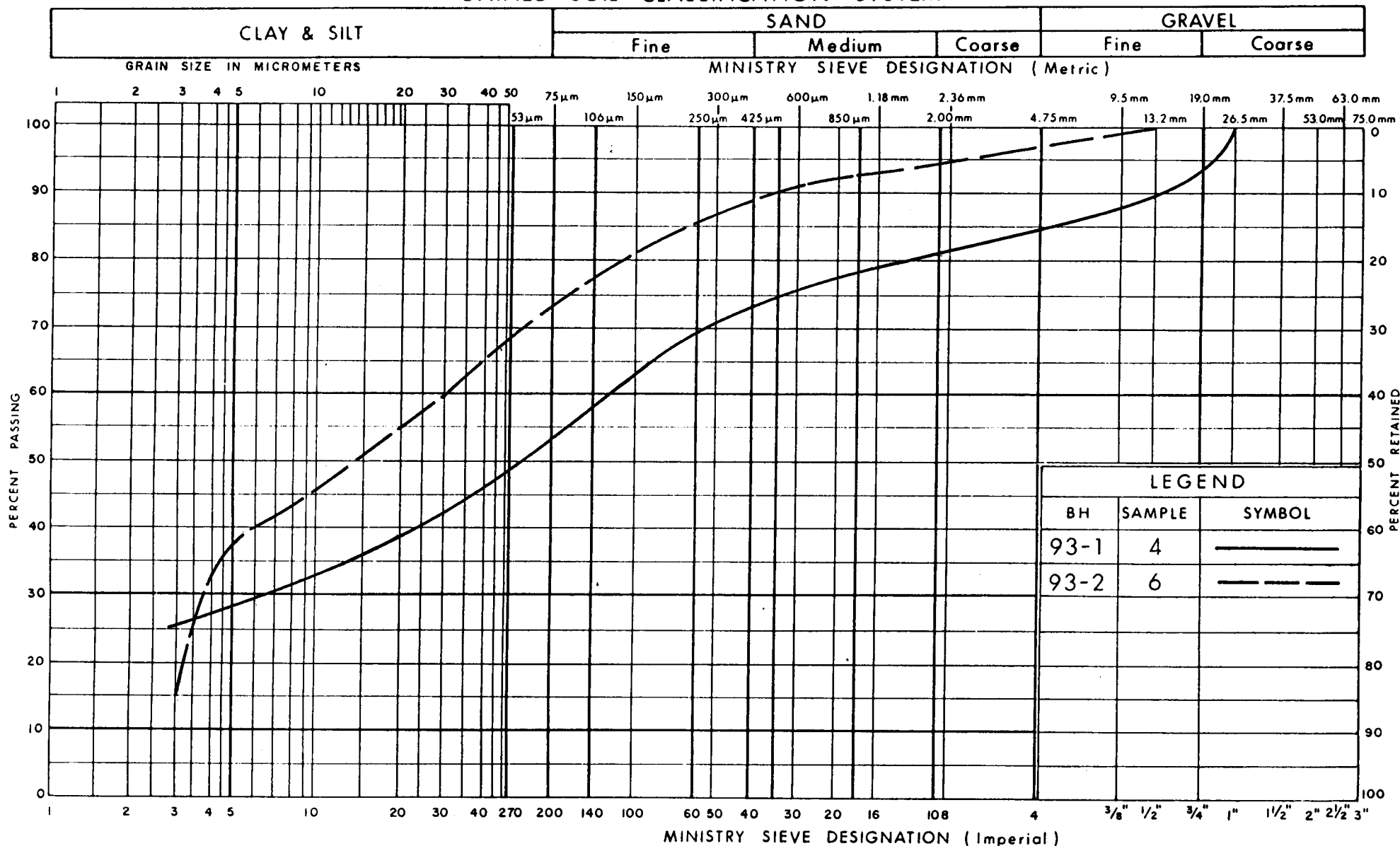
W P 678-90-00

SPT 1018

APPENDIX D

Previous Laboratory Test Results by MTO

UNIFIED SOIL CLASSIFICATION SYSTEM

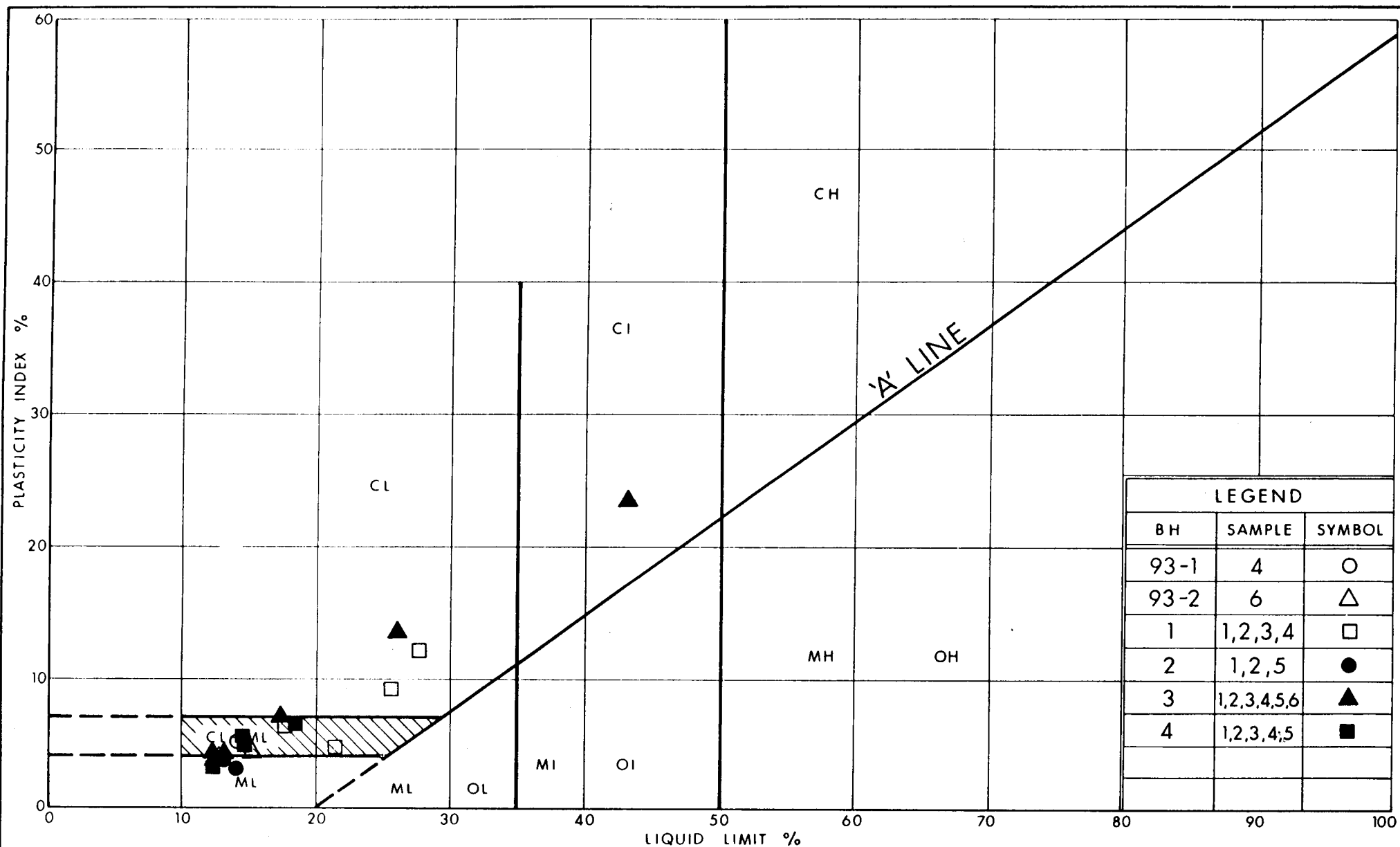


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GRAIN SIZE DISTRIBUTION
CLAYEY SILT, WITH SAND & SOME GRAVEL
(GLACIAL TILL)

FIG No 1

W P 678-90-01



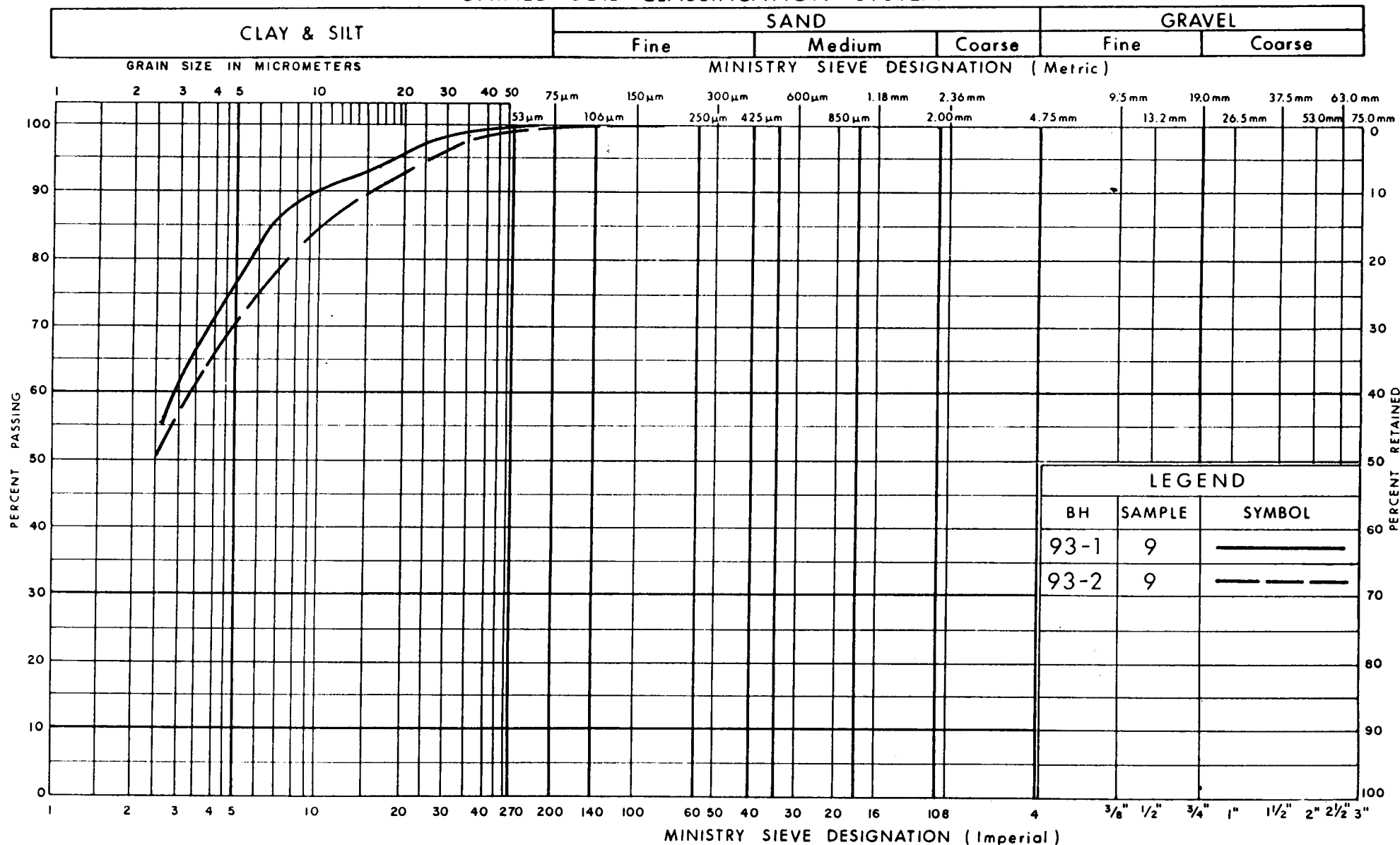
Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT, WITH SAND & SOME GRAVEL (GLACIAL TILL)

FIG No 2

W P 678-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

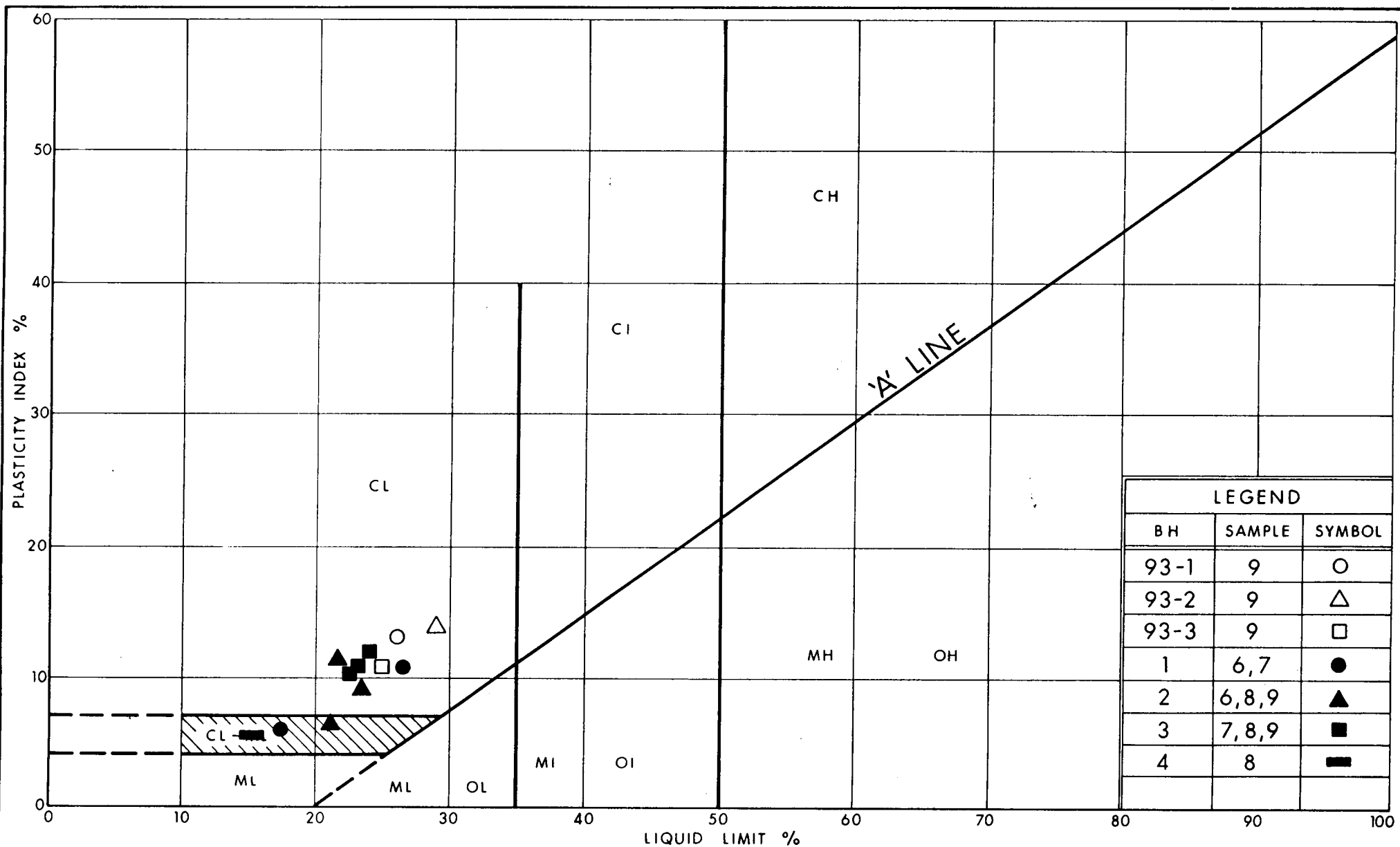


Ontario

Ministry of
TransportationGRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 3

W P 678 -90-01



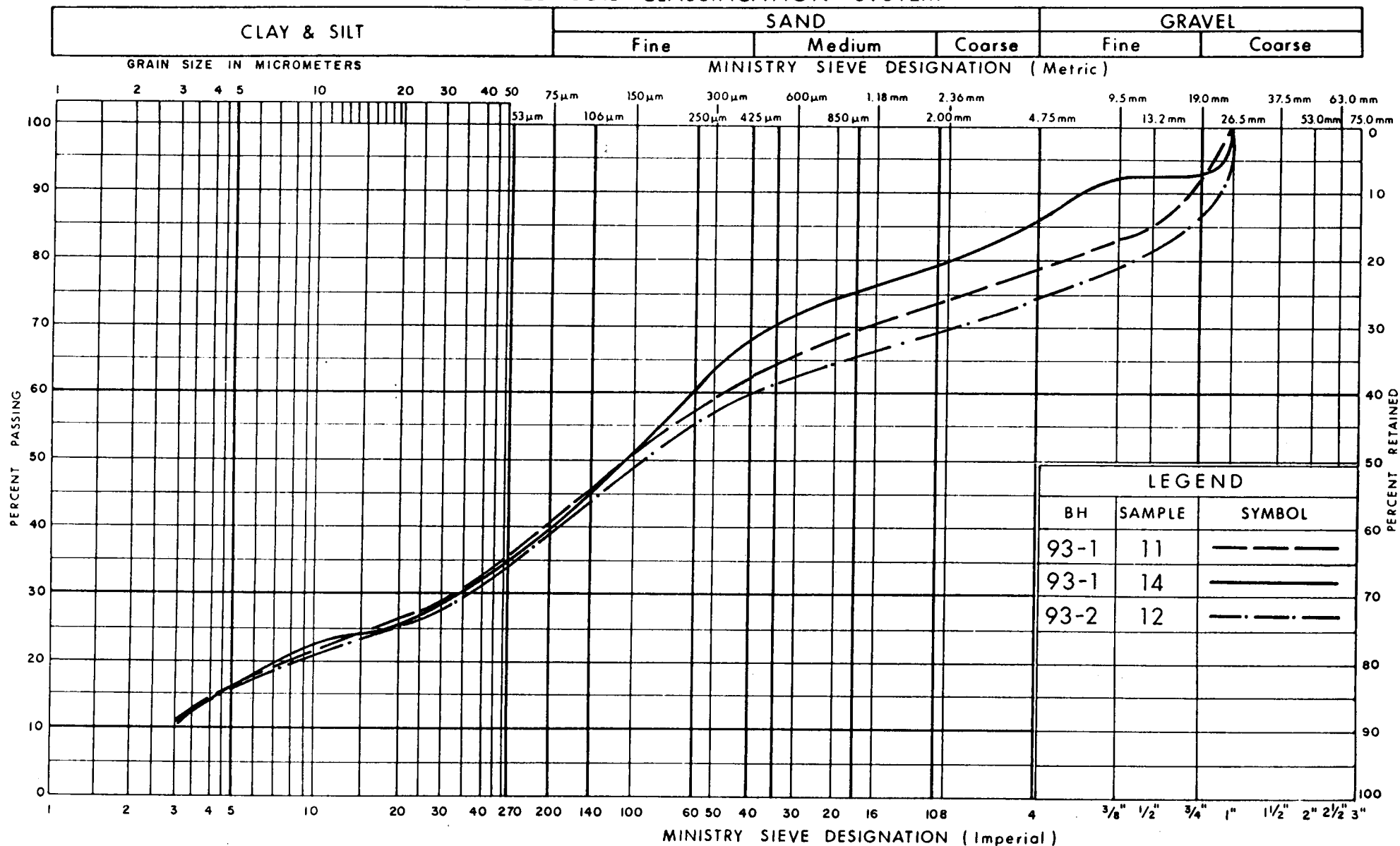
Ministry of
Transportation
Ontario

PLASTICITY CHART CLAYEY SILT

FIG No 4

W P 678-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF SILT, SAND & GRAVEL SOME CLAY
(GLACIAL TILL)

FIG No 5

W P 678 -90 -01

APPENDIX E

Explanation of Terms Used in Report

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:

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

**FOUNDATION DESIGN REPORT
PROPOSED BURNHAM STREET BRIDGE
OVER HIGHWAY 401
COBOURG, ONTARIO
W.P. 678-90-00
SITE: 21-243**

Prepared For:

McCORMICK RANKIN CORPORATION

Prepared by:

SHAHEEN & PEAKER LIMITED

**Project: SPT1018
April 20, 2001
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APPENDICES

REMOVAL OF UNSUITABLE SOILS FROM BENEATH APPROACH FILLS
LIMITATIONS OF REPORT

APPENDIX F
APPENDIX G

**FOUNDATION DESIGN REPORT
PROPOSED BURNHAM BRIDGE OVER HIGHWAY 401
COBOURG, ONTARIO
W.P. 678-90-00**

5. DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

The existing Burnham Street Bridge over Highway 401, which was constructed in 1960, will be replaced with a longer and wider structure. The existing bridge is a two lane, single span, 36 m long structure while the new bridge will be a four lane, two span structure. The central pier of the new bridge will be located at the center of Highway 401 and each span will be 36 m long to allow the widening of Highway 401 from four to six lanes as shown on Drawing No. 2. The new bridge is expected to be a precast concrete girder structure.

At present, initial staging during construction consists of maintaining four lanes of traffic on Highway 401 (two east bound and two west bound lanes, while the speed change lanes are closed to traffic) and two lanes on Burnham Street during the construction of the new bridge, followed with subsequent removal of the existing structure.

The grade of Highway 401 under the centerline of the bridge is approximately 102 m while the top of the bridge (Burnham Street) is 108 to 109 m. The new bridge elevation will be approximately 0.5 to 1.0 m higher. The embankment fills will also be about 0.5 to 1.0 m higher (i.e. up to about 6 to 7 m above the existing grades).

Boreholes were drilled by MTO for the existing bridge in 1958 and also for the then proposed widening of the bridge in 1993. The results of these boreholes and of the boreholes drilled for this present investigation have shown, below some fill, the presence of a surficial layer of silty clay and/or silty clay till, underlain by a major till sheet which consists of clayey silt with sand and some gravel. The clayey silt till has a stiff to hard consistency and extends to an average Elevation of about 94-95 m. It is underlain by an approximately 2 to 6 m thick clayey

silt to silty clay layer. This deposit is generally weak (i.e. soft to very stiff) and compressible. This layer is sandwiched between the upper clayey silt till and a lower, granular till sheet below Elevations 92-89 m. In the upper 1 to 4 m, this lower till sheet has a loose to dense state of compactness becoming very dense below. Most of the boreholes were terminated in this deposit after penetrating it for a maximum vertical distance of 8 m or to Elevation 81 m.

The groundwater level at the site is believed to be at Elevations ranging between 101 and 97 m.

5.2 STRUCTURE FOUNDATIONS

5.2.1 ABUTMENTS

We understand that the new structure will be of "integral abutment" type and will, therefore, be supported on driven H-piles. In our opinion, the subsurface conditions are suitable for the use of integral abutments supported on driven H-piles.

In our analysis, both shallow and deep foundation alternatives have been considered. The use of driven H-piles is recommended to support the abutments, based on reliability.

5.2.1.1 DEEP FOUNDATIONS

5.2.1.1a DRIVEN PILES

The boreholes show that with the prevailing subsurface conditions the use of a low displacement pile, such as a steel H-pile with a heavy section (e.g. HP310 & 110) with reinforced tips as per MTO specifications, would be better suited than other pile types (e.g. steel tube piles, steel H-piles with lighter sections or precast concrete piles).

The following table summarizes the approximate average tip elevations that may be assumed for design purposes.

Table 5.2.1.1.1

Support Location	Reference Borehole	Estimated Pile Tip Elevation	Soil Deposit
South Abutment	102	86.5 m	Very dense Silt and sand till
North Abutment	104A	82.5 m	Very dense Silt and sand till

The following axial resistances are estimated for HP 310 x 110 steel piles driven to practical refusal in the very dense glacial till, as documented in Table 5.2.1.1.1.

Factored Axial Resistance at U.L.S. = 1650 kN/pile

Axial Resistance at S.L.S. = 1100 kN/pile

The piles should be driven using a suitably heavy hammer capable of delivering a rated energy of at least 55 kilojoules/blow, but not more than 70 kilojoules/blow. The driving of the piles in the field should be controlled by a recognized pile driving formula, such as the Hiley Formula. The estimated ultimate resistance of the piles by the Hiley Formula can be calculated by dividing the recommended axial resistance at U.L.S. by a resistance at factor of 0.5, as per current MTO practice. With this criterion, the estimated ultimate axial resistance as per Hiley Formula is 3300 kN (i.e. 1650 divided by 0.5 = 3300).

In accordance with the above criterion, we recommend that the piles be driven to about 1.5 m above the quoted design elevation and driving should then be monitored and controlled by employing the Hiley Dynamic Pile Driving Formula in accordance with MTO Standards SS103-10 and SS103-11.

During the driving process piles which have already been driven should be monitored to determine if they are heaving due to the effects of driving of adjacent piles. If this phenomenon occurs, the affected piles should be re-driven. At least 10% of the piles (but not less than two piles) driven at each support element should be re-tapped not less than 24 hours after the driving of the pile, as per OPSS-903S01, to check that relaxation has not occurred. If it has, then all the piles should be re-tapped. It may be necessary to stagger the driving of the piles. It is

possible that the piles may drive several metres below the estimated pile tip elevations. This aspect should be taken into consideration when ordering piles.

Pre-augering could be used if required to facilitate the installation to an elevation sufficiently above the anticipated pile tip elevation (e.g. about 1.5 m above the pile tip elevation). Normally, the pre-auger consists of a 200 mm hole to push any large size material away from the path of the pile and to reduce resistance of the soil to pile driving. As mentioned before, due to the anticipated hard driving conditions and the presence of cobbles and boulders, the piles should be equipped with reinforced tips as per MTO Standards (OPSD 3301.00).

All pile driving should be carried in accordance with SP903S01.

We do not anticipate structural/foundation damage to the existing structure due to the vibrations caused by pile driving for the new structure. We recommend, however, that a vibration specialist and/or a pile-driving contractor be consulted in this matter. It may also be prudent to conduct vibration monitoring.

For frost protection, all pile caps should have a permanent earth cover of at least 1.5 m.

In cohesionless soils the coefficient of horizontal subgrade reaction can be estimated from:

$$k_s = n_h z / d$$

Where k_s = coefficient of horizontal subgrade reaction

z = depth

d = pile width

n_h = coefficient related to soil density as given in Table 5.2.1.1.2.

Also as presented in the same table are estimated values for angle of internal friction and bulk unit weights.

Where the soil is primarily cohesive, the undrained shear strength of the soil is given.

Table 5.2.1.1.2

Area Reference/ Borehole No.	Applicable Elevation (m)	Soil Type	Bulk Unit Weight (kN/m ³)	Angle of Internal Friction (φ) Degrees	Recommended η_h Value (MN/m ³)	Recommended Undrained Shear Strength (kPa)
South Abutment/ BH102	107.0-103.4	Fill	19.5			70
	103.4-101.1	Silty clay till	21.5			200
	101.1-93.9	Clayey silt till	22.0			200
	83.9-90.5	Clayey silt	19.5			50
	90.5-88.5	Silt and sand till	21.5	32	4.5	
	88.5-83.5	Silt and sand till	22.0	35	11.5	
North Abutment/ BH104 & BH104A	107.0-103.3	Fill	19.0			50
	103.3-100.3	Silty clay	20.5			200
	100.3-94.0	Clayey silt till	22.0			150
	94.0-92.8	Clayey silt till	21.0			80
	92.8-88.8	Clayey silt till	19.5			30
	88.8-86.5	Silt and sand till	21.0	31	4.0	
	86.5-80.9	Silt and sand till	22.0	35	11.5	

The recommended horizontal resistances for HP310x110 steel H-piles are as follows:

Factored Horizontal Resistance at U.L.S. = 130 kN/pile

Horizontal Resistance at S.L.S. = 60 kN/pile

If integral abutments are not constructed then the lateral resistance of the piles can be supplemented, if desired, by the horizontal components of battered piles. In this instance, we recommend that the batter be limited no more than 4:1, as in practice greater batter is difficult to install.

Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used in the embankment fills through which piles would be driven.

In accordance with MTO requirements (MTO Structural Office Standard), piles for integral abutments require a 3 m long flex zone. In essence where a false RSS type abutment is to be constructed, the current MTO standard for the flex zone consists of an annular space in between two concentric corrugated steel pipes (CSP's). One of the CSP's surrounds the H-pile (i.e. has a diameter of about 600 mm surrounding the pile, while the second CSP has a somewhat larger diameter; typically 800 mm for a 310 mm H-pile). The annular space in between the CSP's is the 3 m long flex zone. In accordance with current MTO practices, this space between the CSP's can be left void. After the pile is driven, the space

between the H-pile and the inner CSP is filled with uniform coarse sand. An NSSP should be included in the contract documents specifying the gradation of the sand as follows:

Sieve Size	Percentage Passing
2 mm	100%
600 μm	80-100%
425 μm	40-80%
250 μm	4 – 25%
150 μm	0 – 6%

If a retained soil system is not used, then in accordance with MTO structural office requirements (Report SO-96-01), the flex zone is provided by augering a 600 mm diameter hole 3000 mm deep and filling with loose sand before driving the piles.

Light weight (e.g. HP 310x79) piles are not recommended due to the presence of the upper till and the anticipated coarse soil particles (i.e. cobbles and boulders) in the till deposits, especially in the lower till sheet.

5.2.1.1B CAISSONS

Alternatively, if an integral type is not to be used, the abutments can be founded on drilled and cast-in-place reinforced concrete (caisson) foundations. The following soil resistances can be assigned for the design of caissons.

Table 5.2.1.1.3

Area Reference/ Borehole No.	Existing Ground Elevation at Borehole Location	Recommended Caisson Base Elevation (m)	Factored Bearing Resistance at U.L.S. (kPa)	Bearing Resistance at S.L.S. (kPa)	Subgrade Material
South Abutment/ BH102	109.5	88.0	2300	1500	Very dense sand and silt till
		86.5	4500	3000	Very dense sand and silt till
North Abutment/ BH104 & BH104A	107.8	86.0	2300	1500	Very dense sand and silt till
		84.0	4500	3000	Very dense sand and silt till

During their installation, the caissons would require the use of temporary steel casings to enable the bases to be properly cleaned of any disturbed soils and to enable the inspection and approval of the base by the engineer. The casings would be carefully withdrawn as the concrete is poured.

The presence of cohesionless glacial tills at the proposed base elevations together with the recorded high water levels (i.e. upward gradient) would necessitate special construction measures during the installation of the caissons. For this reason, the use of caissons is not recommended and the use of driven steel H-piles is the preferred option. If, however, it is necessary to use caisson foundations, it is suggested that the recommended higher base elevations be adopted in spite of the lower soil resistances. This is because, while the lower base elevations provide higher soil bearing resistances, the degree of difficulty with the installation of the caissons is expected to increase with increasing depth to be penetrated into the granular till deposit which is easily disturbed during the installation due to the upward groundwater gradient. The severity of the upward gradient and, therefore, the difficulty and cost of dewatering are expected to increase with the depth of penetration. If caisson foundations are to be adopted this should be further discussed with a contractor specializing in this field and also discussed with S&P.

5.2.1.2 SPREAD FOOTING FOUNDATIONS

Spread footings founded on hard native soil or on engineered Granular 'A' pads on the very stiff to hard native soils can also be considered. In this case, however, settlements exceeding 25 mm could occur, especially in areas where the grade will be raised (i.e. the eastern portion of the bridge). For this reason, the use of deep foundations (i.e. driven steel H-piles) is preferred and the use of spread footing foundations is not recommended. In any case, since the bridge will be of integral abutment type, the use of spread footings will not be appropriate.

5.2.2 CENTRAL PIER FOUNDATIONS

5.2.2.1 SPREAD FOOTING FOUNDATIONS

The existing grade at Highway 401 median area under the existing bridge and about 8 m east ranges from about 102.0 m on the west side to about 101.6 m on the east side of the proposed bridge location. Making an allowance of 2.0 m for the thickness of the footing and granular soil cover under the paved median, the underside of the footing will about Elevation 99.6 m. At this elevation, a Factored Bearing Resistance at U.L.S. equal to 450 kPa is feasible for the design of normal spread footing foundations. Assuming a Bearing Resistance at S.L.S. of 250 kPa and a footing width of 7.5 m, the estimated total settlement is of the order of 50 to 60 mm. This is primarily due to the presence of the weak and compressible clayey silt/silty clay layer sandwiched between the upper and lower glacial till deposits between about Elevation 93 and 90 m, as well as the relatively weak nature of the glacial till immediately above and below this clayey silt/silty clay deposit. Due to the relatively wide size of the footing, these weak zones are over-stressed which will lead to total settlements of the magnitude quoted. These settlements are in excess of normally accepted values. In addition, since the abutments will be supported on driven piles (i.e. integral abutments), these total settlements will translate into differential settlements of the order of magnitude quoted (i.e. about 50 mm), not only due to the fact the pile foundations can be expected to settle much less in magnitude, but also due to the anticipated difference in the time rate of settlements. This is because pile foundations supported on the basically granular lower till sheet can be expected to settle rapidly, while the settlement of the spread footing foundations would be much slower due to the presence of clayey soils overlying the lower till sheet.

For the reasons cited above the use of shallow spread footings is not recommended. The central pier should, therefore, be supported on deep foundations.

5.2.2.2 DEEP FOUNDATIONS

5.2.2.2A DRIVEN PILES

The subsurface conditions are suitable for the use of driven H-piles, which are also anticipated to support the abutments.

The use of relatively low displacement steel H-piles is preferable to steel tube piles due to the presence of the upper till sheet, as discussed before. In our opinion, the use of a relatively heavier section such as HP310x110 should be used for the same reason and due to the possible presence of oversized particles in the till deposits.

The following table summarizes the recommended axial pile resistances and approximate pile tip elevations for HP 310x110 steel H-piles, driven to practical refusal in the very dense till at the borehole locations.

Table 5.2.2.2.1

Support Location	Reference Borehole	Existing Ground Surface Elevation (m)	Estimated Pile Tip Elevation (m)	Recommended Factored Axial Resistance at U.L.S. (kN)	Recommended Axial Resistance at S.L.S. (kN)
Central Pier/West Side	103B	102.0	84.0	1650	1100
Central Pier/East Side	103A	101.6	83.5	1650	1100

The details of pile driving were given in Section 5.2.1.1. In this instance also, the piles should be equipped with reinforced tips as per MTO standards and allowance should be made to pre-auger in case it is needed.

The soil parameters for estimating the horizontal subgrade section are given in the following table.

Table 5.2.2.2.2

Area Reference/ Borehole No.	Applicable Elevation (m)	Soil Type	Bulk Unit Weight (kN/m ³)	Angle of Internal Friction (ϕ) Degrees	Recommended n_h Value (MN/m ³)	Recommended Undrained Shear Strength (kPa)
Central Pier/ BH103A	101.0-94.5	Clayey silt till	22.0			180
	94.5-93.4	Clayey silt till	21.5			120
	93.4-89.6	Clayey silt	19.5			35
	89.6-87.0	Silt and sand till	21.5	32	4.5	
	87.0-85.0	Silt and sand till	22.0	33	7.0	
	85.0-81.7	Silt and sand till	22.0	35	11.5	
Central Pier/ BH103B	101.0-93.5	Clayey silt till	22.0			150
	93.5-92.0	Clayey silt till	21.5			120
	92.0-90.0	Clayey silt	19.5			30
	90.0-87.0	Silt and sand till	21.5	30	2.0	
	87.0-85.1	Silt and sand till	22.0	35	11.5	

The recommended horizontal resistances for HP310x110 steel H-piles are as follows:

Factored Horizontal Resistance at U.L.S. = 120 kN

Horizontal Resistance at S.L.S. = 55 kN

Lateral resistances of the piles can be supplemented by horizontal components of battered piles as per clause 6-9.8.2 of O.H.B.D.C.

It should be pointed out that if the construction will be carried out when the Highway is in use, construction methods and equipment will have to be selected with safety and space restrictions in mind. In addition, the staging (sequencing) of the construction will likely require that the central pier foundations for the entire bridge be constructed at once, while the existing bridge is still in use. This dictates that the construction equipment (e.g. pile driver) will also have restricted vertical space when working under the existing bridge (i.e. western half of the proposed bridge).

We understand that the vertical clearance under the existing bridge is about 6.0 m. This can probably be increased by an additional 1.0 to 1.5 m by excavating into the existing grade (pavement). This will increase the vertical clearance to 7.0 to 7.5 m but this will still be insufficient for the operation of a conventional pile driving equipment. In our discussions with some of the local pile driving contractors, we have been informed that with this headroom (clearance) the

use of a hydraulic pile driving hammer is not feasible; however, some firms have pile driving equipment with conventional drop hammers. These are, however, capable of providing only limited energy. Under these circumstances, therefore, full capacity of the piles will not be realized. In this instance also, we recommend the use of a relatively heavy section such as HP310x110 steel H-piles with reinforced tips, as per MTO procedures.

It is our opinion and based on discussions with local contractors, the capacity of the piles driven with such 'restricted headroom equipment' be limited to the following values, but may need to be adjusted depending on the equipment and energy utilized.

Factored Axial Resistance at U.L.S. = 900 kN/pile

Axial Resistance at S.L.S. = 600 kN/pile

The anticipated approximate pile tip elevations at Boreholes 103A and 103B are 84.5 m and 85.5 m, respectively. As mentioned earlier in this report in Section 5.2.1, however, allowance should be made to drive the piles deeper, if needed. With the quoted resistance values, the estimated ultimate axial resistance as per Hiley Formula is 1800 kN. When making these recommendations, we assumed that the pile driving equipment will be capable of delivering a minimum energy of 45 kilojoules/blow (e.g. a 2300 kg hammer with a free drop of 2.0 m or an approximately 3100 kg. hammer dropping 1.5 m).

It should also be pointed out that because of the low vertical clearance, the piles will have to be spliced at short intervals of length (e.g. 3 m). In discussion with local contractors, we were given to understand that with the low overhead conditions, as discussed, the cost of driven piles can be anticipated to be two to three times in comparison with piles driven without such restrictions. In addition, with this kind of operation, the battering of the piles (if required) should be limited to 8:1.

5.2.2.2.B CAISSON FOUNDATIONS

Alternatively, the pier can be founded on drilled and cast-in-place reinforced concrete piles (caissons). The following soil resistances can be assigned to caissons installed with no headroom and equipment restrictions.

Table 5.2.2.2.3

Area Reference/ Borehole No.	Existing Ground Elevation at Borehole Location	Recommended Caisson Base Elevation (m)	Factored Bearing Resistance at U.L.S. (kPa)	Bearing Resistance at S.L.S. (kPa)	Subgrade Material
Central Pier/BH103A	101.6	87.0	2300	1500	Very dense sand and silt till Very dense sand and silt till
		84.0	4500	3000	
Central Pier/BH103A	102.0	86.5	2300	1500	Very dense sand and silt till Very dense sand and silt till
		85.2	4500	3000	

Other details of design and construction for caissons along with our concerns regarding this alternative were discussed in Section 5.2.1.1 of this report.

As mentioned before, staging of the construction sequence will likely require some of the caissons to be installed from under the existing bridge while the structure is still in use. In this instance, caisson drilling equipment capable of operating under low overhead conditions will be required. In general locally available equipment suitable for this purpose have limited capabilities, and are unable to install deep and large diameter caissons. For this reason, if caissons are to be considered, it is recommended that the higher base elevations be adopted for preliminary proportioning purposes, despite the lower soil resistances given in Table 5.2.2.2.3. It should then be checked with local contractors specializing in caisson work, if their equipment is capable of constructing such caissons. In addition, the installation of temporary steel casings is required to enable the base of the caissons to be properly hand prepared and then inspected by the engineer. Under low overhead conditions, these casings will have to be installed in short sections and would have to be screw-on type or they will have to be telescoped. They can also be welded and left in place as permanent casings. The placement of

reinforcing steel cage will also be cumbersome. All these steps will result in a costly operation.

Because of these concerns and considering the fact that the cohesionless lower till deposit into which the caissons will be socketed may get disturbed due to upward water migration (i.e. groundwater level above the top of this lower till layer), the use of caissons is not recommended. This is especially true if the abutments will be supported on driven steel H-piles. If, however, the caisson option is to be further explored, the caisson bases should be placed as high as possible and this should be further discussed with a specialist contractor and with us.

To reduce the problems associated with caisson construction, some other solutions are to use a bentonite or polymer solution to keep the caisson holes open and to use tremie concrete for the installation of the caissons. Since no base inspection can be carried out, in this case the design of the caisson foundation will have to be based on adhesion only.

Under low headroom conditions, mini-pile type foundations are also used. Locally such piles are infrequently utilized and, therefore, a specialized contractor may have to be imported to install such piles. We will be pleased to look into these alternatives if you wish us to do so.

In summary, supporting the central pier on driven H-piles represents, in our opinion, the most practical solution, especially if the abutments are also supported on driven piles. This is particularly true, if it is necessary to construct the central pier foundations while the existing structure is in place.

5.3 LATERAL EARTH PRESSURES

Backfill behind abutments and retaining walls should consist of non-frost susceptible, free draining granular materials in accordance with the Ontario Ministry of Transportation Standards.

Free-draining backfill materials (i.e. Granular A or Granular B) and the provision of drain pipes and weep holes, etc., should prevent hydrostatic pressure

build-up. Computation of earth pressures should be in accordance with O.H.B.D.C. For design purposes, the following parameters (unfactored) can be used.

Compacted Granular 'A'

Unit Weight = 22 kN/m^3

Coefficient of Lateral Earth Pressure:

$$K_a = 0.27$$

$$K_o = 0.43$$

Compacted Granular 'B' Type 1

Unit Weight = 21 kN/m^3

Coefficient of Lateral Earth Pressure:

$$K_a = 0.31$$

$$K_o = 0.47$$

These values are based on the assumption that the backfill behind the retaining structure is free-draining and adequate drainage is provided. As well, it is assumed that the ground behind the retaining structure is level.

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or movements can be allowed such that the active state of earth pressure can develop. If the abutment is restrained and does not allow lateral yielding, then at rest pressures should be used as per Clause C6-7.1 of the O.H.B.D.C., 3rd Edition. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients in accordance with Clause 6-7.4.3, O.H.B.D.C., 3rd Edition.

Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practice.

As an alternative to conventional retaining walls, MTO's Retained Soil System may be used. The following should be included in the Contract Documents:

- identify longitudinal extent in plan of the Retained Soil System
- identify in plan transverse space constraints (top of wall and bottom of wall)
- identify elevation of top of wall and bottom of wall
- include NSSP for Retained Soil Systems in Contract Documents

The Retained Soil System should be of high performance and high appearance.

5.4 APPROACH EMBANKMENTS

The construction of the east half of the new bridge will take place while the existing Burnham Street bridge will be in use (which will later be removed).

On the south side of the existing bridge, the construction will involve the widening of the existing embankment by abutting into it, as well as raising the existing embankment by about 0.5 to 1.0 m. The existing grade at the toe of the embankment is about 103-104 m and since the new grade will be about 109.5 m, the widening will involve raising the grade by up to about 6 m.

Based on the borehole results, no foundation failures are anticipated for the proposed up to 6 m high embankments, provided that all organic soils, weak or otherwise unsuitable materials are removed as per MTO Standards before placing the fill.

Assuming properly compacted, acceptable inorganic earth fill material, 2 horizontal in 1 vertical side slopes can be used. Proper erosion control measures should be implemented both during the construction and permanently. This can be achieved by immediate seeding or sodding (OPSS 572).

All organic and other unsuitable soils should be removed within an envelope given by an imaginary slope not steeper than 1:1 from the toe of the proposed embankment as depicted by the sketch presented in Appendix F. The average thickness of the unsuitable soils to be stripped can be assumed to be about 0.6 m. After stripping, the exposed subgrade should be inspected, approved and properly compacted from the surface, using a suitably heavy compactor, under the supervision of a geotechnical engineer who is familiar with the findings of this report and appointed by the Contract Administrator.

Provided that all organic and otherwise unsuitable materials are removed and the subgrade is properly compacted from the surface as detailed above, the settlement of the foundation materials (i.e. not including the settlement of the embankment material under its own weight) should not exceed 20 mm

increasing easterly to about 40 mm at the extreme easterly edge of the new embankment and about 60% of this settlement should be completed during the construction and within about one month of placing the embankment fill to its full height. The settlement of the embankment fill under its own weight can be expected to be about 25 mm. Such settlements are considered acceptable and will not necessitate preloading or surcharging.

Groundwater level in Borehole 106, which was drilled near the toe of the existing embankment, was recorded at about 1 m below the ground surface. At most locations, stripping is, however, not expected to extend below this level; as well the underlying soils are clayey (i.e. practically impervious). For these reasons, major problems are not anticipated due to groundwater seepage during stripping of subgrade and backfilling. Since the area is relatively low, however, allowance should be made for gravity drainage and pumping from open sumps to remove water from a surface and/or perched water source, should it be needed. In addition if the construction is carried out during a wet season, the first lift may be required to be granular soils.

On the north east side of the bridge, the proposed grade elevation is about 108.5 m and the existing grades adjacent to Burnham Street ramp are generally 107-108 m, within the footprint of the embankment. The grade will therefore be raised by about 0.5 to 1.5 m over the existing grade elevations. Based on the borehole findings, no foundation failures are anticipated resulting from the grade raise. It should, however, be pointed out that signs of ground subsidence were noted in the general area. These appear to be on top of a storm sewer line that was constructed for the existing storm sewer management pond. The ground subsidence could therefore be due to settlement caused by poor compaction of fill placed after the construction of the existing storm sewer pipe and the storm water management pond, immediately to the east, but it could also indicate a potential slope instability. We recommend that this aspect be looked into prior to placing any additional embankment fill.

Assuming properly compacted, acceptable inorganic earth fill material, 2 horizontal in 1 vertical side slopes can be used. Proper erosion control measures should be implemented both during the construction and permanently. This can be achieved by immediate seeding or sodding (OPSS 572).

All organic and other unsuitable soils should be removed within an envelope given by an imaginary slope not steeper than 1:1 from the toe of the proposed embankment as depicted by the sketch presented in Appendix F. The average thickness of the unsuitable soils to be stripped can be assumed to be about 0.2 m. We recommend, however, an additional 0.3 m be stripped. This material can be re-used, if found acceptable. After stripping, the exposed subgrade should be inspected, approved and properly compacted from the surface, using a suitably heavy compactor, under the supervision of a geotechnical engineer who is familiar with the findings of this report and appointed by the Contract Administrator.

Provided that all organic and otherwise unsuitable materials are removed and the subgrade is properly compacted from the surface as detailed above, the settlement of the foundation materials (i.e. including the settlement of the embankment material under its own weight) should not exceed 30 mm and should be substantially completed during the construction and within about six weeks of placing the embankment fill to its full height. These settlements are considered acceptable and will not necessitate preloading or surcharging.

Groundwater level was recorded more than 6 m below the existing grade and, therefore, we do not anticipate problems due to groundwater seepage during stripping of the subgrade and backfilling for the construction of the embankments.

For both approach embankments (i.e. south and north), materials used for the construction should consist of approved, acceptable earth borrow. As mentioned before, oversized materials should not be used in embankment fills through which piles would be driven. The fills should be placed in lifts not exceeding 300 mm before compaction and each lift should be uniformly compacted to at least 95% of the material's Standard Proctor Maximum Dry Density. The degree of compaction within the top 0.5 m of the fill (i.e. the subgrade immediately beneath the granular subbase) should be increased to 98%. The selection, placement and compaction of the fill should be carried out under the supervision of a geotechnical engineer who is familiar with the findings of this report and appointed by the Contract Administrator.

In both cases, proper benching of the existing embankment should be applied as per MTO procedures and Ontario Provincial Standards (OPSD-208.01).

5.5 CONSTRUCTION COMMENTS

The natural surficial soils encountered at the site are basically clayey deposits and can therefore be expected to be relatively impervious. Excessive seepage into temporary excavations extending into these materials is not anticipated and seepage can be handled by gravity drainage and where necessary by pumping from open sumps. Allowance should also be made to handle perched water in the fill materials, especially any granular fill.

The pile caps and any foundations should be placed with a minimum earth cover of 1.5 m for frost protection.

All excavations, shoring and backfilling should be carried out in conformance with the safety regulations of the province, as well as the following specifications.

SP 539S01 – Protection Schemes

SP 902S01 – Excavation and Backfilling to Structures

The surficial natural silty clay and silty clay/clayey silt till deposits can be classified as Type 2 soil while the granular road fill materials can be classified as Type 3 soil (above groundwater table).

Temporary support may be necessary if the grade of the workspace when working on Highway 401 central median under the existing bridge structure is to be lowered to create additional headroom as well as for the proposed grade raise along Burnham Street adjacent to the existing road. The contractor will probably choose to slope the ground rather than shore it for the duration of the construction. If, however, support is necessary, the shoring should be designed so that the lateral movement of any portion of the roadway protection system will not exceed the established criterion for the structure performance level. In this case, the Performance Level should be 2.

Locally, temporary shoring systems generally consist of support provided by conventional soldier piles and timber lagging. The soldier piles can be designed as cantilever structures or supported by raker footings; they can also employ a soil anchor system, depending upon the depth of soil to be retained and the required performance criteria.

Under the existing bridge since the excavations will only be 1 to 2 m deep, it may be feasible to utilize a raker support system. Raker footings are typically shallow footings with minimum embedment and placed at an angle of approximately 45 degrees. Based on the results of Boreholes 103A and 103B, for design of raker footings placed in the stiff to hard clayey silt till and extending at least 0.6 m into the general excavation level, the following resistance values can be used:

U.L.S. = 160 kPa

S.L.S. = 80 kPa

Alternatively, a cantilever type of shoring may be used, if space restrictions dictate this, and the deflection is acceptable.

The coefficient lateral earth pressure parameters given in Table 5.5.1 can be used for the design of the shoring system.

If shoring is required for the grade raise along the east side of Burnham Street then a cantilever type of shoring may be considered and the coefficient of lateral earth pressure parameters given in Table 5.5.1 can be used for the design. If a soil anchor tieback system is required (e.g. at the south east quadrant) then for preliminary design of temporary soil anchors, a tentative bond resistance at U.L.S. of 60 kPa can be used in the silty clay and clayey silt till and S.L.S. will not govern. Bond resistance in the embankment fill and topsoil overlying the natural inorganic soils and in the relatively weak clayey silt deposit underlying the clayey silt till (i.e. below about Elevation 94 m) should not be relied upon.

Table 5.5.1
Recommended Unfactored Parameters for Temporary Shoring Design

Soil Type	Ka	Ko	Kp	(kN ² /m ³)
Granular Fill	0.30	0.45	3.3	21.5
Clayey Fill	0.33	0.50	3.0	21.0
Silty Clay/Clayey silt till	0.30	0.50	3.0	21.5

Vegetation should be established on all slope faces to protect against surficial erosion as per OPSS 572.

5.6 FROST PROTECTION

Design frost penetration for the general area is 1.5 m. Therefore, a permanent soil cover of 1.5 m or its thermal equivalent is required for frost protection of foundations.

6. CLOSURE

We recommend that once the details of the structure are finalized, our recommendations be reviewed for their specific applicability.

The Limitations of Report, as quoted in Appendix G, are an integral part of this report.

Shaheen & Peaker Limited

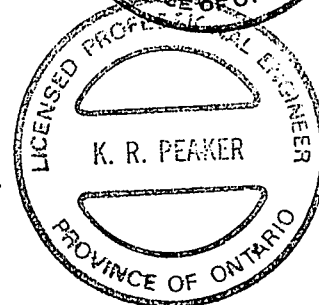


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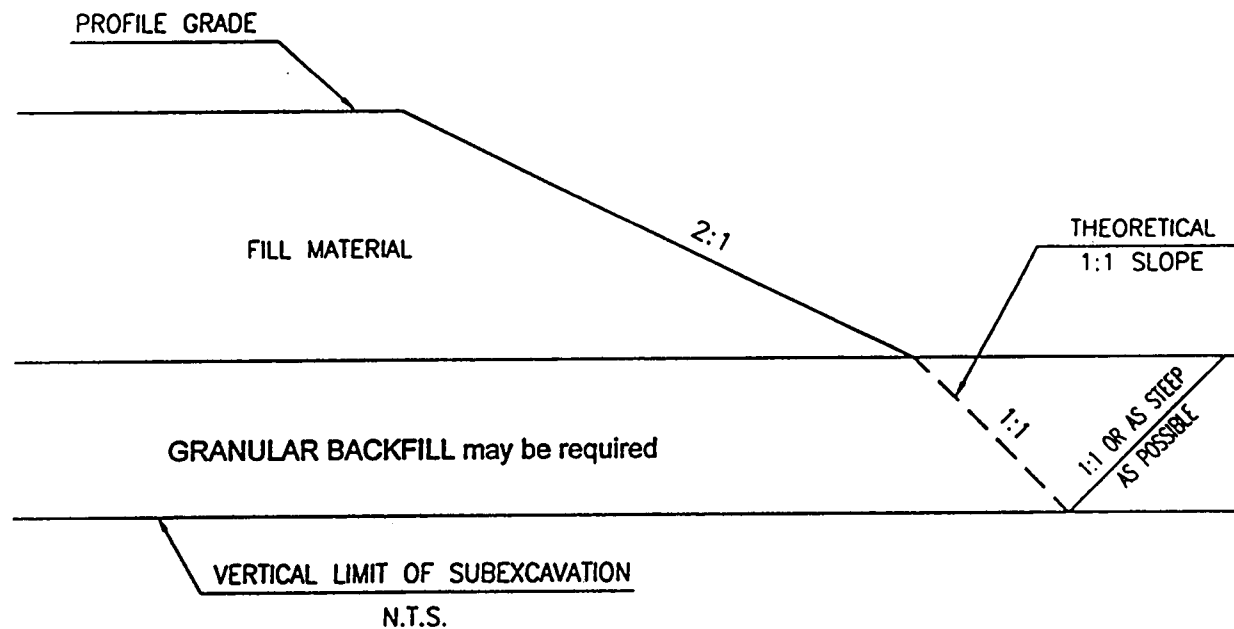
K. R. Peaker, Ph.D., P.Eng.

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APPENDIX F

Removal of Unsuitable Soils From Beneath Approach Fills



REMOVAL OF UNSUITABLE SOILS
FROM BENEATH APPROACH FILLS
N.T.S.

APPENDIX G

Limitations of Report

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Shaheen & Peaker Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 678-90-01 DIST 7
HWY 401 STR SITE 21-243

Bridge Rehabilitation
Hwy 401/Burnham Street (Hwy 18)

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FOUNDATION INVESTIGATION REPORT

FOR:

Bridge Rehabilitation

Hwy. 401/Burnham Street (Hwy. 18)

WP 678-90-01, Site No. 21-243

District 7, Port Hope

Introduction

This report summarizes the information obtained from a Foundation Investigation carried out at the above mentioned site between 93/08/09 and 93/08/13. The existing two lane single span structure is proposed to be widened by an additional lane.

An investigation (WP 56-58) was previously conducted for the existing bridge between 58/04/22 and 58/05/15 which consisted of four boreholes placed just north and south of the existing structure. These borehole Log Sheets are enclosed in the appendix of this report. These boreholes were terminated at 11.3 - 18.7 m depths with in end bearing material.

Three additional sampled boreholes with two cone tests were advanced as part of this project by means of 82 mm hollow stem augers. Two boreholes were placed at the north abutment and one at the south abutment down to a depth of 14.2 m, 17.2 m and 18.7 m.

This report contains factual information obtained from this investigation pertaining to structural foundations, approach embankments and earthworks for the bridge structure as shown on DWG. No. 6789001-A.

Site Description

The site is located at the intersection of Hwy. 401 and Burnham Street (Hwy. 18) approximately 3 km north of the Town of Cobourg in the Township of Hamilton. The existing structure is a one span, two lane closed abutment structure which spans the four lane Hwy. 401.

The topography consists of cultivated fields and flat grass plains. Physiographically, the site is located in the "Iroquois Plain" Region characterized by drumlins and clay plains (Ref: Chapman and Putnam, 1984).

Subsurface Conditions

The subsoil stratigraphy consisted of 4.4 m to 7.3 m thick Clayey Silt, with Sand, and some Gravel (Glacial Till) resting beneath a thin Granular Fill. This layer was found to be weaker in strength at the north abutment. Underlying this deposit was a Clayey Silt with a thickness of 4.4 - 6.0 m. Again this material was found to be weaker at the north abutment. A greater Silt and Sand content at the south abutment may account for the greater consistency recorded. Beyond this weaker stratum a non-cohesive Heterogeneous Mixture of Silt, Sand, and Gravel with some Clay and trace of Cobbles (Glacial Till) was encountered, which extended beyond the termination depth of all boreholes. At the south abutment the glacial till contained a greater percentage of gravel and cobbles. End bearing material was confirmed with in this layer. Cone Penetration test were found to terminate at a depth of 3.3 m to the south and at a much deeper depth of 14 m to the north. This confirms the presence of weaker deposits at the north abutment location.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole Sheets in the appendix. The locations and elevations of the boreholes together with sections based on borehole data are shown on Dwg A and B.

Specific descriptions of the material encountered are given below.

Clayey Silt with Sand and Some Gravel (Glacial Till)

This deposit was encountered underlying a thin 0.2 - 0.5 m granular fill from the existing Hwy. 401. The cohesive Clayey Silt, with Sand and some Gravel (Glacial Till) was found throughout the site with an approximate thickness of 4.4 m -7.3 m. Auger grinding indicate the presence of Gravel and Cobbles.

Results of Grain Size distribution tests carried out on select samples are shown on Figure 1 in the appendix. The results indicate a mixture of Clay, Silt, Sand and Gravel.

The results from the atterberg limit tests performed on the fine fraction of this deposit is summarized as follows:

	<u>Range (%)</u>
Natural Moisture Content (w)	7.0 - 26.0
Liquid Limit (wL)	12.0 - 43.0
Plastic Limit (wp)	8.0 - 19.5
Plastic Index (Ip)	3.0 - 23.5

From the plasticity chart (Figure 2), the layer can be classified as a clayey silt of medium plasticity (CL or CL-ML).

The standard penetration test indicated this deposit was weaker at the north abutment, with "N" values ranging 21 - 28 blows/0.3 m to the south and 8 - 14 blows/0.3 m to the north indicating the material had a stiff to very stiff consistency to the north and very stiff consistency to the south.

Clayey Silt

Underlying the above deposit was a Clayey Silt, trace of Sand with a thickness of 4.4 - 6.0 m. This layer was found to be weaker than the previous Glacial Till.

Results of Grain Size distribution tests carried out on select samples are shown on Figure 3 in the appendix. The results indicate a large percentage of Clay and Silt.

The results from the atterberg limit tests performed on the fine fraction of this deposit is summarized as follows (Figure 4):

	<u>Range (%)</u>
Natural Moisture Content (w)	6.5 - 25.0
Liquid Limit (W_L)	12.5 - 29.0
Plastic Limit (W_p)	8.5 - 15.5
Plastic Index (I_p)	4.0 - 14.0

Vane tests conducted in this layer were found to range between 20 kPa to 44 kPa to the north and 100 kPa to >120 kPa to the south. This material was found to be weaker at the north abutment. This corresponds to a Stiff to Very Stiff consistency at the south abutment and a Firm to Stiff consistency to the north. A greater silt and sand content at the south abutment may account for the greater consistency recorded. Blow counts throughout the site ranged from 5 to 19 blows/0.3 m.

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

Underlying the weak layer described above was a non-cohesive Heterogeneous Mixture of Silt, Sand and Gravel some Clay and trace of Cobbles (Glacial Till) which extended beyond the termination depth of all borehole. At the south abutment this glacial till contained a greater percentage of Gravel and Cobbles. End bearing material was confirmed within this layer.

Results of Grain Size Distribution tests carried out on select samples are shown on Figure 5 in the appendix. The results indicate a large percentage of Silt, Sand and Gravel.

Due to the presence of cobbles and gravel the "N" values varied considerably from 12 to >120 blows/0.3 m. The material can be classified to having a compact to very dense state of denseness.

Groundwater Conditions

Observation of the groundwater level was carried out by measuring the water levels in open boreholes during the course of the investigation. Observations of the groundwater level in the open boreholes generally indicated water was

encountered at depths between 5 and 6.4 m below the ground surface. These readings are expected to be unstabilized. Upon completion of the drilling a piezometer was installed at the north abutment (B.H. #93-3) down within the upper cohesive Glacial Till. Readings indicated the water table to be at a depth of 5.0 m or approximate elevation of 96.5 m. Generally the phreatic surface appears to be relatively low.

Groundwater levels determined at the time of this investigation are subject to seasonal fluctuations and may vary from those discussed above.

Discussion and Recommendations

It is proposed to widen the existing one span structure by adding a third lane. The existing structure is approximately 42 m long and 8.4 m wide and is proposed to be widened to the east an additional 4.1 m to accommodate another lane. The existing structure together with its approaches appear stable. It is understood from plans provided that this closed abutment structure rests of Shallow Spread Footings placed within the native cohesive Glacial Till. The proposed structural widening is expected to be of a similar design.

The report for the existing structure, titled WP 56-58, Hwy. 401 and Gravel Road recommended Shallow Spread Footings with a bearing capacity of 2.5 T.S.F.(265 kPa) down to an elevation of approximately 100 m. A recommendation of Piles was considered if Spread Footings were required to be placed below the above depth.

The natural ground surface at the toe of the embankments varied throughout the site from El. 110.0 m to El. 104.3 m south of Hwy.401 and from El. 101.5 m to El. 105.1 m north. The elevation of the proposed grade is approximately 109 -110 m along the length of the structure.

To facilitate the design and construction of the proposed bridge widening, the following foundation and geotechnical recommendations are provided in the scope of this report.

- 1.) Structural Foundation
- 2.) Lateral Earth Pressure
- 3.) Approach Fills
- 4.) Construction Considerations

1. STRUCTURE FOUNDATION

The predominant soil strata consists of a very stiff Cohesive Glacial Till underlain by a soft to firm Clayey Silt and then a compact to very dense Non-

cohesive Till. The consistency of material indicated that it is only marginally suitable to accommodate the use of shallow spread footings. The weak nature of the material particularly at the north abutment would provide a low bearing capacity for spread footings. In view of the fact that the existing structure appears stable utilizing spread footings we are providing recommendations for the utilization of spread footing foundations.

Option A

It is understood that the proposed structural addition will be of the same design as the existing bridge. Spread footings founded on native glacial till with an assumed footing width of 3 m and constructed as per MTO Standards, the following parameters are recommended.

SPREAD FOOTINGS

	<u>Factored Capacity</u> <u>at U.L.S. (kPa)</u>	<u>Allowable Capacity</u> <u>at S.L.S Type II (kPa)</u>	<u>ELEVATION (m)</u>
South Abutment	450	300	*100.2
North Abutment	350	230	*100.4

* Due to the presence of the weak Clayey Silt layer footings should be placed as high as possible within the upper cohesive Glacial Till. The founding elevations are the same as those of the existing structure.

The base of all footing excavations should be covered immediately upon exposure with a working slab of lean concrete to protect the exposed till from weathering and softening within 4 hours of exposure.

Option B

If the above recommendation is unsuitable due to structural considerations, end bearing deep foundation units may also be utilized. Special consideration would have to be given to their construction in order to prevent any disturbance of the existing foundation elements. Alternatively, structure foundations can be founded on end bearing Reinforced Concrete Caissons installed in drilled shafts.

Reinforced Concrete Caissons could be installed with the least amount of disturbance to the existing structure. As the existing structure is founded on Shallow Spread Footings and with the presence of the weak Clayey Silt layer, disturbance would be a concern with the utilization of Steel-H Piles. The design axial capacities and founding elevations for 0.76 m diameter Concrete Caissons are summarized below:

Axial Capacities - Caissons

<u>Structure</u>	<u>Factored Capacity at U.L.S. (kN)</u>	<u>Bearing Capacity at S.L.S. type II</u>	<u>Estimated Pile Tip Elevation</u>
South Abutment	2250	1500	83 m
North Abutment	2250	1500	84.5 m

Capacity for other Caisson diameters can be obtained in proportion to the respected end bearing areas.

Resistance to lateral load shall be computed in accordance with section 6.8.3.8 of the O.H.B.D.C.

Presence of cohesionless Glacial Till at the proposed tip elevation together with relatively high water levels would necessitate special construction measures during the installation of Caissons, subject to review by this office.

Dewatering

No major dewatering difficulties are anticipated for the excavation of footings and pile caps in consideration of low permeability of the Clayey Silt (Glacial Till). However, if localized seepage or surface water accumulates in excavations, it can be controlled by perimeter ditches and pumping from corner sumps.

2. LATERAL EARTH PRESSURE ON STRUCTURE

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

Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ unfactored)	35°	30°
Unit Weight (kN/m^3), γ	22.8	21.2
*Coefficient of Active Earth Pressure (k_a)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.40
*Coefficient of Earth Pressure at Rest (k_o)		
- S.L.S.	0.43	0.50
- U.L.S.	0.50	0.58

3. APPROACH FILLS

Approach fills of up to 5 m and 6 m to the south and north respectively are required. Based on the above the proposed embankments would be stable utilizing 2H:1V slopes. Some minor settlement within the weak Clayey Silt to Silty Clay deposit is anticipated. However if the spread footings are placed as high as possible or if piles are utilized these should be minimized.

4. Construction Considerations

During excavation, care must be taken to prevent undermining of the existing foundation. If, during excavation, the material at the footing level adjacent to the existing foundation appears to soften and/or be disturbed, it should be carefully excavated and replaced with mass concrete. Some shoring scheme will be required during construction in order to protect the existing fills of the travelled portion of the Highway. Normal construction joints with dowels should

be used to fasten together the footings.

Unfactored Coefficient of Friction of 0.58 should be used for footing located on native soil.

The footing and pile caps should be placed with a minimum earth cover of 1.3 m for frost protection.

Within the limits of the approach fills, if soft soil is encountered, this should be excavated and be replaced by compact granular fill. Embankment fills should be placed and compacted as specified in OPSS 206.07.07 and OPSS 501 series.

Miscellaneous

The fieldwork for this investigation was carried out under the supervision of M. Michalek, Junior Foundation Engineer and D. Singaraja, Student Engineer utilizing equipment owned and operated by Master Soil Investigation Ltd., Toronto.

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

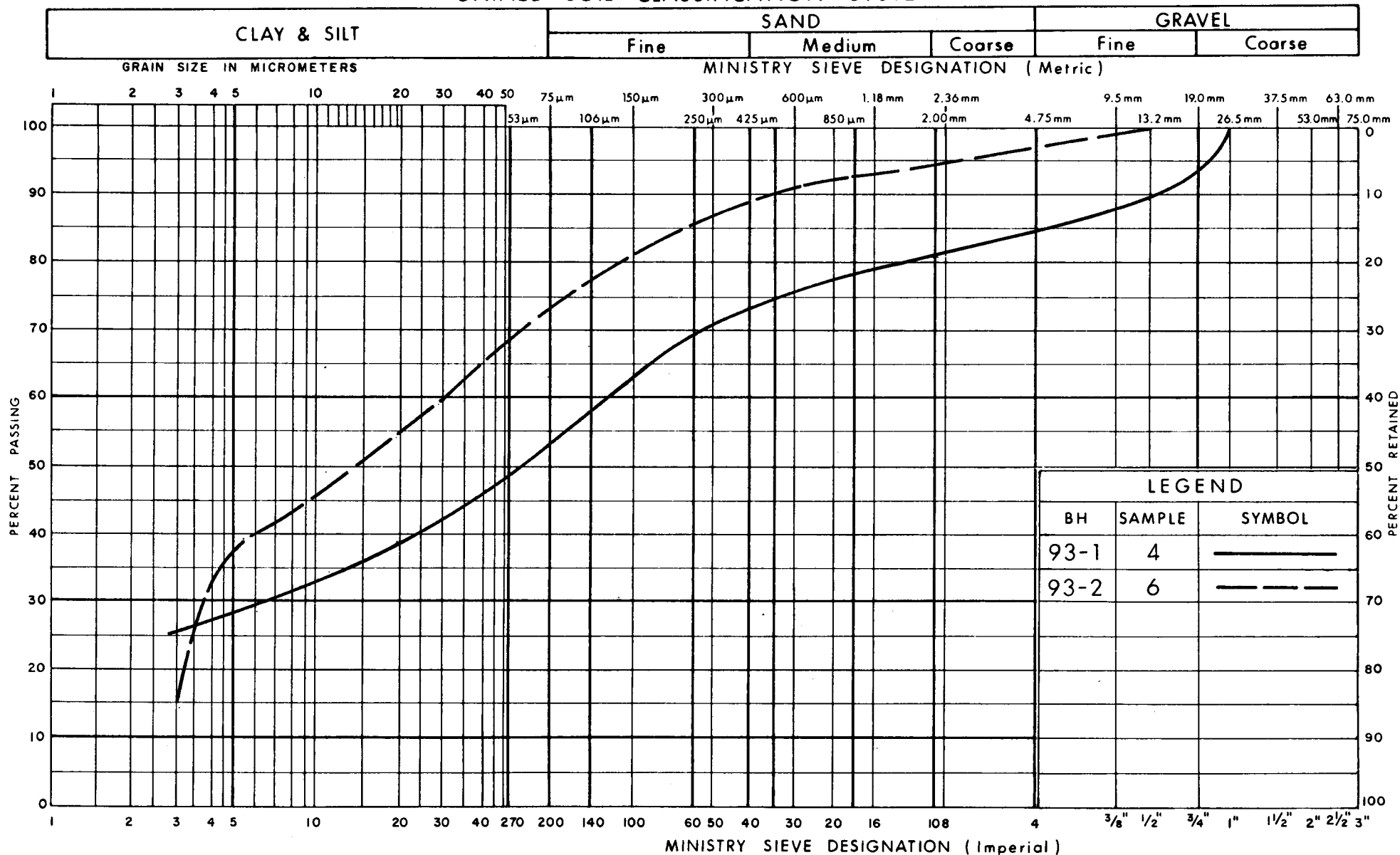
for Taechul Kim
M. Michalek, P. Eng.
Junior Foundation Engineer



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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

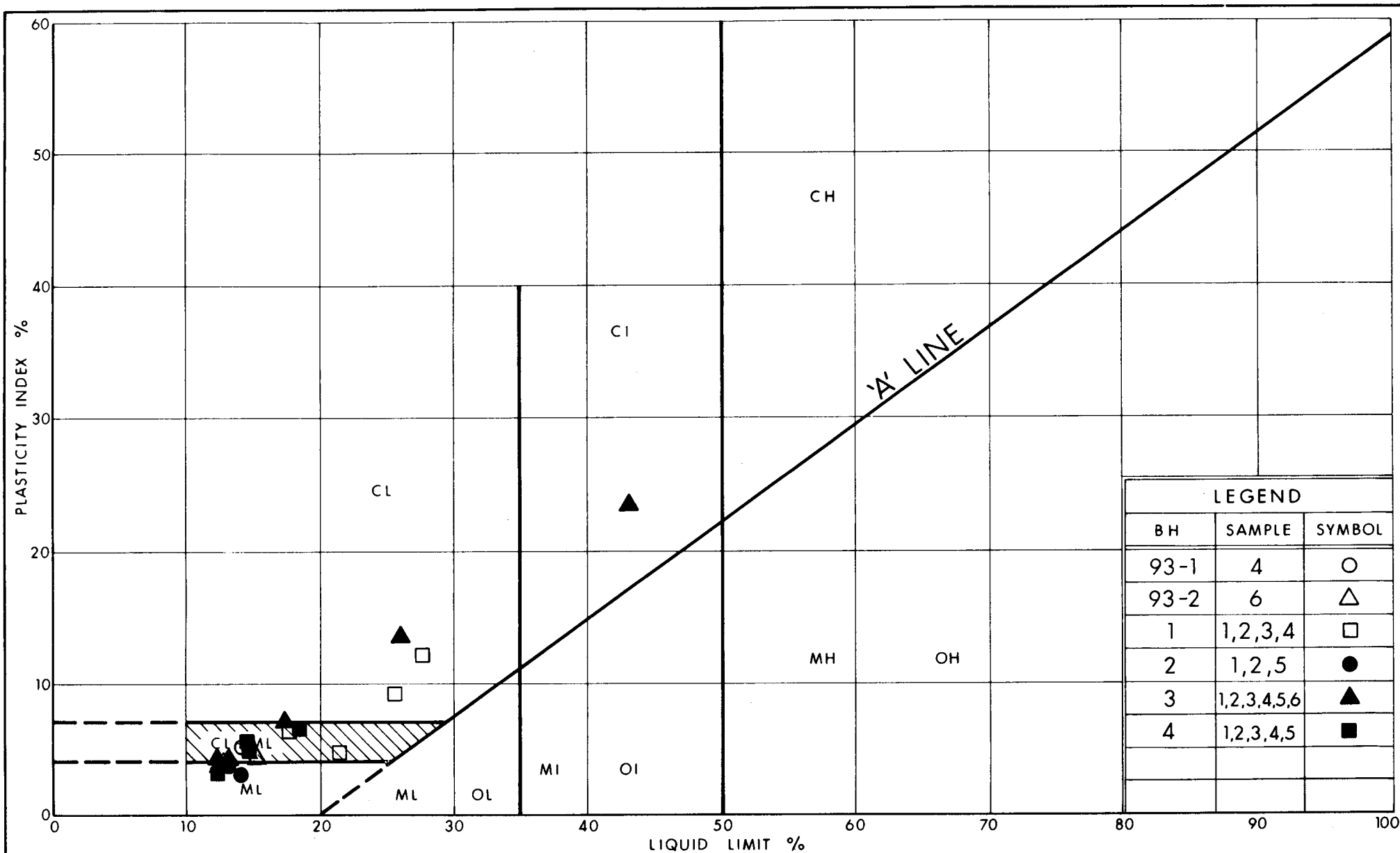


Ministry of
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT, WITH SAND & SOME GRAVEL
(GLACIAL TILL)

FIG No 1

W P 678-90-01



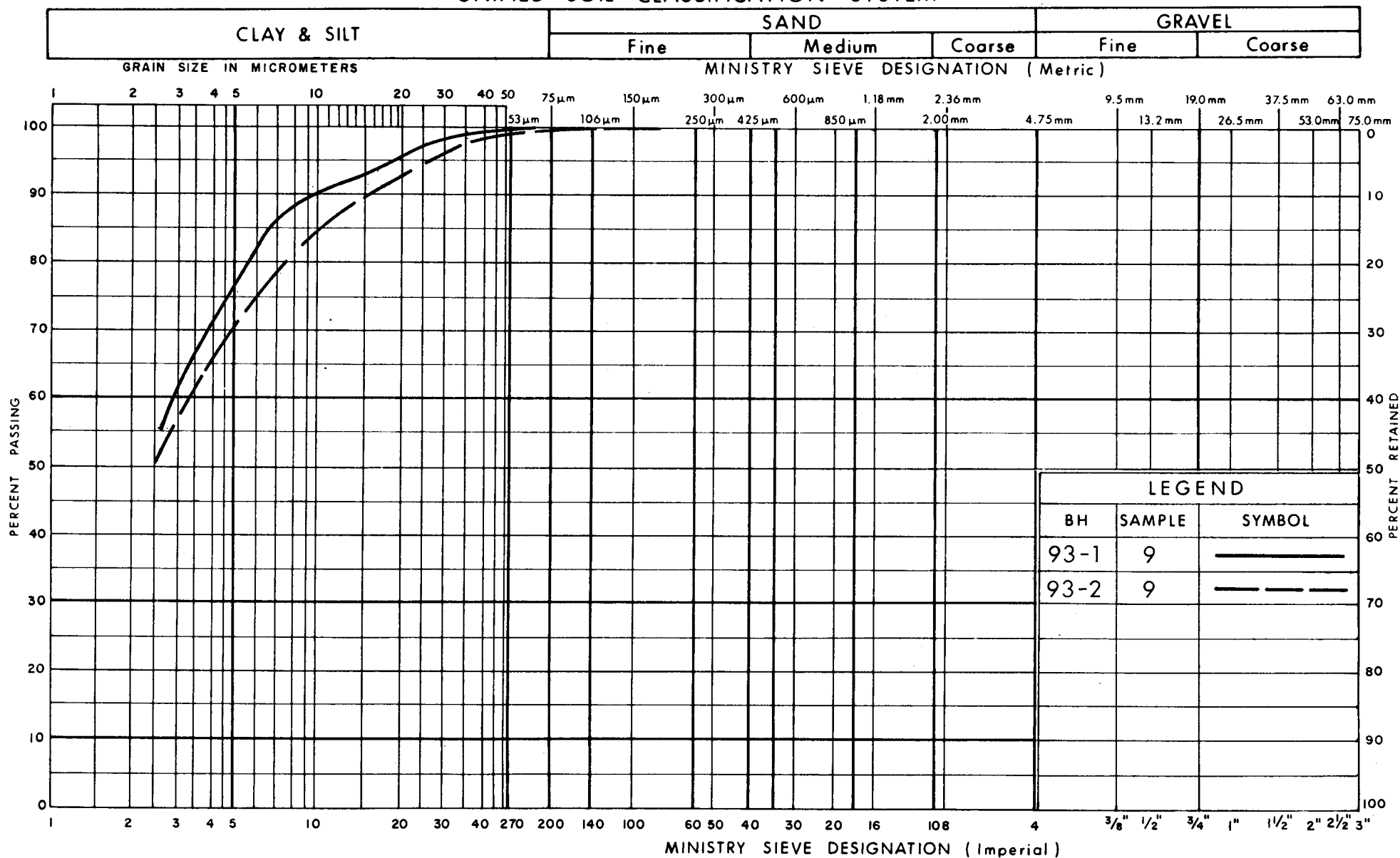
Ministry of
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Ontario

PLASTICITY CHART CLAYEY SILT, WITH SAND & SOME GRAVEL (GLACIAL TILL)

FIG No 2

W P 678-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

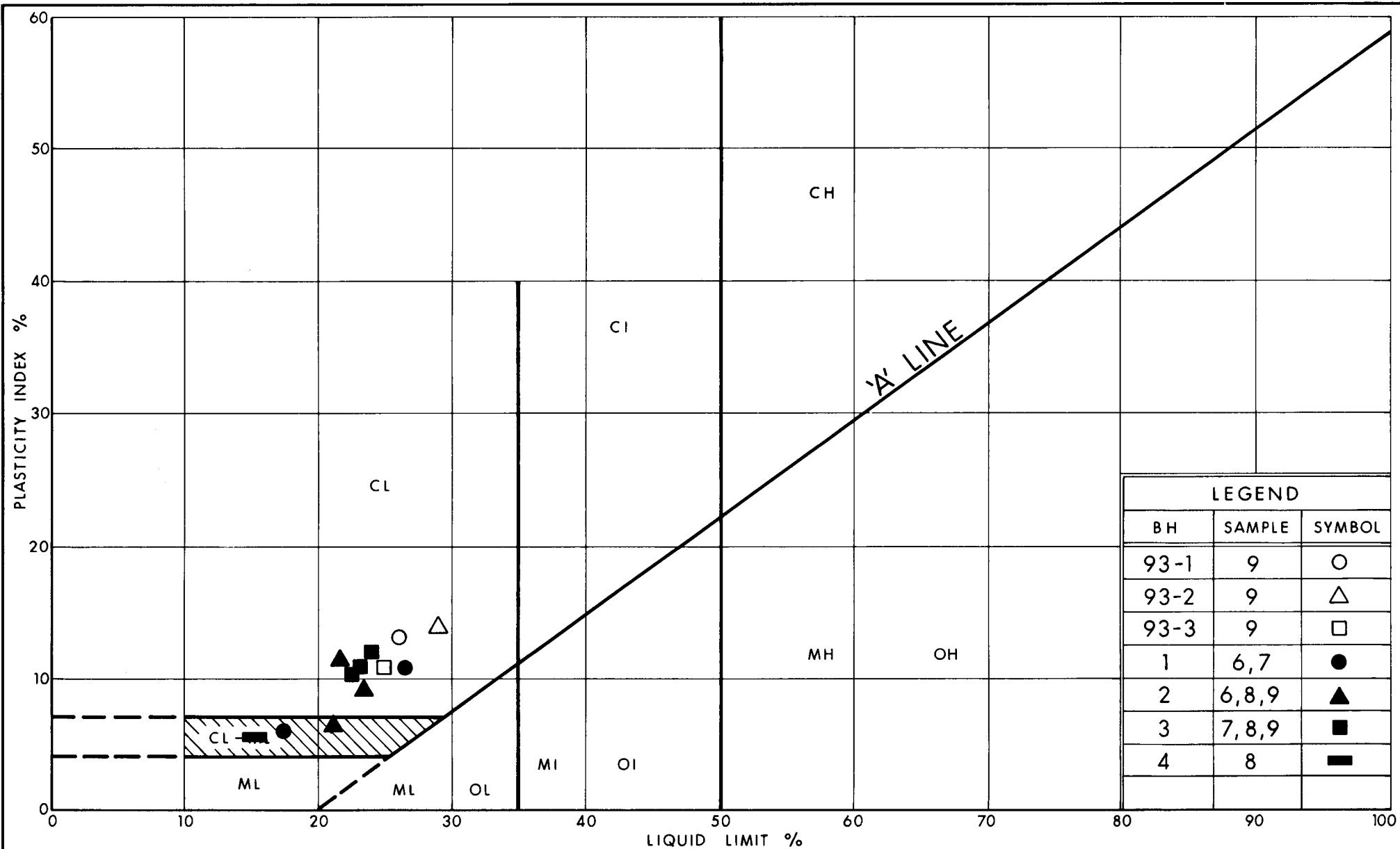


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GRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 3

W P 678 -90-01



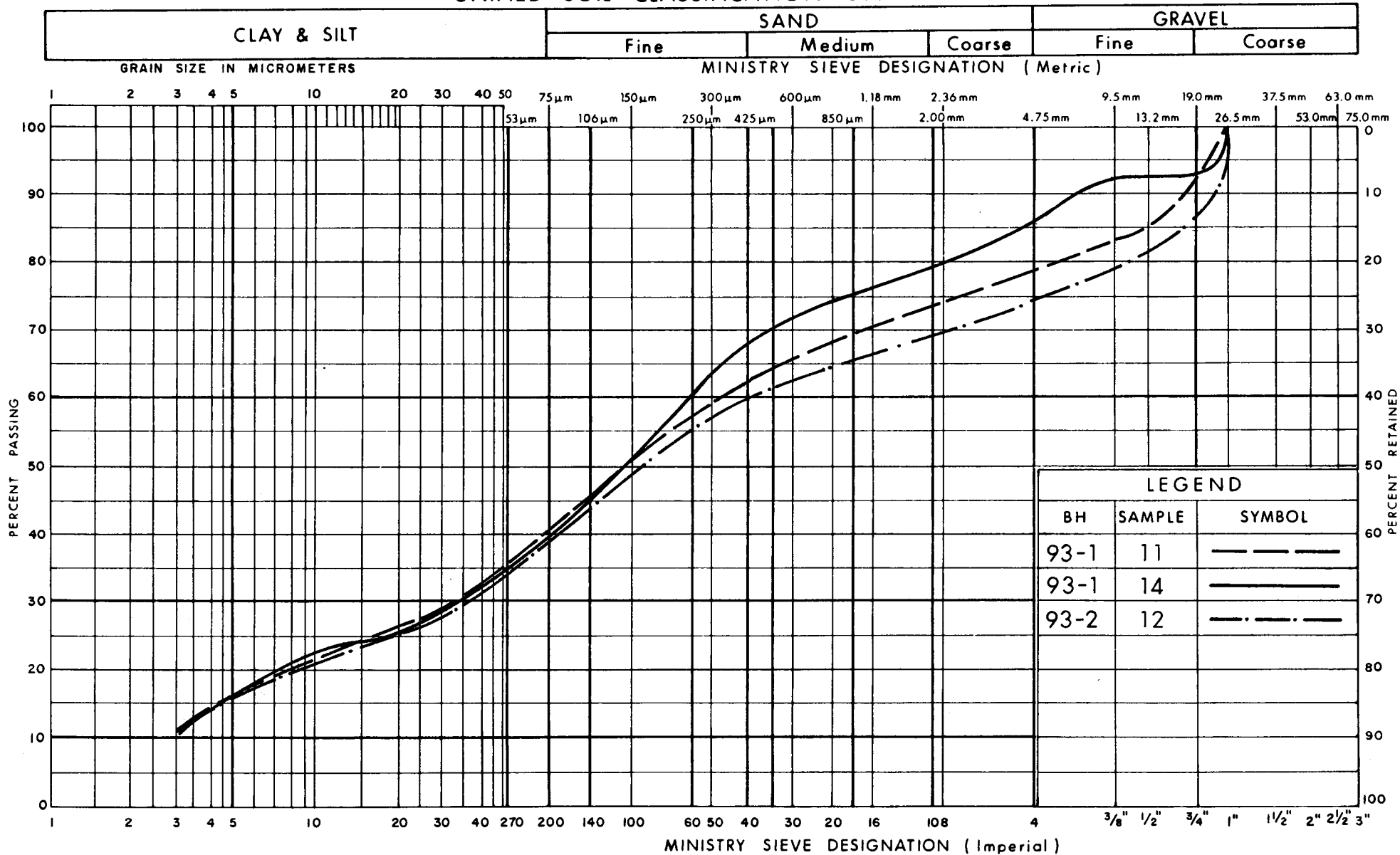
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PLASTICITY CHART CLAYEY SILT

FIG No 4

W P 678-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF SILT, SAND & GRAVEL SOME CLAY
(GLACIAL TILL)

FIG No 5

W P 678 -90 -01

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

1 OF 1

METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 739.5, E 409 383.0 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY AL
 DATUM Geodetic DATE April 22, 1958 CHECKED BY T.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	20 40 60 80 100	20 40 60 80 100					
104.5	Ground Surface														
0.0	Topsoil					*	104								
	Brown		1	SS	14		102								
	Grey						100								
	Clayey Silt With Sand, Some Gravel, Stiff to Hard (Glacial Till)		2	SS	27		98								
			3	SS	24		96								
			4	SS	24		94								
95.4			5	SS	41										
9.1	Clayey Silt, Firm to Stiff		6	SS	5										
93.2			7	SS	8										
11.3	End of Borehole														
	* WL Not Established														

RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 678-90-01 (56-58) LOCATION Co-ords: N 4 871 713.5, E 409 392.5 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY A.L.
 DATUM Geodetic DATE April 30, 1958 CHECKED BY T.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	20 40 60 80 100					
103.6	Ground Surface													
0.0	Clayey Silt With Sand, Some Gravel, Very Stiff to Hard (Glacial Till)		1	SS	16	*	102							
			2	SS	40		100							
			3	SS	70		98							
			4	SS	88		96							
			4A	SS	74									
			5	SS	40		94							
94.8			6	SS	28		92							
8.8	Clayey Silt, Very Stiff		7	SS	20		90							
			8	SS	16		88							
			9	SS	18		86							
90.2			10	SS	40									
13.4	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense to Very Dense (Glacial Till)		11	SS	75									
			12	SS	69									
85.0														
18.6	End of Borehole													
	* WL Not Established													

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 678-90-01 (58-58) LOCATION Co-ords: N 4 871 736.0, E 409 367.5 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring and Cone Test COMPILED BY A.L.
 DATUM Geodetic DATE May 12, 1958 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W		
104.1	Ground Surface												
0.0						*							
			1	SS	7								
			2	SS	45								
			3	SS	16								
			4	SS	34								
			5	SS	52								
94.8			6	SS	26								
9.3			7	SS	34								
			8	SS	6								
			9	SS	6								
89.2			10	SS	32								
14.9			11	SS	30								
85.4			12	SS	118								
18.7	End of Borehole												
	* WL Not Established												

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 678-90-01 (58-58) LOCATION Co-ords: N 4 871 708.0, E 409 370.0 ORIGINATED BY H.S.
 DIST 7 HWY 401 BOREHOLE TYPE Washboring COMPILED BY AL
 DATUM Geodetic DATE May 14, 1958 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
103.9	Ground Surface													
0.0	Topsoil													
	Clayey Silt, Some Sand, Some Gravel, Stiff to Hard (Glacial Till)		1	SS	22		102							
			2	SS	33		100							
			3	SS	30		98							
			4	SS	53		96							
94.8			5	SS	26		94							
9.1	Clayey Silt, Stiff to Very Stiff		6	SS	20		92							
			7	SS	9		90							
89.3			8	SS	9									
14.6	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay, Dense (Glacial Till)		9	SS	37									
88.2														
15.7	End of Borehole													

RECORD OF BOREHOLE No 93-1 1 OF 1 METRIC

W.P. 678-90-01 LOCATION Co-ords: N 4 871 709.7, E 409 401.9 ORIGINATED BY D.S.
 DIST 7 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY D.S.
 DATUM Geodetic DATE Aug. 9, 1993 CHECKED BY T.K.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
101.1	Ground Surface												
0.0	Clayey Silt With Sand, Some Gravel, Very Stiff (Glacial Till)	Brown Grey	1	SS	8		100						14 33 31 22
96.7			2	SS	7.5	/23cm							
4.4			3	SS	28		98						
			4	SS	21								
			5	SS	27								
			6	SS	22		96						
	Clayey Silt, Stiff to Very Stiff		7	SS	11		94						
			8	SS	19								
90.7			9	TW	PH		92					20.8	0 0 65 35
10.4			10	SS	12		90						
			11	SS	28								
	Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay Compact to Very Dense (Glacial Till)		12	SS	42		88						22 39 (39)
			13	SS	76	/25cm	86						
			14	SS	80	/5cm	84						14 46 (40)
82.4			15	SS	100	/10cm							
18.7	End of Borehole * WL Not Stabilized												

RECORD OF BOREHOLE No 93-2 1 OF 1 METRIC

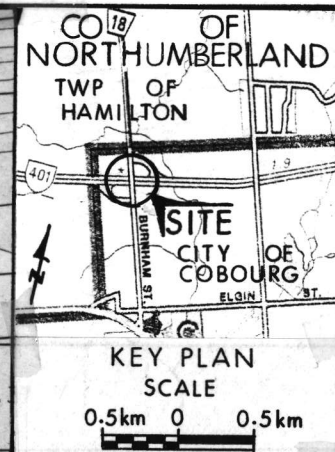
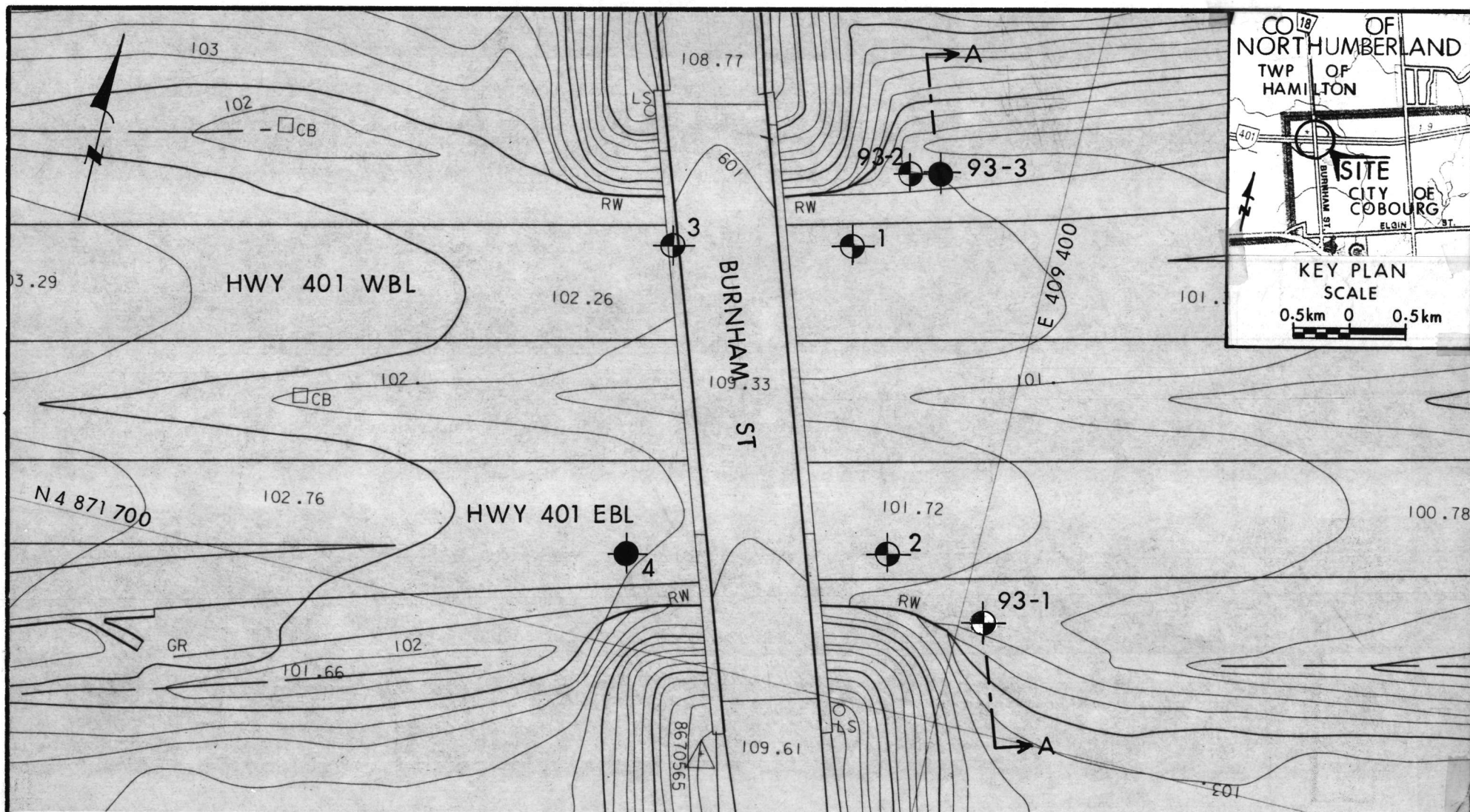
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 DIST 7 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY D.S.
 DATUM Geodetic DATE Aug. 9 and Aug. 10, 1993 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	10 20 30		
101.5	Ground Surface												
0.0			1	SS	8								
			2	SS	12								
			3	SS	19								
			4	SS	14								
			5	SS	9								
			6	SS	10								
			7	SS	10								
94.2			8	SS	7								
7.3			9	TW	PH								
			10	SS	9								
89.8			11	SS	15								
11.7			12	SS	100	/28cm							
			13	SS	84	/23cm							
84.3			14	SS	61	/15cm							
17.2	End of Borehole												
	* WL Not Stabilized												

1 OF 1

W.P. 678-90-01 LOCATION Co-ords: N 4 871 747.7, E 409 388.8 ORIGINATED BY D.S.
DIST 7 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY D.S.
DATUM Geodetic DATE Aug. 13, 1993 CHECKED BY T.K.

+3, x5: Numbers refer to Sensitivity



NOTE

- For Section A-A refer to Dwg-B
- Subsoil information for BH-3, 4 & 93-2 refer to Record of Borehole sheets

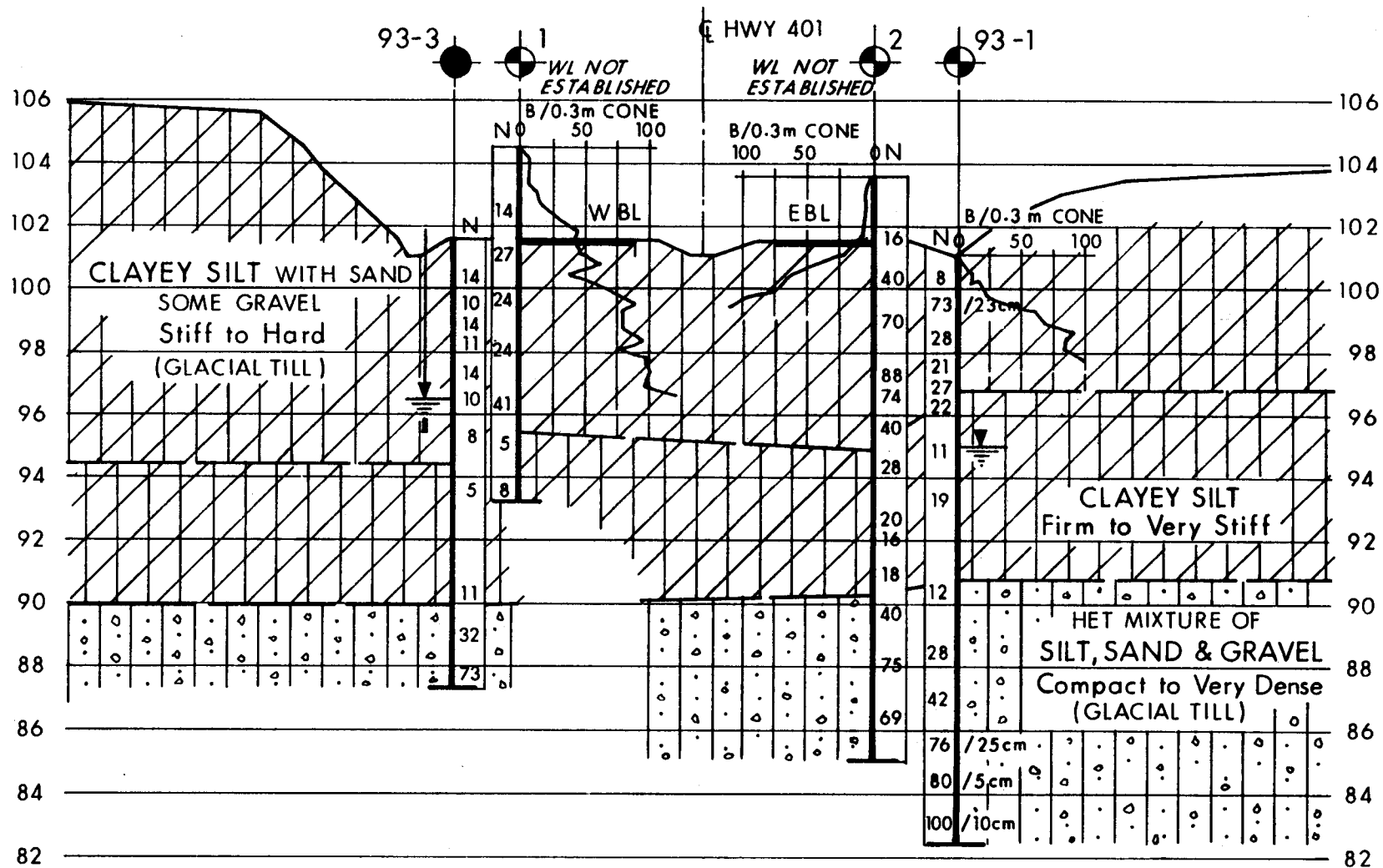
HWY 401/BURNHAM ST (HWY 18)

WP 678-90-01
Dist 7, Hwy 401
Geocres No 30M16-29
Dwg A

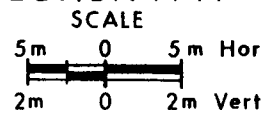
LEGEND

- Borehole
- Borehole & Cone





SECTION A-A



Note:
For Plan refer to Dwg-A

WP 678-90-01
Dist 7, Hwy. 401
Geocres No. 30M16-29
Dwg. B