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DIST. 2 REGION ~~00~~

W.P. No. 40-66-01

CONT. No. 80-77

W. O. No.

STR. SITE No.

HWY. No. 402

LOCATION Feasibility Study

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO 401-186

MEMORANDUM

TO: Mr. I. Ardizone, (2)
Senior Feasibility Planner,
Feasibility Studies Office,
East Building, Downsview.

ATTENTION:

OUR FILE REF.

FROM: Foundations Office,
Design Services Branch,
West Building, Downsview.

DATE: December 6, 1973.

IN REPLY TO DEC 12 1973

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Highway 402 Feasibility Study
County of Middlesex
Twps. of Caradoc and Delaware
District #2, London
W.O. 73-11085 - W.P. 40-66-00

40I14-37
GEOCRES No.

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ao
Attch.
c.c. E. J. Orr
B. R. Davis
A. Rutka
A. Wittenberg
L. E. Walker
B. J. Giroux
J. R. Roy
G. A. Wrong
B. A. Singh
A. P. Watt
Foundations Files
Documents

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FOUNDATION INVESTIGATION REPORT
For
Highway 402 Feasibility Study
County of Middlesex
Twps. of Caradoc and Delaware
District #2 London
W.O. 73-11085 -- W.P. 40-66-00

1. *INTRODUCTION:*

The Foundations Office was requested to carry out a foundation investigation of the alternate routes for Highway 402 between highway 81, north of Strathroy, and Highway 401 southwest of London.

The investigation was requested by Mr. I.Ardizone, Senior Feasibility Planner, Feasibility Studies Office in a memorandum dated October 9th, 1973. Following this request a field investigation was carried out by the Foundations Office to determine the subsoil, and groundwater conditions at various locations along the routes, where structures, cuts, high fill sections or swamp crossings were proposed.

This report contains the results of the field investigation together with our recommendations relating to the foundations, cuts, fills and swamp crossings. Most of this information was contained in a letter sent to the Feasibility Office on November 6th, 1973.

A photo-interpolation report of the selected areas was prepared by Mr. B. S. Mathur, Remote Sensing Engineer, M.T.C., and is included in the Appendix (Drawing 73-11085C).

2. *DESCRIPTION OF THE AREA AND GEOLOGY:*

The area under investigation extends from Highway 81 north of Strathroy to Highway 401 southwest of London for a distance of about 22 miles.

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The area, in general, with the exception of the Thames River valleys, is relatively flat. The ground surface ranges between elevations 670 to 820 feet.

Physiographically, the major portion of the area lies in the region of Caradoc Sand Plain. The plain consists of small clay plains covered with sand or other light textured, water laid deposits. Towards the north end of the area, deep, well drained fine sands are encountered. The entire area is unerlain by glacial till.

3. *FIELD AND LABORATORY INVESTIGATION PROCEDURES:*

The field work consisted of 14 boreholes and 4 dynamic cone penetration tests. The drilling was achieved by a C.M.E. 750 with hollow stem augers and a Penn drill mounted on musked vehicle.

Disturbed samples were obtained by means of standard split spoon samplers driven into the subsoil. The driving energy conformed to the requirements of the Standard Penetration Test (SPT). In the cohesive deposits, where possible, "undisturbed" samples were recovered by means of 2 inch OD Shelby tubes, which were pushed into the soil hydraulically. Where possible, field vane tests were carried out to determine the in-situ undrained shear strength and the sensitivity of the cohesive strata.

Dynamic cone penetration tests were also carried out adjacent to four boreholes (#7, 8, 10 & 11). Driving energy to advance the cones was 350ft lbs. The elevations of the boreholes were determined in the field by personnel from the Southwestern Region Engineering Surveys Office. The exact boring locations were not determined due to the lack of pre-engineering surveying in this area. All field and laboratory test results are recorded on the borelog sheets contained in the Appendix.

Soil samples were examined in the field and again upon arrival in the laboratory. Laboratory tests were carried

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out on representative samples to determine the following physical characteristics:

Natural Moisture Content
Atterberg Limits
Grain-Size Distribution
Bulk Density
Organic Content
Undrained Shear Strength
Effective Stress Parameters

Groundwater levels at the site were determined by recording the levels over the duration of the field work. The locations and elevations of the boreholes as well as a summary of the subsoil are plotted on Drawing 73-11085 A & B attached at the end of this report.

Included in the Appendix are typical grain-size curves (Fig. #1 to 4), two plasticity charts (Fig. #5 and 6) and three effective stress failure circle diagrams (Fig. #7 to 9). The three consolidated undrained triaxial tests with pore pressure measurements gave the following effective stress parameters.

$C' = 0$ $\qquad\qquad$ $\phi' = 28° - 30°$

4. *SITE DESCRIPTION, SUBSOIL CONDITIONS AND RECOMMENDATIONS:*

4.1) *General:*

In the following subsections, each site is considered individually. For each site a description of the site, subsoil conditions in brief, and recommendations are given. The sites are presented generally for north to south.

For preliminary design or estimate purposes the following assumptions may be made:

1. Allowable bearing capacity for spread footings.
   -- 2 tons/square foot
2. Allowable bearing capacity for friction piles.
   -- 25 tons/pile

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3. Allowable bearing capacity for end bearing steel piles.
   -- maximum allowable for section chosen
4. Granular blanket is 18 inches in thickness.

4.2) Route 'D' and County Road 39 (Borehole #11)

Site

The borehole was put down in the middle of a low lying swamp on the north-west side of Middlesex County Road 39. The swamp is about 1,000 feet by 1,500 feet and is surrounded by a 20 foot high ridge on the north side. The county road crosses this swamp and is about 8feet higher than the surrounding area.

Subsoil (Ground elevation 746.0 feet)

0 - 6 feet	Muck and highly organic silt, very soft
6 - 17 feet	Fine sand traces of silt, very loose to compact
17 - 26 feet	Silty sand, compact to very dense

Water level was at ground surface.

Recommendations

If it is decided to carry the proposed Hwy 402 over County Road 39, all organics for the entire width and length (approximately 1,500 feet) of the embankment crossing the swamp should be excavated and replaced with granular material. If the embankment is built with 2:1 side slopes it should be stable. The proposed structure may be supported on spread footings placed within the approach fills, or on short piles driven through the fill to about 30 feet below the present swamp level.

The same recommendations are applicable, if the County Road is raised and is carried over the proposed Hwy 402. All organics under the alignment of Hwy 402 should be removed in any case.

If it is decided to depress either the proposed Hwy 402 or the County Road at this location, then a permanent dewatering scheme will be required and all cut slopes will

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have to be covered with granular blankets. This is necessary because of the relatively high groundwater level and the permeable nature of the subsoil.

4.3) Route 'H' & Sydenham River (Borehole #10)

Site

The borehole was put down on the west side of the Sydenham River. Immediately to the east of the river, the land rises at about 2:1 or steeper slopes to approximately 30 feet above the river. On the west side the land rises very gradually. The river at the time of the investigation was 2-3 feet deep and about 15 feet wide.

Subsoil (Ground elevation 747.3 feet)

0 - 22 feet	Fine sand, traces of silt and clay, loose
22 - 25 feet	Fine sand, compact
25 - 56 feet	Silt, traces of clay and sand, dense to very dense
56 - 114 feet	Clayey silt, very stiff to hard

Water level was 4 feet below the ground surface.

Recommendations

No hard,end bearing stratum was encountered to a depth of 114 feet below the ground, where the borehole was terminated. The upper 22 feet of the subsoil is not suitable for spread footings. If a structure is required it may be supported on:

1. spread footings within the approach fills
or 2. timber piles driven 40 feet into the original ground
or 3. long end bearing steel piles (more than 120 feet long)

4.4) Route 'H' and Concession VI (Borehole #8)

Site

This borehole was located about 1/4 mile south of

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Concession VI. This area is well treed and overgrown with a very dense growth of underbrush. This bush extends for about 3 miles and is about 1/2 mile wide where the proposed route crosses it. The general area is relatively flat.

Subsoil (Ground elevation 786.0 feet)

0 - 1	feet	Organic topsoil
1 - 7.5	feet	Sand, some silt, compact
7.5 - 8	feet	Clayey silt
8 - 23	feet	Fine sand, compact

Water level was 3.5 feet below the ground surface.

Recommendations

No stability problems are anticipated for an embankment crossing this area, provided all organic soil is removed.

4.5) Route 'D' & Hwy 81 (Borehole #9)

Site

The borehole was placed on the west shoulder of Hwy 81. The surrounding area is flat to gently rolling and is cultivated.

Subsoil (Ground elevation 800.6 feet)

0 - 5 feet	Fine sand, fill
5 - 10 feet	Silt, traces of sand, compact
10 - 25 feet	Silt, very dense
25 - 28 feet	Fine sand, very dense
28 - 30 feet	Coarse sand, traces of gravel

Water level is estimated to be at 6 feet below the ground surface.

Recommendations

The proposed structure may be supported on spread footing type foundations, founded in the original ground. A dewatering scheme will be necessary to pour the concrete in the dry, and because the subsoil is likely to 'boil' under

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an unbalanced hydrostatic head.

No stability problems are foreseen for fills or cuts with 2:1 side or forward slopes. However, if it is decided to depress either the highway or the freeway, then the cuts must be blanketed with granular material and a permanent dewatering and drainage scheme will be required.

4.6) Route 'H' & County Road 14 and CNR Tracks(Borehole #7)

Site

The borehole was put down on the south (or east) shoulder of the County Road 14.

Subsoil (Ground elevation 813.8 feet)

0 - 15 feet	Sand, traces of clay and silt, loose
15 - 30 feet	Sand, dense to very dense
30 - 77 feet	Silt, with clay, compact to dense
77 - 85 feet	Sand, some silt and clay, very dense
85 - 131 feet	Silt, traces of clay and sand, dense to very dense

Water level was 7 feet below the ground surface.

Recommendations

The proposed overpass or over head structure may be supported on either of the following:

1. spread footings in the fill
2. spread footings 15 feet below the ground surface
3. perched abutments supported on friction files driven through the fill and about 40 feet into the original ground.

No stability problems are foreseen for 2:1 forward and side slopes.

The proposed underpass or subway structure may be supported on spread footings founded in the original ground.

No stability problems are foreseen for 2:1 cut slopes. A granular blanket and a permanent drainage scheme

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will be required for cuts below the groundwater level.

4.7) Route 'M' & Hwy 81 (Borehole #14)

Site

The borehole was put down on the north shoulder of Hwy 81 and west of the Thames River valley.

Subsoil (Ground elevation 762.5 feet)

0 - 13 feet	Sand, traces of silt and gravel, loose to compact.
13 - 30 feet	Clayey silt to silt, stiff to very stiff
30 - 47 feet	Clayey silt to silt(layered), stiff to very stiff
47 - 54 feet	Sand, some silt, dense
54 - 90 feet	Clayey silt to silt(Layered), stiff to very stiff
90 - 119 feet	Till, hard (very dense)

Water level was 9 feet below the ground surface.

Recommendations

It is proposed to depress the freeway Route 'M' under Hwy 81 at this place. The underpass structure may be supported on spread footings placed in the original ground or on end bearing steel piles driven to about 120 feet below the present ground level.

No stability problems are anticipated for 2:1 side slopes of the cut sections. It is felt that the cut sections may lower the groundwater level below the sand layer. However, if the water level cannot be sufficiently lowered, or if numerous silt seams are encountered in the clayey silt deposit, then it may be necessary to provide a granular blanket and a permanent drainage scheme.

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4.8) *Route 'M' & Thames River Flood Plain(Borehole #13)*

Site

The borehole was put down about 600 feet south of Hwy 2 in the Thames River Flood Plain.

Subsoil *(Ground elevation 682.0 feet)*

0 - 13 feet	Silty sand to sand, loose to very loose
13 - 60 feet	Clayey silt, traces of sand and gravel, very stiff
60 - 80 feet	Till, hard (very dense)

Water level was 6 feet below the ground surface.

Recommendations

It is proposed to cross the Thames River Flood Plain by constructing an embankment across it. The subsoil appears to be competent to support fills, up to 30 feet in height and with 2:1 side slopes. The upper 13 feet of subsoil is loose to very loose, fine sand which should compact under the weight of fills.

4.9) *Route 'L' & 'M' & Thames River (Borehole #2)*

Site

The borehole was put down on top of the east bank of the Thames River. At this location, Route "L" splits off from Route 'M' after Route 'M' has crossed the Thames River Flood Plain. The east bank is about 50-60 feet high, and the natural slopes are 2:1 or steeper.

Subsoil *(Ground elevation 724.5 feet)*

0 - 7 feet	Sand, compact
7 - 32 feet	Clayey silt to silty clay, very stiff
32 - 47 feet	Silt some clay (layered), compact
47 - 56 feet	Silty clay, very stiff
56 - 70 feet	Till, hard (very dense)

Water level was 42 feet below the ground surface.

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Recommendations

The proposed structure at this location would probably require cuts on the east bank and fills on the west bank.

The entire structure may be supported on end bearing steel piles driven into the till layer to approximate elevations 640-650 feet. As an alternative, the east abutment may be founded on spread footings in the original ground, and the west abutment may be founded on spread footings placed within the approach fills.

No stability problems are foreseen for 2:1 forward and side slopes.

4.10) *Route 'M' & Thames River Banks (Borehole #3)*

Site

This borehole was put down on top of the east bank of the Thames River, which meanders at this location. East of the borehole, the land is used for farming, and because of drainage tiles the upper portion of the bank is always in a wet condition.

Subsoil (Ground elevation 721.6 feet)

0 - 4 feet	Sand some gravel, traces of silt
4 - 53 feet	Clayey silt(with silt layers), stiff to very stiff
53 - 57 feet	Till, hard (very dense)

Water level was 25 feet below the ground surface.

Recommendations

At this site, the proposed Route 'M' runs along the river bank, which is about 50 feet high, and may require a cut. No major stability problems are anticipated for the bank or for 2:1 cut slopes. However, because of the high surface water level and the presence of silt layers, the cut slopes may have to be covered with a granular blanket.

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4.11) *Route 'M' & Sharon Creek (Borehole #15)*

Site

The borehole was put down on top of the east bank of Sharon Creek which is about 60 feet deep at this place.

Subsoil (Ground elevation 747.1 feet)

0 - 4 feet	Sand
4 - 18 feet	Clayey silt(with silt layers), very stiff
18 - 24 feet	Silt, some sand and clay, loose
24 - 61 feet	Clayey silt to silt, stiff
61 - 112 feet	Clayey silt, traces of sand and gravel, hard
112 - 131 feet	Till, hard (very dense)

Water level was 17 feet below ground surface.

Recommendations

The proposed structure may be supported on:

1. spread footings founded in the original ground
2. friction piles
3. end bearing steel piles driven into the hard (very dense) till layer (about 120 feet below the ground surface)

No stability problems are foreseen with 2:1 forward and side slopes of the fill or cut sections.

4.12) *Route 'P', 'S' & 'T' and Sharon Creek(Borehole #6)*

Site

The borehole was put down on the shoulder of a township road and on the floor of the Sharon Creek valley. The road crosses Sharon Creek immediately south of this location. The valley is about 60 feet deep.

Subsoil (Ground elevation 682.5 feet)

0 - 8 feet	Sand, some gravel traces of silt, compact
8 - 73 feet	Clayey silt, some sand, very stiff
73 - 76 feet	Till, hard (very dense)

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Artesian water was encountered at 73 feet and rose to the ground surface.

Recommendations

If it is decided to cross the Sharon Creek at this place, an embankment will be required.

No stability problems are foreseen for the embankment with 2:1 forward and side slopes. If a structure is required it may be supported on spread footings placed in the compacted fill embankment or on friction piles driven through the fill to about 50 feet below the existing ground level.

4.13) *Route 'P' & Thames River (Borehole #4 & #5)*

Site

At this location Route 'P' crosses the Thames River in a broad valley some 2,000 feet wide. Boreholes #4 & #5 were put down on the west side of the Thames River. Borehole #4 was located in the valley floor and Borehole #5 was located on top of the valley.

Subsoil *(Ground elevation 678.9 feet)*
Borehole #4

0 - 18 feet	Silty sand to sandy silt, some clay, very loose
18 - 30 feet	Clayey silt, traces of sand and gravel, very stiff
30 - 46 feet	Till, hard (Very dense)

Water level was 11 feet below the ground surface.

(Ground elevation 742.6 feet)
Borehole #5

0 - 17 feet	Clayey silt to silty clay, very stiff
17 - 95 feet	Silty clay (with silt layers), stiff to very stiff
95 - 108 feet	Till, hard (very dense)

Water level was 22 feet below the ground surface.

Recommendations

The proposed structure may be supported on end bearing steel piles driven about 10 feet into the hard (very dense) till layer. No problems are anticipated for cuts through the banks and fills through the valley floor, provided 2:1 slopes are used.

4.14) *Route 'R' Thames River (Borehole #12)*

Site

This borehole was put down on the west side of the Thames River on the flood plain. The west bank of the valley is gradually sloping, but the east bank is relatively steep (about 2:1).

Subsoil (Ground elevation 678.2 feet)

0 - 9 feet	Clayey silt, stiff to very stiff
9 - 13 feet	Sand, compact
13 - 31 feet	Till, hard (very dense)

Recommendations

The proposed structure may be supported on end bearing steel piles driven about 10 feet into the hard (very dense) till deposit, some 25 feet below the surface.

No stability problems are foreseen for fills and cuts with 2:1 forward and side slopes.

5. *CONCLUSION:*

Our field investigation indicated that all investigated sites are feasible from foundation point of view. No major foundation problems are foreseen along any route which will render it unsuitable. The lengths of various structures are not dependent upon foundation requirements but will be governed by geometric or hydrological constraints.

Route 'J' was not investigated because permission to enter the property could not be obtained.

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6. *MISCELLANEOUS:*

The field work was carried out from October 15th to November 6th, 1973 under the direction of Mr. P. Korgemagi and Mr. L. J. Hodge, Project Foundations Engineers. The entire project was under the supervision of Mr. A. Prakash, Senior Foundations Engineer.

The equipment used was owned and operated by Dominion Soils Investigation Ltd., Toronto and P.V.K. and Sons Ltd., Burford.

This report was prepared by Mr. P. Korgemagi and reviewed by Mr. A. Prakash.

P. Korgemagi, P. Eng.,

A. Prakash, P. Eng.,

PK/ji
December 5, 1973.

APPENDIX I

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 2

JOB 73-11085 LOCATION Routes L & M & Thames River ORIGINATED BY PK

W.P. 40-66-00 BORING DATE October 15, 1973 COMPILED BY WJA

DATUM Geodetic BOREHOLE TYPE Hollow stem auger CHECKED BY [signature]

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	REMARKS GR.SA.SI.CL.
724.5	Ground Level					
0.0	Sand some gravel, traces of silt Brown, compact				720	
717.5		1	SS	11		14 79 (7)
7.0	Silty clay to clayey silt Firm to very stiff Grey-brown	2	SS	6		
		3	SS	11	710	
		4	SS	11		
		5	SS	15	700	
692.5		6	SS	17		
32.0	Silt some layered clay Compact Grey-brown	7	SS	20	690	
		8	SS	15		▼682.5
677.5		9	SS	13	680	
47.0	Silty clay Stiff Brown	10	SS	12		
668.5					670	
56.0	Heterogeneous Mixture of clayey silt, sand and gravel(till) Very stiff	11	SS	22		
	V. Stiff / Hard (Compact - very dense)				660	
654.7		12	SS	100/4"		30 31 29 10
69.8	End of Borehole					

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE

LIQUID LIMIT W_L; PLASTIC LIMIT W_P; WATER CONTENT W — WATER CONTENT % (10, 20, 30)

BULK DENSITY γ P.C.F.

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE № 2A

JOB 73-11085
LOCATION Routes L & M and Thames River
ORIGINATED BY PK

W.P. 40-66-00
BORING DATE October 16th, 1973
COMPILED BY WJA

DATUM Geodetic
BOREHOLE TYPE Hollow Stem Auger
CHECKED BY [signature]

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.	WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
724.5	Ground Level								
0.0	Sand some gravel traces of silt Compact				720				
717.0 / 7.5	Silty clay to clayey silt Firm to very stiff	1	TW	PH		2240 > +			
					710				
		2	TW	PH		2240 > +		124	0 0 49 51
					700				
692.5		3	TW	PH		2240 > +		129	Ø' = 28° C' = 0
32.0	Silt some clay layered Compact				690				
		4	TW	PH		2240 > +			0 1 84 15 ▼ 682.5
677.5					680				
47.0	Silty clay Stiff	5	TW	PH		S=3.2 +			
671.5 / 53.0	End of Borehole								

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE (scale 400 800 1200 1600 2000)

LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W (scale 10 20 30)

15 / 20 / 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 3

JOB 73-11085 | LOCATION Route 'M' and Thames River | ORIGINATED BY PK

W.P. 40-66-00 | BORING DATE October 16th, 1973 | COMPILED BY WJA

DATUM: Geodetic | BOREHOLE TYPE Hollow Stem Auger | CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.	WATER CONTENT %	REMARKS GR.SA.SI.CL
721.6	Ground Level								
0.0 / 717.6	Sand some gravel, traces of silt					720			
4.0	Silty clay with silt layers Stiff to very stiff		1	SS	17				
			2	SS	8	710	2240 > +		0 0 49 51
			3	TW	PH		2240 > +		
			4	SS	12	700			
			5	TW	PH				▼ 696.6 Ø'=275° C'=0
			6	SS	10	690	2240 > +		
			7	TW	PH				0 0 36 64
			8	TW	PH	680	2240 > +		
			9	SS	13				
668.6			10	SS	15	670			
53.0 / 664.3	Het. Mix. of clay silt, sand&gravel (till) Hard(v.dense)		11	SS	100/3"				5 27 54 14
57.3	End of Borehole								

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 400 800 1200 1600 2000

LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; W_P — W — W_L; WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.

20 / 15 ✧ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 4

JOB 73-11085 | LOCATION Routes 'P' and Thames River | ORIGINATED BY PK
W.P. 40-66-00 | BORING DATE October 23rd, 1973 | COMPILED BY WJA
DATUM: Geodetic | BOREHOLE TYPE Hollow Stem Auger | CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	WATER CONTENT %	REMARKS GR.SA.SI.CL.
678.9	Ground Level						
0.0	Top Soil						
1.0	Silty sand to sandy silt. Some clay traces of gravel. Very loose - Compact	1	SS	6			
		2	SS	2	670		0 50 38 12 ▼ 667.9
		3	AS				
661.9		4	SS	12			8 27 43 22
17.0	Clayey silt, traces of sand and gravel. Very Stiff	5	SS	17	660		
655.4	Grey. Hard	6	SS	100/0"			
23.5	End of Borehole. Probable limestone boulder						

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W
WATER CONTENT % 10 20 30
BULK DENSITY γ P.C.F.

15 20 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 4A

JOB 73-11085 | LOCATION Routes 'P' and Thames River | ORIGINATED BY PK

W.P. 40-66-00 | BORING DATE October 23, 24, 1973 | COMPILED BY WJA

DATUM Geodetic | BOREHOLE TYPE Hollow Stem Auger | CHECKED BY [signature]

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FOOT	ELEV. SCALE	WATER CONTENT % (Wp — W — WL)	REMARKS GR.SA.SI.CL
678.9	Ground Level						
0.0	Top Soil						
1.0	Silty sand to sandy silt, brown. Some clay, traces of gravel. Very loose				670		
		1	SS	3			▼667.9
660.9 / 18.0	Clayey silt. Traces of gravel and sand, grey. Very Stiff				660		
		2	SS	18		O————	
		3	SS	20			
649.4 / 29.5	Het. Mix. of silt, sand, Gravel and Clay (till). Boulders. Grey. Very ~~Stiff~~ Hard (Very dense)				650		
		4	SS	26		O ———	6 28 46 20
		5	SS	100/7"			
					640		
		6	SS	100/7"		O	20 36 33 11
632.9		7	SS	99			
46.0	End of Borehole						

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT ———

SHEAR STRENGTH P.S.F.: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.

15 ◇ 5 (20 / 10) % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 5

JOB	73-11085	LOCATION	Route 'P' and Thames River	ORIGINATED BY	PK
W.P.	40-66-00	BORING DATE	October 22nd, 1973	COMPILED BY	WJA
DATUM	Geodetic	BOREHOLE TYPE	Hollow Stem Auger	CHECKED BY	[signature]

SOIL PROFILE: ELEV. / DEPTH; DESCRIPTION; STRAT. PLOT. SAMPLES: NUMBER; TYPE; BLOWS/FOOT. ELEV. SCALE. DYNAMIC PENETRATION RESISTANCE: BLOWS / FOOT. SHEAR STRENGTH P.S.F.: o UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE; 400 800 1200 1600 2000. LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; W_P — W — W_L; WATER CONTENT %: 10 20 30. BULK DENSITY γ P.C.F. REMARKS: GR. SA. SI. CL.

ELEV. / DEPTH	DESCRIPTION
742.6	Ground Level
0.0	Clayey silt to silty clay Brown Very stiff
725.6 17.0	Silty clay Traces of sand with silt layers Stiff to very stiff Hard
647.6 95.0	Het. Mix. of clay, silt, gravel and sand (Till) Hard (Very dense)

NUMBER	TYPE	BLOWS/FOOT	SHEAR STRENGTH P.S.F.	BULK DENSITY P.C.F.	REMARKS (GR. SA. SI. CL.)
1	SS	19			
2	SS	13			
3	SS	16			0 0 62 38
4	SS	9			▼ 720.6
			> + 2240		
5	SS	11			
6	TW	PH	2240	124	Ø' = 31° C' = 0
			> +		
7	SS	14			
8	SS	15			0 2 56 42
9	SS	18			
10	SS	14			
			> + 2240		
11	TW	PH			
12	SS	19			
13	SS	18			
14	SS	62			2 11 49 38
15	SS	100/7"			16 40 29 15

ELEV. SCALE: 740, 730, 720, 710, 700, 690, 680, 670, 660, 650, 640

15 20 5 10 % STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 5 Continued

JOB 73-11085
W.P. 40-66-00
DATUM Geodetic

LOCATION Route 'P' and Thames River
BORING DATE October 23rd, 1973
BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY PK
COMPILED BY WJA
CHECKED BY [signature]

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
638.6										
104.0	Het.Mix. of clay, silt, gravel & sand (Till) Hard(V.dense)		16	SS	100/4"					
634.3 108.3	End of Borehole									
						630				

OFFICE REPORT ON SOIL EXPLORATION

15 20 5 10 % STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 6

JOB 73-11085 | LOCATION Routes 'P' & 'S' and Sharon Creek | ORIGINATED BY PK
W.P. 40-66-00 | BORING DATE October 17th and 18th, 1973 | COMPILED BY WJA
DATUM Geodetic | BOREHOLE TYPE Hollow Stem Auger | CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	REMARKS (GR. SA. SI. CL.)
682.5	Ground Level					Artesian Head
0.0	Sand some gravel and silt. Compact, brown	1	SS	16	680	
675.0 / 7.5	Clayey silt some sand, traces of gravel. Grey. Very stiff	2	SS	19	670	
		3	SS	22		
		4	SS	20	660	
		5	SS	19		3 13 48 36
		6	SS	18	650	
		7	SS	17		
		8	SS	16	640	
		9	SS	22	630	
		10	SS	29	620	
618.5 / 64.0	Heterogeneous Mixture of silt, sand, gravel and clay (Till). Hard (very dense)	11	SS	40	610	19 26 38 17
						Encountered ▽609.5
607.0 / 75.5	End of Borehole	12	SS	100/6"		

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F. — O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE
LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; WATER CONTENT % 10 20 30
BULK DENSITY γ P.C.F.

15 20 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE № 7

JOB 73-11085 | LOCATION Route 'H' and County Road 14 | ORIGINATED BY PK

W.P. 40-66-00 | BORING DATE October 29th and 30th, 1973 | COMPILED BY PK

DATUM Geodetic | BOREHOLE TYPE Hollow Stem Auger and Cone Test | CHECKED BY [signature]

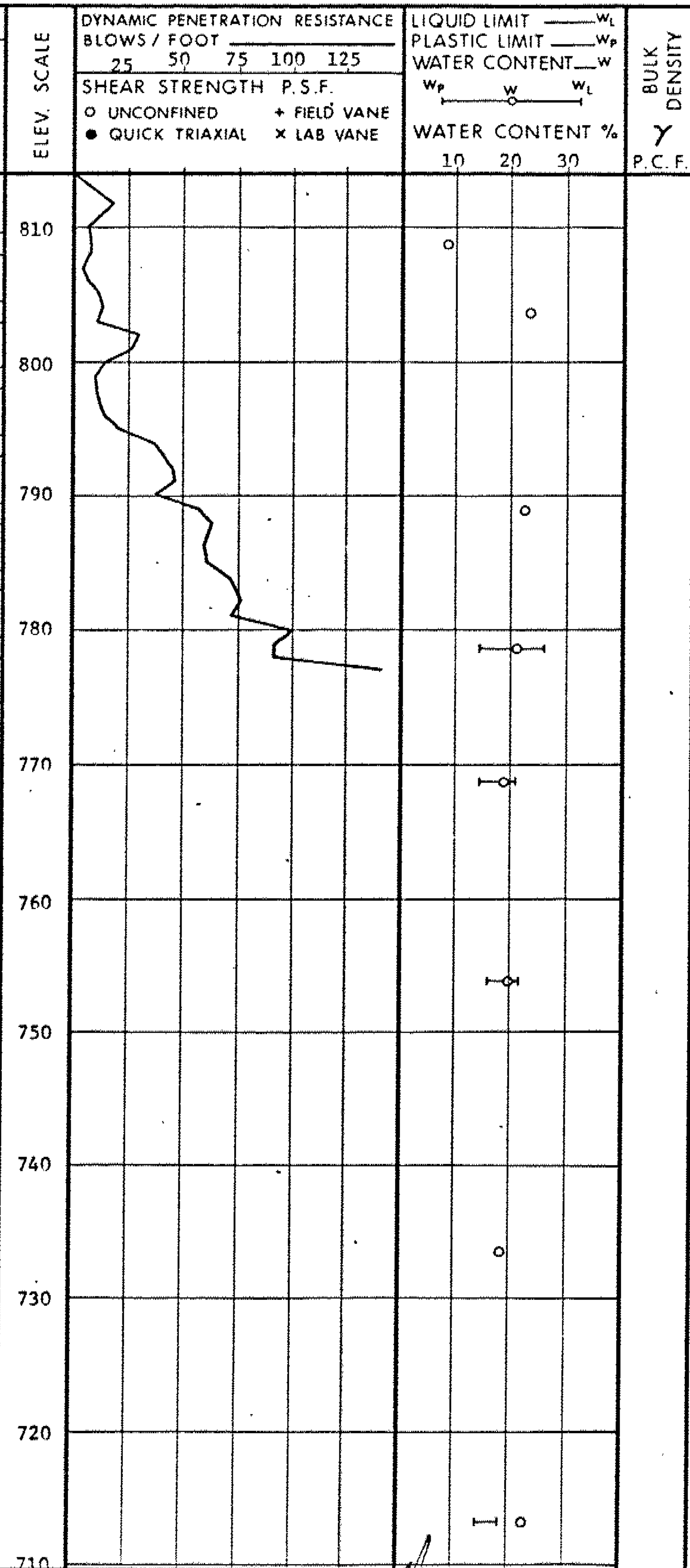
Soil Profile

ELEV. / DEPTH	DESCRIPTION
813.8	Ground Level
0.0 – 783.8	Sand traces of clay and silt Brown Loose to dense
30.0 – 736.8	Silt with clay traces of sand. Greyish brown Compact to dense
77.0 – 728.8	Sand some silt and clay Very dense
85.0	Silt traces of clay and sand Dense

Samples

NUMBER	TYPE	BLOWS/FOOT	REMARKS GR.SA.SI.CL
1	SS	8	0 87 (13)
2	SS	9	
3	SS	38	0 88 (12)
4	SS	56	
5	SS	49	
6	SS	35	
7	SS	21	
8	SS	17	0 3 76 21
9	SS	18	
10	SS	35	0 0 67 33
11	SS	25	
12	SS	23	
13	SS	50	0 67 (33)
14	SS	43	
15	SS	27	

Water level: 806.8



15 20 5 10 % STRAIN AT FAILURE

Continued

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 7 Continued

JOB 73-11085 LOCATION Route 'H' and County Road 14 ORIGINATED BY PK

W.P. 40-66-00 BORING DATE October 29th and 30th, 1973 COMPILED BY PK

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger and Cone Test CHECKED BY [signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT — W_L PLASTIC LIMIT — W_P WATER CONTENT — W; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
709.8	Continued									
104.0	Silt traces of clay and sand Very dense									
						700				
			16	SS	154					0 3 91 6
						690				
682.8			17	SS	58			o		
131.0	End of Borehole									

20
15 ✧ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

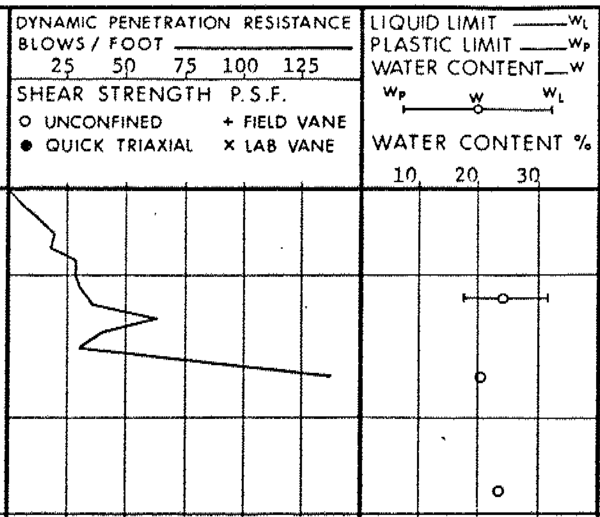
RECORD OF BOREHOLE № 8

JOB 73-11085 — LOCATION Route 'H' and Concession V — ORIGINATED BY PK

W.P. 40-66-00 — BORING DATE November 6th, 1973 — COMPILED BY PK

DATUM Geodetic — BOREHOLE TYPE Auger and Cone Test — CHECKED BY [illegible]

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	REMARKS GR.SA.SI.CL.
786.0	Ground Level					
0.0	Top Soil					
1.0	Sand some silt and clay	1	SS	11		0 ▼ 47 (53) 782.5
778.5	Compact				780	
7.5	Clayey silt	2	SS	13		
7.9	Sand traces of clay and silt	3	SS	18		
	Compact				770	
		4	SS	12		0 94 (6)
763.5		5	AS	–		
22.5	End of Borehole					



20 15 ◇ 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 9

JOB 73-11085 | LOCATION Route 'D' and Highway 81 | ORIGINATED BY LJH
W.P. 40-66-00 | BORING DATE October 31st, 1973 | COMPILED BY PK
DATUM Geodetic | BOREHOLE TYPE Auger | CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % (10, 20, 30)	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
800.6	Ground Level									
0.0	Sand (Fill) Compact					800				
795.6 / 5.0	Silt, traces of clay and sand; compact / very dense		1	SS	14			○ (~21)		0 3 90 7; ▼ 794.8
			2	SS	82	790				
			3	SS	176			○ (~19)		
	Compact to very dense		4	SS	177	780				0 1 98 1
775.6 / 25.0	Sand; Very dense; Traces of gravel									
770.6 / 30.0	End of Borehole									

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

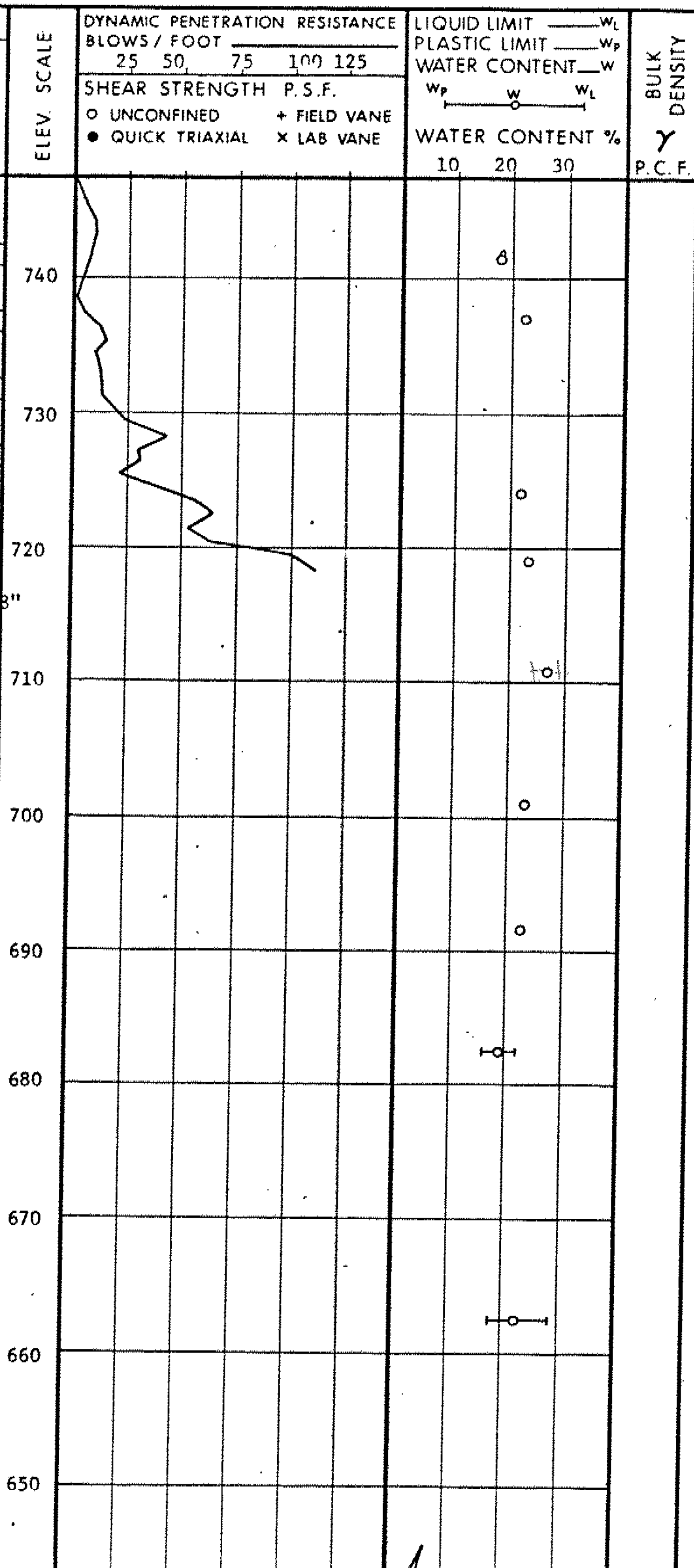
RECORD OF BOREHOLE Nº 10

JOB 73-11085 LOCATION Route 'H' and Sydenham River ORIGINATED BY LJH

W.P. 40-66-00 BORING DATE November 2nd and 5th, 1973 COMPILED BY PK

DATUM Geodetic BOREHOLE TYPE Auger and Cone Test CHECKED BY [signature]

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	REMARKS GR.SA.SI.CL.
747.3	Ground Level				
0.0					▼ 742.8
	very loose	1	SS	3	
	Fine sand traces of silt and clay	2	SS	8	
		3	SS	6	0 94 (6)
	Compact	4	SS	10	
722.3		5	SS	19	0 93 (7)
25.0		6	SS	39	0 7 88 5
		7	SS	100/3"	
	Silt traces of clay and sand	8	SS	67	
	Dense to very dense	9	SS	57	0 2 94 4
		10	SS	67	
690.8		11	SS	25	
56.5					
	Clayey silt	12	SS	27	
		13	SS	38	0 0 66 34
	Very stiff to hard	14	SS	15	
		15	SS	26	



20 15 ◇ 5 10 % STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 10 Continued

JOB 73-11085 — LOCATION Route 'H' and Sydenham River — ORIGINATED BY LJH

W.P. 40-66-00 — BORING DATE November 2nd and 5th, 1973 — COMPILED BY PK

DATUM Geodetic — BOREHOLE TYPE Auger and Cone Test — CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W — WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
643.3	Continued									
104.0	Clayey silt traces of sand Very stiff to hard		16	SS	16	640		W_P–W–W_L (approx. 25–37)		
631.8			17	SS	27					0 4 56 40
115.5	End of Borehole									

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

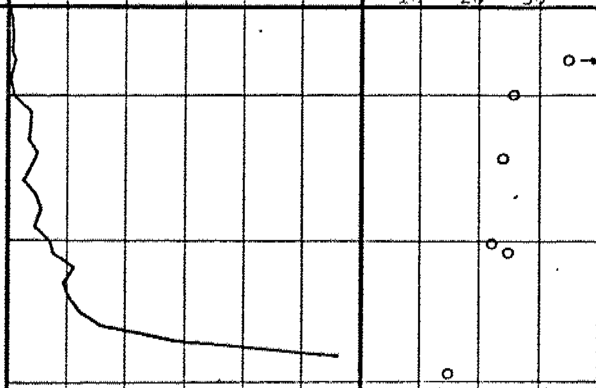
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE № 11

JOB 73-11085	LOCATION Route 'D' and County Road 39		ORIGINATED BY LJH
W.P. 40-66-00	BORING DATE October 31st to November 1st, 1973		COMPILED BY PK
DATUM Geodetic	BOREHOLE TYPE Auger and Cone Test		CHECKED BY [signature]

SOIL PROFILE		SAMPLES							
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (25 50 75 100 125); SHEAR STRENGTH P.S.F. (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % (10 20 30)	BULK DENSITY γ P.C.F.	REMARKS GR SA. SI. CL.
746.0	Ground Level									746.0
0.0	Peat (organics) Very soft		1	SS	0				656%	Org. 47.7%
740.8 / 5.2	Silt		2	SS	5	740				Org. 3.5% Org. 1.2%
5.5	Sand traces of silt and gravel									0 83 17
			3	SS	1					
	Very loose to compact									
729.0			4	SS	11	730				5 87 (8)
17.0	Silty sand									
	Compact to very dense		5	SS	26					0 51 (49)
719.5			6	SS	95	720				
26.5	End of Borehole									



20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 12

JOB 73-11085
W.P. 40-66-00
DATUM Geodetic

LOCATION Routes 'R' and Thames River
BORING DATE October 22nd, 1973
BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY PK
COMPILED BY WJA
CHECKED BY [signature]

SOIL PROFILE: ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % (10 20 30)	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
678.2	Ground Level									
0.0	Clayey silt, traces of sand Stiff Brown		1	SS	13	670				
669.2 9.0	Sand, some silt traces gravel, brown, loose		2	SS	9					9 53 38
666.2 12.0	Silt with sand traces of clay and gravel Very dense Grey		3	SS	163/9"					▽ 664.2 1 35 60 4
			4	SS	100/2"	660				
			5	SS	151					4 28 60 8
646.9			6	SS	100/10"	650				
31.3	End of Borehole									

20
15 ✧ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 13

JOB 73-11085 — LOCATION Route 'M' and Thames River Flood Plain — ORIGINATED BY PK

W.P. 40-66-00 — BORING DATE October 26th, 1973 — COMPILED BY WJA

DATUM Geodetic — BOREHOLE TYPE Hollow Stem Auger — CHECKED BY [signature]

SOIL PROFILE

ELEV. / DEPTH	DESCRIPTION
682.0	Ground Level
0.0	Silty sand traces of clay. Brown, loose
672.0 / 10.0	Sand traces of silt clay & organics very loose
669.0 / 13.0	Clayey silt, traces of sand and gravel. Grey, firm to very stiff
622.3 / 59.7	Heterogeneous Mixture of sand, silt, clay, and gravel (Till). Hard (very dense)
601.8 / 80.2	End of Borehole

SAMPLES

NUMBER	TYPE	BLOWS/FOOT	SHEAR STRENGTH P.S.F.	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
1	SS	6			▼ 676.5
2	SS	1		o	0 82 18
3	SS	7	2240		
4	TW	PH		138	8 24 47 21
5	SS	25			
6	SS	22			
7	SS	25			
8	SS	21			0 10 50 40
9	SS	25			
10	SS	16			
11	SS	51			5 25 40 30
12	SS	102			
13	SS	100/8"			16 29 35 20

ELEV. SCALE: 680, 670, 660, 650, 640, 630, 620, 610

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE — 400 800 1200 1600 2000

LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W — WATER CONTENT % 10 20 30

15 20 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 14

JOB 73-11085 LOCATION Routes 'M' and Highway 81 ORIGINATED BY PK

W.P. 40-66-00 BORING DATE October 24th, 1973 COMPILED BY WJA

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger and Cone Test CHECKED BY

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	SHEAR STRENGTH P.S.F.	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
762.5	Ground Level						
0.0	Sand traces of silt and gravel Brown Grey Loose to grey Dense	1	SS	5			0 89 11
							▼753.4
		2	SS	32			
749.5 / 13.0	Clayey silt to silt Stiff-very stiff Layered	3	SS	24			0 5 60 35
		4	SS	16			
		5	TW	PH	2240	129	0 0 84 16
		6	SS	10	2240		
		7	TW	PH			
		8	SS	PH			
		9	TW	PH			
715.0 / 47.5	Fine sand some silt Dense	10	AS				
		11	SS	38			
709.0 / 53.5	Layered Clayey silt to silt Grey-brown Stiff-very stiff	12	SS	15			
		13	SS	12			0 4 57 39
		14	SS	14			
		15	SS	21			
672.5 / 90.0	Silt traces of clay Grey, compact	16	SS	23			0 0 90 10

ELEV. SCALE: 760, 750, 740, 730, 720, 710, 700, 690, 680, 670, 660

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 400 800 1200 1600 2000

LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W — WATER CONTENT % 10 20 30

15 20 5 10 % STRAIN AT FAILURE

Continued

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

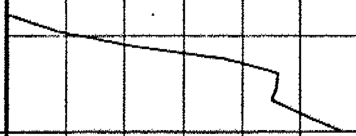
RECORD OF BOREHOLE Nº 14 Continued

JOB 73-11085 — LOCATION Route 'M' and Highway 81 — ORIGINATED BY PK

W.P. 40-66-00 — BORING DATE October 25th, 1973 — COMPILED BY WJA

DATUM Geodetic — BOREHOLE TYPE Hollow Stem Auger — CHECKED BY [signature]

ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT (25, 50, 75, 100, 125); SHEAR STRENGTH P.S.F. (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % (10, 20, 30)	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
658.5	Continued									
104.0	Silt, traces of clay Compact (Grey)									
656.5 / 106.0	Heterogeneous Mixture of sand, silt, clay and gravel Grey, (compact to Very Dense) (Till) Very Stiff to Hard		17	SS	21	650				
643.5 / 119.0	End of Borehole									



20
15 ⊕ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 15

JOB 73-11085 — LOCATION Route 'M' and Sharon Creek — ORIGINATED BY PK

W.P. 40-66-00 — BORING DATE October 19th, 31st, November 1st, 1973 — COMPILED BY WJA

DATUM Geodetic — BOREHOLE TYPE Hollow Stem Auger — CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F.	WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
747.1	Ground Level								
0.0 / 743.1	Fine sand some gravel Brown								
4.0	Clayey silt to silt Grey-brown Stiff	1	SS	14	740				
		2	SS	14					0 0 63 37
		3	SS	10	730				
729.1 / 18.0	Silt some sand and clay Loose	4	SS	7		2240			▼728.1; 0 16 68 16
723.1 / 24.0	Clayey silt to silt Stiff	5	SS	13	720	S=1.87			
		6	TW	PH		2240		123	ø' = 29 C' = 0
		7	SS	15	710				
		8	SS	11					0 0 60 40
		9	SS	13	700	2240			
		10	SS	11					0 1 64 35
					690				
686.1 / 61.0	Clayey silt trace of sand and gravel Hard	11	TW	PH					
					680				
		12	SS	35					
					670				
		13	SS	46					
					660				
		14	SS	37					
					650				
		15	SS	29					

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F.: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (400 800 1200 1600 2000)

LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W (10 20 30)

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

Continued

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 15 Continued

JOB 73-11085 | LOCATION Route 'M' and Sharon Creek | ORIGINATED BY PK

W.P. 40-66-00 | BORING DATE October 19th, 31st, & November 1st, 1973 | COMPILED BY PK

DATUM Geodetic | BOREHOLE TYPE Hollow Stem Auger | CHECKED BY [signature]

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % 10 20 30	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
645.1	Continued									
104.0	Clayey silt traces of sand and gravel Hard					640				
			16	SS	41					20 25 34 21
635.1 / 112.0	Heterogeneous Mixture of sand, silt, gravel and clay (Till) Hard (very dense)					630				
			17	SS	100/9"					
						620				
616.1			18	SS	107/6"					
131.0	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20 / 15 ⌖ 5 / 10 % STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION

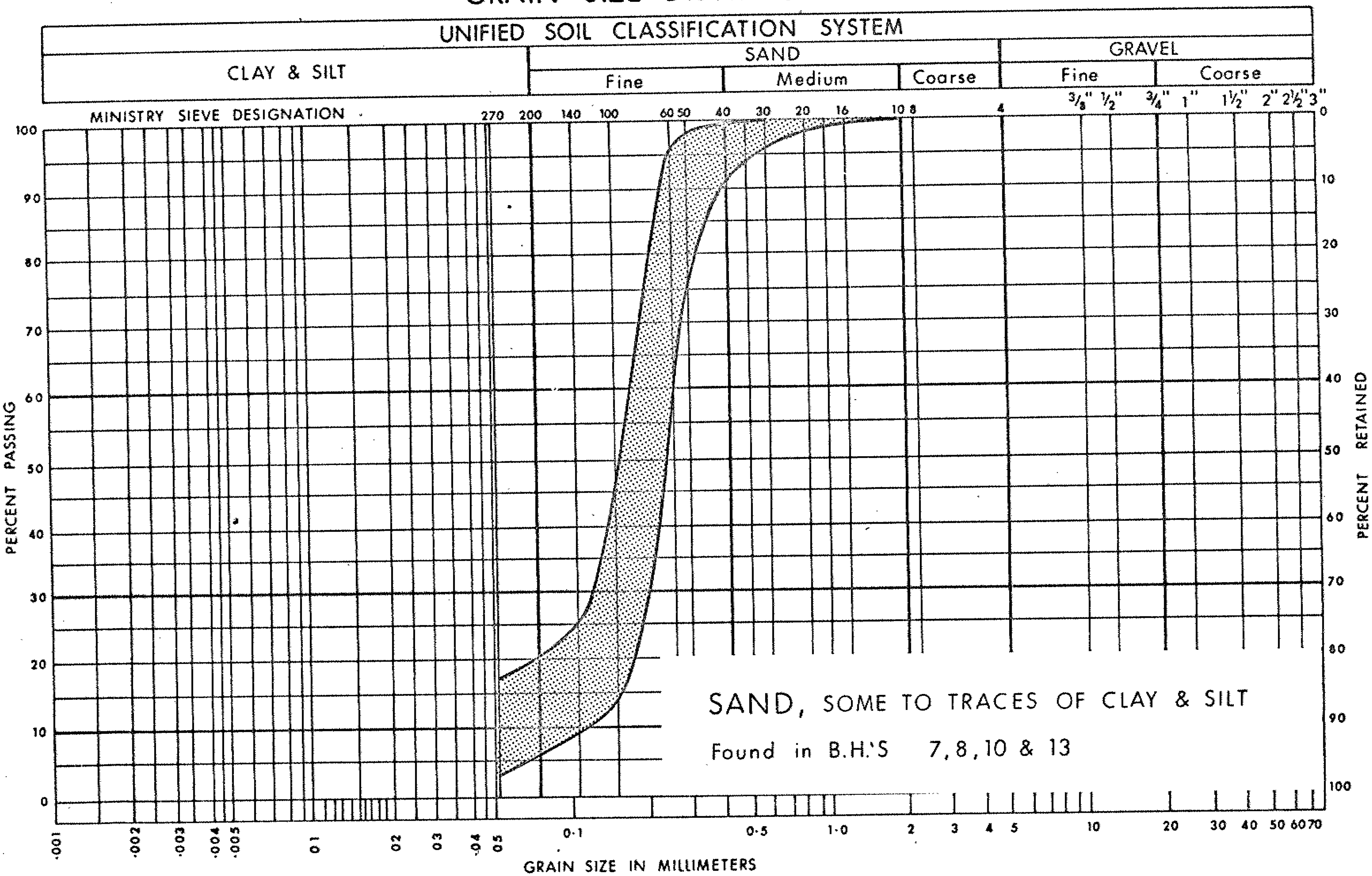


FIG. 1

W.O. 73-11085

GRAIN SIZE DISTRIBUTION

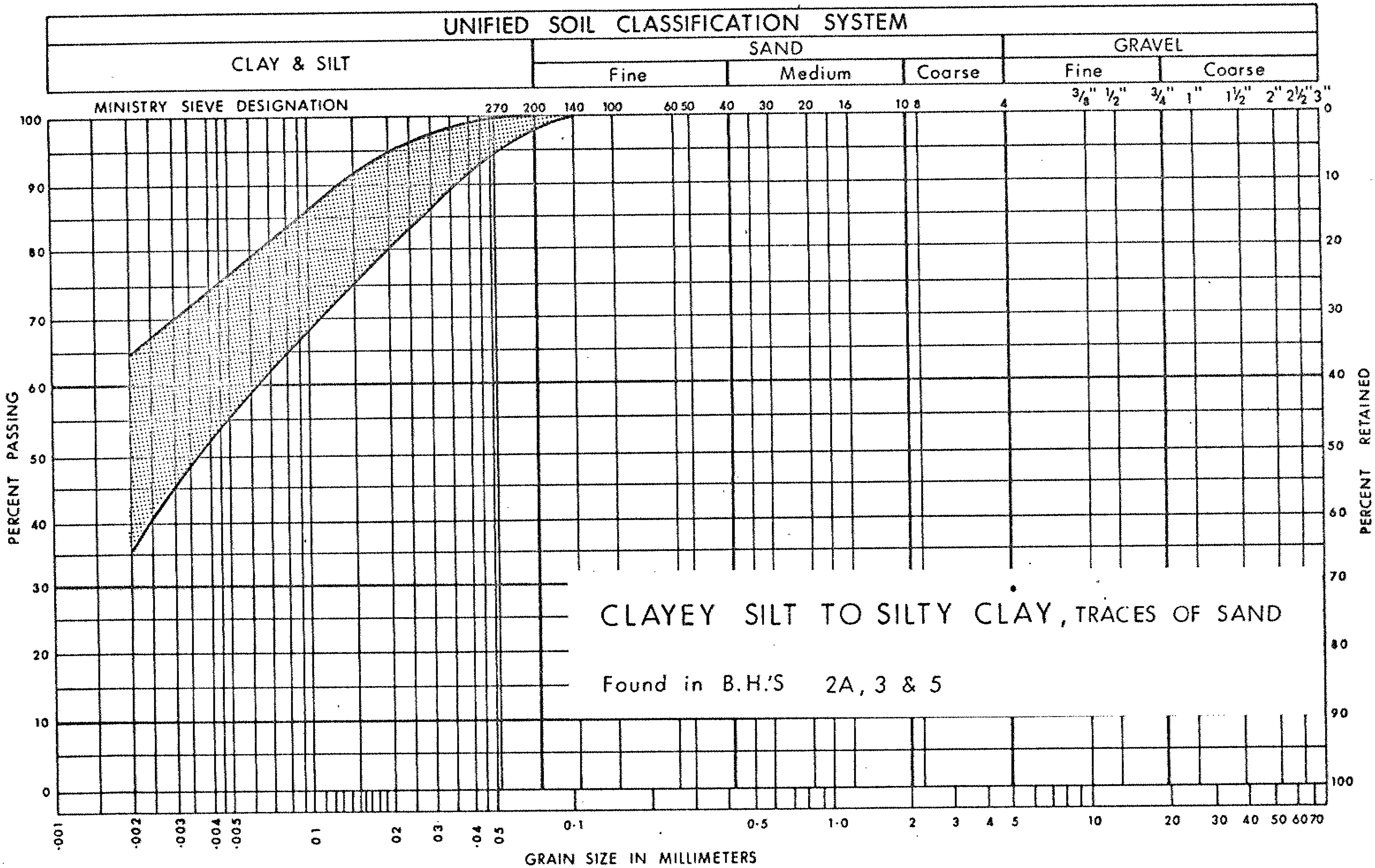


FIG. 2

W.O. 73-11085

GRAIN SIZE DISTRIBUTION

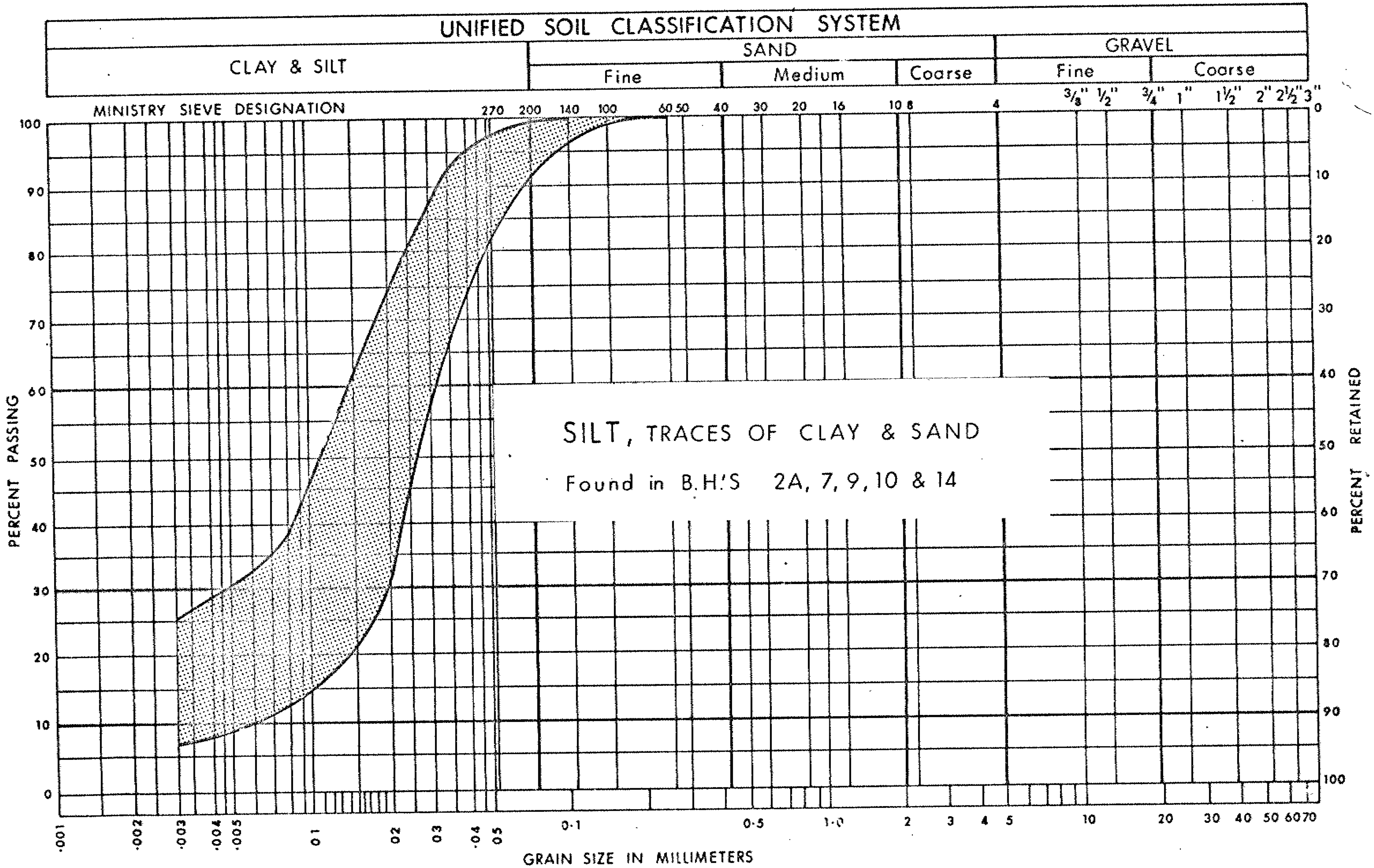


FIG. 3

W.O. 73-11085

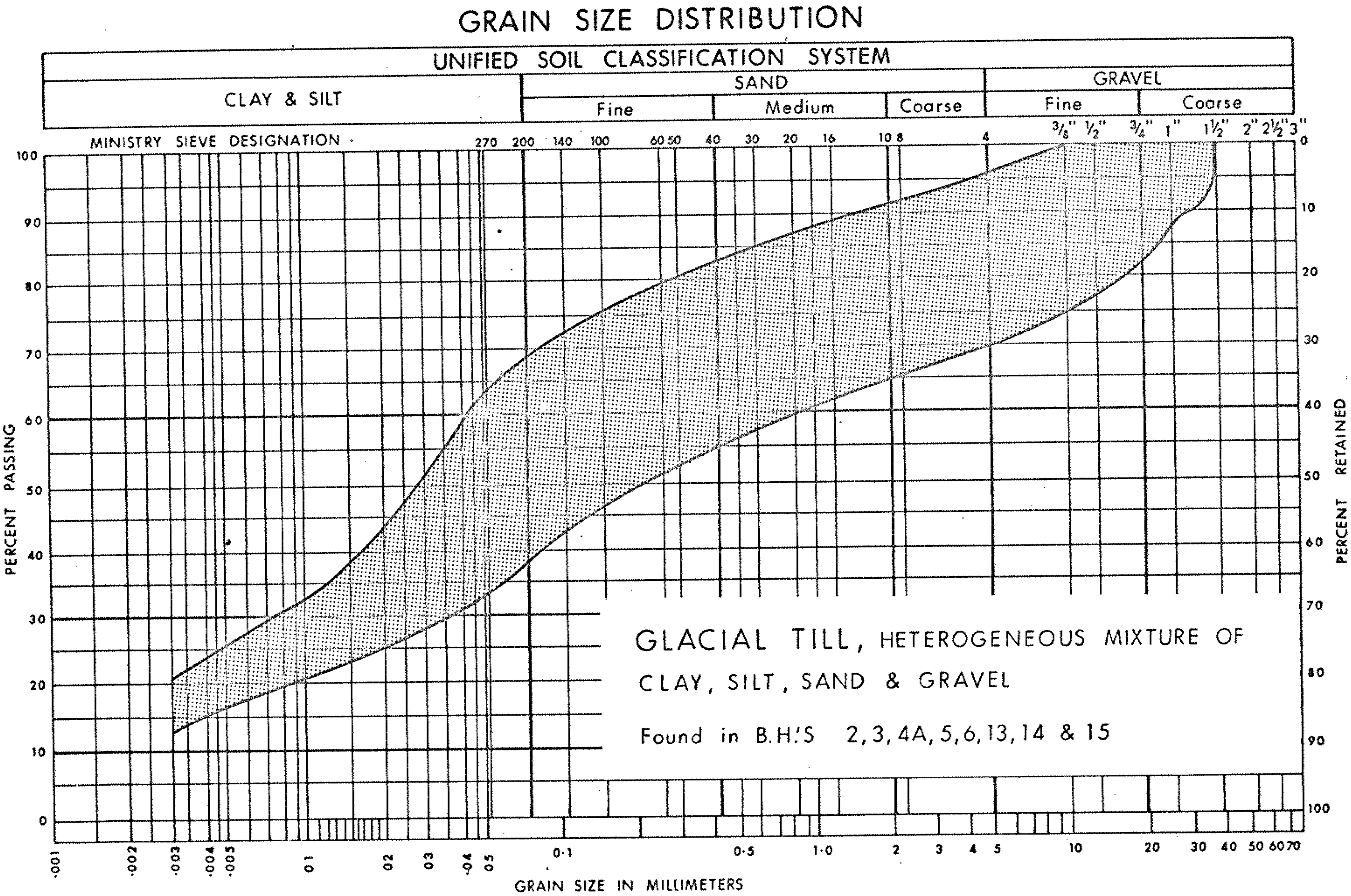


FIG. 4

W.O. 73-11085

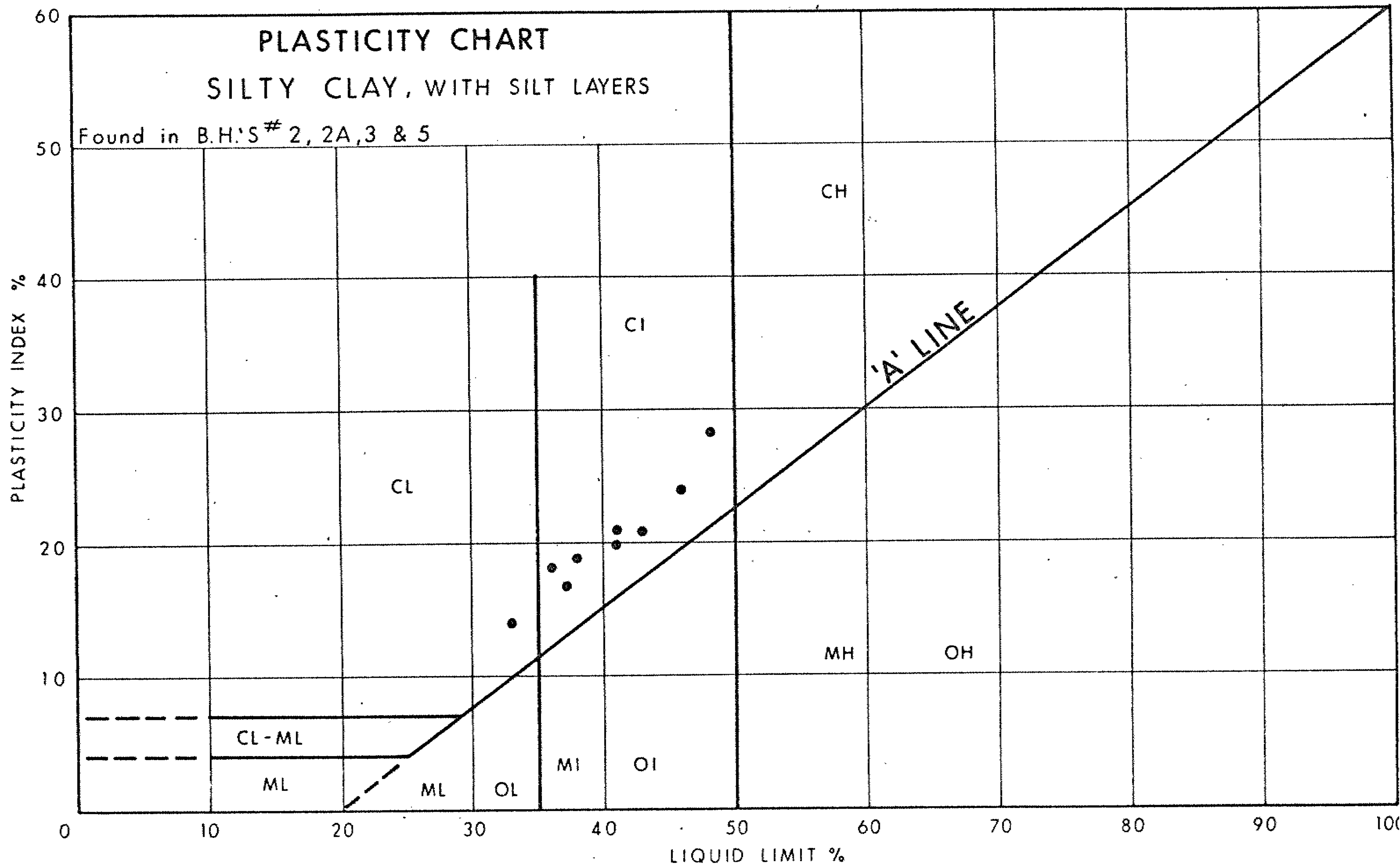


FIG. 5

W.O. 73-11085

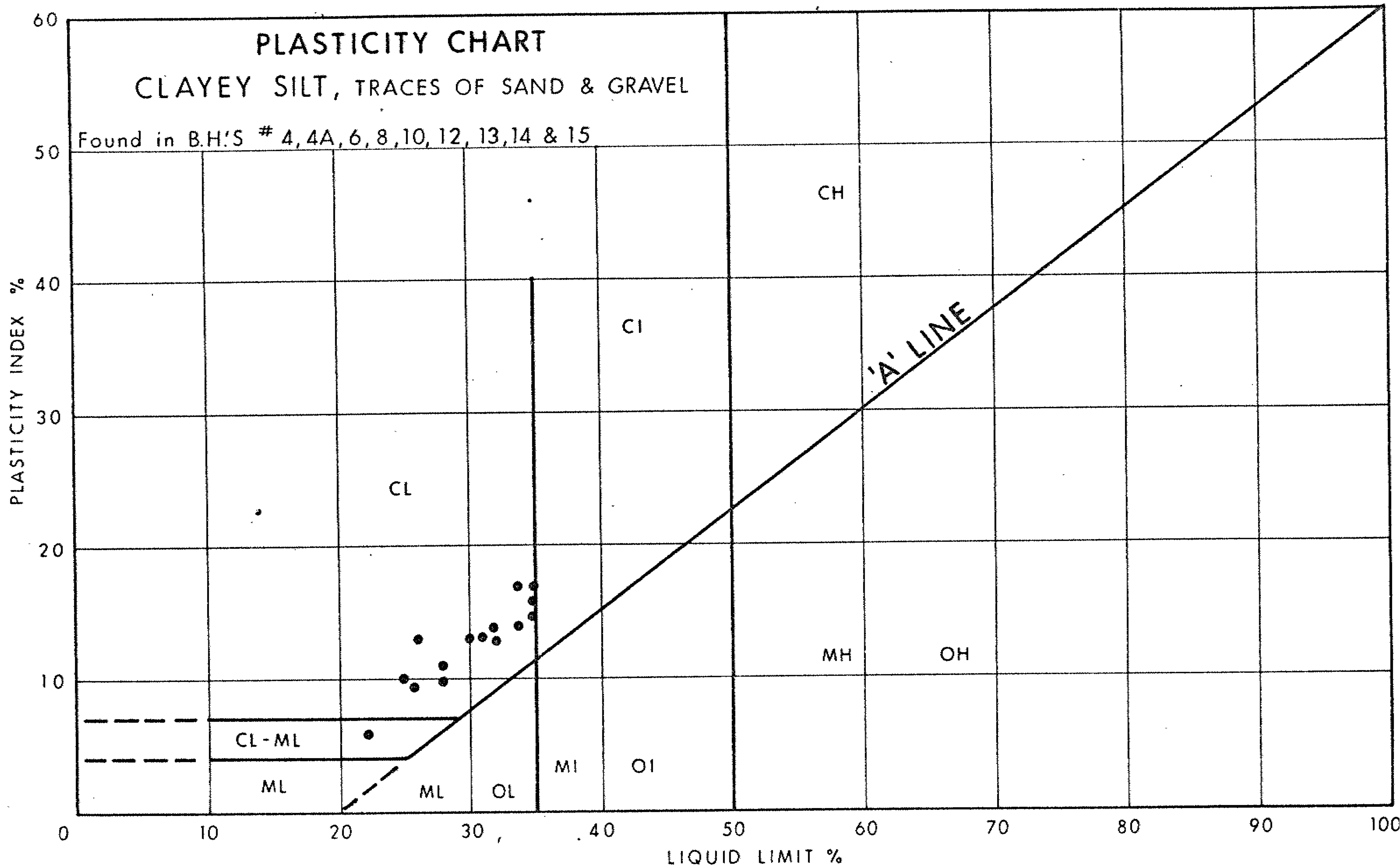
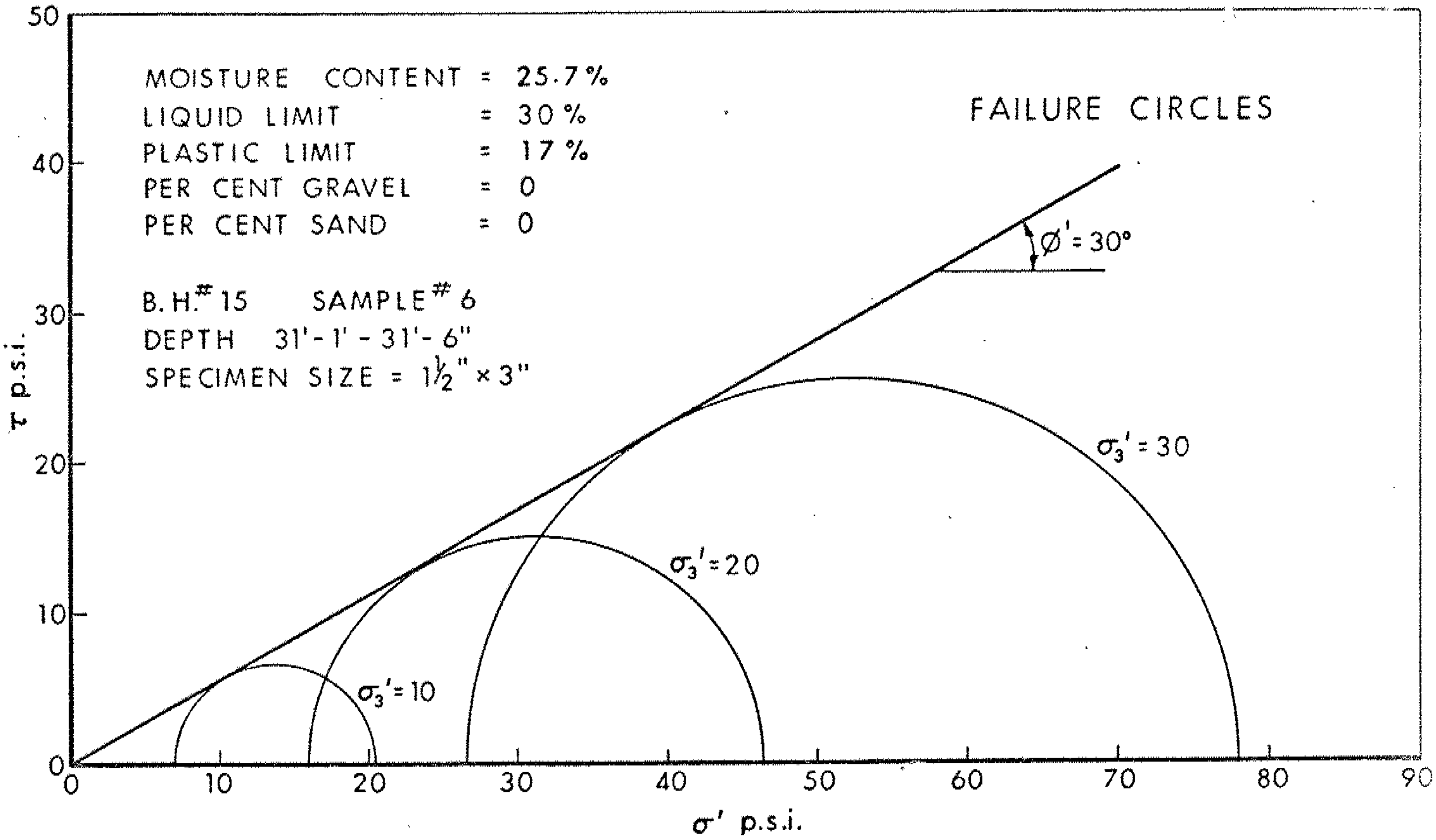


FIG. 6

W.O. 73-11085



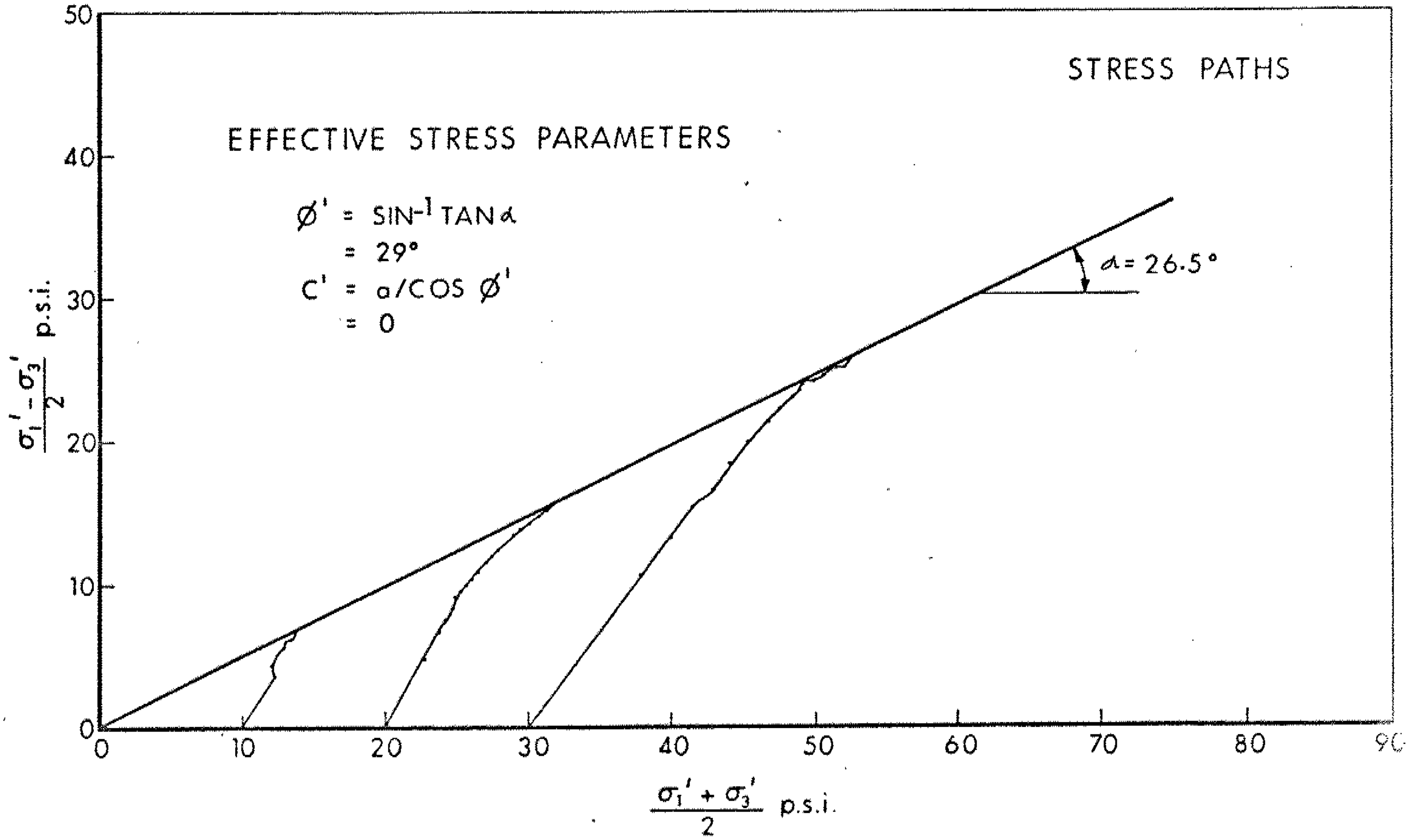
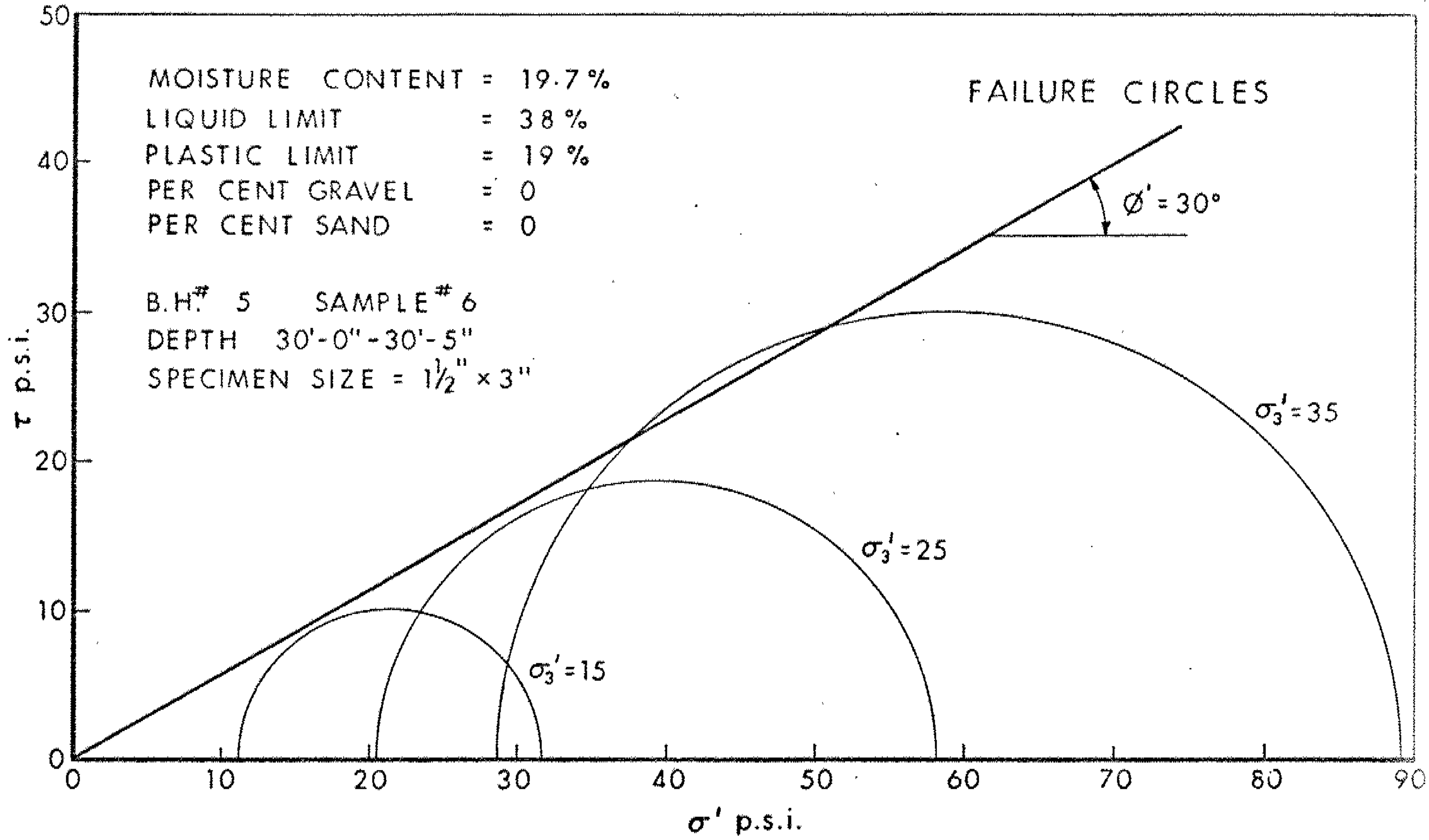


FIG. 7

W.O. 73-11085



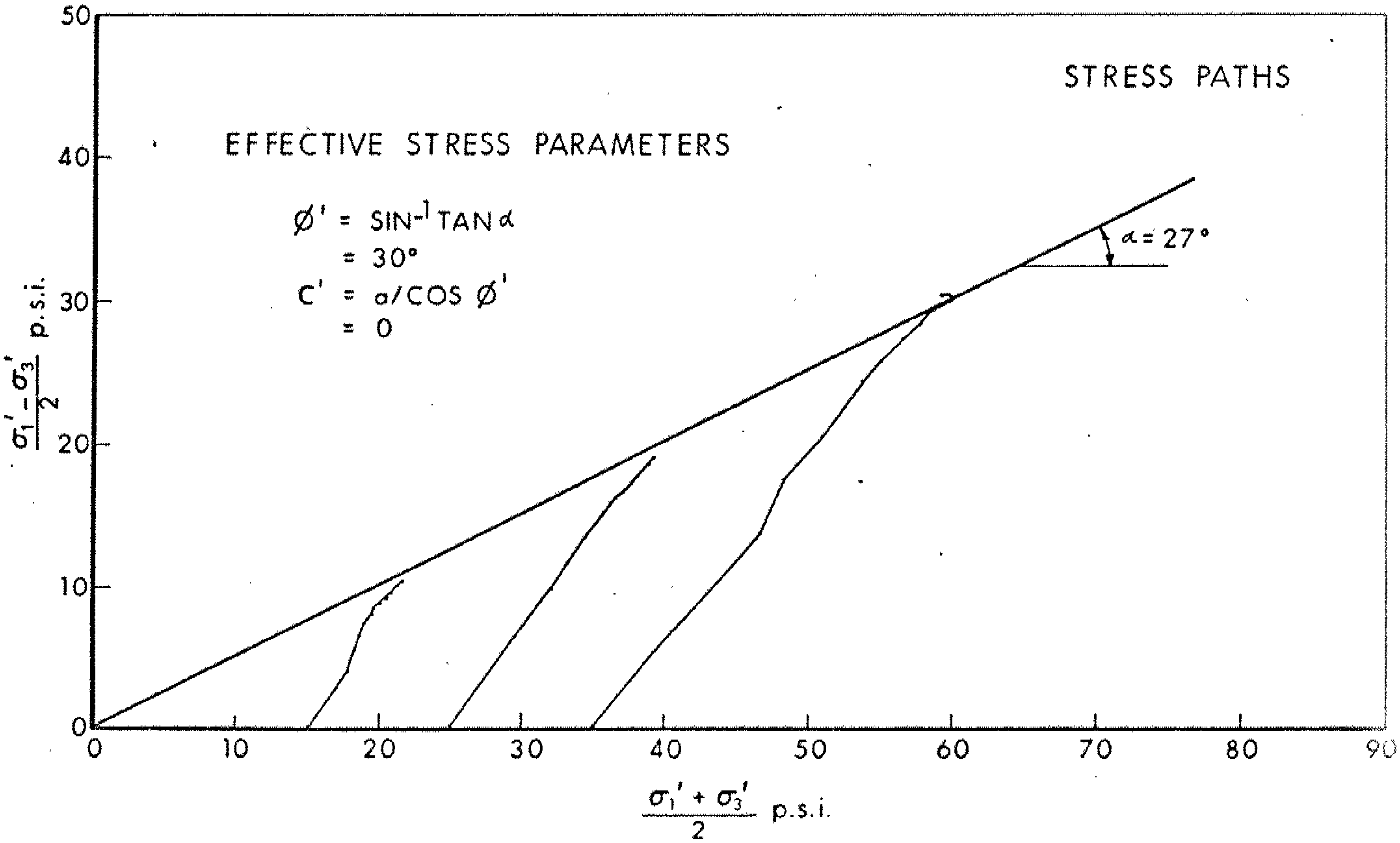


FIG. 8

W.O. 73-11085

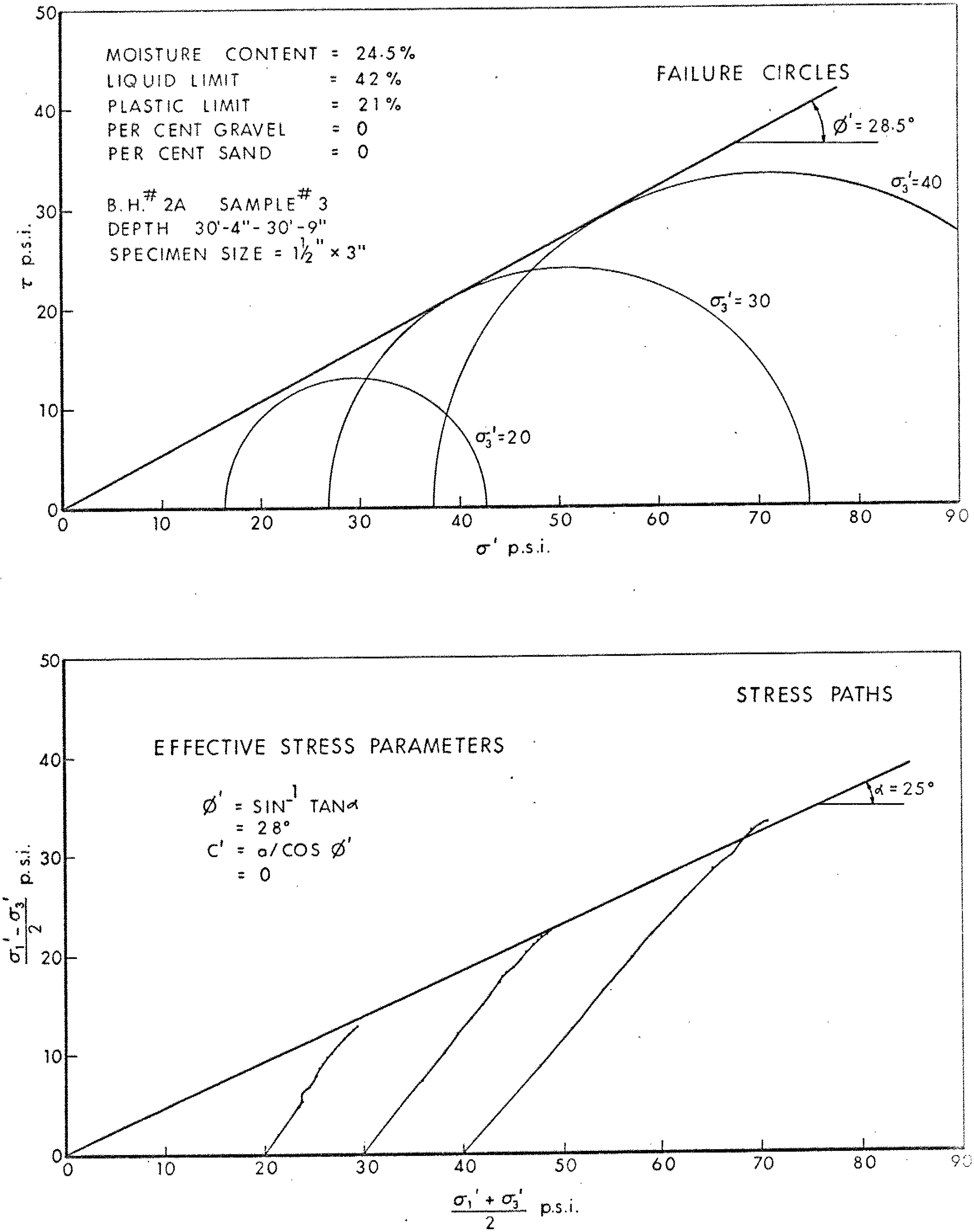


FIG. 9

W.O. 73-11085

FD-[illegible] (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N'= STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	c LB./SQ.FT.
VERY SOFT	0 - 250
SOFT	250 - 500
FIRM	500 - 1000
STIFF	1000 - 2000
VERY STIFF	2000 - 4000
HARD	> 4000

DENSENESS	'N' BLOWS / FT.
VERY LOOSE	0 - 4
LOOSE	4 - 10
COMPACT	10 - 30
DENSE	30 - 50
VERY DENSE	> 50

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

FD-9b (Revision 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
w_S	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT — IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION — IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION — IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION — IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY. DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

S.
MR. MITCHELL

CON II
LOT 28
ADELAIDE TWP.

F 245 1180

1 - 59

ROAD JURISDICTIONS

KING'S HIGHWAY
COUNTY ROAD
COUNTY SUBURBAN ROAD
TOWNSHIP ROAD
ROAD LEGALLY OPEN BUT NOT NECESSARILY PASSABLE
INDIAN RESERVE BOUNDARY
URBAN CORPORATE LIMIT
URBAN LIMIT
RAILWAY AND STATION
TOWNSHIP BOUNDARY
COUNTY BOUNDARY
BUILT UP AREA

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation

NO.	ELEVATION	STATION	OFFSET
2	724.5	AS SHOWN ON PLAN	
3	721.6		
4	673.9		
5	742.6		
6	682.5		
7	813.8		
8	786.0		
9	800.6		
10	747.3		
11	746.0		
12	678.2		
13	682.0		
14	762.5		
15	747.1		

— NOTE —

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

REVISIONS		
DATE	BY	DESCRIPTION

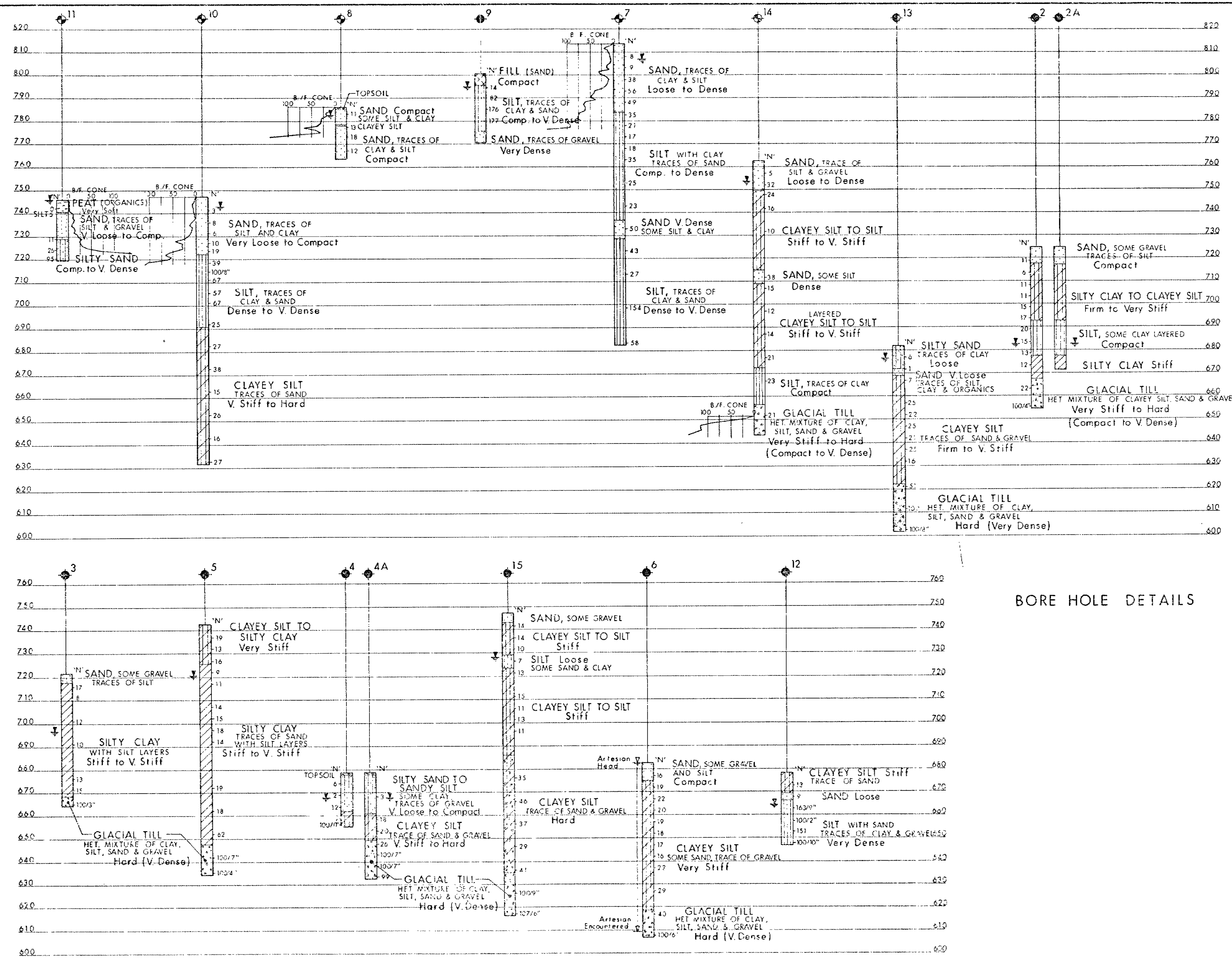
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

FEASIBILITY STUDY

HIGHWAY NO PROP. 402 DIST NO. 2
CO MIDDLESEX
TWP ____ LOT ____ CON ____

BORE HOLE LOCATIONS

SUBMD P.K.	CHECKED	W.P. NO.	DRAWING NO. 73-11085A
DRAWN	CHECKED	W.C. NO. 73-11085	
DATE Nov 6, 1973		SITE NO	BRIDGE DRAWING NO
APPROVED		CONT NO	



BORE HOLE DETAILS

KEY PLAN
SCALE IN MILES

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation Oct. & Nov 1973

NO.	ELEVATION		

— NOTE —

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

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

FEASIBILITY STUDY

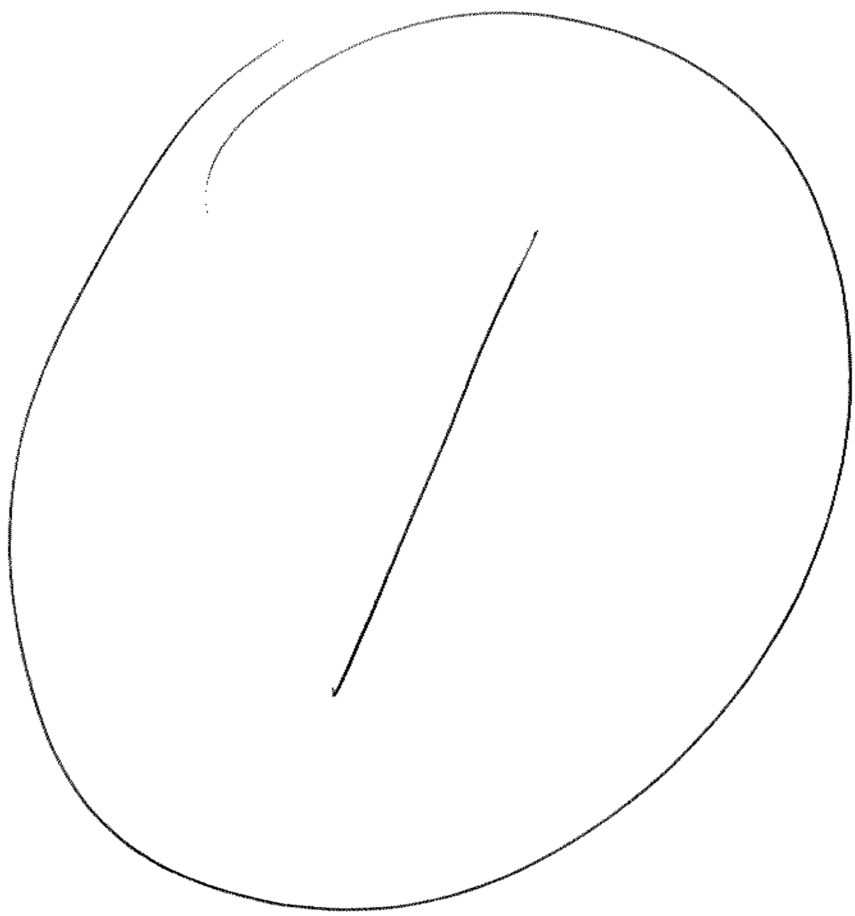
HIGHWAY NO. PROP. 402 DIST. NO. 2
CO. MIDDLESEX
TWP. LOT CON

SOIL STRATIGRAPHY

SUBM'D P.K.	CHECKED	W.P. NO. 40-66-[illegible]	DRAWING NO. 73-11085B
DRAWN	CHECKED	W.O. NO. 73-11085	
DATE Nov. 22, 1973		SITE NO.	BRIDGE DRAWING NO.
APPROVED		CONT. NO.	

35MM

DRAWING



H. Q. GOLDER & ASSOCIATES LTD.
SOIL AND FOUNDATION ENGINEERS
HEAD OFFICE - TORONTO, ONTARIO

H. Q. GOLDER
V. MILLIGAN
L. G. SODERMAN
J. L. SEYCHUK

747 HYDE PARK ROAD
LONDON, ONTARIO
471-9600

REPORT

TO

R. C. DUNN & ASSOCIATES LIMITED

ON

SUBSURFACE INVESTIGATION

FOR

GILES BRIDGE

COUNTY OF MIDDLESEX

DELAWARE ONTARIO

Distribution:

8 copies - R. C. Dunn & Associates Limited,
London, Ontario.

2 copies - H. Q. Golder & Associates Ltd.,
London, Ontario.

November, 1968. 68628

TABLE OF CONTENTS

ABSTRACT

The results of an investigation to determine the subsoil and ground-water conditions at the proposed site of the new Giles Bridge over the Thames River south of Delaware, Ontario, are reported.

The four principal soil types found to exist at this site have been described as follows: 1) very loose to loose brown silty sand, 2) compact or very stiff stratified silt and silty clay, 3) very stiff to hard grey clayey silt till, and 4) very dense grey silty sand till. Limestone bedrock underlies the very dense silty sand till stratum.

It is recommended that the proposed four span structure be supported on piers bearing directly upon the competent till layer and that the abutments be supported on steel pipe piles filled with concrete. The driven pipe piles with tip elevations as specified will derive their design capacity of 40 tons per pile, primarily from end bearing in the very dense till stratum.

The approach fills and river bank slopes as proposed are not steeper than 2 horizontal to 1 vertical and are considered adequate. Rip-rap protection to above the high water level for the river bank and approach fill slopes is recommended.

INTRODUCTION

H. Q. Golder & Associates Ltd. has been retained by R. C. Dunn & Associates Limited to carry out a subsurface investigation at the site of the proposed Giles Bridge crossing of the Thames River south of Delaware, Ontario.

The purpose of the investigation was to determine the subsurface soil and ground-water conditions at the proposed site and to make recommendations for the design of the bridge foundations, roadway cut and construction of the approach embankments.

PROCEDURE

Six boreholes and eight dynamic cone penetration tests were put down between October 7 and 22, 1968 using diamond drillrigs supplied and operated by the F. E. Johnston Drilling Co. Ltd. In order to carry out two borings located in the river channel, the drillrig was mounted on a raft. Two additional boreholes were made at the proposed east approach cut location to assess the suitability of this material for use as approach fill. A power auger supplied by the F. E. Johnston Drilling Co. Ltd.

was used to make these two boreholes. Sounding of the river bottom along the proposed bridge centreline was carried out by hand probing with a steel rod from a small boat.

Ground-water information was obtained during drilling and from standpipes and piezometers installed in the boreholes upon the completion of drilling.

The locations of the boreholes and soil stratigraphy sections are shown on Figures 1 and 2. A log of each borehole is given in the Record of Borehole sheets following the text of this report. The soil samples obtained during drilling were brought to our London laboratory for detailed examination and representative testing. The test results are given in the Record of Borehole sheets and grain size distribution curves are shown on Figures 5 to 9 inclusive. The standard Proctor compaction test results of the proposed cut material are shown on Figures 3 and 4.

The elevations of boreholes were obtained from R. C. Dunn & Associates Limited and are understood to be referred to the local datum used in Middlesex County.

SITE AND GEOLOGY

The site of the proposed bridge over the Thames River is situated about 3 miles south of Delaware, Ontario, on a road between Lots 12 and 13 in Concession I of Township of Delaware, Middlesex County, Ontario

The proposed site is located within an old glacial spillway of the physiographic region known as the Caradoc Sand Plain. This spillway at present serves as the flood plain of the Thames River flowing through this lowland along the bottom of the 90 foot high Mount Elgin Ridge located on the east side of the river.

In the flood plain loose granular alluvium is underlain by the very stiff or very dense glacial till of the Wisconsin Glaciation, whereas the high ridge at the east side of the river is of lacustrine origin and consists of very stiff or compact stratified clay, silt and sand underlain by the glacial till. This stratified stratum can probably be attributed to the Maumee-Whittlesey periods of the Great Lakes history.

SUBSURFACE CONDITIONS

Four principal soil types were encountered at this site. These have been described as follows: (1) very loose to loose brown silty sand with occasional roots (alluvium), (2) compact or very stiff stratified silt and silty clay (lacustrine deposit), (3) very stiff to hard grey clayey silt and sand with a trace to some fine gravel (glacial till), and (4) very dense grey silty sand with a trace to some clay and gravel (glacial till).

In general the main river channel has been formed in the brown silty sand alluvium stratum which is underlain by the competent till strata. The river bottom between station 23+20 and 24+90 consists of clayey silt till. It is believed that the scouring action of the river has removed the relatively loose silty sand alluvium in this section. The elevation of the upper horizon of this exposed clayey silt till did not vary abruptly across the site indicating that scouring or stream bed erosion has not been significant. The grain size distribution curves of representative samples from various strata are shown on Figures 5 to 9 inclusive.

Brown Silty Sand (Alluvium)

The alluvial deposit of brown silty sand with occasional roots was encountered in boreholes 1, 4 and 5 on the flood plain. The average thickness of this deposit was about 10 feet between elevations 140 and 158. The "N" values obtained from standard penetration tests ranged from 3 to 20 blows per foot with a representative value of about 5 blows per foot. The average natural water contents were 12 per cent at boreholes 1 and 5 and 32 per cent at borehole 4 near the river. The relative density of this stratum is loose and the material is considered to be very susceptible to scouring.

Stratified Silt and Clay (Lacustrine)

The lacustrine deposit of grey stratified silt and clay was encountered at boreholes 6, 7 and 8 located on the east river bank above elevation 160. This fairly thick stratum is overlain by about 10 feet of brown mottled clayey silt at boreholes 7 and 8.

The "N" values ranged from 9 to 37 with an average value of 20 blows per foot and the consistency based on the "N" values is very stiff. The Atterberg limit tests gave liquid and plastic limits of 32 and 19 respectively with a plasticity index of 13. The natural water content varied from 12 to 31 per cent with an average value of 20 per cent. The representative value above elevation 215 was 16 per cent.

Standard Proctor compaction tests were carried out to determine the suitability of this stratum as a fill material for approach embankments. For the predominantly silty soil which occurred at the location of borehole 7, the maximum dry density was found to be 123.4 pounds per cubic foot at an optimum water content of 12 per cent. For the predominantly clayey soil which occurred at the location of borehole 8, the values of maximum dry density and optimum water content were 115.7 pounds per cubic foot and 15 per cent respectively. (See Figures 3 and 4.)

Grey Clayey Silt (Glacial Till)

The glacial till stratum of grey clayey silt with a trace to some sand and fine gravel was encountered in all boreholes except borehole 8. This layer is overlain by the brown silty sand alluvium or grey stratified silt and clay of lacustrine origin and is underlain by the very dense grey silty sand till stratum. The upper surface of this stratum is presently exposed in the river bottom due to the removal of the alluvium by river scouring.

The "N" values ranged from 18 to 43 blows per foot with an average value of 27 blows per foot. The natural water content varied from 14 to 20 per cent with an average value of 18 per cent. The results of Atterberg limit tests gave liquid and plastic limits of 29 and 18 respectively with a corresponding plasticity index of 11. The liquidity index of 0.1 to 0.5 for this clayey silt till indicates a high degree of overconsolidation.

It is noteworthy that the exposed surface of this stratum in the bottom of the river channel is at approximately the same elevation as the upper surface of the buried portion of this stratum on both sides of the channel which is not subject to scouring. This indicates that this grey clayey silt till stratum is relatively non-susceptible to river scouring.

Grey Silty Sand (Glacial Till)

The coarse textured stratum of glacial till consisting of grey silty sand with a trace to some clay and gravel was encountered below the grey clayey silt till at boreholes 1 to 6 inclusive. The upper surface elevations of this stratum varied between 125 and 132 across the site.

The relative density of this stratum is very dense. "N" values of over 100 blows per foot and the natural water contents varying between 5 and 11 per cent confirm the low void ratio consistent with a very dense state. This very dense till layer, locally called hard pan, is considered an excellent bearing stratum for end bearing piles.

Miscellaneous

A 10 foot thick brown to rusty brown highly fissured mottled clayey silt layer was encountered near the ground surface at boreholes 7 and 8; this layer is probably the weathered upper portion of the lacustrine deposit, having average "N" values of 33 blows per foot and a natural water content varying from 13 to 19 per cent with an average value of 16 per cent.

At borehole 8, this stratum underlies about 5 feet of rusty brown slightly stratified fine to medium sand which had "N" values of 6 blows per foot and a water content of 8 per cent.

It is known that the limestone bedrock in this area is overlain by the very dense grey silty sand till stratum. The thickness of the overburden was not proven at this site, but it is believed to be over 100 feet.

GROUND-WATER CONDITIONS

Ground-water information was obtained from observations made during drilling and from piezometers and standpipes installed in the boreholes which were measured on November 12, 1968, 3 weeks following the completion of drilling. Soundings were made in the river on October 17, 1968. The details of ground-water and river water levels are given on the Record of Borehole sheets and on Figure 2.

The ground-water table on the east side of the river channel was close to the ground surface elevation of 148 at boreholes 4 and 5, and sloped upward towards the east with elevations of 166, 209 and 236 at boreholes 6, 8 and 7, respectively. On the west side of the river, the ground-water level was at elevation 148 at borehole 1 and probably follows the upper surface of the grey silty clay till stratum which dips slightly toward the river.

The lower grey silty sand till stratum is under slight artesian pressure several feet above the normal ground-water level at the river channel section. (See borehole 4.) This condition exists due to the impervious stratum of grey silty clay till above it.

DISCUSSION

It is proposed to replace the existing 3 span simply supported through truss Giles Bridge with a deck type structure located immediately south of the existing bridge as shown on Figure 1. The proposed new bridge will consist of a 4 span structure continuous over 3 piers and simply supported at each abutment. The approach embankments will vary in height from 15 feet above existing ground surface at the west bank to 30 feet above existing ground surface at the east bank. This will elevate the new bridge deck approximately 20 feet and 7 feet above the bridge deck elevations at the east and west abutments. A maximum cut of 30 feet is proposed to achieve the required approach grade on the east bank. It is understood that the maximum allowable differential settlements between piers or between pier and abutment is 1.0 inch .

Foundations

Piers:

The very dense competent till stratum which exists at a relatively constant elevation across the site is an ideal bearing stratum to support spread footings directly or to serve as the end bearing stratum for driven piles. At the west pier and centre pier locations spread footings may be founded at or below elevation 128 using a net bearing pressure of at least 4 tons per square foot. Founding footings on the till layer at this elevation will involve excavations varying from about 7 feet to 9 feet at the west and centre pier locations respectively.

The use of spread footings at the east pier location designed for 4 tons per square foot at or below elevation 128 will necessitate an excavation depth of about 20 feet below the water table through at least 10 feet of loose silty sand. This would require using interlocking steel sheeting driven to penetrate the till layer for at least 12 inches. A recommended alternative to the use of spread footings at this pier location is the use of steel pipe piles driven to practical refusal at elevation 125 and filled with concrete. The safe allowable load per pile is considered to be at least 40 tons for a 12 inch diameter pile driven to a final set of about 10 blows per inch using a driving energy of 15 foot kips per blow. The piles could be capped at about 4 feet below existing ground level eliminating the need for a deep sheeted excavation.

Abutments:

Due to the presence of both the loose alluvial soil and the compressible clayey silt till which exists at the proposed abutment locations, the use of spread footing support is not considered feasible. It is recommended that the abutments be supported on steel pipe piles driven to practical refusal in the dense till stratum at or below elevation 125 and then filled with concrete.

A design load per pile of 40 tons may be used provided the 12 inch diameter pipes are driven to a set of 10 blows per inch using a driving of 15 foot kips per blow with a tip elevation at or below 125. The front and back row of piles at each abutment should be raked in opposite directions.

Approach Embankments

At the west abutment location the approach fill is to be constructed to a height of about 15 feet above present ground surface. Normal stripping of the topsoil layer should be carried out prior to the placing and compacting of the fill material. Abutment piles should be driven through the in place compacted fill. Standard side slopes of 2 horizontal to 1 vertical may be used. There is no apparent danger of river bank instability due to the approach fill loading.

At the east abutment location the proposed grade is such that the approach fill will be about 30 feet above present ground surface. Due to the combination of the high ground-water table and the silty fine sand underlying the topsoil layer, particularly at the toe of the slope in the vicinity of borehole 5, it may be necessary to place a 12 inch layer of granular filter over the fine silty sand prior to placing the compacted fill. This will insure that the base layer of the approach fill can be adequately compacted and prevent a slope failure within the fill. The requirement of the granular zone can be decided upon completion of the stripping and foundation preparation. A dry construction and pre-construction period could obviate the necessity of the granular filter layer. Standard 2 horizontal to 1 vertical side slopes may be used with no danger of an approach fill or river bank slope failure.

Suitability of Cut Material as Approach Fill

In the vicinity of borehole 8 where the cut depth is about 20 feet, the material within this depth consists of sand overlying a desiccated brown clayey silt. The in place water content of this clayey silt material is at or slightly above (1 to 2 per cent) the Proctor optimum water content. (See Figure 4.) This material is considered acceptable as approach fill.

In the vicinity of borehole 7 where the cut depth is generally less than 20 feet, the material is predominantly a silt and the in situ water content is about 5 per cent above the Proctor optimum value. (See Figure 3.) Use of this material as approach fill would require a reduction of the water content of at least 5 per cent which could only be achieved during under ideal hot and dry weather conditions.

The slopes for the roadway cut should be 2 horizontal to 1 vertical. Protection of these slopes with sod or mulch and seed to produce a grass covered slope will be necessary to prevent surface sloughing and gullying due to storm runoff. There are several local surface failures evident in the existing cut for the existing road.

River Bank Slope Protection

In order to prevent stream erosion of the approach fill slopes, it is recommended that rip-rap protection to above river high water level be provided. The rip-rap should consist of stone up to 12 inches in diameter which should be placed on a 12 inch filter layer of well graded sand and gravel having a D_{85} size of about 1.5 inches.

This filter layer is particularly necessary at the west approach fill between elevations 140 and 155 where the loose silty sand alluvium is exposed in the river bank slopes. This layer is also exposed at the toe of the slope below elevation 147 on the east river bank slope and the filter blanket must be provided here as well.

Y. D. Kim

L. G. Soderman, P. Eng.

YDK/LGS:cmm
November, 1968
68628

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS	auger sample
CS	chunk sample
DO	drive open
DS	Denison type sample
FS	foil sample
RC	rock core
ST	slotted tube
TO	thin-walled, open
TP	thin-walled, piston
WS	wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*N, blows/ft.*
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	c_u, *lb./sq. ft.*
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

C	consolidation test
H	hydrometer analysis
M	sieve analysis
MH	combined analysis, sieve and hydrometer[1]
Q	undrained triaxial[2]
R	consolidated undrained triaxial[2]
S	drained triaxial
U	unconfined compression
V	field vane test

NOTES:

[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) *Consistency*

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_P)/I_P$
I_C	consistency index $= (w_L - w)/I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
k	coefficient of permeability
j	seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	
c'	effective cohesion intercept	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

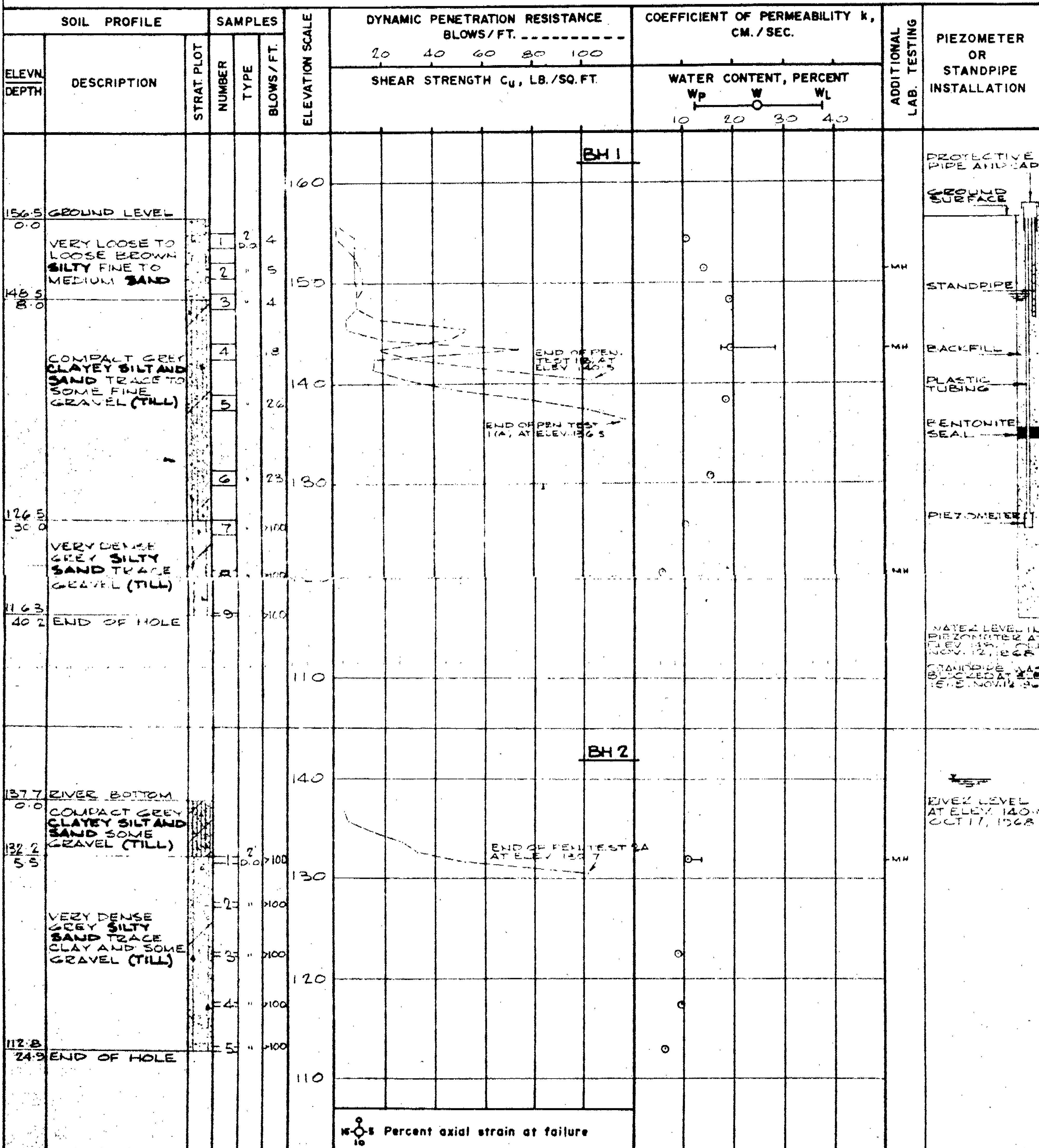
PROJECT No. [illegible]

RECORD OF BOREHOLES 1 & 2
AND PEN. TESTS 1A, 1B & 2A

LOCATION See Figure 1 | BORING DATE OCT. 7-21, 1968 | DATUM LOCAL

BOREHOLE TYPE WASH BORING | BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES | PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN [illegible]
CHECKED [illegible]

RECORD OF BOREHOLES 3 & 4 AND PEN. TESTS 4A & 4B

LOCATION See Figure 1 — BORING DATE OCT 10-17, 1968 — DATUM LOCAL

BOREHOLE TYPE WASH BORING — BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES — PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

BH3

River level at elev. 140.0, Oct. 17 1968

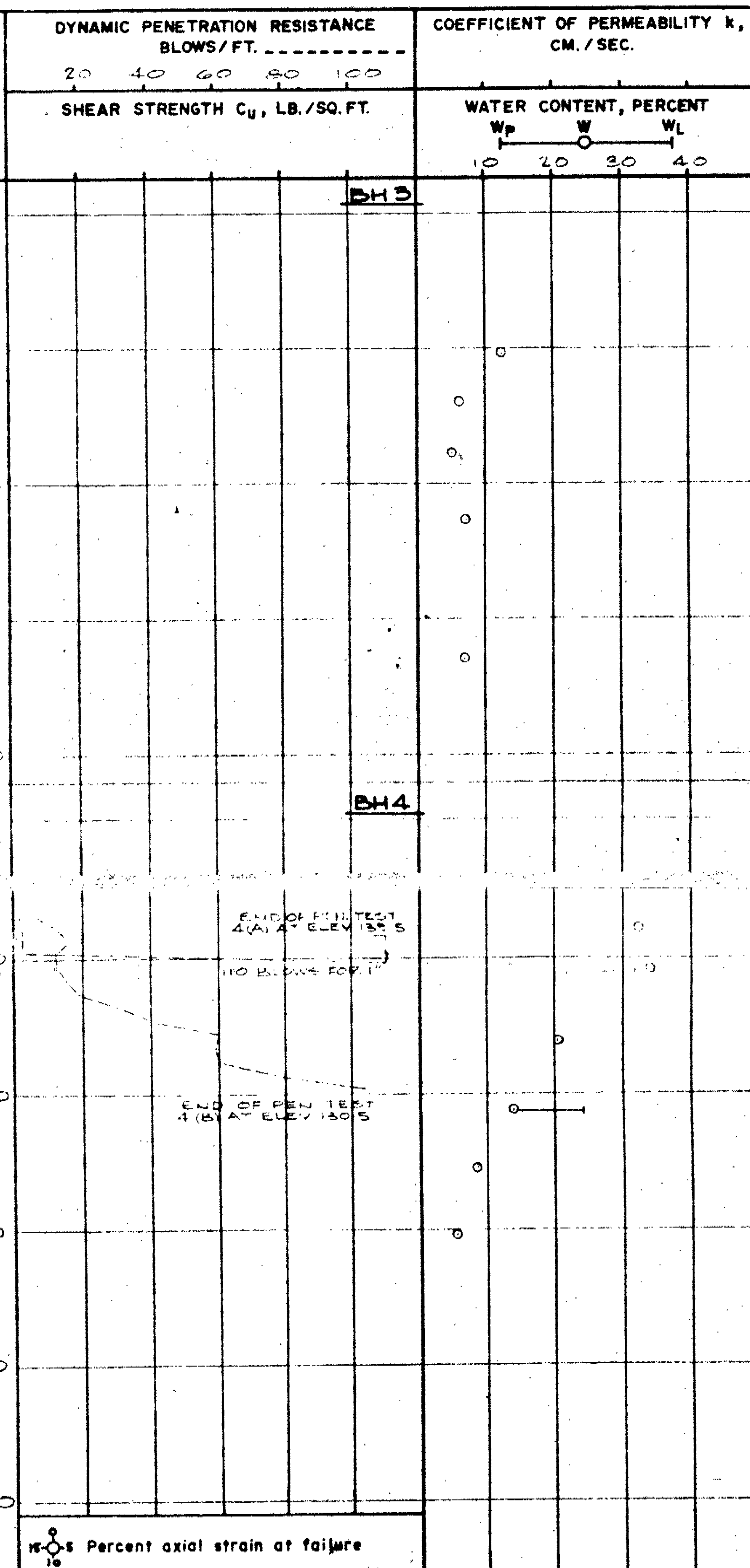
ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
135.4	RIVER BOTTOM			
0.0	VERY STIFF TO HARD GREY CLAYEY SILT AND SAND TRACE TO SOME GRAVEL (TILL)	1	2" D.O.	38
127.9 / 7.5	VERY DENSE GREY SILTY SAND TRACE CLAY AND SOME GRAVEL (TILL)	2	"	70
		3	"	>100
		4	"	>100
		5	"	>100
106.5		6	"	>100
28.9	END OF HOLE			

BH4

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
144.5	GROUND LEVEL			
0.0	VERY LOOSE TO LOOSE DARK BROWN SILTY SAND OCCASIONAL ROOTS	1	2" D.O.	3
		2	"	5
136.5 / 8.0	VERY STIFF GREY CLAYEY SILT AND SAND TRACE GRAVEL (TILL)	3	"	23
		4	"	17
129.5 / 15.0	VERY DENSE GREY SILTY SAND TRACE CLAY SOME GRAVEL (TILL)	5	"	70
		6	"	>100
		7	"	>100
		7A / 7B	"	>100
		8	"	>100
107.0		9	"	>100
37.5	END OF HOLE			

Additional lab. testing: MH (elev. 130)

Piezometer or standpipe installation (BH4): PROTECTIVE PIPE AND CAP; GROUND SURFACE; PLASTIC TUBING; BACKFILL; BENTONITE SEAL; PIEZOMETER; WATER LEVEL AT ELEV. 145.5 ON NOV. 12, 1968



15 ◊ 5 Percent axial strain at failure (10)

VERTICAL SCALE 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN L.A.A. — CHECKED Y.O.K.

RECORD OF BOREHOLE 5
AND PEN. TESTS 5A & 5B

LOCATION See Figure 1 **BORING DATE** OCT. 11 & 15, 1968 **DATUM** LOCAL

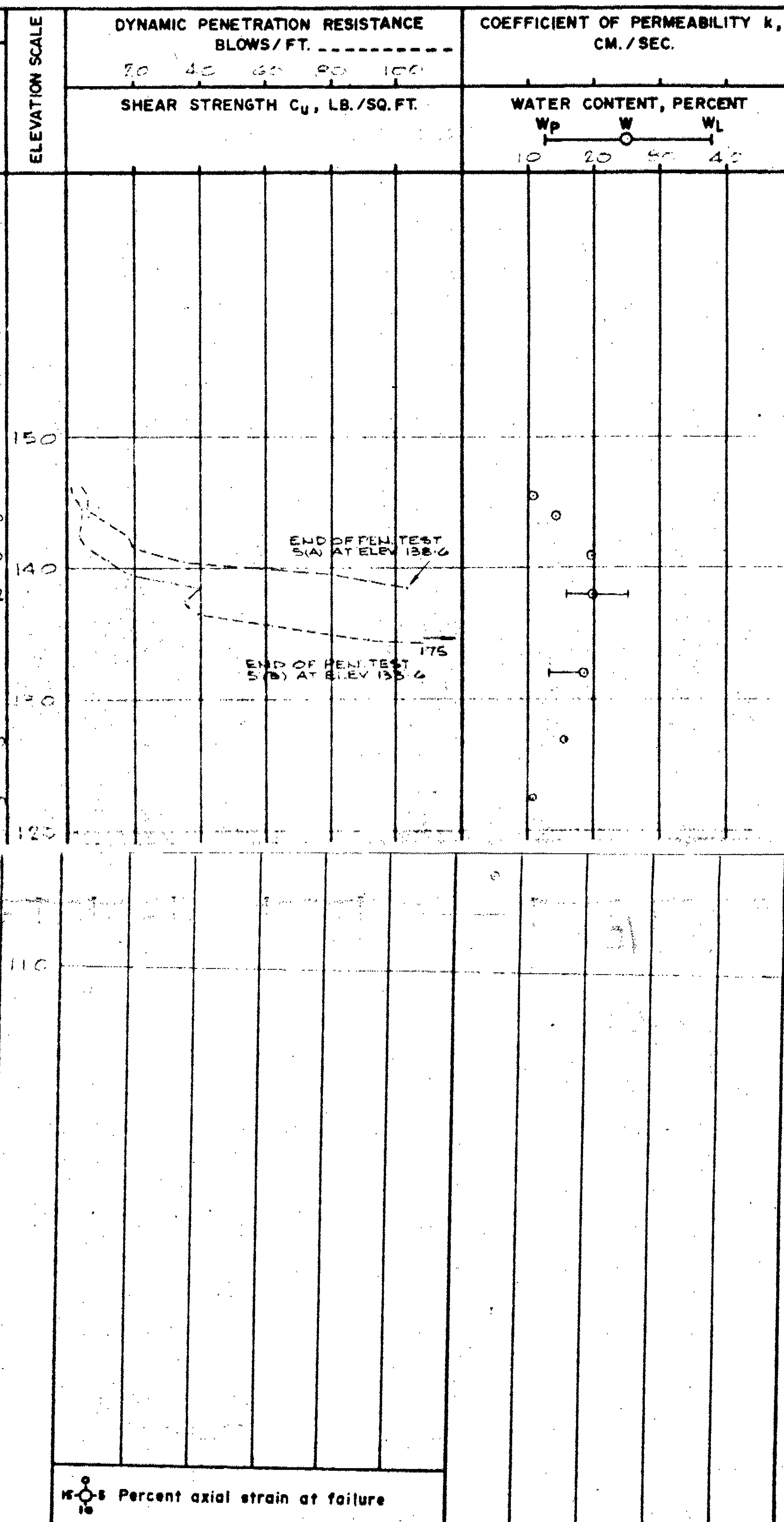
BOREHOLE TYPE WASH BORING **BOREHOLE DIAMETER** NX CASING

SAMPLER HAMMER WEIGHT 140 LB. **DROP** 30 INCHES **PEN. TEST HAMMER WEIGHT** 140 LB. **DROP** 30 INCHES

ELEVN. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
147.6	GROUND LEVEL					PROTECTIVE PIPE AND CAP; GROUND SURFACE
0.0	LOOSE TO COMPACT DARK BROWN **SILTY SAND** OCCASIONAL ROOTS	1	2" D.O.	5		
		2		20		
141.6 / 6.0	VERY STIFF GREY **CLAYEY SILT** SOME SAND AND GRAVEL **(TILL)**	3		20		PLASTIC TUBING
		4		22	MH	STANDPIPE
		5		15		BENTONITE SEAL
127.6 / 20.0		6		>100		BACKFILL
	VERY DENSE GREY **SILTY SAND** TRACE CLAY (TILL)	7		>100		
		8		>100		
112.3 / 35.3	END OF HOLE	9		>100	MH	PIEZOMETER

WATER LEVEL IN PIEZOMETER AT ELEV. 147.1 ON NOV. 12, 1968

WATER LEVEL IN STANDPIPE AT ELEV. 147.1 ON NOV. 12, 1968



Percent axial strain at failure

VERTICAL SCALE 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN L.A.A.

CHECKED Y.O.K.

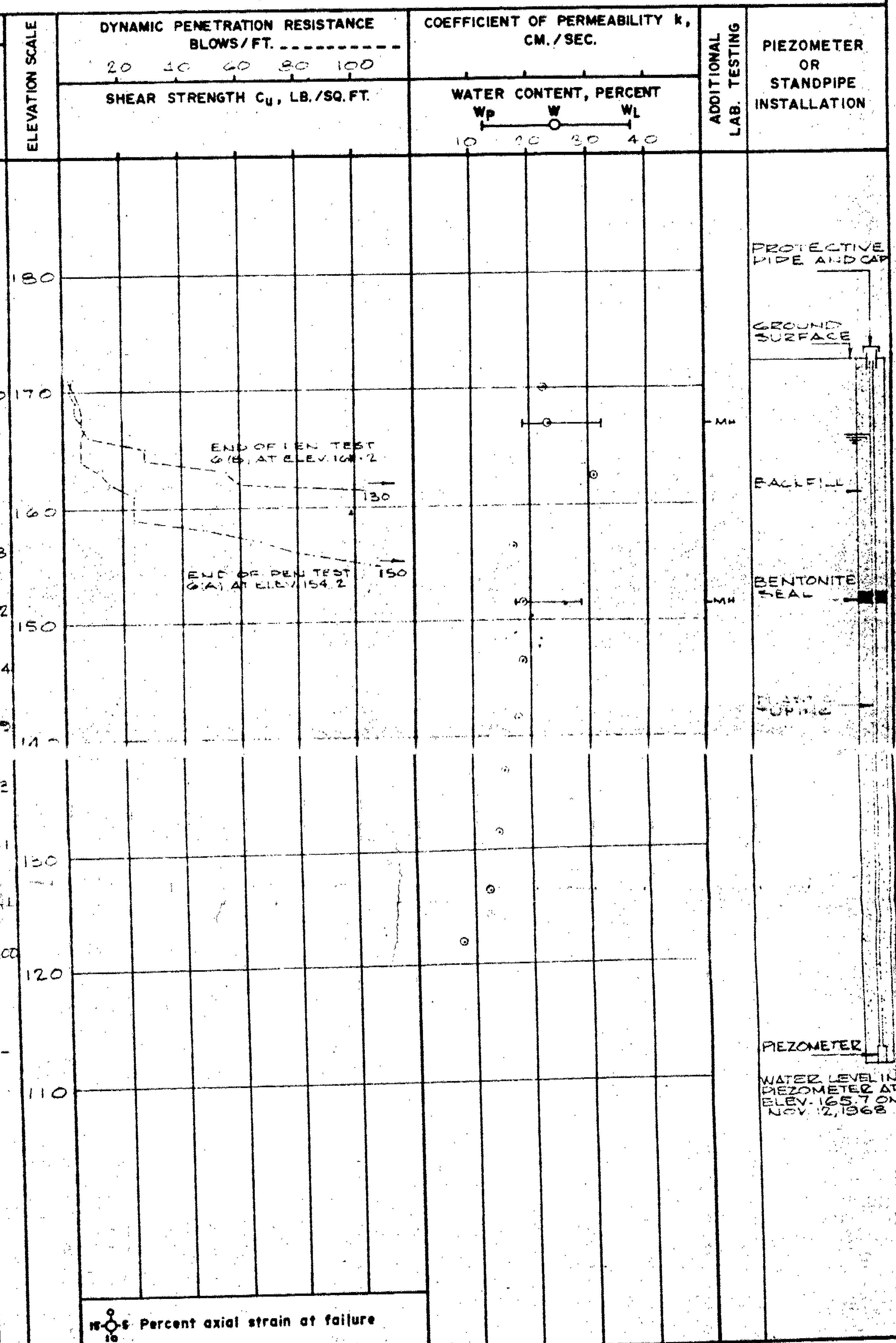
RECORD OF BOREHOLE 6
AND PEN. TESTS 6A & 6B

LOCATION See Figure 1 | BORING DATE OCT. 8-10, 1968 | DATUM LOCAL

BOREHOLE TYPE WASH BORING | BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES | PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
172.2 / 0.0	GROUND LEVEL			
	VERY STIFF LIGHT BROWN STRATIFIED **SILTY CLAY**	1	2" DO	20
		2	"	9
		3	"	11
160.2 / 12.0	VERY STIFF TO HARD GREY **CLAYEY SILT** SOME SAND TRACE GRAVEL **(TILL)**	4	"	18
		5	"	32
		6	"	34
		7	"	39
		8	"	42
		9	"	41
		10	"	41
126.2 / 46.0	VERY DENSE GREY **SILTY SAND** TRACE CLAY SOME GRAVEL (TILL)	11	"	>100
		12	AXT R.C.	-
110.7 / 61.5	END OF HOLE			



VERTICAL SCALE 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN L.A.A.

CHECKED J.D.R.

RECORD OF BOREHOLES 7 & 8

LOCATION See Figure 1 BORING DATE OCT. 22, 1968 DATUM LOCAL

BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5"

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. / SHEAR STRENGTH C_u, LB./SQ.FT.	COEFFICIENT OF PERMEABILITY k, CM./SEC. / WATER CONTENT, PERCENT W_p W W_L (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.					
	BH 7									
	TOPSOIL									PROTECTIVE PIPE AND CAP
238.8	GROUND LEVEL					240				GROUND SURFACE
0.5	STIFF TO HARD BROWN TO RUSTY BROWN MOTTLED **CLAYEY SILT** OCCASIONAL ROOTS		1	2" D.O.	12					
			2	"	36					
230.3			3	"	66	230				
8.5	COMPACT GREY STRATIFIED **SILT** WITH THIN (1/8" TO 1") SEAMS OF CLAYEY SILT		4	"	20					PLASTIC TUBING
			5	"	27				MH	BACKFILL
			6	"	25	220				
213.8										STANDPIPE
212.3	VERY STIFF BROWN **CLAYEY SILT** TRACE SAND AND GRAVEL (TILL)		7		26					
26.5	END OF HOLE					210				WATER LEVEL IN STANDPIPE AT ELEV. 225.8 ON NOV. 12, 1968
	BH 8									
						240				PROTECTIVE PIPE AND CAP
[illegible]	GROUND LEVEL									GROUND SURFACE
0.0	LOOSE RUSTY BROWN SLIGHTLY STRATIFIED FINE TO MEDIUM **SAND**		1	2" D.O.	6					
230.5										
5.5	HARD BROWN TO RUSTY BROWN MOTTLED **CLAYEY SILT**		2	"	34	230				
			3	"	48					PLASTIC TUBING
			4	"	35				MH	
222.0										BACKFILL
14.0	VERY STIFF TO HARD GREY STRATIFIED **CLAYEY SILT** WITH OCCASIONAL LAYERS OF SILT		5	"	18	220				
			6	"	37					
			7	"	22	210				
			8		17					
199.5			9	"	19	200				STANDPIPE
36.5	END OF HOLE									WATER LEVEL IN STANDPIPE AT ELEV. 210.0 ON NOV 12, 1968
						190				

15 ○ 5 Percent axial strain at failure
10

VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

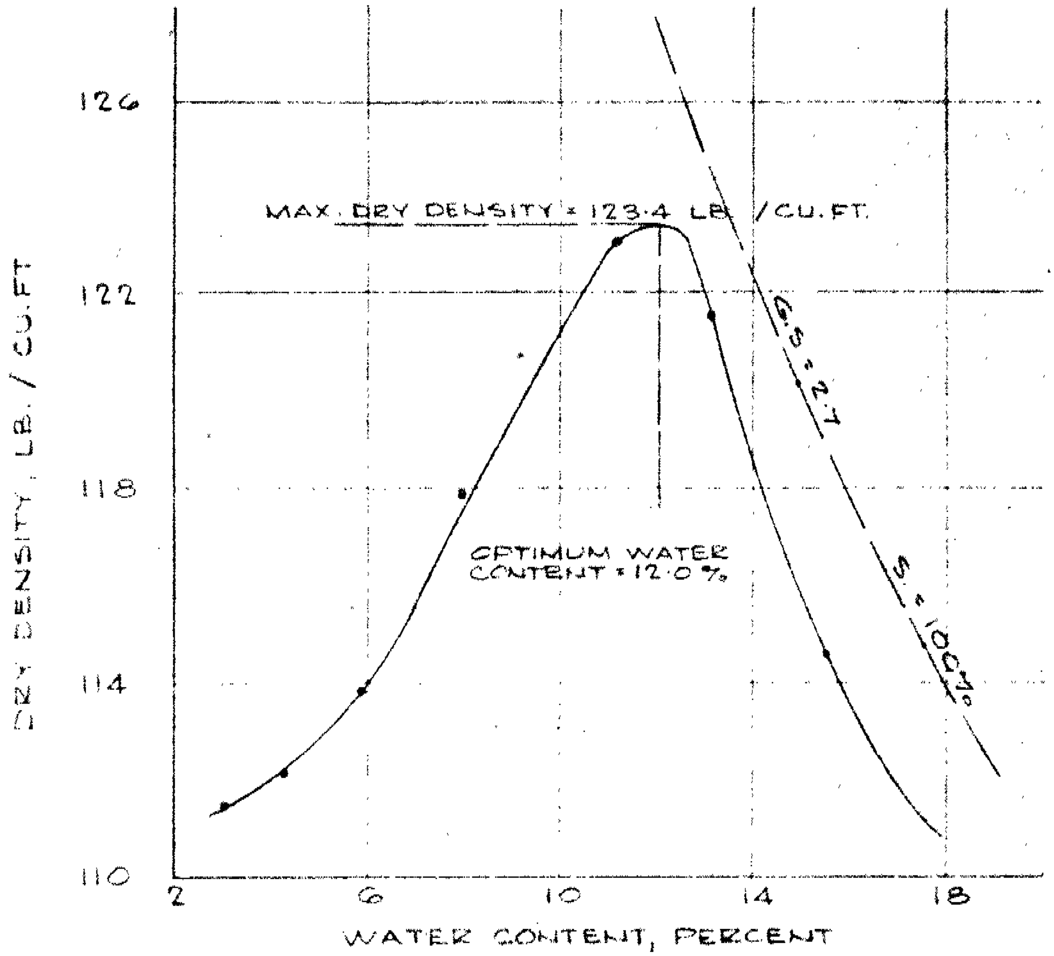
DRAWN ...
CHECKED ...

PROJECT No. G8625

STANDARD PROCTOR COMPACTION TEST

FIGURE 3

GREY SILT, TRACE CLAY



CHUNK SAMPLE (ELEV. 230 TO 214), BOREHOLE No. 7

PROCTOR MAXIMUM DRY DENSITY - 123.4 LB./CU.FT.
OPTIMUM WATER CONTENT - 12.0 %
AVERAGE NATURAL WATER CONTENT - 17.0 %

NOTE :- COMPACTION TEST CARRIED OUT ON MATERIAL PASSING No. 4 SIEVE.

GOLDER & ASSOCIATES

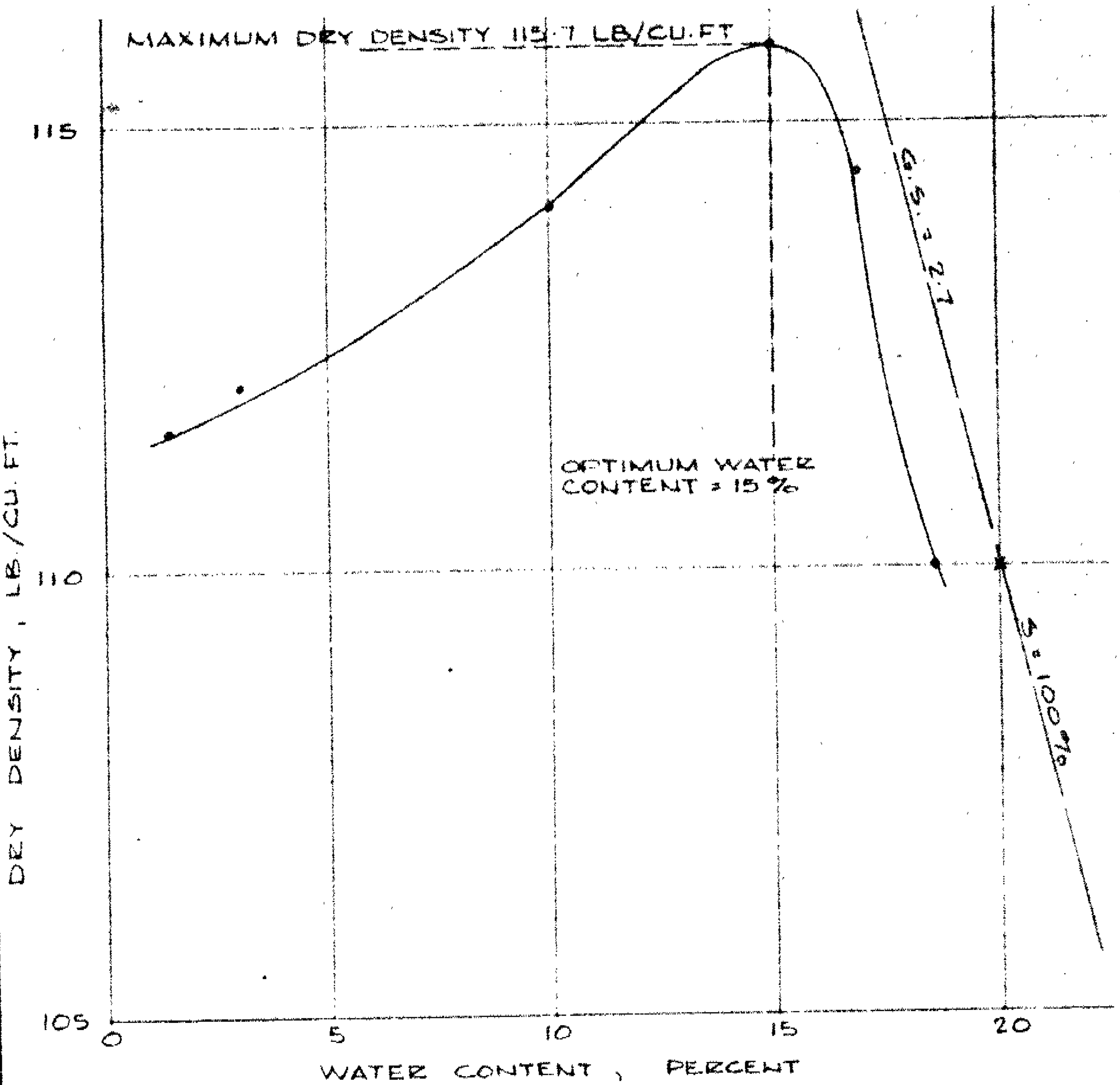
Made LAA
Chkd. [illegible]
Appd. [illegible]

PROJECT No. [illegible]

STANDARD PROCTOR COMPACTION TEST

FIGURE 4

GREY CLAYEY SILT.



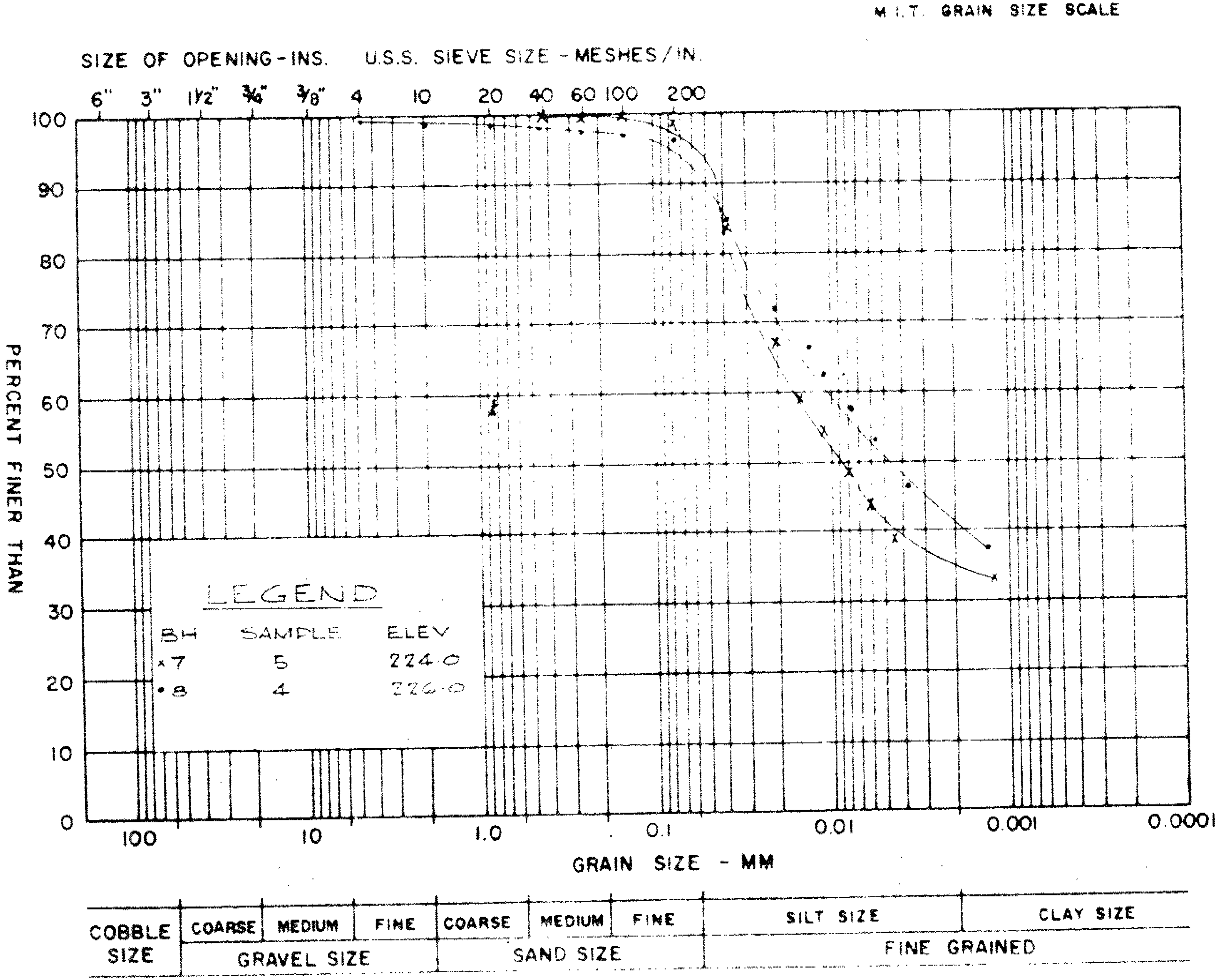
CHUNK SAMPLE (ELEV. 222 TO 215) BOREHOLE No. 8.

PROCTOR MAXIMUM DRY DENSITY = 115·7 LB./CU FT.
OPTIMUM WATER CONTENT = 15 %
AVERAGE NATURAL WATER CONTENT = 15 %

NOTE :- COMPACTION TEST CARRIED OUT ON MATERIAL PASSING No. 4 SIEVE
- FOR GRAIN SIZE DISTRIBUTION SEE FIG. 5

GOLDER & ASSOCIATES

Made [illegible]
Chkd. [illegible]
Appd. [illegible]



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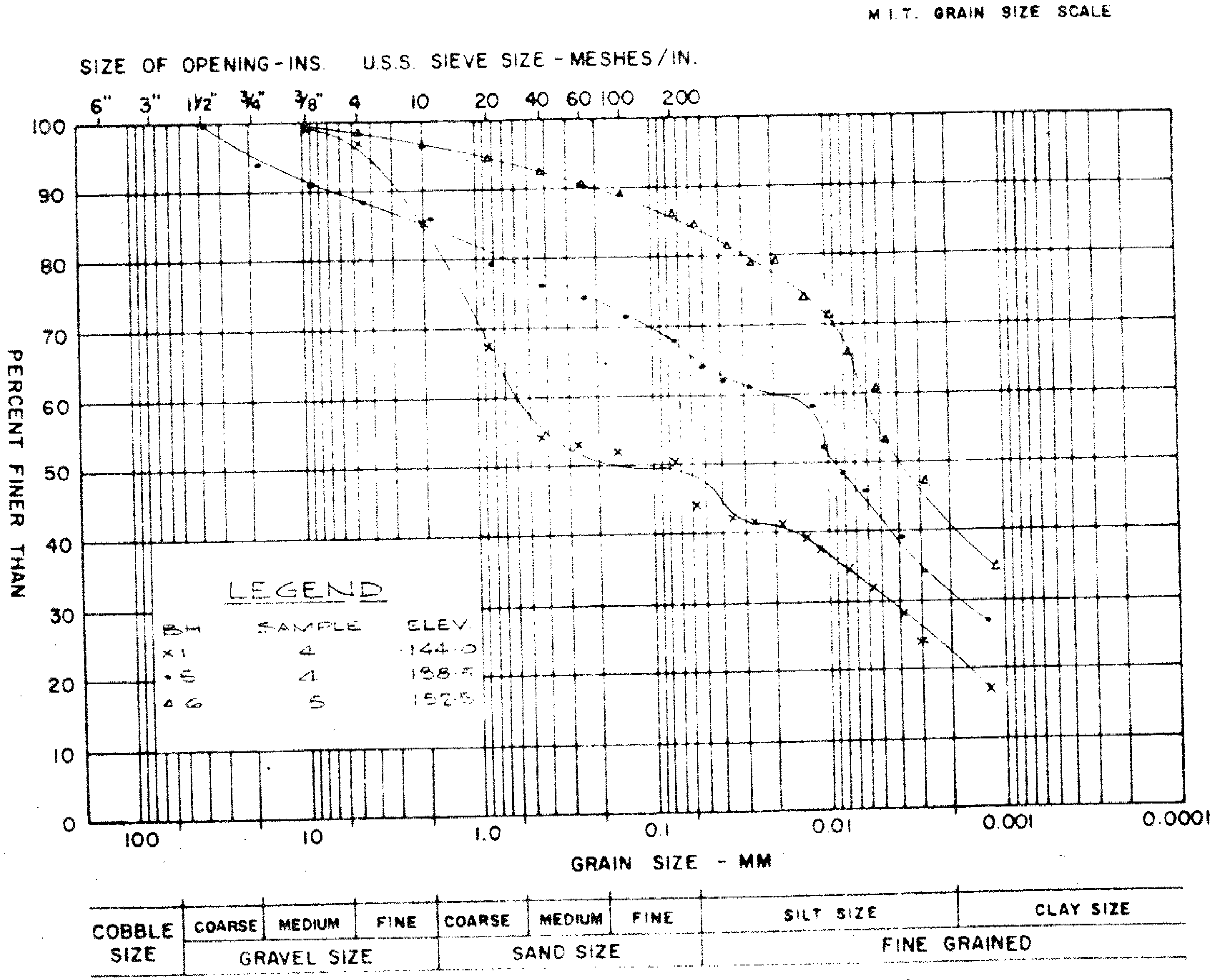
GRAIN SIZE DISTRIBUTION

CLAYEY SILT

FIGURE 5

PROJECT No.



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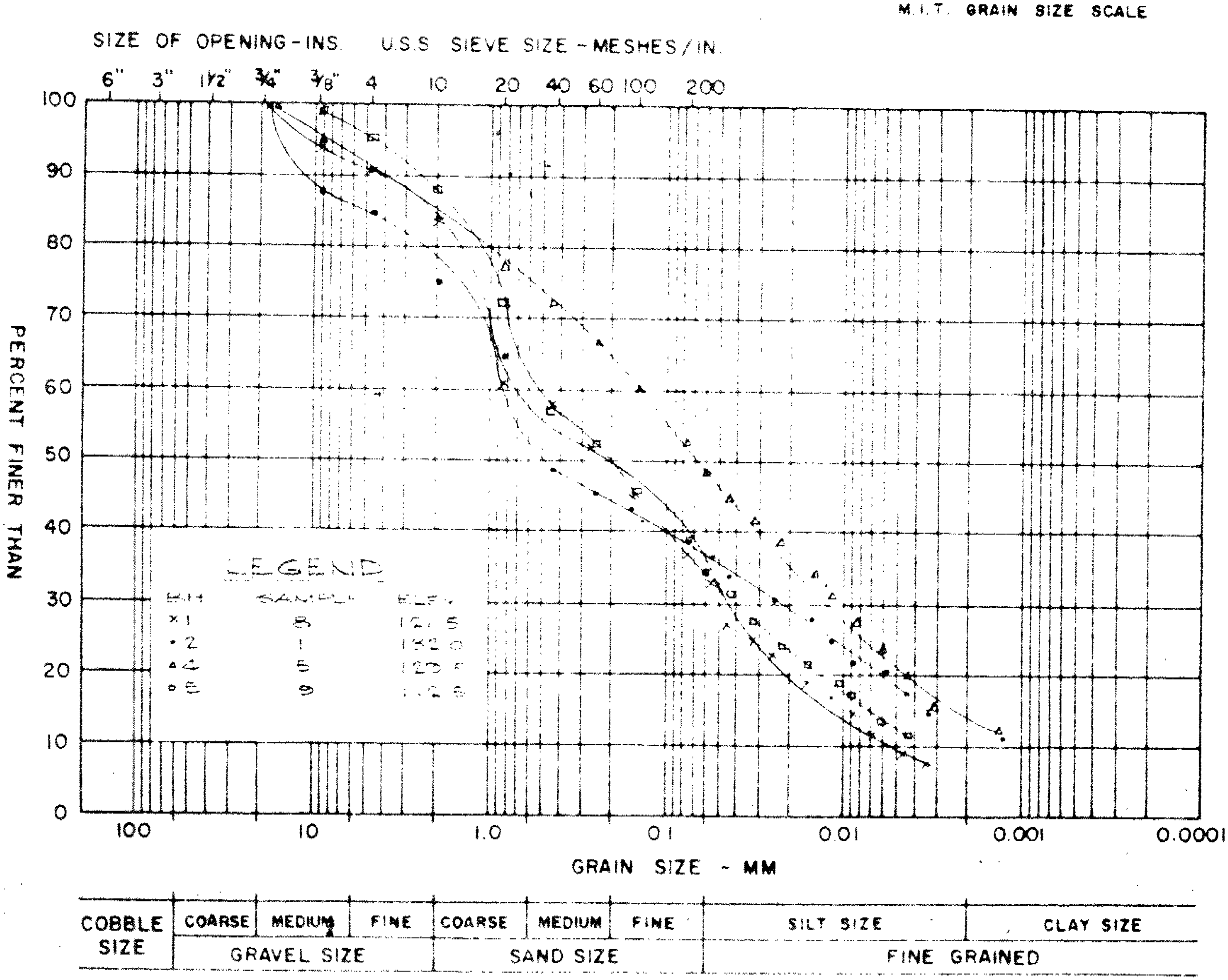
GRAIN SIZE DISTRIBUTION

CLAYEY SILT TO CLAYEY SILT AND SAND (TILL)

FIGURE 6

GOLDER & ASSOCIATES

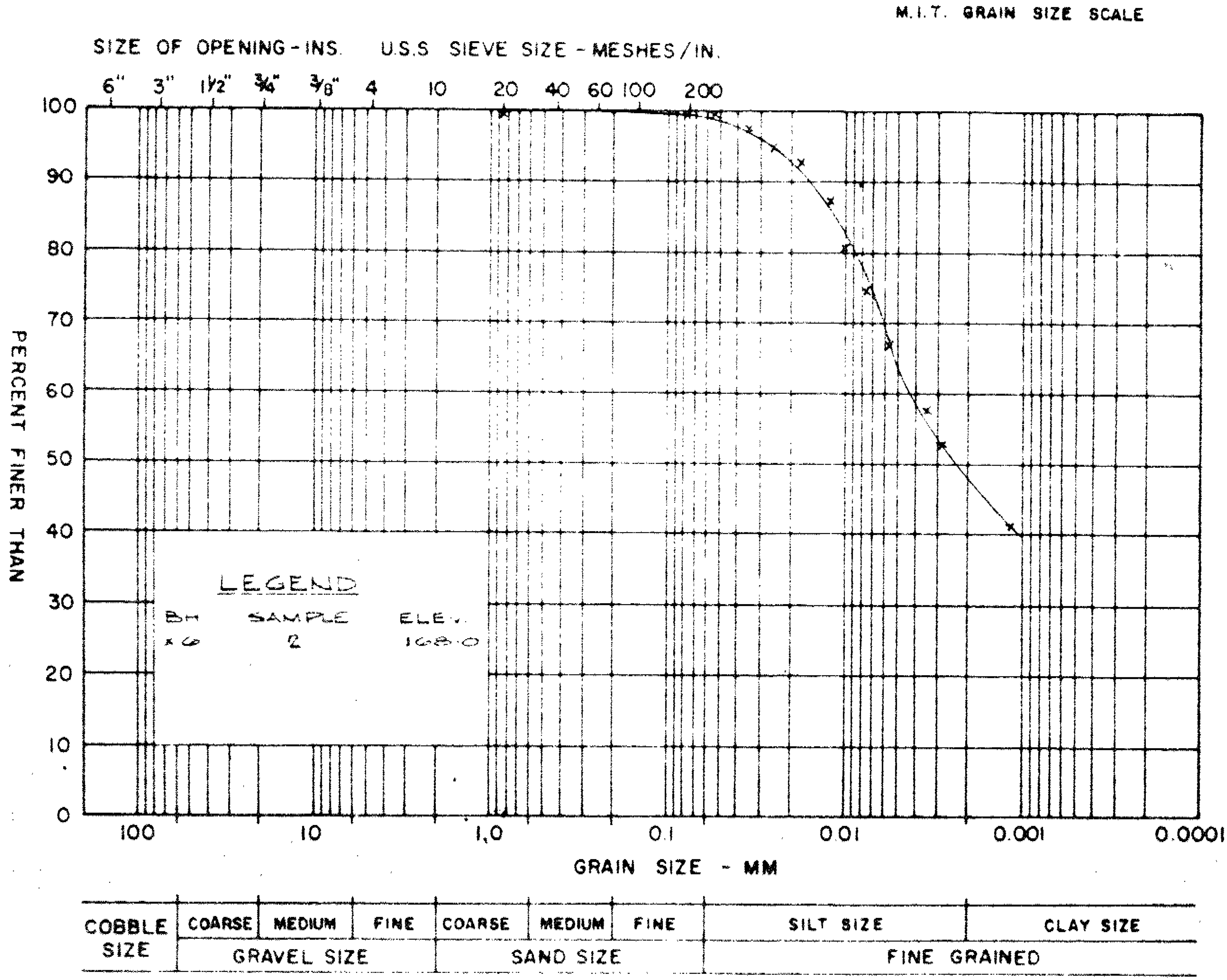


GRAIN SIZE DISTRIBUTION

SILTY SAND (TILL)

FIGURE 7

PROJECT No [illegible]

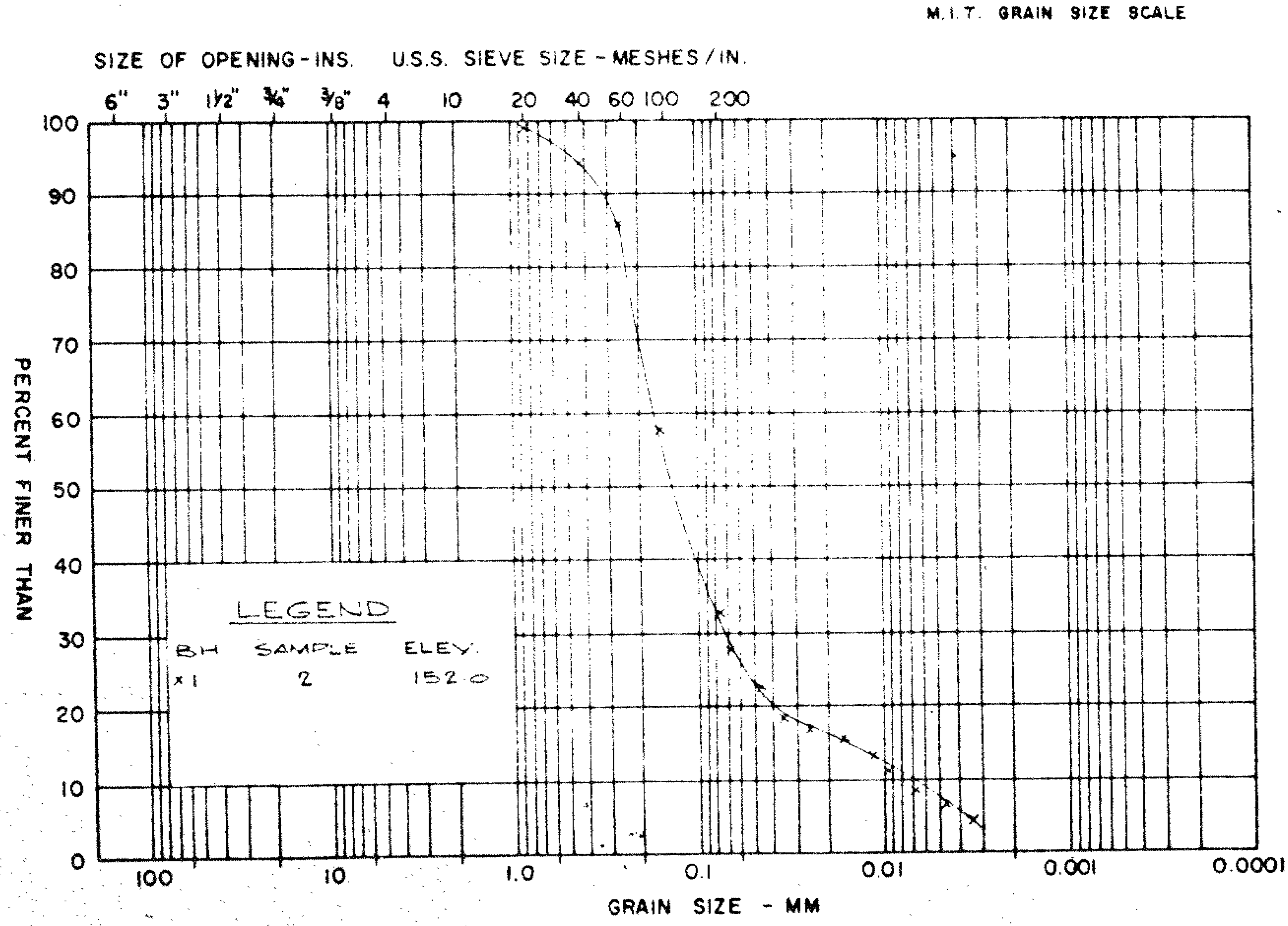


GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIGURE 8



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

SILTY SAND

FIGURE 9

R. C. DUNN AND ASSOCIATES LTD.
CONSULTING ENGINEERS
747 HYDE PARK ROAD
LONDON ONTARIO.

Report on

SOIL INVESTIGATION

for

TROOPS BRIDGE

LOTS 21 & 22, CONCESSION 2

TOWNSHIP OF CARADOC

by

DOMINION SOIL INVESTIGATION LIMITED
369 Queens Avenue
LONDON ONTARIO

Reference No. 6-5-L2
June 2nd, 1966

CONTENTS

ENCLOSURES

I INTRODUCTION

In accordance with a letter of authorization, dated May 12, 1966, a soil investigation has been carried out in the Township of Caradoc where it is proposed to construct a new bridge across the C.N.R. railway.

The structure will be located on Lots 21 and 22, Concession 2 of the Township and is named Troops Bridge.

It is understood that the proposed structure is a 3 span precast concrete girder type with an overall span of about 120 feet. The requirements of the project were discussed with Mr. N. M. Warner, P. Eng., who supplied the foregoing information.

The purpose of this investigation was to reveal the subsurface conditions at the site and to determine the relevant soil properties for the design and construction of the bridge foundations.

II FIELD WORK

The field work, consisting of 2 boreholes, was carried out during the period May 11 to 13, 1966, at the locations shown on Enclosure 2. The holes were advanced by washboring methods, and were lined with Bx casing.

Standard Penetration Tests using a 2-inch outside diameter split-spoon sampler were performed at frequent intervals of depth, using a driving force of a 140 lb. hammer falling freely through 30-inches. The tube is first driven an initial 6-inches to allow for the presence of disturbed material at the bottom of the borehole. The number of standard blows required to drive the sampler a further 12-inches was recorded as the standard penetration resistance (or 'N' value). This test determines the relative density of granular strata and gives an indication of the consistency of cohesive strata. It also enables samples to be obtained for classification purposes.

The results of the field tests are presented on the Geotechnical Data Sheets, Enclosures 3 and 4. Elevations were referred to the top of rail at the centre line of the bridge, El. 810.63 feet.

III SUBSURFACE CONDITIONS

Detailed descriptions of the strata encountered in each borehole are given on the Geotechnical Data Sheets, comprising Enclosures 3 and 4, and a general picture of the soil stratigraphy is given in the form of a Subsurface Profile on Enclosure 2.

Both boreholes encountered loose sandy and clayey silt deposits which extend from the ground surface to a depth of 4.5 feet. These deposits are probably fill material which was excavated during construction of the railway cut at this section of the track.

Natural subsoil was encountered at El. 814± in both boreholes and consists of sandy silt soil down to the limit of the boreholes at a depth of 35 feet. Grain size analyses of this stratum, which are plotted on Enclosures 5 and 6, indicate that the soil consists of 75% medium to coarse silt and 25% fine sand. The relative density of the stratum is estimated to be 'dense' to 'very dense' based on standard penetration test results ranging from 26 blows per foot to refusal values of 100 blows for less than 1 foot penetration of the sampler.

The colour of the silt stratum changes from brown to grey at El. 790±, and indicates that the low summer water table is at about this elevation. The water levels observed in the boreholes can be attributed partly to washwater used in the boring operation and partly to the excessive rainfall prior to commencement of the drilling.

IV DISCUSSION

It is understood that the bridge will have three spans of about 40 feet supported by piers on spread footings at each side of the track and abutments supported on either piles or spread footing foundations.

Piers

The top of the rail is at El. 810.63, therefore the pier footings will be supported at about El. 805 to provide sufficient cover for frost protection. This elevation lies within the stratum of dense sandy silt and on the basis of the borehole results, a maximum allowable soil pressure of 8000 p.s.f. may be used in the design of footings. Total settlement of footings mobilizing the above soil pressure is estimated to be less than 1/2 inch.

Abutments

The abutments may be supported on spread footings at or below El. 813 using a maximum allowable soil pressure of 8000 p.s.f. Total settlement of footings mobilizing the above soil pressure is estimated to be less than 3/4 inch.

Alternatively stub abutments may be supported on piles driven into the very dense sandy silt stratum. It is estimated that concrete filled steel tube piles will develop their full working load when driven into the very dense sandy silt material, therefore the depth of penetration will depend on the length of embedment required for lateral support. Also, due to the very dense nature of the subsoil, it may be necessary to use jetting or pre-augering to achieve the required depth of penetration.

For preliminary design purposes, it is estimated that 10-inch and 12-inch diameter steel tube piles will develop working loads of 40 and 50 tons respectively. In practice the piles should be driven to a satisfactory set in accordance with a recognised dynamic pile driving formula.

Construction

The sandy silt subsoil is susceptible to disturbance by the 'pumping' action of heavy equipment. It is therefore recommended that excavations be carried out by a back-hoe type of machine in order to keep disturbance to a minimum. The footing grade should be inspected to confirm that no loose or disturbed soil is present.

Yours very truly,

DOMINION SOIL INVESTIGATION LIMITED

REGISTERED PROFESSIONAL ENGINEER
C.J.W. ATKINSON
PROVINCE OF ONTARIO

C.J.W. Atkinson, M.Sc., P.Eng.,
Branch Manager

CJWA:jms

Enclosures

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.

BOULDER	COBBLE	GRAVEL		SAND			SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
		COARSE	FINE	COARSE	MEDIUM	FINE						
ø > 8"	3"	3/4"	4.76mm	2.0	0.42	0.074	0.002 >		NO SIZE LIMIT			

U.S. Standard Sieve Size: No.4 No.10 No.40 No.200

SAMPLE TYPES.

AS	Auger sample	RC	Rock core	TP	Piston, thin walled tube sample
CS	Sample from casing	%	Recovery	TW	Open, thin walled tube sample
ChS	Chunk sample	SS	Split spoon sample	WS	Wash sample

SAMPLER ADVANCED BY static weight : w
" pressure : p
" tapping : t

OBSERVATIONS MADE WHILE CORING: Steady pressure; No pressure; Intermittent pressure; Washwater returns; Washwater lost

PENETRATION RESISTANCES.

SYMBOL:

DYNAMIC PENETRATION RESISTANCE : to drive a 2"ϕ, 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

STANDARD PENETRATION RESISTANCE, -N- : to drive a 2" outside dia, split spoon sampler 1 foot into the ground, expressed in blows per foot.

EXTRAPOLATED -N- VALUE — 322

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

SOIL PROPERTIES.

W %	Water content	γ	Natural bulk density (unit weight)	k	Coeff. of permeability
LL %	Liquid limit	e	Void ratio	C	Shear strength — in terms of total stress
PL %	Plastic limit	RD	Relative density	ϕ	Angle of int. friction — in terms of total stress
PI %	Plasticity index	C_v	Coeff. of consolidation	C'	Cohesion — in terms of effective stress
LI	Liquidity index	m_v	Coeff. of volume compressibility	ϕ'	Angle of int. friction — in terms of effective stress

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —

TRIAXIAL COMPRESSION TEST ◉ — UNCONFINED COMPRESSION TEST ● St — LABORATORY VANE TEST X St — FIELD VANE TEST + St — POCKET PENETROMETER TEST ▼ St

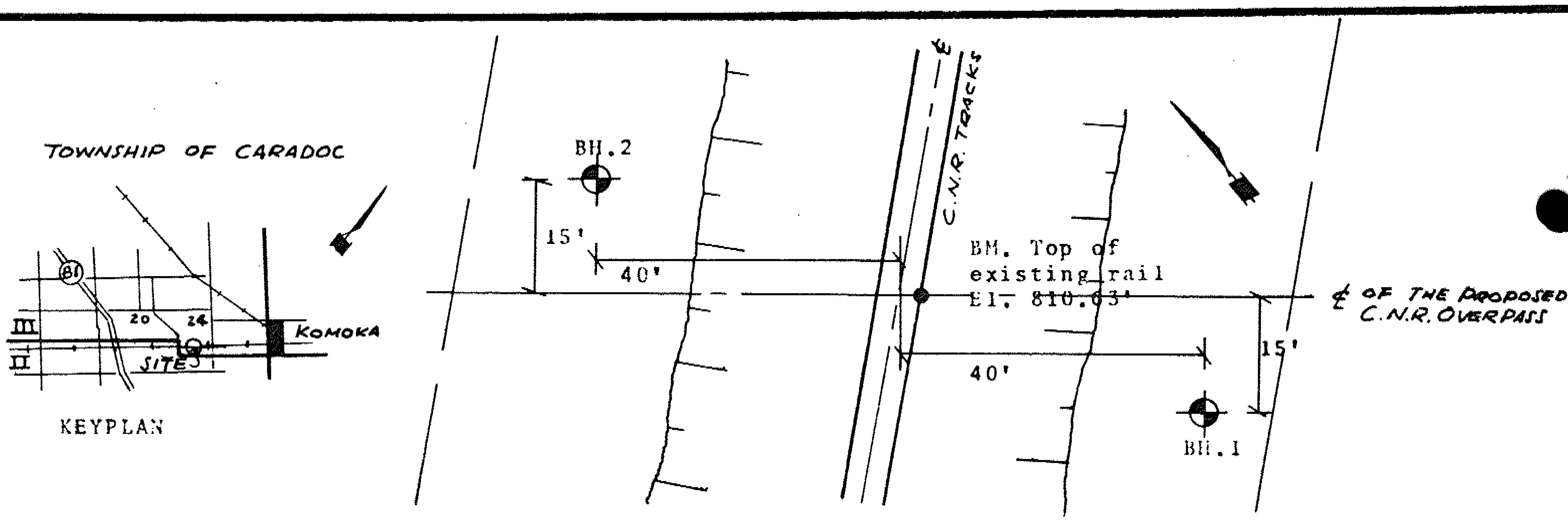
Strain at failure is represented by direction of stem: 20% (up), 5% (right), 10% (down), 15% (left)

St : sensitivity = $\frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$

SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :
Very loose	0 – 15 %
Loose	15 – 35 %
Compact	35 – 65 %
Dense	65 – 85 %
Very dense	85 – 100 %

COHESIVE SOILS :	C lbs/sq.ft.
Very soft	less than 250
Soft	250 – 500
Firm	500 – 1000
Stiff	1000 – 2000
Very stiff	2000 – 4000
Hard	over 4000



LOCATION OF BOREHOLES

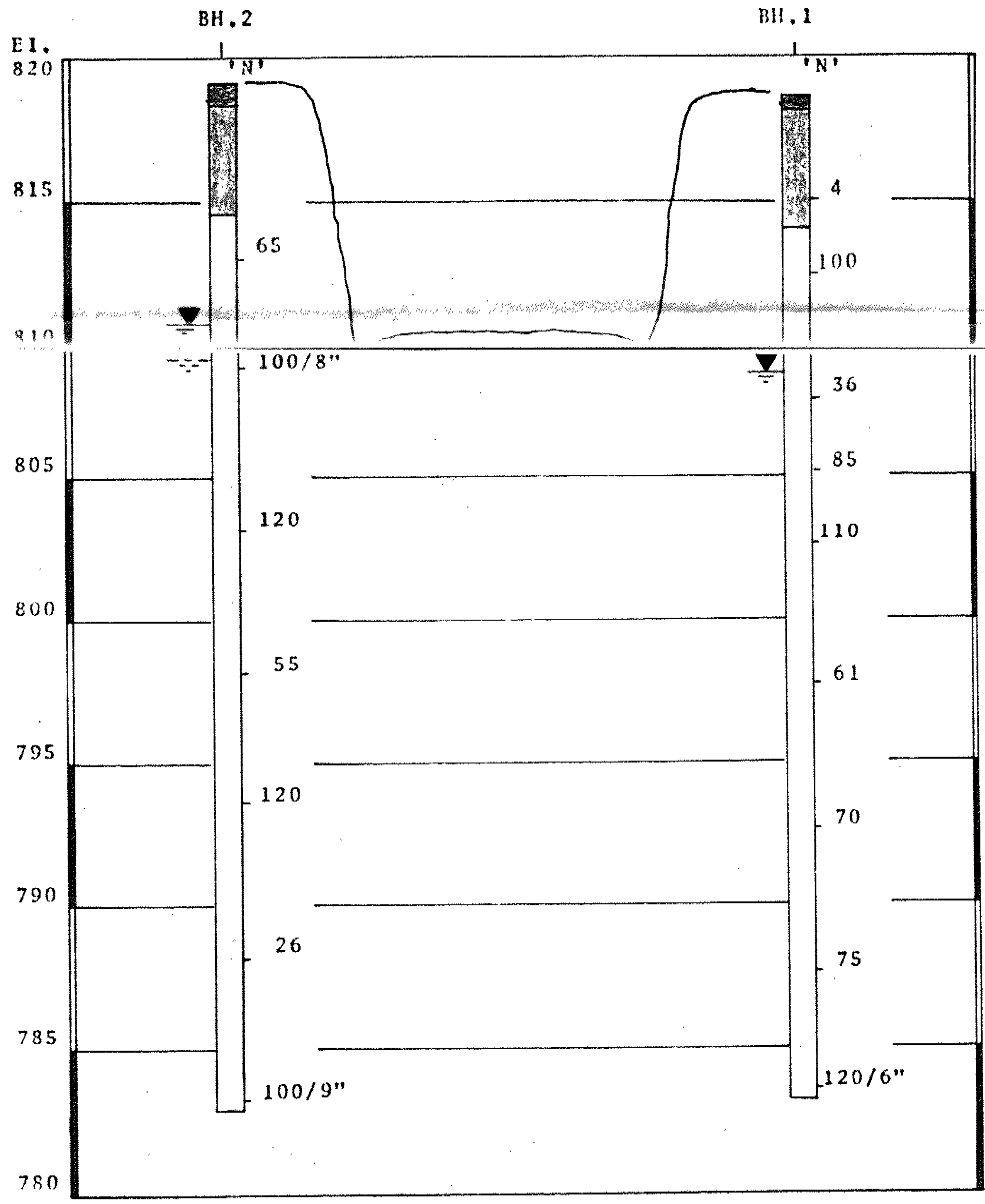
Scale 1-inch to 20 feet

LEGEND

Topsoil

Loose Clayey Silt

Dense to very dense Silt with a little fine sand



SUBSURFACE PROFILE
Vert. Scale 1-inch to 5 feet

GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 1 . . .

OUR REFERENCE NO. 6-5-L2

CLIENT: R. C. Dunn & Associates
PROJECT: Troops Bridge
LOCATION: Township of Caradoc
DATUM ELEVATION:

METHOD OF BORING: Washboring
DIAMETER OF BOREHOLE: Bx (3-inch)
DATE: May 13, 1966

ENCLOSURE NO. 3

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	N or Advancement of Sampler	PENETRATION RESISTANCE blows per foot (20 40 60 80 100) / SHEAR STRENGTH lbs/sq ft	CONSISTENCY water content % (PL W LL)	REMARKS
818.2	0.0	Ground Surface						
	0.5	Topsoil						
815		Loose brown clayey sandy	1	SS	4			
	4.5	silt.						
		Dense	2	SS	100			
810		to						W. L. El.808.2 May 13, 1966
		very dense	3	SS	36			
805		brown	4	SS	85			
		medium to	5	SS	110			
800		coarse						
		silt, with	6	SS	61			
795		a						
		little fine	7	SS	70			
790		sand.						
		grey	8	SS	75			
785								
	35.5		9	SS	120/ 6" (140)			
		End of Borehole						

VERTICAL SCALE: 1 IN TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE

CH'D:

OUR REFERENCE NO. 6-5-L2

GEOTECHNICAL DATA SHEET FOR BOREHOLE ..2....

CLIENT: R. C. Dunn & Associates
PROJECT: Troops Bridge
LOCATION: Township of Caradoc
DATUM ELEVATION:

METHOD OF BORING Washboring
DIAMETER OF BOREHOLE Bx (3-inch)
DATE: May 11 & 12, 1966

ENCLOSURE NO. 4

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	SAMPLES NUMBER	TYPE	—N— or Advancement of Sampler	PENETRATION RESISTANCE blows per foot (20 40 60 80 100) / SHEAR STRENGTH lbs/sq ft	CONSISTENCY water content % (PL W LL)	REMARKS
819.1	0.0	Ground Surface						
	0.8	Topsoil						
815	4.5	Brown clayey silt, trace of organics						
		Dense to very dense brown medium to coarse silt, with a little fine sand.	1	SS	65	o		
810								W. L. El. 810.9
			2	SS	100/ 8"	o		Cave-in El. 809.1 May 13, 1966
805								
			3	SS	120	o		
800								
			4	SS	55	o		
795								
			5	SS	120	o		
790		grey						
			6	SS	26	o		
785								
	36.3		7	SS	100/ 9"	o		
		End of Borehole						

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

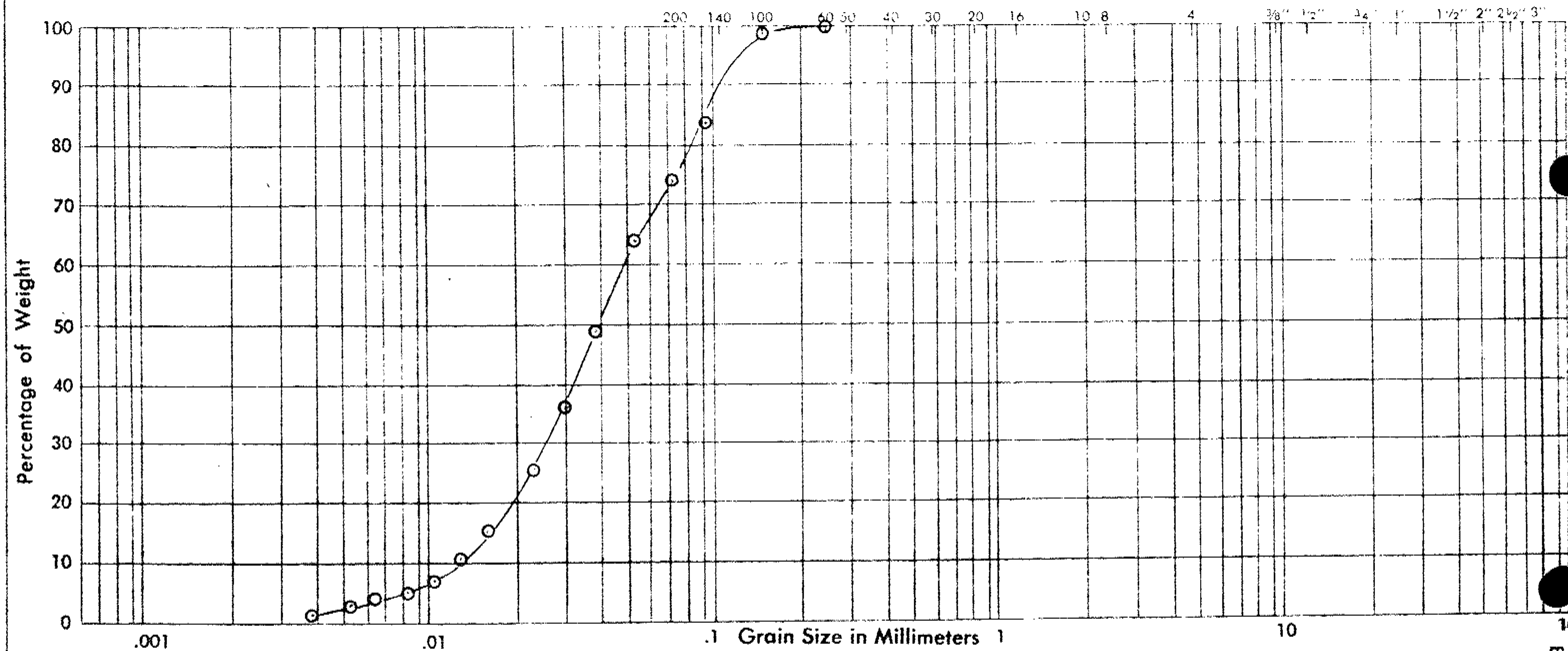
MADE: CH'D:

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 6-5-L2

UNIFIED SOIL CLASSIFICATION SYSTEM	SILT AND CLAY	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



PROJECT: Troops Bridge
LOCATION: Twp. of Caradoc
BOREHOLE NO.: 1
SAMPLE NO.: 2
DEPTH OF SAMPLE: 5 feet
ELEVATION OF SAMPLE: 813

COEFFICIENT OF UNIFORMITY 3.5
COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
MEDIUM TO COARSE SILT WITH A LITTLE FINE SAND

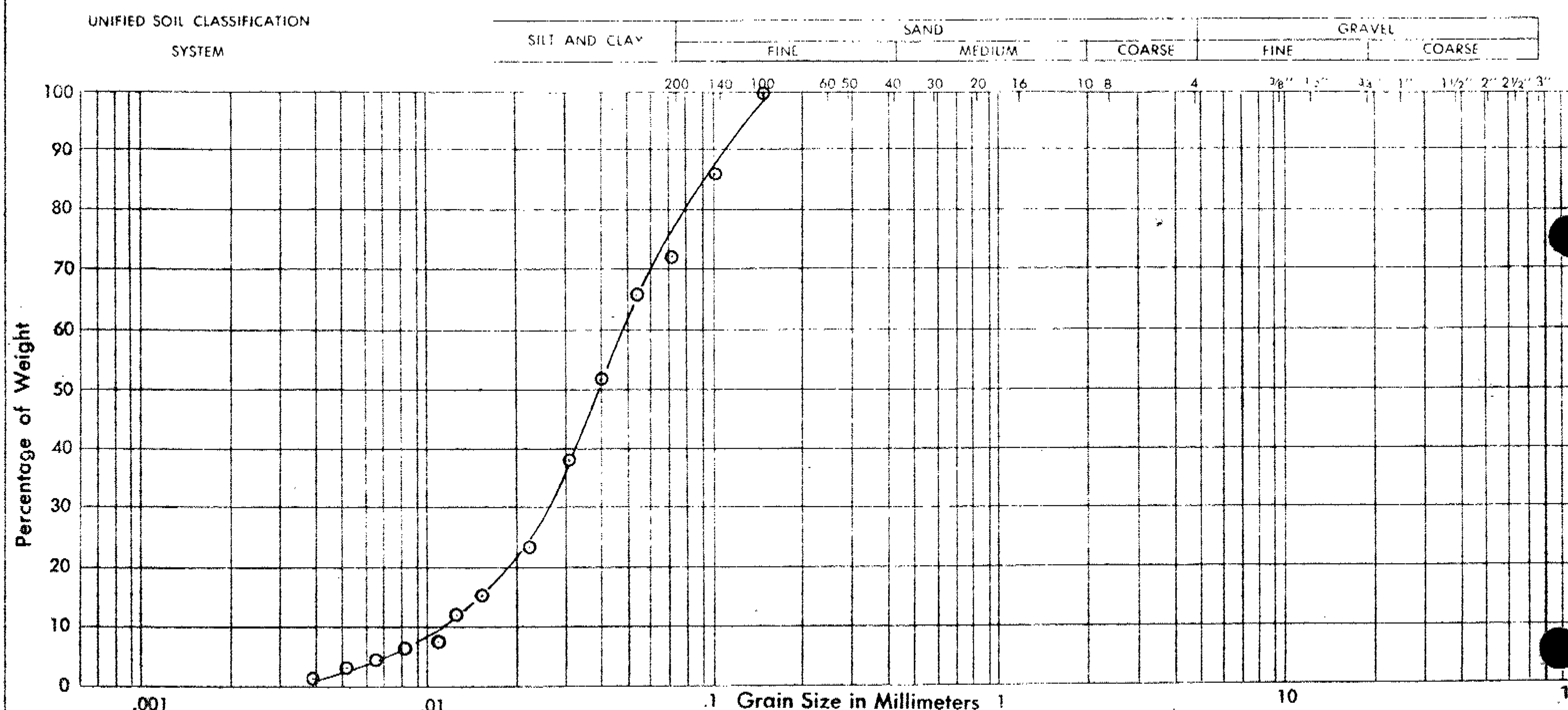
PLASTIC PROPERTIES:
LIQUID LIMIT % =
PLASTIC LIMIT % =
PLASTICITY INDEX % =
MOISTURE CONTENT % -
ACTIVITY

Enclosure No.

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-5-L2



Enclosure No. 6

PROJECT: Troops Bridge
LOCATION: Twp. of Caradoc
BOREHOLE NO.: 2
SAMPLE NO.: 1
DEPTH OF SAMPLE: 5 feet
ELEVATION OF SAMPLE: 814

COEFFICIENT OF UNIFORMITY 4
COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
MEDIUM TO COARSE SILT WITH A LITTLE FINE SAND.

PLASTIC PROPERTIES:

LIQUID LIMIT	%	—
PLASTIC LIMIT	%	—
PLASTICITY INDEX	%	—
MOISTURE CONTENT	%	—
ACTIVITY		

F.F.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: I. Ardizone
Senior Feasibility Planner
Feasibility Studies Office
East Building, Downsview

ATTENTION: N. M. Upton
Feasibility Planner

OUR FILE REF.

FROM: Foundations Office
Design Services Branch
West Building, Downsview

DATE: November 6, 1973

IN REPLY TO

SUBJECT: HWY. 402 FEASIBILITY STUDY

W.O. 73-11085 W.P. 40-66-00

We have recently completed our field investigation for the above project. As discussed with you, we are submitting a brief site and subsoil description and our tentative recommendations relating to the foundations, cuts and fills for each site.

For preliminary design or estimate purposes the following assumptions may be made:

1. Allowable bearing capacity for spread footings - 2 tons/square feet.
2. Allowable bearing capacity for friction piles - 25 tons/pile.
3. Allowable bearing capacity for end bearing steel piles-maximum allowable for the section chosen.
4. Granular blanket is 18 inches in thickness.

We believe that this will enable you to proceed with your design and evaluation work. A set of log sheets will be forwarded to you as soon as they are finalized. One complete report will follow in due course. If you need further information, please do not hesitate to contact this office.

ROUTE 'D' & COUNTY ROAD 39 (BOREHOLE #11)

Site

The borehole was put down in the middle of a low lying swamp on the north-west side of Middlesex County Road 39. The road crosses this swamp and is about 8 feet higher than the surrounding ground level.

Subsoil (Ground elevation 746.0 feet)

0 - 6 feet	Muck and highly organic silt, very soft
6 - 13 feet	Fine sand, very loose to compact
17 - 25 feet	Silty sand, compact to very dense

Water level is at ground surface.

....2

Recommendations

If it is decided to carry the proposed Hwy. 402 over County Road 39, all organics for the entire width and length (approximately 1500 feet) of the embankment crossing the swamp should be excavated and replaced with granular material. Embankment built with 2:1 side slopes should be stable. The proposed structure may be supported on spread footings placed within the approach fills, or on short piles driven through the fill to about 30 feet below the present swamp level.

The same recommendations are applicable, if the County Road is raised and is carried over the proposed Hwy. 402. However, all organics under the alignment of Hwy. 402 should be removed in this case also.

If it is decided to depress either the proposed Hwy. 402 or the County Road at this location, then a permanent dewatering scheme will be required and all cut slopes will have to be covered with granular blankets. This is necessary because of the relatively high ground water level and the permeable nature of the subsoil.

ROUTE 'H' & SYDENHAM RIVER (BOREHOLE #10)

Site

The borehole was put down on the west side of the Sydenham River immediately to the east of the river, the land rises at 2:1 or steeper slopes to approximately 30 feet above the river. On the west side the land rises very gradually, the river at the time of the investigation was 2-3 feet deep and about 15 feet wide.

Subsoil (Ground elevation 747.3 feet)

0 - 22 feet	Fine sand, loose
22 - 25 feet	Fine sand, compact
25 - 55 feet	Fine sand to silt, dense to very dense
55 - 114 feet	Clayey silt, very stiff

Water level was 4 feet below the ground surface.

Recommendations

No hard, end bearing stratum was encountered to a depth of 114 feet below the ground, where the borehole was terminated. The upper 22 feet of the subsoil is not suitable for spread footings. The proposed structure may therefore, be supported on:

1. spread footings within the approach fills
or 2. timber piles driven 40 feet into the original ground
or 3. long end bearing steel piles (more than 120 feet long)

No stability problems are anticipated for 2:1 side and forward slopes of the fills.

ROUTE 'D' & HWY. 81 (BOREHOLE #9)

Site

The borehole was placed on the west shoulder of Hwy. 81. The surrounding area is flat to gently rolling and is cultivated.

....3

Subsoil (Ground elevation 800.6 feet)

0 - 5 feet	Fine sand, fill
5 - 10 feet	Silt, compact
10 - 25 feet	Silt, very dense
25 - 28 feet	Fine sand, very dense
28 - 30 feet	Coarse sand, gravel

Water level is estimated to be at 5 feet below the ground surface.

Recommendations

The proposed structure may be supported on spread footing type foundations, founded in the original ground. A dewatering scheme will be necessary to pour the concrete in the dry, and because the subsoil is likely to "boil" under an unbalanced hydrostatic head.

No stability problems are foreseen for fill or cuts with 2:1 side or forward slopes. However, if it is decided to depress either the highway or the freeway, then the cuts must be blanketed with granular material and a permanent dewatering and drainage scheme will be required.

ROUTE 'H' & COUNTY ROAD 14 AND CNR TRACKS (BOREHOLE #7)

Site

The borehole was put down on the south (or east) shoulder of the County Road 14.

Subsoil (Ground elevation 813.8 feet)

0 - 15 feet	Sand, loose
15 - 30 feet	Sand, dense to very dense
30 - 110 feet	Silt, compact to dense
110 - 131 feet	Silt, very dense

Water level at 17 feet below the ground surface.

Recommendations

The proposed overpass or overhead structure may be supported on either of the following:

1. spread footings in the fill
2. spread footings 15 feet below the ground surface
3. perched abutments supported on friction files driven through the fill and about 40 feet into the original ground.

No stability problems are foreseen for 2:1 forward and side slopes.

The proposed underpass or subway structure may be supported on spread footins founded in the original ground.

No stability problems are foreseen for 2:1 cut slopes. A granular blanket and a permanent drainage scheme will be required for cuts below the ground water level.

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ROUTE 'M' & HWY. 81 (BOREHOLE #14)

Site

The borehole was put down on the north shoulder of Hwy. 81 and west of the Thames River valley.

Subsoil (Ground elevation 762.5 feet)

0 - 13 feet	Sand, loose to compact
13 - 34 feet	Clayey silt, stiff to very stiff
34 - 44 feet	Clayey silt to silt, stiff to very stiff
44 - 54 feet	Sandy silt to silty sand, dense
54 -111 feet	Clayey silt to silt, very stiff
111 - feet	Till very dense

Water level is at 9 feet below the ground surface.

Recommendations

It is proposed to depress the freeway Route 'M' under Hwy. 81 at this place. The underpass structure may be supported on spread footings placed in the original ground or on end bearing steel piles driven to about 120 feet below the present ground level.

No stability problems are anticipated for 2:1 side slopes of the cut sections. It is felt that the cut sections may lower the ground water level below the sand layer. However, if the water level cannot be sufficiently lowered or if numberous silt seams are encountered in the clayey silt deposit, then it may be necessary to provide a granular blanket and a permanent drainage scheme.

ROUTE 'M' & THAMES RIVER FLOOD PLAIN (BOREHOLE #13)

Site

The borehole was put down about 600 feet south of Hwy. 2 in the Thames River Flood Plain.

Subsoil (Ground elevation 682.0 feet)

0 - 13 feet	Fine sand, loose to very loose
13 - 60 feet	Clayey silt, very stiff
60 - 80 feet	Till, very dense

Recommendations

It is proposed to cross the Thames River Flood Plain by constructing an embankment across it. The subsoil appears to be competent to support fills, up to 30 feet in height and with 2:1 side slopes. The upper 13 feet of subsoil is loose to very loose, fine sand which should compact under the weight of fills.

ROUTE 'L' & 'M' & THAMES RIVER (BOREHOLE #2)

Site

This borehole was put down on top of the east bank of the Thames

....5

River. At this location, Route 'L' splits off from Route 'M' after Route 'M' has crossed the Thames River Flood Plain. The east bank is about 50 - 60 feet high and the natural slopes are 2:1 or steeper.

Subsoil (Ground elevation 724.5 feet)

0 - 7 feet	Sand, compact
7 - 32 feet	Clayey silt, very stiff
32 - 47 feet	Silt, compact
47 - 66 feet	Clayey silt, very stiff
66 - 70 feet	Till, very dense

Water level is at 45 feet below the ground surface.

Recommendations

The proposed structure at this location would probably require cuts on the east bank and fills on the west bank.

The entire structure may be supported on end bearing steel piles driven into till layer to approximate elevations 640 - 650 feet. As an alternative, the east abutment may be founded on spread footings in the original ground, and the west abutment may be founded on spread footings placed within the approach fills.

No stability problems are foreseen for 2:1 forward and side slopes.

ROUTE 'M' & THAMES RIVER BANKS (BOREHOLE #3)

Site

This borehole was put down on top of the east bank of the Thames River, which meanders at this location. East of the borehole, the land is used for farming, and because of drainage tiles the upper portion of the bank is always in a wet condition.

Subsoil (Ground elevation 721.6 feet)

0 - 4 feet	Silty sand
4 - 53 feet	Clayey silt (with silt layers), very stiff
53 - 57 feet	Till, very dense

Water level is at 25 feet below ground surface.

Recommendations

At this site, the proposed Route 'M' runs along the river bank, which is about 50 feet high, and may require a cut. No major stability problems are anticipated for the bank or for 2:1 cut slopes. However, because of the high surface water level and the presence of silt layers the cut slopes would have to be covered with a granular blanket.

ROUTE 'M' & SHARON CREEK (BOREHOLE #15)

Site

....6

The borehole was put down on top of the east bank of Sharon Creek which is about 50 feet deep at this place.

Subsoil (Ground elevation 747.1 feet)

0 - 4 feet	Sand
4 - 61 feet	Clayey silt (with silt layer), very stiff
61 - 112 feet	Clayey silt, hard
112 - 131 feet	Till, hard

Water level is 17 feet below ground surface.

Recommendations

The proposed structure may be supported on:

1. spread footings founded in the original ground
2. friction piles
3. end bearing steel piles driven into the hard till layer (about 120 feet below the ground surface)

No stability problems are foreseen with 2:1 forward and side slopes of the fill or cut sections.

ROUTE 'P', 'S' & 'T' AND SHARON CREEK (BOREHOLE #6)

Site

The borehole was put down on the shoulder of a township road and on the flow of the Sharon Creek valley. The road crosses Sharon Creek immediately south of this location. The valley is about 50 feet deep.

Subsoil (Ground elevation 682.5 feet)

0 - 8 feet	Silty sand, compact
8 - 73 feet	Clayey silt, very stiff to hard
73 - 76 feet	Till, very dense

Artesian water was encountered at 73 feet and rose to the ground surface.

Recommendations

If it is decided to cross the Sharon Creek at this place, an embankment will be required.

No stability problems are foreseen for the embankment with 2:1 forward and side slopes. The proposed structure may be supported on spread footings placed in the compacted fill embankment or on friction piles driven through the fill to about 50 feet below the existing ground level.

....7

ROUTE 'P' & THAMES RIVER (BOREHOLE #4 & 5)

Site

At this location Route 'P' crosses the Thames River in a broad valley some 2,000 feet wide. Boreholes #4 & 5 were put down on the west side of the Thames River. Borehole #4 was located in the valley floor and Borehole #5 was located on top of the valley.

Subsoil (Ground elevation 678.9 feet)
Borehole #4

0 - 8 feet	Clayey silt, firm to stiff
8 - 17 feet	Sandy silt, very loose
17 - 33 feet	Till, very stiff
33 - 46 feet	Till, hard (very dense)

Water level is at 11 feet below the ground surface.

(Ground elevation 742.6 feet)
Borehole #5

0 - 88 feet	Clayey silt (with silt layers), very stiff
88 - 108 feet	Till, very dense

Water level is 32 feet below the ground surface.

Recommendations

The proposed structure may be supported on end bearing steel piles driven about 10 feet into the very dense till layer. No problems are anticipated for cuts through the banks and fills through the valley floor, provided 2:1 slopes are used.

ROUTE 'R' THAMES RIVER (BOREHOLE #12)

Site

This borehole was put down on the west side of the Thames River on the valley floor. The west bank of the valley is gradually sloping, but the east bank is relatively steep (about 2:1).

Subsoil (Ground elevation 678.2 feet)

0 - 9 feet	Clayey silt, stiff to very stiff
9 - 13 feet	Sand, compact
13 - 31 feet	Till, very dense

Recommendations

The proposed structure may be supported on end bearing steel piles driven about 10 feet into the very dense till deposit.

No stability problems are foreseen for fills and cuts with 2:1 forward and side slopes.

....8

ROUTE 'H' AND CONCESSION VI (BOREHOLE #8)

Site

This borehole was located about ¼ mile south of Concession VI. The area is well treed and overgrown with a very dense growth of underbrush. This bush extends for about 3 miles and is about ½ mile wide where the proposed route crosses it. The general area is relatively flat.

Subsoil (Ground elevation 786.0 feet)

0 - 1 feet	Organic top soil
1 - 22 feet	Fine sand, compact

Water level is at 3.5 feet below the ground surface.

Recommendations

No stability problems are anticipated for an embankment crossing this area, provided all organic soil is removed.

CONCLUSION

Our field investigation indicates that all investigated sites are feasible from foundation point of view. No major foundation problems are foreseen along any route which will render it unsuitable. The lengths of various structures are not dependent upon foundation requirements but will be governed by geometric or hydrological constraints.

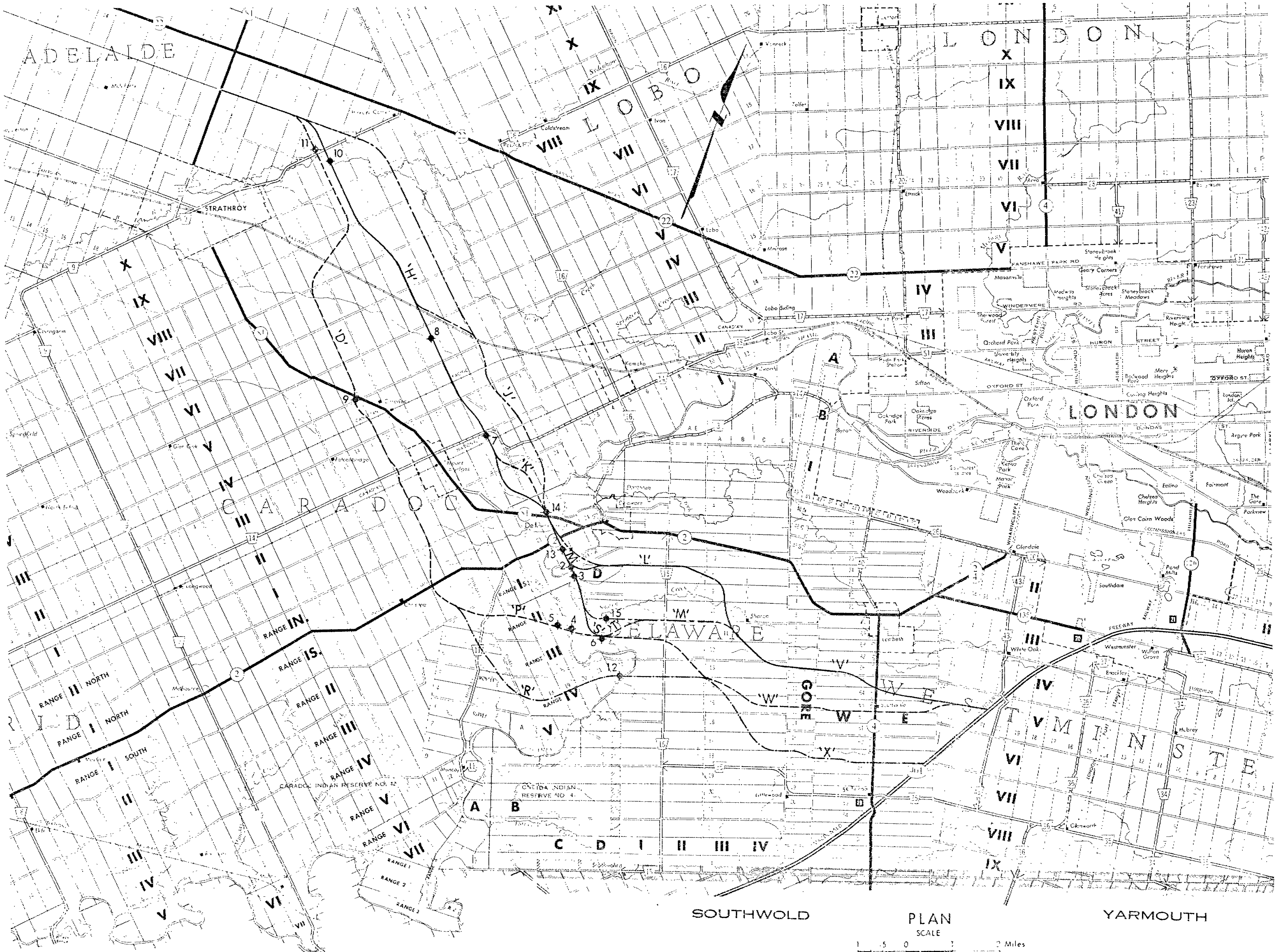
Route 'J' was not investigated because permission to enter the property could not be obtained.

A Prakash

Anand Prakash
Senior Foundation Engineer

AP/ji

c.c. A. Wittenberg
J. L. Keen
A. P. Watt
J. R. Roy
Foundations Files
Documents



ROAD JURISDICTIONS

- KING'S HIGHWAY
- COUNTY ROAD
- COUNTY SUBURBAN ROAD
- TOWNSHIP ROAD
- ROAD LEGALLY OPEN BUT NOT NECESSARILY PASSABLE
- INDIAN RESERVE BOUNDARY
- URBAN CORPORATE LIMIT
- URBAN LIMIT
- RAILWAY AND STATION
- TOWNSHIP BOUNDARY
- COUNTY BOUNDARY
- BUILT UP AREA

LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation.

NO.	ELEVATION	STATION	OFFSET
2	724.5	AS SHOWN ON PLAN	
3	721.6		
4	678.9		
5	742.6		
6	682.5		
7	613.8		
8	786.0		
9	800.6		
10	747.3		
11	746.0		
12	678.2		
13	682.0		
14	762.5		
15	747.1		

— NOTE —

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

REVISIONS DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

FEASIBILITY STUDY

HIGHWAY NO PROP 402 DIST NO. 2
CO MIDDLESEX
TWP LOT CON

BORE HOLE LOCATIONS

SUBMD P K	CHECKED	WP NO 40-66-00	DRAWING NO 73-11085A
DRAWN	CHECKED	AC NO 73-11085	BRIDGE DRAWING NO
DATE Nov 1973		SITE NO	
APPROVED		CONT NO	

Mr. A. Wittenberg,
Manager, Systems Design,
London.

Materials and Testing Office,
London.

Mr. D. King.

June 18, 1974.

W.P. 40-66, Highway #402,
County Road 14 to East of Thames
River, London District.

This confirms our comments re the soil conditions and gradeline for the above length of Highway #402 discussed with you and R. Bratty of Giffels, Davis and Jorgensen Limited, June 13, 1974.

For convenience the proposed cut sections are discussed individually.

1. Station 465 - Station 488 + 20 = (Station 0 + 00), Vicinity County Road #14.

   (i) Mainly fine to medium sand and gravel to 18', suitable for fill if drained - saturated at 4'.

   (ii) Mixture of silts and clays at two boreholes, could cause excavation problems (Station 468 + 00 centreline and Station 0 + 00 centreline).

   (iii) Because of high water table would suggest the grade raise and overhead structures in this area. If the lower grade is to be used a permanent drainage scheme and granular blankets on the slopes will be required for cuts below the ground water level.

2. Station 35 - Station 64, Proposed Cut.

   (i) The subsoil strata in this area consist of a 3' - 6' layer of fine to very fine sand suitable for fill if drained (saturated at 3') overlying clay and very fine sand layers which are unsuitable for fill due to high moisture content and mixture to a depth of 10' - 20'. Below this depth a fine sand suitable for fill, if drained, is found.

(ii) The proposed grade in this length should be kept up high in view of the poor subsoils and high moisture contents as well as to avoid as much of the unsuitable material as possible since this latter material would have to be wasted.

3. Station 72 - Station 105, Proposed Cut from North of Highway #81 to North of Highway #2.

(i) The upper 10' - 16' in this cut consists of a fine sand and fine gravel suitable for fill if drained (saturated at 3' +). Below this depth clays with high moisture contents are encountered. These clays would have to be wasted.

(ii) A grade raise into the sand layer would be preferable in conjunction with a grade raise on Highway #81. A permanent drainage scheme would be required with possibly a granular blanket on the slopes of cuts below the ground water level. The deeper the cut the more waste of clay material would be required.

4. Station 147 - Station 160 ±, Proposed Cut South of Thames River.

(i) The upper 7' - 8' of this cut consists of a fine to medium sand and coarse sand suitable for fill if drained (water at 3'). Below this depth high moisture content clays (8% - 10% above optimum moisture content) are encountered. These clays can be considered unsuitable for fill purpose and also slope stability problems may arise.

(ii) With the proposed grade in this cut, the clay cut material should be considered as waste in the design quantity calculations.

5. Station 253 - Station 257 approximately.

The cut proposed near the Howlett Property is also in a wet to saturated clay (moistures above optimum). Most of this material would have to be considered as waste.

Based on the above data it would certainly appear evident that cuts in the sand layer would affect ground water conditions and wells located near the alignment. This problem will be persued further by our Foundation Section and quite likely by another Consultant specializing in these types of problems.

Additional boreholes are to be placed south of the Lockwood Property this week and this data will be made available along with recommendations when this work is completed.

J. G. Forster

J. G. FORSTER,
SENIOR SOILS ENGINEER.

JGF:hp.

c.c.- Giffels, Davis & Jorgensen Ltd.,
ATT: R. Bratty,
K. Selby,
G. A. Wrong,
J. McKeown,
File.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO:	Mr. C. Mirza, Head, Soil Mechanics Section, Downsview.	FROM:	Materials and Testing Office, London.
ATTENTION:	Mr. K. Selby,	DATE:	June 13, 1974.
OUR FILE REF.		IN REPLY TO	

SUBJECT: W.P. 40-66, Highway #402, Highway #401 to County Road #14 to Mt. Brydges, London District.

As discussed with you by telephone today, enclosed is the soils data and other available information for the portion of Highway #402 between the Thames River at Delaware and County Road #14.

The proposed grade is critical in this area because of its effect on the ground water table and wells located near the proposed route. The proposed cuts will lower the groundwater but to what depth and distance from the cut is not known. Residents in the area are quite concerned over the drawdown effect.

Your comments and any recommendations you may have re this area would be appreciated.

J. G. Forster

J. G. FORSTER,
SENIOR SOILS ENGINEER.

JGF:hp.
c.c. - File.

73-11085

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO:	A. G. Stermac Principal Foundation Engineer Foundation Office West Bldg, Downsview	FROM:	Feasibility Studies Office East Bldg. Downsview.
ATTENTION:	A. Prakash Sr. Foundation Eng.	DATE:	October 9, 1973
OUR FILE REF.		IN REPLY TO	

SUBJECT:

Re: Highway 402 Feasibility Study

Further to our meeting of October 3, 1973, I hereby make a request for a Foundation Investigation of the alternate routes for Highway 402 between Highway 81 north of Strathroy and Highway 401 southwest of London. These alternate routes are shown on the enclosed county map.

The information we would like to receive from your office will be used, with many other factors, to evaluate and compare each alternate route in order to determine the most feasible location for this Highway.

This investigation should identify any foundation problems, that would be encountered at the four crossings of the Thames River, as well as at the crossings of the Sydenham River and Sharon Creek. Stability problems should also be investigated where the routes run close to the banks of the Thames River and its flood plain.

Problems associated with any normal cuts and fills should be included. Also, we would like to know of any difficulties that might be experienced in -

1. depressing County Rd. 39 under the freeway
2. depressing the freeway route 'H' or 'J' under County Rd. 14 and the C. N. R. tracks together
3. depressing the freeway route 'M' under Highway #81 and then raising it above Hwy. 2 across the Thames River Flood Plain.

Any problems associated with the placing of fill material in the flood plain should be included.

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Jan 15/74

All the structures are also shown on the enclosed map and any foundation problems that might be associated with their construction are necessary. It is hoped that the Thames River structure be at least 30' wider than the actual river banks in order to provide a 15' track on either side of the river for the movement of farm vehicles and for the continuation of bridle paths and foot paths along the Thames River banks.

I understand that there are some muck soil areas where Highway 402 crosses Co. Road #39 and also in Cons. V & VII, Lots 20 & 21 south of the C.N.R. tracks.

Some information might be obtained from the builders of the Gile's Bridge across the Thames River between Lots 12 & 13 of Con. I of Delaware Township.

It would be very much appreciated if we could have this information by the first week in November 1973 as we are commencing the evaluation stage in the second week of that month. However, a Preliminary Recommendation would be very useful before the end of October.

N.M. Upton
Feasibility Planner

for: I. Ardizone
Sr. Feasibility Planner

c.c. H.A. McNeely
D.J.S. King
R.W. Bratty

Encl:

Mr. J.G. Forester,
Senior Soils Engineer,
Materials & Testing Office,
Southwestern Region, London.

Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

July 8th, 1974.

RE: Highway 402, Feasibility Study,
(Thames River to County Road #14),
District #2, London,
W.O. 73-11085, W.P. 40-66-00.

We have reviewed the soils and groundwater data supplied by you for the abovementioned portion of Hwy. 402. We carried out a foundation investigation for Hwy. 402 in October-November, 1973. Our investigation revealed that in this portion of Hwy. 402, the subsoil consists of:

> 13-30 ft. of sand to silty sand, followed by 34-47 ft. of clayey silt to silt, followed by 0-8 ft. of fine sand, which in turn, is underlain by a clayey silt to silt deposit, followed by a deep deposit of glacial till. Our borings did not extend to bedrock, which is about 200 ft. deep in this area.

Most of the wells indicated by you, draw their water from the surficial waterbearing sand to silty sand stratum. The ground surface and the static water levels slope, in general, in an easterly direction. If a cut is made for Hwy. 402, this will interfere with the ground-water flow through the surficial sand stratum. Consequently, water levels in the wells will also be affected. In the immediate vicinity of the cut, groundwater will be lowered to the full depth of the cut. The magnitude of the drawdown will decrease with increasing distance from the cut. We feel that on the west side, the influence should not extend beyond 1000 ft. from the cut. Since the ground surface and the groundwater levels are sloping in an easterly direction, the cut will block off the flow of water to the east of it, and may render the wells dry.

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Mr. J.G. Forester - RE: W.P. 40-66-00.

A similar opinion was stated by Mr. D. Pirie of the Ministry of the Environment. We had a discussion with Mr. Ken Gaff of the Ministry of the Environment, and he is willing to give further opinion on this matter. Therefore, we recommend that all data be sent to him for his consideration. His address is as follows:

Mr. Ken Gaff,
Geologist,
Ministry of the Environment,
985 Adelaide Street,
LONDON, Ontario.

A. Prakash,
Senior Engineer,
For: K.G. Selby,
Supervising Engineer.

AP/mj
C.C. Files
Documents

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DRAWING