#62-F-226-C

W.P.# 177-61

HWY.# 401 @

MALLORY TWN.

RD. BRIDGE

Mr. A. M. Toye,
Bridge Engineer,
Bridge Division.

Attention: Mr. S. McCombie.

Mr. A. G. Stermac,
Principal Foundation Engr.,
Foundation Section,
Materials & Research Division.

December 13, 1962.

FOUNDATION INVESTIGATION REPORT BY -
H. Q. Golder and Associates, Limited,
Proposed Mallorytown Road Bridge,
Highway #401, Line 'G', District #8.
W.P. 177-61.

Attached, we are forwarding to you the report for the above-mentioned foundation investigation submitted by the Consultant.

We have reviewed the report and, on the basis of the presented factual data and information, we agree with the conclusions and recommendations contained therein.

We believe the information provided, will prove adequate for your future design work. However, should there be any queries in connection with this project, please do not hesitate to contact our Office.

K. Y. Lo,
SUPERVISING FOUNDATION ENGR.
For:

A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.

KYL/MdeF
Attach.

cc: Messrs. A. M. Toye (2)
H. A. Tregaskes
H. D. McMillan
J. Ford
E. A. Cash
J. E. Gruspier
T. J. Kovich
E. R. Saint
J. Roy
F. Norman
A. Watt

Foundations Office
Gen. Files.

BA 1550

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS

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

2444 BLOOR STREET WEST
TORONTO 9, ONTARIO
767-9201
763-4103

REPORT

TO

DEPARTMENT OF HIGHWAYS, ONTARIO

ON

SOIL CONDITIONS AND FOUNDATIONS

PROPOSED MALLORYTOWN ROAD BRIDGE

HIGHWAY 401 - LINE G

WP 177-61

GANANOQUE ONTARIO

Distribution:

15 copies - Department of Highways, Ontario,
Toronto, Ontario.

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

December, 1962

6263

ABSTRACT

The results of an investigation to determine the soil conditions at the site of the proposed Mallorytown Road bridge approximately 0.5 miles southeast of Mallorytown, Ontario are reported and recommendations are given for the foundation design of the proposed structure and approach embankments.

The site is underlain by a stratum of generally hard to stiff silty clay which rests on bedrock at a shallow depth. A thin layer of silty sand and gravel was encountered immediately above the rock surface in a few borings.

The piers and abutments for the proposed bridge structure may be founded on spread footings founded on bedrock. Alternative schemes for founding the abutments are discussed in the report.

The approach earthfill embankments may be constructed with side and end slopes of 2 horizontal to 1 vertical.

Settlement of the structure and approach embankments, if founded as recommended, will be negligible.

TABLE OF CONTENTS

INTRODUCTION

H. Q. Golder & Associates Ltd. have been retained by the Department of Highways, Ontario by letter dated November 15th, 1962 to carry out a soil investigation for the proposed Mallorytown Road bridge structure over proposed Highway 401, Line G, near Gananoque, Ontario.

The purpose of the investigation was to determine the soil conditions at the site and to make recommendations concerning the foundation design of the proposed structure and its approach embankments.

PROCEDURE

The field work was carried out between November 22nd, and November 28th, 1962. During this period 5 borings each with an accompanying dynamic penetration test and 5 additional dynamic penetration tests were put down by two machine drillrigs.

The locations of all borings and dynamic penetration tests put down during the investigation are shown on Figure 1, and a section of the inferred soil stratigraphy is given on Figure 2. The detailed log of each boring and penetration test is given on the Records of Boreholes.

The soil samples obtained during the investigation were returned to our laboratory for examination and testing. The results of the laboratory testing are plotted on the Records of Boreholes and on the figures.

All boreholes were located with respect to the centre-line of proposed Highway 401, Line G, as staked in the field. The borehole elevations were referred to a bench mark located in the southeast root of a 3.5 feet elm tree 105 feet left of station 92+23 on Highway 401, Line G. The elevation of this bench mark is given as 333.95, Geodetic.

SITE TOPOGRAPHY AND GEOLOGY

The proposed bridge structure is to be located on County Road No. 5A approximately 0.5 miles southeast of Mallorytown in the County of Leeds, Ontario. This area lies within the physiographic region known as the "Leeds Knobs and Flats" (Chapman and Putnam, 1951) and consists primarily of scattered knobs of rock between which lie clay deposits laid down by the Champlain sea. The clay plains are typically gently undulating farmed land. The proposed site is located in one of these plains.

Bedrock in this area is mainly sedimentary and derived metamorphosed rocks of Precambrian age. The surface elevation of bedrock varies appreciably within small areas.

SOIL CONDITIONS

A stratum of mottled grey and brown to grey silty clay was encountered below shallow topsoil in all boreholes. This material which had some thin layers or lenses of fine to medium sand was about 5 to 18 feet in total thickness. Two grain size distribution curves for the silty clay are shown on Figure 3. Atterberg limit

tests carried out on samples of the clay gave liquid limits from about 25 to 52 with corresponding plasticity indices between about 5 and 26. These results are summarized on the plasticity chart, Figure 5.

Four undrained triaxial compression tests on samples of the clay gave undrained shear strength values of about 1,800 to 4,300 pounds per square foot assuming the shear strength to be half the compressive strength.

A thin deposit of compact to very dense brown silty sand and gravel up to 1.3 feet in thickness was encountered below the silty clay stratum in boreholes 1, 2 and 4. One grain size distribution curve for this material is shown on Figure 4.

Bedrock was encountered below the silty clay in boreholes 3 and 5 and below the thin deposits of sand and gravel in boreholes 1, 2 and 4. The rock is a hard, generally sound, grey crystalline rock.

WATER CONDITIONS

Water level observation pipes were installed in all boreholes. Details of these installations are given on the Records of Boreholes. The latest available water levels in the observation pipes are given on the Records of Boreholes and on Figure 2.

DISCUSSION

General

It is proposed to elevate the existing Mallorytown Road near Mallorytown, Ontario over the proposed Highway 401, Line G. A skew bridge structure with four spans of 48, 82, 82 and 48 feet, a width of about 35 feet, and approach embankments up to 27 feet in height above the existing ground level are proposed for the grade separation. The bridge structure will have a skew angle of about 60 degrees to the existing Mallorytown Road.

Foundation Design

In view of the relatively shallow depths to bedrock at the proposed pier locations we recommend that the three piers be founded on spread footings resting on bedrock. For footings founded below any upper weathered zone in the rock an allowable bearing pressure up to 40 tons per square foot may be used for design. Based on an examination of the rock core recovered during the investigation, the weathered zone of bedrock, if any exists, is only a few inches in thickness. No artesian water pressures were noted in the bedrock or overburden during or following drilling operations.

The abutments may also be founded on spread footings founded in bedrock; however, since this would entail up to about 20 feet of excavation at the south abutment it may be desirable to found this abutment on spread footings founded in the silty clay stratum. Based on undrained shear strength values for the

silty clay ranging from about 1,800 to 4,300 pounds per square foot, an allowable net bearing pressure of 5,000 pounds per square foot may be used for design of spread footings founded at a depth of at least 5 feet below the present ground surface.

We suggest that consideration be given to founding the abutments on spread footings founded in the approach embankments. In this case the material below, and in the vicinity of, the footings should be well compacted granular borrow. The design bearing pressure for spread footings founded in the approach fill will be dependent upon the as-compacted characteristics of the material used in the embankments but for well-compacted granular borrow should be at least 5,000 pounds per square foot.

Where the rock surface slopes, as at the proposed location of the south abutment the footing may have to be stepped and dowelled into the rock to prevent possible shear at the footing - rock interface.

Settlement of the piers and abutments, if founded as discussed above, will be negligible.

We recommend that free draining granular backfill be placed behind the proposed abutments. This backfill should extend at least 4 feet horizontally away from the abutment wall and have provision for drainage to ensure that no excess hydrostatic or ice pressures build up behind the walls. In the design of the abutments it is recommended that an earth pressure coefficient, K, of 0.3 be used, provided that some minor movement

of the top of the abutment can be accommodated.

The approach earthfill embankments should be constructed of well compacted essentially granular borrow and have side and end slopes of 2 horizontal to 1 vertical. All slopes should be sodded or seeded and mulched to combat erosion of the slopes. Settlement of proposed embankments due to consolidation of the subsoil should be less than 1 inch.

McC/jb
6263

N. R. McCammon, P. Eng.

December, 1962

V. Milligan, P. Eng.

LIST OF STANDARD ABBREVIATIONS

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

SAMPLE TYPES

A.S. – Auger Sample
C.S. – Chunk Sample
D.O. – Drive Open
D.S. – Denison Type Sample
F.S. – Foil Sample
R.C. – Rock Core
S.T. – Slotted Tube
T.O. – Thin-walled, Open
T.P. – Thin-walled, Piston
W.S. – Wash Sample

PENETRATION RESISTANCES

Dynamic Penetration Resistance – The energy required to drive a 2 inch diameter, 60 degree cone attached to the end of the drilling rods into the ground: expressed in blows per foot, where each blow represents 4,200 inch-pounds of energy.

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 into the ground.

Sampler advanced by static weight – weight, hammer – Wh
Sampler advanced by pressure – pressure, hydraulic – Ph
Sampler advanced by pressure – pressure, manual – Pm

SOIL DESCRIPTION

The standard terminology for the descriptions of the relative density of cohesionless soils and the consistency of cohesive soils is as follows:

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

Consistency	c, 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

SOIL TESTS

C – Consolidation Test
H – Hydrometer Analysis
M – Sieve Analysis
MH – Combined Analysis, Sieve and Hydrometer
Q – Undrained Triaxial
Qc – Consolidated Undrained Triaxial
S – Drained Triaxial
U – Unconfined Compression
V – Field Vane Test

Note: Undrained triaxial tests in which pore pressures are measured are shown as Q' or Q'c.

SOIL PROPERTIES

γ – Total Unit Weight
γ_d – Dry Unit Weight
γ_b – Submerged Unit Weight
L_L – Liquid Limit
P_L – Plastic Limit
W – Natural Water Content
G – Specific Gravity
e – Void Ratio
K – Coefficient of Permeability
c – Undrained Shear Strength (½ Compressive Strength)
St – Sensitivity
ϕ' – Effective Angle of Shearing Resistance
c' – Effective Cohesion Intercept
Cc – Compression Index
Cv – Coefficient of Consolidation

PROJECT No. 6263

RECORD OF BOREHOLE 1

LOCATION SEE FIGURE 1 BORING DATE NOV. 21- 23, 1962 DATUM GEODETIC

BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER BX CASING

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

ELEVN / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.
330.3 / 0.0	GROUND LEVEL				
	HARD TO VERY STIFF GREY-BROWN TO GREY SILTY CLAY BECOMING A CLAYEY SILT TO SILT WITH INCREASING DEPTH FEW FINE TO MEDIUM SAND LAYERS OR LENSES BELOW ABOUT EL. 318.		1	2" DO	26
			2	DO	33
			3	DO	18
			4	TO	16
			5	DO	16
			6	TO	Pm
311.8 / 18.5	(VERY DENSE GRAVEL IN A RUSTY BROWN SILTY SAND MATRIX)		7	DO	52
19.3	HARD GREY CRYSTALLINE ROCK (BEDROCK)		8	AXT RC	-
			9	"	-
			10	"	-
300.5 / 29.8	END OF HOLE				

ELEVATION SCALE: 330, 325, 320, 315, 310, 305, 300

DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT ----- 20 40 60 80 100

SHEAR STRENGTH C, LB./SQ.FT. ●-Q 1000 2000 3000 4000 5000

104 BLOWS FOR LAST 6 INCHES
END OF PEN. TEST AT ELEV. 311.8

LIQUID LIMIT L_L
PLASTIC LIMIT P_L
WATER CONTENT W

WATER CONTENT, PER CENT 10 20 30 40

γ=134 MH
γ=128 MH
γ=124 MH

LAB. TESTING

STANDPIPE INSTALLATION: GROUND LEVEL, CAP, CEMENT PLUG, SAND AND GRAVEL BACKFILL, STANDPIPE

W.L. IN STANDPIPE AT ELEV. 329.4 DEC. 10, 1962

20 / 15 / 5 / 10 PERCENT STRAIN AT FAILURE

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN M.N.
CHECKED M.M.

PROJECT No. 6263

RECORD OF BOREHOLES 2 & 3

LOCATION SEE FIGURE 1 BORING DATE NOV. 26 - 27, 1962 DATUM GEODETIC

BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER BX CASING

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

BOREHOLE 2

ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FT.
332.3 / 0.0	GROUND LEVEL				
	FIRM MOTTLED GREY AND BROWN SILTY CLAY		1	2" DO	5
			2	"	18
326.7 / 5.6	COMPACT BROWN SILTY SAND AND GRAVEL				
325.4 / 6.9	HARD GREY CRYSTALLINE ROCK (BEDROCK)		3	AXT RC	-
			4	"	-
316.1 / 16.2	END OF HOLE				

2/ 100 BLOWS FOR LAST 7 INCHES
END OF PEN. TEST AT ELEV. 324.7

W.L. IN STANDPIPE AT ELEV 330.4 DEC. 10, 1962

BOREHOLE 3

ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS / FT.
331.7 / 0.0	GROUND LEVEL				
	STIFF MOTTLED GREY-BROWN TO GREY SILTY CLAY		1	2" DO	14
			2	"	20
			3	"	19
321.7 / 10.0	HARD GREY CRYSTALLINE ROCK (BEDROCK)		4	AXT RC	-
			5	"	-
311.6 / 20.1	END OF HOLE				

3/ 100 BLOWS FOR LAST 5 INCHES
END OF PEN. TEST AT ELEV. 321.3

W.L. IN STANDPIPE AT ELEV. 330.4 DEC. 10, 1962

ELEVATION SCALE: 335, 330, 325, 320, 315, 310

DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT: 20, 40, 60, 80, 100

SHEAR STRENGTH C, LB./SQ.FT.

LIQUID LIMIT L_L
PLASTIC LIMIT P_L
WATER CONTENT W
P_L W L_L
WATER CONTENT, PER CENT: 10, 20, 30, 40

LAB. TESTING: MH

STANDPIPE INSTALLATION: CAP, GROUND LEVEL, CEMENT PLUG, SAND AND GRAVEL BACKFILL, STANDPIPE

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN A.W.
CHECKED

PROJECT No. 6265

RECORD OF BOREHOLES 4 & 5

LOCATION SEE FIGURE 1 BORING DATE NOV. 27, 1962 DATUM GEODETIC

BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 8x CASING

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

BOREHOLE 4

ELEVN/DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.
332.2	GROUND LEVEL			
0.0	FIRM TO STIFF MOTTLED GREY-BROWN TO GREY SILTY CLAY	1	2" DO	7
		2	"	9
326.1				
6.3	(DENSE SAND)	3	AXT RC	-
	HARD GREY CRYSTALLINE ROCK (BEDROCK)	4	"	-
		5	"	-
314.2				
18.0	END OF HOLE			

100 BLOWS FOR LAST 6 INCHES
END OF PEN. TEST AT ELEV. 325.7

W.L. IN STANDPIPE AT ELEV. 330.3 DEC. 10, 1962

BOREHOLE 5

ELEVN/DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.
331.9	GROUND LEVEL			
0.0	STIFF MOTTLED GREY AND BROWN SILTY CLAY	1	2" DO	8
		2	"	6
		3	2" TO Pm	
324.9				
7.0	HARD GREY CRYSTALLINE ROCK (BEDROCK)	4	AXT RC	-
		5	"	-
314.9				
17.0	END OF HOLE			

4 BLOWS FOR LAST 9 INCHES
END OF PEN. TEST AT ELEV. 325.1
HAMMER BOUNCING

20 / 15 / 5 / 10 PERCENT STRAIN AT FAILURE

W.L. IN STANDPIPE AT ELEV. 330.1 DEC. 11, 1962

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN M.W.
CHECKED A.J.C.

PROJECT No. 6263

RECORD OF BOREHOLES 6, 7, & 8

LOCATION SEE FIGURE 1 BORING DATE NOV. 28, 1962 DATUM GEODETIC

BOREHOLE TYPE PENETRATION TEST BOREHOLE DIAMETER —

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

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT 20 40 60 80 100 / SHEAR STRENGTH C, LB./SQ.FT.	LIQUID LIMIT L_L · PLASTIC LIMIT P_L · WATER CONTENT W (P_L W L_L) / WATER CONTENT, PER CENT
ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FT.	ELEVATION SCALE		
332.1	GROUND LEVEL					335	6/	
0.0	DYNAMIC PENETRATION TEST ONLY - NO SAMPLES TAKEN					330		
327.0								
5.1	END OF PEN. TEST BOULDER OR BEDROCK					325	50 BLOWS FOR LAST INCH HAMMER BOUNCING	
332.3	GROUND LEVEL					335	7/	
0.0	DYNAMIC PENETRATION TEST ONLY - NO SAMPLES TAKEN					330		
325.8								
6.5	END OF PEN. TEST BOULDER OR BEDROCK					325	16 BLOWS FOR LAST 6 INCHES HAMMER BOUNCING	
332.0	GROUND LEVEL						8/	
0.0	DYNAMIC PENETRATION TEST ONLY - NO SAMPLES TAKEN					330		
323.0						325		
9.0	END OF PEN. TEST BOULDER OR BEDROCK						120 BLOWS FOR LAST 12 INCHES	
						320		

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN M.W.
CHECKED J. M/L

PROJECT No. 263

RECORD OF BOREHOLES 9 & 10

LOCATION SEE FIGURE 1 BORING DATE NOV. 28, 1962 DATUM GEODETIC

BOREHOLE TYPE PENETRATION TEST BOREHOLE DIAMETER —

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

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT 20 40 60 80 100 / SHEAR STRENGTH C, LB./SQ.FT.	LIQUID LIMIT L_L PLASTIC LIMIT P_L WATER CONTENT W / WATER CONTENT, PER CENT
ELEVN/DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.			

9/

331.0 GROUND LEVEL

0.0 DYNAMIC PENETRATION TEST ONLY - NO SAMPLES TAKEN

317.8 13.2 END OF PEN. TEST BOULDER OR BEDROCK

330 325 320 315

82 BLOWS FOR LAST 2 INCHES

10/

331.0 GROUND LEVEL

0.0 DYNAMIC PENETRATION TEST ONLY - NO SAMPLES TAKEN

317.6 13.4 END OF PEN. TEST BOULDER OR BEDROCK

330 325 320 315

100 BLOWS FOR LAST 5 INCHES

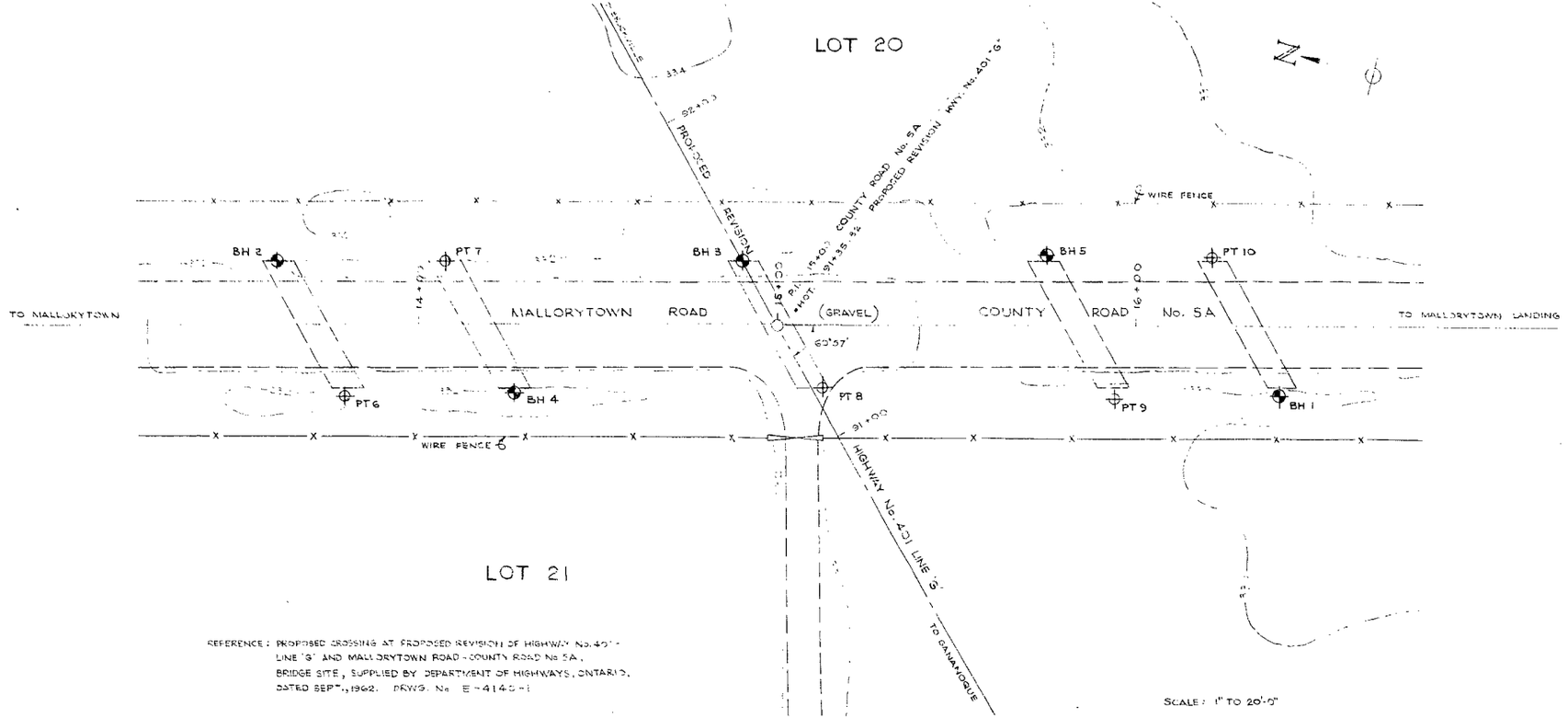
VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN M.W.
CHECKED

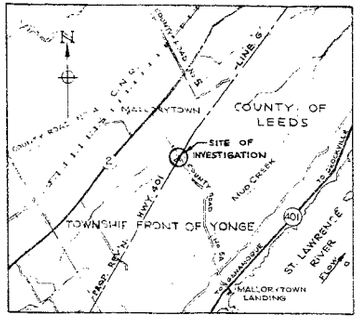
BORING PLAN

FIGURE 1



REFERENCE: PROPOSED CROSSING AT PROPOSED REVISION OF HIGHWAY No. 401 - LINE 'G' AND MALLORYTOWN ROAD - COUNTY ROAD No. 5A, BRIDGE SITE, SUPPLIED BY DEPARTMENT OF HIGHWAYS, ONTARIO, DATED SEPT., 1962. DRWG. No. E-4145-1

SCALE: 1" TO 20'-0"



KEY PLAN
SCALE: 1" TO 0.8 MI.

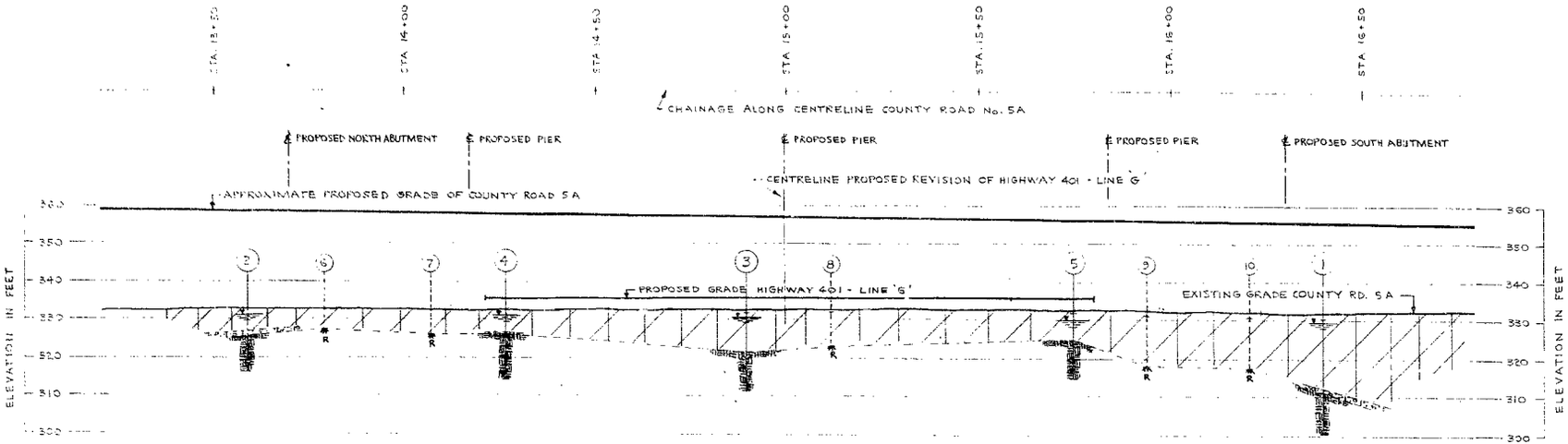
LEGEND

- BOREHOLE WITH PENETRATION TEST IN PLAN.
- PENETRATION TEST IN PLAN
- PROPOSED FOOTING LOCATIONS

GOLDER & ASSOCIATES

Made P.C.
Chkd. [illegible]
Appd. [illegible]

SOIL STRATIGRAPHY | FIGURE 2



SCHEMATIC SECTION ALONG CENTRELINE COUNTY RD. 5A

SCALE 1" TO 20'-0"

REFERENCE : (SEE FIGURE 1)

LEGEND

(5) BOREHOLE WITH PENETRATION TEST IN ELEVATION

(5) PENETRATION TEST IN ELEVATION

WATER LEVEL IN BOREHOLE, DEC. 10, 1962.

STRATIGRAPHY

HARD TO FIRM GREY BROWN TO GREY SILTY CLAY TO CLAYEY SILT ; FEW FINE TO MEDIUM SAND LAYERS.

COMPACT TO VERY DENSE BROWN SILTY SAND AND GRAVEL.

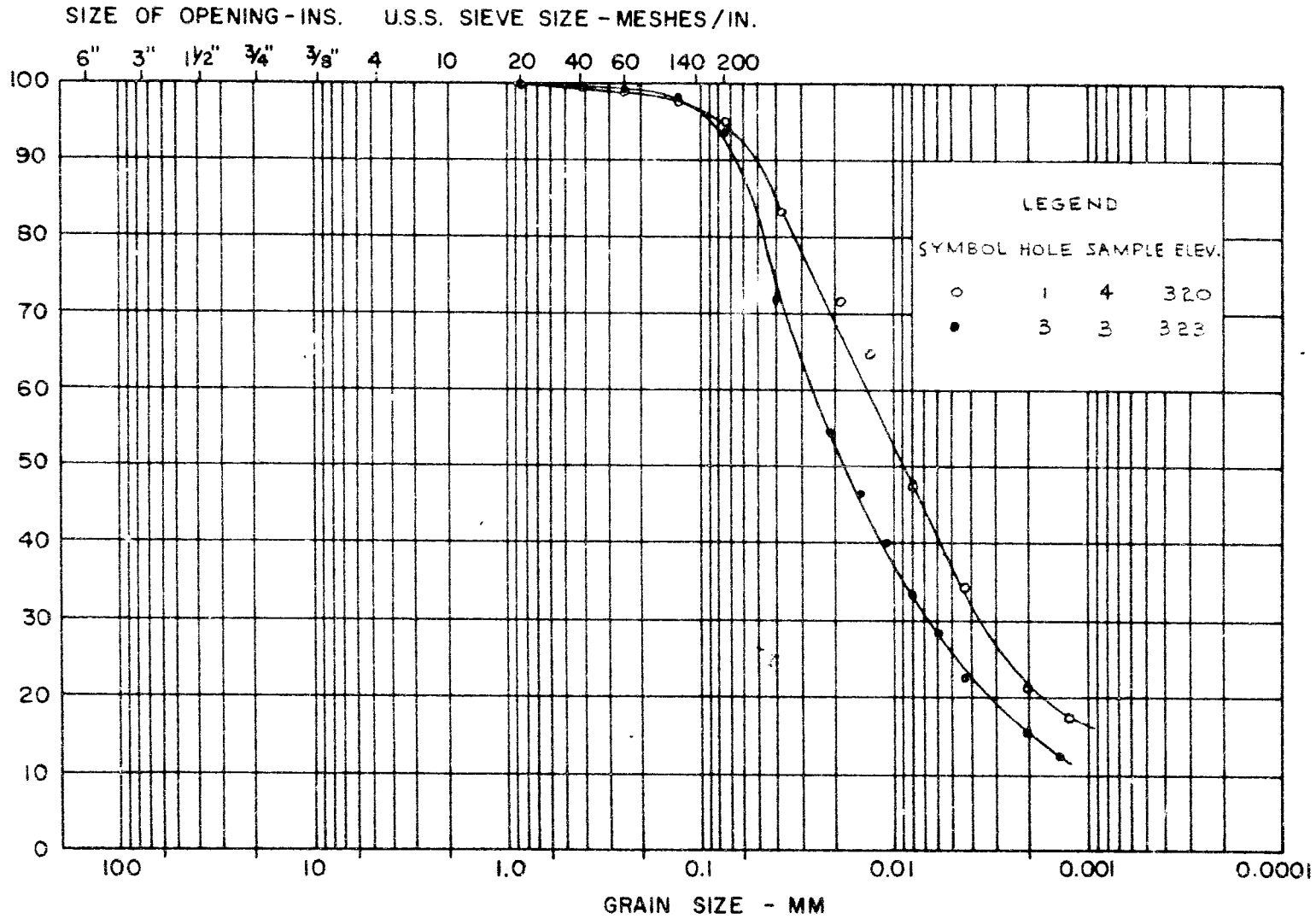
HARD GREY CRYSTALLINE ROCK (BEDROCK).

R REFUSAL - BOULDER OR BEDROCK.

COLDER & ASSOCIATES

Made W.C.
Chkd. H.M.B.
Appd. F.A.

M.I.T. GRAIN SIZE SCALE

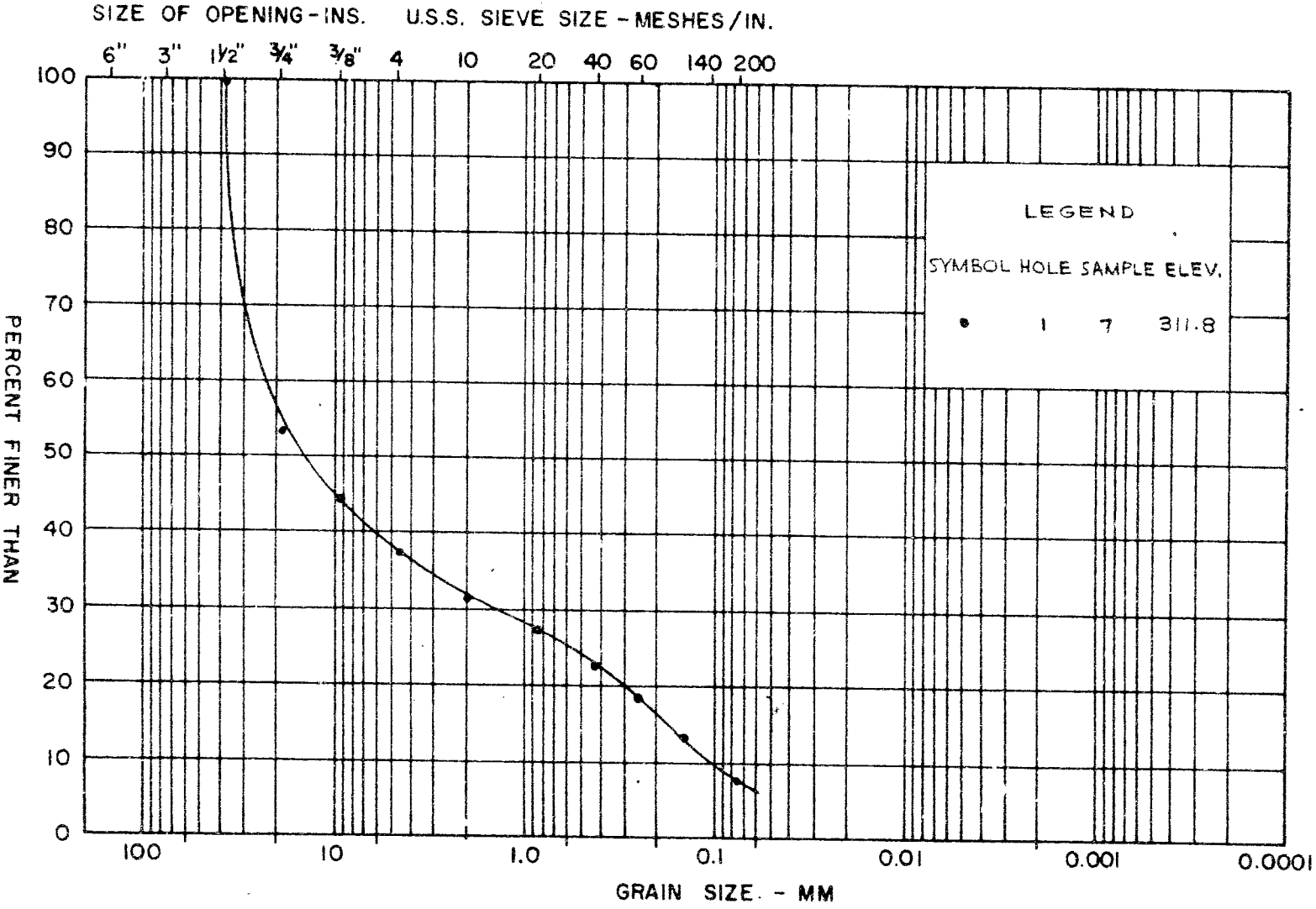


GRAIN SIZE DISTRIBUTION

FIGURE 3

GOLDER & ASSOCIATES

M.I.T. GRAIN SIZE SCALE



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

SILTY SAND AND GRAVEL

GRAIN SIZE DISTRIBUTION

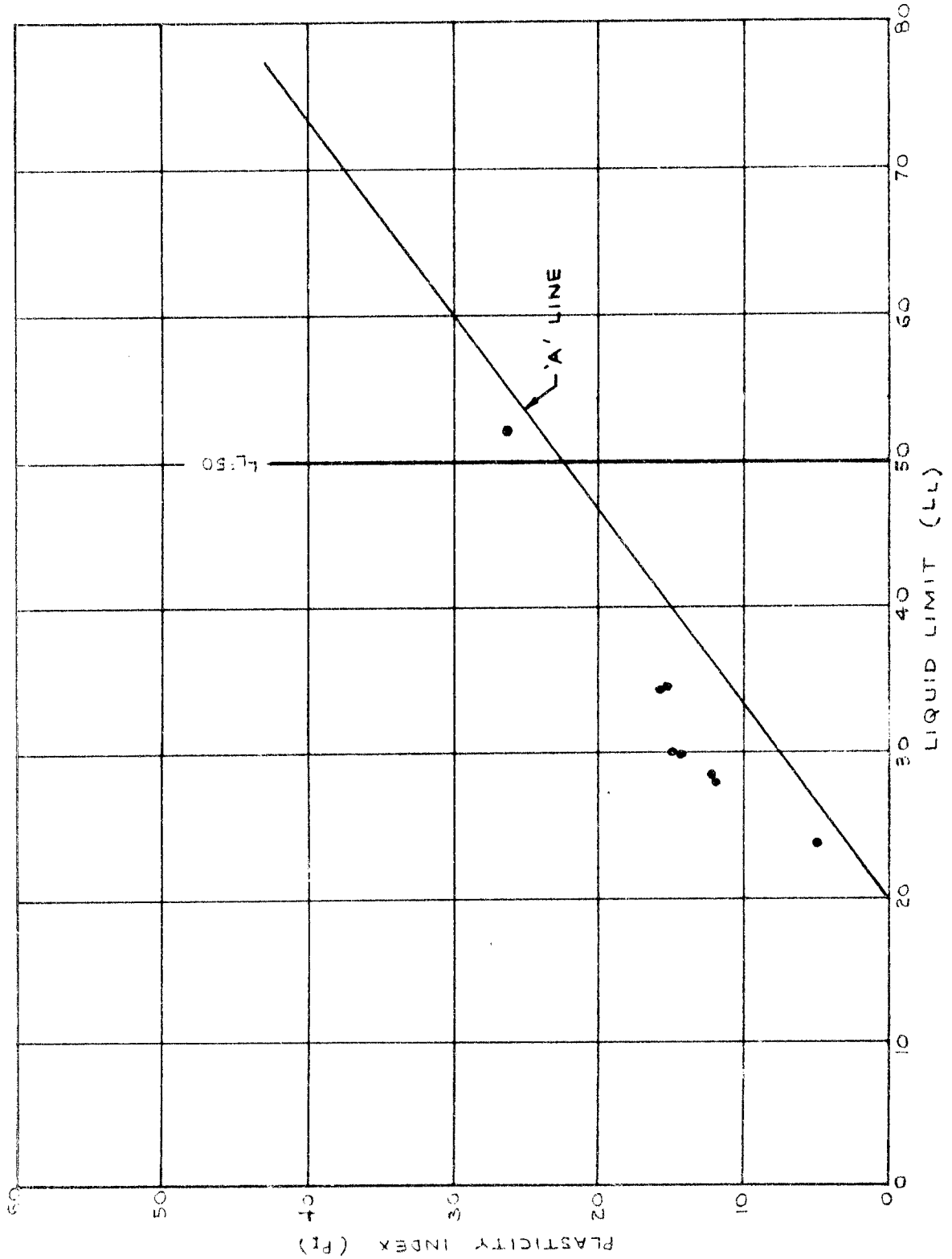
FIGURE 4

GOLDER & ASSOCIATES

PLASTICITY CHART

FIGURE 5

SILTY CLAY



GOLDER & ASSOCIATES