

afp

Mr. C. S. Grebski,
Bridge Design Engineer,
Bridge Division,
Admin. Bldg.

Foundation Section,
Materials & Testing Div.,
Room 107, Lab. Bldg.

July 6, 1967

Kettle Creek Bridge at St. Thomas Wes. Limits
W.P. 312-65, Site No. 5-63, Hwy. #4
-- District #2 (London) --

We have reviewed the Preliminary Bridge Plan Drawing B-6195-P1 for the above mentioned structure, and submit the following comments:

Further to the request of Mr. J. L. Keen of your office, we have obtained from Franki of Canada, the suggested procedures for the installation of 20" ϕ steel tube concrete filled caissons founded at elev. 63⁰ with a safe design load of 150 tons. A copy of the letter from Franki of Canada Ltd. is enclosed for your information.

If the outlined procedure is followed for the construction of the caissons, we have no comments pertaining to the structure foundations.

MD/WMEP
Attach.

M. Devata
M. Devata,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Sternac,
PRINCIPAL FOUNDATION ENGR.

cc: Messrs. G. McCombie
A. Watt
Foundations Files
Gen. Files

FRANKI

CANADA LIMITED

THORNCLIFFE SQUARE, UNIT No. 3

P.O. BOX 190

STATION "R"

TORONTO, 17, ONT.

TELEX NO.

02-2159

CABLEGRAMS
"FRANKIPILE"

TELEPHONE:

421-7710



Our Reference:
X. 6867

July 4, 1967

Department of Highways,
Materials & Testing Division,
Downsview, Ontario

Attention: Mr. M. Devata

Dear Sirs:

Re: WP 312-65

It is understood that you wish us to make some suggestions on the installation procedures of 20 inch diameter steel tube concrete filled caissons at the pier locations of the above job. The caissons are to be founded at elevation 630 and the design load is to be 150 tons.

The following procedures are suggested for your consideration:-

- (1) Use 20 inch diameter casing of not less than $\frac{1}{2}$ inch wall thickness.
- (2) Drive casing through the clay stratum to the till stratum where it would be expected to refuse to normal driving procedures.
- (3) Clean out casing in normal manner.
- (4) Churndrill the casing through till to elevation 630, while maintaining a head of water inside the casing at least equal to the hydrostatic pressure at the bottom of the casing to avoid disturbance of the till near and at foundation level.

- (5) When casing has reached elevation 630 form water tight concrete seal at the bottom of the casing.
- (6) Dewater casing and form dry plug on top of seal.
- (7) Drive with internal hammer on plug to required capacity.

It has been mentioned in the past that after a seal has been obtained, an enlarged base could be formed at the bottom of the casing in the normal Franki manner. This procedure however is dependant upon making a water tight seal and upon the height of seal required to obtain water tightness. Since these are variables that cannot now be determined, it is recommended that capacity be obtained by driving resistance rather than by depending upon the feasibility of making a Franki base.

The above procedures are believed to be feasible based on the present information available. They are submitted to you however without commitment on our part.

If you wish to discuss this matter in further detail, we shall be pleased to do so.

Yours very truly,
FRANKI CANADA LIMITED



A. Prior, P.Eng.
Chief Engineer

AP/eh

Department of Highways Ontario

Copy for the information of

Mr. A. Stermac, Principal Foundation Engineer,
Room 107, Lab. Building

Mr. A. Watt,
Regional Bridge Location Engineer,
London Regional Office,
London, Ontario

Bridge Division,
Downsview, Ontario

June 19, 1967

**Kettle Creek Bridge
at St. Thomas West Limits
W.P. 312-65, Site No. 5-63
Highway 4, District No. 2**

Attached herewith are prints of the Preliminary Bridge Plan
Drawing D-6195-F1 for the above-mentioned structure.

The estimated cost of the proposed structure is \$138,000.
This cost includes tender, materials, engineering and sundry
construction.

Any comments or revisions you may have should be submitted
within three weeks.

CSG:rd

C.S. Grebski,
Bridge Design Engineer

Attach.

c.c. S. McCombie
A. Stermac
R. Forrest
E. Cross



Hwy. 401 & Keele St.,
Downsview, Ontario.

Tel. 248-3282
(Area Code 416)

Materials and Testing Division

June 27, 1967

Mr. A. Prior,
Frankl of Canada Ltd.,
25 Overlea Blvd.,
Toronto, Ontario.

Re: Proposed Kettle Creek Bridge
At St. Thomas West Limits
Hwy. #4, District #2 (London)
W.P. 312-65 -- Site 5-63

Dear Mr. Prior:

Further to our telephone conversation of June 22, 1967, as requested by you, we are enclosing the necessary drawings and log sheets of the above mentioned project, so that you can supply us with the detailed procedure of the installation of 20" \emptyset steel tube concrete-filled caissons to elev. 630 at the pier locations of the structure.

This information is required by the Bridge Office very shortly, and we would therefore request an answer at your earliest possible convenience.

MD/MdeF

Very truly yours,



M. Devata,
Supervising Foundation Engr.
For:
A. G. Stermac,
Principal Foundation Engr.

Proposed Kettle Creek Bridge
at St Thomas West Limits
W P 312-65, Site 5-63
Hwy # 4 Dist # 2

Supply all equipment etc L.S.
Construct 8 Franki Caissons
20" ϕ to elev $\frac{630}{625}$ - $q_{safe} = 150$ tons } $\$10,000$ for 8 piles.

Note - The above price excludes the cost of 20" ϕ tubular piles and cement. D.H.O. supplies the pipe (20" ϕ) and cement for the aggregate.

M. Devata
May 21/67.

The above information was given to Tim Keen on May 29th/67.

\$27.00 to clay
\$54.00 to fill
\$2000 to supply all equipment

MEMORANDUM

To: Mr. A.G. Stermac, P.Eng.,
Principal Foundation Engineer,
Foundations Section,
Room 107, Lab. Building

FROM: Bridge Division,
Downsview, Ontario

DATE: May 17, 1967

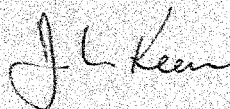
OUR FILE REF.

IN REPLY TO

SUBJECT: Kettle Creek Bridge
at St. Thomas West Limits
W.P. 312-65, Site 5-63
Highway 4, District No. 2

Enclosed please find a sketch showing our proposed arrangement for the above structure. This sketch will be used by the Consultant assigned this project for the preparation of the Preliminary Plan, Drawing D6195-P1.

I would appreciate if you would review the foundation arrangement and provide us with your comments, if you have any. A particular feature of a somewhat unusual nature is the large diameter concrete filled tube piles, acting as "trestle" piers.

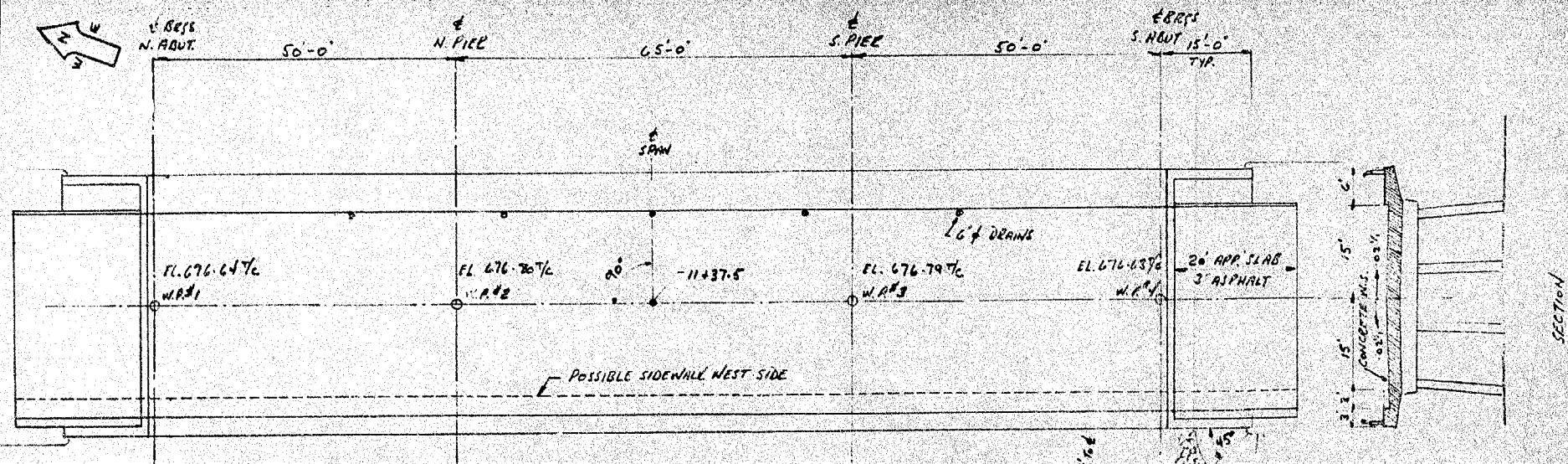


J.L. Keen,
Regional Bridge Project Engineer

JLK:rd

Attach.

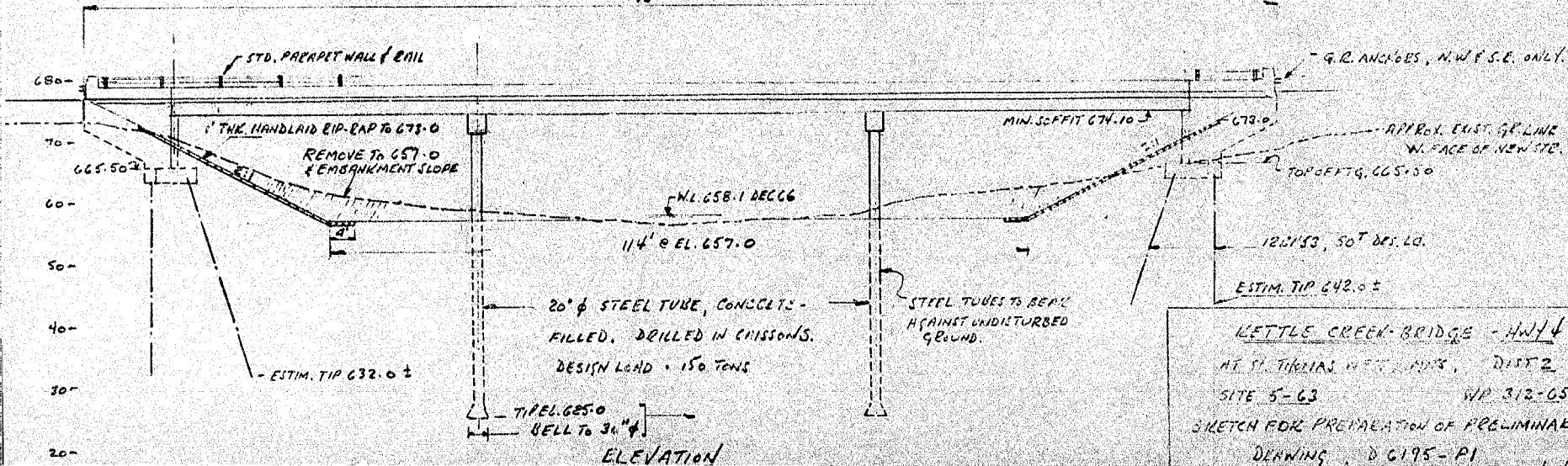
c.c. A.P. Watt



PLAN
1" = 20'
195'-0"

W.P. - DENOTES WORKING POINT
T/C - " TOP OF CONCRETE FINISHING SURFACE ON STRUCTURE.

APPROX. LIMITS OF R.P. END DEFINE ON PRELIMINARY



LETTLE CREEK BRIDGE - HWY 4
AT ST. THOMAS, WET. MUS., DIST. 2
SITE 5-63 WP 312-65
SKETCH FOR PREPARATION OF PRELIMINARY
DRAWING D 6195-P1

Mr. B. K. Davis,
Bridge Engineer,
Bridge Division.

Foundation Section,
Materials & Testing Div.,
Room 107, Lab. Bldg.

Attention: Mr. S. McCombie

March 7, 1967

MAR - 7 1967

FOUNDATION INVESTIGATION REPORT FOR C.N.O.
BY: H. G. Golder and Associates Limited -
Proposed Kettle Creek Bridge, Hwy. No. 4,
St. Thomas, Ont. -- District #2 (London).
W.P. 312-65

Attached, please find the above mentioned report prepared and submitted by the consultant, H. G. Golder and Associates Ltd.

We have reviewed the report and have found that it contains enough factual information which is well presented.

It is recommended in the report that the piers and abutments be founded on piles which will presumably meet refusal within the first few feet of penetration into the very dense sandy silt till layer.

The protection of the abutment footings against scour action, should be decided on hydrological grounds.

The problem of protecting the pier foundations should be carefully studied in view of the fact that the piles will be relatively very short and, if exposed, could possibly fail due to lack of lateral support.

Should you wish to discuss any aspects of this report, please feel free to contact our Office.

AGS/edw

Attach.

cc: Messrs. H. K. Davis (2)
H. A. Tregaskes
D. S. Ferren
A. Gater
H. C. Sernier
A. J. Watt
J. Eoy
D. A. Singh

Foundations Office ✓

Gen. Files

Afternoon
A. C. Starnes
PRINCIPAL FOUNDATION ENGINEER

H. Q. GOLDER & ASSOCIATES LTD

CONSULTING CIVIL ENGINEERS
HEAD OFFICE - TORONTO, ONTARIO

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

747 HYDE PARK ROAD
LONDON, ONTARIO
471-9600

March 3, 1967

Department of Highways, Ontario,
Materials and Testing Division,
Highway 401 and Keele Street,
Downsview, Ontario.

Attention: Mr. A. G. Stermac, Principal Foundation Engineer

Re: Proposed Bridge Replacement
Kettle Creek and Highway No. 4.
W.P. 312-65

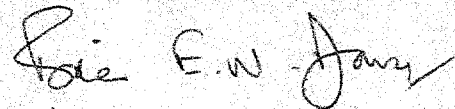
Dear Sirs:

We are mailing today under separate cover eleven copies of our report entitled Soil Conditions and Foundations, Proposed Bridge Replacement, Kettle Creek and Highway No. 4 plus one Mylar Tracing of The Boring Plan and Soil Stratigraphy Section.

We assure you of our best attention at all times.

Yours truly,

H. Q. GOLDER & ASSOCIATES LTD



Brian E. W. Dowse, P.Eng.

BEWD:mr
67508

Box. 401 & Apple St.,
Lewiston, Ontario.

January 31, 1967

Materials and Testing Division

R. A. Solder and Associates Ltd.,
2444 Bloor Street West,
Toronto, Ontario.

Attention: Mr. J. L. Savage

Re: Letter of Authority -- Foundation Investigation
A.R. 112-63; Bridge Site 5-63,
Little Creek Bridge at St. Thomas West Limits,
Reg. 6 -- District No. 2 (London).

Dear Sir:

Please consider this your authority to carry out a foundation investigation at the above mentioned crossing.

The available necessary plans showing the location of the crossing and suggested structure spans, as well as road grade, were given to your representative on January 30, 1967.

You are requested to commence the investigation as soon as possible and submit eleven (11) copies of your report to the Foundation Section by not later than March 7, 1967.

Should any problems arise during the investigation, or should you require additional information, please contact the Foundation Section in Toronto, or Mr. A. A. Watt, Regional Bridge Location Engineer, London - 335 Buxton Street, London, Ontario - phone No: 451-1400 (Area Code R 4). Mr. J. Roy, Regional Materials Engineer, London, will be advised of your organization carrying out this investigation, and should you have any queries, you are free to contact his office.

We understand that you will undertake this investigation from your London Office.

The field work should, at all times, be supervised by a qualified Civil Engineer. Any deviation from this agreement has to meet our prior approval.

cont'd. /2 ...

H. P. Collier & Sonos, Ltd.
Attn: Mr. J. L. Sogren

January 31, 1967

Previous requirements as to preliminary corobole information and laboratory testing program, should be followed.

Since the drawing accompanying the foundation report, showing the location of borings, the inferred subsoil conditions, etc., is to become a contract drawing, you are requested to prepare it in accordance with the A.S.C. Standards. To enable you to do this, we are supplying you with a sample drawing with all the necessary explanations, together with linen sheet for your drawing. You are also requested to provide us with a Cransler copy of the drawing.

Charges for the work performed will be in accordance with your schedule of rates, dated October 1, 1955, and invoice to be addressed to the attention of the undersigned.

We are attaching Purchase Order 1-03820, covering the purchase of any and all material required for this work, in order that you may use this as a basis for exemption from the Federal Tax for such purchases. The Exemption Certificate is printed thereon.

Yours very truly,

A. Rucka

A. Rucka

MATERIALS & TESTING ENGINEER

ASB/ndf
Attach.

cc: Messrs. S. McCable
A. Carter
E. C. Dornier
A. K. Watt
J. Roy
H. Koning
Mrs. I. Steinberg
E. Szymanski (2) ✓
A. Crosby
Foundations Files
Gen. Files

Mr. R. G. Gascoyne,
Regional Functional Planning
Engineer,
London.

Materials and Testing,
London.

June 17, 1966.

file
als
Golden 167

- W.P. 312-65, Hwy. #4, Kettle Creek Bridge,
at St. Thomas West Limits.

As requested on the preliminary functional planning report dated May 11, 1966, a hand auger investigation was carried out at the existing Kettle Creek Structure on Highway #4 just south of Highway #3 to determine general foundation conditions and feasibility of placing a Bailey Bridge and approaches for detour purposes.

Bore holes placed to a 4' depth on both sides of the creek and existing structure encountered firm silty clay at all locations. On Highway #3 the structures constructed over Dodd and Kettle Creeks under Contract 58-650 just north of the proposed structure were placed on bearing piles driven to Elevation 634 and on spread footings founded at Elevation 645. It is therefore anticipated that the proposed structure can be constructed on either spread footings or on short bearing piles driven into the stiff silty clay parent material.

For detour purposes a Bailey Bridge and approaches could be constructed on either side of the existing structure without foundation problems.

The alternate detours for consideration were inspected and found as follows:

(1) Talbot Street From Highway #3 S. W'ly.

This street consists of 0.2 miles asphalt surface in fair to poor condition, 0.2 miles concrete and asphalt in fair condition and 0.2 miles asphalt in very poor condition. The latter section shows bad rutting and break-up and would require reconstruction for use as detour. The former two sections should be resurfaced if the street is used as a detour.

(2) Wilson and Elgin Streets.

Wilson Street from Highway #4 W'ly. 0.8 miles consists of an asphalt surface in poor condition. The surface is badly cracked, dished and distorted and would probably deteriorate rapidly under detour traffic. The section of Elgin Street consists of an Asphalt surface in fair to good condition and it appears that it would probably serve as a portion of the detour without much damage.

Granular material suitable for sub-base can be obtained within 3 to 4 miles from the proposed project. G. B. C. Class "A" would probably have to be hauled from the Byron area.

A. M. Batten
A. M. BATTEN,

AMB:np.

FOR: J. R. ROY,
REGIONAL MATERIALS ENGINEER.

C.C. - G. A. Wrong,
J. A. Stermac,
A. Gater,
A. Watt,
A. M. Batten,
File.

Note: Advised John Roy that it would be better not to mention 4 ft deep holes because from the foundation point of view they have no significance. He agreed.
June 22/66 *A. M. Batten*

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS
HEAD OFFICE - TORONTO, ONTARIO

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

W.P. 312 - 65

747 HYDE PARK ROAD
LONDON, ONTARIO
471-9600

REPORT

TO

DEPARTMENT OF HIGHWAYS, ONTARIO

ON

SOIL CONDITIONS AND FOUNDATIONS

PROPOSED BRIDGE REPLACEMENT
KETTLE CREEK AND HIGHWAY NO. 4

ST. THOMAS

ONTARIO

Distribution:

- 11 copies - Department of Highways, Ontario,
Toronto, Ontario
- 2 copies - H. Q. Golder & Associates Ltd.,
London, Ontario

March, 1967

67508

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ABSTRACT

The results of an investigation to determine the subsurface conditions at the site of the proposed replacement bridge to carry Highway No. 4 over Kettle Creek on the outskirts of St. Thomas, Ontario are reported. Recommendations are made for the foundation design of the proposed structure and approach embankments.

It was found that the site is underlain by loose to compact alluvial sands over firm to hard silty clay. Below the clay a very dense sandy silt till was encountered across the site. The groundwater in the upper sands is a few feet above the water level in the creek. Artesian water pressure was encountered at the contact zone between the clay and the till.

It is recommended that the abutments and piers be founded on piles driven to refusal into the very dense sandy silt till. Recommendations are made for protecting the pile caps for the piers from scour.

No river approach embankment or river bank stability problems are anticipated at the site.

INTRODUCTION

H. Q. Golder and Associates Ltd have been retained by the Department of Highways, Ontario, to carry out a subsurface investigation at the site of the proposed bridge replacement at Kettle Creek on Highway No 4 on the outskirts of St. Thomas, Ontario. The purpose of this investigation was to determine the subsurface and ground-water conditions at the proposed abutment and pier locations and to make recommendations for the foundation design of the proposed structure.

PROCEDURE

The field work for this investigation was carried out between February 6 and 18, 1967. A total of 4 boreholes, each accompanied by a dynamic cone penetration test and 5 additional dynamic cone penetration tests were put down using a skid mounted diamond drillrig supplied and operated by Canadian Longyear Limited. The borings which were started in NX casing size and completed in AX, were put down to depths ranging from 37 feet to 51 feet. The piezometric ground-water level was observed during the investigation in the open casing and up to 10 days after completion of the field work by readings

taken in piezometers installed in each of the boreholes. The field work was supervised throughout by members of our engineering staff.

A detailed log for each of the borings and dynamic penetration tests is given on the Record of Borehole and Record of Penetration Test sheets following the text of this report. The location of the borings put down in this investigation together with a section of the inferred soil stratigraphy is shown on Figure 1.

The soil samples obtained during the investigation were brought to our laboratory for detailed examination and testing. The results of the laboratory tests are shown on the Record of Boreholes and on Figures 2 to 5 inclusive.

The elevations given in this report are referred to a bench mark located at the south east corner of a concrete base of a restaurant sign 133 feet right of St. 8 + 45. The elevation of this bench mark was given as 673.82 as referred to Geodetic datum.

SITE AND GEOLOGY

The existing bridge carrying Highway 4 over Kettle Creek is a three span reinforced concrete arch and slab structure. The proposed replacement structure will follow an alignment about 6 feet west of the existing structure with new centreline grade about 1 foot above the existing grade.

The site of the proposed structure is located about 100 feet downstream from the confluence of Dodds Creek into Kettle Creek. The creek under normal conditions of flow is about 50 feet wide but under conditions of heavy run-off, as experienced during the latter part of the field work, can increase its width to 100 feet. The normal water level in the creek is approximately elevation 657 increasing to about elevation 658 during heavy run-off. The elevation of the general ground level in the region of the bridge site is 674 with the valley floor being about 16 feet lower, at about elevation 658. The river banks in the region of the existing structure have a maximum slope of 2.5 horizontal to 1 vertical and an average slope of 4 horizontal to 1 vertical.

The available geological information for this part of South Western Ontario indicates that the subsoil in the area is a clay deposit forming part of the Ekfrid Clay Plain which apparently varies greatly in thickness. The clay deposits are normally underlain by hard glacial till which in turn overlies limestone bedrock of the Delaware formation at depth.

SUBSOIL CONDITIONS

The detailed stratigraphy encountered in the four boreholes and inferred in the penetration tests is shown on the Record of Boreholes and the Record of Penetration Test sheets. The stratigraphy interpolated from this data is presented on Figure 1. The soil conditions at this site may be summarized in the following manner.

The site is covered on both sides of the creek by surficial alluvial deposits of loose to compact brown silty sand with a trace of gravel except in borehole 4 where the surficial deposit is brown clayey silt. These deposits vary from 2.5 feet to 9 feet in thickness across the site being thicker generally on the south side of the creek. The natural water content of the sand ranges from 13 to 21 percent with an average value of 17 percent. The grain size

distribution curves for samples tested from this stratum are presented as Figure 2. Four feet of loose fill forming a part of the side slopes of the roadway embankments was encountered in borehole 1 above the sand.

Below the alluvial deposits there is a stratum of grey silty clay that varies from a maximum thickness of 16 feet in borehole 1 to a minimum of 5.5 feet in borehole 8. The consistency of the clay is generally stiff to hard except in borehole 4 where it was found to be firm with an unconfined shear strength of 880 pounds per square foot. The liquid limit varies from 26 to 38 with an average value of 33 and the natural water content varies from 17 to 21 percent with an average value of 22 percent. The grain size distribution curves for samples tested from this stratum are presented as Figure 3.

Between the silty clay and the very dense underlying till a thin layer of silt was encountered in borehole 1. The natural water content was measured to be 13 percent and the grain size distribution curves is presented on Figure 4. In borehole 6 a thin deposit of clayey silt was encountered at

this level and its natural water content was measured to be 10 percent and its grain size distribution curve is shown on Figure 4.

Below these upper strata the entire site is underlain by very dense grey sandy silt till with a trace of gravel and clay. The till contains numerous gravel, cobbles and occasional zones of boulders. The natural water content of the till varies from 7 to 13 percent with an average value of 9 percent. The grain size distribution curves for this stratum are presented as Figure 5.

GROUND-WATER CONDITIONS

A piezometer was installed in each borehole after completion of drilling and the details of its depth and seal are given as sketches on the Records of Boreholes. Readings taken up to ten days after completion of the drilling showed the groundwater in the upper sands to have stabilized at between elevations 658.4 and 666.5 indicating that it is influenced by the level of the water in the creek.

An artesian ground-water condition, encountered at the top of the till in boreholes 1 and 4, was measured to be as high as elevation 665. This probably originates in thin sand seams between the till and the silty clay.

DISCUSSION

General

It is understood that the existing reinforced concrete arch and slab bridge is to be replaced by a triple span structure having two 48 foot long end spans and a centre span 96 feet long. The proposed highway centreline grade is to be raised to elevation 677.

Foundations

The existence of a layer of loose to compact sands of variable consistency across the site makes the use of a spread footing type of foundation for the piers and abutments undesirable due to possible differential settlements.

It is therefore recommended that the piers and abutments for the bridge be founded on piles driven to refusal in the very dense sandy silt till. Refusal of the

piles (possible BP 12 x 53lb. H-piles) may be considered as a final set of 10 blows/inch when driven with a hammer developing 20,000 ft.lb. of energy per blow. The design capacity of an H-pile driven in such a manner can be taken as 50 tons per pile. It is anticipated, based on an average pile penetration of about 2 to 5 feet into the till, that the penetration of the piles will be no deeper than the following elevations:

<u>Location</u>	<u>Elevation</u>
North Abutment	637 to 643
North Pier	637 to 640
South Pier	639 to 642
South Abutment	644 to 649

It is recommended that the base of the pile cap of both east and west abutments be founded about 3 feet below finished ground level and be protected against scour of the underlying sand by driving steel sheet piling to toe into the till around the base of each abutment. The base of the pile cap for the north pier should be founded at elevation 652 or lower and for the south pier should be founded at elevation 655 or lower to provide adequate protection against scour. If it is required to place the pier pile caps any higher than these elevations it would be necessary to protect the piers from scour by driving steel sheet piling to toe into the till around the base of each pier.

GOLDER & ASSOCIATES

If retaining type abutments are used, it is recommended that free draining and non-frost susceptible granular backfill be used behind the abutments. The granular backfill should be compacted in horizontal thin layers and should extend horizontally from the back face of the abutment walls for a minimum distance of 6 feet. A maximum loose layer thickness of 18 inches may be used providing vibratory equipment is used for compaction of each layer. It is recommended that, providing there is effective drainage behind the walls, a co-efficient of earth pressure at rest, K_0 of 0.4 and a total unit weight, γ , of 135 pounds per cubic foot be used for the compacted granular backfill in the design of the walls.

Approach Embankments

The maximum height of either of the approach embankments is no greater than a few feet above existing ground level and therefore the embankments are quite stable.

Slopes of River Banks

The slopes of the river banks appear to be stable in the vicinity of the proposed bridge site. The average

height of the river bank is 16 feet and maximum slope is about 2.5 horizontal to 1 vertical.

It is not considered necessary to provide any rip rap protection along the banks of the river as there are no apparent indications of bank erosion.

Brian E. W. Dowse

Brian E. W. Dowse, P. Eng.



Brian E. W. Dowse

for L. G. Soderman, P. Eng.

BEWD:mr
67508

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

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

<i>WH</i>	sampler advanced by static weight— weight, hammer
<i>PH</i>	sampler advanced by pressure—pressure, hydraulic
<i>PM</i>	sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

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

(b) *Cohesive Soils*

<i>Consistency</i>	<i>c_u, lb./sq. ft.</i>
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

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

NOTES:

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

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

LIST OF SYMBOLS

I. GENERAL

τ	= 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

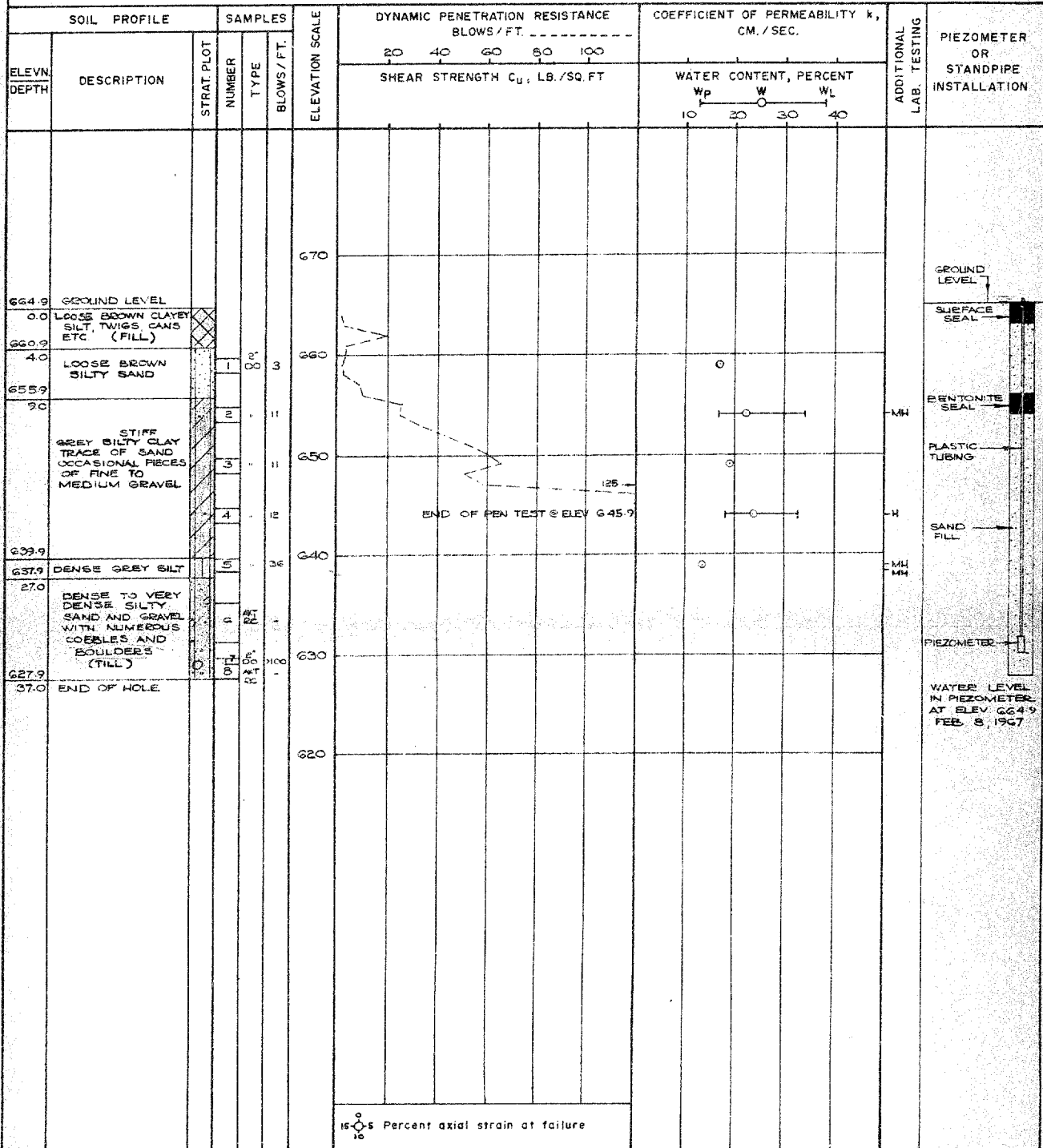
(e) Shear strength

τ_f	shear strength
c'	effective cohesion
ϕ'	effective angle of shearing resistance, or friction
c_u	apparent cohesion*
ϕ_u	apparent angle of shearing resistance, or friction
μ	coefficient of friction
S_r	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.

RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE FEB. 8-8, 1967 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NY BX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



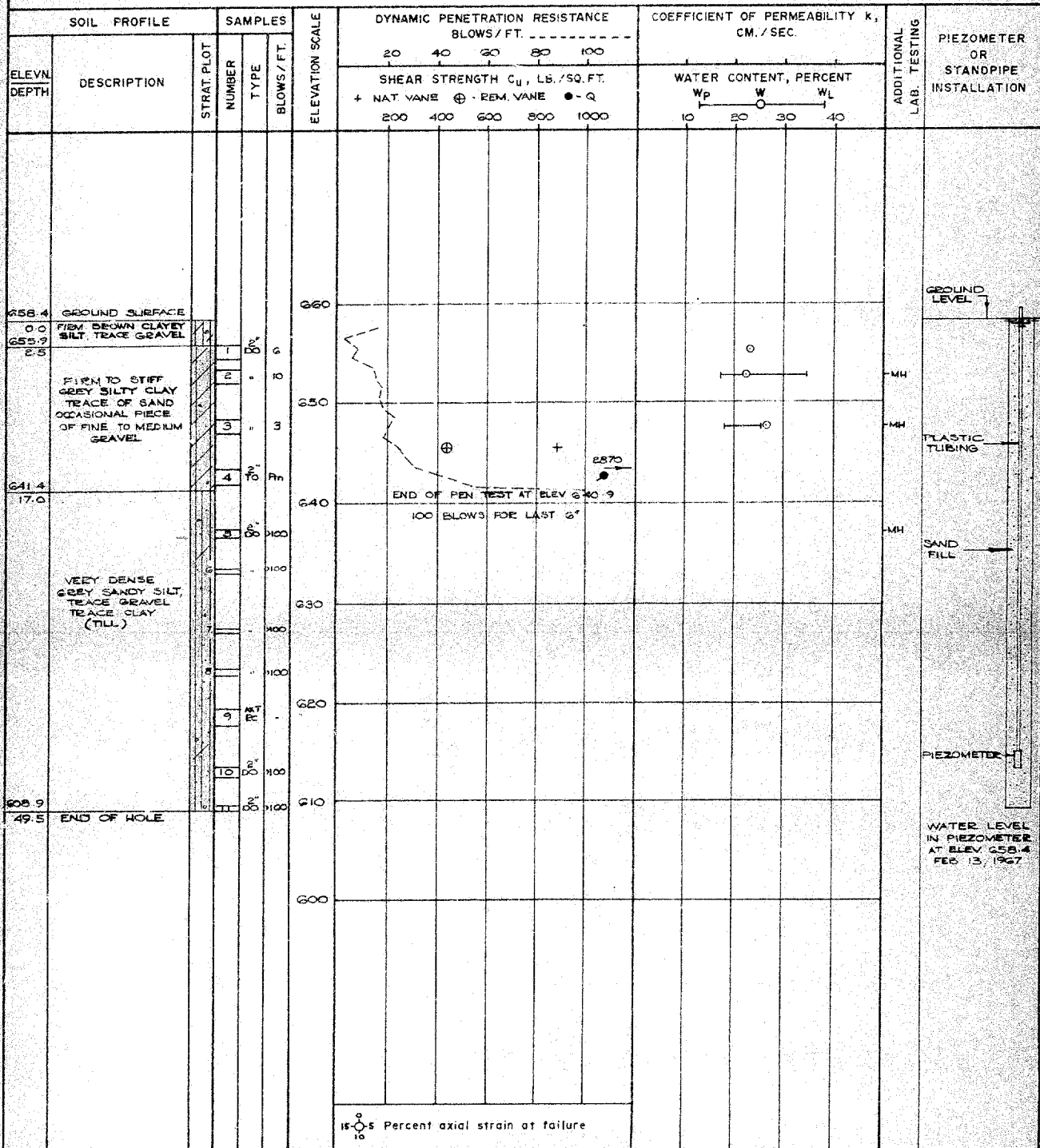
VERTICAL SCALE
 1 INCH TO 10' - 0"

GOLDER & ASSOCIATES

DRAWN
 CHECKED

RECORD OF BOREHOLE 4

LOCATION See Figure 1 BORING DATE FEB. 8, 1967 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NX, BX & AX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



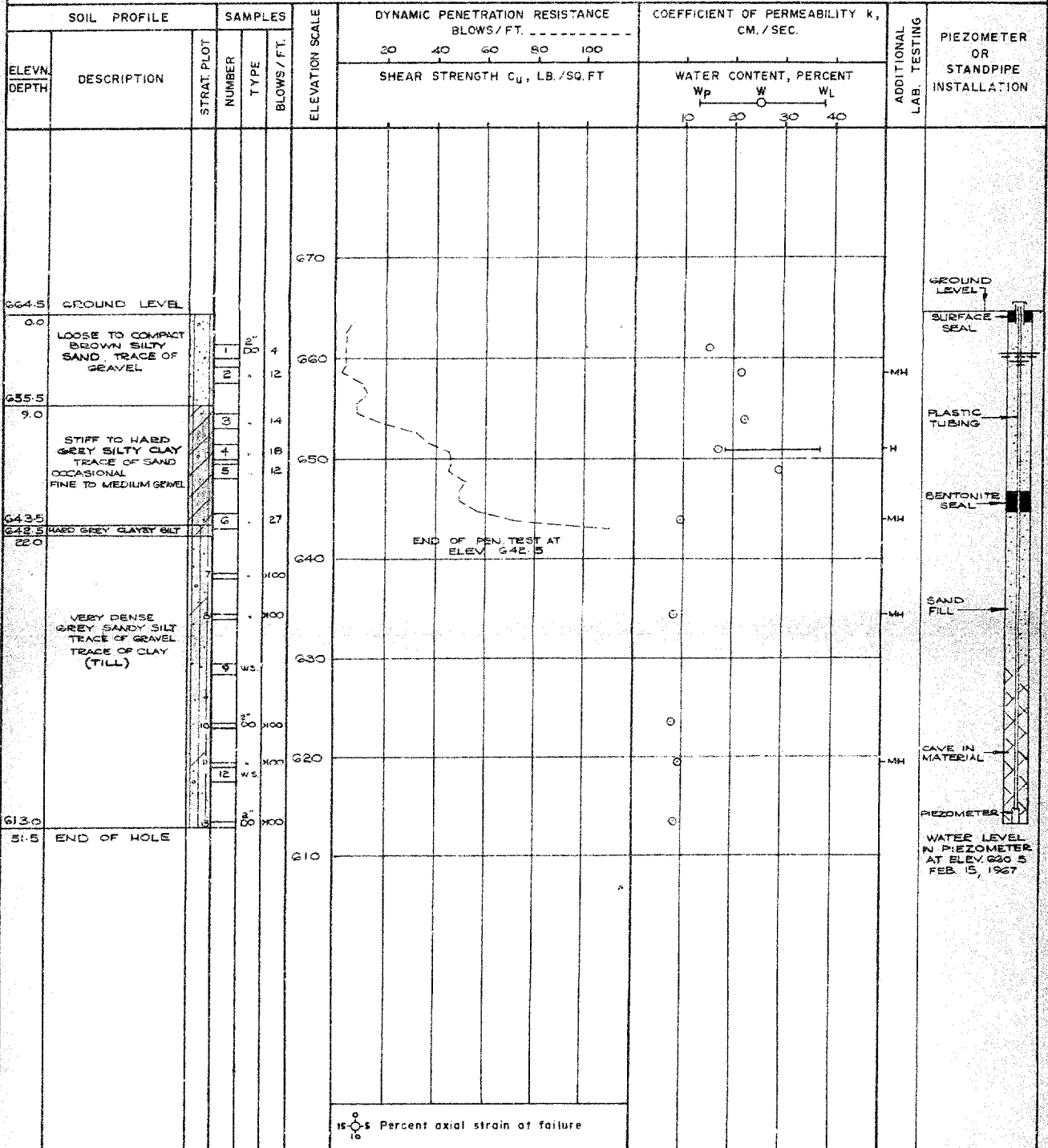
VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN
 CHECKED

RECORD OF BOREHOLE 6

LOCATION See Figure 1 BORING DATE FEB. 14 & 15, 1967 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NX, BX & AX CASING
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



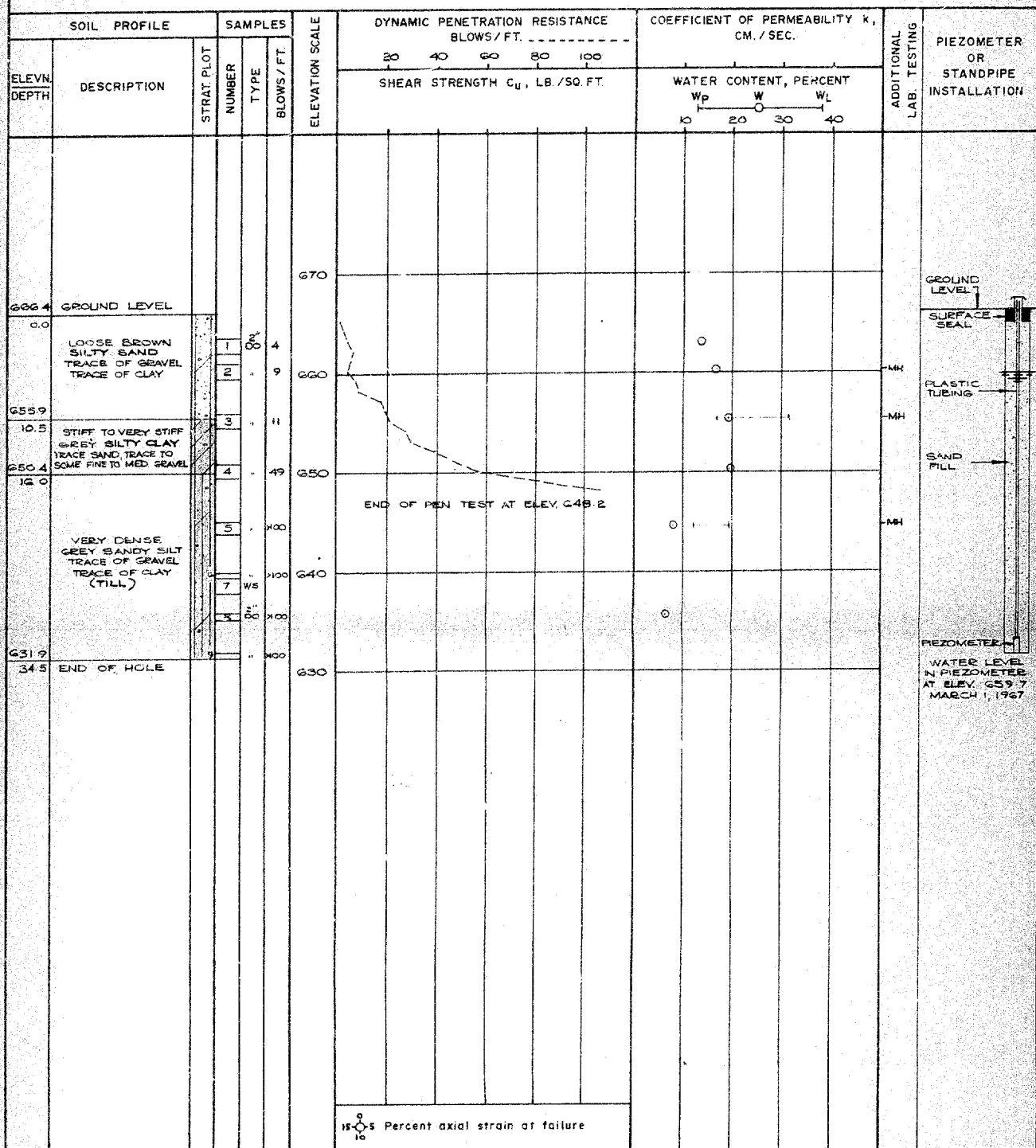
VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN
 CHECKED



RECORD OF BOREHOLE 8

LOCATION See Figure 1 BORING DATE FEB. 12-13, 1967 DATUM GEODETIC
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NX, BX & AX 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 
CHECKED 

PEN. TEST

-40 Figure 1

FEB 8, 1967

DATUM GEODETIC

BOREHOLE TYPE

PENETRATION TEST

BOREHOLE DIAMETER -



LB. DROP - INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

15-0-5 Percent axial strain at failure

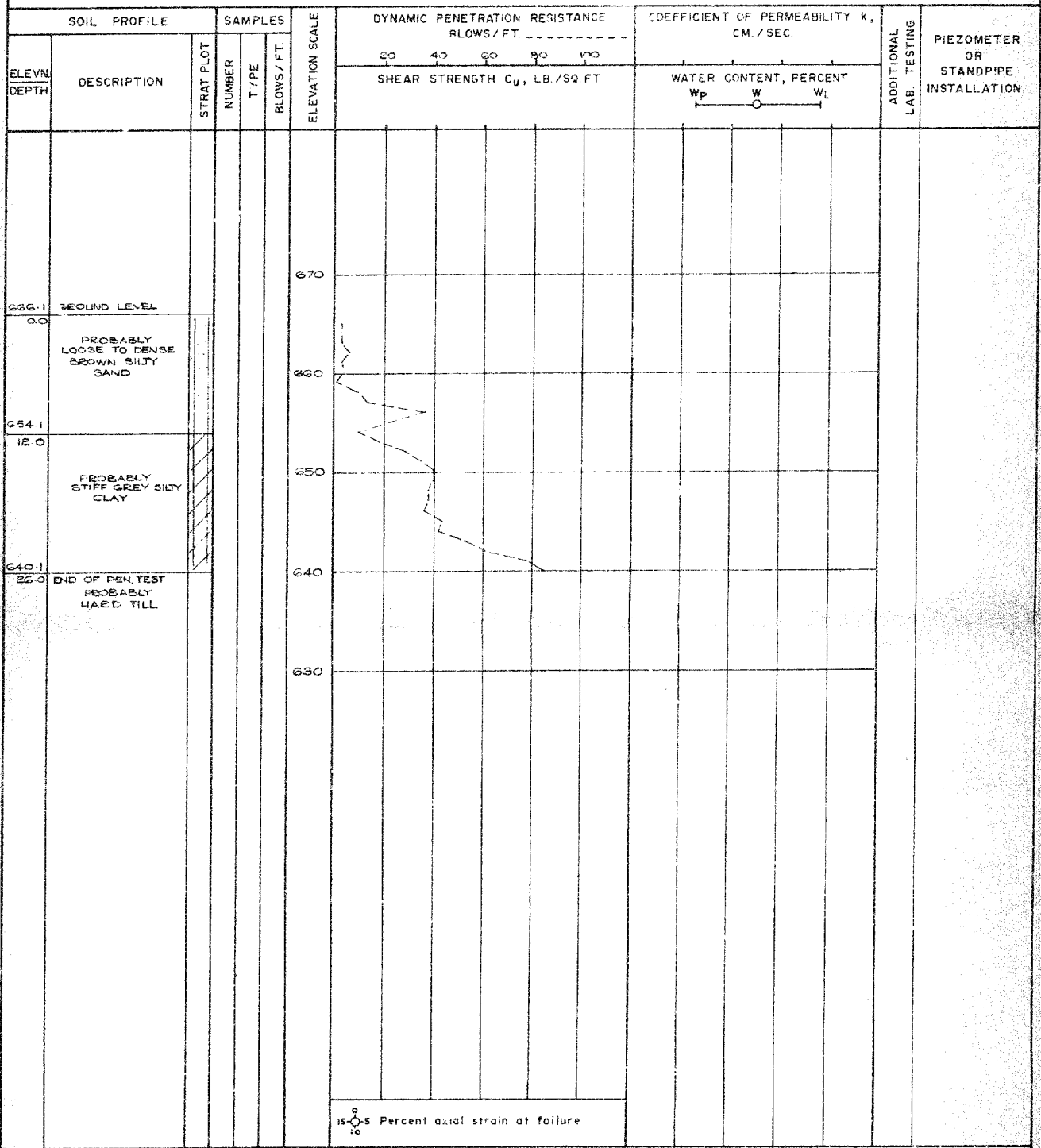
VERTICAL SCALE
1 INCH TO 10' - 0"

GOLDER & ASSOCIATES

DRAWN 
CHECKED 

PEN. TEST RECORD OF BOREHOLE 3

LOCATION See Figure 1 BORING DATE FEB 8, 1967 DATUM GEODETIC
 BOREHOLE TYPE PENETRATION TEST BOREHOLE DIAMETER -
 SAMPLER HAMMER WEIGHT - LB. DROP - INCHES PEN. TEST HAMMER WEIGHT 140 LB DROP 30 INCHES



VERTICAL SCALE
 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

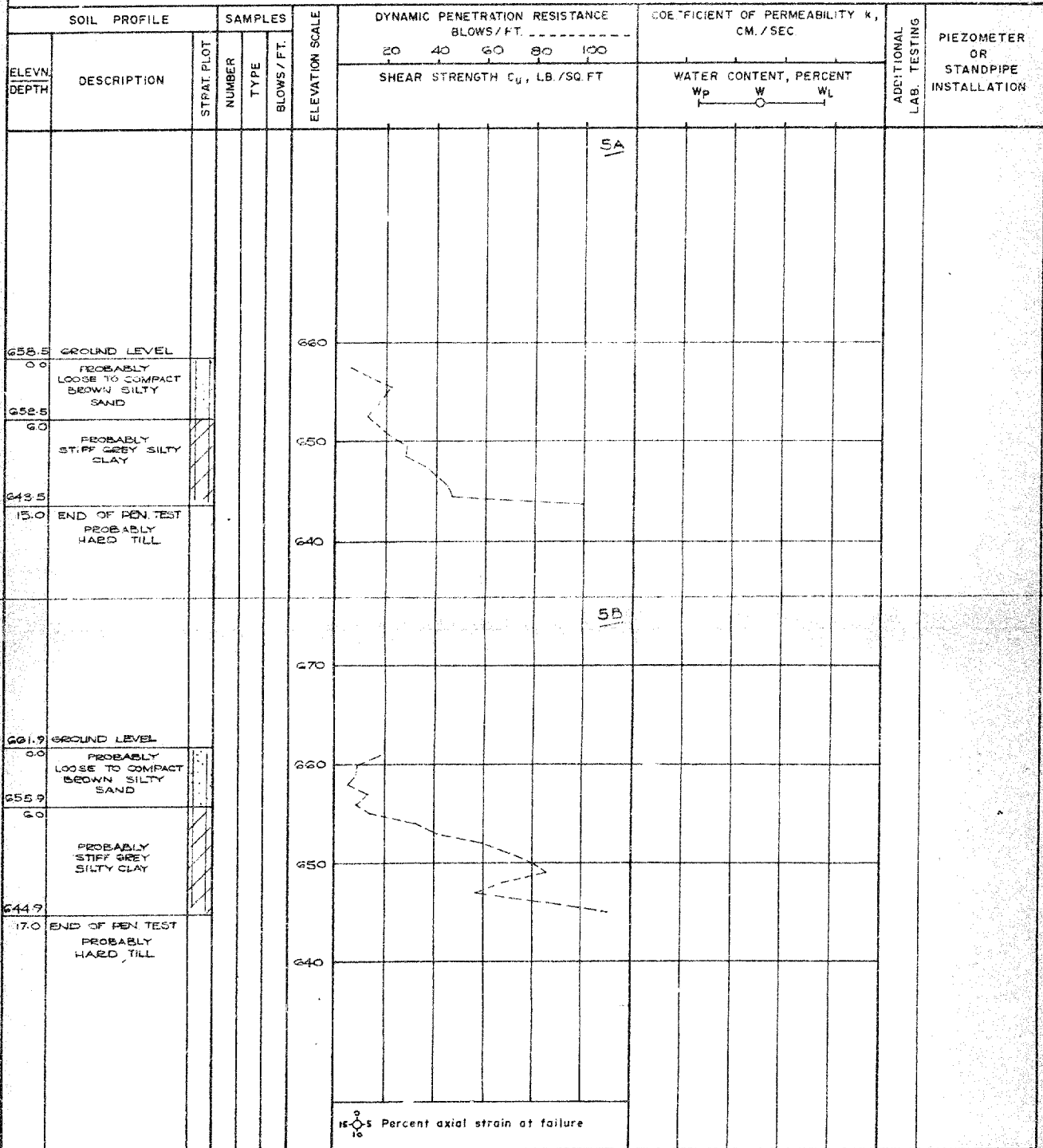
DRAWN *EL*
 CHECKED *DC*

PEN TEST RECORD OF BOREHOLE 5A & 5B

LOCATION See Figure BORING DATE FEB. 14, 1967 DATUM GEODETIC

BOREHOLE TYPE PENETRATION TEST BOREHOLE DIAMETER -

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



VERTICAL SCALE
1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN
CHECKED

PEN TEST RECORD OF BOREHOLE 7

LOCATION See Figure 1 BORING DATE FEB. 12, 1967 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 / FT. -----	COEFFICIENT OF PERMEABILITY k , CM. / SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION									
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER		TYPE	BLOWS / FT.	20			40	60	80	100	WATER CONTENT, PERCENT				
					SHEAR STRENGTH C_u , LB. / SQ. FT					WATER CONTENT, PERCENT		W_p W W_L						
267.9 0.0	GROUND LEVEL				670													
656.9 11.0	PROBABLY LOOSE TO DENSE BROWN SILTY SAND				660													
649.9 18.0	PROBABLY STIFF GREY SILTY CLAY				650													
	END OF PEN. TEST PROBABLY HARD TILL				640													
					<div>Percent axial strain at failure</div>													

Percent axial strain at failure

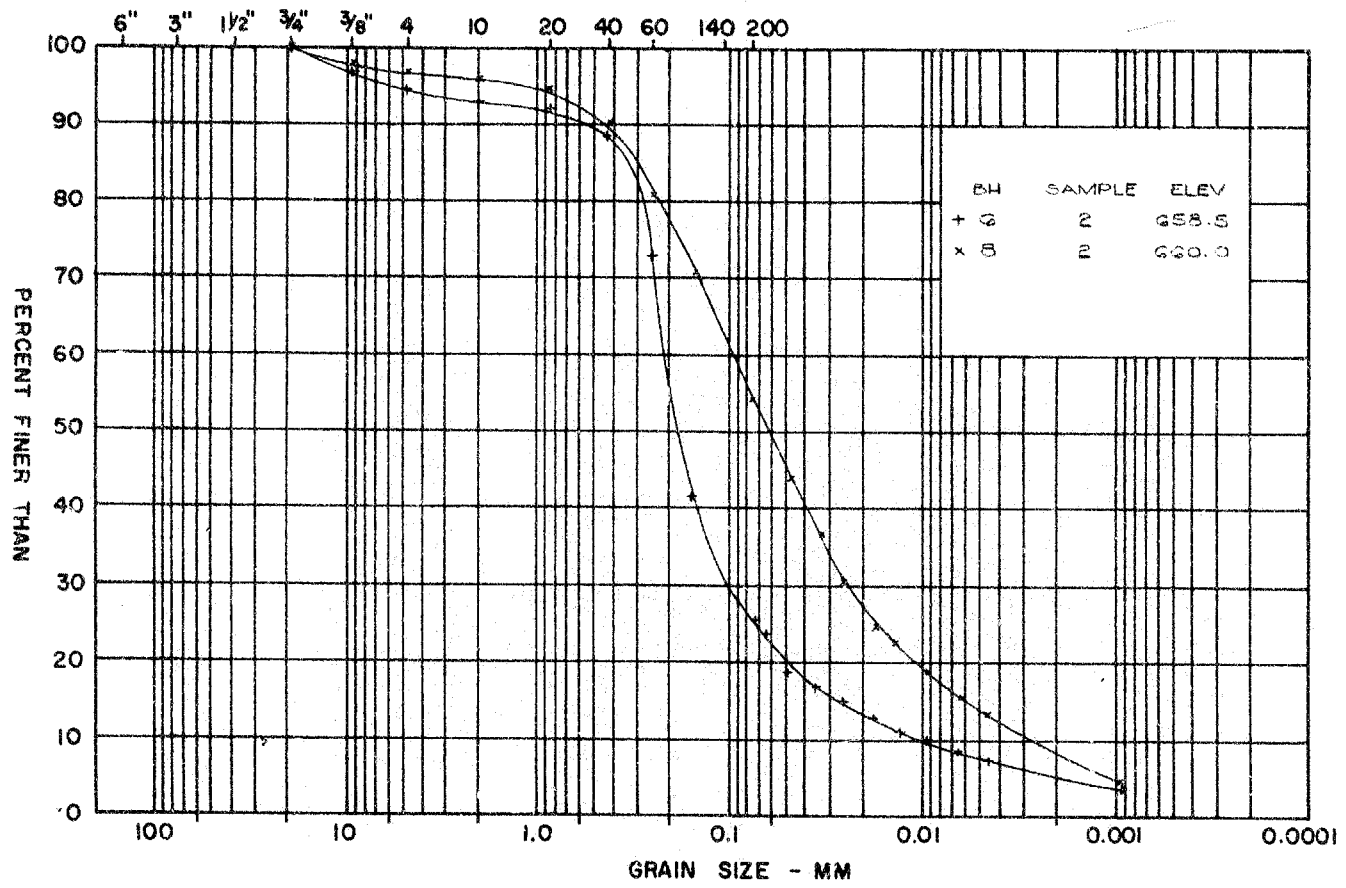
VERTICAL SCALE
1 INCH TO 10' 0"

COLDER & ASSOCIATES

DRAWN
CHECKED

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING-INS. U.S.S. SIEVE SIZE - MESHES/IN.



GOLDER & ASSOCIATES

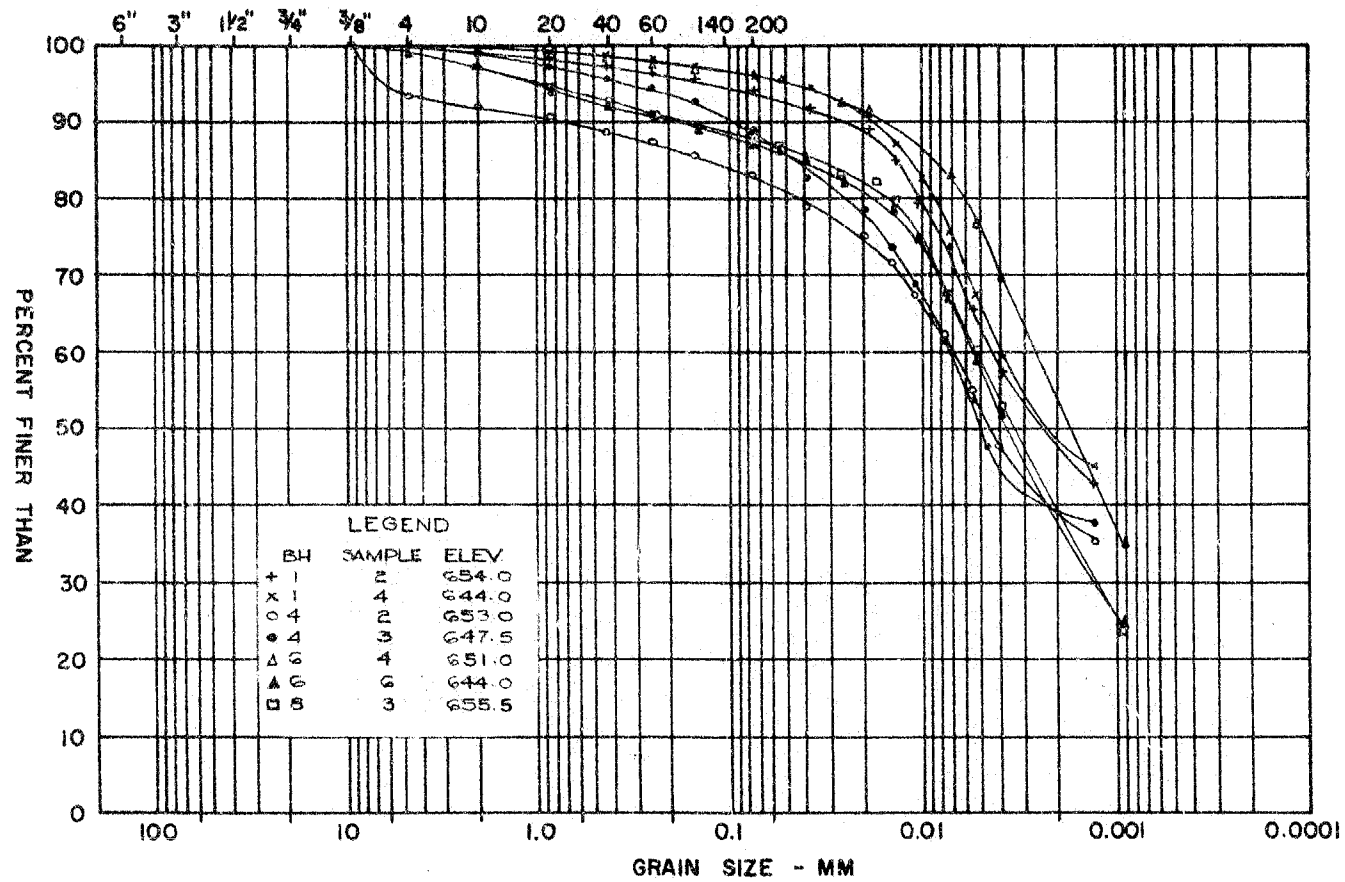
COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE		CLAY SIZE	
	GRAVEL SIZE			SAND SIZE			FINE GRAINED			

GRAIN SIZE DISTRIBUTION
SILTY SAND

FIGURE 2

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES / IN.



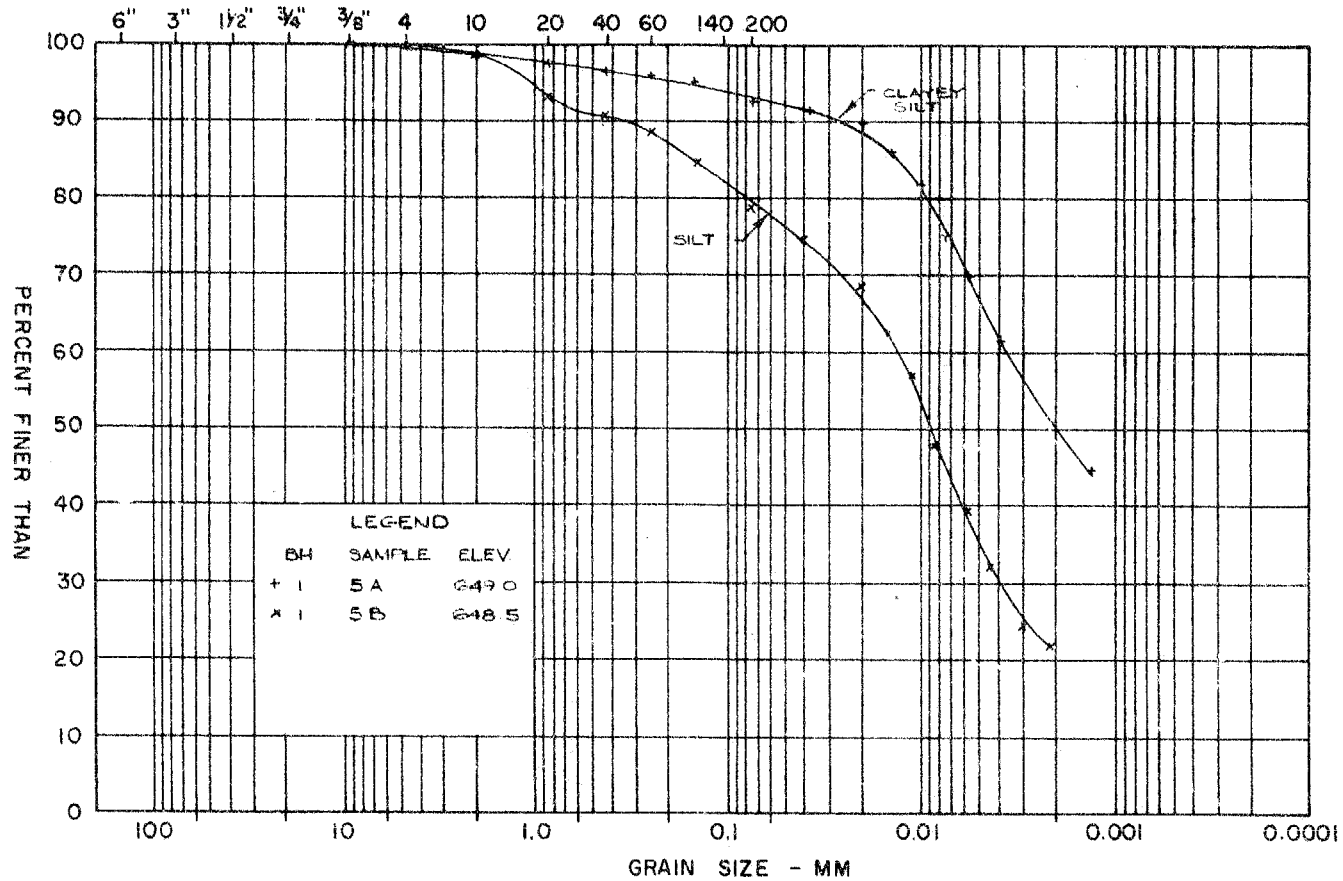
GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIGURE 3

GOLDER & ASSOCIATES

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.



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

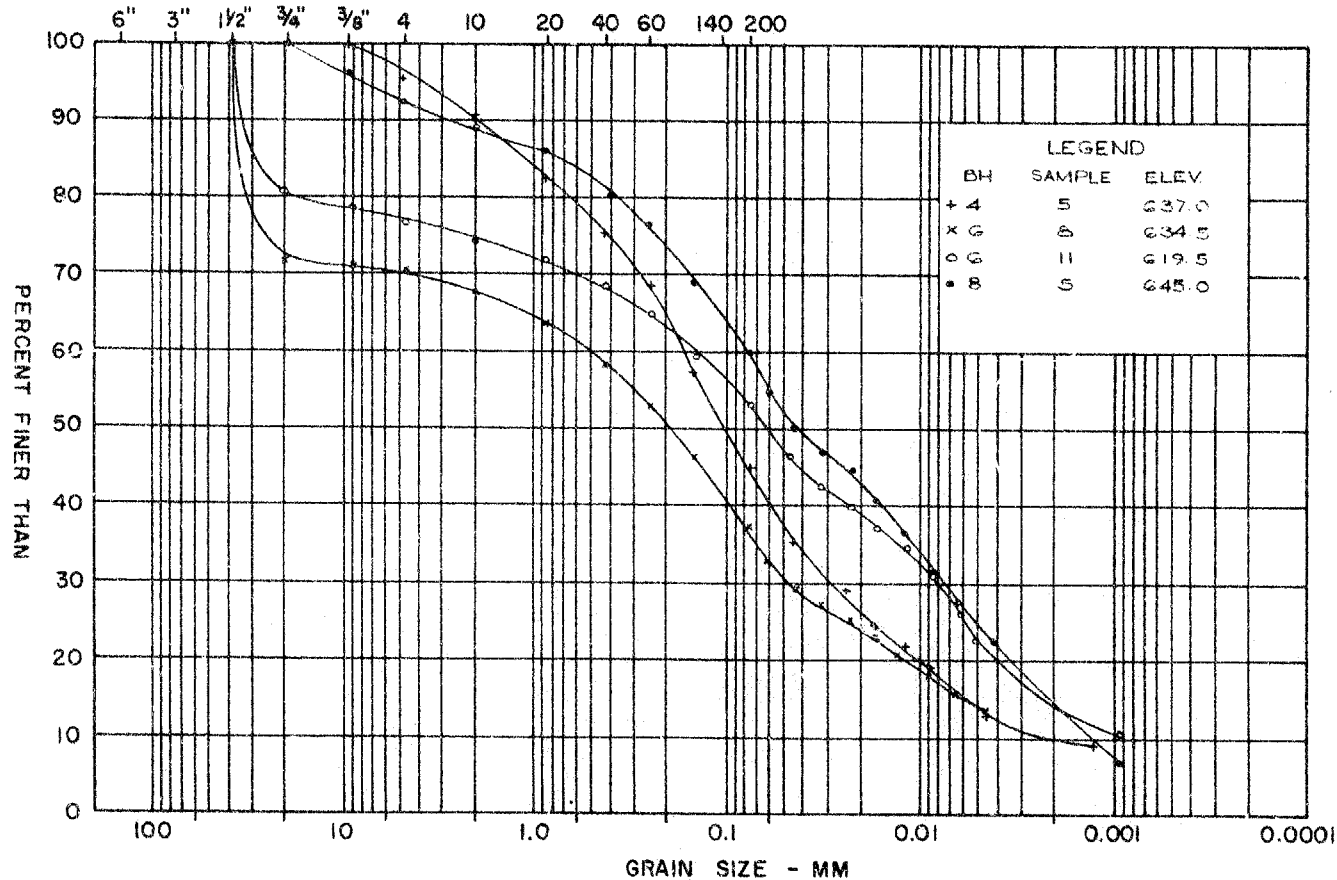
GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

FIGURE 4

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.

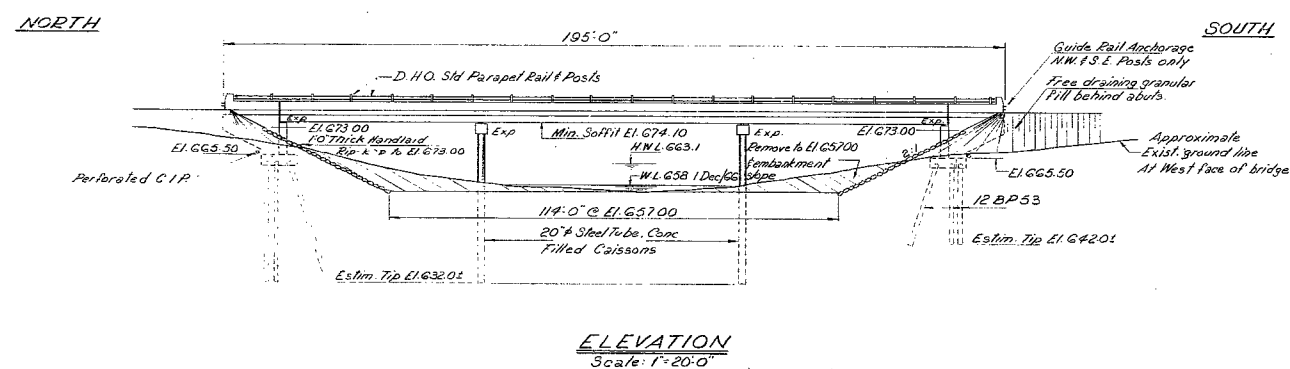
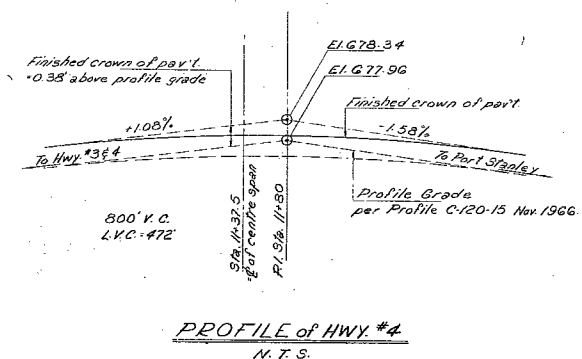
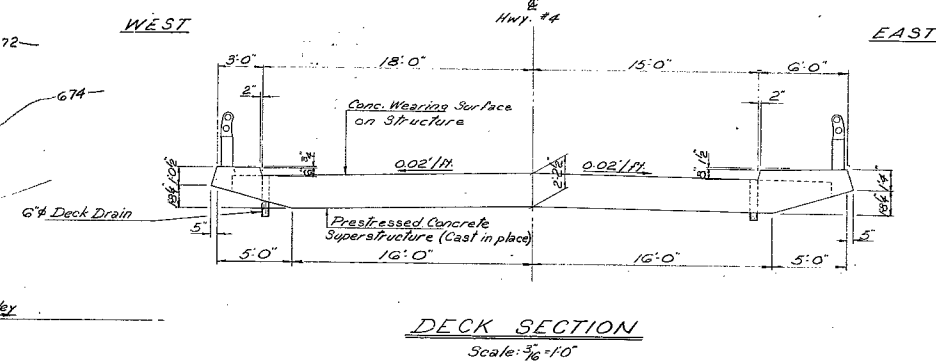
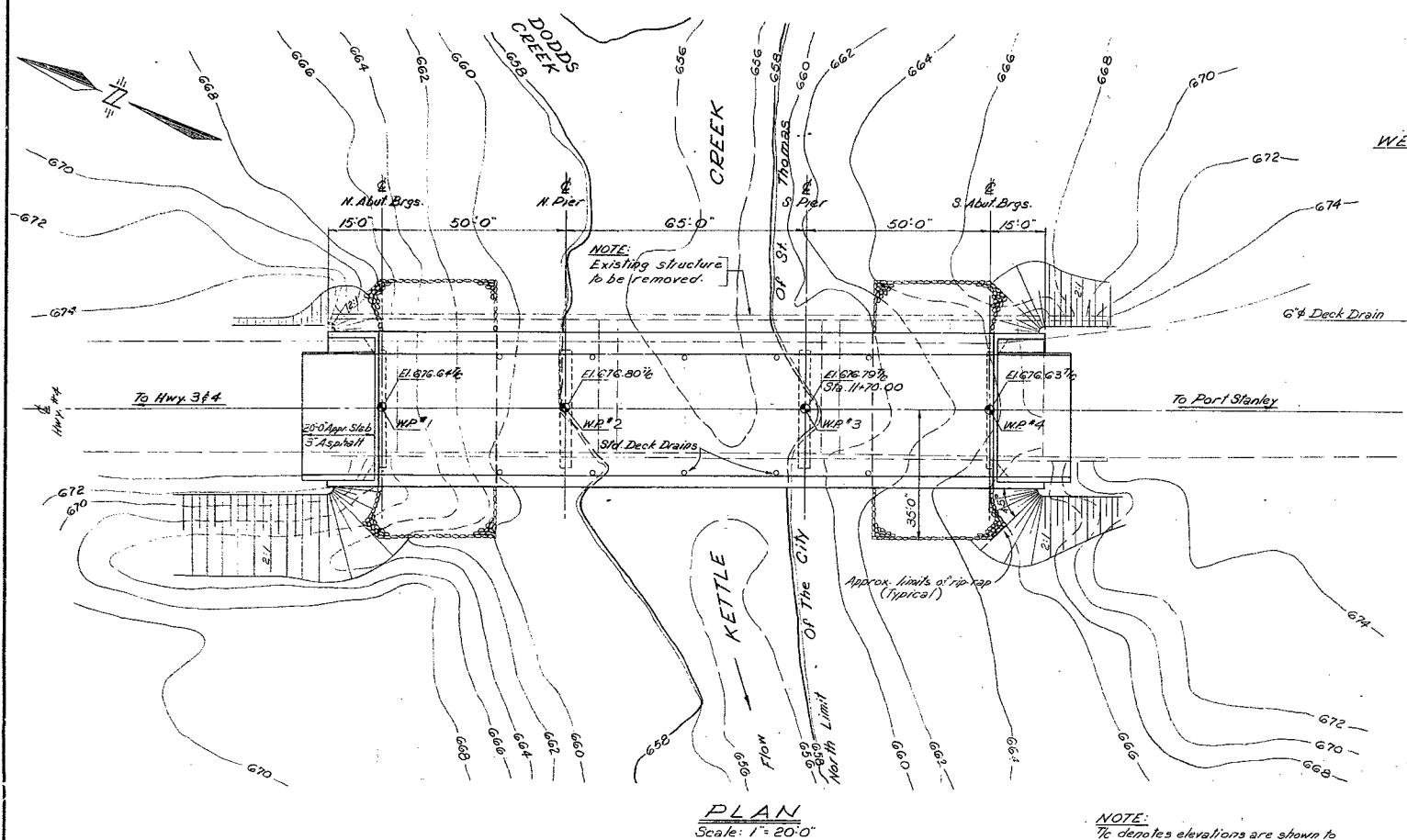
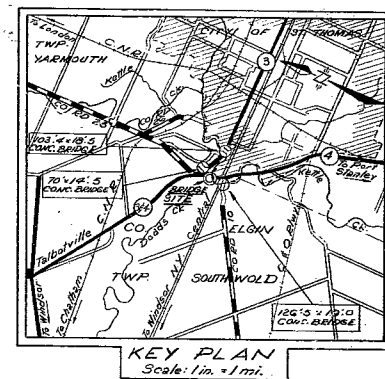


GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION
TILL

FIGURE 5

#67-F-208
W.P. #312-65
HWY #4
KETTLE
CREEK
BRIDGE



NOTE:
T/c denotes elevations are shown to top of concrete wearing surface.
W.P. denotes working point.

G.B.M. No 1641 Elev. 760.265
Holy Angels Roman Catholic Church on Talbot St.
Tablet in stone-work of east side wall, 43 feet from
front corner and in first course above basement window sills.

[illegible][illegible]

DEPARTMENT OF HIGHWAYS ONTARIO			
BRIDGE DIVISION			
EWBANK, PILLAR & ASSOCIATES, LTD. CONSULTING ENGINEERS.			
<u>KETTLE CREEK BRIDGE</u> <i>At St. Thomas West Limits</i>			
KING'S HIGHWAY No. <u>4</u>		DIST. No. <u>2</u>	
CO. <u>Southwold</u>		LOT <u>45</u>	
TWP. <u>Elgin</u>		CON. <u>N.T.R.</u>	
<u>PRELIMINARY PLAN</u>			
APPROVED _____ <small>BRIDGE ENGINEER</small>		SITE No. <u>5-63</u> W.P. No. <u>312-65</u>	
DESIGN <u>C.S.L.</u> CHECK <u>C.L.E.</u>		CONTRACT No. _____	
DRAWING <u>F.L.W.</u> CHECK <u>C.L.E.</u>		DRAWING No. <u>D-6195-P1</u>	
DATE <u>June 1947</u> LOADING <u>WS 24-44</u>			