

#66 - F-283 M

HIGHBURY BRIDGE #171

LONDON TWP.

**H. Q. GOLDER & ASSOCIATES LTD.**

**CONSULTING CIVIL ENGINEERS**

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**REPORT**

**TO**

**66-F-283M**

**R. C. DUNN & ASSOCIATES LIMITED**

**ON**

**SUBSURFACE CONDITIONS AND FOUNDATIONS**

**PROPOSED HIGHBURY BRIDGE #171**

**TOWNSHIP OF LONDON**

**ONTARIO**

**Distribution:**

- 6 copies - R. C. Dunn & Associates Limited,  
London, Ontario.**
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**May, 1966**

**66026**

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## ABSTRACT

The results of an investigation to determine the subsoil and groundwater conditions at the site of the proposed Highbury Bridge No. 171 over the north branch of the Thames River at Highbury Avenue in the Township of London, Ontario are reported. Recommendations are made for foundation design and construction procedures.

At the proposed bridge location the existing river channel is some 200 feet wide and is about 10 to 15 feet below the surrounding ground surface which is at about elevation 810. Outside the existing river bed the site is surficially covered by some 6 feet of loose to dense alluvial silty sand and gravel which is underlain by as much as 30 feet of very stiff to hard clayey silt till. The clayey silt till is in turn underlain by a very dense basal silty sand and gravel till with numerous cobbles and boulders throughout. On the river bottom the basal granular till is generally encountered directly underlying a river bed deposit of loose sand, gravel and boulders. An artesian head of about 1.5 feet above river level (measured during the period of the investigation) was encountered within the basal till below river bottom. It was found that the piezometric groundwater level within the overburden on the banks was some 10 to 15 feet below ground surface.

The abutments and river piers can be carried on piles and spread footing foundations respectively, as discussed in the report. It is recommended that the north abutment be shifted so that the necessary sheet piling required during construction of the proposed abutment does not interfere with the existing wing wall or its footing.

It will be necessary to construct the abutments and piers in the dry; to facilitate this a sheet pile cofferdam is recommended. However, the boulder content within the basal granular till stratum at some locations will require that special sheet piling installation techniques be used as discussed in the report.

Other considerations, such as scour protection, are also discussed in the report.

## INTRODUCTION

H. Q. Golder & Associates Ltd., have been retained by R. C. Dunn & Associates Limited, Consulting Engineers to the London Suburban Roads Commission, to carry out a subsurface investigation for the proposed Highbury Bridge #171 over the north branch of the Thames River at Highbury Avenue in the Township of London, Ontario. The purpose of this investigation was to determine the subsoil and groundwater conditions at the site and to provide information for the foundation design and construction of the proposed bridge structure.

## PROCEDURE

The field work for this investigation was carried out during the period of February 28 to April 1, 1966. A total of seven boreholes (numbered 1 to 7 inclusive), two of which were accompanied by a dynamic cone penetration test, were put down to depths of between 13 and 50 feet by the wash-boring method and due to boulders in the overburden by diamond drilling methods. In addition 5 dynamic cone penetration tests (numbered 8 to 12, inclusive) as well as one hand auger hole were put down on the site. Boreholes 1 and 2 were put down using a diamond machine drillrig supplied and operated by Canadian Longyear Limited, while the remaining boreholes and dynamic

cone penetration tests were put down using a diamond machine drill-rig supplied and operated by the F.E. Johnston Drilling Company Ltd. Boreholes 4, 5, 6 and 7, as well as penetration test 8, were put down through the existing river bottom by the diamond drillrig which was mounted on a barrel raft. Following completion of the boring operations at boreholes 1, 2, 3 and 5 a sealed piezometer was installed to determine the groundwater conditions across the site. The field work was supervised throughout by an engineer from our staff.

A detailed log for each of the borings and penetration tests is given on the Record of Borehole and Record of Penetration Test sheets following the text of this report. The borehole locations together with sections of the inferred soil stratigraphy across the site are shown on Figure 1.

The samples obtained during this investigation were brought to our laboratory for detailed examination and testing. The results of the laboratory testing are shown on the Record of Borehole sheets and on Figures 2 to 5, inclusive.

The elevations given in this report were supplied to us by R. C. Dunn and Associates Limited and are referred to Geodetic datum.

SITE AND GEOLOGY

The site of the proposed Highbury Bridge #171 over the north branch of the Thames River at Highbury Avenue is located slightly north of the City of London in the Township of London, Ontario.

The river lies within a broad ancient valley, the floor of which is fairly flat and level and is some 50 feet below the surrounding ground surface. At the proposed crossing the river channel is some 200 feet wide and is about 10 to 15 feet below the crest of the bank, which is at about elevation 805. It is understood that the high water level of the river is at about elevation 808; the low water level during the period of the investigation was found to be about elevation 795.

Based on available geological information it is known that the site of the proposed bridge structure is underlain by up to about 100 feet of glacio-fluvial sands and gravels deposited during the last period of glaciation. These materials were deposited by the Thames spillway which flowed out of the glacier when it stood at about Ingersoll. Bedrock, which consists of limestone of the Norfolk formation, underlies the site at a depth of greater than 100 feet.

## SUBSURFACE CONDITIONS

The detailed stratigraphy encountered at the borings is given on the Record of Borehole sheets. Following is a summarized account of the subsurface conditions across the site of the proposed structure.

### i) Outside Existing River Bed

The borings put down outside the existing river bed, namely boreholes 1, 2 and 3, encountered up to about 6 feet of recent alluvial deposits consisting generally of brown silty sand with some gravel. At the proposed south abutment location, borehole 1, the alluvium contained a trace to some organic matter, while at the north abutment location the alluvium contained numerous cobbles and boulders necessitating the use of diamond drilling methods at the borehole 3 location. Two grading curves carried out on typical samples of the deposit, obtained with 1½ inch I.D. sampling equipment, are shown on Figure 2. Based on standard penetration test results the relative density of alluvium is loose to dense on the south bank of the river and dense to very dense on the north bank.

Underlying the recent alluvial deposits the borings encountered from 20 to 30 feet of silt till. The till consists of grey clayey silt to silty clay with sand and a trace to some gravel.



Three grading curves carried out on samples of the clayey silt till, obtained with 1½ inch I.D. sampling equipment, are shown on Figure 3. The undrained shear strength of the clayey silt till was measured by two laboratory undrained triaxial compression tests. These two tests, which are plotted on the Record of Borehole sheets, gave undrained shear strength values of about 2,500 lb/sq.ft. and 3,500 lb/sq.ft. Standard penetration tests were also carried out in the till stratum; the penetration tests gave "N" values ranging between about 20 blows/ft. and 60 blows/ft. Based on the above testing the consistency of the till is estimated to range from very stiff to hard and to be generally very stiff.

The till is underlain at a depth of some 20 to 35 feet by a stratum of silty sand and gravel to gravel with some silt and sand. Cobbles and boulders were encountered throughout the stratum. This stratum which has been identified as a sandy till, was penetrated for up to about 15 feet; the base of the till, however, was not proven at the borings. Grading curves for typical samples of the silt and sand till, obtained with 1½ inch I.D. sampling equipment, are shown on Figures 4 and 5. Standard penetration tests carried out in this stratum gave "N" values generally in excess of 100 blows/ft. indicating that the relative density of the stratum is very dense.

ii) Within Existing River Bed

The borings put down in the existing river bed were positioned so as to correspond to the two proposed pier locations. At each of these borehole locations a shallow river bed layer of generally loose sand, gravel and boulders varying in thickness from about 2 feet to 4 feet was encountered. Below this depth of loosened material, considered to be the scour depth, the dense sandy till stratum was encountered. The till stratum is basically sandy in nature and contains numerous cobbles and boulders with a net content of less than 10 percent. The thickness of the stratum was not proven beyond a thickness of about 26 feet (borehole No. 7). Obtaining samples in this layer was extremely difficult due to the presence of cobbles and boulders and as a consequence, on completion of borehole No. 5, it was not possible to ascertain that the material was not recent river transported material deposited in a scour hole. Additional borings numbered 6 and 7 were put down to verify the origin of the deposit; tactile examination of samples recovered confirmed that the stratum was the original sandy till stratum encountered in other borings in the City of London. Typical grading curves carried out on samples from this deposit are shown on Figures 4 and 5 referred to above.

The stratigraphy across the site (see Figure 1) shows

clearly that the upper clayey silt till stratum has been eroded by the present river course. This stratum is evidenced by each of the river bank borings.

iii) Existing Backfill - South Abutment

The proposed new south abutment location is sufficiently near the existing abutment to interfere with the proposed bottom piles of the new abutment. In order to determine whether or not a temporary sheet pile retaining wall required to support the existing roadway fill could be driven through the existing backfill, several penetration tests and one auger hole were put down (penetration tests 9 to 12, inclusive). These tests showed that the backfill is essentially a clean sand with fine to medium gravel sizes throughout with no boulders or concrete rubble. Original brown clayey silt till was encountered at a depth of 15 feet below present pavement surface at penetration test 12, where the auger hole was put down.

GROUNDWATER CONDITIONS

The groundwater conditions at the site were determined during and following the period of the investigation by readings taken in sealed piezometers installed in boreholes 1, 2, 3 and 5 as well as observations made during the drilling operations. The

final set of piezometer readings was taken on April 7, 1966. These readings indicate that on the banks of the river, in the vicinity of the existing bridge structure, the piezometric ground water level is some 10 to 15 feet below ground surface, that is at about elevation 796, while along the river bottom an artesian head of the order of 1.5 feet above river level (refer to Record of Borehole sheets) was encountered within the basal sand and silt till, i.e. between about elevations 796 and 798.

#### DISCUSSION OF RESULTS

The soil investigation was carried out in two stages. Initially borings numbered 1, 2 and 3 were made for the purpose of a preliminary study of type of structure, number of spans, number of piers and method of substructure support. On completion of a review of the preliminary data with the design consultant Mr. N. Warner, of R. C. Dunn & Associates Ltd., the final stage borings and penetration tests were planned and carried out. The final structure proposed is a 3-span continuous steel girder structure having a total span of 260 feet. The short shaft abutments are to be supported on steel H piles while the two intermediate river bed piers are to be supported directly on the till river bed stratum.

Several meetings were held with Mr. Warner as the design

progressed. The following summary of our recommendations pertaining to sub-structure design and river bank slopes is included for record purposes.

1. The most practical type of bearing piles to be used as abutment support is considered to be steel H piles. These piles should be driven to penetrate the lower sandy till stratum. The recommended design working load per pile is 35 tons and a 12 BP 54 section is recommended. Practical refusal to pile advance (i.e. 10 blows/inch for last 12 inches) can be expected at about elevation 775 at the south abutment and at elevation 770 at the north abutment location. This will necessitate pipe lengths of not more than 40 feet.
2. In order to obviate the necessity of providing sheet piling to support the existing roadway for a height of about 20 feet while the existing wing wall is removed to facilitate the driving of abutment bearing piles, it is recommended that the location of the north abutment be shifted so that these piles do not interfere with the existing wing wall or its footing. This will necessitate exerting roadway support only to a depth to the underside of the proposed abutment footing rather than to the underside of the existing wing wall footing.

3. It is recommended that the river piers be founded on spread footings bearing directly on the dense to very dense sandy till stratum. A safe net bearing pressure of 3 tons/sq.ft. may be used in design. The recommended elevation to the underside of the footing is 785 at the south pier and 775 at the north pier. Heavy rip rap as scour protection at each pier location has been recommended. Gabion baskets placed on a prepared pit run gravel bed (maximum grain size 4 inches) are considered acceptable as rip rap protection.
4. Due to the numerous cobbles and boulders at the pier locations it will be virtually impossible to drive a steel sheet pile cofferdam and then excavate. The technique of setting up a template and threading the piles then excavating ahead of the piling where necessary seems to be the most practical construction method for pier placement at this site. This technique was used successfully at a bridge site upstream of this structure at Plover Mills. It will not be possible to drive the sheeting below the proposed underside of the footing using this technique. It is recommended that the excavation be over-dug to a depth of 12 inches below proposed footing base elevation and that a 12 inch concrete base seal be poured. This can be placed under water if necessary.

At the south pier location the excavation will be principally through the clayey silt till stratum, very few boulders if any were encountered within this deposit and thus it should be possible to drive steel sheeting at this location. Steel sheeting should be left in place at both pier locations.

5. It is recommended that the abutment embankment slopes be maintained at 2 horizontal to 1 vertical. There is considerable scouring of the river bank slopes evidenced on the north bank at the bridge location and slope trimming and rip rap protection to above high water level is recommended. Gabion baskets placed on pit run gravel are recommended also. The river bank slope in front of the north abutment should be protected with rip rap and river bottom scour protection should be continuous in the area of the north pier. The river bank slope in front of the south abutment should also be protected with rip rap. Rip rap in the area of the south pier need only extend slightly beyond the perimeter of the pier excavation.

If any details presented in this report require clarification or further consideration please do not hesitate to call our office.

LGS:hdg  
66026  
May 13, 1966.

*B.T. Darch,*  
per L. G. Soderman, P.Eng.

**GOLDER & ASSOCIATES**

## 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

<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<sub>u</sub>, 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

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

### NOTES:

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

<sup>2</sup>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
$\sigma$	normal stress
$\sigma'$	normal effective stress ( $\bar{\sigma}$ is also used)
$\tau$	shear stress
$\epsilon$	linear strain
$\epsilon_{xy}$	shear strain
$\nu$	Poisson's ratio ( $\mu$ is also used)
$E$	modulus of linear deformation (Young's modulus)
$G$	modulus of shear deformation
$K$	modulus of compressibility
$\eta$	coefficient of viscosity

### III. SOIL PROPERTIES

#### (a) Unit weight

$\gamma$	unit weight of soil (bulk density)
$\gamma_s$	unit weight of solid particles
$\gamma_w$	unit weight of water
$\gamma_d$	unit dry weight of soil (dry density)
$\gamma'$	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

$\tau_f$	shear strength
$c'$	effective cohesion
$\phi'$	effective angle of shearing resistance, or friction
$c_u$	apparent cohesion*
$\phi_u$	apparent angle of shearing resistance, or friction
$\mu$	coefficient of friction
$S_t$	sensitivity

} in terms of effective stress  
 $\tau_f = c' + \sigma' \tan \phi'$

} in terms of total stress  
 $\tau_f = c_u + \sigma \tan \phi_u$

\*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

See Figure 1

BORING DATE                    MARCH 1 - 2, 1966

DATUM                      GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER                      NX 4 BX CASING

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

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. ----- 20 40 60 80 100		COEFFICIENT OF PERMEABILITY $k_v$ , CM./SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVATION DEPTH	DESCRIPTION	STRAT. PLAT NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ. FT.	WATER CONTENT, PERCENT W <sub>p</sub> W      W <sub>L</sub>			
796.0	GROUND LEVEL								ORGANIC CONTENT 13.5%	<p>GROUND LEVEL</p> <p>SURFACE SEAL</p> <p>ELASTIC TUBING</p> <p>BENTONITE SEAL</p> <p>PIEZOMETER</p> <p>W.L. IN PIEZOMETER EEL 797.5 ON APRIL 7, 1966</p>
0.0	LOOSE BROWN SILTY SAND TRACE OF ORGANICS	1	D.O.	3						
793.5		2	"	23						
2.5		3	"	40						
	VERY STIFF TO HARD GREY CLAYEY SILT WITH TRACE TO SOME SAND AND GRAVEL (TILL)	4	"	85						
		5	"	45						
777.5		6	"	100						
18.5	VERY DENSE GREY SANDY SILT, SOME GRAVEL, COBBLES AND BOULDERS (TILL)	7	"	100						
771.0		8	"	100						
25.0	END OF HOLE									

VERTICAL SCALE  
1 INCH TO 10' - 0"

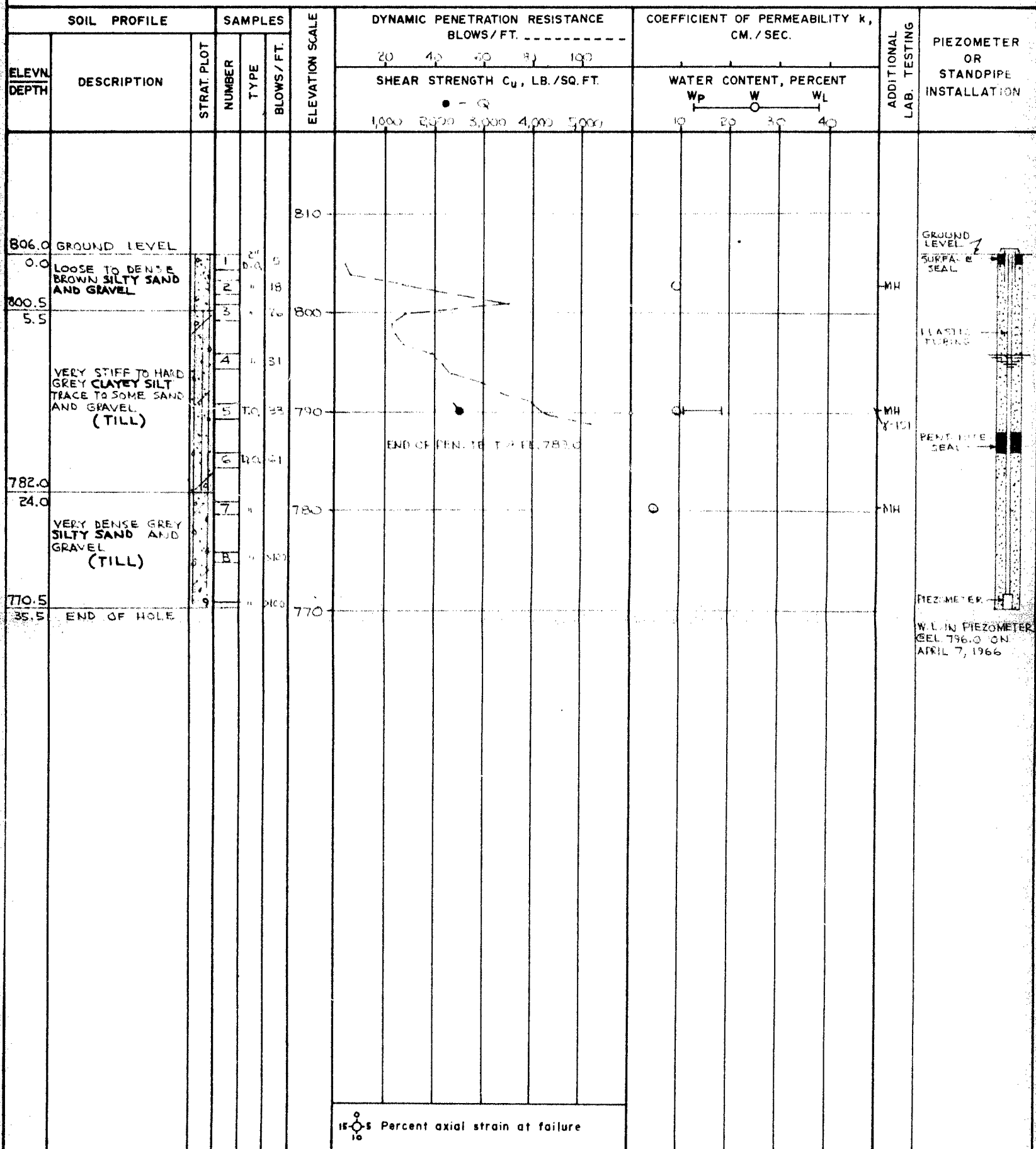
**GOLDER & ASSOCIATES**

DRAWN JA  
CHECKED ETD

DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

## RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE MARCH 3 4, 1966 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



VERTICAL SCALE

1 INCH TO 10'-0"

GOLDER &amp; ASSOCIATES

DRAWN J.A.

CHECKED J.A.

LOCATION	See Figure 1	BORING DATE	MARCH 7-9, 1966	DATUM	GEODETIC
	BOREHOLE TYPE	WASH BORING		BOREHOLE DIAMETER	NX & BX CASING
SAMPLER HAMMER WEIGHT 140 LB.	DROP 30 INCHES			PEN. TEST HAMMER WEIGHT 140 LB.	DROP 30 INCHES

DRAWN ..... J.A. ....  
CHECKED B.T.D.



DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

# RECORD OF BOREHOLE 5

LOCATION See Figure 1 BORING DATE MARCH 17-22, 1966 DATUM CELESTIC  
BOREHOLE TYPE WATER BORED BOREHOLE DIAMETER 8X CASING  
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. -----					COEFFICIENT OF PERMEABILITY k, CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH C <sub>u</sub> , LB./SQ. FT.					WATER CONTENT, PERCENT W <sub>p</sub> W      W <sub>L</sub> 10      20      30      40				
794.8	RIVER LEVEL					800										<p>RIVER LEVEL</p> <p>RIVER BOTTOM</p> <p>PLASTIC TUBING</p> <p>SAND &amp; GRAVEL FILL</p> <p>BENTONITE SEAL</p> <p>PIEZOMETER</p>
785.4	RIVER BOTTOM					790										
0.0	LOOSE TO COMPACT SAND, GRAVEL AND BOULDERS		1	AX RC		780										
781.4			2	AX RC	47											
4.0			3	AX RC												
			4	AX RC	210											
	DENSE TO VERY DENSE GREY SANDY SILT WITH FINE TO COARSE GRAVEL, NUMEROUS COBBLES AND BOULDERS (TILL)		5	AX RC												
			6	AX RC												
			7	AX RC	210	770										
			8	AX RC												
761.4			9	AX RC	30											
24.0	END OF HOLE		10	AX RC		760										
						15-5 Percent axial strain at failure										

15-10 Percent axial strain at failure

VERTICAL SCALE  
1 INCH TO 10'-0"

GOLDER & ASSOCIATES


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CHECKED B.T.D.

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CONDITION OF ORIGINAL DOCUMENT

## RECORD OF BOREHOLE 6

LOCATION See Figure 1 BORING DATE MAY 11 1962 DATUM GEOMETRIC  
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NO. 5. A. LATHING  
 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. -----					COEFFICIENT OF PERMEABILITY $k$ , CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVN. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH $C_u$ , LB./SQ.FT.					WATER CONTENT, PERCENT W <sub>P</sub> W      W <sub>L</sub>					
796.3	RIVER LEVEL				800											
787.5	RIVER BOTTOM				790											
786.5	LOOSE SAND, GRAVEL AND BOULDERS		1	SP. 1	78											
	DENSE TO VERY DENSE GREY SANDY SILT, SOME FINE TO COARSE GRAVEL NUMEROUS COBBLES AND BOULDERS (TILL)		2	SP. 2	780											
774.2			3	SP. 3												
13.3	END OF HOLE		4	SP. 4	770											

NO ARTESIAN  
HEAD OBSERVED  
DURING DRILLING
 Percent axial strain at failure

 VERTICAL SCALE  
 1 INCH TO 10'-0"

GOLDER &amp; ASSOCIATES

 DRAWN *RH*  
 CHECKED *RH*

LOCATION	See Figure 1	BORING DATE	MARCH 29-31, 1966	DATUM	GEODETIC
BOREHOLE TYPE	WASH BORING	BOREHOLE DIAMETER	8X NX CASING		
SAMPLER HAMMER WEIGHT 140 LB.	DROP 50 INCHES	PEN. TEST HAMMER WEIGHT	- LB.	DROP	- INCHES

SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FT.	COEFFICIENT OF PERMEABILITY k, CM. / SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVN. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		BLOWS / FT.	SHEAR STRENGTH C <sub>u</sub> , LB./SQ.FT.	WATER CONTENT, PERCENT W <sub>p</sub> W      W <sub>L</sub>		
796.3	RIVER LEVEL									
791.8	RIVER BOTTOM									
0.0	LOOSE SAND GRAVEL AND BOULDERS									
787.8										
4.0										
	DENSE TO VERY DENSE GREY SANDY SILT SOME FINE TO COARSE GRAVEL, NUMEROUS COBBLES AND BOULDERS (TILL)									
761.8										
30.0	END OF HOLE									

ARTESIAN HEAD OF 1.5' ABOVE RIVER LEVEL SHOWN WHEN HOLE AT DEPTH OF 18' BELOW RIVER BOTTOM ON MARCH 30, 1966

MH

Percent axial strain at failure

DRAWN EH  
CHECKED RTD



PEN. TEST 8, 9 & 10

<b>LOCATION</b>	<b>See Figure 1</b>	<b>BORING DATE</b>	MARCH 17 & MARCH 31, 1966	<b>DATUM</b>	GEOLOGIC
<b>BOREHOLE TYPE</b>	<b>PENETRATION TEST</b>		<b>BOREHOLE DIAMETER</b>		
<b>SAMPLER HAMMER WEIGHT - LB.</b>	<b>DROP - INCHES</b>	<b>PEN. TEST HAMMER WEIGHT 145 LB. DROP 30 INCHES</b>			

[illegible]

VERTICAL SCALE  
1 INCH TO

**GOLDER & ASSOCIATES**

DRAWN ..... RH  
CHECKED ..... EJD

# PEN. TEST 11 & AUGERHOLE 12 RECORD OF BOREHOLE

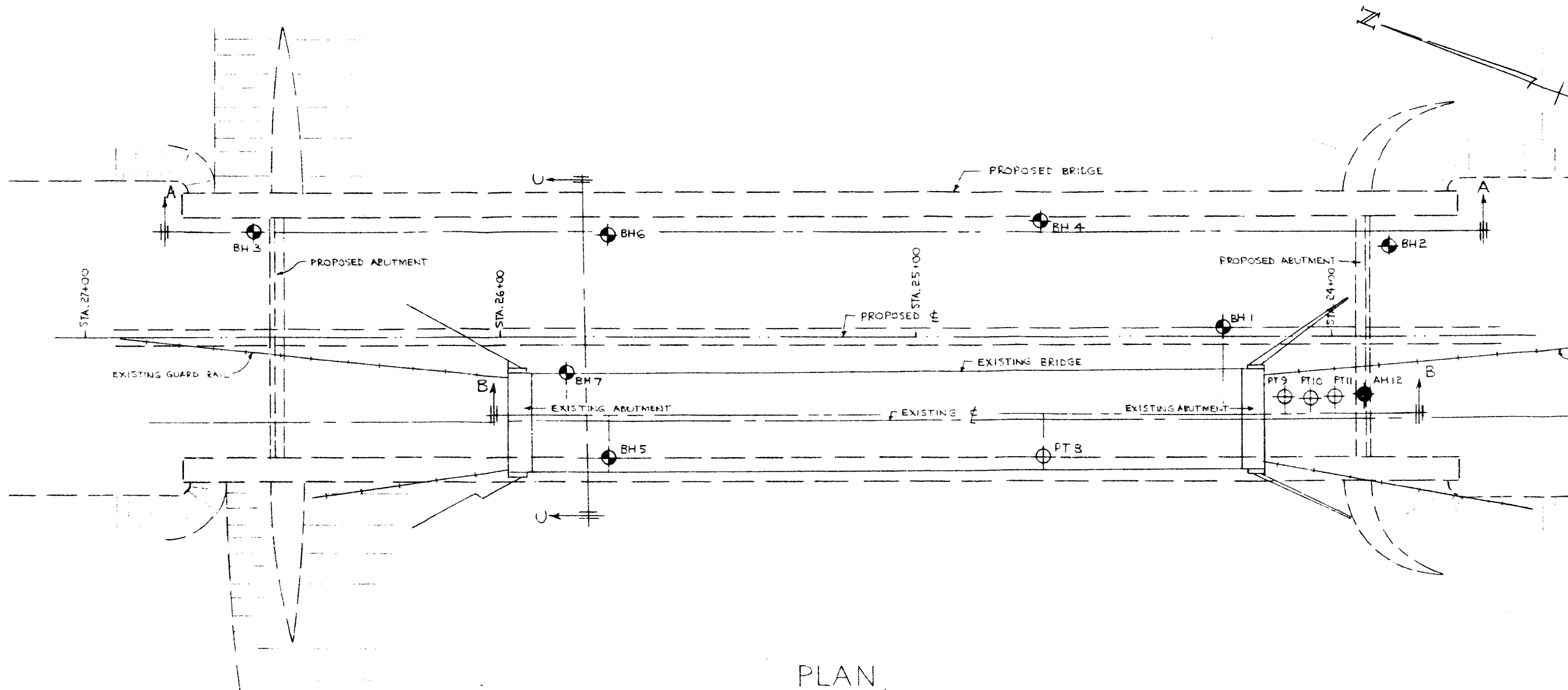
LOCATION See Figure 1 BORING DATE MARCH 21, 1966 DATUM GEODETIC  
BOREHOLE TYPE PEN. TEST & AUGER HOLE BOREHOLE DIAMETER 4.5"  
SAMPLER HAMMER WEIGHT - LB. DROP - INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

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.	SHEAR STRENGTH $C_u$ , LB. / SQ. FT.	WATER CONTENT, PERCENT W <sub>p</sub> W      W <sub>L</sub>			
							PEN. TEST 11				
821.0	APPROXIMATE GROUND LEVEL				830						
					820						
					810						
803.0	18.0 END OF PEN. TEST				800						
							AUGERHOLE 12				
821.0	APPROXIMATE GROUND LEVEL				820						
0.0					810						
	BROWN SAND AND GRAVEL (FILL)										
806.0	15.0										
	STIFF BROWN CLAYEY SILT (TILL)										
797.5	23.5 END OF AUGER HOLE				800						
	(HARD GREY CLAYEY SILT TILL ON AUGER TIP AT EL. 797.5)				790						
						15-0-5 Percent axial strain at failure					

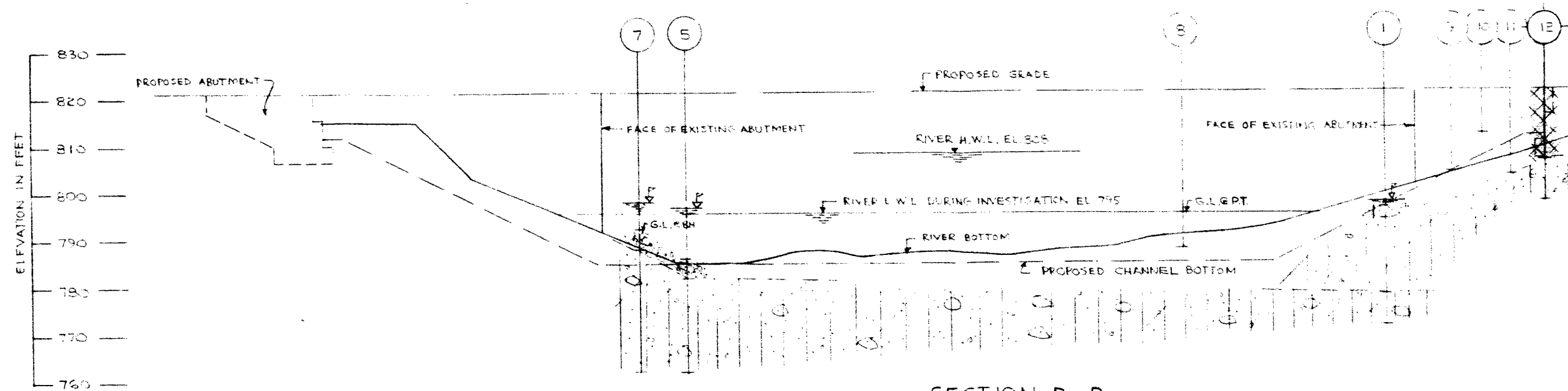
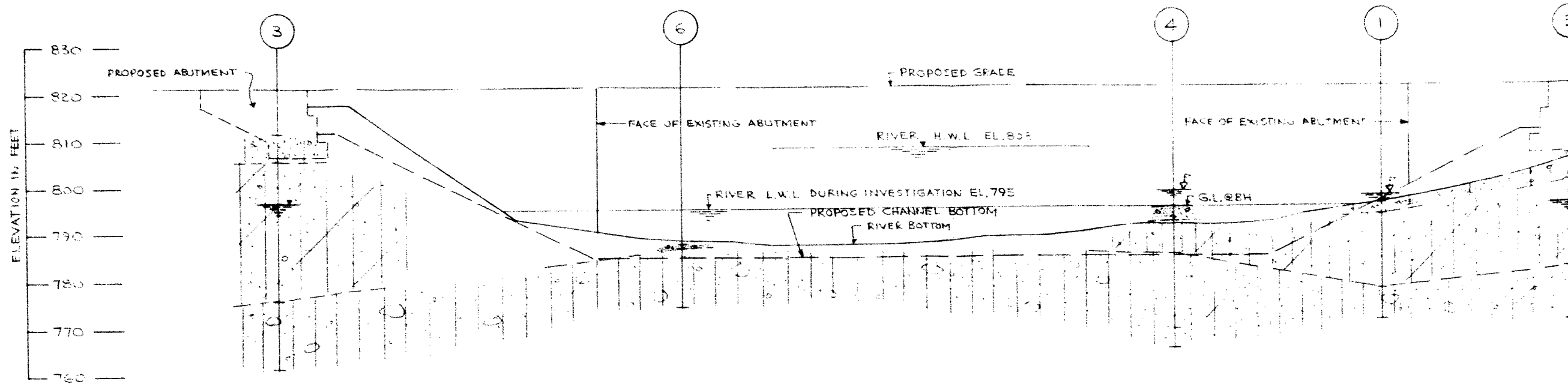
VERTICAL SCALE  
1 INCH TO 10'-0"

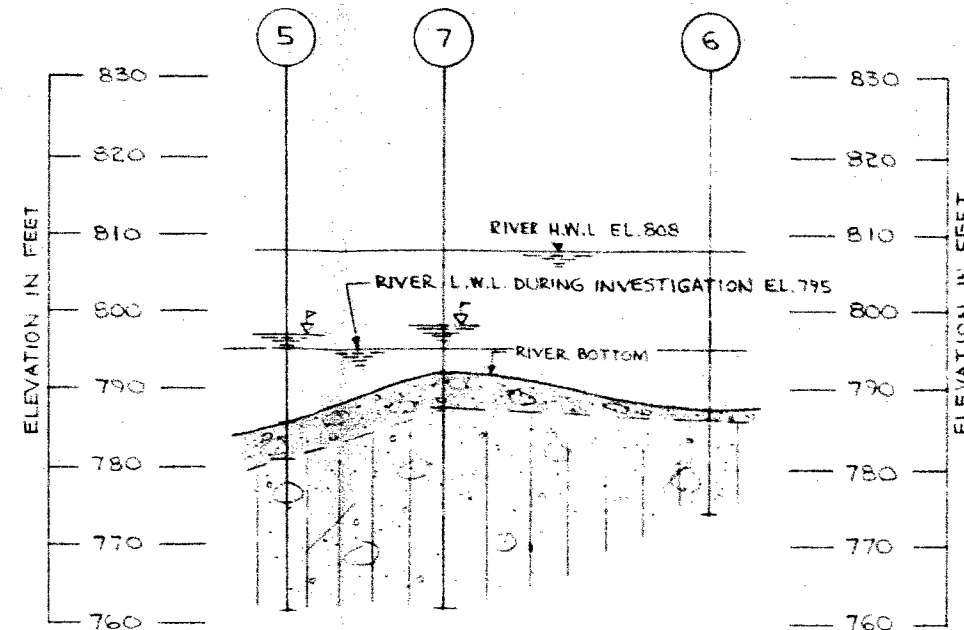
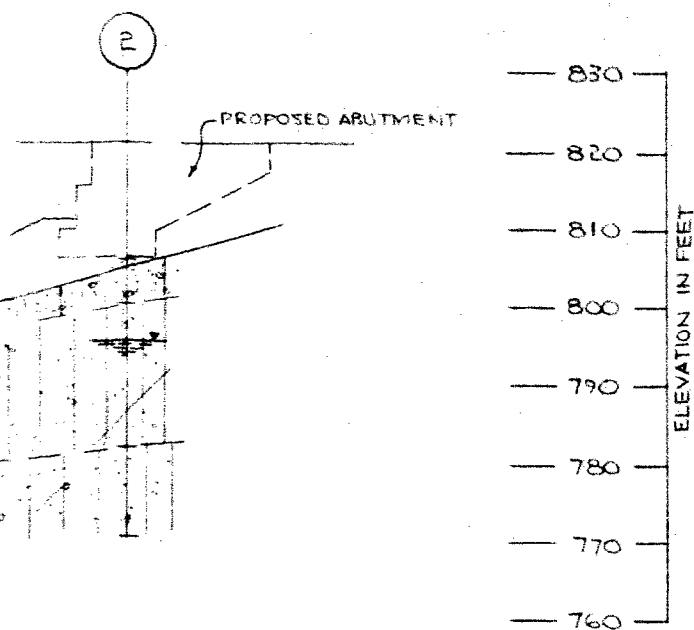
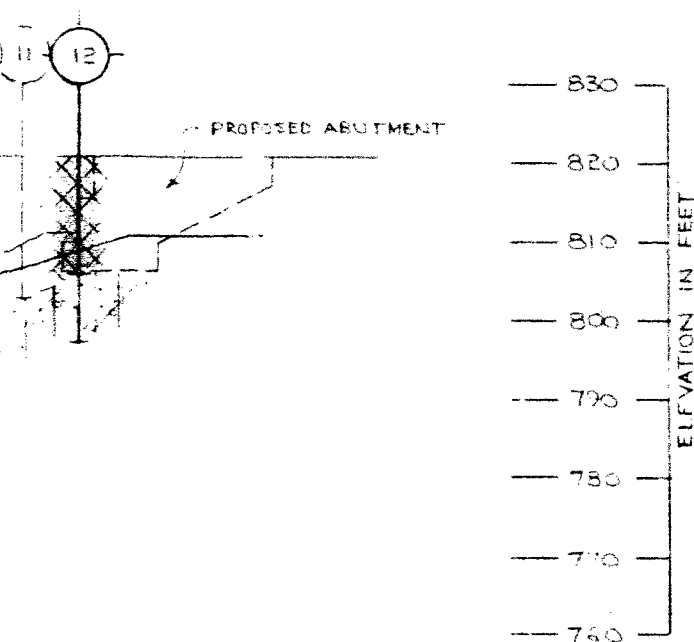
GOLDER & ASSOCIATES

DRAWN *RT*  
CHECKED *RT*








PLAN  
SCALE: 1" TO 20'



SECTION C-C  
SCALE: 1" TO 20'









## STRATIGRAPHY

-  BROWN SAND AND GRAVEL (FILL)
-  LOOSE TO DENSE BROWN SILTY SAND AND GRAVEL, TRACE OF ORGANIC MATTER AT BOREHOLE 1 (RECENT ALLUVIUM)
-  LOOSE TO COMPACT SAND AND GRAVEL WITH OCCASIONAL BOULDERS (RECENT RIVER DEPOSIT)
-  VERY STIFF TO HARD GREY CLAYEY SILT WITH A TRACE TO SOME SAND AND GRAVEL (TILL)
-  DENSE TO VERY DENSE GREY SILTY SAND TO SANDY SILT WITH SOME GRAVEL NUMEROUS BOULDERS THROUGHOUT (TILL)

## REFERENCE

R.C. DUNN & ASSOCIATES LTD. - DRWG. NO. P-1, Highbury Ave. Bridge, located on County Rd. # 23 over Thames River in Con. IV, Township of London, dated Mar. 2, 1966.

## LEGEND

-  BOREHOLE IN PLAN
-  BOREHOLE IN ELEVATION
-  AUGER HOLE IN PLAN
-  AUGER HOLE IN ELEVATION
-  PENETRATION TEST IN PLAN
-  PENETRATION TEST IN ELEVATION
-  WATER LEVEL IN BOREHOLE, APRIL 7, 1966
-  ARTESIAN WATER PRESSURE ENCOUNTERED IN SAND AND SILT TILL (FOR DATE READINGS TAKEN REFER TO RECORD OF BOREHOLE SHEETS)

NOTE: FOR RIVER LEVEL AT TIME OF INVESTIGATION REFER TO RECORD OF BOREHOLE SHEETS.

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.

Drawn: APRIL 18, 1966

GOLDER & ASSOCIATES

Made by J.A.  
Chkd. J.A.  
Appd. J.A.

PROJECT NO. 66025

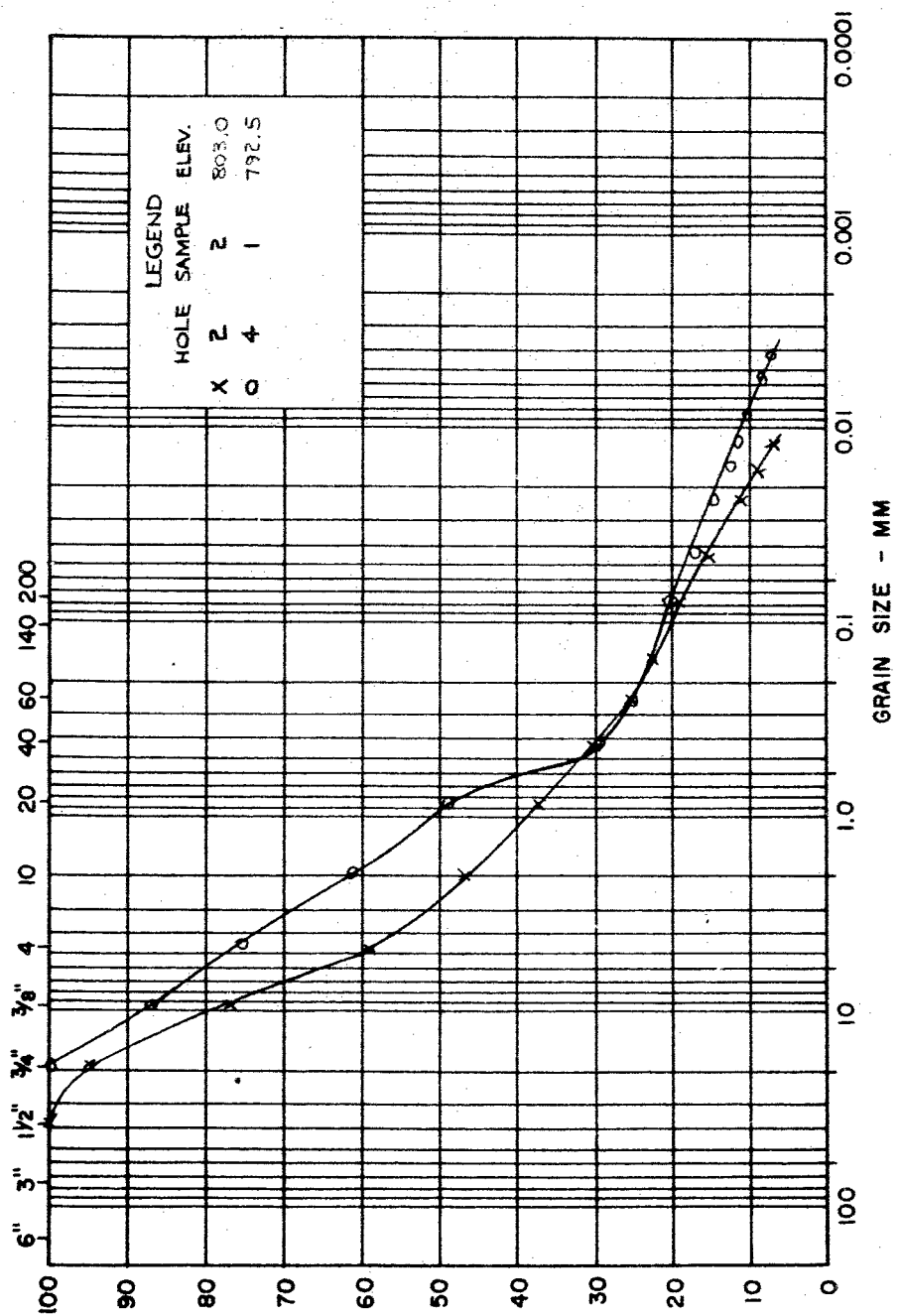
# GRAIN SIZE DISTRIBUTION

## SILTY SAND AND GRAVEL

FIGURE 2

M.I.T. GRAIN SIZE SCALE

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



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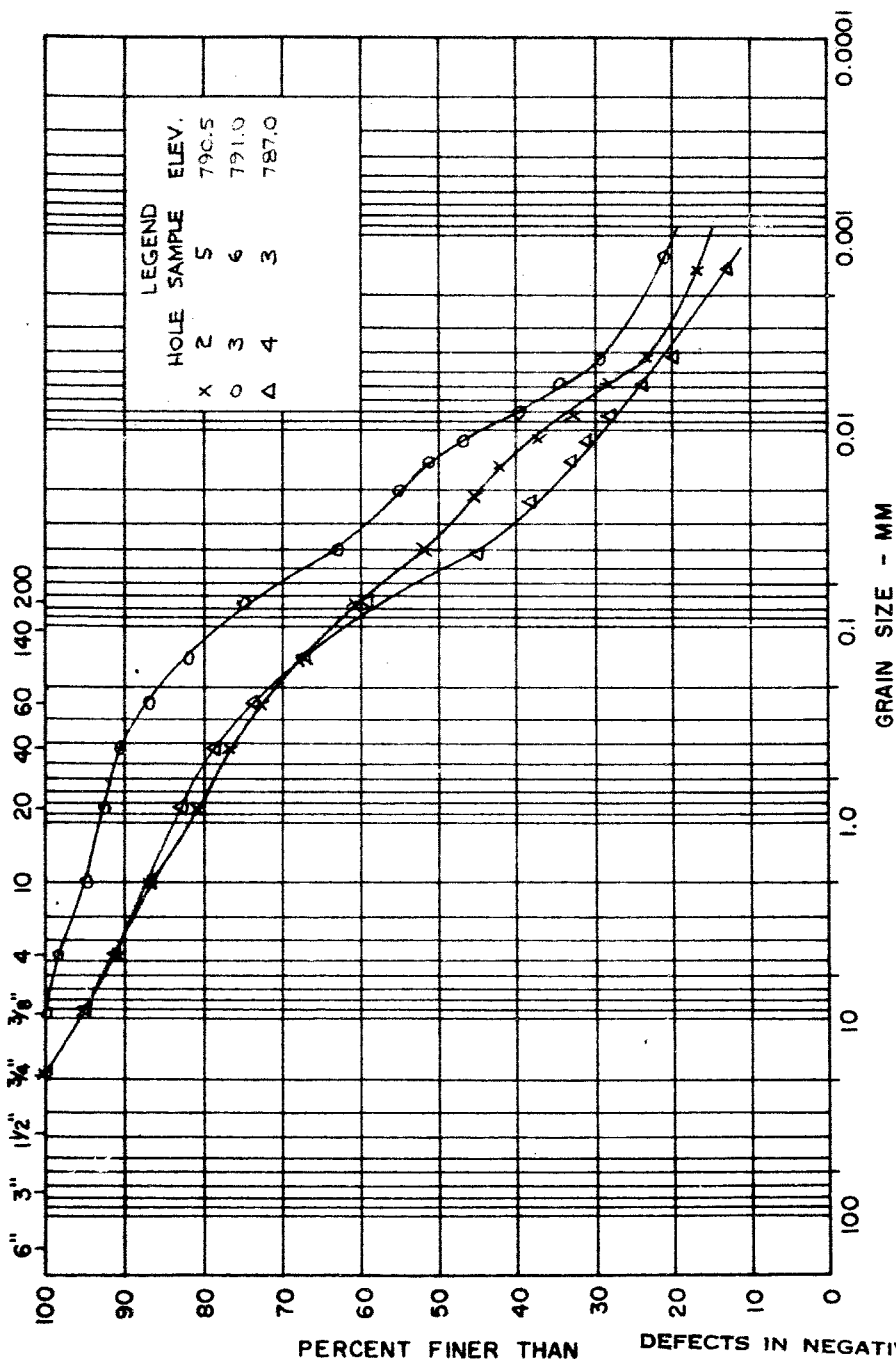
PROJECT NO. 563118

# GRAIN SIZE DISTRIBUTION CLAYEY SILT (TILL)

FIGURE 3

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	

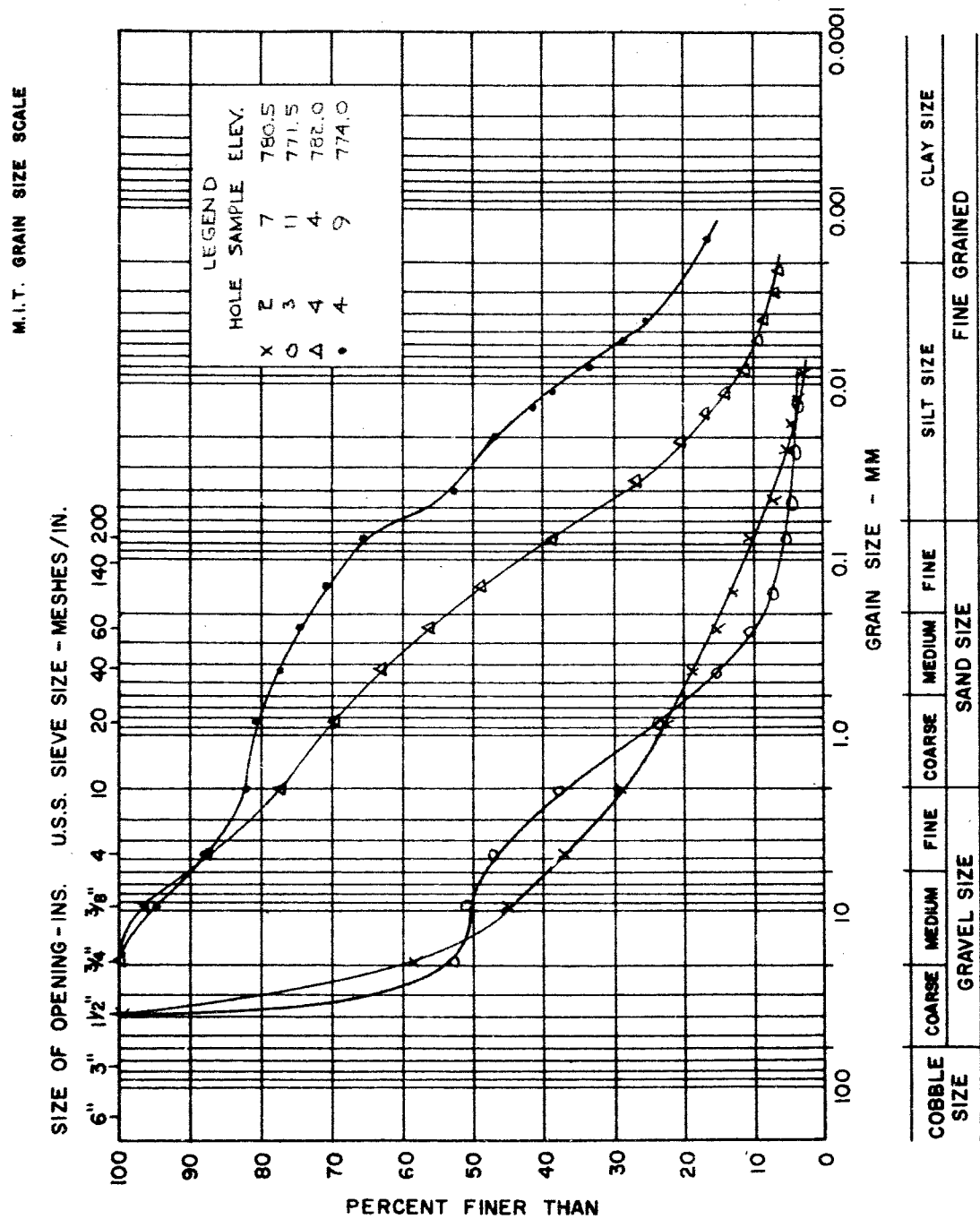
PERCENT FINER THAN DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

GOLDER & ASSOCIATES

PROJECT 66026

# GRAIN SIZE DISTRIBUTION SILTY SAND TO SANDY SILT (TILL)

FIGURE 4





# GRAIN SIZE DISTRIBUTION

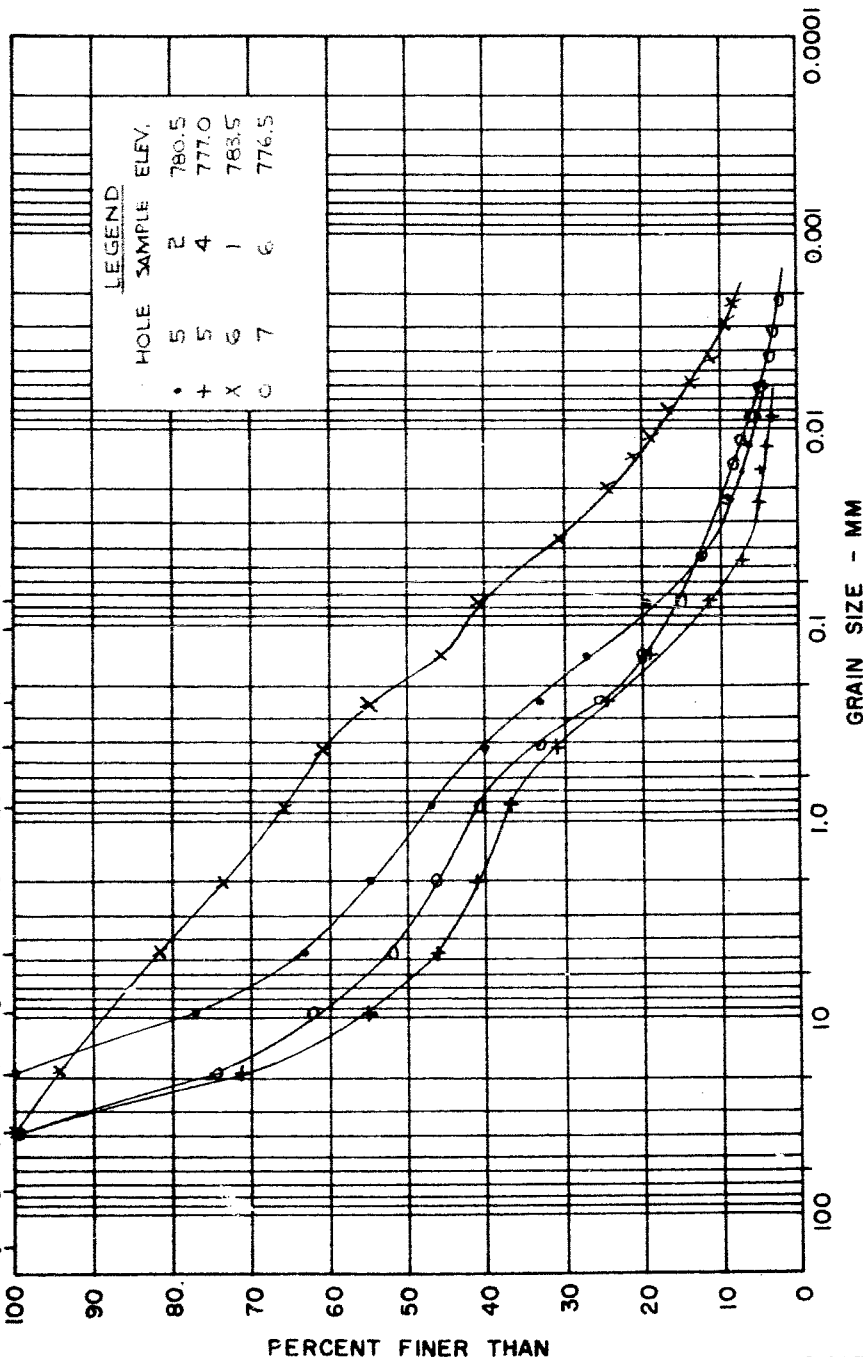
SILTY SAND TO SANDY SILT (TILL)

FIGURE 5

M.I.T. GRAIN SIZE SCALE

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

6" 3" 1 1/2" 3/4" 3/8" 20 40 60 140 200



GOLDER & ASSOCIATES

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