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HWY. No. \_\_\_\_\_

LOCATION BREWER MILLS RD  
& CATARAQUI RIVER

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

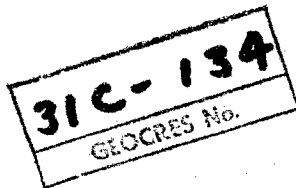
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REPORT

TO

J. M. TOMLINSON & ASSOCIATES LTD.

ON

SUBSURFACE CONDITIONS AND FOUNDATIONS

PROPOSED BREWERS MILLS ROAD BRIDGE

FRONTENAC COUNTY

BREWERS MILLS

ONTARIO

Distribution:

- 6 copies - J. M. Tomlinson & Associates Ltd.,  
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- 2 copies - H. Q. Golder & Associates Ltd.,  
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October, 1965

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REPORT ON SUBSURFACE CONDITIONS AND FOUNDATIONS

BREWERS MILLS ROAD BRIDGE

INTRODUCTION

We have been retained by J. M. Tomlinson & Associates Ltd., Consulting Engineers, to carry out a subsurface investigation for the proposed bridge over the Rideau Canal along the new alignment of Brewers Mills Road in Frontenac County, Ontario. The purpose of this investigation was to determine the subsurface conditions at the site and to provide information for the foundation design and construction of the new bridge structure and approach embankments.

PROCEDURE

The field work for this investigation was carried out during the period September 22 to 30, 1965. A total of seven boreholes were put down by the wash-boring method using a diamond machine drillrig supplied and operated by the F. E. Johnston Drilling Co. Ltd. under the full time supervision of an engineer from our staff. Dynamic penetration tests were carried out adjacent to each borehole as well as at two other locations shown on Figure 1. Borings 1, 2

and 3 and penetration test 4 were put in the canal at the proposed pier locations from a light raft to depths ranging up to 30 feet below the canal water level. The land boring depths ranged from about 17 feet at boring 5 to about 43 feet at boring 7. Sealed piezometers were installed in borings 5 and 7 to determine the groundwater level.

A detailed log for each boring is given on the Records of Boreholes following the text of this report. The locations of the borings and the dynamic penetration tests, together with a section of the inferred subsurface stratigraphy across the site, are given on Figure 1.

The samples obtained during the investigation were brought to our laboratory in Toronto for detailed examination and testing. The results of these tests are given on the Records of Boreholes and on Figure 2 to 5, inclusive.

The elevations in this report were provided by J. M. Tomlinson & Associates Ltd. and it is understood that they are referred to Geodetic Datum.

#### SITE AND GEOLOGY

The site is located at the crossing of the proposed

Brewers Mills Road realignment over the Rideau Canal (Cataragui River), approximately  $\frac{1}{2}$  mile south-west of the intersection of the existing Brewers Mills Side Road and Highway 15, in the County of Frontenac, Ontario. Although the canal width is about 130 feet at the site, the length of the crossing is some 160 feet since the proposed alignment crosses the canal at a skew angle of about  $37^{\circ}$ . The terrain at the west bank of the canal rises gradually some 30 to 40 feet in a horizontal distance of about 200 feet along the proposed centreline and rock outcrops are visible at several locations adjacent to the centreline. Along the east bank, the ground surface is fairly flat for about 200 feet along the proposed centreline; beyond this a rock outcrop rises abruptly some 40 to 50 feet.

From available geological information it is known that the site lies within an area consisting primarily of scattered knobs of rock between which lie clay deposits laid down by the Champlain sea. Bedrock in this area consists of metamorphosed sedimentary and igneous rocks of Precambrian age. The surface elevation of bedrock varies appreciably within small areas.

#### SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each borehole is given on the Records of Boreholes. Following is a summary

account of the subsurface conditions at the site of the proposed crossing.

A thin cover of topsoil up to 6 inches thick was encountered in all borings put down on land. Underlying the topsoil, in borings 7 and 9 on the east side of the canal, there is a 1 to 2 foot thick layer of loose grey brown silt with some clay to sandy silt. A grain size distribution curve obtained from a sample of the sandy silt is shown on Figure 3.

A deposit of grey brown sand to silty fine sand underlies the silt layer in boreholes 7 and 9. The sand deposit, which contains scattered small shells, has a thickness of about 3 feet. One grading curve obtained from a sample of the sand is shown on Figure 3. Based on the standard penetration tests, the results of which are given on the Records of Boreholes, the relative density of the sand is generally compact.

The borings show that the river bottom is underlain by a 3 to 4 foot thick deposit of very soft to soft grey clayey silt. A grading curve for a sample of this river bed deposit is given on Figure 2.

A stratum of sensitive grey layered silty clay to clayey

silt was encountered beneath the soft river bed deposit of clayey silt and the surficial sand deposit in the land borings to the east of the river. At borehole 5 on the west side of the river the clay directly underlies the topsoil. The thickness of the clay stratum ranges from about 4 feet in boring 5 to 22 feet in boring 7. The upper portion of the stratum is essentially comprised of silty clay while the lower portion is mainly a clayey silt. The layering is more pronounced in the lower clayey silt portion of the stratum where numerous  $\frac{1}{4}$  to  $\frac{1}{2}$  inch thick layers of dark grey silty clay occur together with occasional  $\frac{1}{16}$  inch thick sand seams. The silty clay generally has a fissured, blocklike structure.

Atterberg limit tests carried out on the silty clay gave liquid limits ranging from 30 to 46 with corresponding plasticity indices of about 14 to 27. The liquidity index of the silty clay is between about 0.1 and 0.7. Liquid limits determined for the clayey silt portion of the stratum ranged from 23 to 27 with plasticity indices of from 8 to 10 and a liquidity index of from 0.4 to 1.0.

Four laboratory triaxial compression tests on samples of the clay gave undrained shear strength values of from 1,300 to 3,600 lb/sq.ft. In addition, in situ vane shear tests within the

clay stratum gave undrained shear strengths in excess of 2,000 lb/sq.ft., except for one value of about 1,400 lb/sq.ft. in boring 3 put down in the river. Based on these results, together with the standard penetration tests which gave "N" values of 3 to 30 blows/ft., the consistency of the clay stratum is generally stiff in the river borings and very stiff outside the river area. A summary plot of undrained shear strength versus elevation for the clay to clayey silt stratum is given on Figure 5.

A thin layer of dense sand, gravel and cobbles underlies the sensitive clay stratum and overlies bedrock in the river borings. This is similarly the case in borehole 5 on the west bank of the river where a 2 foot thick layer of silty sand to sand and gravel overlies the bedrock. Two grading curves on samples from this granular layer are given on Figure 4.

Bedrock occurs across the site at a depth of about 6 feet in borehole 5 to a 27 foot depth in borehole 7. As shown by the stratigraphic section on Figure 1, there is a general trend for the bedrock surface to drop off across the site from an elevation of about 305 on the west side of the river down to about elevation 280 on the east side of the river, though abrupt changes in bedrock elevation within short horizontal distance are possible (see boreholes



7 and 8 at east pier location). Bedrock was proved in each boring, except borehole 9, by core drilling in AXT size for depths of from 10 feet in borehole 1 to 16 feet in borehole 7. It is an igneous rock in boreholes 1, 3 and 5 while in boring 7 it is a crystalline limestone with numerous horizontal fractures. In borehole 8 the rock is igneous in the upper portion becoming crystalline limestone with depth. The reverse is the case in borehole 2. The bedrock across the site is generally sound but contains random fractures which are usually orientated in a horizontal direction. Some of these fractures are open as evidenced by total loss of drilling water in borehole 5 at a depth of about 2 feet below bedrock surface.

Sealed piezometers were installed in borings 5 and 7 to determine the groundwater level. Details of these installations are given on the Records of Boreholes. The groundwater level, as measured in the borings immediately after completion of the field work, was found to be within one foot of the canal or river water level which was at about elevation 304 at the time of the investigation. No noticeable artesian condition was encountered within the bedrock.

## DISCUSSION

### General

It is understood that Brewers Mills Road is to be

realigned as shown on the key plan on Figure 1. The bridge across the Rideau Canal (Cataraqui River) will possibly be a 3 span, two lane structure, some 245 feet in overall length. A 25 foot high approach fill, some 200 feet long, will be required at the east end of the proposed bridge.

### Foundations

The bedrock, which underlies the site at a relatively shallow depth, is a competent foundation stratum for the support of the proposed bridge structure and it is recommended that the piers and the west abutment be founded in it. Excavations for the pier foundations will have to be carried down through some 10 feet of soft to stiff clayey silt to silty clay overburden underlying the river bed. With 5 to 6 feet of water in the river at the pier locations, it will be necessary to construct a steel sheeted cofferdam driven to bedrock to control the inflow of water into the excavations. Alternatively, an impervious earth fill dyke could be placed outside the perimeter of the proposed excavations to control the water. Regardless of which method is employed to control the river water there will be some seepage of water into the excavations from the relatively pervious thin granular layer overlying bedrock. It will therefore be necessary to pump from sumps in the bottom of the

excavations when the granular layer is reached to provide relatively dry conditions.

Control of river water would not be required if the canal is drained during the period of pier construction. In this case the pier excavations to bedrock could be carried out in open cut using side slopes of about 1 horizontal to 1 vertical through the clay overburden. However, seepage of groundwater from the granular layer above bedrock will have to be controlled, as discussed above.

Excavation to bedrock for the west abutment support should not present any construction problems since there is only about 6 feet of overburden above the bedrock and the groundwater level is at the bedrock surface.

The borings show that the bedrock underlying the site is generally sound. For spread footings placed in the bedrock, an allowable bearing pressure of up to 25 tons/sq.ft. may be used in design.

At the east abutment location, the depth of overburden varies from about 19 feet at the south end to about 27 feet at the north end of the abutment. The approach fill to the bridge will

be some 25 feet high at this abutment location. If a simply supported bridge structure with spill through abutments is to be used, the east abutment could be founded on a spread footing placed directly in the roadway approach fill. If this method is utilized, the embankment in the abutment zone should be constructed of well graded granular material, placed in 9 to 12 inch lifts and compacted to at least 100 per cent of the standard Proctor maximum dry density. The side and end slopes of the embankment should not be any steeper than 2 horizontal to 1 vertical. The footing within the embankment fill should be placed at a depth such that a minimum cover of 6 feet is maintained in all directions. Provided that strict control is exercised during compaction, the total settlement of a spread footing founded within the embankment fill and imposing a bearing pressure of 1 ton/sq.ft. should be within about 3 inches.

If a settlement of the abutment footing of the order of 3 inches cannot be tolerated, the stub abutment should be founded on piles driven through the approach fill and to the underlying bedrock. A 12 inch steel "H" section pile, if driven to practical refusal in the bedrock, could carry a design load of 70 tons.

#### Approach Embankments

It is understood that the approach fill to the east

abutment will be about 25 feet in height above existing ground surface over a length of about 200 feet. At the west abutment the roadway approach fill will be of minor extent due to the existing topography.

Provided that the surface cover of topsoil and silt is removed beneath the full base width of the embankments prior to placement of the fill and the embankments are constructed of suitable material, there should be no overall stability problem with the roadway approach fills using conventional 2 horizontal to 1 vertical side and end slopes. Reference to the contour plan on Figure 1 indicates that, with the east abutment at the location shown, there is insufficient space between the abutment and the top of the east river bank to accommodate a 2 horizontal to 1 vertical embankment end slope. Computations were therefore carried out to determine the steepest end slope for an embankment, constructed of well compacted granular material, that would be stable at this location. On the basis of these computations, where an average undrained shear strength of 1,500 lb/sq.ft. was used for the silty clay stratum overlying the bedrock, the end slope of the embankment could be made no steeper than 1.5 horizontal to 1 vertical. If this end slope is used, it is recommended that the east abutment be supported on non-displacement type piles, such as "H" piles, driven through the

embankment to the underlying bedrock and not on a spread footing placed within the embankment itself. Alternatively the end spans of the proposed bridge could be lengthened to accommodate 2 horizontal to 1 vertical embankment end slopes.

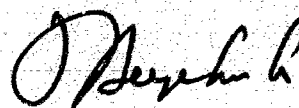
To prevent surface water erosion and gullyng of the embankment slopes, provision should be made for sodding them as soon as possible following construction. Rip-rap or similar protective means should also be placed over the river banks in the abutment areas to prevent possible erosion undermining of the banks and roadway embankments.

The settlement of a 25 foot high approach fill constructed of well compacted granular "B" material, due to consolidation of the underlying silty clay stratum, could be of the order of 2 to 3 inches over a period of several years. If dumped rockfill is used to construct the embankment some additional settlement can be expected due to settlement within the rockfill itself. The order of magnitude of settlement in a 25 foot high rockfill embankment could also be of the order of 2 to 3 inches over a period of about 1 year. If the rockfill is rolled during construction, the settlement within

the fill itself would be less than given above.



*for* L. R. Lahti, P.Eng.



J. L. Seychuk, P.Eng.

LRL:HDG

65105

October 13, 1965.



## 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<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

|           |  |
|-----------|--|
| <i>C</i>  | consolidation test                                   |
| <i>H</i>  | hydrometer analysis                                  |
| <i>M</i>  | sieve analysis                                       |
| <i>MH</i> | combined analysis, sieve and hydrometer <sup>1</sup> |
| <i>Q</i>  | undrained triaxial <sup>2</sup>                      |
| <i>R</i>  | consolidated undrained triaxial <sup>2</sup>         |
| <i>S</i>  | drained triaxial                                     |
| <i>U</i>  | unconfined compression                               |
| <i>V</i>  | 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<br>= $-\Delta e / (1+e) \Delta \sigma'$ |
| $C_c$ | compression index = $-\Delta e / \Delta \log_{10} \sigma'$           |
| $c_c$ | coefficient of consolidation   |
| $T_v$ | time factor = $c_v / d^2$ ( $d$ , 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                             |
| $S_f$    | 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

LOCATION See Figure 1

BORING DATE SEPT. 23-27, 1965

DATUM GEODETIC

BOREHOLE TYPE WASH BORING

BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

| SOIL PROFILE   |  | SAMPLES     |        |      | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE<br>BLOWS/FT. ----- |    |    |    |    | COEFFICIENT OF PERMEABILITY k,<br>CM./SEC. |   |  |  |  | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |
|----------------|--|-------------|--------|------|-----------------|---|----|----|----|----|--|---|--|--|--|----------------------------|---|
| ELEV.<br>DEPTH | DESCRIPTION  | STRAT. PLOT | NUMBER | TYPE |                 | BLOWS/FT.   | 20 | 40 | 60 | 80 | 100  | WATER CONTENT, PERCENT<br>Wp      W      Wl |  |  |  |                            |   |
| 304.0          | WATER LEVEL  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 0.0            |  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
|                | WATER  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 298.0          | RIVER BOTTOM   |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 8.0            |  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
|                | PROBABLY CLAYEY<br>SILT TO SILTY CLAY<br>WITH SOME SAND<br>TO SILTY CLAY |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 290.3          |  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 13.7           |  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
|                | HARD SOUND LIGHT<br>TO DARK GREY<br>IGNEOUS <b>BIOROCK</b>               |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 280.7          |  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |
| 23.3           | END OF HOLE  |             |        |      |                 |   |    |    |    |    |  |   |  |  |  |                            |   |

NO SAMPLES TAKEN

WEIGHT OF RODS

END OF PEN. TEST @ ELEV. 291.7  
100 BLOWS FOR LAST 4 INCHES

PERCENT CORE RECOVERY

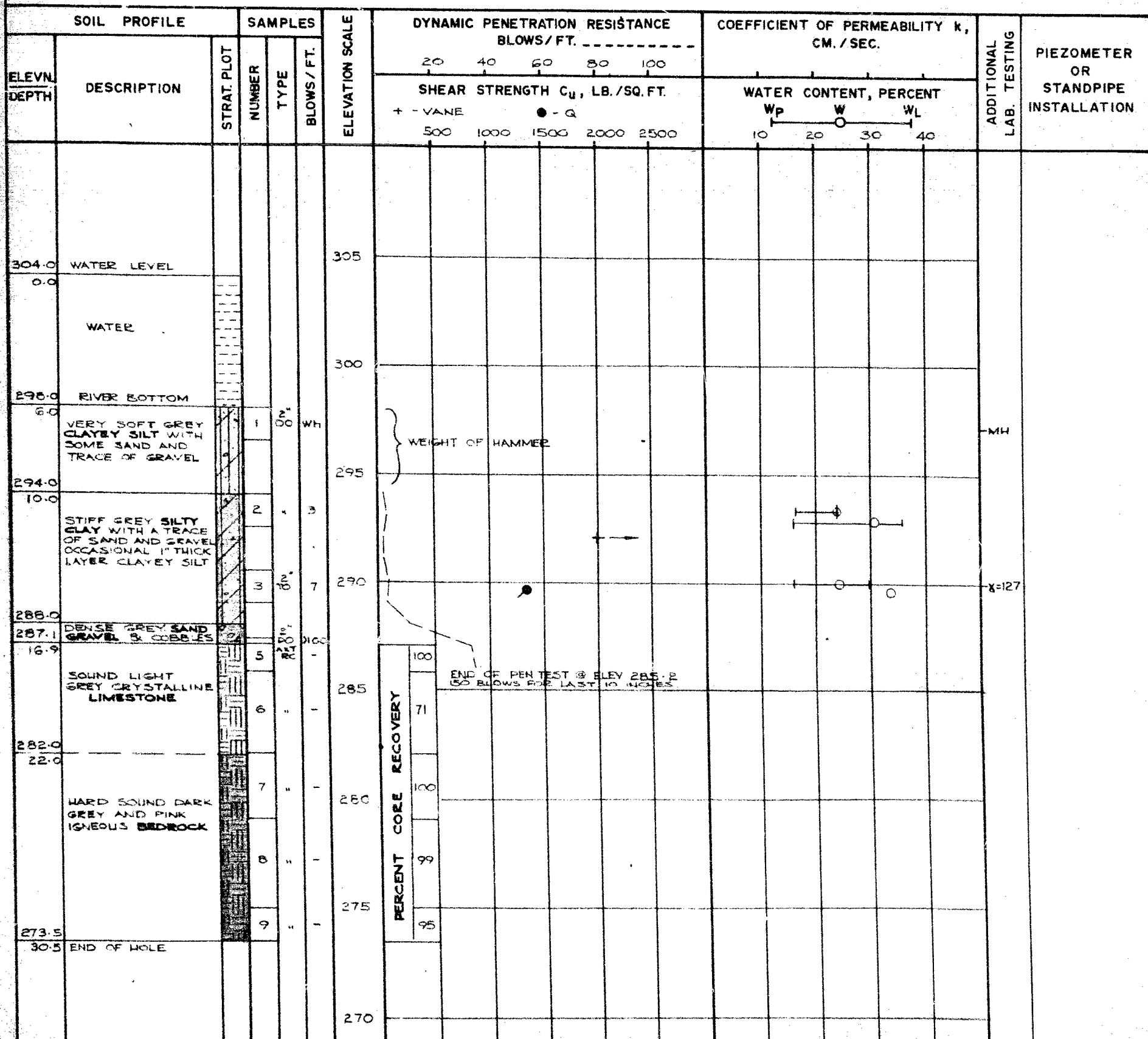
80

100

91

# RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE DATUM GEODETIC  
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NX CASING  
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



# RECORD OF BOREHOLE 3

## LOCATION

**See Figure**

**BORING DATE**

SEPT. 23 & 24, 1965

DATUM GEODETIC

**BOREHOLE TYPE**

WASH BORING

BOREHOLE DIAMETER NX CASING

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

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

| SOIL PROFILE       |   |             | SAMPLES |        |             | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE<br>BLOWS / FT. -----           |    |    |    |     | COEFFICIENT OF PERMEABILITY, k,<br>CM. / SEC. |      |      |      | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |
|--------------------|---|-------------|---------|--------|-------------|-----------------|---|----|----|----|-----|---|------|------|------|----------------------------|---|
| ELEVATION<br>DEPTH | DESCRIPTION   | STRAT. PLT. | NUMBER  | TYPE   | BLOWS / FT. |                 | SHEAR STRENGTH $C_u$ , LB. / SQ. FT.<br>+ VANE    ⊕ - REM. V. |    |    |    |     | WATER CONTENT, PERCENT                        |      |      |      |                            |   |
|                    |   |             |         |        |             |                 | 20  | 40 | 60 | 80 | 100 | 500   | 1000 | 1500 | 2000 |                            |   |
| 304.2              | WATER LEVEL   |             |         |        |             | 305             |   |    |    |    |     |   |      |      |      |                            |   |
| 0.0                | WATER   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
| 298.7              | RIVER BOTTOM  |             |         |        |             | 300             |   |    |    |    |     |   |      |      |      |                            |   |
| 5.5                | VERY SOFT GREY CLAYEY SILT WITH SOME SAND, TRACE OF GRAVEL                                |             | 1       | 2" DO  | WH          |                 |   |    |    |    |     |   |      |      |      |                            |   |
| 295.2              |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
| 9.0                | STIFF GREY SILTY CLAY WITH 1" THICK LAYERS OF CLAYEY SILT AND 1/4" THICK FINE SAND LAYERS |             | 2       | "      | 3           | 295             |   |    |    |    |     |   |      |      |      |                            |   |
| 290.3              |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
| 289.5              |   |             | 3       | "      | 21          | 290             |   |    |    |    |     |   |      |      |      |                            |   |
| 14.7               |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             | 4       | AXT RC | -           |                 |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             | 5       | "      | -           | 285             |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             | 6       | "      | -           | 280             |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
| 274.2              |   |             | 7       | "      | -           | 275             |   |    |    |    |     |   |      |      |      |                            |   |
| 30.0               | END OF HOLE   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             |         |        |             |                 |   |    |    |    |     |   |      |      |      |                            |   |
|                    |   |             |         |        |             | 270             |   |    |    |    |     |   |      |      |      |                            |   |

# PEN TEST RECORD OF ~~BOREHOLE~~ 4

LOCATION See Figure 1

BORING DATE SEPT. 24, 1965

DATUM GEODETIC

BOREHOLE TYPE

PENETRATION TEST

BOREHOLE DIAMETER

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<br>BLOWS / FT. ----- | COEFFICIENT OF PERMEABILITY $k$ ,<br>CM. / SEC. |  |  |  | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |
|-----------------|---|-------------|---------|------|-------------|-----------------|---|---|--|--|--|----------------------------|---|
| ELEVN.<br>DEPTH | DESCRIPTION   | STRAT. PLOT | NUMBER  | TYPE | BLOWS / FT. |                 | 20 40 60 80 100                                     | WATER CONTENT, PERCENT<br>$w_p$ $w$ $w_L$       |  |  |  |                            |   |
|                 |   |             |         |      |             |                 | SHEAR STRENGTH $c_u$ , LB./SQ. FT.                  |   |  |  |  |                            |   |
| 304.2           | WATER LEVEL   |             |         |      |             | 305             |   |   |  |  |  |                            |   |
| 0.0             | WATER   |             |         |      |             |                 |   |   |  |  |  |                            |   |
| 299.2           | RIVER BOTTOM  |             |         |      |             | 300             |   |   |  |  |  |                            |   |
| 5.0             | PROBABLY VERY<br>SOFT CLAYEY SILT<br>TO STIFF SILTY<br>CLAY |             |         |      |             | 295             |   |   |  |  |  |                            |   |
| 290.4           | END OF PEN TEST<br>REFUSAL PROBABLY<br>BEDROCK              |             |         |      |             | 290             |   |   |  |  |  |                            |   |

WEIGHT OF HAMMER

END OF PEN TEST @ ELEV. 290.4  
90 BLOWS FOR LAST 10 INCHES

# RECORD OF BOREHOLE 5

LOCATION

See Figure

1

BORING DATE

SEPT. 25

DATUM GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

| SOIL PROFILE   |  |             | SAMPLES |           |           | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE<br>BLOWS/FT. ----- |    |    |    |     | COEFFICIENT OF PERMEABILITY k,<br>CM./SEC. |    |    |  | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |
|----------------|--|-------------|---------|-----------|-----------|-----------------|---|----|----|----|-----|--|----|----|--|----------------------------|---|
| ELEV.<br>DEPTH | DESCRIPTION  | STRAT. PLOT | NUMBER  | TYPE      | BLOWS/FT. |                 | 20  | 40 | 60 | 80 | 100 | WATER CONTENT, PERCENT                     |    |    |  |                            |   |
|                |  |             |         |           |           |                 | SHEAR STRENGTH C <sub>u</sub> , LB./SQ. FT.       |    |    |    |     | W <sub>P</sub> W      W <sub>L</sub>       |    |    |  |                            |   |
|                |  |             |         |           |           |                 |   |    |    |    | 10  | 20   | 30 | 40 |  |                            |   |
|                |  |             |         |           |           | 315             |   |    |    |    |     |  |    |    |  |                            |   |
| 311.3          | GROUND LEVEL   |             |         |           |           |                 |   |    |    |    |     |  |    |    |  |                            |   |
| 0.2            | TOP SOIL   |             | 1       | DR        | 12        | 310             |   |    |    |    |     |  |    |    |  |                            |   |
|                | STIFF TO VERY STIFF<br>GREY BROWN SILTY<br>CLAY WITH TRACE<br>OF SAND, SMALL<br>ROOTS      |             | 2       | "         | 12        |                 |   |    |    |    |     |  |    |    |  |                            |   |
| 307.3          |  |             | 3       | "         | 18        |                 |   |    |    |    |     |  |    |    |  |                            |   |
| 4.0            | DENSE BROWN SILTY<br>SAND WITH SOME<br>CLAY TO SAND AND<br>GRAVEL                          |             | 4       | "         | 38        |                 |   |    |    |    |     |  |    |    |  |                            |   |
| 305.1          |  |             |         |           | 100       | 305             |   |    |    |    |     |  |    |    |  |                            |   |
| 6.2            |  |             | 6       | ART<br>RC | -         |                 |   |    |    |    |     |  |    |    |  |                            |   |
|                | HARD SOUND LIGHT<br>TO DARK GREY<br>IGNEOUS BEDROCK,<br>OCCASIONAL HORIZONTAL<br>FRACTURES |             | 7       | "         | -         | 300             |   |    |    |    |     |  |    |    |  |                            |   |
|                |  |             | 8       | "         | -         |                 |   |    |    |    |     |  |    |    |  |                            |   |
| 294.2          |  |             |         |           |           | 275             |   |    |    |    |     |  |    |    |  |                            |   |
| 17.1           | END OF HOLE  |             |         |           |           |                 |   |    |    |    |     |  |    |    |  |                            |   |
|                |  |             |         |           |           | 290             |   |    |    |    |     |  |    |    |  |                            |   |

GROUND LEVEL

SURFACE SEAL

BENTONITE SEAL

PLASTIC THUMB

SAND FILL

PIEZOMETER

WATER LEVEL IN PIEZOMETER @ ELEV 303.8 SEPT. 30, 1965

GROUND LEVEL

SURFACE SEAL

BENTONITE SEAL

PLASTIC TUBING

SAND FILL

PIEZOMETER

WATER LEVEL  
IN PIEZOMETER  
@ ELEV 303.8  
SEPT. 30, 1965

PEN. TEST  
**RECORD OF BOREHOLE 6**

LOCATION See Figure 1

BORING DATE SEPT. 25, 1965

DATUM GEODETIC

BOREHOLE TYPE PENETRATION TEST

BOREHOLE DIAMETER -

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<br>BLOWS/FT. ----- | COEFFICIENT OF PERMEABILITY $k$ ,<br>CM./SEC. |                     | ADDITIONAL<br>LAB. TESTING | PIEZOMETER<br>OR<br>STANDPIPE<br>INSTALLATION |
|----------------|--|-------------|---------|------|-----------|-----------------|---|---|---------------------|----------------------------|---|
| ELEV.<br>DEPTH | DESCRIPTION  | STRAT. PLT. | NUMBER  | TYPE | BLOWS/FT. |                 | 20 40 60 80 100                                   | WATER CONTENT, PERCENT                        |                     |                            |   |
|                |  |             |         |      |           |                 | SHEAR STRENGTH $C_u$ , LB./SQ.FT.                 |   | $W_p$ $W$ $W_L$<br> |                            |   |
| 311.6          | GROUND LEVEL   |             |         |      |           | 315             |   |   |                     |                            |   |
| 0.0            |  |             |         |      |           |                 |   |   |                     |                            |   |
|                | PROBABLY STIFF<br>SILTY CLAY TO<br>SAND AND GRAVEL<br>WITH DEPTH |             |         |      |           | 310             |   |   |                     |                            |   |
| 305.4          |  |             |         |      |           |                 |   |   |                     |                            |   |
| 6.2            | END OF PEN TEST<br>REFUSAL PROBABLY<br>BEDROCK                   |             |         |      |           | 305             |   |   |                     |                            |   |
|                |  |             |         |      |           |                 | 100 BLOWS FOR LAST 2 INCHES                       |   |                     |                            |   |

# RECORD OF BOREHOLE 7

LOCATION

See Figure

BORING DATE SEPT 25 & 27, 1965

DATUM GEODETIC

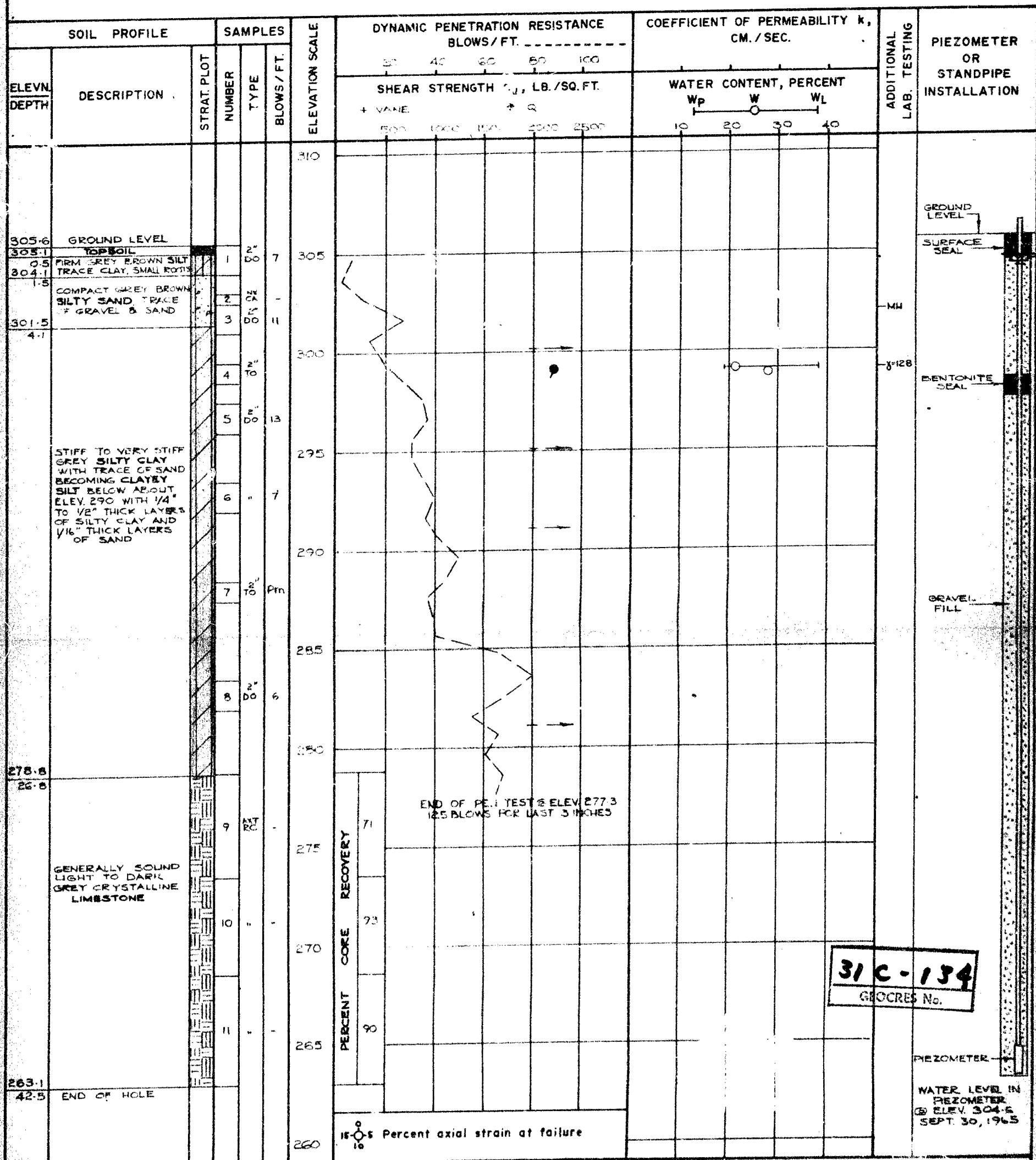
BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE  
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN BY  
CHECKED BY





# RECORD OF BOREHOLE 9

**LOCATION**

**See Figure**

1

**BORING DATE**

SEPT. 29 & 30, 1965

DATUM GEODETIC

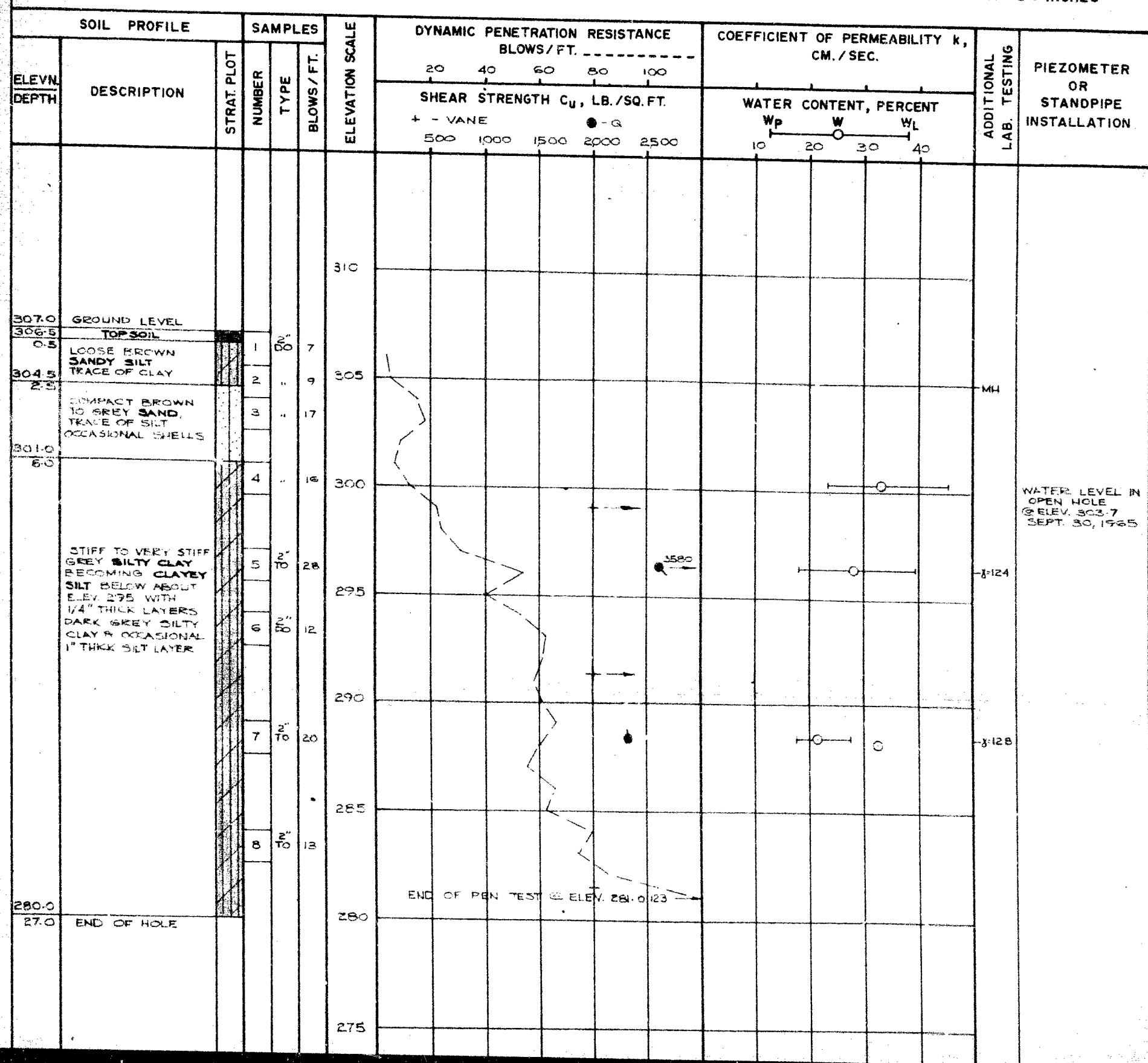
BOREHOLE TYPE

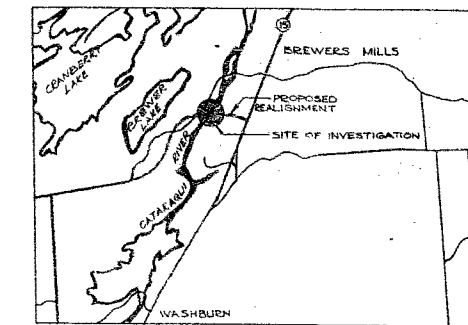
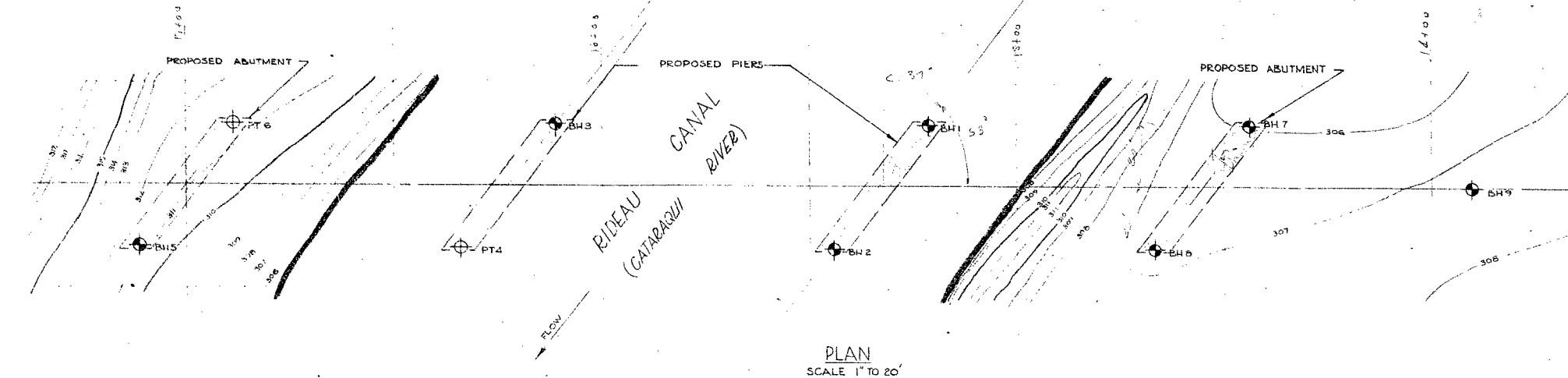
WASH BORING

BOREHOLE DIAMETER NX CASING

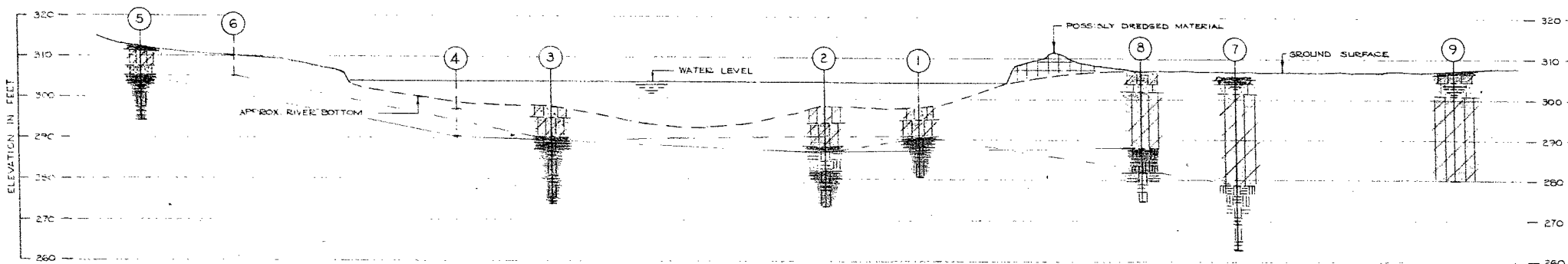
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES





### STRATIGRAPHY



#### REFERENCE

J.M. TOMLINSON & ASSOCIATES LTD.  
593 BRANT ST. BURLINGTON ONT.  
BREWERS MILLS ROAD  
FRONTENAC COUNTY  
JOB NO. 6507-1 SK-3

#### LEGEND

- BOREHOLE IN PLAN
- ⊕ PENETRATION TEST IN PLAN
- ① BOREHOLE IN ELEVATION
- ≡ WATER LEVEL IN BOREHOLE SEPT. 20, 1965
- ④ PENETRATION TEST IN ELEVATION

- TOPSOIL
- LOOSE BROWN SANDY SILT TO FIRM BROWN SILT, TRACE OF CLAY
- COMPACT GREY BROWN SILTY SAND TO SAND, TRACE OF SILT
- VERY SOFT TO SOFT GREY CLAYEY SILT (REVERSED DEPOSIT)
- STIFF TO VERY STIFF GREY SILTY CLAY TO LAYERED CLAYEY SILT
- DENSE GREY SAND, GRAVEL AND COBBLES
- SOUND GREY IGNEOUS BEDROCK
- SOUND LIGHT GREY CRYSTALLINE LIMESTONE BEDROCK
- ⬇ REFUSAL TO PENETRATION TEST, PROBABLY BEDROCK

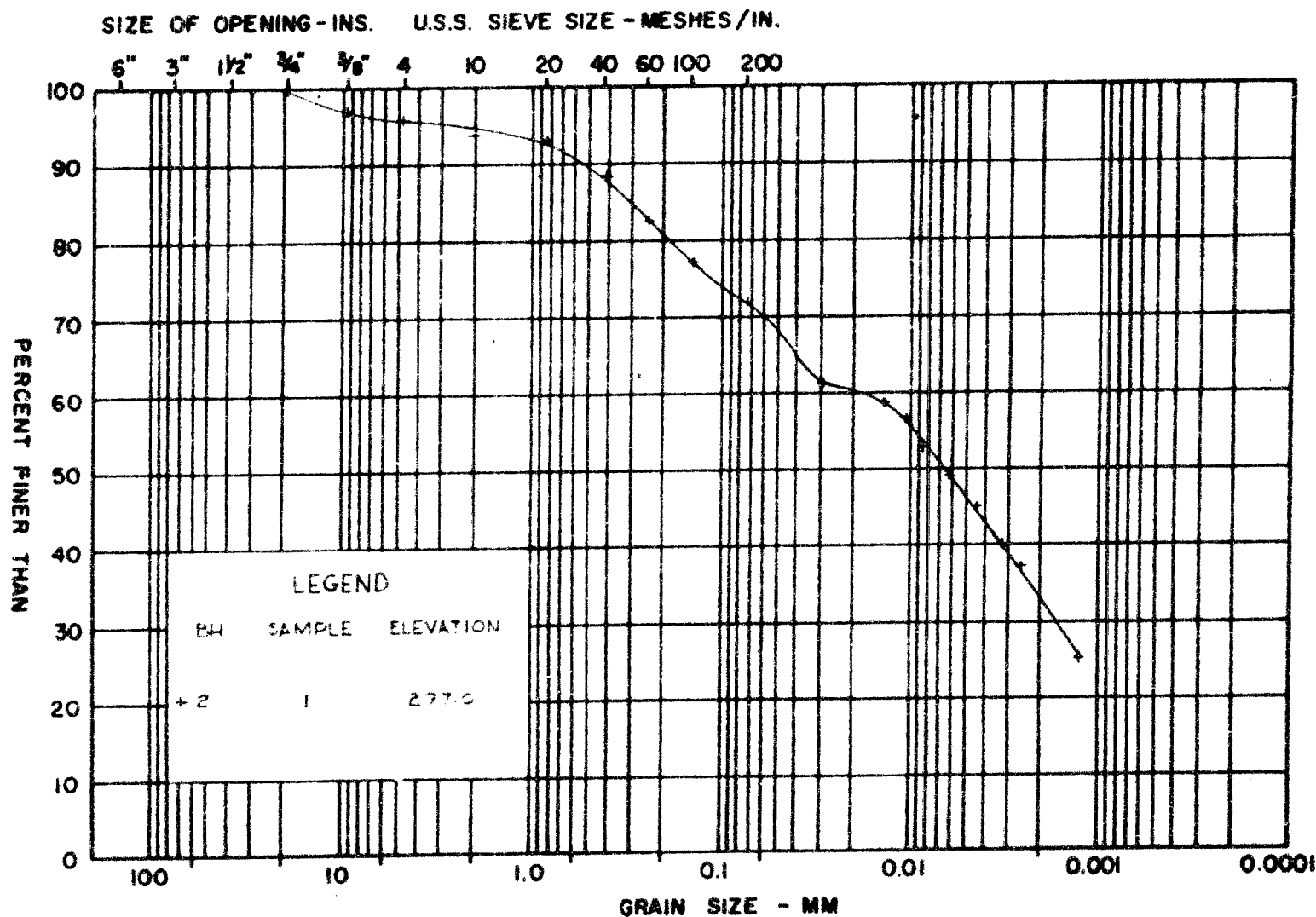
SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT SPARSE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.

Drawn OCT. 7, 1965

GOLDER & ASSOCIATES

Made by  
Chkd. by  
Appd. by

M.I.T. GRAIN SIZE SCALE



GOLDER & ASSOCIATES

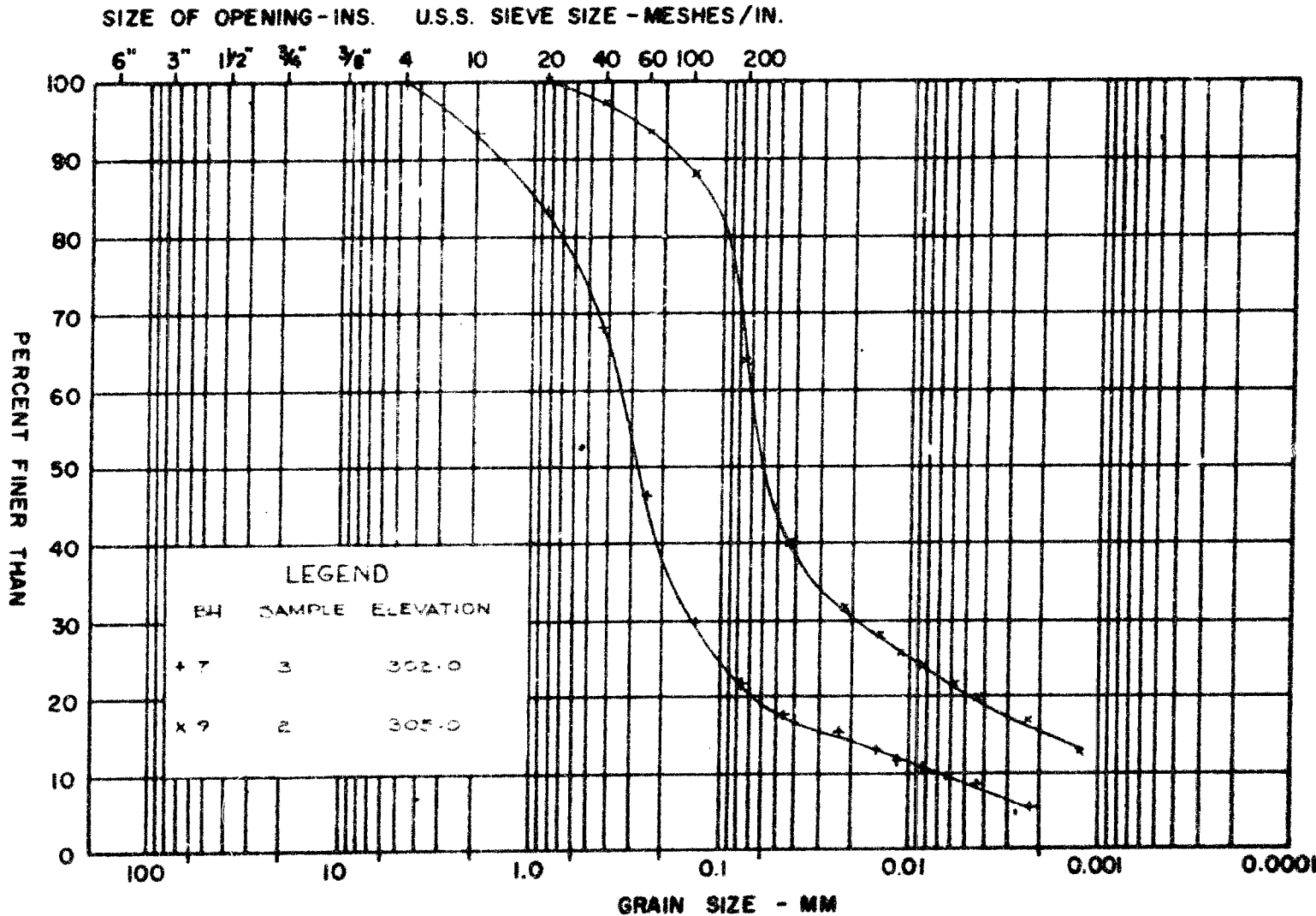
GRAIN SIZE DISTRIBUTION  
CLAYEY SILT (RIVER BED DEPOSIT)

FIGURE 2

M.I.T. GRAIN SIZE SCALE

GRAIN SIZE DISTRIBUTION  
SUELFICIAL SANDY SILT TO SILTY SAND DEPOSIT

FIGURE 3



GOLDER & ASSOCIATES

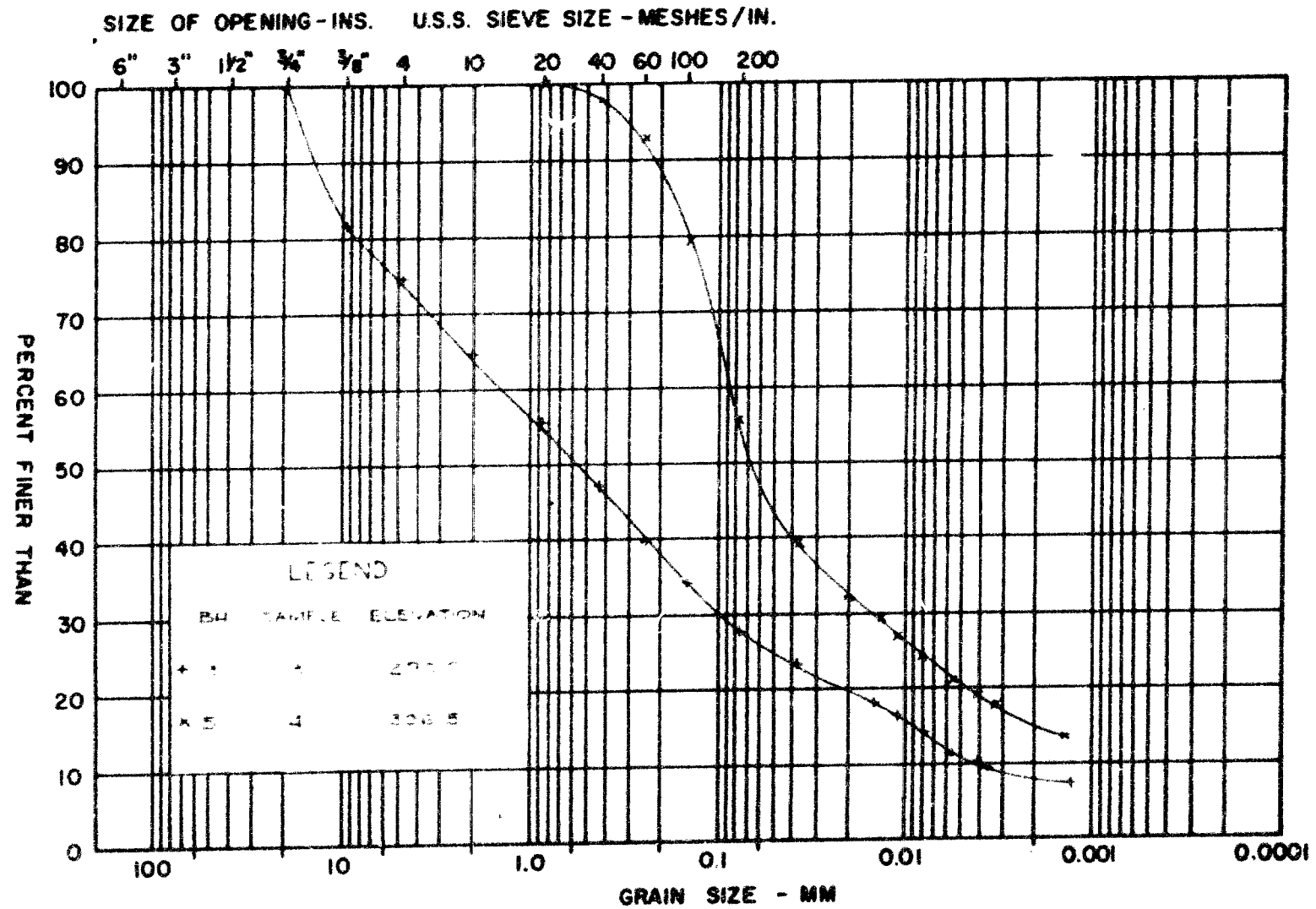
| COBBLE<br>SIZE | COARSE      | MEDIUM | FINE | COARSE    | MEDIUM | FINE | SILT SIZE    |  | CLAY SIZE |
|----------------|-------------|--------|------|-----------|--------|------|--------------|--|-----------|
|                | GRAVEL SIZE |        |      | SAND SIZE |        |      | FINE GRAINED |  |           |

M.I.T. GRAIN SIZE SCALE

GRAIN SIZE DISTRIBUTION  
SCALAR: DEPOSIT OVERLYING BEDROCK

FIGURE 4

GOLDER & ASSOCIATES





PROJECT NO. -- 65105 --

- PROJECT NO. -- 65105 --

PROJECT NO. -- 65105 --

PROJECT NO. -- 65105 --

PROJECT NO. -- 65105 --

PROJECT NO. -- 65105 --