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STR. SITE No. \_\_\_\_\_

HWY. No. 99

LOCATION ~~HWY~~ HWY: 99 west  
of HWY. 8, DUNDAS

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

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REPORT

TO

PHILIPS & ROBERTS LIMITED

ON

SITE INVESTIGATION

PROPOSED WIDENING & RECONSTRUCTION

HIGHWAY NO. 99

TOWN OF DUNDAS

ONTARIO



Distribution:

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## ABSTRACT

The results of an investigation to determine the soil and groundwater conditions for the proposed widening and reconstruction of Highway 99 over a length of 9,700 feet to the west of Highway 8 in the Town of Dundas, Ontario are reported and criteria are established to assist in the design of the highway improvement.

It was found that an extensive stratum of glacial till underlies the western and central portions of the route. The glacial till at a few locations is overlain by a thin layer of fill or shallow recent deposits of sands and silts. The eastern portion of the route is generally covered throughout by fill or recent deposits of sands, silts and clayey silts up to about 20 feet thick. These recent surface deposits are generally underlain by lacustrine silty clay.

The groundwater level in the borings was generally found to be about 5 to 10 feet below the proposed roadway grade, but varies along the route from about 3 to 40 feet below proposed grade. No major problems due to groundwater are anticipated during construction.

The two main cuts in the western portion of the route will be made through stiff to hard clayey glacial till. The material removed from these sections can in general be used as earth borrow to bring low lying areas, where embankments are required, to roadway subgrade elevation. Cuts and fills with 2 horizontal to 1 vertical side slopes will in general have adequate stability. The possibility of local instability of a 30 foot high fill in the vicinity of station 61+00 is discussed in the report.

The subsoil along the route which will form the subgrade is competent for the support of the pavement but is moderately frost-susceptible. A total flexible pavement design thickness of 30 inches is suggested. Provisions should be made to prevent ponding of water on the subgrade surface and promote drainage from the pavement base-course materials as discussed in the report.

Recommendations for foundation design of retaining walls, where space restrictions dictate vertical cuts, and a storm sewer beneath a roadway embankment are given in the report.

## INTRODUCTION

H. Q. Golder & Associates Ltd. have been retained by Philips & Roberts Limited, Consulting Engineers, to carry out a soil investigation for the proposed widening and reconstruction of Highway 99 (Governor's Road) in the Town of Dundas, Ontario. The total length of highway to be improved is approximately 9,700 feet.

The purpose of the investigation was to determine the soil and groundwater conditions at the site and, based on this information, to make recommendations to ensure the stability of cut and fill slopes and retaining walls along the proposed route. In addition, comments are to be included on pavement design and the use of material excavated in cut sections as general earth borrow.

## PROCEDURE

The field work for the investigation was carried out between December 1 and December 23, 1964. During this period, 26 boreholes, ranging in depth from about 15 to 32 feet, were put down by means of a mobile power auger and a skid-mounted machine drill-rig. Both the above machines were supplied and operated by the F.E. Johnston Drilling Co. Ltd. Two test pits were also put down by a mechanical backhoe to obtain bulk samples of material from two

proposed cut sections to assess the suitability of this material as general earth borrow. The test pits were approximately 12 feet deep. The field work was carried out under the supervision of engineering staff of H. Q. Golder & Associates.

The locations of the boreholes and test pits put down during the investigation are shown on Figures 1 and 2. A detailed log for each boring and test pit is given on the Records of Boreholes following the text of this report. Sections of the inferred soil stratigraphy along the centreline of the proposed route are given on Figures 3 and 4.

The soil samples obtained during the investigation were brought to our Toronto laboratory for examination and testing. The results of the tests are given on the Records of Boreholes and on the figures.

The locations and elevations of the boreholes and test pits were supplied by Philips & Roberts Limited. The elevations are referred to Geodetic datum.

#### SITE AND GEOLOGY

The proposed widening and reconstruction extends west-erly for a distance of approximately 9,700 feet along Highway 99 from the junction of Highway 8 near the center of the Town of Dundas, Ontario.

The eastern portion of Highway 99 crosses the pre-glacial Dundas Valley which joined the basins of Lake Erie and Lake Ontario. This valley was largely filled with drift material during the last glacial advance and the drift deposits were covered by post-glacial lake deposits. The western portion of Highway 99 is generally underlain by glacial till. The entire area is underlain by red coloured Queenston Shale of Ordovician Age.

#### SOIL CONDITIONS

The detailed stratigraphy encountered in each boring and test pit is given on the Records of Boreholes. The stratigraphy along the proposed route has been interpolated from this data and is presented on Figures 3 and 4. Following is an account of the inferred soil conditions at the site.

The western and central portions of the route are covered at a few locations by fill up to about 7 feet thick or shallow recent deposits of sands and silts. An extensive stratum of glacial till underlies this area. The eastern portion of the route is generally covered by fill or recent deposits of sands, silts and clayey silts up to about 20 feet thick. These recent surface deposits are generally underlain by a lacustrine deposit of silty clay.

The glacial till underlying the central and western

portions of the route, west of about Tally Ho Road, was penetrated for as much as 30 feet by the borings but was not completely penetrated. The till is composed of grey clayey silt to silty clay with some sand and scattered gravel dispersed throughout. The upper portion of the stratum has been weathered brown and slightly desiccated. Typical grain size distribution curves for the till are shown on Figures 10 to 15, inclusive. In boreholes 4, 12 and 14, zones of brown silty sand and gravel to sand with some silt and gravel were encountered within the till stratum. These zones in general separated the non-weathered and the weathered till. Typical grain size distribution curves for this granular material are shown on Figure 16.

Atterberg limit determinations indicate that the till has a liquid limit of about 20 to 40 with an average value of about 30. The plasticity index is between about 7 and 23 with an average of about 13. The natural in situ water content of the till ranges between 10 and 25 percent and is, in general, within about 3 percent above or below the plastic limit. The natural water content of the silty sand and gravel inclusions within the till ranges between about 13 and 15 percent. The results of 13 unit weight determinations indicate that the till has a total unit weight of about 124 to 144 lb/cu.ft. and an average unit weight of about 135 lb/cu.ft. There is no apparent pattern to an increase or decrease in the measured unit weight with depth.



The undrained shear strength of the till was determined by laboratory unconfined compression tests on relatively undisturbed samples. The results of these tests, which gave values ranging from about 1,500 to 6,000 lb/sq.ft., are plotted on the Records of Boreholes. Based on these results together with the in situ standard penetration test values, which in general range between about 17 and 54 blows/ft., the till is very stiff to hard. However, the upper 2 to 3 feet of the weathered till is occasionally firm to stiff as in boreholes 3, 6, 10, and 14. There are also some firm to stiff areas within the till as in boreholes 7 and 15. Standard penetration tests carried out in the silty sand and gravel zones indicate that the material is generally compact.

The results of standard Proctor compaction tests carried out on bulk samples of till obtained in test pits 1 and 2 are shown on Figure 18. Grain size distribution curves for the till material used in the tests are shown on Figure 14. For the silty clay material encountered in test pit 1 the maximum standard Proctor dry density is about 103 to 107 lb/cu.ft., at an optimum water content of about 22 to 20 percent. This is at about the natural in situ water content of the soil. The clayey silt material encountered in test pit 2 has a Proctor maximum dry density of about 114 lb/cu.ft. at an optimum water content of about 16 percent, which is again at about the natural in situ water content of the soil.

The glacial till, outside the limits of the existing roadway, is generally covered by a thin layer of topsoil. Between about stations 82+50 and 87+00, at boreholes 4 and 26, up to 5 feet of recent swamp deposit was encountered at ground surface. The swamp deposit consists of brown organic sandy silt to clayey silt. Based on one laboratory test the organic content of this deposit was found to be about 9 percent and the total unit weight about 111 lb/cu.ft. The water content of the clayey silt portion of the swamp deposit is about 33 to 52 percent and a single Atterberg limit determination indicates that the liquid limit is about 62 and the plasticity index about 26. Standard penetration tests carried out in the swamp deposit gave "N" values of 3 to 12 blows/ft. indicating a generally loose density. The recent swamp deposit is underlain by about 2 feet of compact brown silty sand and gravel which overlies the till stratum.

In the central portion of the route, between about stations 44+00 and 63+00, a surface layer of roadway fill up to about 7 feet thick covers the glacial till at the boring locations. The fill, as shown by the grading curves on Figure 5, is essentially composed of clayey to sandy silt with a trace to some gravel. The water content of the fill varies from about 17 percent near the surface of the layer to about 29 percent with depth. Based on the standard penetration test results the clayey portions of the fill are firm to stiff and the granular portions loose to compact. At

borehole 9, located near the toe of the existing roadway embankment at station 61+40, the surface layer of firm clayey silt fill is underlain by a 9 foot thick recent deposit of very loose to loose silty fine sand overlying the extensive till stratum.

Surface deposits, probably of lacustrine origin, cover the proposed route at the borehole locations in the eastern portion of the site between about stations 10+00 and 42+00. These surface deposits are generally about 5 feet thick but are occasionally up to 23 feet thick, as in borehole 22. The deposits are composed of material varying from a silty sand and gravel to stratified sands, silts and clayey silts. Typical grain size distribution curves for samples from these deposits are shown on Figures 6 to 9, inclusive. The natural water content of the clayey silt portions ranges between about 10 and 32 percent with one value as high as 84 percent for the grey silt with some organic matter encountered in borehole 18. The water content of the silty sand and gravel is as low as 5 percent. Based on one determination a clayey portion of these deposits has a liquid limit of about 48 and a plasticity index of about 28. Standard penetration test results indicate that the surface deposits are generally very loose to compact, becoming dense to very dense with depth as in boreholes 21 and 22.

In the eastern portion of the route, extending easterly

from about station 10+00 across Spencer Creek to the junction of Highways 99 and 8, a fairly extensive section of fill was encountered by the borings. On the west bank of the creek the fill is about 13 feet thick and is composed of brown silty sand, gravel, ashes, coal, brick fragments and occasional boulders. The fill on the east bank is some 11 feet thick and is comprised of brown silty sand and gravel with a trace to some clay. Typical grain size distribution curves for the fill are shown on Figure 5. Based on the standard penetration test results the fill is generally loose to compact.

To the east of about station 25+00, the site beneath the surface deposits is generally underlain by a lacustrine deposit of silty clay with some sand and numerous sand and sandy silt layers throughout. Typical grain size distribution curves for this material are shown on Figure 17. The natural water content of the silty clay deposit is between about 20 and 30 percent. Standard penetration tests gave "N" values ranging from about 8 to 35 blows/ft., indicating that the silty clay is firm to hard. However, the higher range of "N" values was generally obtained in portions of the deposit where the sand layers are prominent and it is considered that the consistency of the silty clay is essentially firm to very stiff and generally stiff.

GROUNDWATER CONDITIONS

Following completion of each boring a standpipe was installed for groundwater level observation. Periodic water level readings were taken in these installations during the course of the field work. The installation details together with the latest readings obtained on December 15, or December 21, 1964 are shown on the Records of Boreholes and on Figures 3 and 4.

The readings show that the groundwater level is generally within the upper portion of the glacial till stratum in the western portion of the proposed route and approximately follows the boundary between the recent surface deposits and the underlying silty clay stratum in the eastern portion of the route. In the swampy area, at boreholes 4 and 26, the groundwater level is at ground surface. From the readings obtained the groundwater level is generally some 5 to 10 feet below the proposed roadway grade but varies from about 3 feet, in borehole 2, to as much as 38 feet, in borehole 9, below the proposed grade.

DISCUSSIONGeneral

It is understood that the existing highway is to be realigned and widened to 3 lanes with a total roadway width of 32 feet. The eastern portion of the route is to be constructed

as an urban highway with sidewalk, curbs, gutters, and storm sewers while the western portion of the route is to be constructed as a rural highway with open ditches provided for drainage. The centre-line of the proposed realignment in relation to the existing roadway, together with the proposed final roadway grade are shown on Figures 1 to 4, inclusive.

### Cut Sections

As shown by the grade line on Figure 4, there are two major areas where cuts to a depth of as much as about 20 feet below existing ground surface will be required. These cut sections are in the western portion of the site and will extend from about station 69+00 to 75+00 and between about station 79+00 and 82+00.

The borings put down in the above sections show that the material to be excavated is in general a stiff to hard clayey silt to silty clay till. The glacial till is a competent material and excavations to the required depth can be made in it using side slopes of  $1\frac{1}{2}$  horizontal to 1 vertical or even steeper without danger of overall instability. However, roadway cuts with side slopes of  $1\frac{1}{2}$  horizontal to 1 vertical in this material would in general be surficially unstable over the long term. It is therefore recommended, in order to minimize surficial instability, that the side slopes be made no steeper than 2 horizontal to 1 vertical. Where it is necessary, due to space restrictions, to use  $1\frac{1}{2}$  to 1 side

slopes a bench or berm, about 4 feet wide, should be provided half way up the slope when the height of cut is in excess of about 15 feet.

Provision should be made for sodding or seeding and mulching of the side slopes as soon as possible following construction to prevent surface water erosion and gullyng of the glacial till. Similarly, the open ditches in the cut sections should be lined to prevent erosion undermining of the cut slopes and roadway.

When subgrade elevation is reached in the cuts, the surface of the glacial till should be proof-rolled to at least 100 percent of the standard Proctor dry density. As the natural in situ water content of the till at subgrade elevation is close to the optimum compaction water content (See Figure 18), no compaction difficulties are anticipated. After proof-rolling the subgrade should be covered with the pavement sub-base material as soon as possible to prevent softening of the glacial till due to the elements and construction traffic. Further, to prevent rutting, construction traffic should not be allowed on the subgrade during periods of precipitation.

No major construction problems due to groundwater are anticipated as the groundwater level was found to be below the proposed excavation level.

Besides the above major cut sections, several minor cuts up to some 10 feet deep will be required along the remainder of the central and eastern portions of the route. Reference to Figures 3 and 4 shows that these cuts will be in the glacial till or in the recent essentially granular deposits covering the route and the same procedures as outlined above should in general be followed. Due to space restrictions the cuts in the eastern portion of the route will be supported by retaining walls, which are discussed in a later section of this report.

#### Fill Sections

As shown by Figures 1 to 4, inclusive, there are two areas in the western portion of the site where major fills will be required. In the first area, which extends between about station 74+00 and 78+00, up to about 20 feet of fill will be required above existing ground surface. The second area, in the vicinity of station 61+00, will require some 30 feet of fill to widen and raise the grade of the existing roadway embankment on the north side.

Borehole 6 shows that the first area is covered by a thin layer of topsoil followed by stiff to hard clayey silt till. Beyond about the toe of the existing roadway embankment, the second area, as shown by borehole 9, is covered by firm clayey silt fill overlying a deposit of loose sand which rests on



stiff to very stiff clayey silt till. There should be no stability problem with the proposed roadway embankment using 2 horizontal to 1 vertical side slopes in the area of borehole 6, provided the topsoil overlying the glacial till subsoil is removed and the embankment is constructed of suitable material properly compacted in lifts during placing. As the existing generally firm clayey silt fill overlying the sand deposit in the second area may be variable in strength, there could be local failures during construction of the 30 foot high embankment. If possible local failures of the embankment can not be tolerated during construction, then the existing fill overlying the sand must be completely removed to ensure stability.

In addition to the above major fills several other fill sections about 5 to 10 feet high will be required along the route. The borings in these other areas show that, in general, there should be no stability problem with the proposed embankments, provided all topsoil and any organic deposits, such as the swamp deposit encountered by borings 4 and 26 in the vicinity of station 85+00, are stripped beneath the full base width of the proposed fills prior to their construction.

As in the cut sections, it is recommended that the side slopes of the embankments be covered by sod or seeded and mulched as soon as possible after construction to prevent surface

water erosion and gullying.

The glacial till or the granular portions of the recent deposits, removed from the cut sections along the route, may in general be used as fill to bring the proposed roadway embankments to pavement subgrade elevation. Reference to Figures 3 and 4 shows that the till from the two main cut sections in the western part of the site will provide the major source of borrow material along the route. As the till material is essentially a silty clay to clayey silt it will be necessary, due to its high silt and clay content, to exercise water content control within narrow limits during field compaction in order to achieve satisfactory results. The results of three standard Proctor compaction tests, given on Figure 18, show that the optimum water content is about 20 to 22 percent for the silty clay portion of the till (obtained from test pit 1) and about 16 percent for the clayey silt portion of the till (obtained from test pit 2). Based on laboratory water content determinations on samples of the till, the in situ water content is generally at or within a few percent of the optimum compaction water content.

If the till material obtained from the cut sections is used as general embankment fill, it should be compacted to 95 percent of the maximum standard Proctor dry density. The material should be laid down and compacted in lifts not exceeding 9 inches

in thickness, any lumps present pulverized and the material allowed to dry or wetted, if necessary, to bring it near the optimum water content for compaction. If satisfactory results are to be obtained with the use of the clayey till, strict control will be necessary and an experienced contractor should be employed.

The upper foot of the embankment fill, which will form the subgrade surface, should be compacted to 100 percent standard Proctor dry density. The subgrade should be covered with the pavement sub-base material as soon as possible to prevent softening and rutting due to construction traffic.

#### Pavement

Along the highway realignment at about the proposed grade line, the subgrade material in the cut sections generally consists of stiff to hard clayey till in the western portion of the route and recently deposited compact silty sands to stiff clayey silts in the eastern portion of the route. Both the till and the recent deposits, including the sandy fill at the extreme eastern part of the site, are moderately frost-susceptible although the recent deposits, due to a more uniform gradation and layered structure, have in general a higher frost-susceptibility than the less permeable and relatively homogeneous till material.

In the design of pavements the first criterion to be

examined is the supporting strength of the subgrade. Provided the very stiff till and generally compact recent deposits are proof-rolled at subgrade elevation prior to placement of the pavement base-course, their strength will not be the governing factor in design. The frost-susceptibility of these materials, the depth of frost penetration and the position of the groundwater table will be the controlling factors.

In the south-western Ontario region the depth of frost penetration in ground with no snow cover or insulating effect, could be of the order of 4 to 5 feet. Therefore, to prevent frost penetration into the subgrade with consequent ice lens formation, heaving and loss of strength in frost-susceptible subgrade materials near the groundwater level, a combined thickness of asphalt and non-frost-susceptible base-course of 4 to 5 feet would be required. Thus to completely eliminate frost action on pavement supported by a frost-susceptible subgrade a generally uneconomical thickness of base-course is required.

With provision of adequate base-course and subgrade drainage, it has been experienced in Ontario that frost action damage to pavements on frost-susceptible subgrades may be reduced to tolerable limits if the combined thickness of flexible pavement is about  $\frac{1}{2}$  the total depth of frost penetration. In the Hamilton area this would make the flexible pavement thickness about 30 inches.

For the till and recent deposits, which will form the subgrade materials along the route, it is suggested that the total pavement design thickness should be a minimum of 30 inches. This could consist of 4 to 5 inches of asphalt followed by 26 inches of free draining and non-frost-susceptible granular base-course materials. The bottom 4 inches of the base-course resting on the subgrade should be composed of a filter sand, such as washed concrete sand. The upper 9 inches of the base-course forming the pavement sub-base should be select Granular "A" or washed crushed stone, as specified by D.H.O., and the remainder of the base-course could be D.H.O. granular "B" with less than 5 percent silt sizes. The granular materials for the pavement should be laid down and compacted in lifts to at least 95 percent of the modified Proctor dry density using a heavy vibratory roller.

To prevent ponding of water on the subgrade material, the subgrade surface should be crowned throughout the route. For fill sections of the roadway above existing ground surface, the base-course material should extend across the complete top width of the embankment to promote base-course drainage. At cut sections in the urban portion of the route drainage trenches, backfilled with free-draining granular material, taken several feet into the subgrade and placed on either side of the roadway at about the curb line, should be provided. Similarly, at cut sections in the western rural portion of the route, the drainage ditches should

be taken about 2 to 3 feet below the subgrade surface to prevent possible ponding of water in the pavement sub-base materials.

The roadway sub-base material should in all cases be placed to extend into the drainage trenches or ditches. Where the roadway surface is to be at about existing ground surface provision for drainage from the sub-base should also be made.

### Retaining Walls

Due to space restrictions caused by private properties, retaining walls will be required in two cut sections of the eastern portion of the route at the locations shown on Figure 1. The retaining walls will be as much as 15 feet high above the roadway surface and will probably be of the reinforced concrete cantilever type.

Borings 18, 21 and 22, put down in the retaining wall areas, show that the subsoil below the proposed roadway grade is dense to very dense and consists of silts, silty sands, clayey silts and sands with gravels. The proposed retaining walls may be founded below the roadway surface, at the minimum depth required for adequate frost protection, using an allowable footing bearing pressure of up to 4 tons/sq.ft. Settlement of the retaining walls imposing the above loading should be less than 1 inch, provided the in situ density of the subsoil at and below foundation grade is not reduced during construction. To prevent

disturbance of the subsoil in foundation excavations, due to surface water and construction operations, it is recommended that a thin working mat of lean concrete be laid down as soon as possible after foundation grade is reached and the excavations kept dry.

Backfill for the retaining walls consisting of free-draining and non-frost-susceptible granular material is recommended. The granular backfill should extend at least 4 feet horizontally behind the retaining walls and provision for drainage from this material should be made to ensure that no hydrostatic or ice pressures build up behind the walls. With full effective drainage behind the walls, it is recommended that a coefficient of active earth pressure,  $K_A$ , = 0.3 and a total unit weight,  $\gamma$ , = 135 lb/cu.ft. for the compacted granular backfill be used in the design of the walls. For the computation of sliding resistance along a rough concrete footing resting on the sandy to clayey subsoil, a coefficient of 0.4, which is the ratio of horizontal sliding resistance to normal bearing pressure, may be used.

#### Culvert

It is understood that a 36 inch diameter culvert, to carry storm drainage across the highway, is to be provided at about station 28+00. The invert of the culvert or storm sewer is to be at about elevation 359 and the proposed roadway grade

in this vicinity is to be at about elevation 375. Thus some 13 feet of roadway fill will be placed above the culvert.

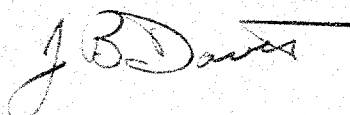
Borehole 18 put down at the proposed culvert location shows that the subsoil below invert elevation consists of about 7 feet of loose silt to clayey silt alluvium overlying stiff to hard clayey till. With the widening of the existing roadway and the addition of fill to bring the roadway to the proposed grade, some settlement in the loose alluvial deposit will take place. As the alluvium is essentially granular in nature the major portion of the settlement will take place during construction. If a rigid concrete pipe placed in the loose alluvium is provided for the storm sewer the resultant differential settlement could cause cracking of the concrete pipe. To prevent the possibility of cracking it is recommended that a flexible pipe, such as a corrugated steel culvert, be used beneath the complete base width of the roadway embankment.

At least 2 feet of bedding material, consisting of sand and gravel well compacted during placing in 9 inch lifts, should be placed beneath the flexible culvert. The base width of the bedding pad should be at least twice the pipe diameter. Prior to placing of the bedding material the surface of the alluvium, at a 2 foot depth below invert elevation, should be thoroughly compacted by a vibratory roller. The fill surrounding the culvert

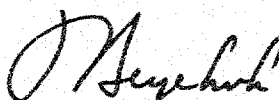


above the bedding pad should be a free-draining granular material, free of particles larger than 3 inches in diameter, placed in loose lifts not exceeding 9 inches and well compacted. The backfill material should be brought up evenly on both sides of the culvert and carried to a height of at least one foot above the top of the culvert before construction equipment is allowed over the culvert.

If a flexible pipe can not be used and it is necessary to provide a rigid concrete pipe beneath the embankment, the loose alluvium beneath invert elevation should be removed in a trench at least 10 feet wide and replaced with suitable granular material laid down and well compacted in lifts.



J. B. Davis



J. L. Seychuk, P.Eng.

JLS JBD HJB

64151

February 5, 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

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

### II. PENETRATION RESISTANCES

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

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

WH	sampler advanced by static weight—weight, hammer
PH	sampler advanced by pressure—pressure, hydraulic
PM	sampler advanced by pressure—pressure, manual

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

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

#### (b) Cohesive Soils

Consistency	<i>c<sub>u</sub></i> , lb./sq. ft.
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

### IV. SOIL TESTS

C	consolidation test
H	hydrometer analysis
M	sieve analysis
MH	combined analysis, sieve and hydrometer <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 = $-\Delta e / \Delta \log_{10} \sigma'$
$c_c$	coefficient of consolidation
$T_v$	time factor = $c_d / d^2$ ( $d$ , 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
$S_i$	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

STATION: 96+40, 12.5' LEFT

LOCATION See Figure 2

BORING DATE DECEMBER 1, 1964

DATUM GEORETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

SAMPLER HAMMER WEIGHT 140 LB

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		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ. FT.	WATER CONTENT, PERCENT			
								Wp	W		
							</				

CAP -  
GROUND  
LEVEL  
SURFACE  
SEA

GRAVEL  
TILL

STANDPIPE

WL IN STANDPIPE  
AT ELEV. 448.2  
DEC. 15, 1964

# RECORD OF BOREHOLES 2 & 3

LOCATION

See Figure 2

BORING DATE SEPTEMBER 3, 1964

DATUM

30MS-108

COVERED NO.

BOREHOLE TYPE

POWER AND/OR PNEUMATIC

BOREHOLE DIAMETER 4.5 INCHES

SAMPLER HAMMER WEIGHT 140 LB.

DROP 30 INCHES

PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

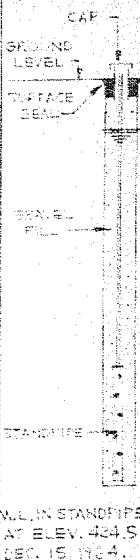
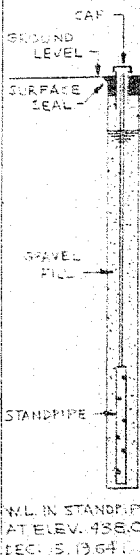
SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----					COEFFICIENT OF PERMEABILITY $k_v$ , CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ. FT.					WATER CONTENT, PERCENT					
							0-11					Wp      W      Wl					
							1000 2000 3000 4000 5000					25      40      60      80					
2/ STATION 03+45, 16 LEFT																	
440.2	GROUND LEVEL																
440.0	DARK BROWN SILTY TOPSOIL		1	SC	440												
			2	SC	439												
	VERY STIFF TO HARD BROWN CLAYEY SILT SOME SAND (WEATHERED TILL)		3	SC	438												
437.4			4	SC	437												
437.3			5	SC	436												
	VERY STIFF TO HARD GRAY CLAYEY SILT SOME SAND & WATERED GRAVEL (TILL)		6	SC	435												
423.7			7	SC	434												
423.7	END OF HOLE																
3/ STATION 07+57, 12 LEFT																	
426.5	GROUND LEVEL																
426.0	DARK MOTTLED BROWN CLAYEY SILT WITH SAND AND GRAVEL (TOPSOIL)		1	SC	426												
			2	SC	425												
	FIRM TO VERY STIFF BROWN CLAYEY SILT SOME SAND & OCCASIONAL MOTTLED GRAVEL (WEATHERED TILL)		3	SC	424												
419.6			4	SC	423												
419.6			5	SC	422												
	HARD GRAY CLAYEY SILT SOME SAND AND MOTTLED GRAVEL (TILL)		6	SC	421												
410			7	SC	420												
410	END OF HOLE																
Percent axial strain at failure																	

15-0-5 Percent axial strain at failure

VERTICAL SCALE  
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN  
CHECKED



# RECORD OF BOREHOLE 4

STATION: 82+30, 6' LEFT.  
LOCATION See Figure 2

BORING DATE DECEMBER 3, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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 $k_v$ , CM. / SEC.					ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER		TYPE	SHEAR STRENGTH $C_u$ , LB./SQ. FT.					WATER CONTENT, PERCENT						
						0 - 10 1,000 2,000 3,000 4,000 5,000					$W_p$ $W$ $W_L$ 20   40   60   80						
422.6	GROUND LEVEL																
0.0	SOFT DARK BROWN CLAYEY SILT WITH NUMEROUS ROOTS AND TWIGS (SWAMP DEPOSIT)		1	PO	3												
418.1			2		6												
4.5	COMPACT BROWN SILTY SAND AND GRAVEL		3		15												
6.1			4		22												
6.5	VERY STIFF GREY CLAYEY SILT SOME SAND AND FINE GRAVEL (TILL)		5		20												
413.4			6		25												
9.2			7		15												
	COMPACT BROWN FINE TO COARSE SAND AND FINE GRAVEL, SOME SILT (NO NOTICEABLE STRATIFICATION)		8	AS	-												
398.1																	
24.5	VERY STIFF GREY CLAYEY SILT SOME SAND, TRACE GRAVEL (TILL)																
393.6																	
25.0	END OF HOLE																

WL IN OPEN HOLE  
AT GROUND LEVEL  
ELEV. 422.6 ON  
DEC. 15, 1964.

WATER CONTENT 3.2%

MH

MH

# RECORD OF BOREHOLE 5

STATION 80+60, E  
LOCATION See Figure 2

BORING DATE DECEMBER 3, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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		SHEAR STRENGTH C <sub>u</sub> , LB./SQ. FT.					WATER CONTENT, PERCENT					
						0 - U					W <sub>p</sub> W      W <sub>L</sub>					
						1000	2000	3000	4000	5000	20	40	60	80		
443.4	GROUND LEVEL															
442.0	DARK BROWN SILTY TOPSOIL		1	10	7											
440.0			2	10	14											
	STIFF TO HARD BROWN CLAYEY SILT TO SILTY CLAY WITH SOME SAND (WEATHERED TILL)		3	10	46											
			4	10	39											
			5	10	36											
438.0			6	10	34											
436.4			7	10	41											
			8	10	25											
	VERY STIFF TO HARD GREY TO GREY-BROWN CLAYEY SILT WITH SOME SAND AND SPATTERED GRAVEL (TILL)		9	10	32											
			10	10	31											
			11	10	28											
412.4	END OF HOLE		12	10	33											

GROUND LEVEL  
CLAYEY TO HARD BROWN CLAYEY SILT TO SILTY CLAY WITH SOME SAND (WEATHERED TILL)

STANDPIPE

W.L. IN STANDPIPE  
AT ELEV. 426.8  
DEC. 15, 1964.

## RECORD OF BOREHOLE 6

LOCATION STATION: 76+87, 13.5' RIGHT  
See Figure 2.

BORING DATE DECEMBER 4, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

[illegible]



## RECORD OF BOREHOLE 7

LOCATION STATION 73+63.5, R.  
See Figure 2

BORING DATE DECEMBER 5, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER ALLEY BORING

BOREHOLE DIAMETER 4.5 INCHES

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
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.		SHEAR STRENGTH $C_u$ , LB./SQ.FT.					WATER CONTENT, PERCENT					
							1000	2000	3000	4000	5000	Wp	W	WL			
450.8	GROUND LEVEL																
448.8	0.0 VERY SOFT DARK BROWN SILTY TOPSOIL.		1	SP	2	450.0											
446.1	1.5 LOOSE BROWN SILTY FINE SAND TO SANDY SILT.		2		3												
444.5			3		6	446.0											
			4		27												
	STIFF TO HARD BROWN SILTY CLAY TO CLAYEY SILT, SOME SAND & SCATTERED GRAVEL (WEATHERED TILL).		5		24	440.0											
			6		25												
433.0			7		20	436.0											
431.5			8		8												
			9		5	430.0											
	STIFF TO VERY STIFF GREY SILTY CLAY WITH SOME SAND AND SCATTERED GRAVEL (TILL)		10		11	425.0											
			11		10	420.0											
418.8	END OF HOLE																

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STANDPIPE DRY TO  
ELEV. 428.8 AND  
BLOWN, DEC. 15/64.

## RECORD OF BOREHOLES 8 &amp; 9

LOCATION

See Figure 2

BORING DATE DECEMBER 5 & 16, 1964

DATUM      GEODETIC

BOREHOLE TYPE POWER ALGER 3 WATCH BOSSING

BOREHOLE DIAMETER 4.9 INCHES EX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT		LB.	DROP	INCHES
1	10	10	10	10
2	10	10	10	10
3	10	10	10	10
4	10	10	10	10
5	10	10	10	10
6	10	10	10	10
7	10	10	10	10
8	10	10	10	10
9	10	10	10	10
10	10	10	10	10
11	10	10	10	10
12	10	10	10	10
13	10	10	10	10
14	10	10	10	10
15	10	10	10	10
16	10	10	10	10
17	10	10	10	10
18	10	10	10	10
19	10	10	10	10
20	10	10	10	10
21	10	10	10	10
22	10	10	10	10
23	10	10	10	10
24	10	10	10	10
25	10	10	10	10
26	10	10	10	10
27	10	10	10	10
28	10	10	10	10
29	10	10	10	10
30	10	10	10	10
31	10	10	10	10
32	10	10	10	10
33	10	10	10	10
34	10	10	10	10
35	10	10	10	10
36	10	10	10	10
37	10	10	10	10
38	10	10	10	10
39	10	10	10	10
40	10	10	10	10
41	10	10	10	10
42	10	10	10	10
43	10	10	10	10
44	10	10	10	10
45	10	10	10	10
46	10	10	10	10
47	10	10	10	10
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51	10	10	10	10
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53	10	10	10	10
54	10	10	10	10
55	10	10	10	10
56	10	10	10	10
57	10	10	10	10
58	10	10	10	10
59	10	10	10	10
60	10	10	10	10
61	10	10	10	10
62	10	10	10	10
63	10	10	10	10
64	10	10	10	10
65	10	10	10	10
66	10	10	10	10
67	10	10	10	10
68	10	10	10	10
69	10	10	10	10
70	10	10	10	10
71	10	10	10	10
72	10	10	10	10
73	10	10	10	10
74	10	10	10	10
75	10	10	10	10
76	10	10	10	10
77	10	10	10	10
78	10	10	10	10
79	10	10	10	10
80	10	10	10	10
81	10	10	10	10
82	10	10	10	10
83	10	10	10	10
84	10	10	10	10
85	10	10	10	10
86	10	10	10	10

SOIL PROFILE		SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT.		COEFFICIENT OF PERMEABILITY $k_v$ , CM./SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION					
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ. FT.					WATER CONTENT, PERCENT				
							1000	2000	3000			4000	5000	$W_p$	$W$	$W_L$

VERTICAL SCALE

1 INCH TO 5' 0"

**GOLDER & ASSOCIATES**

30 75-108

DRAWN 2/16/62

CHECKED *h*

RECORD OF BOREHOLE 10

STATION: 58 + 19.5 24' LEFT

LOCATION

See Figure 2

BORING DATE DECEMBER 7, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.0 INCHES

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

[illegible]

## RECORD OF BOREHOLE II

STATION: 54+82.43' RIGHT  
LOCATION See Figure 2

BORING DATE DECEMBER 7, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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 $k_v$ , CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.		SHEAR STRENGTH $C_u$ , LB./SQ. FT.  1000 2000 3000 4000 5000	WATER CONTENT, PERCENT  20 40 60 80					
								Wp	W	WL			
411.2	GROUND LEVEL												
0.0	DARK BROWN SILTY TOPSOIL		1	2"	10								
0.8			2	"	16								
			3	"	48								
	VERY STIFF TO HARD REDDISH-BROWN TO BROWN SILTY CLAY WITH SOME SCATTERED GRAVEL (PROBABLY LIMESTONE AND SHALE FRAGMENTS) (WEATHERED TILL)		4	"	51								
			5	"	18								
			6	"	16								
			7	"	35								
389.7			8	"	26								
21.5	VERY STIFF SILTY CLAY WITH SOME SAND AND OCCASIONAL SAND STRIPS OR LENSES TO 1" THICK (MLL)												
384.7			9	"	21								
26.5	END OF HOLE												

CAP  
GROUND LEVEL  
DIFFUSE SEALGRAVEL  
FILL

STANDPIPE

W.L. IN STANDPIPE  
AT ELEV. 335.0  
DEC. 15, 1964

## RECORD OF BOREHOLE 12

STATION: 52 + 20, 32' RIGHT  
LOCATION See Figure 2

BORING DATE DECEMBER 17, 1964

DATUM GEODETIC

BOREHOLE TYPE WASH BORING

BOREHOLE DIAMETER 5X 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 $C_u$ , LB./SQ. FT.	WATER CONTENT, PERCENT <div><math>W_p</math>      <math>W</math>      <math>W_L</math> 20      40      60      80</div>		
381.6	GROUND LEVEL									
380.0	VERY LOOSE TO COMPACT BROWN SANDY SILT, TRACE TO SOME CLAY & GRAVEL (FILL)		1	L.O.	3					
377.0			2	"	11					
374.5	FIRM TO STIFF BROWN CLAYEY SILT WITH SOME SAND AND GRAVEL (WEATHERED TILL)		3	"	12					
373.1			4	T.O.	6					
368.5	COMPACT BROWN SILT TO MEDIUM SAND CLAY SILT OCCASIONALLY INTO BROWN CLAY LAYERS		5	L.O.	4					
			6	"	21					
365.3			7	"	11					
362.3	COMPACT TO DENSE BROWN SILTY SAND AND GRAVEL BECOMING CLAYEY WITH INCREASING DEPTH (NLL)									
360.1			8	"	16					
361.5	END OF HOLE									

CAT

GROUND LEVEL

SURFACE SEAL

MH

GRAVEL FILL

STANDPIPE

W. IN STANDPIPE  
AT ELEV. 373.8  
DEC. 21, 1964.

WATER IN STANDPIPE  
AT ELEV. 373.9  
DEC. 21, 1964.

## RECORD OF BOREHOLES 13 &amp; 14

LOCATION

See Figure 1

BORING DATE DECEMBER 7-8, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

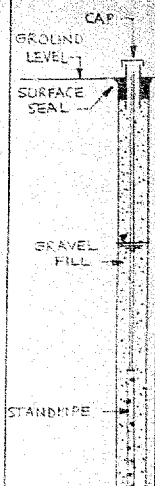
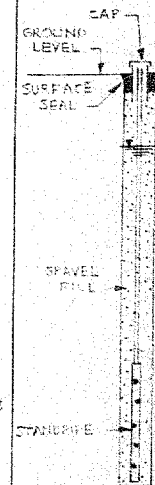
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE		SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE	COEFFICIENT OF PERMEABILITY $k$ , CM./SEC.			ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
ELEV. DEPTH	DESCRIPTION	STRAT. LOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ. FT.	WATER CONTENT, PERCENT				
								1,000	2,000			3,000
							0 - U. 20 40 60 80					
STATION: 43+15, 30' RIGHT												
379.7	GROUND LEVEL											
378.3	DARK BROWN SILTY TOPSOIL		1	P.O.	4							
376.3	WEATHERED TILL (FILL)		2		7							
375.8			3		8							
	STIFF & HARD REDDISH-BROWN TO BROWN CLAYEY SILT, SOME SAND AND SCATTERED GRAVEL (WEATHERED TILL)		4		35							
			5		56							
368.0			6		25							
363.2	VERY STIFF GREY CLAYEY SILT WITH SOME SAND AND SCATTERED GRAVEL (TILL)		7		22							
363.2	END OF HOLE											
STATION: 44+47, 52' LEFT												
370.8	GROUND LEVEL											
364.3	FIRM TO STIFF BROWN TO RED-BROWN CLAYEY SILT TO SANDY SILT WITH NUMEROUS RED SHALE FRAGMENTS (TILL FILL)		1	P.O.	14							
361.5			2		14							
361.5	STIFF BROWN CLAYEY SILT, SOME SAND AND GRAVEL (WEATHERED TILL)		3		8							
358.9			4		2							
354.3	COMPACT BROWN SILTY SAND AND GRAVEL		5		27							
354.3			6		30							
354.3	HARD GREY SILTY CLAY WITH SOME SAND AND GRAVEL (TILL)		7		33							
354.3	END OF HOLE											
15-10-5 Percent axial strain at failure												

VERTICAL SCALE  
1 INCH TO 5'-0"

GOLDER &amp; ASSOCIATES

30ms-108  
CHECKED BYDRAWN  
CHECKED

## RECORD OF BOREHOLE 15

STATION: 40+86, 7' RIGHT  
LOCATION See Figure 1

BORING DATE DECEMBER 5, 1964

DATUM GEOIDETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE		STRAT PLOT	SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----					COEFFICIENT OF PERMEABILITY K, CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION			
ELEV., DEPTH	DESCRIPTION		NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH C <sub>u</sub> , LB./SQ. FT.					WATER CONTENT, PERCENT							
							1000	2000	3000	4000	5000	W <sub>p</sub>	W	W <sub>L</sub>			20	40	60
408.4	GROUND LEVEL				405														
0.0	SILTY TOPSOIL		1	2	400														
0.6	STIFF TO VERY STIFF BROWN FAINTLY STRATIFIED CLAYEY SILT, SILTY CLAY AND SILT		2		400														
3.14			3																
7.0	VERY STIFF BROWN GRAY SILT TO SILTY CLAY WITH SOME SAND AND FINE GRAVEL (WEATHERED TILL)		4		335														
8.9			5																
14.5			6		330														
			7																
	STIFF TO VERY STIFF GRAY SILTY CLAY WITH SOME SAND AND GRAVEL (TILL)		8		385														
			9		350														
37.7	END OF HOLE				375														

GROUND  
LEVEL  
SURFACE  
SEALSTAND  
PIPE

STANDPIPE

W.L. IN STANDPIPE  
AT ELEV. 37.7  
DEC. 15, 1964

# RECORD OF BOREHOLES 16 & 17

LOCATION See Figure

BORING DATE DECEMBER 9 1964

DATUM T.M. DETIC

BOREHOLE TYPE FOWNS ADAPK BOREHOLE

BOREHOLE DIAMETER 4.5 INCHES

SAMPLER HAMMER WEIGHT 140 B. DROP 20 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 $C_u$ , LB. / SQ. FT.		WATER CONTENT, PERCENT			
							1000 2000 3000 4000 5000		$W_p$ $W$ $W_L$			
						0 - 5		20 40 60 80				

323.6	GROUND LEVEL				323.6	16/ STATION 134+12.48 LEFT						CAP -
0.0	LOOSE BROWN SILTY FINE SAND WITH SOME ROOTS AND TWIGS (FILL)		1	0.0	323.6							GROUND LEVEL
321.6			2	17	321.6							SURFACE SEAL
	STIFF TO VERY STIFF BROWN SILTY CLAY WITH SOME SAND - SCATTERED GRAVEL (WEATHERED TILL)		3	21	321.6							GRAVEL FILL
			4	27	321.6							
			5	21	321.6							
380.4			6	21	380.4							STANDPIPE
15.8	STIFF GREY SILTY CLAY WITH SOME SAND AND SCATTERED GRAVEL (TILL)		7	11	377.1							
377.1	END OF HOLE				377.1							W.L. IN STANDPIPE AT ELEV. 385.8 DEC. 15, 1964.

326.3	GROUND LEVEL				326.3	17/ STATION 134+12.48 RIGHT						CAP -
0.0	STIFF BROWN SILTY CLAY TO CLAYEY SILT SOME SAND, ROOTS AND TWIGS IN UPPER 2.5 OCCASIONAL FINE SAND BEAMS (1" TO 1/2" THIN) BELOW ELEV. 320.5.		1	0.0	326.3							GROUND LEVEL
			2	10	326.3							SURFACE SEAL
320.3			3	10	320.3							
6.0	DENSE TO VERY DENSE BROWN SILT, TRACE TO SOME CLAY WITH OCCASIONAL LAYERS OR LENSES (TYPICALLY 2" TO 4" THICK) OF SILTY CLAY AND FINE SAND		4	14	320.3							GRAVEL FILL
			5	11	320.3							
			6	15	320.3							
			7	14	320.3							
377.8			8	14	377.8							STANDPIPE
18.0	STIFF BROWN SILTY CLAY WITH SOME SAND AND OCCASIONAL SCATTERED GRAVEL (TILL)		9	14	377.8							
374.8	END OF HOLE				374.8							STANDPIPE DRY TO ELEV. 374.8 DEC. 15, 1964.

5 Percent axial strain at failure

15% Percent axial strain at failure

VERTICAL SCALE  
1 INCH TO

GOLDER & ASSOCIATES

3045-108

DRAWN  
CHECKED





## RECORD OF BOREHOLE 20

STATION 18+70, 23.5' LEFT  
LOCATION See Figure 1

BORING DATE DECEMBER 10, 1954

DATUM            GEODETIC

BOREHOLE TYPE POWER ADPAC BORING

BOREHOLE DIAMETER 4.5 INCHES

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT --- LB. DROP --- INCHES

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE BLOWS / FT.		COEFFICIENT OF PERMEABILITY $k_v$ CM. / SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVATION DEPTH	DESCRIPTION	STRAT. PLOT NUMBER	TYPE	BLOWS / FT.	ELEVATION SCALE	SHEAR STRENGTH $C_u$ , LB. / SQ. FT.	WATER CONTENT, PERCENT. <div style="display: flex; align-items: center; justify-content: center;"> <div style="margin-right: 10px;"><math>W_p</math></div> <div style="margin-right: 10px;"><math>W</math></div> <div><math>W_L</math></div> </div>		
345.5	GROUND LEVEL								
0.0	DARK BROWN SANDY AND SILTY <b>TOP SOIL</b>	1	1	10	345.5				
1.1	VERY LOOSE TO LOOSE BROWN <b>SILTY FINE SAND</b> TO <b>SILT</b> WITH SOME CLAY. SOME SILTY CLAY LAYERS WITH INCREASING DEPTH.	2	2	10	344.4				
336.5		3	3	10	343.3				
1.0	STIFF MOTTLED GREY AND BROWN <b>SILTY CLAY</b> WITH SOME SAND AND SCATTERED GRAVEL.	4	4	11	342.3				
531.5		5	5	12	341.3				
14.0	FIRM TO STIFF GREY <b>SILTY CLAY</b> WITH SOME SAND AND SCATTERED GRAVEL.	6	6	13	340.3				
22.0		7	7	14	339.3				
28.0	END OF HOLE	8	8	15	338.3				
320					320				

# RECORD OF BOREHOLE 21

STATION 14+22.48 RIGHT

LOCATION

See Figure 1

BORING DATE DECEMBER 11, 1964



DATUM GEODETTIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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.N. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ. FT.				WATER CONTENT, PERCENT $W_p$ $W$ $W_L$ 20      40      60      80
342.3	GROUND LEVEL										
	LOOSE BROWN SILTY FINE AND MEDIUM SAND BECOMING A LAYERED SAND AND CLAYEY SILT BELOW ELEV. 335.0. SOME ROOTS AND TWIGS IN UPPER PART.		1	2	3						
			2		6						
			3		10						
			4		10						
331.9			5		26						
10.4	VERY DENSE SAND GRAVEL AND ANGULAR ROCK FRAGMENTS IN A GREY-BROWN SILT MATRIX.		6		300						
			7		32						
324.9			8		21						
17.4			9		23						
	OTHER TO VERY STIFF GREY SILTY CLAY WITH NUMEROUS SAND AND SANDY SILT LAYERS.		10		30.14						
			11		20.76						
309.5											
33.0	END OF HOLE										
											W.L. IN STANDPIPE AT ELEV. 325.1 DEC. 16, 1924.

 WL IN STANDPIPE  
AT ELEV. 323.3  
DEC. 19, 1964.

# RECORD OF BOREHOLE 22

LOCATION STATION 12+80.34' LEFT  
See Figure 1

BORING DATE DECEMBER 14, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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 $k_v$ , 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 $W_p$ $W$ $W_L$ 20      40      60      80			

CAP  
GROUND  
LEVEL  
SURFACE  
SEAL

MH

MH

MH

GRAVEL  
FILL

MH

STANDPIPE

W.L. IN STANDPIPE  
AT ELEV. 317.1  
DEC. 21, 1964.

## RECORD OF BOREHOLES 23 &amp; 24

LOCATION

See Figure 1

BORING DATE DECEMBER 14-15, 1964

DATUM GEODETTIC

BOREHOLE TYPE

POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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 $C_u$ , LB./SQ. FT.					WATER CONTENT, PERCENT $W_p$ $W$ $W_L$ 20      40      60      80
280.0 0.0	GROUND LEVEL		1	10	11	21.0	23/ STATION 7+57.41 RIGHT					CAP GROUND LEVEL SURFACE SEAL
	GENERALLY VERY LOOSE TO COMPACT BROWN SAND, GRAVEL, LACHES, COAL AND SAND FRAGMENTS, BONES AND OCCASIONAL BOLLWEIG (FILL)		2	1	1	26.0						MH
			3	14	14	26.0						
			4	20	20	26.0						
			5	40	40	26.0						
277.4 12.5			6	17	17	27.5						MH
	STIFF TO VERY STIFF GREY CLAYEY SILT TO SILTY CLAY WITH SOME SAND AND SCATTERED GRAVEL		7	30	30	27.0						
268.4 21.5	END OF HOLE											
284.7 0.0	GROUND LEVEL		1	6	6	28.5	24/ STATION 13+22.33 LEFT					CAP GROUND LEVEL SURFACE SEAL
	LOOSE TO COMPACT DARK BROWN TO BROWN SILTY SAND & GRAVEL WITH ROCK FRAGMENTS (FILL)		2	40	40	28.0						MH
			3	40	40	27.5						
273.6 10.9			4	30	30	27.0						
	VERY LOOSE TO COMPACT BROWN-BROWN SILTY SAND WITH LAYERS OF VERY SILTY CLAY WITHIN AND VERY SILTY CLAY WITHIN AND VERY SILTY CLAY BELOW ELEV. 270.7		5	24	24	27.0						
268.3 16.5	END OF HOLE											
						15-10 Percent axial strain at failure						

VERTICAL SCALE  
1 INCH TO 5 FEET

GOLDER &amp; ASSOCIATES

30M 5-108

GEORES No.

DRAWN  
CHECKED

## RECORD OF BOREHOLE 25

LOCATION STATION C+73, 18.5' RIGHT  
See Figure 1

BORING DATE DECEMBER 15, 1964

DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING

BOREHOLE DIAMETER 4.5 INCHES

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		BLOWS/FT.	SHEAR STRENGTH C <sub>u</sub> , LB./SQ.FT.	WATER CONTENT, PERCENT W <sub>p</sub> W      W <sub>L</sub> 20      40      60      80		
287.6	GROUND LEVEL									
285.1	2.0' COMPACT BROWN SILTY CLAY & GRAVEL TO SURFACE SILT-CLAY FILL (FILL)		1	10.1B	285					
285.1			2	10.1B	286					
285.1			3	10.1B	287					
285.1			4	10.1B	288					
285.1			5	10.1B	289					
285.1			6	10.1B	290					
285.1			7	10.1B	291					
285.1			8	10.1B	292					
285.1			9	10.1B	293					
285.1			10	10.1B	294					
285.1			11	10.1B	295					
285.1			12	10.1B	296					
285.1			13	10.1B	297					
285.1			14	10.1B	298					
285.1			15	10.1B	299					
285.1			16	10.1B	300					
285.1			17	10.1B	301					
285.1			18	10.1B	302					
285.1			19	10.1B	303					
285.1			20	10.1B	304					
285.1			21	10.1B	305					
285.1			22	10.1B	306					
285.1			23	10.1B	307					
285.1			24	10.1B	308					
285.1			25	10.1B	309					
285.1			26	10.1B	310					
285.1			27	10.1B	311					
285.1			28	10.1B	312					
285.1			29	10.1B	313					
285.1			30	10.1B	314					
285.1			31	10.1B	315					
285.1			32	10.1B	316					
285.1			33	10.1B	317					
285.1			34	10.1B	318					
285.1			35	10.1B	319					
285.1			36	10.1B	320					
285.1			37	10.1B	321					
285.1			38	10.1B	322					
285.1			39	10.1B	323					
285.1			40	10.1B	324					
285.1			41	10.1B	325					
285.1			42	10.1B	326					
285.1			43	10.1B	327					
285.1			44	10.1B	328					
285.1			45	10.1B	329					
285.1			46	10.1B	330					
285.1			47	10.1B	331					
285.1			48	10.1B	332					
285.1			49	10.1B	333					
285.1			50	10.1B	334					
285.1			51	10.1B	335					
285.1			52	10.1B	336					
285.1			53	10.1B	337					
285.1			54	10.1B	338					
285.1			55	10.1B	339					
285.1			56	10.1B	340					
285.1			57	10.1B	341					
285.1			58	10.1B	342					
285.1			59	10.1B	343					
285.1			60	10.1B	344					
285.1			61	10.1B	345					
285.1			62	10.1B	346					
285.1			63	10.1B	347					
285.1			64	10.1B	348					
285.1			65	10.1B	349					
285.1			66	10.1B	350					
285.1			67	10.1B	351					
285.1			68	10.1B	352					
285.1			69	10.1B	353					
285.1			70	10.1B	354					
285.1			71	10.1B	355					
285.1			72	10.1B	356					
285.1			73	10.1B	357					
285.1			74	10.1B	358					
285.1			75	10.1B	359					
285.1			76	10.1B	360					
285.1			77	10.1B	361					
285.1			78	10.1B	362					
285.1			79	10.1B	363					
285.1			80	10.1B	364					
285.1			81	10.1B	365					
285.1			82	10.1B	366					
285.1			83	10.1B	367					
285.1			84	10.1B	368					
285.1			85	10.1B	369					
285.1			86	10.1B	370					
285.1			87	10.1B	371					
285.1			88	10.1B	372					
285.1			89	10.1B	373					
285.1			90	10.1B	374					
285.1			91	10.1B	375					
285.1			92	10.1B	376					
285.1			93	10.1B	377					
285.1			94	10.1B	378					
285.1			95	10.1B	379					
285.1			96	10.1B	380					
285.1			97	10.1B	381					
285.1			98	10.1B	382					
285.1			99	10.1B	383					
285.1			100	10.1B	384					
285.1			101	10.1B	385					
285.1			102	10.1B	386					
285.1			103	10.1B	387					
285.1			104	10.1B	388					
285.1			105	10.1B	389					
285.1			106	10.1B	390					
285.1			107	10.1B	391					
285.1			108	10.1B	392					
285.1			109	10.1B	393					
285.1			110	10.1B	394					
285.1			111	10.1B	395					
285.1			112	10.1B	396					
285.1			113	10.1B	397					
285.1			114	10.1B	398					
285.1			115	10.1B	399					
285.1			116	10.1B	400					
285.1			117	10.1B	401					
285.1			118	10.1B	402					
285.1			119	10.1B	403					
285.1			120	10.1B	404					
285.1			121	10.1B	405					
285.1			122	10.1B	406					
285.1			123	10.1B	407					
285.1			124	10.1B	408					
285.1			125	10.1B	409					
285.1			126	10.1B	410					
285.1			127	10.1B	411					
285.1			128	10.1B	412					
285.1			129	10.1B	413					
285.1			130	10.1B	414					
285.1			131	10.1B	415					
285.1			132	10.1B	416					
285.1			133	10.1B	417					
285.1			134	10.1B	418					
285.1			135	10.1B	419					
285.1			136	10.1B	420					
285.1			137	10.1B	421					
285.1			138	10.1B	422					
285.1			139	10.1B	423					
285.1			140	10.1B	424					
285.1			141	10.1B	425					
285.1			142	10.1B	426					
285.1			143	10.1B	427					
285.1			144	10.1B	428					
285.1			145	10.1B	429					
285.1			146	10.1B	430					
285.1			147	10.1B	431					
285.1			148	10.1B	432					
285.1			149	10.1B	433					
285.1			150	10.1B	434					
285.1			151	10.1B	435					
285.1			152	10.1B	436					
285.1			153	10.1B	437					
285.1			154	10.1B	438					
285.1			155	10.1B	439					
285.1			156	10.1B	440					

## RECORD OF BOREHOLE 26, TEST PIT 1

LOCATION

See Figure 2

BORING DATE

DECEMBER 18 22 1964

DATUM GEODETIC

BOREHOLE TYPE

WASH BORING

BOREHOLE DIAMETER

EX CASING

SAMPLER HAMMER WEIGHT 140 LB.

DROP 30 INCHES

PEN. TEST HAMMER WEIGHT

LB. DROP — INCHES

[illegible]

## RECORD OF TEST PIT 2

LOCATION See Figure 2

BORING DATE DEC. 22, 1964

DATUM GEODETIC

BOREHOLE TYPE —

BOREHOLE DIAMETER —

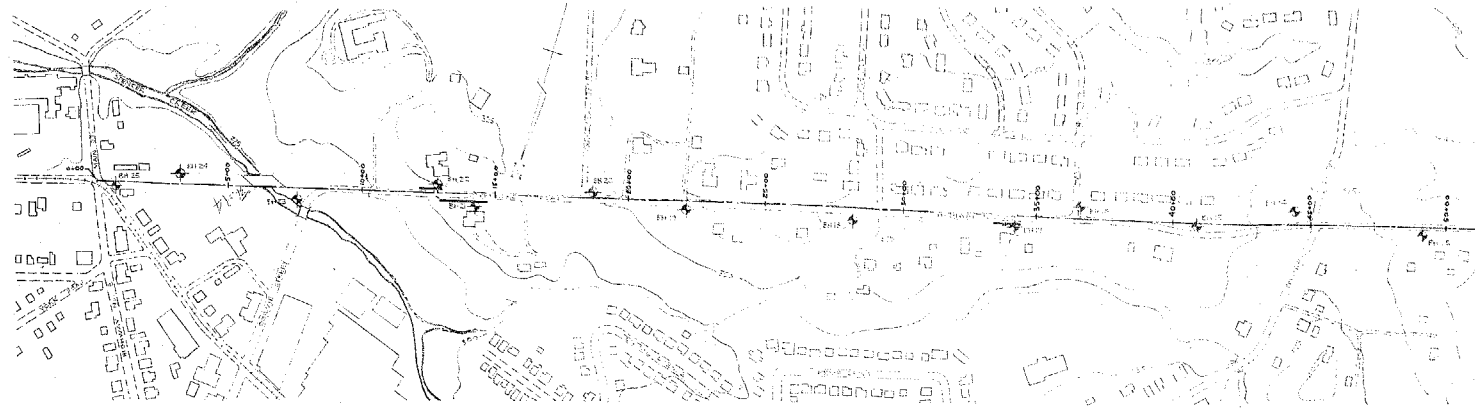
SAMPLER HAMMER WEIGHT — LB. DROP — INCHES

PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

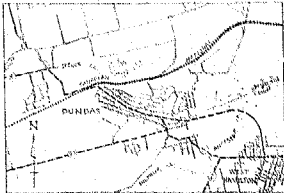
SOIL PROFILE		SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----	COEFFICIENT OF PERMEABILITY k, CM./SEC.			ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
ELEVATION DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH $C_u$ , LB./SQ.FT	WATER CONTENT, PERCENT				
								$W_p$	$W$			$W_L$
443.5	GROUND LEVEL											
0.0	BROWN SILTY CLAY TO CLAYEY SILT, TRACE TO SOME SAND AND OCCASIONAL GRAVEL DISPERSED THROUGHOUT (WEATHERED TILL)		1	CS	440						MH	
			2	-	435						MH	
431.5			3	-	430						MH	
12.0	BOTTOM OF PIT											

TEST PIT DRY  
DURING EXCAVATION  
DEC. 22, 1964.





SCALE 1" TO 50'-0"



KEY PLAN  
SCALE 1" TO 1/4" MILE

LEGEND

- Symbol: Boring location in plan
- Symbol: Approximate location of existing retained walls

REFERENCE: THE CORPORATION OF THE CITY OF HAMILTON, ONT.,  
COMMON PLAN, 1210000000, COMPILED BY THE CORPORATION,  
MAY 1978, JULY 1978, CANADIAN AERIAL SERVICE LTD., OTTAWA.

Drawn: DEC. 28, 1984.

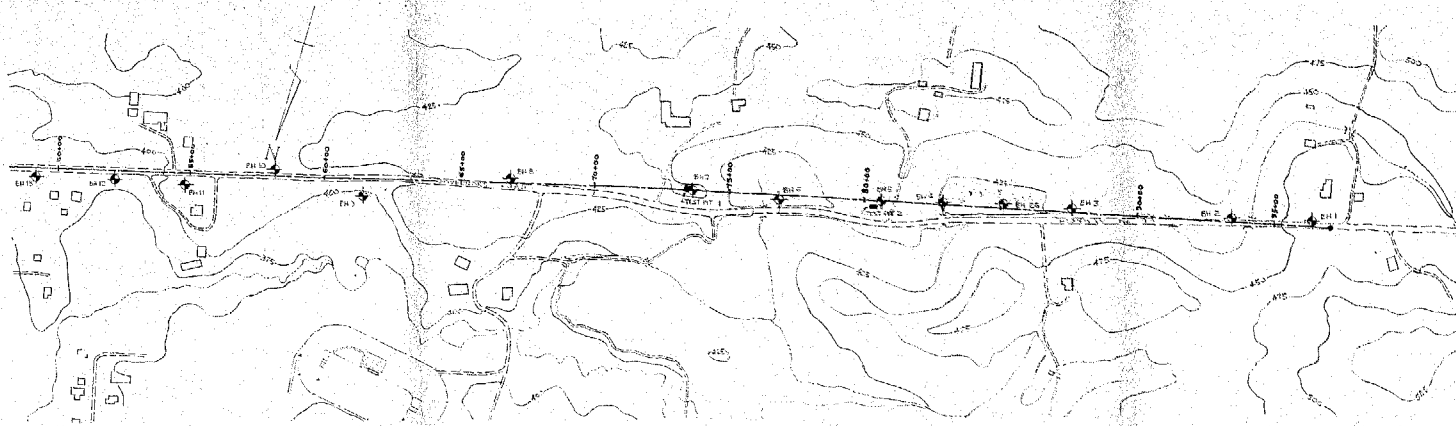
GOLDER & ASSOCIATES

3015-108  
GOLDER & ASSOCIATES

Drawn: J.H.B.  
Checked: J.H.B.  
Approved: J.H.B.

LEGEND

- ◆ BOREHOLE IN PLAN
- TEST PIT IN PLAN



SCALE 1" = 100'-0"

30MS-108  
GEOREG. No.

THIS MAP IS THE PROPERTY OF THE U.S. ARMY CORPS OF ENGINEERS. IT IS TO BE USED ONLY FOR THE PURPOSES FOR WHICH IT WAS PREPARED. IT IS NOT TO BE USED FOR ANY OTHER PURPOSES WITHOUT THE WRITTEN PERMISSION OF THE U.S. ARMY CORPS OF ENGINEERS.

Drawn: DEC. 22, 1964

GOLDER & ASSOCIATES

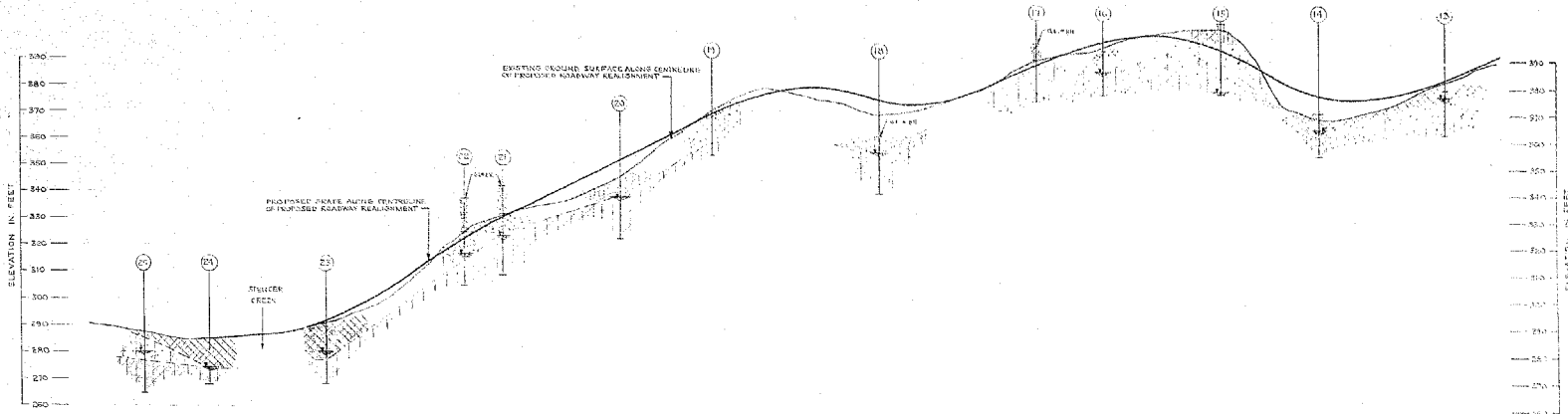
Made by  
J. H. H. H.  
April 21, 1965

LEGEND

- BOREHOLE IN ELEVATION  
+ WATER LEVEL IN BOREHOLE, DEC 15 - 22, 1964

STRATIGRAPHY

- VERY COARSE TO COMPACT BROWN SAND, GRAVEL, ADDED FRILLS, GALLINUS AND OCCASIONAL BOLLERS (FILL)
- LOOSE TO COMPACT BROWN SILTY FINE SAND, SOME GRAVEL, CLAYEY SILT, SOME SAND AND GRAVEL (FILL)
- VERY FINE TO FINE SILTY SAND AND GRAVEL (RECENT DEPOSIT)
- STIFF BROWN STRATIFIED CLAYS, SILTS AND SANDS (ANCIENT DEPOSIT)
- VERY COARSE TO COMPACT BROWN SILTY FINE SAND TO CLAYEY SILT (RECENT DEPOSIT)
- LOOSE TO CLAYEY BROWN LAYERED CLAYEY SILT AND SILTY FINE SAND (RECENT DEPOSIT)
- STIFF TO HARD BROWN CLAYEY SILT TO SILTY CLAY, SOME SAND AND STRATIFIED GRAVEL (WEATHERED TILL)
- STIFF TO HARD BROWN CLAYEY SILT TO SILTY CLAY WITH SOME SAND AND STRATIFIED GRAVEL (TILL)
- CLAYEY TO BROWN SILTY SAND AND GRAVEL, SOME SANDS WITHIN TILL
- HARD TO HARD BROWN TO BROWN SILTY CLAY WITH SOME SAND, HUMUS AND CASE TO SANDY SILT LAYERS



SCHEMATIC SECTION ALONG CENTERLINE OF PROPOSED HIGHWAY 22  
STATION 0+00 TO 50+00

HORIZONTAL SCALE 1" = 500' VERTICAL SCALE 1" = 10'

GENERAL NOTE: ALL BOREHOLES WERE DRILLED BY THE TARRANT COUNTY SOIL BUREAU. THE BOREHOLE LOGS WERE OBTAINED FROM THE TARRANT COUNTY SOIL BUREAU. THE BOREHOLE LOGS WERE OBTAINED FROM THE TARRANT COUNTY SOIL BUREAU.

THIS SECTION WAS PREPARED BY THE TARRANT COUNTY SOIL BUREAU. THE BOREHOLE LOGS WERE OBTAINED FROM THE TARRANT COUNTY SOIL BUREAU. THE BOREHOLE LOGS WERE OBTAINED FROM THE TARRANT COUNTY SOIL BUREAU.

Drawn DEC. 22, 1964.

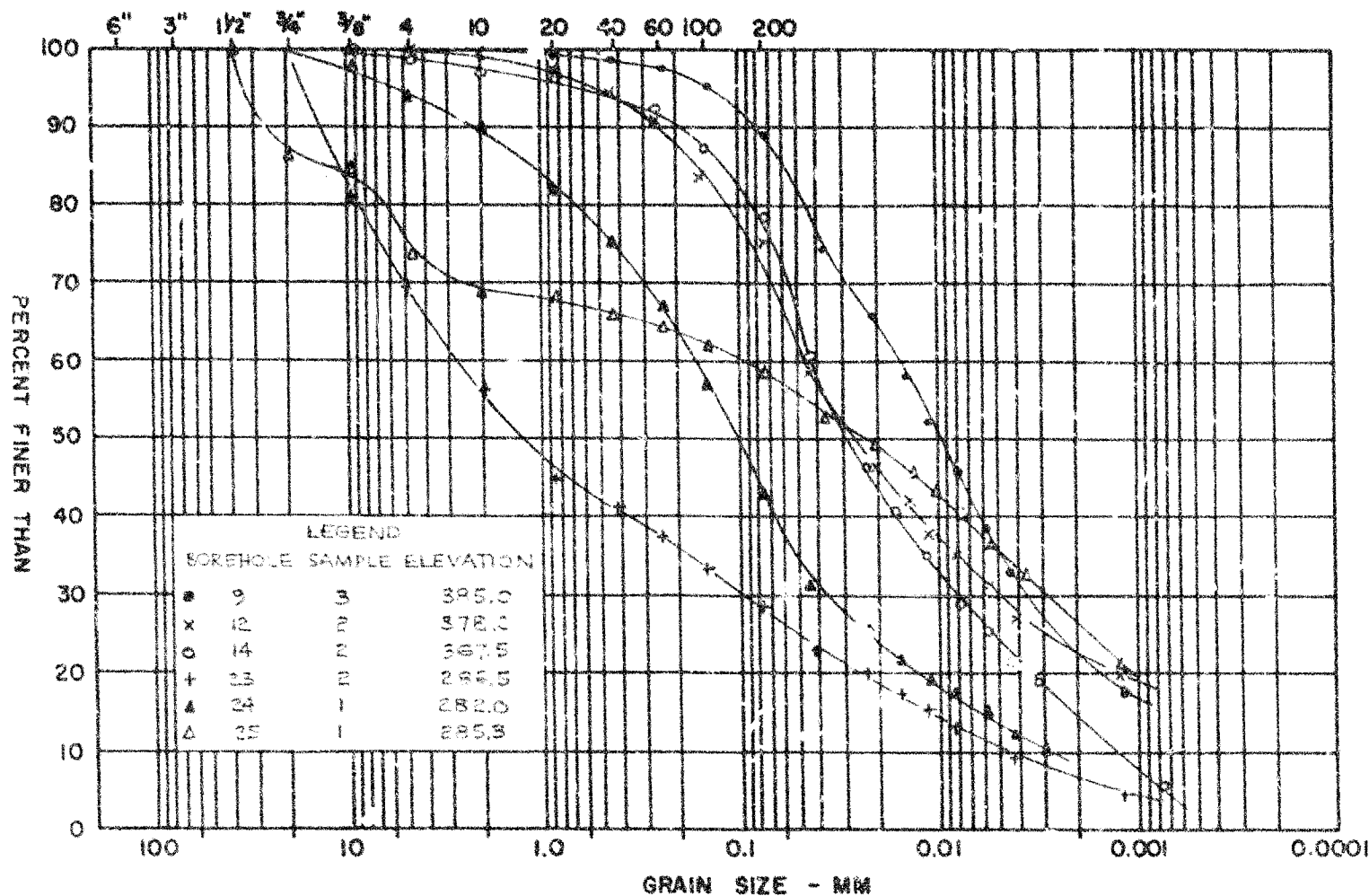
GOLDER & ASSOCIATES

Model  
Checked  
Approved



## M.I.T. GRAIN SIZE SCALE

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



GOLDER &amp; ASSOCIATES

GRAIN SIZE DISTRIBUTION  
(FILL)

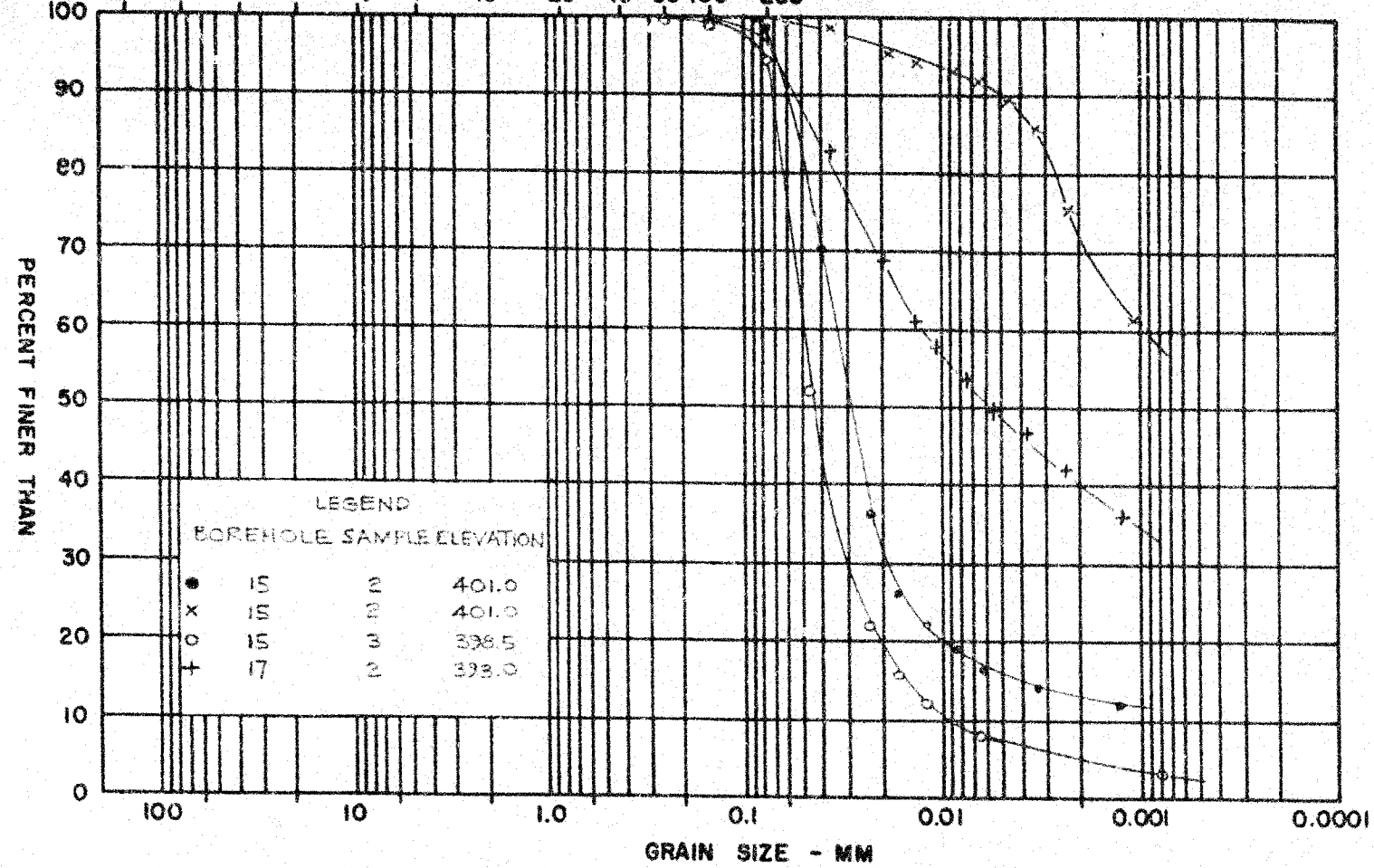
FIGURE

(1)

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" 4 10 20 40 60 100 200



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

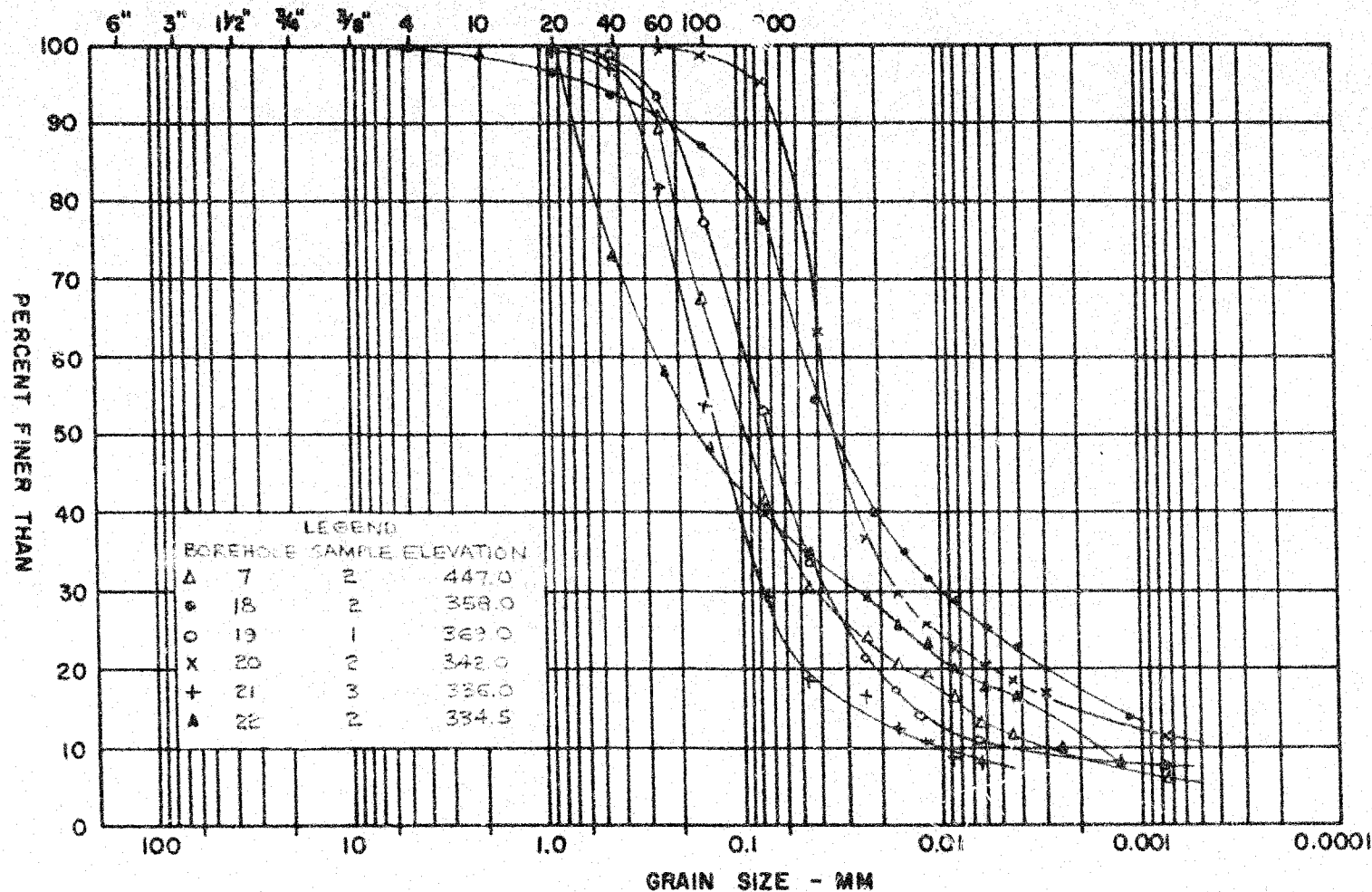
GRAIN SIZE DISTRIBUTION  
STRATIFIED CLAYS, SILTS & SANDS (RECENT DEPOSIT)

FIGURE

GOLDER & ASSOCIATES

M.I.T. GRAIN SIZE SCALE

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



GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION  
SILTY SAND TO CLAYEY SILT (NECENT DEPOSIT)

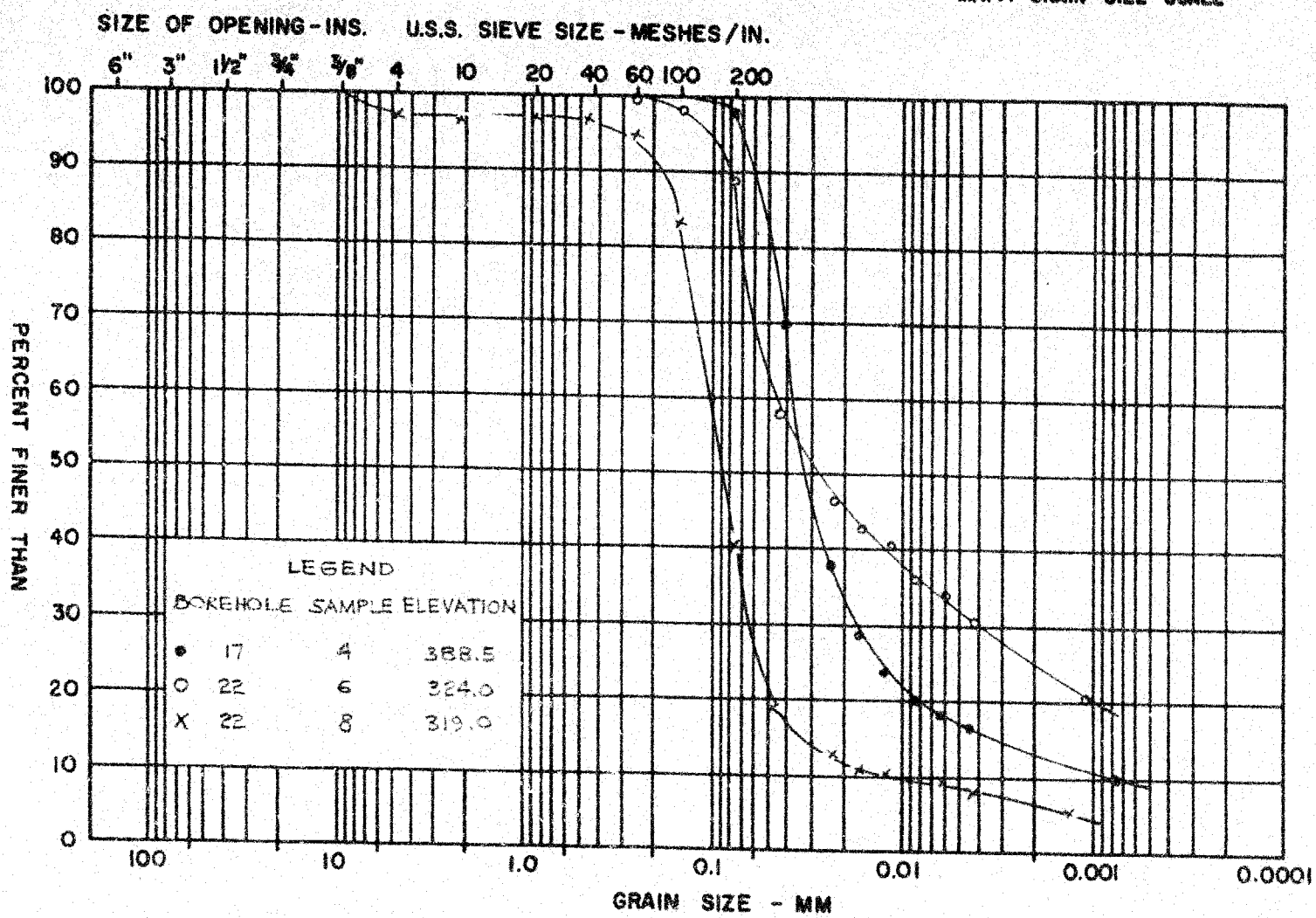
FIGURE 7

M.I.T. GRAIN SIZE SCALE

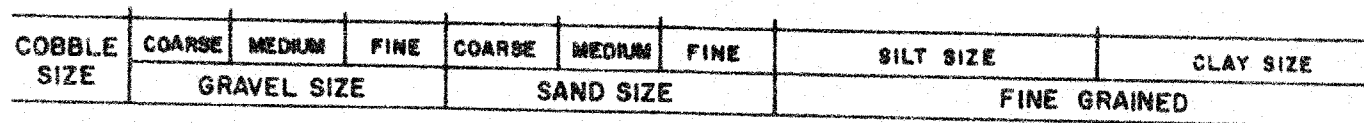
GRAIN SIZE DISTRIBUTION  
SILTY FINE SAND, SOME CLAY LAYERS (RECENT DEPOSIT)

FIGURE 0

GOLDER & ASSOCIATES







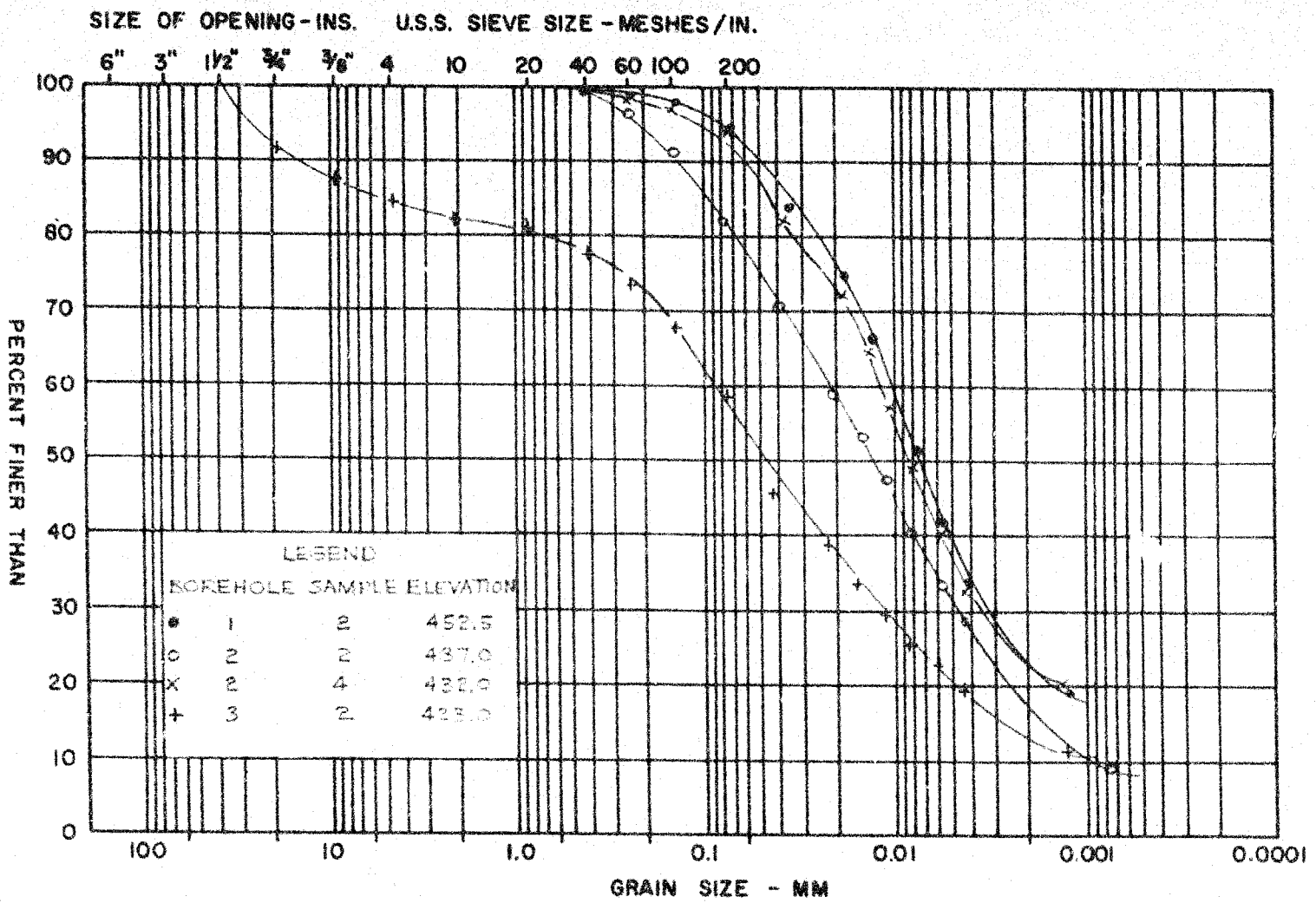
GOLDER & ASSOCIATES

M.I.T. GRAIN SIZE SCALE

GRAIN SIZE DISTRIBUTION  
(WEATHERED TILL)

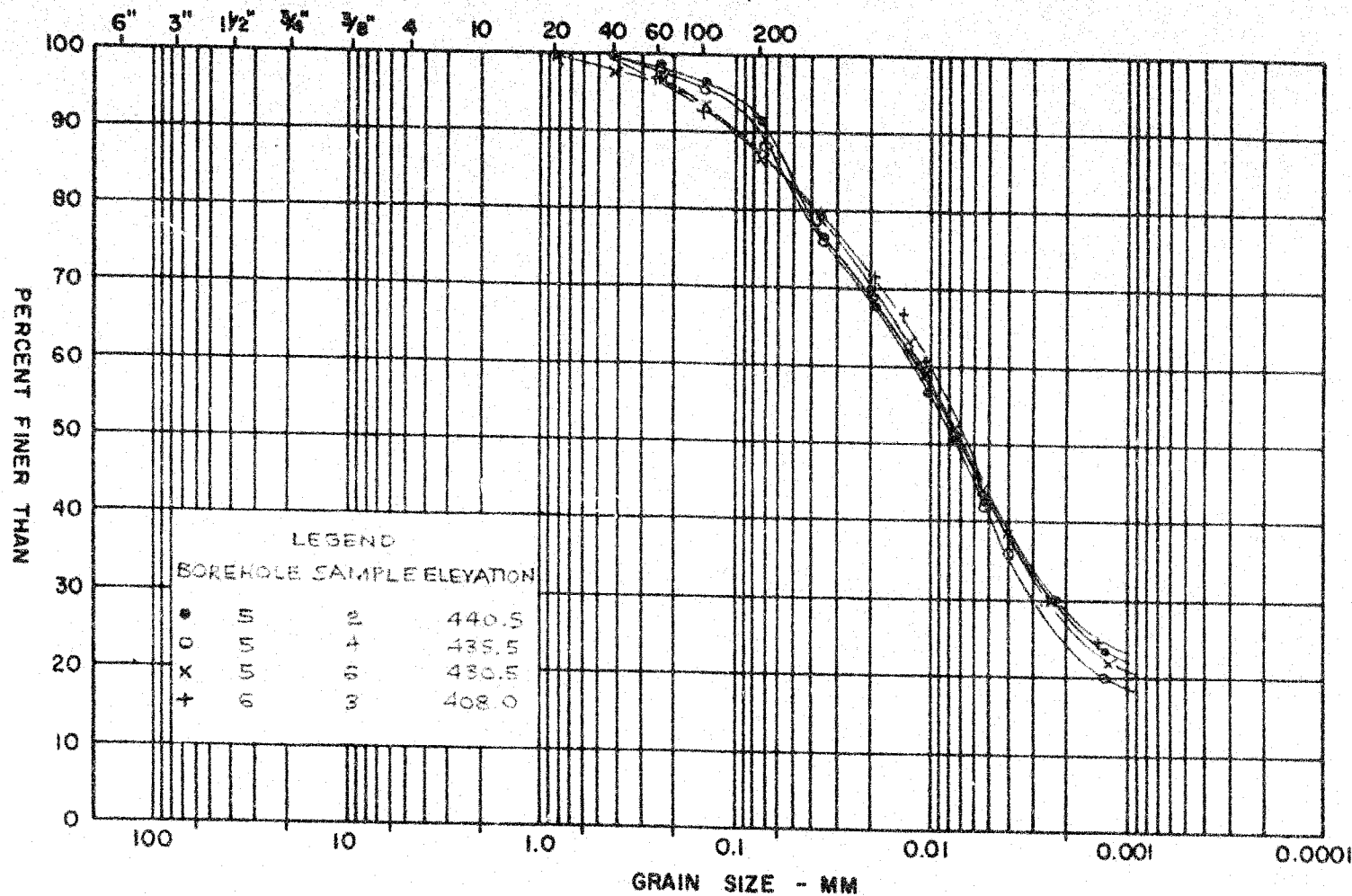
FIGURE 10

GOLDER & ASSOCIATES



M.I.T. GRAIN SIZE SCALE

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



GOLDER &amp; ASSOCIATES

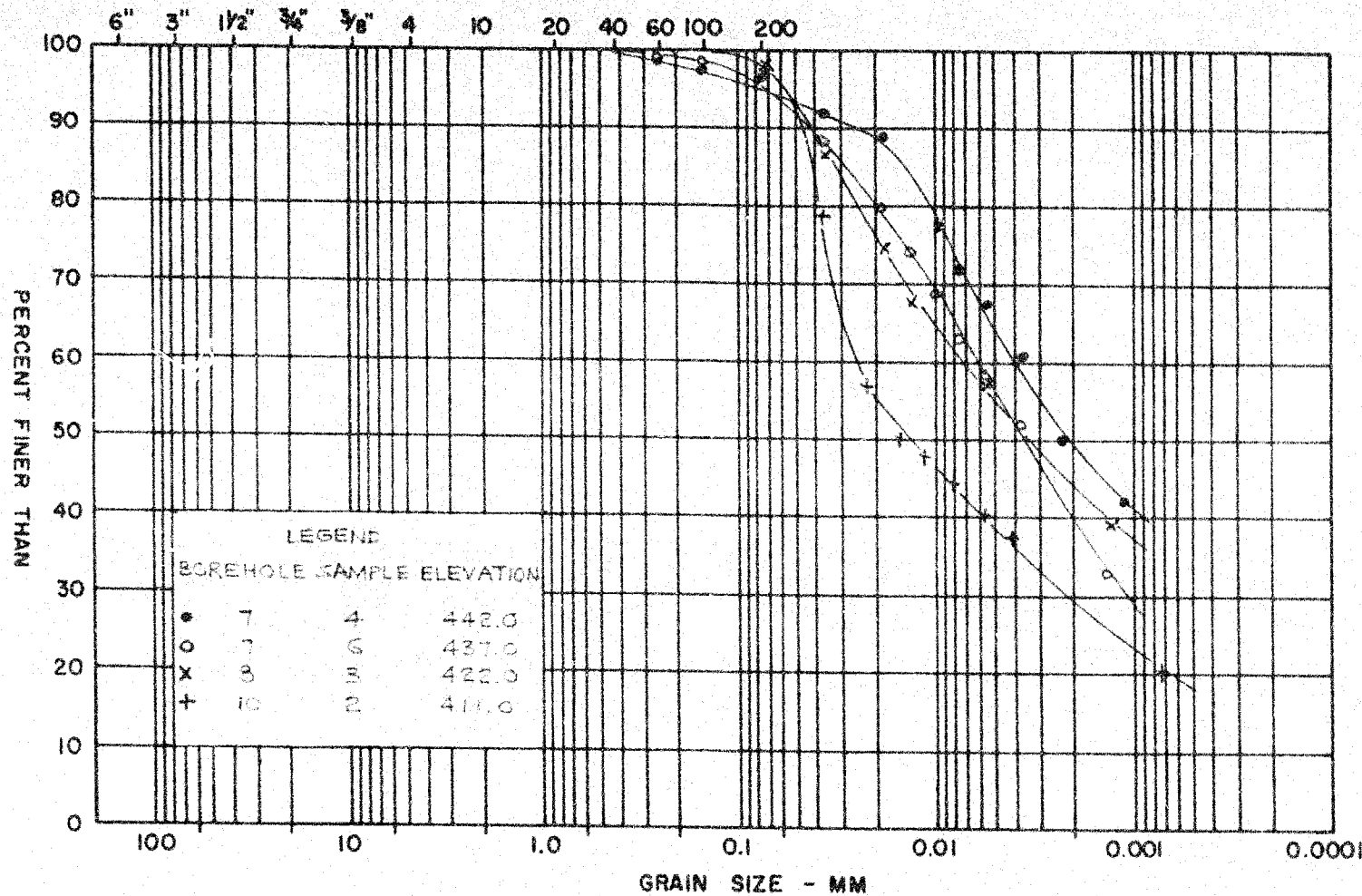
GRAIN SIZE DISTRIBUTION  
(WEATHERED TILL)

FIGURE 11

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

## M.I.T. GRAIN SIZE SCALE

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



GOLDER &amp; ASSOCIATES

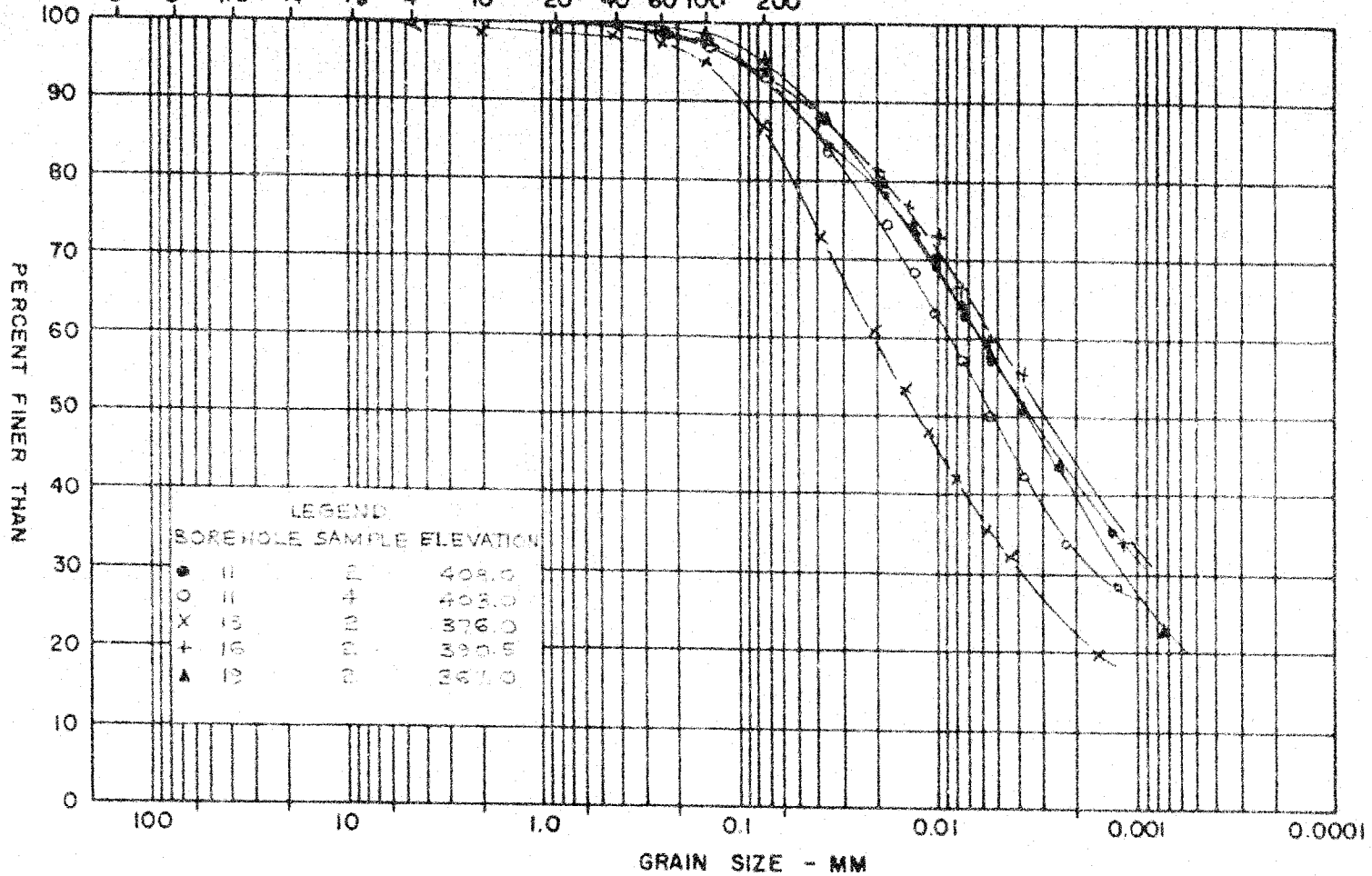
GRAIN SIZE DISTRIBUTION  
(WEATHERED TILL)

FIGURE 12

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"   4   10   20   40   60   100   200



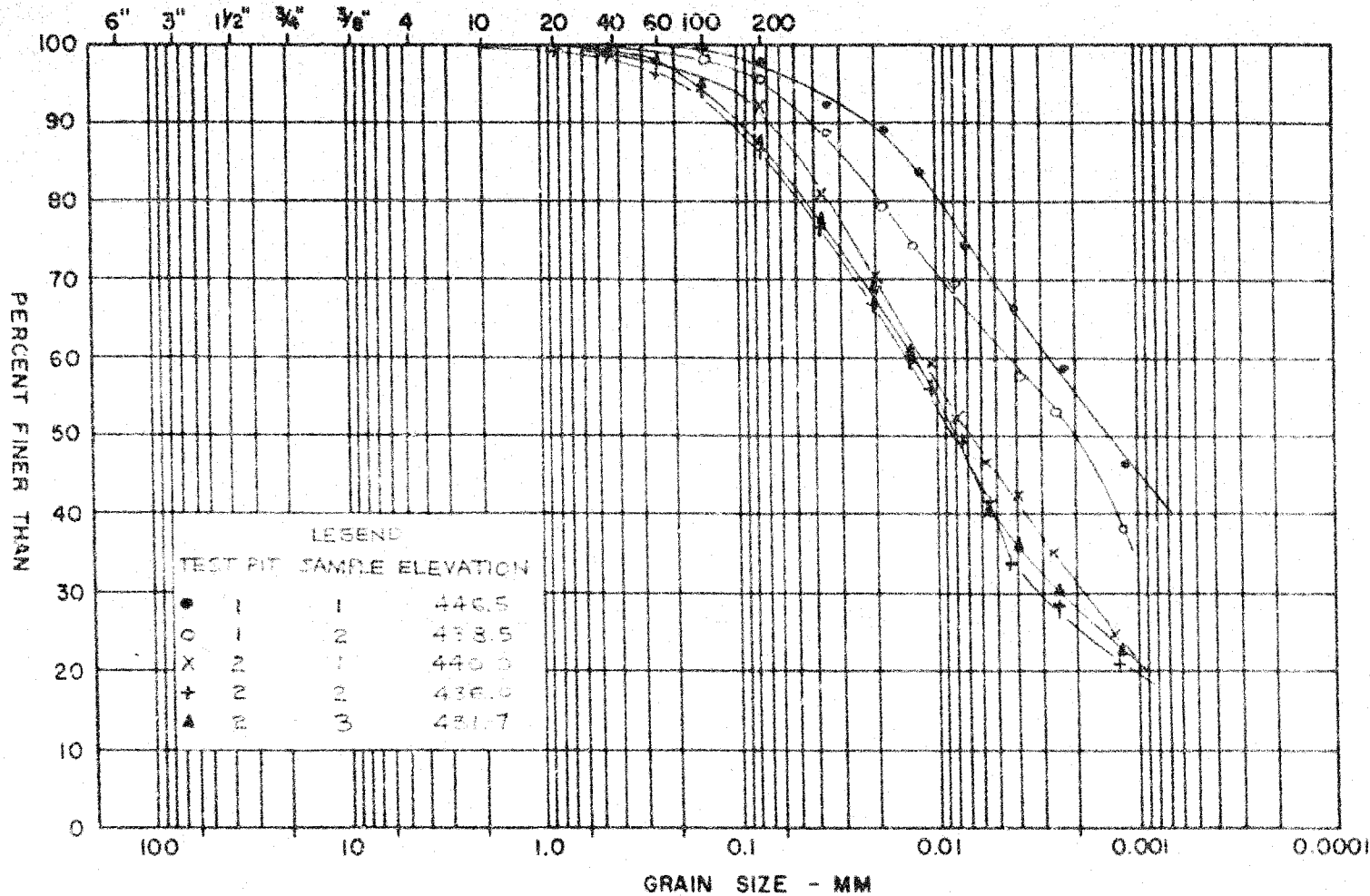
GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION  
(WEATHERED TILL)

FIGURE 10

M.I.T. GRAIN SIZE SCALE

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



GRAIN SIZE DISTRIBUTION  
(WEATHERED TILL)

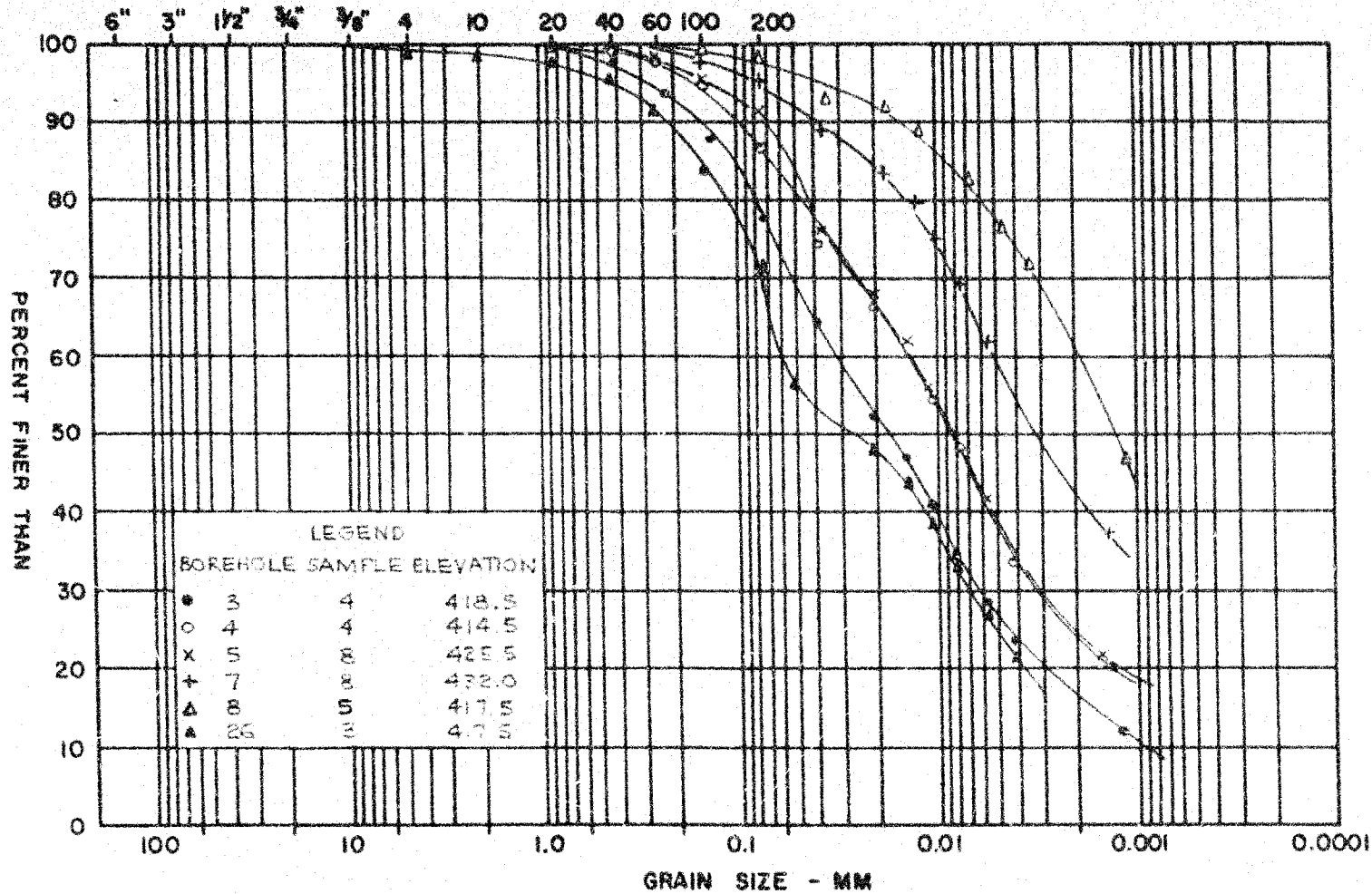
FIGURE 14

GOLDER & ASSOCIATES



## M.I.T. GRAIN SIZE SCALE

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



GOLDER &amp; ASSOCIATES

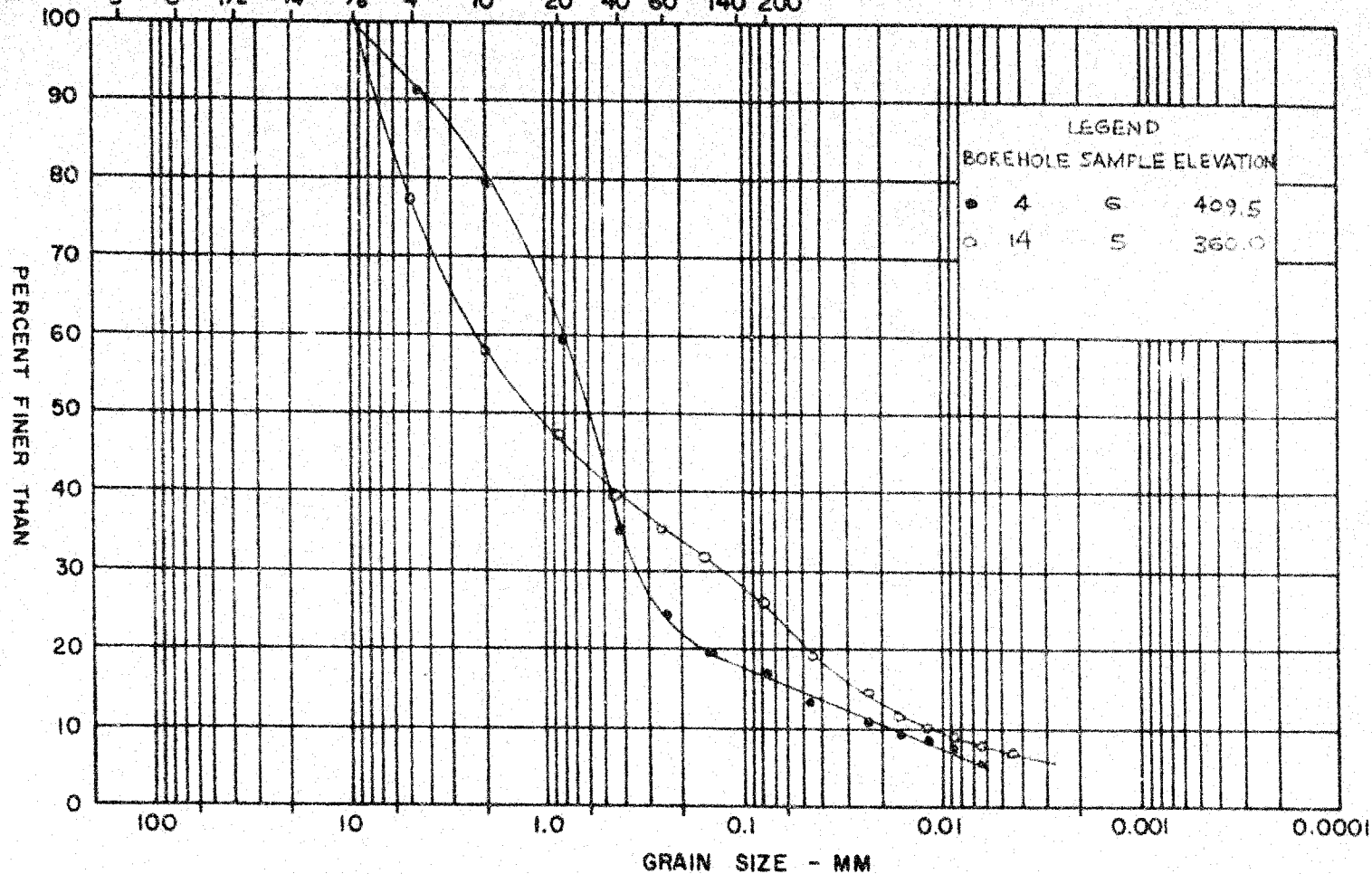
GRAIN SIZE DISTRIBUTION  
(TILL)

FIGURE 10

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" 4 10 20 40 60 140 200



GOLDER & ASSOCIATES

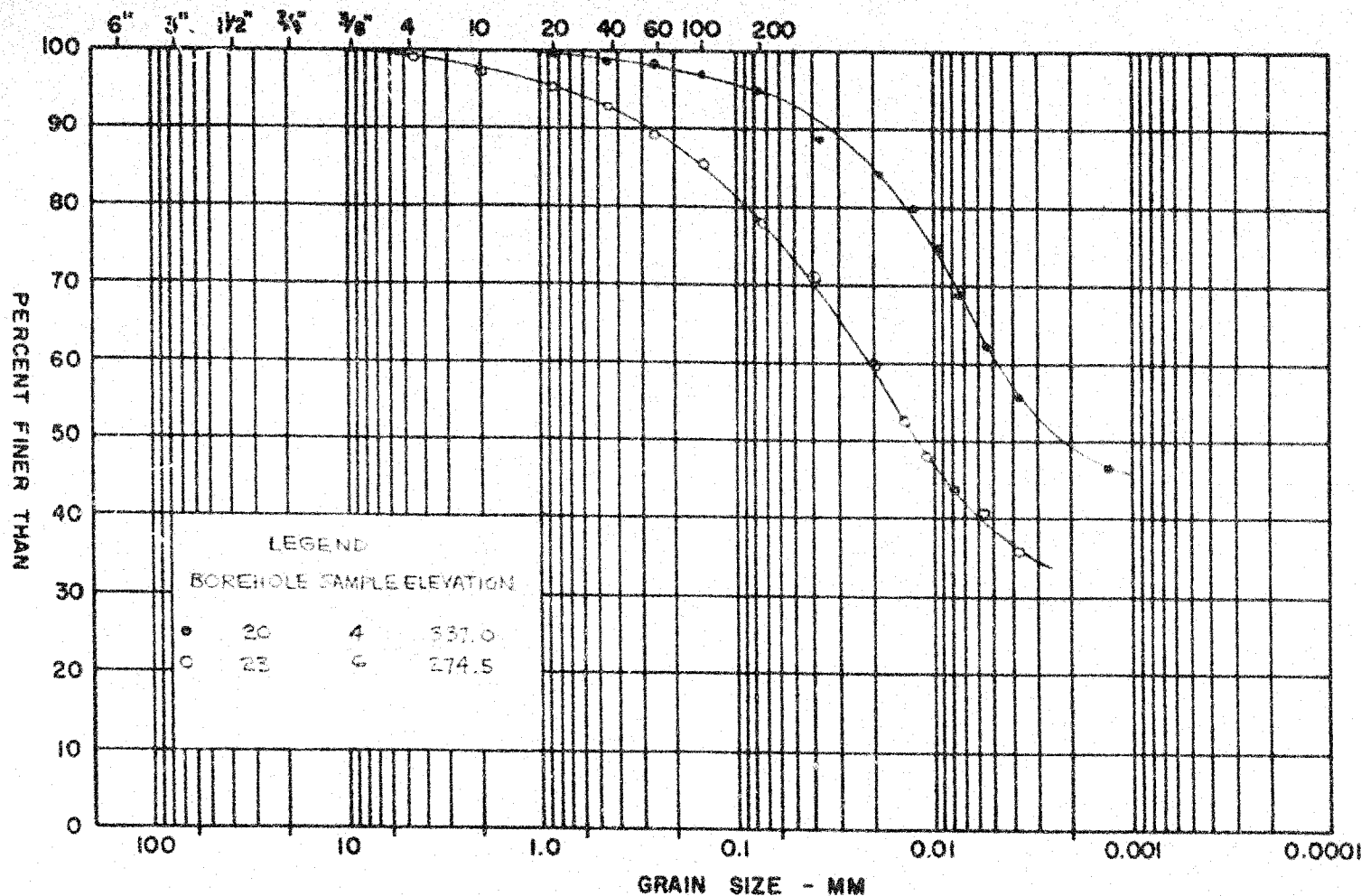
GRAIN SIZE DISTRIBUTION  
(SAND ZONES WITHIN TILL)

FIGURE 10



## M.I.T. GRAIN SIZE SCALE

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



GOLDER &amp; ASSOCIATES

GRAIN SIZE DISTRIBUTION  
SILTY CLAY, SOME SAND

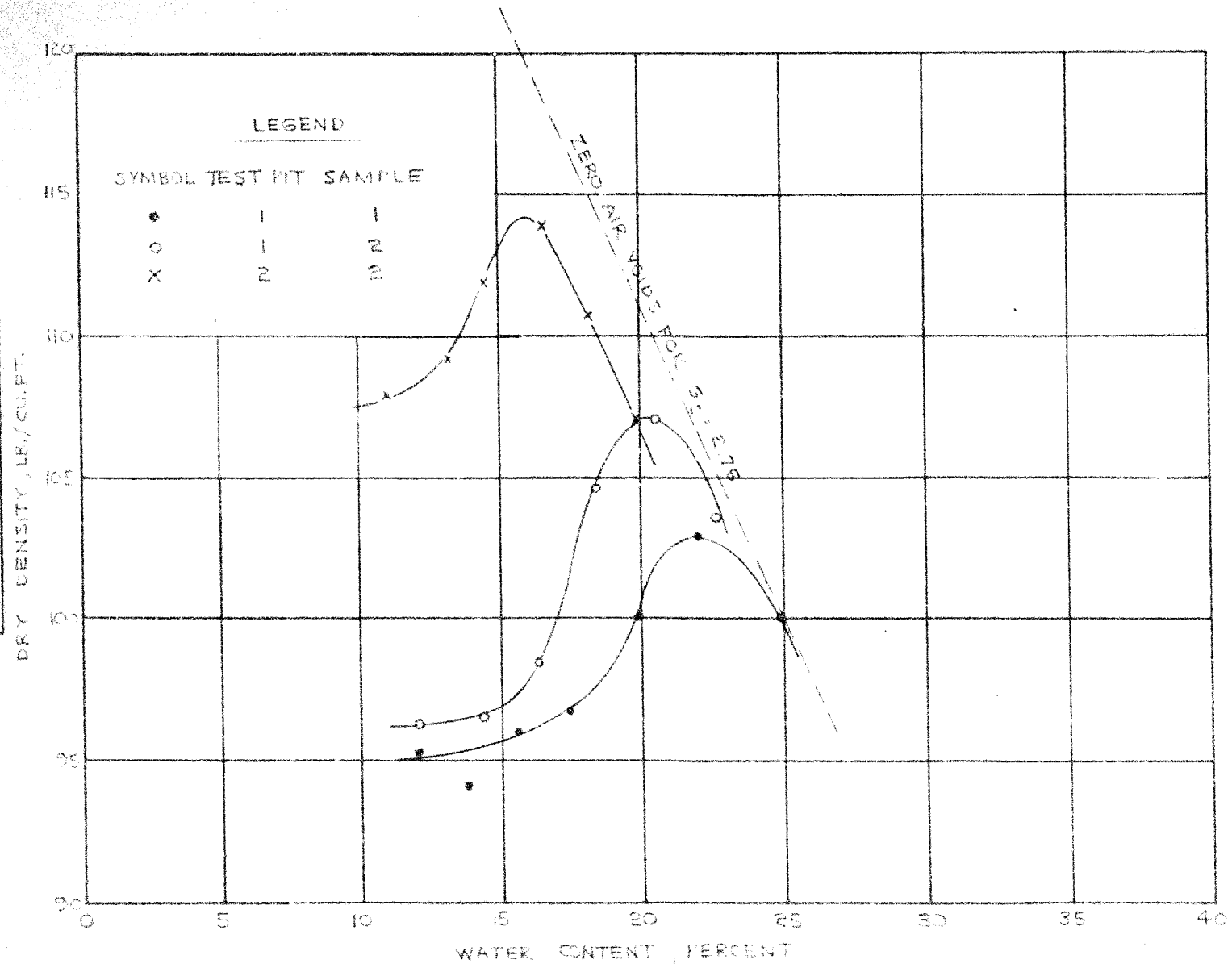
FIGURE 17

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

RESULTS OF STANDARD PROCTOR COMPACTION TESTS  
TILL MATERIAL

FIGURE 13

NOTE: FOR GRAIN SIZE DISTRIBUTION CURVES SEE FIGURE 14.



GOLDER & ASSOCIATES