HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK

DAM & RESERVOIR

HANCOCK BROOK, CONNECTICUT

DESIGN MEMORANDUM NO. 6

EMBANKMENTS & FOUNDATIONS

U.S. Army Engineer Division, New England
Corps of Engineers Waltham, Mass.

AUGUST 1962

30

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
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SUBJECT: Hancock Brook Dam and Reservoir, Hancock Brook, Housatonic River Basin, Connecticut, Design Memorandum No. 6 - Embankments and Foundations

TO: Chief of Engineers
ATTN: ENGCW-E
Department of the Army
Washington, D.C.

There is submitted for review and approval Design Memorandum No. 6 - Embankments and Foundations for the Hancock Brook Dam and Reservoir, Hancock Brook, Housatonic River Basin, Connecticut, in accordance with EM 1110-2-1150.

FOR THE DIVISION ENGINEER:

John Wm Leslie

JOHN WM. LESLIE
Chief, Engineering Division

1 Incl.
Des. Memo No. 6
(10 cys)

FLOOD CONTROL PROJECT

HANCOCK BROOK DAM

HANCOCK BROOK

HOUSATONIC RIVER BASIN

CONNECTICUT

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2	Site Geology	21 Feb 1962	23 Mar 1962
3	General Design	27 Mar 1962	3 May 1962
4	Relocations	18 Apr 1962	4 Jun 1962
5	Concrete Materials	20 Nov 1961	7 Dec 1961
6	Embankments and Foundations	10 Aug 1962	
7	Real Estate	2 Jul 1962	
8	Detailed Design of Structures	27 Jul 1962	
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HANCOCK BROOK DAM AND RESERVOIR
DESIGN MEMORANDUM NO. 6
EMBANKMENTS AND FOUNDATIONS

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U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
OFFICE OF THE DIVISION ENGINEER
WALTHAM 54, MASS.

FLOOD CONTROL PROJECT

HANCOCK BROOK DAM AND RESERVOIR

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HOUSATONIC RIVER BASIN
CONNECTICUT

DESIGN MEMORANDUM NO. 6

EMBANKMENTS AND FOUNDATIONS

AUGUST 1962

A. INTRODUCTION

1. Location and Description of Project. The Hancock Brook Reservoir Project is located in the State of Connecticut on Hancock Brook, a tributary of the Naugatuck River, which in turn is a tributary of the Housatonic River. The dam site is in the township of Plymouth, Connecticut and about 3.4 miles above the confluence of Hancock Brook and the Naugatuck River. The completed structures will consist of an earth fill dam and dike, with appurtenant structures, a railroad relocation, and a highway relocation. Locations, arrangements, and details of the structures are shown on Plates Nos. 6-1 through 6-4.

2. Pertinent Data.

a. Purpose. Flood Control and Wildlife Management.

b. Drainage Area at Dam Site. 12.0 square miles

c. Reservoir Elevations, M.S.L.

(1) Wildlife Management Pool - 460

(2) Spillway Crest - 484

(3) Maximum Surcharge - 500

(4) Top of Dam and Dike - 505

d. Dam

(1) Maximum Height above Streambed - 57 feet

(2) Length - 630 feet

e. Dike

(1) Maximum Height Above Reservoir Side Toe - 35 feet

(2) Length - 2,300 feet

3. General Notes. Programs of subsurface investigations and soils engineering studies were undertaken for the design of the Hancock Brook Dam and Dike and the railroad and highway relocations. Subsurface investigations included subsurface explorations and laboratory test programs performed to determine the distribution and characteristics of foundation and embankment materials and to determine soil conditions pertinent to excavations and to the design and construction of embankments. Soil engineering studies, based on data obtained from the subsurface investigations, were conducted to develop safe and economical earthwork designs and construction methods, and to obtain pertinent soils data required for the designs for certain of the concrete structures.

B. SUBSURFACE INVESTIGATIONS

4. Subsurface Explorations. Subsurface explorations were laid out and made in conformance with current criteria and practices as described in the pertinent sections of the Engineering Manual for Civil Works Construction. The majority of the explorations were drive sample borings or machine excavated test pits. The subsurface exploration program

completed to date is considered adequate for design purposes for the dam and the dike. Additional explorations are in progress to obtain data for construction control and for the foundation designs for the bridges and the various drainage structures for the relocations. The locations, types and general purposes of the explorations completed prior to Feb. 1962 are discussed in Design Memorandum No. 2 "Site Geology." The location of subsurface explorations completed prior to May 7, 1962, except those along the railroad relocation, the locations of which are indicated on the soil profile, are shown on Plates Nos. 6-5 and 6-6. The geology of the site and area pertinent to the types and distribution of soils is described in Design Memorandum No. 2, "Site Geology."

5. Laboratory Tests.

a. General. All laboratory tests, except as noted, were performed in accordance with current standard procedures as described in the Engineering Manual for Civil Works Construction and other publications of the Corps of Engineers. All soil samples were classified visually in the laboratory in conformance with the Unified Classification System. Grain size analysis and determinations of Atterberg Limits were performed on selected samples to confirm visual classification and to provide more precise data where considered necessary. Specific gravities were determined for selected samples. Natural moisture contents were determined for selected samples of soil, particularly those from the proposed impervious borrow area and those of impervious material from required railroad relocation excavations. These moisture contents were determined for both the total material and for the component passing the No. 4 Sieve. Standard AASHO Compaction Tests were performed on samples considered

representative of the impervious and random embankment materials. Natural density tests were performed on chunk samples from a test pit in the borrow area and from a test pit on the railroad relocation alignment.

b. Permeability Tests. Permeability tests were performed in the laboratory on selected samples of embankment materials using de-aired water and a falling head type of test apparatus. The permeameters were 5.5 inch diameter lucite cylinders. Each specimen was prepared so that its length was equal to or slightly less than its diameter. Prior to testing, each specimen was de-aired under a vacuum not greater than 15 psi. The maximum applied hydrostatic head was not permitted to exceed 120 centimeters and generally was on the order of 60 centimeters. Permeability tests were performed on specimens prepared at various densities in order to obtain the relationship of the void ratio and the coefficient of permeability for each soil sample.

c. Shear Tests. The shear strength characteristics of selected samples of impervious embankment materials, fault gouge material, and material from the dam foundation were determined for the fractions of the samples passing the No. 4 Sieve under the conditions outlined in the Engineering Manual for Civil Works Construction. Specimens of the impervious embankment materials were compacted at moisture contents representative of anticipated placement moisture contents. The Standard AASHO Compaction Test curves were used in establishing the specimen densities at the various moisture contents. Specimens of the fault gouge material were compacted to approximately maximum Standard AASHO Compaction Test density while specimens of the material from the dam foundation were compacted to a density approximating the estimated natural in-place density of the material. Those specimens which were prepared for the consolidated-

drained (S) and the consolidated-undrained (R) triaxial compression tests were saturated under a back pressure prior to testing. The shear tests performed on the samples of impervious embankment materials and the fault gouge material were triaxial compression tests done on 2.8 inch and 1.4 inch diameter specimens, respectively, having minimum slenderness ratios greater than 2.1. The shear test performed on the sample of material from the dam foundation was a direct shear test done on specimens 3 inches square and 1/2-inch thick.

6. Presentation of Data. The data obtained from subsurface explorations and the results of soil tests are presented in this memorandum. Graphic logs of subsurface explorations based on amended field logs and showing other pertinent data and detailed description of bedrock are presented in Appendix C. Engineering soils reports (engineering logs of soils explorations) are presented in Appendix D. These reports were prepared for all pertinent explorations by the design soils engineer with the aid of laboratory test data and the assistance of an experienced soils classifier. Included in these reports are the description of soils and soils strata based on the engineer's examination of the samples and on his interpretation of all test results and exploration data. These descriptions include the consistency of the material, estimated or measured percentages of the soil components, color, stratification, presence of foreign matter, geological names, and other data considered to be of significance in determining the characteristics of materials for design and construction purposes. Soil profiles of the dam embankment foundation and of the railroad relocation based on these engineering logs are shown on Plates 6-7 through 6-9. The profile for the railroad relocation is also

applicable to the dike foundation. Plates showing selected laboratory test results are included in this memorandum. A summary of laboratory test results is presented in Appendix A. Detailed shear test data are presented in Appendix B.

C. CHARACTERISTICS OF FOUNDATION SOILS

7. Dam Embankment

a. Distribution and Description

(1) Right Abutment and Spillway. The overburden in the right abutment of the dam foundation and the adjacent spillway channel area is a shallow deposit of variable sands, gravels, boulders and cobbles which ranges in thickness from 1 to 15 feet and averages about 8 feet. The underlying bedrock surface is extremely irregular with numerous outcrops to the right (west) of Waterbury Road. Numerous large rock blocks and boulders are scattered on the ground surface between these outcrops. The overburden is capped with about one foot of topsoil and forest debris and about two feet of sandy silt and gravelly sandy silt containing numerous roots and cobbles. A deeper deposit of these silts overlies bedrock to a depth of 6 feet adjacent to Waterbury Road in the vicinity of the centerline of the dam. Overburden materials beneath the silt capping consist principally of variable brown, loose to compact silty sandy gravel, sandy gravel, gravelly sand, and gravelly silty sand. These materials are roughly stratified in the right abutment area and more definitely stratified in the spillway channel area. Silt contents of the gravels generally range from 5 to 20 percent of the component passing the No. 4 Sieve. The gravel contents of the sands generally range from 10 to 35 percent with silt contents ranging from 5 to 25 percent of the component passing the No. 4 Sieve. In the spillway area, the materials tend

to be more gravelly in the approach channel area than in the discharge channel area. In general, the silt contents of the materials in the spillway area are lower than those of the materials on the right abutment area. Subsurface water levels, in general, occur at the surface of the bedrock.

(2) Valley Section. The overburden in the valley section of the dam embankment foundation area consists principally of variable sands and gravels with boulders and occasional silt pockets and lenses. The overburden ranges in thickness from 3 to 30 feet and averages about 25 feet. Except at the ends of this section of the dam foundation area, the underlying bedrock surface is essentially horizontal and relatively smooth at approximately El. 420. Immediately above the bedrock surface, there is a concentration of boulders and cobbles in the overburden about 8 feet in thickness. The overburden is capped with surficial deposits of topsoil, soft organic silt and soft to stiff laminated silt and sand with occasional clay laminae varying from 1 to 9 feet in thickness. The thickness of this capping is greatest in the bar type deposit on the left bank of the river in the vicinity of borings FD-15 and FD-27. Overburden materials beneath the capping consist of generally brown, moderately compact to compact roughly stratified variable gravelly silty sand and silty sandy gravel with occasional phases of silty medium to fine sand and fine sand. Some thin, sandy silt lenses occur scattered throughout the overburden. A 5-foot pocket or lens of compact non-plastic sandy silt overlies the bedrock on the left bank in the vicinity of boring FD-25. In general, silt contents of the gravels ranges from 10 to 20 percent of the component of the material passing the No. 4 Sieve. For the sands, in general, the gravel contents range from 5 to 35 percent and the silt contents from 10

to 25 percent of the component passing the No. 4 Sieve. Both the sands and the gravels contain varying amounts of coarse mica particles. Subsurface water levels are generally at or near the river level in this section of the foundation area.

(3) Left Abutment. The overburden in the left abutment is a shallow variable deposit of sands and gravels with numerous cobbles and boulders. The overburden ranges from 10 to 15 feet in thickness and overlies a highly irregular bedrock surface. The overburden is capped with about 1.5 feet of topsoil and forest debris. Beneath this capping the overburden materials consist of variable gravelly silty sands and silty sandy gravels. Silt contents of the gravels generally range from 10 to 25 percent of the component passing the No. 4 Sieve. Gravel contents of the sands, in general, range from 10 to 35 percent and the silt contents from 10 to 25 percent of the component passing the No. 4 Sieve.

b. Shear Strengths. Extensive shear tests were not performed on samples of soils from the foundation area of the dam embankment. A direct-shear consolidated-drained (S) test was run on material from the foundation considered to be representative of the most micaceous phase of the foundation soils. For this test a composite sample, LB-1, was made up from materials from J-6, FD-24, and from J-6 and J-12, FD-28. The test specimens were compacted to a density of 109 p.c.f., which density is estimated to be approximately equal to the natural density. The test was of the controlled-strain type using a rate of strain of 0.02 inch per minute as determined from the consolidation characteristics of the test specimens in order to assure adequate dissipation of pore pressures during the test. The test results indicated an angle of internal friction of

35.1 degrees with no cohesion. On the basis of the grain size characteristics and visual examination of samples, together with the shear test results, it is considered that an angle of internal friction of 30 degrees with no cohesion would be a reasonable and conservative estimate for the shear strength of the bulk of the foundation soils for use in stability studies. No shear tests were performed on samples of the sandy silts which occur in limited and scattered pockets and lenses throughout the foundation. On the basis of grain-size characteristics and visual examination of the samples, however, it is considered that an angle of internal friction of 25 degrees with no cohesion would be a reasonable and conservative estimate for the shear strength of these silts for use in stability studies.

c. Permeability. Permeability tests were not run on samples of soils from the foundation area of the dam embankment. On the basis of visual examination of samples and grain-size distribution curves, it is estimated vertical permeability coefficients range from 1.0×10^{-4} cm/sec to 20×10^{-4}-cm/sec horizontal coefficients of permeability being from 9 to 25 times the vertical.

d. Consolidation. Consolidation tests were not performed on samples of soils from the foundation area of the dam embankment. The soft and compressible surficial deposits will be removed prior to construction of the embankment. The compressibility characteristics and generally high natural densities of the other overburden materials are such that little or no settlement of the foundation is anticipated under the proposed embankment loadings.

8. Dike Embankment.

a. Distribution and Description. The overburden in the foundation area of the dike embankment consists of a deposit of glacial outwash sands and gravels overlying a glacial till deposit at depths of from 1 to over 15 feet below the ground surface. The total thickness of overburden in this area is not known but the borings indicate that it varies from 14 to over 40 feet and that the bedrock surface is irregular. At the northern end of the area there is a concentration of surficial boulders which appears to have resulted from the clearing of the cultivated portions of the area to the south. The overburden is capped with from 1 to 3 feet of topsoil. The materials in the outwash deposit are principally brown loose to moderately compact, roughly stratified, variable gravelly silty medium to fine sand, silty medium to fine sand, silty fine sand, sandy gravel and silty sandy gravel with cobbles and boulders. The deposit also includes occasional pockets or lenses of gray stiff stratified sandy silt containing strata or laminae of clay and silty fine sand. Gravel contents of the outwash sands range from 0 to 30 percent while their silt contents range generally from 20 to 40 percent of the component passing the No. 4 sieve. There are occasional sand strata, however, in which the silt contents may be as low as 10 percent of the component passing the No. 4 Sieve. The silt contents of the outwash gravels range from 5 to 25 percent of the component passing the No. 4 sieve. The material in the glacial till deposit is principally a gray brown or gray, compact, gravelly silty medium to fine sand containing cobbles and boulders. Gravel contents are generally less than 20 percent and silt contents range from 35 to 50 percent of the component passing the No. 4 Sieve. The

material is generally non-plastic. Subsurface water levels in the foundation area of the dike embankment have not been definitely established but there are indications that over most of the area, levels within 3 or 4 feet of the ground surface can be expected during the wetter seasons.

b. Shear Strengths. No shear tests were performed on samples of soils from the foundation area of the dike embankment. On the basis of experience with similar materials, it is estimated that the sands and gravels in the outwash deposits have undisturbed shear strenght parameters of at least $\phi = 30$ degrees and $c = 0$ for both the R (consolidated-undrained) and the S (consolidated-drained) condition and that the silt lenses and pockets have undisturbed shear strength parameters of at least $\phi = 25$ degrees and $c = 0$ for the same conditions. It is considered that the undisturbed shear strength of the material in the glacial till deposit in the foundation area of the dike is at least equal to the strength of the impervious embankment material to be obtained from the excavations for the railroad relocation.

c. Permeability. Permeability tests were not performed on samples of soil from the foundation area of the dike embankment. On the basis of visual examination of samples, grain-size distribution curves, and experience with similar materials it is estimated that the vertical coefficients of permeability for the outwash materials range from 0.1 to 20×10^{-4} cm/sec with the horizontal coefficients being about 9 times the vertical. Permeability tests performed on a sample of impervious embankment materials indicate that vertical coefficients of permeability for the glacial till range from 0.01 to 0.1×10^{-4} cm/sec with the horizontal coefficients being about 4 times the vertical.

d. Consolidation. Consolidation tests were not performed on samples of soils from the foundation area of the dike embankment. The compressibility characteristics and generally high natural densities of those materials are such that no significant settlements are anticipated under the proposed embankment loadings.

9. Railroad Embankment. The overburden in the foundation area of the railroad embankment north of Sta. 33+00 consists of a glacial till deposit overlain in part by up to 15 feet of glacial outwash sands and gravels. The overburden is capped with about one foot of topsoil and in certain low areas with up to three feet of swamp deposits of soft organic materials. The materials in the glacial till deposit are essentially the same as those in the foundation area of the dike. While the outwash sands and gravels are generally similar to those in the dike foundation, their silt contents are significantly lower. With the removal of the topsoil and swamp deposits by stripping operations, it is anticipated that the railroad embankment can be constructed with no significant foundation settlements and with adequate foundation stability against shear failure.

10. Highway Embankment. The principal embankment for the highway relocation will be constructed across the swampy area downstream of the dam. The overburden in this area is up to 60 feet in thickness and consists of from 1 to 4 feet of soft surficial swamp deposits or topsoil overlying a stratified deposit of generally loose sands, silty sands, silty fine sands and sandy silts with occasional gravel strata and numerous micaceous phases. The sandy silts and silty fine sands in the foundation area of this embankment are considered to be moderately compressible and some foundation settlement is anticipated. The major part

of the settlement will occur during construction, however, and since the embankment height is relatively low no serious settlement problem is anticipated. In order to avoid damage to the completed pavement, paving of the embankment will be deferred for as long a period as practicable.

D. CHARACTERISTICS OF FOUNDATION BEDROCK

11. General

a. Dam Embankment. The bedrock at the project site is a highly variable schistose rock displaying varying degrees of alteration and quartz injection. The generalized structure of the bedrock is one of a low angle foliation dip to the west and a steeply dipping randomly spaced joint pattern parallel and normal to the structural foliation. Rock on the right abutment of the dam is generally open and weathered to depths of 10 to 15 feet and it is predicted that the natural rock surface will present an irregular stepped structure. The left abutment will present a somewhat smoother surface due to the foliation dip more closely approximately the natural rock surface. The rock surface of the pre-glacial stream bed is expected to be relatively flat with generally little to no weathering of the rock surface.

b. Concrete Structures. The foundation grades for concrete structures at the dam have been generally selected below the zone of most intense weathering and close jointing. No special foundation treatment is considered necessary for the spillway sill or retaining wall structure. Line drilling will be required along the conduit excavation below the top of conduit to assist in preservation of side rock. A detailed discussion of rock conditions in relation to concrete structures is discussed in Design Memorandum No. 2, "Site Geology" and No. 8 "Detailed Design of Structures."

12. Special Rock Conditions. It is anticipated that large quantities of rock excavation in the railroad relocation will be unsuitable for use as rock fill or slope protection material due to a highly brecciated rock condition. Random composite samples of the fault gouge material indicate a material with about 16% passing the No. 200 Sieve fraction. The zone of faulted rock will not consist wholly of uniformly fine grained materials but will contain random brecciated pieces of more resistant quartzitic rock types and recemented highly friable schist fragments. The actual quantities of unsuitable rock cannot be accurately predicted and mixing of fine rock gouge with the generally poor quality rock in the area could result in an estimated 60% of the rock that would be unsuitable for use as a free draining material.

E. CHARACTERISTICS OF EMBANKMENT MATERIALS.

13. General. The quantities of materials to be excavated in the construction of the highway and railroad relocations will be considerably in excess of the quantities of material required for the construction of the relocation fills. The total excess quantities of these materials will be approximately equal to those required for the construction of the embankments for the dam and dike except for a shortage of impervious embankment materials. While the utilization of these materials in the dam will require extensive stockpiling, there will be a significant savings in so doing in comparison to other schemes involving the spoiling of these materials and the construction of the dam from borrow materials. The embankments for the dam and the dike, therefore, have been designed on the basis of utilizing excess materials from the relocation excavations and from the required excavations for the dam itself. As a result of a

reconnaissance made for borrow sources of additional quantities of impervious embankment materials, a deposit of glacial till was located on a hillside about one-half mile south of the damsite (Area A). This deposit was explored and found to contain an adequate quantity of suitable impervious embankment material and was therefore selected as the source for impervious borrow materials. Reconnaissance and investigations were also carried out to locate sources of granular and pervious types of materials which would be required to facilitate utilization of the materials from the relocation excavations in the dam and the dikes. The characteristics and sources of the various materials selected for use in the embankments are discussed below.

14. Embankment Materials from Required Excavations.

a. Distribution and Description.

(1) Random Embankment Materials. Materials from required excavation for use in the random fill zones of the dam and dike embankments will be obtained from the glacial outwash deposits in the upper portions of the excavations for the railroad relocation and from the excavations for the highway relocation. The materials in these deposits consist principally of highly variable gravelly silty medium to fine sands and silty medium to fine sands with occasional gravel phases and numerous lenses and pockets of sandy silt. Gravel contents of the sands are generally less than 30 percent. Silt contents of the sands vary widely ranging from 5 to 45 percent of the components passing the No. 4 Sieve. As a rule, however, the silt contents are lower and less variable at the southerly end of the excavations ranging from 5 to 30 percent of the components passing the No. 4 Sieve. The larger silt pockets and lenses

encountered in the excavations will be separated and placed in the spoil areas. By obtaining random embankment materials from the southerly end of the railroad excavations to the extent feasible and by eliminating the larger silt pockets and lenses, it is anticipated that the bulk of the resulting random embankment materials will consist of gravelly silty medium to fine sands and silty medium to fine sands having silt contents ranging from 10 to 30 percent of the component passing the No. 4 Sieve.

(2) Impervious Embankment Materials. Materials for use in the impervious fill sections of the embankments for the dam and the dike will be obtained, in part, from the required earth excavations for the railroad relocation and, to a lesser extent, from borrow excavations in Area A. The materials from the railroad excavations will be obtained from the glacial till deposit in the lower portion of the cuts between approximately Stations 43+00 and 55+00. These materials, in general, consist of moderately compact to compact gray brown and gray gravelly silty medium to fine sands with cobbles. Gravel contents vary from 5 to 25 percent and silt contents generally from 35 to 45 percent of the component passing the No. 4 Sieve.

(3) Pervious Embankment Materials. Materials for use in the pervious fill section of the dam will consist of granular materials excavated in the construction of the foundation cut-off of the dam and to a lesser degree from earth excavation in the spillway. These materials consist of well-graded gravelly silty sand and silty sandy gravel having gravel contents ranging from 5 to 70 percent and silt contents ranging generally from 5 to 20 percent of the component passing the No. 4 Sieve. Silt pockets and lenses encountered in the excavations from which the pervious fill is being obtained will be separated and spoiled.

(4) Highway and Railroad Embankment Materials. Materials for use in the highway and railroad relocation embankments will consist of materials from required earth excavations for the relocations and those materials from the required rock excavations for the relocations which are not utilized as rock slope protection materials. These materials will consist of earth, brecciated rock, and rock. The earth materials will consist principally of gravelly silty sands and silty sandy gravels generally similar to the random embankment materials except that wider variations in gradation are anticipated. The brecciated rock (fault gouge) after compaction, will be essentially a micaceous gravelly silty sand. The remaining rock will be similar to that described in Paragraph 17 for rock slope protection except that compaction is expected to produce a higher percentage of fines.

b. Permeability.

(1) Random Embankment Materials. Permeability tests were not performed on samples of random embankment materials. On the basis of visual examination of samples, grain-size distribution curves, and experience with similar materials, it is estimated that the vertical coefficients of permeability of a compacted fill of these materials will be variable ranging from 0.1 to 20 x 10^{-4} cm/sec with the horizontal coefficients being about 9 times the vertical.

(2) Impervious Embankment Materials. Permeability tests performed on a sample of impervious embankment material from the railroad relocation area indicate that the vertical coefficient of permeability of compacted fills of impervious embankment material obtained from the required excavations will range from 0.01 to 0.10 X 10^{-4} cm/sec with the horizontal coefficient being about 9 times the vertical.

(3) Pervious Embankment Materials. Permeability tests were not performed on samples of pervious embankment materials. On the basis of visual examination of samples, grain-size distribution curves and experience with similar materials, it is estimated that the vertical coefficient of permeability of a compacted fill of these materials will range from 1 to 20 x 10^{-4} cm/sec. with the horizontal coefficients being about 9 times the vertical.

c. Consolidation. Consolidation tests were not performed on samples of embankment materials from required excavations. Experience with similar materials indicates that they are of low compressibility when compacted and that no significant settlements will occur in compacted fills of these materials.

d. Compaction.

(1) Random Embankment Materials. Standard AASHO compaction tests were performed on three samples of random embankment materials from test pit BT-2 located on the railroad relocation. The samples were silty medium to fine sands containing little or no gravel and about 40 percent silt. They are consequently considered to be representative only of the siltier phases of the materials to be obtained from the railroad excavation. Maximum test densities ranged from 118.9 to 123.0 pcf at optimum moisture contents of from 10.8 to 11.8 percent. The natural moisture contents of the samples averaged about 3.8 percent above optimum. It is estimated on the basis of visual examination of all samples, their grain-size distribution curves and experience with similar types of materials, that maximum densities of the bulk of the random embankment materials will be significantly higher than those determined for the samples from BT-2

and will be in the range between 120 and 130 pcf. Natural moisture contents appear to be relatively high for all these materials but it is anticipated that as a result of seasonal drying, combined with the effects of construction operations, placement moisture contents less than 2 percent above optimum, can be obtained without difficulty.

(2) Impervious Embankment Materials. A Standard AASHO compaction test was performed on a sample of impervious embankment material from test pit HT-4A located on the railroad relocation alignment. This sample is considered to be representative of the bulk of the impervious embankment materials to be obtained from required excavations. The maximum test density was 130.8 pcf at an optimum moisture content of 9.4 percent. The natural density of this material, as indicated by chunk samples, is over 98 percent of the maximum test density and the natural moisture content about one percent below optimum. It is estimated, however, on the basis of the moisture contents of samples from other explorations that natural moisture contents of these materials, in general, are at or slightly above optimum.

(3) Pervious Embankment Materials. No compaction tests were performed on samples of pervious embankment materials. On the basis of experience with similar materials, it is estimated that ~~maximum~~ test densities of these materials are on the order of 125 pcf and that while optimum moisture contents vary, the sensitivity to changes in moisture content is relatively low. In general, it is anticipated that moisture contents during placement will be within a range permitting adequate compaction.

(4) Highway and Railroad Embankment Materials. No compaction tests were performed on samples representative of the bulk of the highway and railroad embankment materials. Since these materials are essentially of the same type as the random embankment materials, it is estimated that their compaction characteristics are approximately identical. A compaction test was performed on a sample of the brecciated rock (fault gouge) in the Harvard Miniature Compaction Test apparatus. The material was placed in the mold in 3 layers and each layer compacted with 25 blows of 40 pound spring tamper. The maximum test density was 119.6 pcf at an optimum moisture content of 11.2 percent. The test was performed on the portion of the sample passing the No. 4 Sieve.

e. Shear Strengths.

(1) Random Embankment Materials. Shear tests were not performed on samples of random embankment materials from required excavations. Experience with similar types of materials indicates that a comparatively wide range of shear strengths may be expected for these materials. It is considered that the portion of random embankment materials having the least shear strength will have strengths slightly greater than that of the impervious embankment materials. In view of this and the probability that significant quantities of impervious materials may be used as random embankment materials, it is considered reasonable to assign the same shear strength to both types of materials.

(2) Impervious Embankment Materials. Sample B-1 from test pit BT-4A on the railroad alignment was selected for shear testing as being representative with respect to gradation and other physical characteristics of the bulk of impervious embankment materials to be

obtained from required excavations for the railroad relocation. Test specimens were compacted at optimum moisture content, optimum plus 2 percent, and optimum minus 2 percent to corresponding densitites on the compaction test curves. All tests were of the controlled-strain type using rates of strain of 0.025 inch per minute for the Q (unconsolidated-undrained) and the R (consolidated-undrained) tests, and 0.003 inch per minute for the S (consolidated-drained) tests. The latter rate of strain was determined from the consolidation characteristics of the test specimens in order to assure adequate dissipation of pore pressures during these tests.

(3) Pervious Embankment Materials. Shear tests were not performed on samples of pervious embankment materials. On the basis of experience with similar materials, it is estimated that the assignment of a shear strength parameter of $\phi = 32$ degrees with no cohesion would be reasonably conservative for design purposes. In this connection it is pointed our that a combined sample of material from the dam foundation similar to the coarser portion of the pervious embankment materials was tested and found to have an S (consolidated-drained) shear strength of $\phi = 35.1$ degrees and no cohesion.

(4) Highway and Railroad Embankment Materials. Shear tests were not performed on samples of rock and earth embankment materials for the highway and railroad embankments. It is considered that the shear strengths of the earthfills and rockfills will be more than adequate for the selected embankment sections. A direct shear test performed on a sample of the brecciated rock (fault gouge) from the railroad relocation showed this material to have an R (consolidated-undrained) shear strength

of ϕ = 25.4 degrees and c = 0.75 TSF. On the basis of these test results it is considered reasonable to assume and S (consolidated-drained) shear strength of at least ϕ = 30 degrees and no cohesion for design purposes.

15. Borrow Materials.

a. General. Impervious embankment materials required in addition to those available from the earth excavations for the railroad relocation will be obtained from a borrow area to be established in Area A. The limits of this borrow area will be based upon final quantity figures.

b. Distribution and Description of Materials. The overburden in Area A consists of a glacial till deposit partially capped with a relatively thin deposit of glacial outwash sands in the portion of the area above Elev. 550. The area is covered with about one foot of top-soil. The materials in the glacial till deposit are gray brown to gray, moderately compact to very compact gravelly silty medium to fine sands with cobbles. These materials are generally non-plastic but occasional slightly plastic phases occur in the deeper portions of the deposits. Gravel contents of the materials are generally less than 20 percent while silt contents range from 30 to 45 percent of the component passing the No. 4 Sieve. The outwash sands in the capping consist of brown loose to moderately compact roughly stratified gravelly silty sand and silty sand with cobbles. Gravel contents are generally less than 30 percent and silt contents range from 10 to 20 percent of the component passing the No. 4 Sieve. It is estimated that sufficient impervious material for embankments can be obtained from the lower part of this area where removal of the outwash sands would not be required. In the event that

operations have to be extended requiring excavation of the outwash materials, they could be utilized in the highway or railroad embankments or in the random fill sections of the dam or dike.

c. Permeability. Permeability tests were performed on a sample of the more pervious phase of the impervious embankment materials from Area A. On the basis of the results of these tests, visual examination of other samples and their grain-size characteristics, it is estimated that the vertical coefficients of permeability of compacted fills of these materials will range from 0.1 to 0.5×10^{-4} cm/sec. with the horizontal coefficient being 9 times the vertical.

d. Consolidation. Consolidation tests were not performed on samples of impervious embankment materials from Area A. Experience with similar materials indicates that they are of low compressibility and that no significant settlements will occur in compacted fills of these materials.

e. Compaction. Standard AASHO compaction tests were performed on two samples of impervious embankment materials from Area A representative of the coarser phases of these materials near the ground surface. On the basis of the results of these tests and experience with materials similar to the finer phases of the materials in this deposit, it is anticipated that maximum test densities for these materials will range from 120 to 130 pcf at optimum moisture contents ranging from 9 to 12 percent. Natural moisture contents of these materials are generally above optimum but it is expected that drying incidental to excavation and spreading operations will result in placement moisture contents ranging from 2 percent below to 2 percent above optimum.

f. Shear Strengths. On the basis of data obtained from the subsurface explorations, the material between depths of 2.2 and 10.0 feet at boring BD-2 was considered to be representative with respect to gradation and other physical characteristics of the bulk of the impervious embankment material to be obtained from borrow excavations in Area A and was consequently selected for shear testing. A composite sample (B-4) was obtained from test pit BT-6 located within 5 feet of BD-2 for shear testing. The gradation of this sample was different from that of the samples taken from BD-2 and was representative of the coarser phase of the soils in the deposit. It is considered, however, that this sample is actually more representative of the bulk of the impervious embankment material as it will come from the borrow excavations than the small individual samples from the borings. All tests were performed on previously described in sub-paragraph 14e(2) for shear tests on impervious materials from required excavations.

16. Embankment Drainage Materials and Gravel Bedding.

a. General. Reconnaissance was made to locate sources of gravel bedding materials and embankment drainage materials for use in the drainage blankets and other drainage features of the embankments. It was found that considerable quantities of relatively clean sand and gravels are available in the terrace formations within the limits of the reservoir. There are presently two commercial suppliers of concrete aggregate working in some of the terraces between 1.4 and 2 miles upstream of the dam site. In view of the proximity of these developed sources and the relatively small quantity of material required, the expense of exploring and developing other areas is not considered justified especially since the Government will acquire these sources for the reservoir. Reconnaissance beyond

the limits of the reservoir area indicated that there are at least four commercial sources of sands and gravels within 10 miles of the dam site. On the basis of the foregoing considerations, it has been decided to have the contractor furnish embankment drainage materials and gravel bedding for this project from approved sources which will include the two within the reservoir from which the contractor will be permitted to obtain the material without charge.

b. Sources.

(1) McCleary Brothers Company. McCleary Brothers Company operates a crushing and washing plant within the reservoir limits about 1.4 miles by paved road upstream of the dam site. Materials for the plant are obtained from a low terrace on the west side of Todd Hollow Brook and another terrace on the east side of the brook adjacent to Todd Hollow Road. The materials in the west pit consist of gravelly sands and sandy gravels with cobbles and small boulders. The materials in the east pit are generally sandier and more variable. The gravels from this source have fine contents of less than 15 percent of the component passing the No. 4 Sieve. The sands vary from well graded sands containing less than 10 percent gravel to gravelly sands containing from 30 to 50 percent gravel. Fine contents of the sands are generally less than 5 percent of the component passing the No. 4 Sieve.

(2) Johnson Sand and Gravel Company. The Johnson Sand and Gravel Company operates a processing plant within the limits of the reservoir about 2 miles by paved road upstream of the dam site. Materials for the plant are obtained from two pits in terraces on the west side of Todd Hollow Brook. The materials from this source are essentially the same as those in the McCleary pits.

c. Gradation Specifications.

(1) General. Investigations of the various sources of gravel bedding and embankment drainage materials indicate that the following gradation specifications can be satisfied by materials available from the two sources within the reservoir limits or from commercial sources within 10 miles of the dam site. The specifications for materials which will act as filters have been established in accordance with the filter design criteria set forth in the Engineering Manual for Civil Works Construction.

(2) Gravel Bedding. Gravel bedding materials for use in the embankments and elsewhere on the project shall consist of reasonably well graded bank-run sandy gravel furnished by the contractor from approved sources. Of the portion of the material passing the 3-inch sieve, from 25 to 60 percent shall pass the No. 4 Sieve and of the component passing the No. 4 Sieve, no more than 15 percent shall pass the No. 200 Sieve.

(3) Gravel Fill. Gravel fill material for use in the embankments and elsewhere on the project shall consist of reasonably well graded bank-run sandy gravel or gravelly sand furnished by the contractor from approved sources. Of the portion of the material passing the 3-inch Sieve from 25 to 60 percent shall pass the No. 4 Sieve and of the component passing the No. 4 Sieve, no more than 10 percent shall pass the No. 200 Sieve.

(4) Sand Fill. Sand fill material for use in the embankments and elsewhere on the project shall consist of reasonably well graded bank-run gravelly sand or sand furnished by the contractor from approved sources. Of the portion of the materials passing the 3-inch Sieve,

from 50 to 100 percent shall pass the No. 4 Sieve and of the component passing the No. 4 Sieve, no more than 10 percent shall pass the No. 200 Sieve.

d. Permeability. Permeability tests were not performed on samples of gravel bedding and embankment drainage materials. On the basis of visual examination of samples, grain size characteristics, the specified gradations, and experience with similar materials, it is estimated that vertical coefficients of permeability for these materials will be in excess of 100×10^{-4} cm/sec and that the horizontal coefficients will be about 9 times the vertical.

e. Shear Strengths. Shear tests were not performed on samples of gravel bedding and embankment drainage materials. Experience with similar materials indicate that the following estimated shear strength parameters are reasonably conservative:

Material	Ø, degrees	c, T/SF
Gravel Bedding	35	0
Gravel Fill	35	0
Sand Fill	30	0

17. Rock Slope Protection. Rock slope protection materials will be selected from the required rock excavations for the project. The materials to be used on the dam and dike embankments will be obtained from the excavations for the outlet works and spillway and, in part, from the excavations for the highway relocation. The rock materials is generally a weak (1000 psi unconfined compressive strength) highly foliated mica schist which displays a relatively high resistance to alteration under the magnesium sulfate soundness test (0.17% loss in 5 cycles). The unit

weight of the rock is approximately 175 p.c.f. The major portion of the rock, because of its highly fissile nature, is susceptible to breakdown from excavation, stockpiling, handling and trafficking. To the extent practicable, rock slope protection materials will be obtained selectively from the sounder phases of the rock being excavated. However, it is anticipated that rock slope protection layers will contain high percentages of rock dust and small rock fragments. On the basis of experience with similar types of rock slope protection materials, it is estimated that the angle of internal friction for the materials for this project will be about 35 degrees.

F. DESIGN OF EMBANKMENTS

18. Criteria. Current design criteria as set forth in the pertinent sections of the Engineering Manual for Civil Works Construction were followed in the design of the embankments for this project.

19. Materials for Embankment Construction.

a. Materials from Required Excavations.

(1) Earth. Present estimates indicate that there will be about 378,000 cubic yards of earth excavation required for the construction of this project. The estimated quantities of the various types of material to be excavated are as follows:

Type of Material	Quantity
Stripping	88,000 c.y.
Random Embankment Materials and Relocation Embankment Materials	210,000 "
Pervious Embankment Materials	30,000 "
Impervious Embankment Materials	50,000 "

The foregoing quantities represent excavation volumes to which a balance factor must be applied to obtain the corresponding embankment quantities. To account for losses due to shrinkage, oversize stones, waste, and other causes a balance factor of 0.7 has been selected for those materials which will be stockpiled prior to placement in an embankment and those materials excavated from the dam foundation and the spillway area. For all other earth materials which will be placed directly in the embankment a balance factor of 0.8 has been selected.

(2) Rock. It is estimated that there will be about 86,000 cubic yards of rock excavation required for the construction of this project. About 36,000 cubic yards of this total will consist of poor quality rock from the railroad relocation whcih will be utilized in the construction of the railroad embankments. Another 6,000 cubic yards of this total will consist of unusable rock from the excavations for the spillway and outlet works which will be placed in the spoil areas. The remaining 44,000 cubic yards of material will consist of relatively sound rock which will be utilized as rock slope protection material to the extent required. Excess sound rock will be incorporated into the railroad embankments. Considering bulking, losses due to stockpiling and transportation, the breakdown of the material due to handling, rehandling and compaction, and possible inaccuracies in quantity determinations; a balance factor of 1.0 has been selected for all materials to be obtained from the required rock excavations.

b. Borrow. The quantity of impervious embankment materials from the required excavations will not be sufficient to complete the impervious fill zones of the dam and dike embankments. The required

additional material will be obtained from a borrow area to be established in Area A. It is estimated that over 100,000 cubic yards of impervious material are available from this area, which would required about 15,000 cubic yards of stripping and the removal of about 30,000 cubic yards of overlying sandy materials. Present estimates indicate that less than 40,000 cubic yards of impervious material will be required from borrow. This quantity could be obtained from the lower portion of Area A by removing approximately 5,000 cubic yards of overlying materials. To account for losses due to shrinkage, waste, oversize stones, and other causes a balance factor of 0.9 has been selected for the impervious embankment materials obtained from Area A.

c. Materials Furnished by the Contractor. Gravel bedding and embankment drainage materials will be furnished by the contractor from approved sources.

d. Materials Usage. A chart indicating the proposed usage of materials from required excavations and borrow excavations is shown on Plate No. 6-33. The quantities on the chart are preliminary and will be subject to change during final design studies.

20. Selection of Embankment Sections.

a. General. The selection of the embankment sections for this project was influenced in great measure by the large volume of required excavations and the economic desireability of utilizing materials from these excavations to the maximum practicable extent. The selection of the embankment section for the dam was also influenced by the fact that completion of the relocations would proceed the construction of the dam. Typical embankment sections are shown on Plates Nos. 6-16 through 6-19.

b. Dam. The embankment section selected for the dam consists of an inclined upstream impervious fill zone, with a contiguous impervious foundation cut-off to bedrock, a random fill zone, a pervious fill zone, an inclined downstream sand fill zone, a horizontal drainage blanket, and rock slope protection with gravel bedding. The pervious fill zone has been designed so that it can be constructed of materials from the excavation of the foundation cut-off trench and the spillway channel as the excavation progresses. The proportions of the various zones have been selected so as to reduce the amount of borrow and the stockpiling of materials from the relocation excavations to the extent feasible. The foundation cut-off was selected in preference to an upstream impervious blanket as furnishing more adequate control of seepage through the pervious strata of the embankment foundation at a cost not significantly greater than that of blanket.

c. Dike. The embankment section selected for the dike consists of an inclined impervious fill zone with a contiguous reservoir side impervious fill blanket, a random fill zone, a small sand fill zone, rock slope protection with gravel bedding on the reservoir side slopes and seeded topsoil on the landside slopes. This type of section was selected so as to facilitate direct utilization of materials from required excavations and to minimize use of impervious material so that more would be available for use in the dam embankment. The impervious blanket was selected in lieu of a foundation cut-off as being more practicable with respect to construction and as providing adequate seepage control with the relatively low heads involved.

d. Relocation Embankments. The embankment sections selected for the railroad and highway relocations will consist of zones of materials

from required rock and earth excavations. To the extent practicable, the materials from the rock excavations will be placed in the lower portions of the embankments located within the reservoir. Rock slope protection with gravel bedding will be provided for the embankments as required.

21. Slope Protection. Slope protection consisting of materials from required rock excavations and of gravel bedding will be provided to prevent erosion by waves and rainwater. Slopes on the reservoir sides of the embankments will be subject to the action of waves up to 2.3 feet in height. The minimum thickness of graded riprap and the stone sizes required for this wave height by current criteria for various embankment slopes are as follows:

Slope	Min. Thickness in inches	Stone Weight in lbs. Min.	Max.	Avg.
1 on 2	12	6	200	50
1 on 25	12	5	170	42
1 on 3	12	4	130	32

While materials from required rock excavations will not meet the above requirements without processing, it is considered that equivalent protection will be developed by those materials if placed in layers 2 feet thick. Rock slope protection on the downstream slope of the dam embankment will be 2 feet thick in order to permit use of a larger portion of the available rock excavation without processing and to avoid the construction difficulties involved in the placement of relatively thin layers of stone.

22. Seepage Control, Dam and Dike.

a. Through Seepage.

(1) Dam. Pore pressures and exit velocities resulting

from through seepage will be controlled by the arrangement and differences in permeability of the impervious, random, pervious and sand fill zones and the horizontal drainage blanket. Although it has been assumed for stability studies that the permeabilities of the random and impervious fill zones are the same, it is more probable that the random fill will be significantly more pervious and that in actuality no significant seepage pore pressures will develop in the dam embankment at locations where they could effect its stability. The quantities of seepage passing through the dam embankment will not be significant.

(2) Dike. Pore pressures and exit velocities resulting from through seepage will be controlled by the arrangement and differences in permeability of the impervious, random, and sand fill zones. The quantities of seepage passing through the dike embankment will not be significant.

b. Foundation Seepage.

(1) Dam. Seepage through the overburden in the foundation of the dam embankment will be controlled by an impervious cut-off to bedrock having a bottom width of 25 feet and the horizontal drainage blanket. While the bottom width of the cut-off is greater than that required by seepage control criteria, it was selected as being the minimum practicable width for construction. Seepage through the bedrock on the abutments will be controlled by a grout curtain. While a grout curtain is not considered necessary to control seepage through the bedrock in the valley section of the dam foundation, provision will be made for the treatment of any small faults or open joints encountered during excavation of the cut-off trench. If these openings are small, localized grouting will be employed while larger openings will be filled to twice their width with concrete.

If adequate sealing by grout or concrete should prove impracticable, relief drainage will be provided in the form of drain holes drilled in the rock under the downstream portion of the embankment.

(2) Dike. Seepage through the foundation of the dike embankment will be provided by an impervious blanket on the reservoir side of the dike. The dimensions of the blanket have been selected so that seepage gradients through the foundation will not exceed 10 percent with the reservoir pool at its maximum level and so that seepage gradients through the blanket will not exceed those through its foundation.

c. Construction Requirements. In order to assure the maximum efficiency of the seepage control features described above, the following construction requirements will be incorporated in the contract specifications.

(1) Impervious Fills on Bedrock. It will be specified that all bedrock surfaces upon or against which impervious fill is to be placed shall be prepared in such a manner as to assure:

(a) The tightest practicable contact between the fill and the bedrock surface.

(b) Adequate compaction of the fill adjacent to the bedrock surface.

(c) Protection against the migration of fill materials into joints and similar openings in the bedrock under seepage forces.

(2) Drainage Blanket on Bedrock. It will be specified that all bedrock surfaces upon or against which the drainage blanket is to be places shall be prepared in such a manner as to assure adequate drainage of the joints and similar openings in the bedrock beneath the blanket.

23. Embankment Stability, Dam and Dike.

a. General. The dam and dike embankments have been analyzed for stability against shear failure using the method of infinitestimal slices excpet for certain special studies in which the wedge analysis method was used. The design shear strengths and unit weights for the impervious embankment materials were selected on the basis of laboratory test results. The design shear strengths and unit weights for the other embankment materials were selected on the basis of experience with similar types of materials.

b. Conditions Analyzed.

(1) End of Construction. The embankment were analyzed for stability at the end of construction on the assumption that the time required to construct the embankment would be too short to permit either consolidation of the impervious and random embankment materials under the applied embankment loads or the dissipation by drainage of the induced pore pressures in the same materials. Since the conditions of this assumption are analogous to those of the unconsolidated-undrained (Q) shear test, the analyses were made using design shear strengths for the impervious and random embankment materials based on this test condition.

(2) Operating Conditions.

(a) Steady Seepage. The dam embankment was analyzed for stability under the steady seepage condition. For purposes of this analysis, a flow net was constructed for the embankment section based on the assumption of equal permeabilities for the impervious and random fill zones. This flow net is shown on Plate No. 6-32. Design shear strengths based on the consolidated-drained (S) and consolidated-undrained (R) shear strengths were used in the analysis.

(b) Partial Pool. The dam and dike embankment were analyzed for stability at various reservoir pool levels to determine the pool level at which embankment stability would be at a minimum. Design shear strengths for the consolidated-undrained (R) condition were used for the impervious and random fill zones for this analysis.

(c) Sudden Drawdown. The dam and dike embankment were analyzed for stability during sudden drawdown of the reservoir pool using design shear strengths for the condolidated-undrained (R) condition for the impervious and random fill zones. Drawdown from maximum pool (Elev. 500) and from spillway crest (Elev. 484) to the inlet sill (Elev. 454) were considered in these analyses.

c. Selection of Design Values.

(1) Unit Weights. The impervious, random, and pervious materials for the embankment will be compacted with sheepsfoot or rubber-tired rollers in accordance with a compaction specification which has been used by this Division in the past for embankments of similar materials. Experience with this specification indicates that the densities of the upper layers of fills compacted at moisture contents within the range anticipated for this project will average about 98 percent of maximum test densities while the densities of the lower layers will approach 100 percent. The design unit weight for the impervious material, therefore, has been selected on the basis on maximum test densities as adjusted to include the weight of the average stone content. The design unit weights for the other embankment materials and the foundation materials have been selected on a similar basis using estimated densities based on experience with similar materials. The various design unit weights selected for this project are tabulated below.

Material	Design Unit Weight in Pounds per Cubic Foot			
	Dry	Moist	Saturated	Submerged
Rock Slope Protection	120	-	140	78
Gravel Bedding	135	140	145	83
Sand Fill and Gravel Fill	120	132	138	76
Random, Pervious & Impervious Fill	130	140	145	83
Foundation Soils	125	135	140	78

(2) Shear Strength. The design shear strength parameters for the various embankment and foundation materials have been selected on the basis of conservative interpretations of laboratory shear test results and experience with similar materials. For the stability analyses, it has been assumed that the shear characteristics of the random materials would be the same as those of the impervious materials. While this is a very conservative assumption, it is considered justified since the impervious materials are the more critical with respect to shear strength and since it is probable that some impervious material may be placed in the random fill zones. The design shear strength parameters for the impervious and random materials, therefore, have been selected on the basis of the minimum values indicated by shear tests performed on samples of impervious materials. The design shear strength parameters for the other embankment materials have been selected on the basis of experience with similar materials. The design shear strength parameters for the foundation soils have been selected on the basis of experience with similar soils augmented by limited shear testing. The design shear strength parameters selected for the various materials are tabulated below.

Material	Design Shear Strength Parameters					
	S Condition (CD)		R Condition (CU)		Q Condition (Q)	
	ø degrees	c T/SF	ø degrees	c T/SF	ø degrees	c T/SF
Rock Slope Protection	35	0	-	-	-	-
Gravel Bedding	35	0	-	-	-	-
Sand Fill & Gravel Fill	32	0	-	-	-	-
Pervious Fill	32	0	-	-	-	-
Random Fill & Impervious Fill	34.6	0	22.4	0.1	21.3	0.4
Foundation, Dam	30	0	-	-	-	-
Foundation, Dike	34.6	0	22.4	0.1	21.3	0.4

d. Sections Analyzed.

(1) Dam. The downstream portion of the dam embankment at Sta. 6+60 was selected for analysis for the steady seepage and end of construction conditions as being the most critical with respect to stability because the slope height at this point is greatest for this side of the dam. Upstream portions of the dam embankment at Sta. 5+50, 6+40, and 7+70 were selected for analysis for the partial pool, sudden drawdown, and end of construction conditions. The presence of the berm on the upstream slope at varying elevations along the dam necessitated the analysis of these three sections to determine which were critcial with respect to stability for the various conditions. The section at Sta. 5+50 was selected because it has the greatest height of continuous slope above the berm, that at 6+40 because it has the maximum total slope height, and that at 7+70 because it has the greatest continuous slope height below the

berm combined with an appreciable depth of foundation soil.

(2) Dike. The upsteam portion of the dike embankment at Sta. 46+50 was selected for analysis for the sudden drawdown partial pool and end of construction conditions as being the most critical with respect to stability because it has the maximum slope height. The downstream portion of the dike embankment was not analyzed inasmuch as its height is low, seldom exceeding 10 feet.

e. Results of Embankment Stability Analyses. The results of the embankment stability analyses are summarized on Plates Nos. 6-20 through 6-23 for the dam and on Plate No. 6-28 for the dike. Typical analyses are shown on Plates Nos. 6-24 through 6-27 and 6-29 through 6-31. The minimum factors of safety against shear failure are as follows:

	Minimum Factor of Safety	
	Reservoir Side (U/S)	Land Side (D/S)
DAM		
End of Construction	2.09 @ Sta. 6+40	1.65 @ Sta. 6+60
Steady Seepage	-	1.48 @ Sta. 6+60
Partial Pool (Pool @ Elev. 476)	1.57 @ Sta. 5+50	-
Sudden Drawdown		
From Max. Pool	1.07 @ Sta. 5+50	-
From Spillway Const.	1.18 @ Sta. 7+70	-
DIKE		
End of Construction	2.80 @ Sta. 46+50	-
Partial Pool (Pool @ Elev. 483)	1.46 @ Sta. 46+50	-
Sudden Drawdown		
From Max. Pool	1.08 @ Sta. 46+50	-
From Spillway Crest	1.31 @ Sta. 46+50	-

The foregoing minimum factors of safety are considered to be adequate and the results of the stability analyses indicate that the selected embankment sections are safe against shear failure.

f. Special Stability Studies. The downstream portion of the dam embankment was analyzed for stability against shear failure by the wedge method to determine the possible effects of the occasional silt lenses and pockets in the foundation soil. Assuming strength parameters of ϕ=25 degrees and c=0 for the silt and assuming that a pocket or lense occurred in a continuous horizontal layer it was determined that the factor of safety against failure by this mode is in excess of 1.5. In view of this and the probability that the silt pockets or lenses are not continuous this factor of safety is considered adequate

24. Stability of Relocation Embankments. No stability analyses were made of the embankments for the railroad and highway relocations. The sections selected are of the types normally used for highways and railroads except that flatter slopes have been adopted in those reaches of the embankments subject to reservoir drawdown.

25. Settlements. The foundation and embankment materials for the dam and dike are of types which normally exhibit very low compressibility. No significant settlements are therefore anticipated in either the foundations of these embankments. Settlements of the relocation embankments will be within normal limits for this type of construction.

26. Removal and Disposal of Unsuitable Materials. All topsoil and other organic surficial materials will be removed from the dam and dike embankment foundation areas together with surficial boulders and rock blocks. In addition, the swamp deposits of soft organic silt, and laminated

silt and sand in the valley section of the dam foundation will be removed to their full depths. The the extent required, the topsoil thus removed will be utilized on those portions of the cut slopes which are to be seeded. All other unsuitable materials thus removed will be placed in designated spoil areas. The stripping for the relocation embankments will be required to the extent normal for this type of construction.

27. Construction Considerations.

a. Dewatering Construction Areas. The specifications will require the dewatering of all areas in which embankment fill is to be placed for the dam and the dike including the foundation cut-off for the dam. The dewatering of other construction areas will be required to the extent necessary to facilitate construction operations. All earth excavations for the project, except those for stripping and the removal of unsuitable materials, shall be done in the dry to reduce the quantity of excavated earth to be spoiled because of excessive moisture contents resulting from high groundwater levels. It is anticipated that the dewatering of the construction areas in general will be possible by the usual methods of construction drainage including open pumping. In the cut-off excavation, however, special methods such as well pointing may be necessary.

b. Rate of Embankment Construction. The length of the dam embankment and the topography of its foundation are such that construction in partial reaches is neither practicable or desirable. Construction of the dam embankment to its full length therefore will be specified. Construction of the dike embankment in partial reaches is feasible, however, and the specifications will permit such construction provided

that the partial reaches are at least 200 feet in length with end slopes no steeper than 1 on 4. Construction of the relocation embankments in partial reaches will also be permitted provided that the lengths of the reaches are adequate to allow proper compaction. Construction of the dam and dike embankments to their full width (with the top surfaces of all fill at the same level) will be required except that construction of the pervious fill zone of the dam and of the random fill zone of the dike will be allowed in advance of other zones to the extent necessary to facilitate direct utilization of materials from the required excavations in these zones.

c. Sequence of Construction. The railroad and highway relocations must be completed prior to the start of construction of the dam in order that traffic will not be interrupted. Direct utilization in the dam embankment of excavated material from the relocations therefore, is not possible and stockpiling will be required. Construction of adequate stockpiles of impervious and random embankment materials from the relocation excavations for use in the dam embankment will be required to be done prior to the use of such materials in the relocation embankments or in the dike embankment.

G. PERMANENT CUT SLOPES

28. Earth Cut Slopes.

a. Dam. In general, all permanent earth cut slopes in the spillway, intake, and outlet channels will be topsoiled and seeded for protection against erosion. Rock slope protection and gravel bedding, however, will be placed on those slopes which may be subject to damage from run-off, seepage, or frost action.

b. Borrow Area A. Permanent earth and slopes in the excavated portion of Borrow Area A will be finished at 1 on 3 slopes, covered with a layer of stripping material and seeded for protection against erosion.

c. Relocations.

(1) Railroad. The principal permanent earth cuts for the railroad relocation will be made through highly variable deposits of glacial outwash sands and gravels with silt lenses and pockets and into underlying glacial till. It is anticipated that considerable subsurface seepage will emerge on the east side of the cuts from the large drainage areas above them despite the construction of interceptor ditches. This seepage will tend to be concentrated at the interface of the outwash and till deposits. On the west side of the cuts, normal seepage will be insignificant, but at high reservoir stages seepage through the dike foundation will emerge on some of these cut slopes. Slopes on the west side of the cuts have been established at 1 on 2 which slope is considered to be satisfactory with respect to stability and maintenance since the average height of the slopes are low. Slopes in the vicinity of the toe of the dike will be provided with rock slope protection and gravel bedding for the control of seepage emergence. Slopes on the east side of the cuts which are less than 30 feet in height have also been established at 1 on 2. Slopes on the east side of the cuts which are over 30 feet in height, principally in the reach between approximately Sta. 50+00 and 56+00 have been tentatively established at 1 on 2.5. The railroad, however, has indicated a desire for the construction of somewhat steeper slopes with berms in this reach. A study is being made of the relative costs of the two types of slopes. In the event that the bermed type of

slope should be selected on the basis of this study, its design will be discussed in a supplement to this report. A layer of stripping material will be placed on all cut slopes and seeded except where rock slope protection and gravel bedding are to be provided for seepage control.

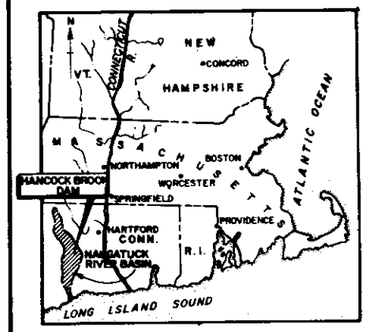
(2) Highway. The principal permanent earth cut for the highway will be made through a shallow deposit of loose to moderately compact silty sands and gravels. The drainage area above the cut is small and subsurface seepage is therefore expected to be limited in quantity. The cut slopes have been established at 1 on 2. Finished slopes will be covered with a layer of stripping material and seeded.

29. Rock Cut Slopes. Highly variable conditions of the bedrock, including structural folding, jointing, faulting and fault gouge; and their relationship to the rock cut will determine the final shape of stable rock cuts and any necessary treatment. Based on the data available from borings and observation of rock exposures the following design slopes are considered stable within practicable excavation limits subject to minor modifications as necessary during construction to treat local areas of critical rock structure.

Location	Slope (Approximate)
Railroad Relocation	
Easterly Slopes (Sound Rock)	2 on 1
Westerly Slopes (Sound Rock)	4 on 1
East and West Slopes (Zones of Fault Gouge)	1 on 1 (Drained and Protected Condition)

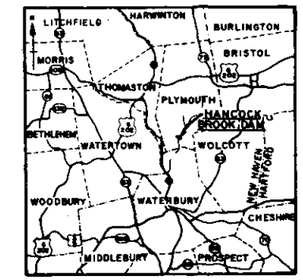
Location	Slope (Approximate)
Highway	
Easterly Slopes (Northwesterly Cuts)	3 on 1
Dam Site	
Westerly Slopes	4 on 1
Easterly Slopes	3 on 1

Rock bolts will be used in areas of deep rock cuts to assist in stabilizing the rock slopes. Based on the prevailing westerly dipping structure of the rock it is anticipated that rock bolts will be largely confined to the westerly slopes. Overburden and loose rock will be removed for a distance of 10 feet back from the top of slope to minimize the amount of rock falls.



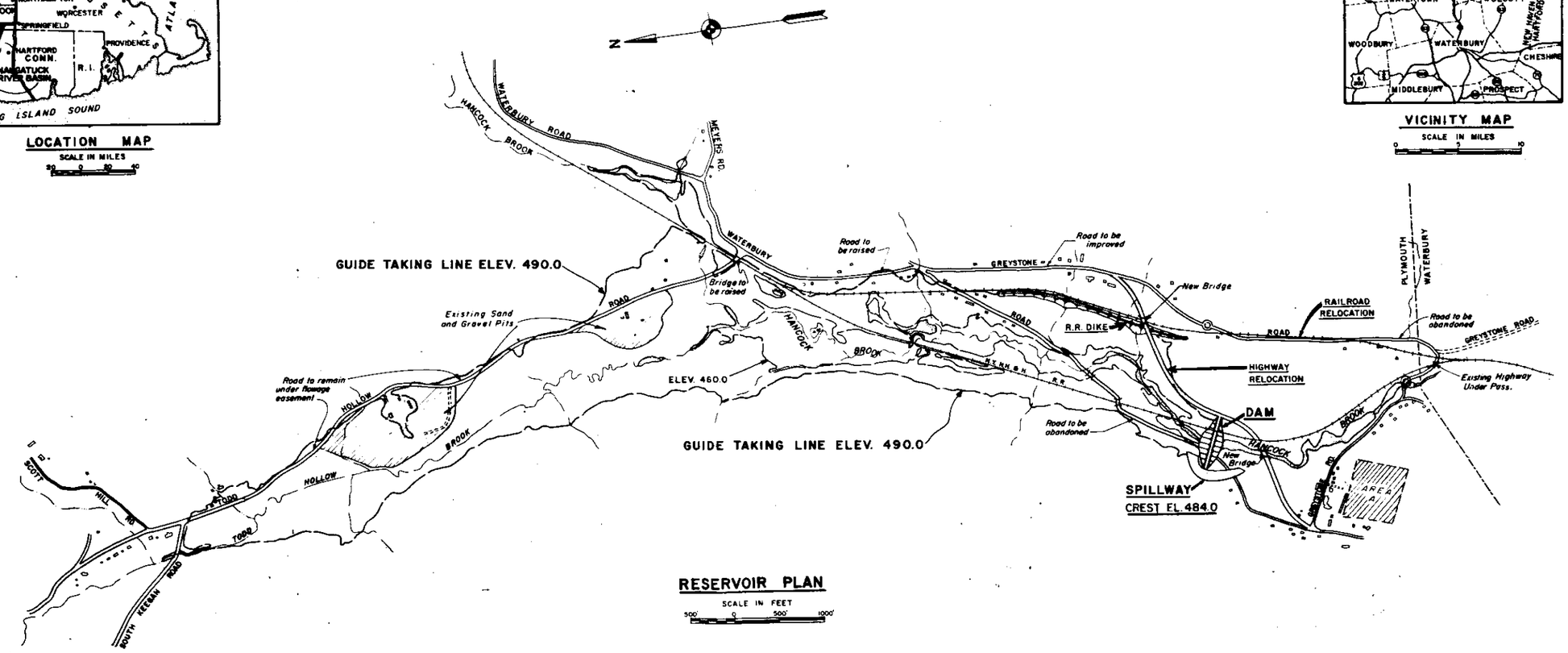
LOCATION MAP

SCALE IN MILES



VICINITY MAP

SCALE IN MILES



RESERVOIR PLAN

SCALE IN FEET

HOUSATONIC RIVER FLOOD CONTROL

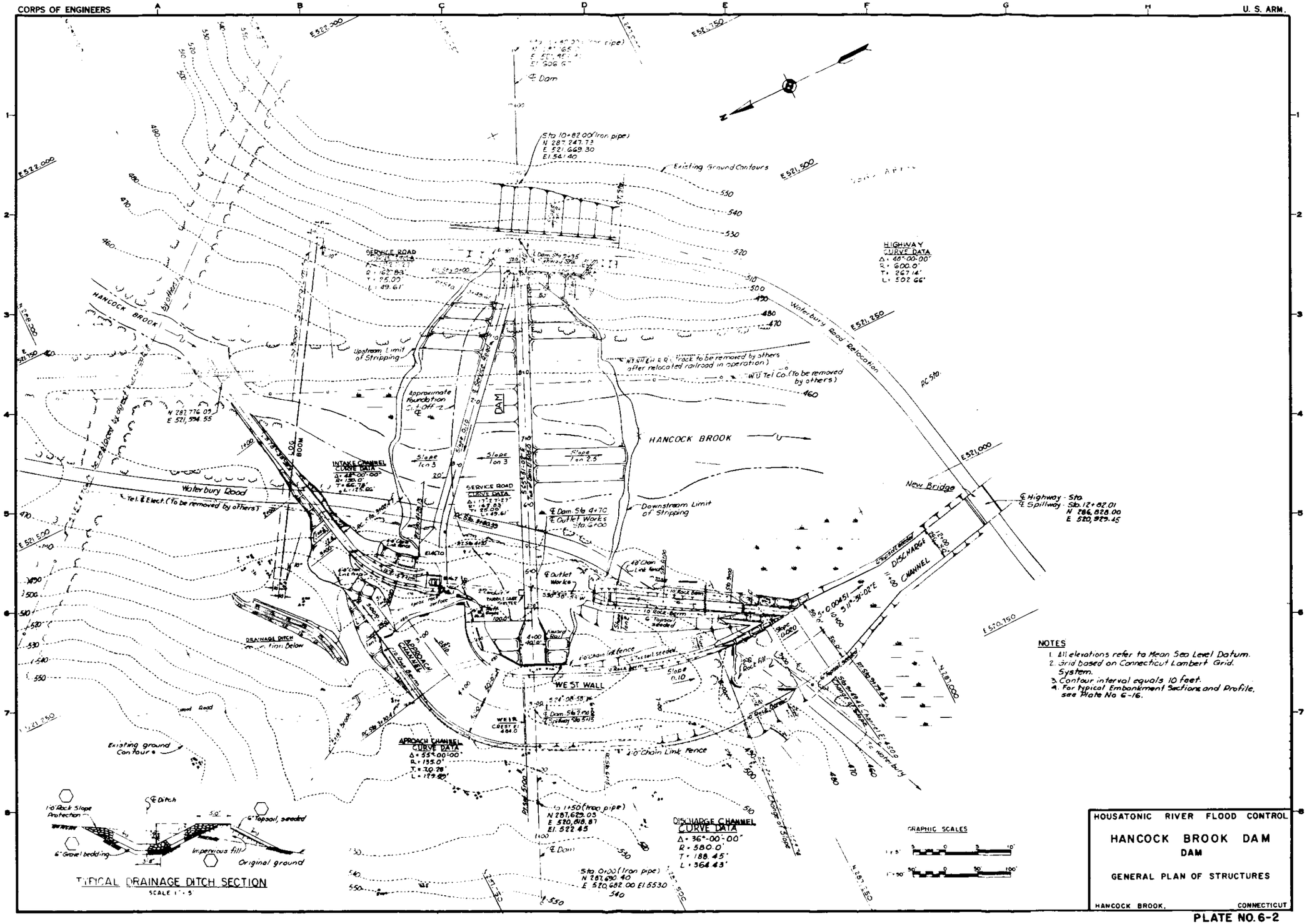
HANCOCK BROOK DAM

RESERVOIR MAP AND LOCATION OF BORROW AREAS

HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-1

CORPS OF ENGINEERS U. S. ARMY



NOTES

1. All elevations refer to Mean Sea Level Datum.
2. Grid based on Connecticut Lambert Grid System.
3. Contour interval equals 10 feet.
4. For typical Embankment Sections and Profile, see Plate No 6-16.

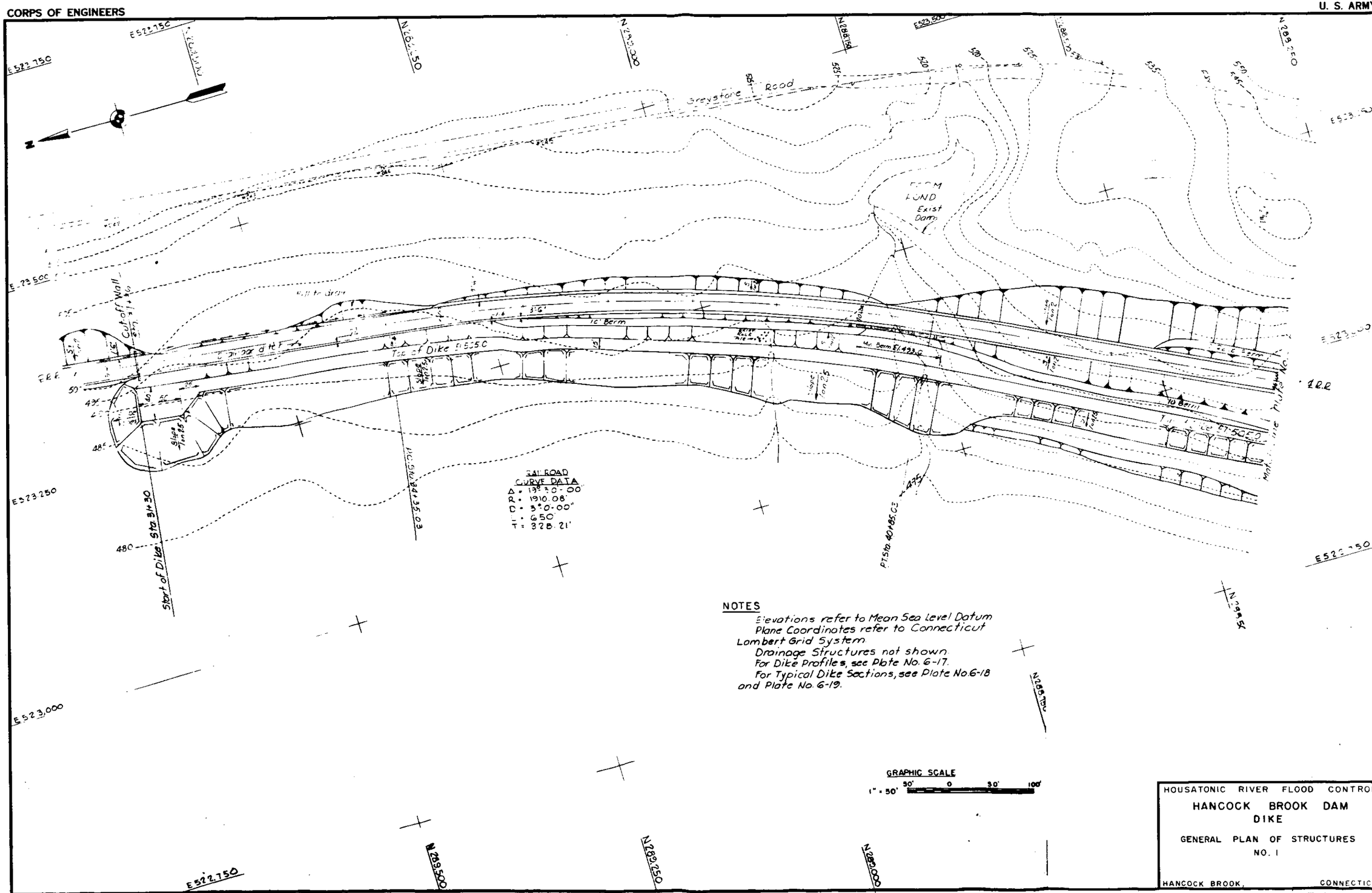
HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM
DAM

GENERAL PLAN OF STRUCTURES

HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-2



NOTES

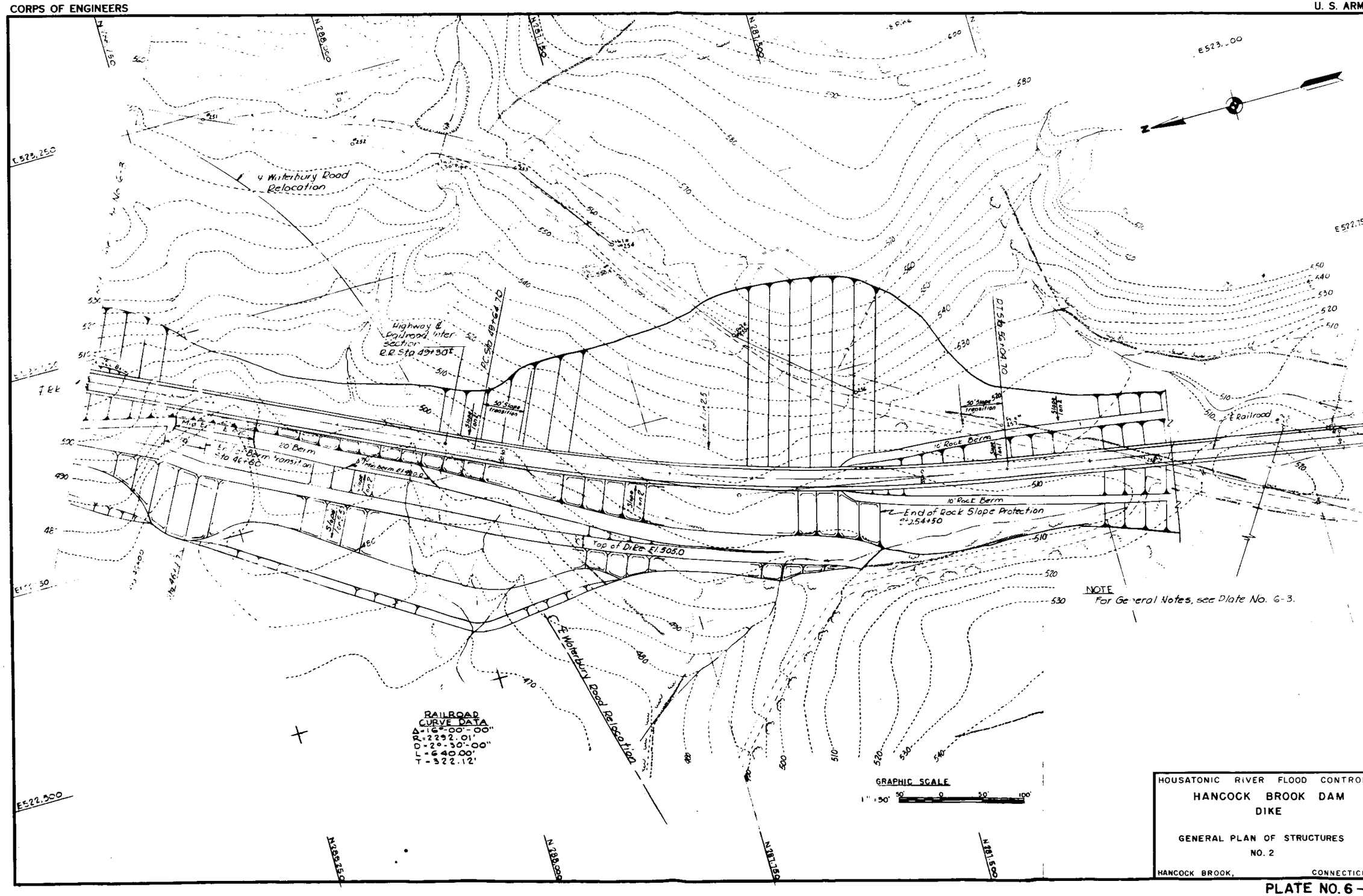
Elevations refer to Mean Sea Level Datum
Plane Coordinates refer to Connecticut Lambert Grid System.
Drainage Structures not shown.
For Dike Profiles, see Plate No. 6-17.
For Typical Dike Sections, see Plate No. 6-18 and Plate No. 6-19.

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM
DIKE

GENERAL PLAN OF STRUCTURES
NO. 1

HANCOCK BROOK, CONNECTICUT

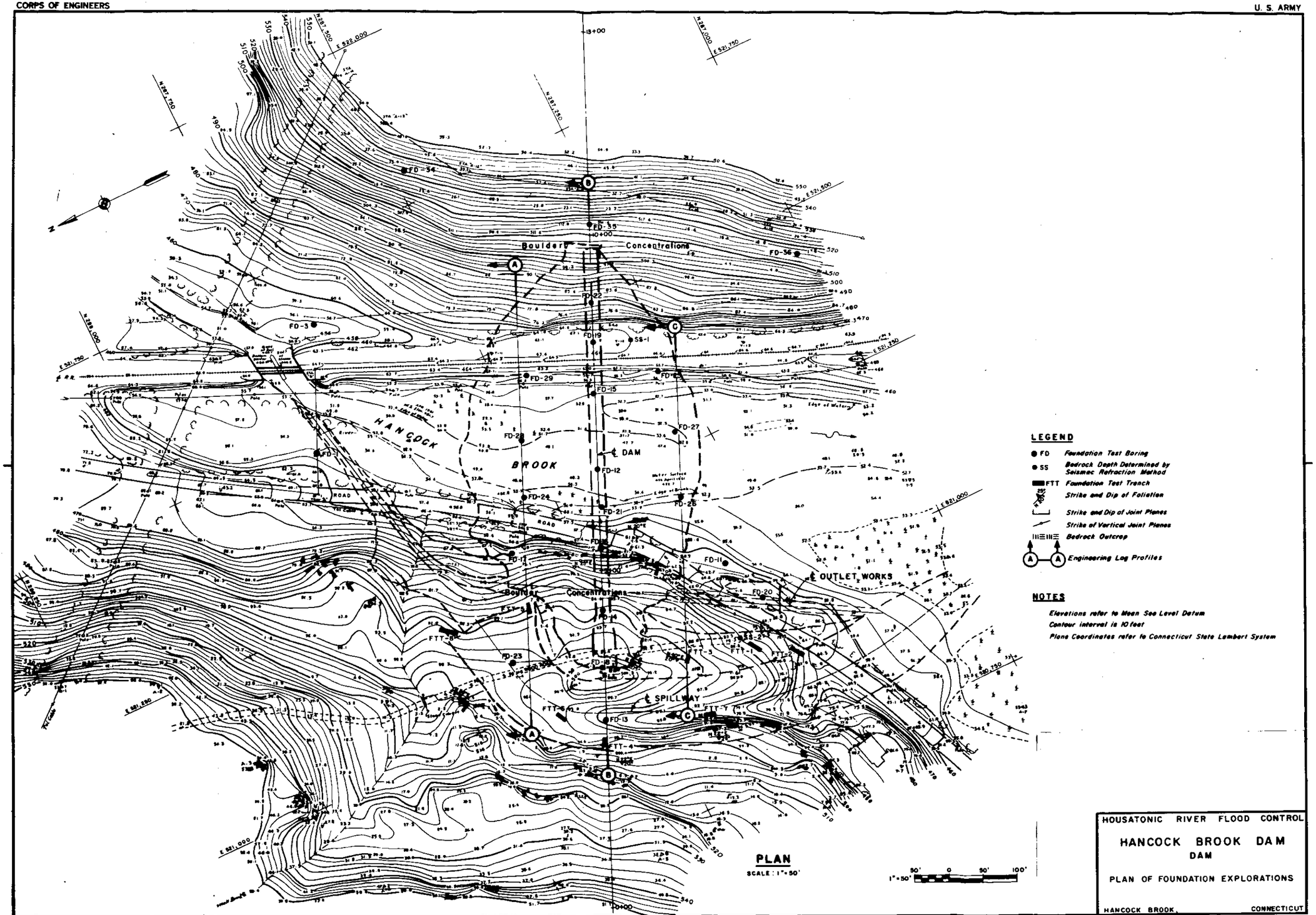


HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM
DIKE

GENERAL PLAN OF STRUCTURES
NO. 2

HANCOCK BROOK, CONNECTICUT



HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

DAM

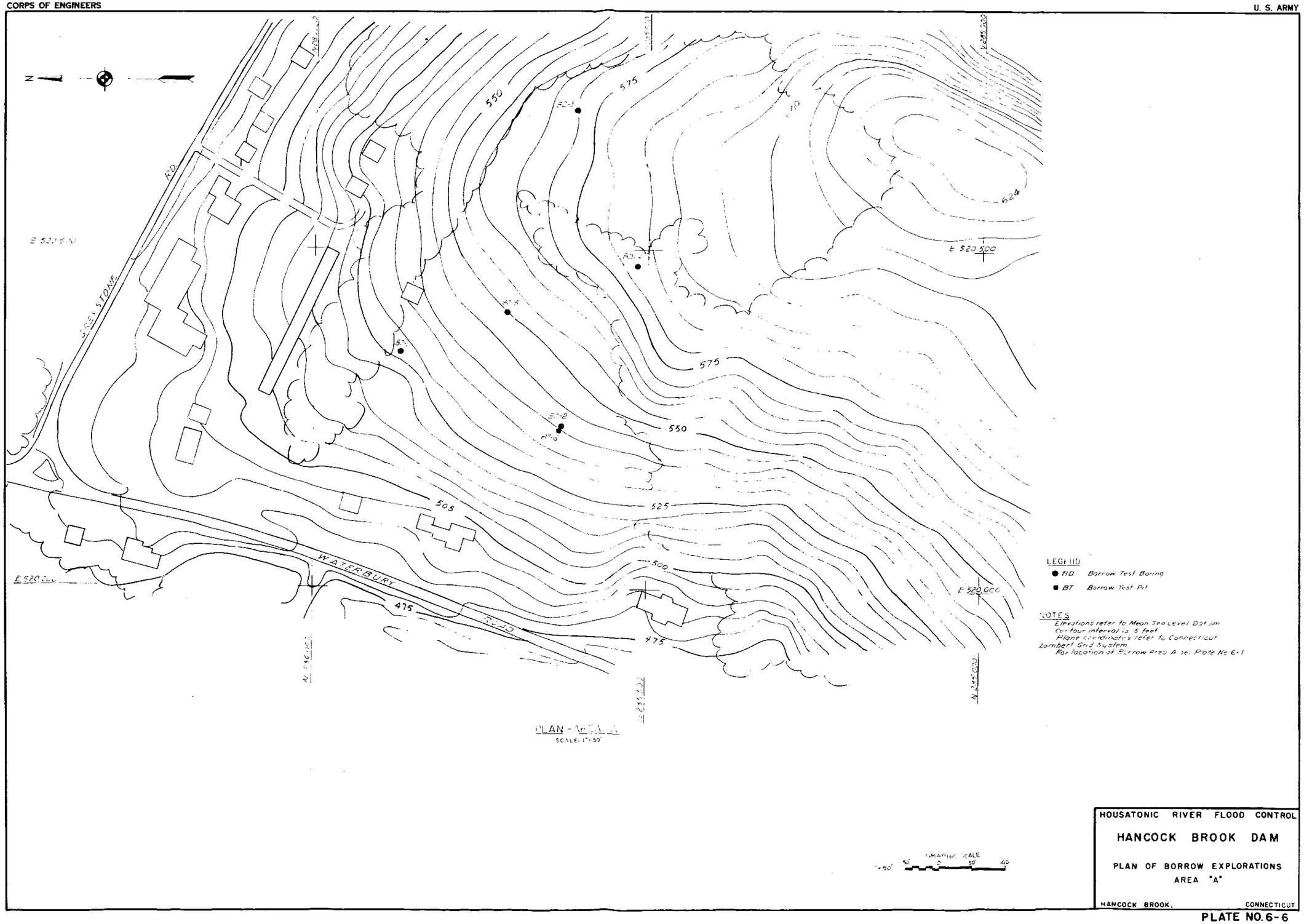
PLAN OF FOUNDATION EXPLORATIONS

HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-5

CORPS OF ENGINEERS

U. S. ARMY



PLAN - AREA A

SCALE: 1" = 50'

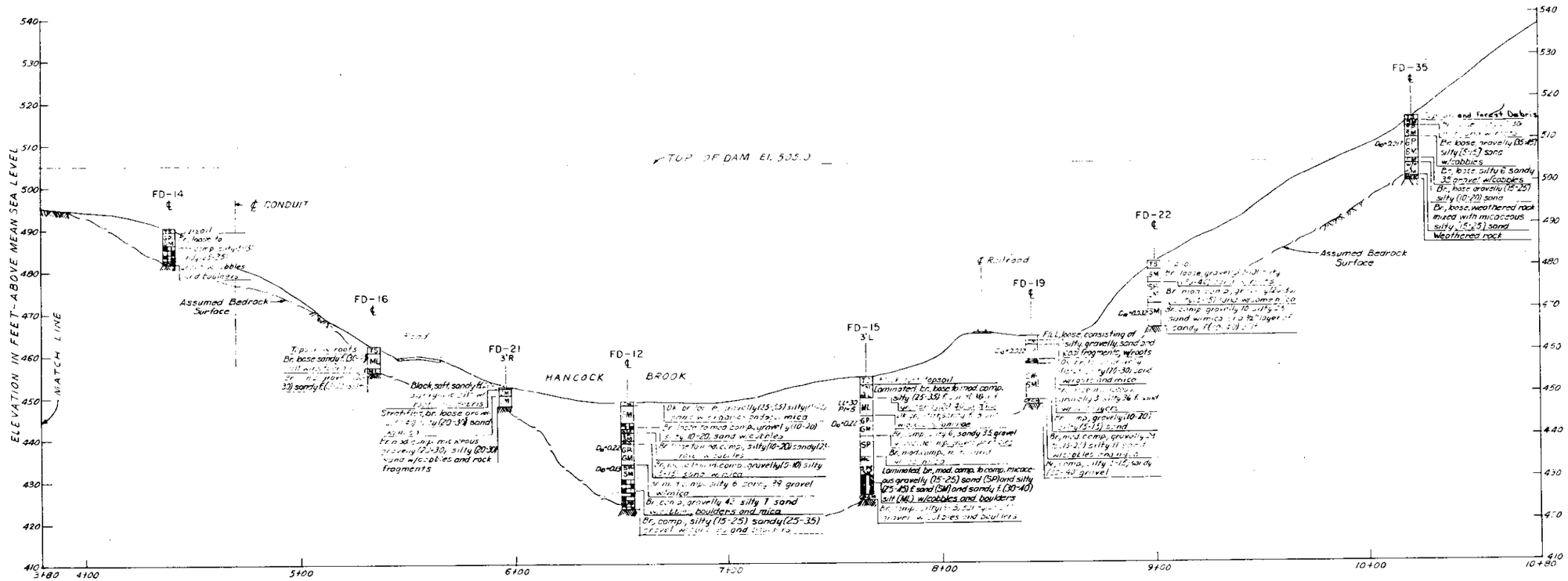
HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

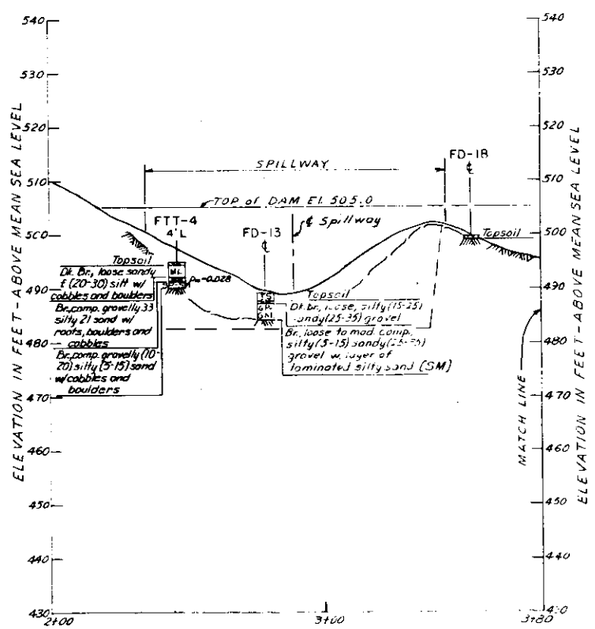
PLAN OF BORROW EXPLORATIONS
AREA "A"

HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-6



ENGINEERING LOG PROFILE B-B, ALONG DAM ℄



LOG PROFILE B-B (Continued)

NOTES

For Location of Explorations see Plate 6-5

For Legend of Engineering Logs see Appendix D

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

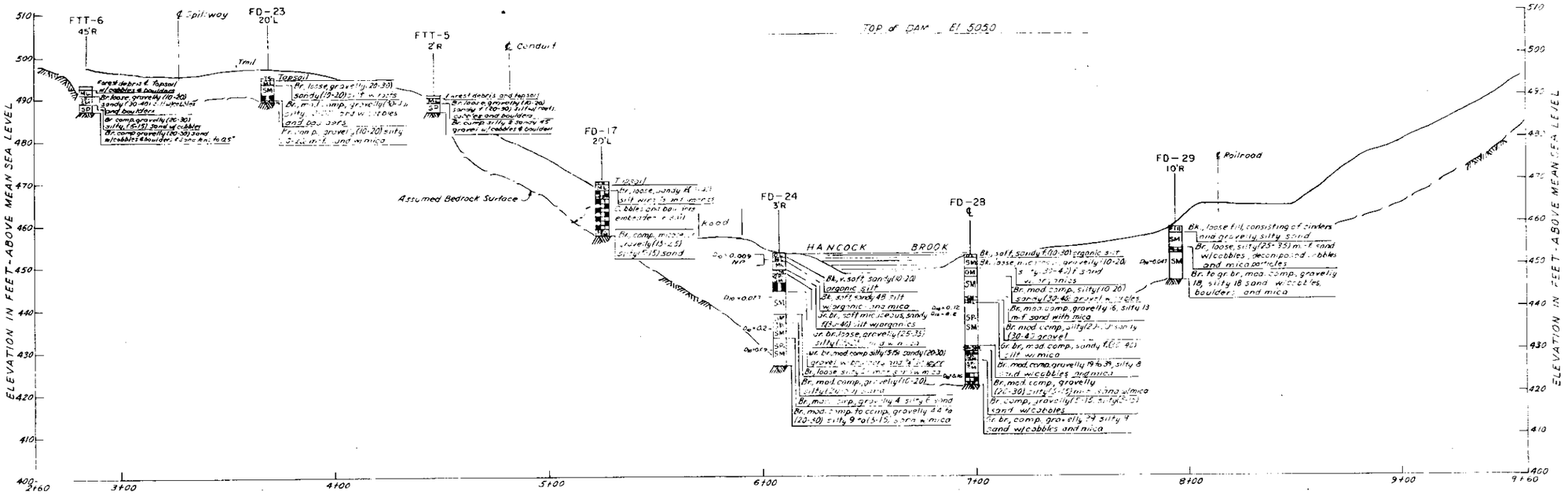
DAM

ENGINEERING LOG PROFILE

B-B

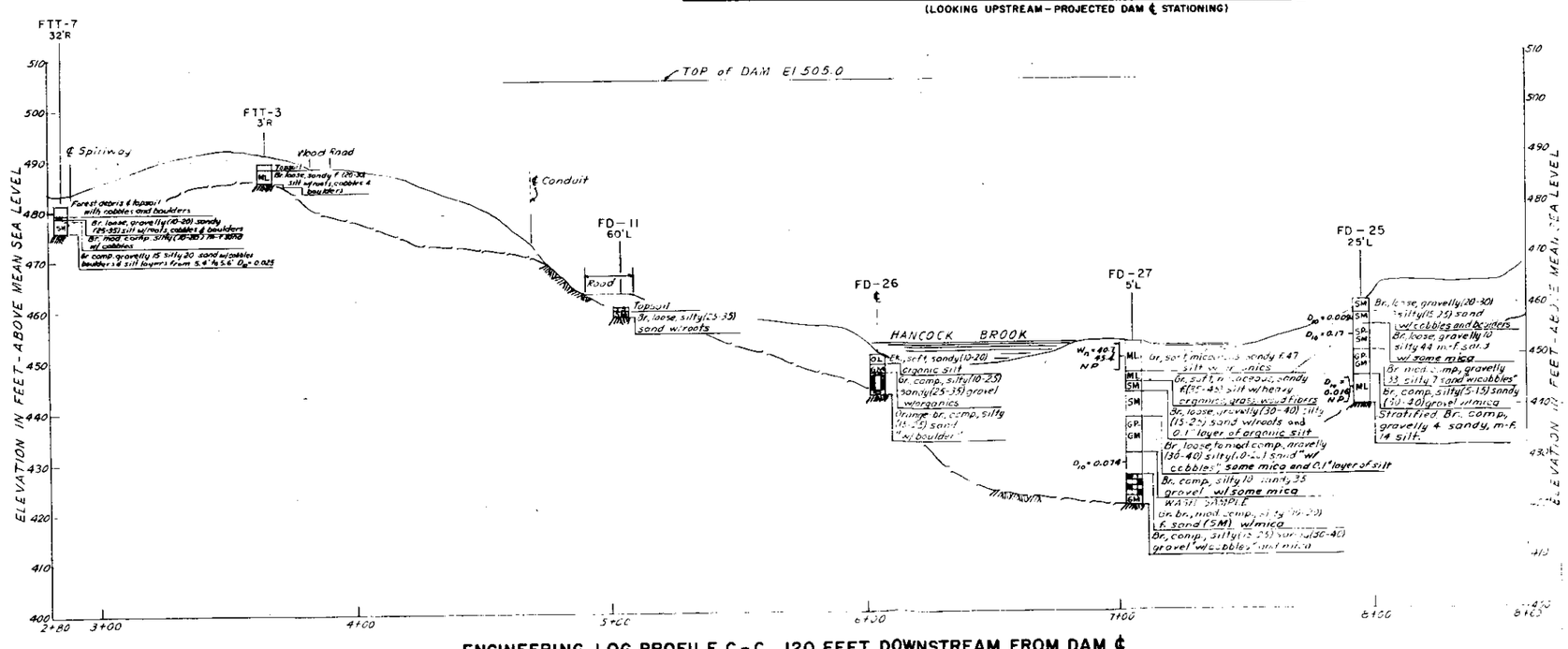
HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-7



ENGINEERING LOG PROFILE A-A, 110 FEET UPSTREAM FROM DAM ℄

(LOOKING UPSTREAM - PROJECTED DAM ℄ STATIONING)



ENGINEERING LOG PROFILE C-C, 120 FEET DOWNSTREAM FROM DAM ℄

(LOOKING UPSTREAM - PROJECTED DAM ℄ STATIONING)

NOTES

For Location of Explorations see Plate No. 6-5

For Legend of Engineering Logs see Appendix D

HOUSATONIC RIVER FLOOD CONTROL

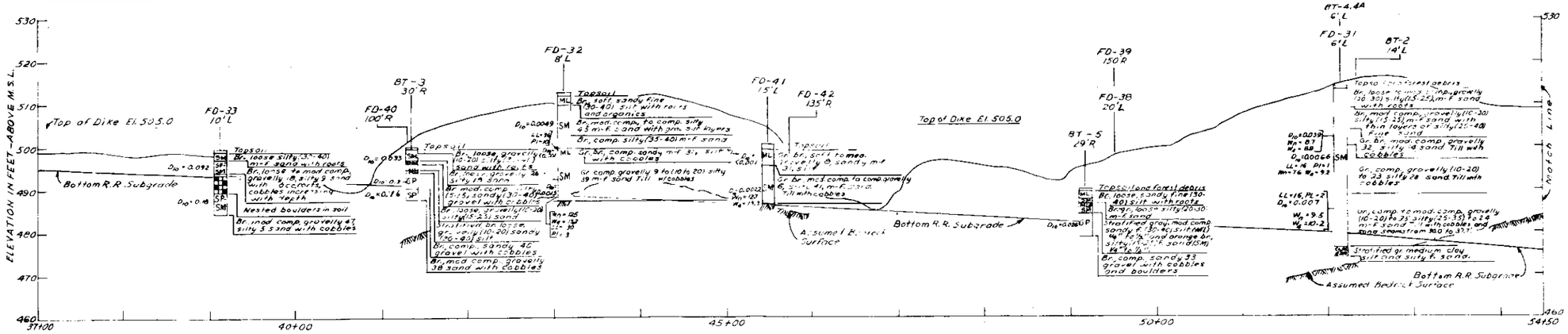
HANCOCK BROOK DAM

DAM

ENGINEERING LOG PROFILE

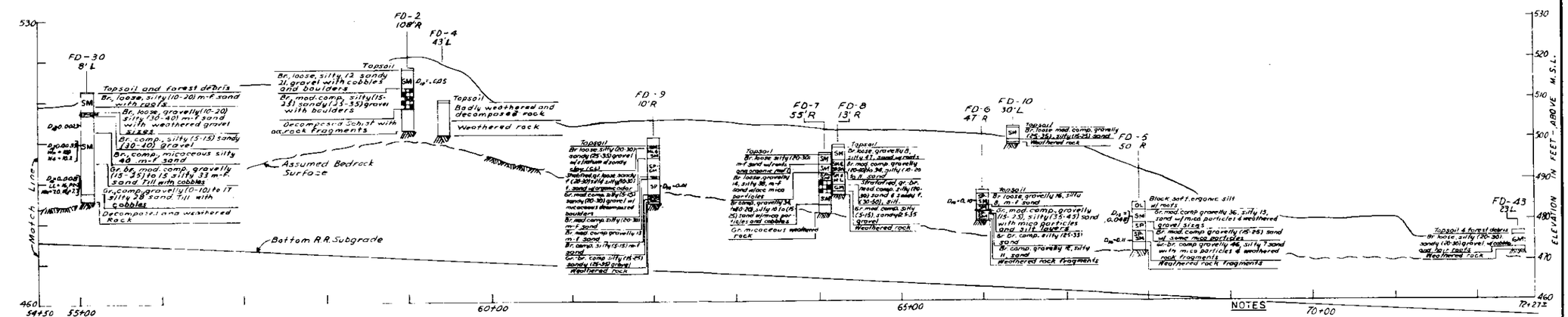
A-A AND C-C

HANCOCK BROOK, CONNECTICUT



ENGINEERING LOG PROFILE D-D, ALONG ℄ OF RAILROAD RELOCATION (continued)

(LOOKING SOUTHEAST)



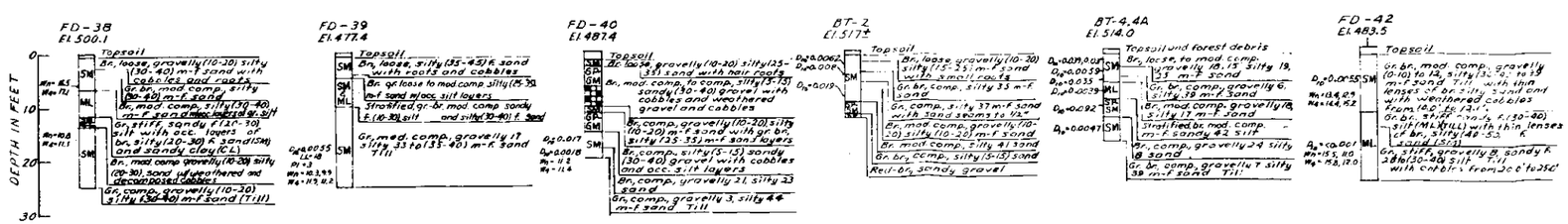
ENGINEERING LOG PROFILE D-D, (continued)

NOTES

Elevations refer to Mean Sea Level Datum

For Location of Log Profile see Plate No. 6-5

For Legend of Engineering Logs, see Appendix D.



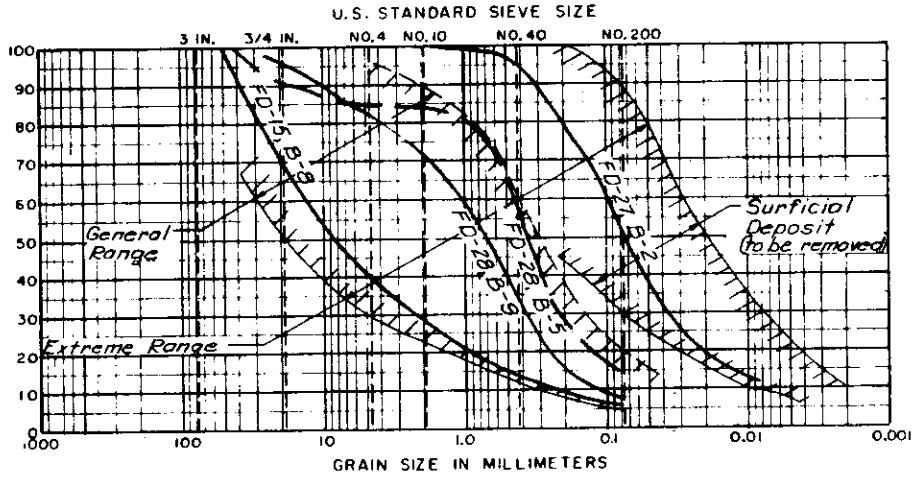
HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

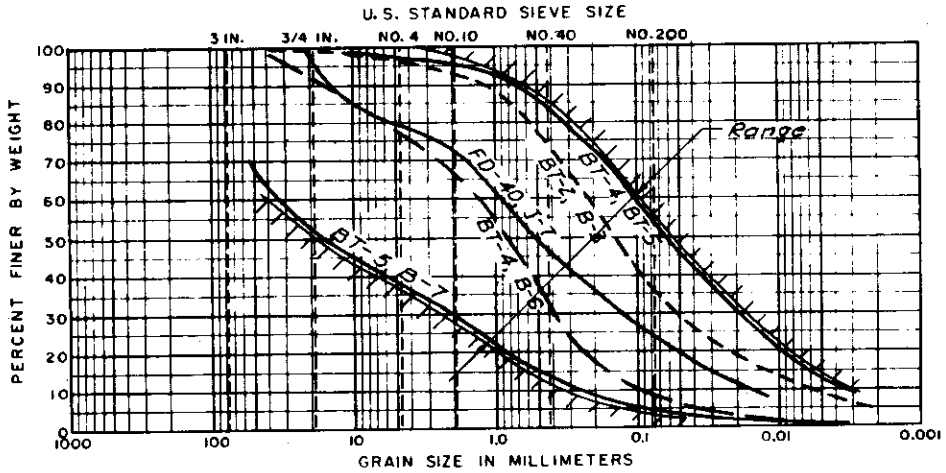
RAILROAD RELOCATION,
ENGINEERING LOG ℄
PROFILE D-D

HANCOCK BROOK, CONNECTICUT

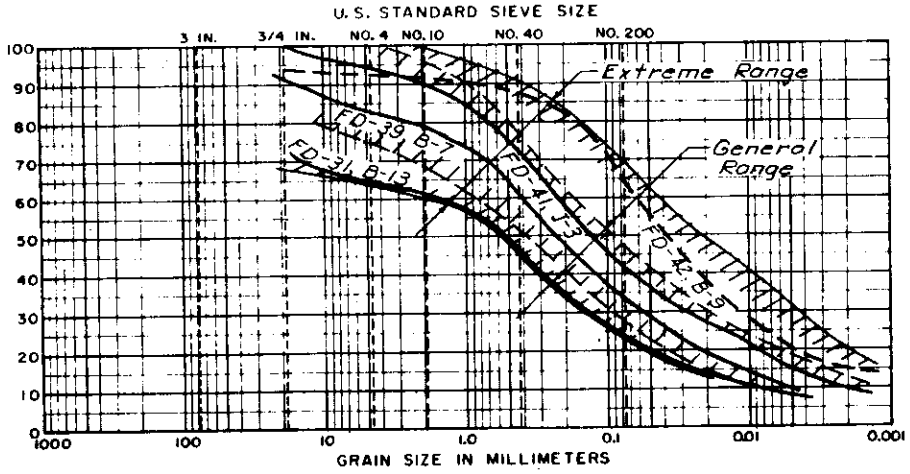
DAM



DIKE



OUTWASH MATERIAL



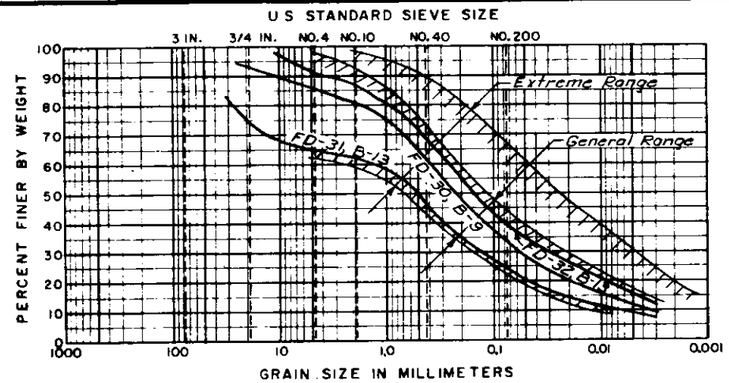
GLACIAL TILL

HOUSATONIC RIVER FLOOD CONTROL

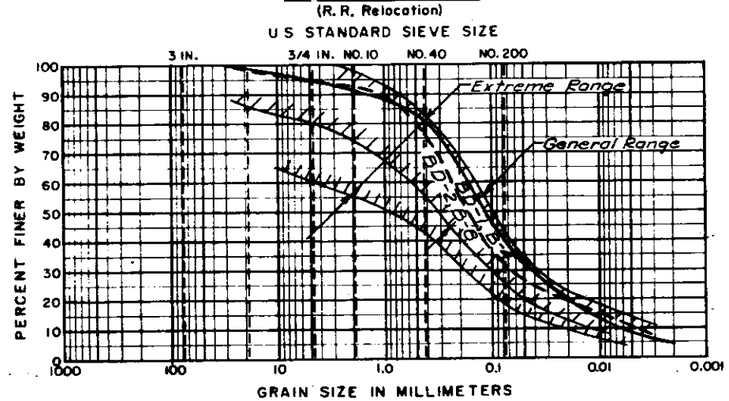
HANCOCK BROOK DAM

SELECTED TEST DATA
FOUNDATIONS
DAM AND DIKE

HANCOCK BROOK, CONNECTICUT

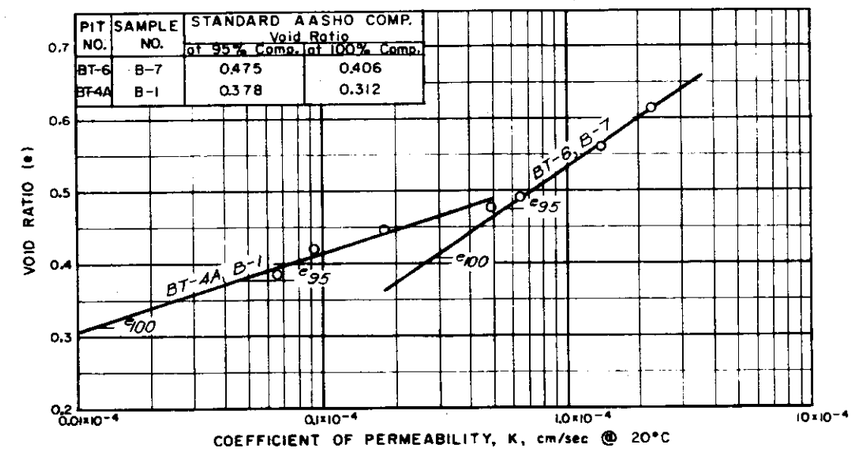


Required Excavations
(R. R. Relocation)

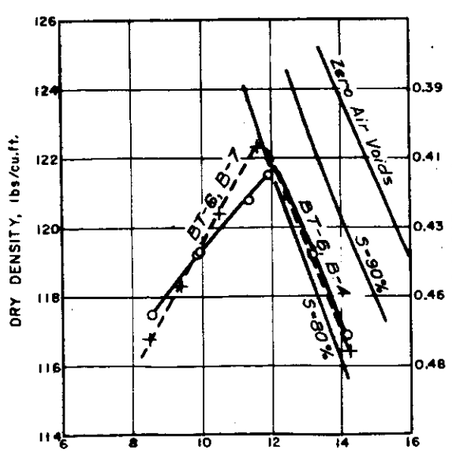


Area "A"

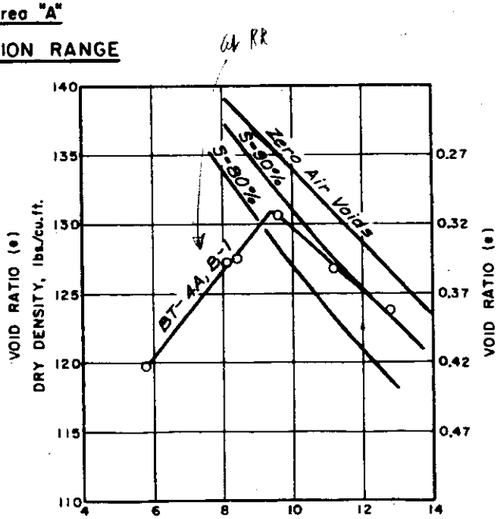
GRADATION RANGE



PERMEABILITY vs VOID RATIO

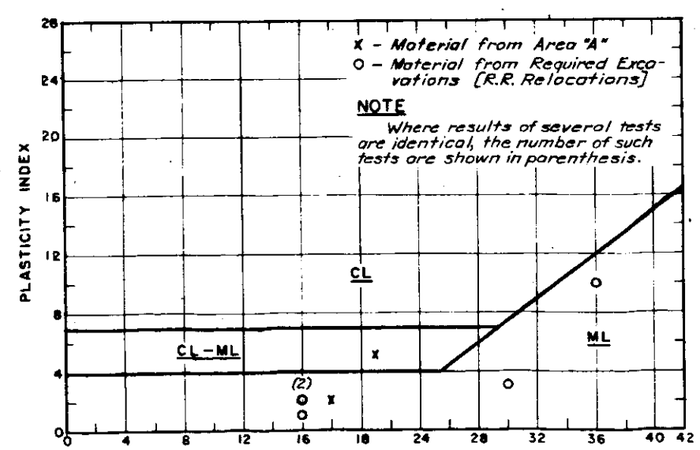


Area "A"



Required Excavations
(R R Relocation)

STANDARD AASHO COMPACTION TEST CURVES



ATTERBERG LIMITS

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

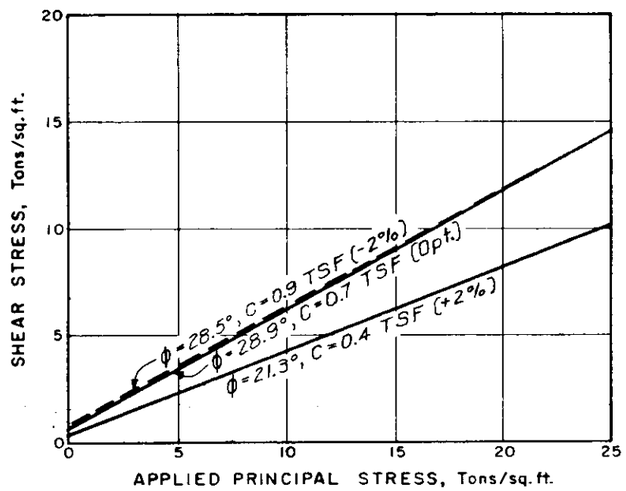
SELECTED TEST DATA

IMPERVIOUS EMBANKMENT MATERIALS

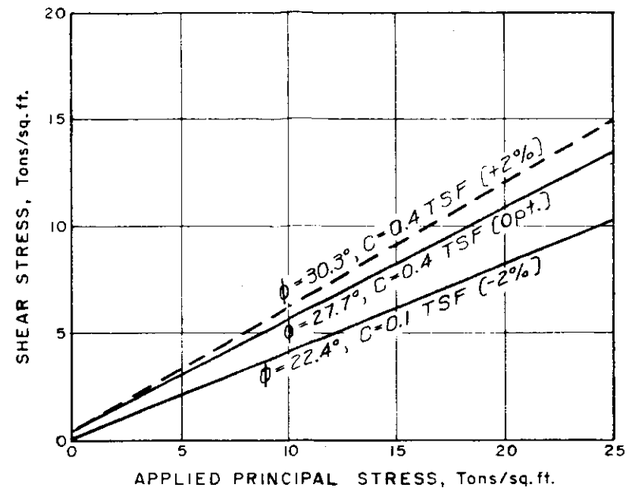
AREA "A"

AND REQUIRED EARTH EXCAVATIONS

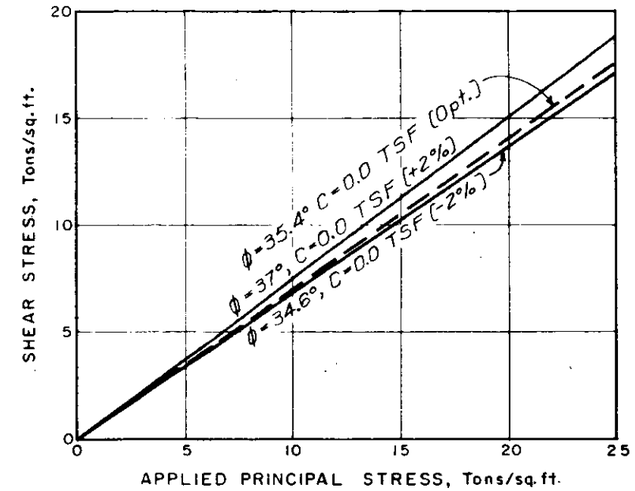
HANCOCK BROOK, CONNECTICUT



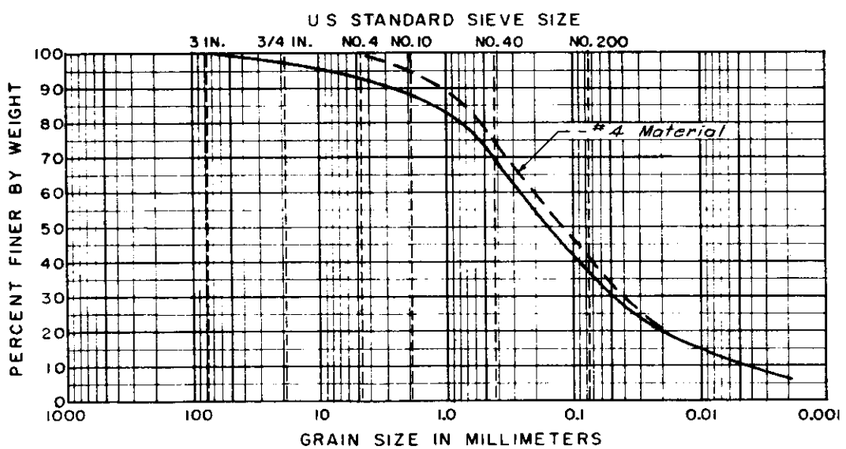
Q TEST (U-U) BT-4A, B-1



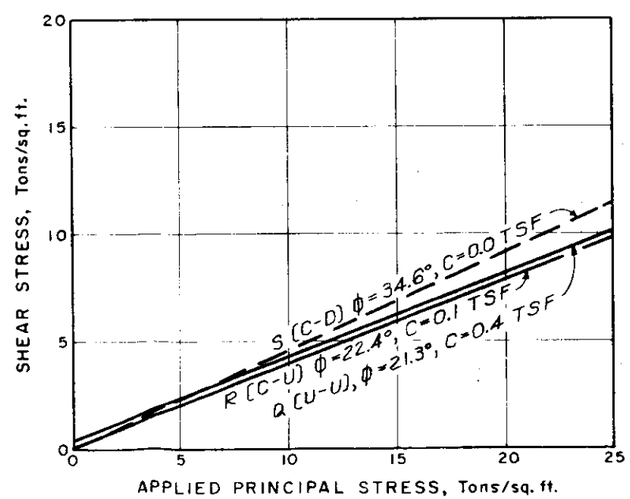
R TEST (C-U) BT-4A, B-1



S TEST (C-D) BT-4A, B-1



GRADATION CURVES BT-4A, B-1



DESIGN SHEAR STRENGTHS

NOTES

Atterberg Limits = Non-Plastic

All tests of triaxial compression type.

Tests performed on component of samples passing No. 4 Sieve.

Figures in parenthesis represent differences between molding water content and optimum water content.

Detailed Shear Test Data bound in Appendix B.

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

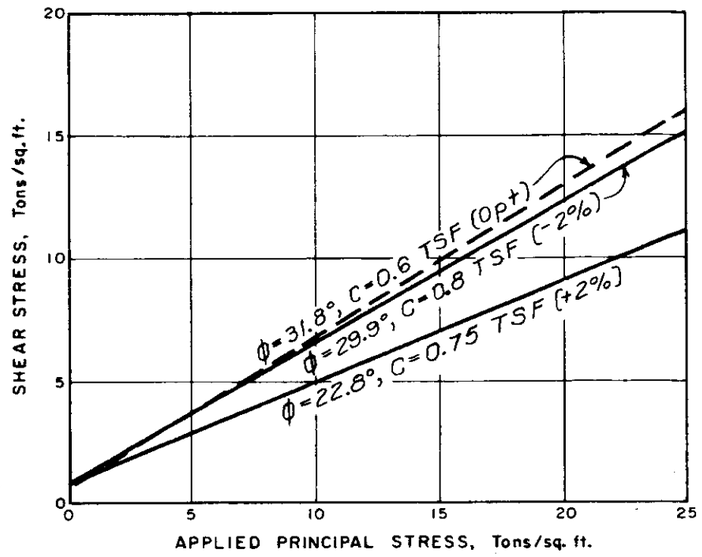
SELECTED SHEAR STRENGTH DATA

IMPERVIOUS EMBANKMENT MATERIAL

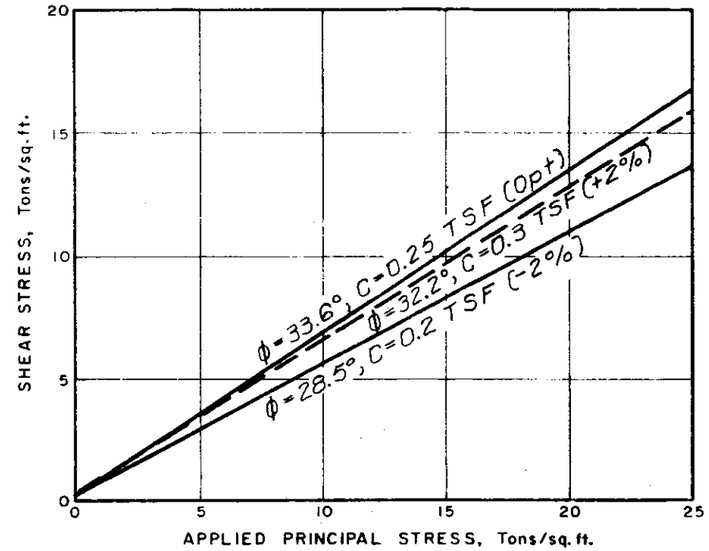
FROM

REQUIRED EARTH EXCAVATIONS

HANCOCK BROOK, CONNECTICUT



Q TEST (U-U) BT-6, B-4



R TEST (C-U) BT-6, B-4

NOTES

Atterberg Limits = Non-Plastic.

All tests of triaxial compression type.

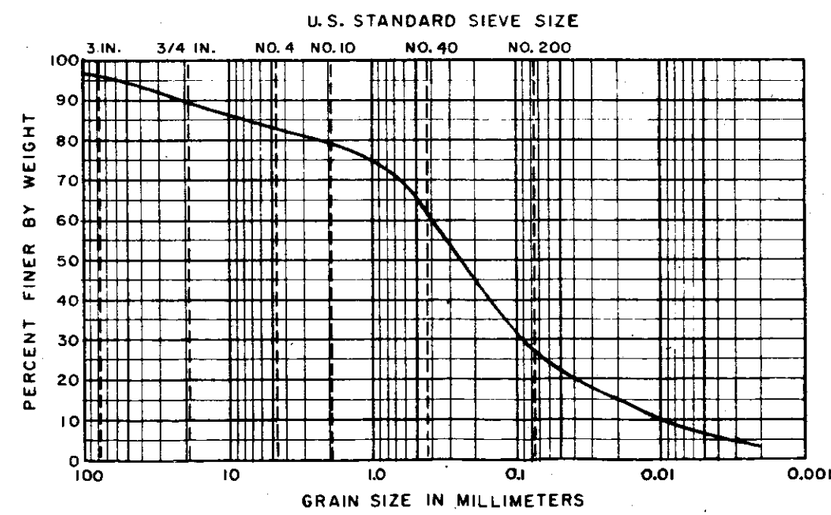
Tests performed on component of samples passing No. 4 Sieve.

Figures in parenthesis represent differences between molding water content and optimum water content.

Detailed shear data bound in Appendix B

Not Completed
to be Submitted Later

S TEST (C-D) BT-6, B-4



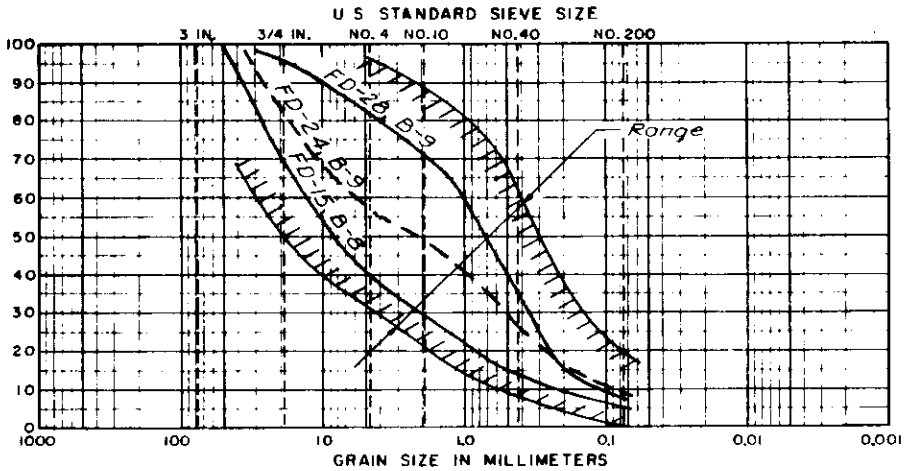
GRADATION CURVE
(BT-6, B-4)

HOUSATONIC RIVER FLOOD CONTROL

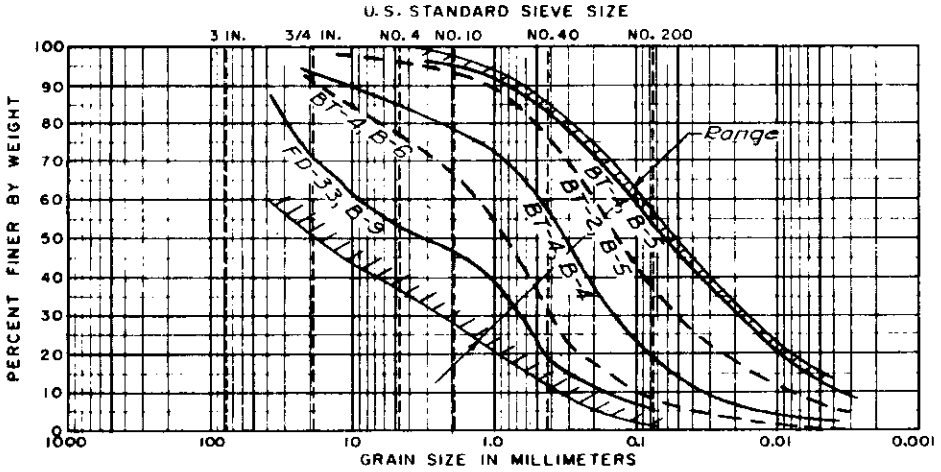
HANCOCK BROOK DAM

SELECTED SHEAR STRENGTH DATA
IMPERVIOUS EMBANKMENT MATERIAL
AREA "A"

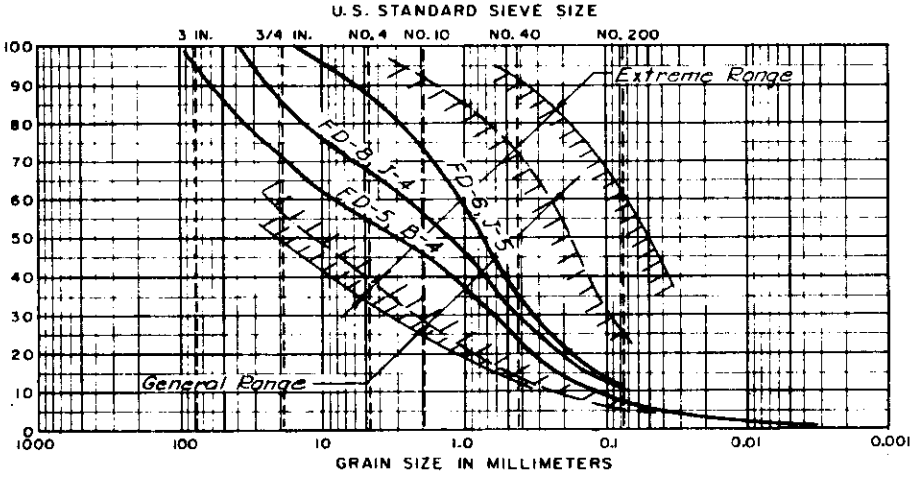
HANCOCK BROOK, CONNECTICUT



Material from Excavation in Dam Foundation and Spillway Channel
(Pervious Fill)



Outwash Materials from Excavations in R.R. Relocation
(Sta. 35+00 to Sta. 59+00)
(Random Fill)



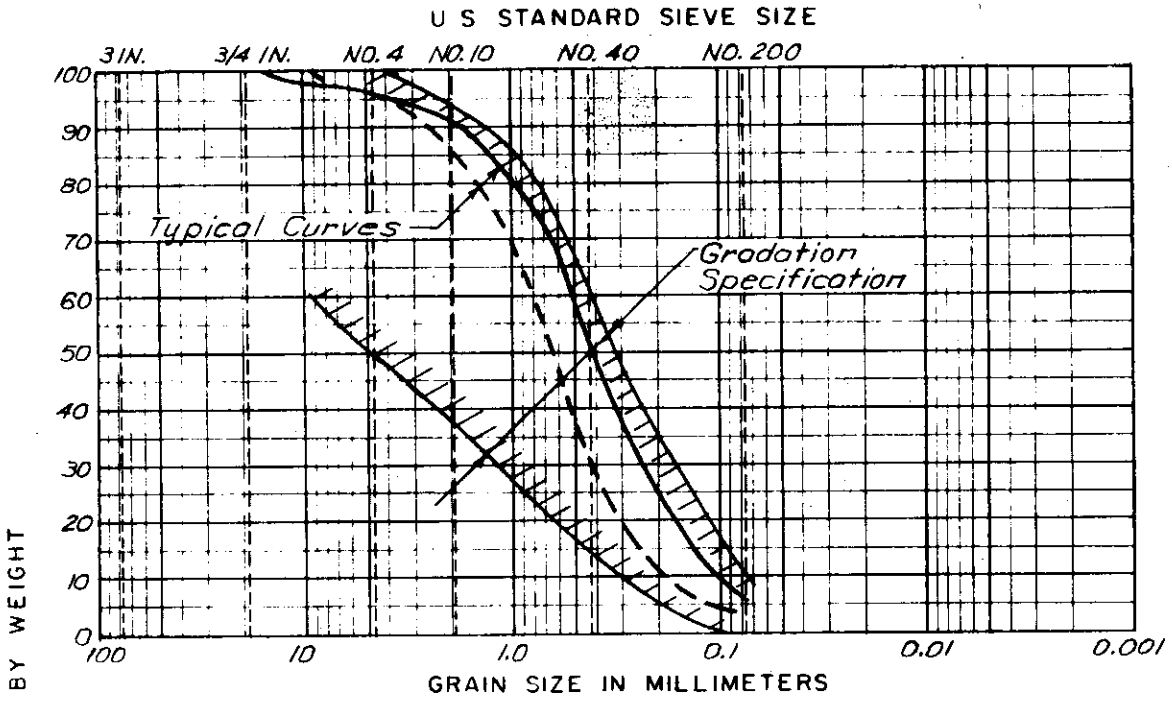
Outwash Materials from Excavations in R R Relocation
(Sta. 59+00 to Sta. 91+00)
(Random Fill)

HOUSATONIC RIVER FLOOD CONTROL

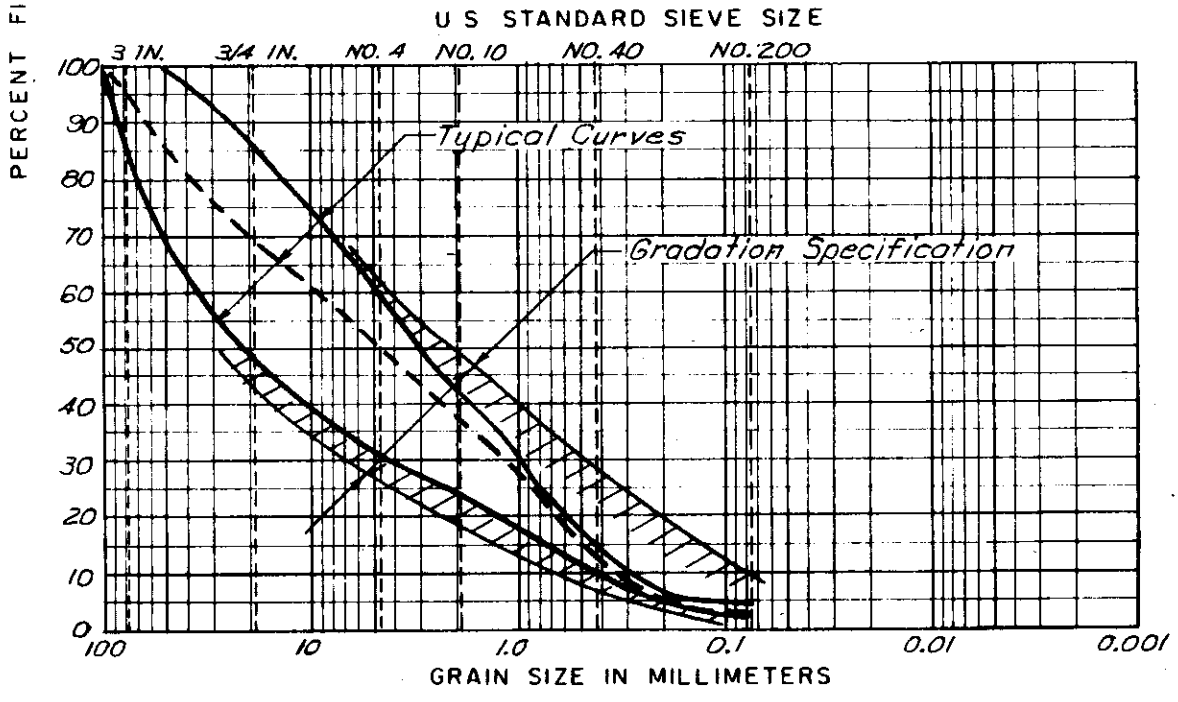
HANCOCK BROOK DAM
SELECTED TEST DATA
RANDOM AND PERVIOUS
EMBANKMENT MATERIALS
FROM
REQUIRED EARTH EXCAVATIONS

HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-14



SAND FILL



GRAVEL FILL and GRAVEL BEDDING

HOUSATONIC RIVER FLOOD CONTROL

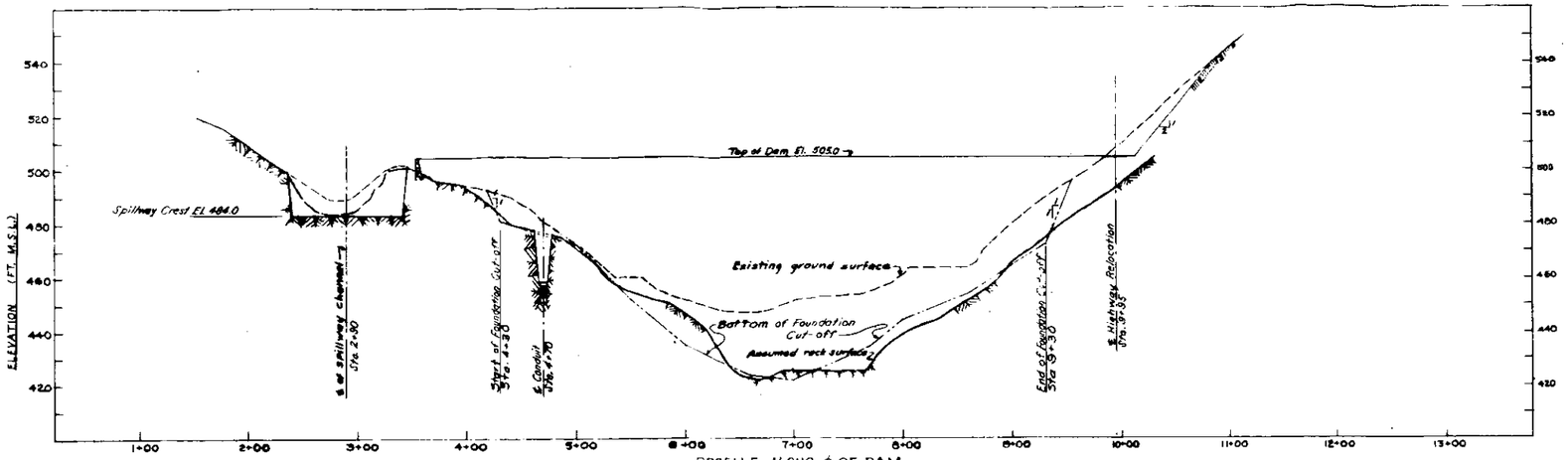
HANCOCK BROOK DAM

SELECTED TEST DATA

PERVIOUS EMBANKMENT MATERIALS

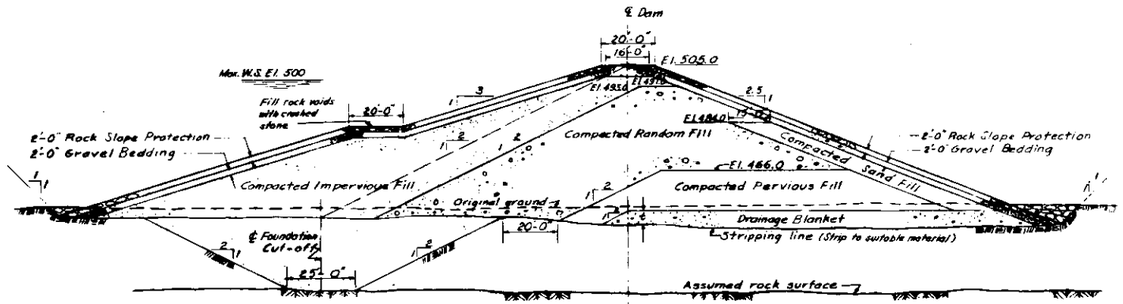
HANCOCK BROOK, CONNECTICUT

CORPS OF ENGINEERS U.S. ARMY



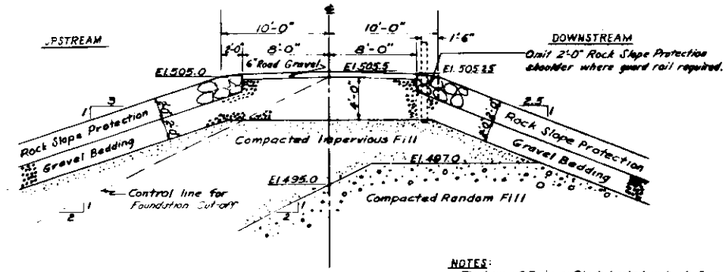
PROFILE ALONG ℄ OF DAM

Scales: Hor. 1" = 50' Vert. 1" = 20'



SECTION - STA. 7+00

Scale: 1" = 20'



TOP OF DAM DETAIL

Scale: 1" = 5'

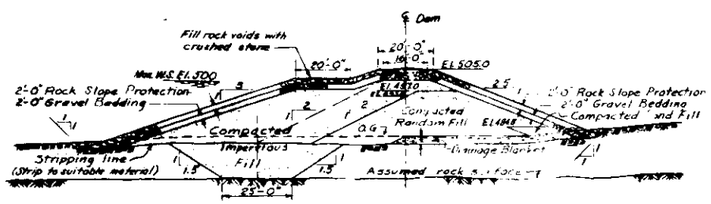
NOTES:

Thickness of Drainage Blanket, which extends from Sta. 4+50 to Sta. 9+20, shall be as follows:

Location	X
Sta. 4+50 to 5+20	3"
Sta. 5+20 to 8+00	6"
Sta. 8+00 to 9+20	3"

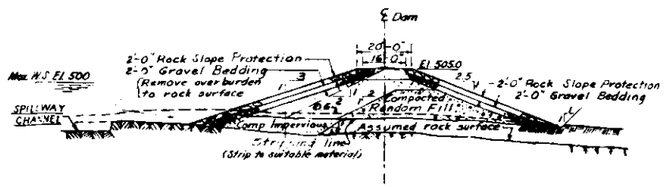
Foundation Cut-off side slopes shall be as follows:

Location	Slope
Sta. 4+30 to 5+30	1 on 1.5
Sta. 5+30 to 8+50	1 on 2.0
Sta. 8+50 to 9+30	1 on 1.5



SECTION - STA. 9+00

Scale: 1" = 20'



SECTION - STA. 4+50

Scale: 1" = 20'

GRAPHIC SCALES

1" = 5' 5 0 5' 10'

1" = 20' 20' 0 20' 40'

1" = 50' 50' 0 50' 100'

HOUSATONIC RIVER FLOOD CONTROL

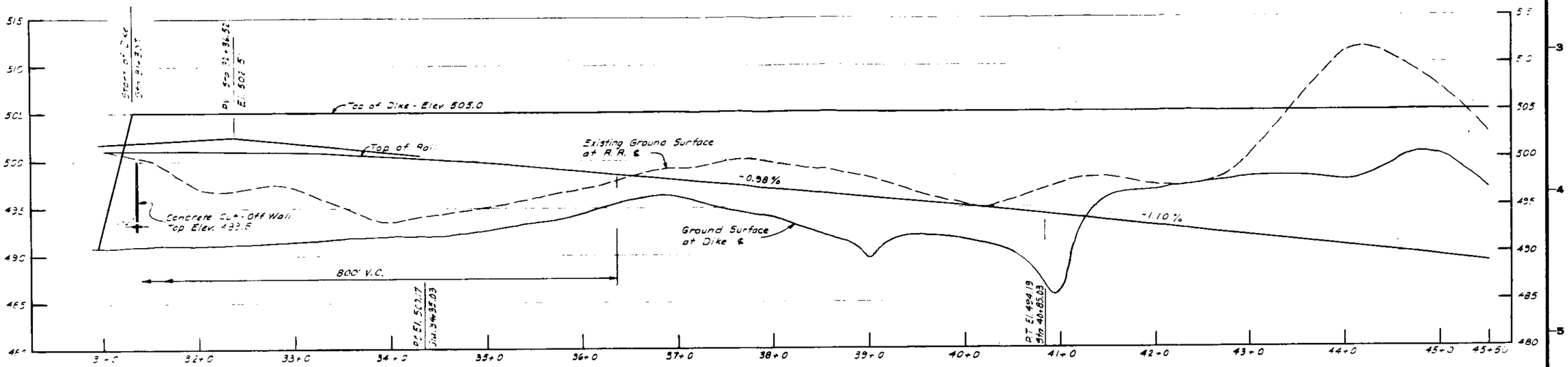
HANCOCK BROOK DAM

DAM

TYPICAL EMBANKMENT SECTIONS AND PROFILE

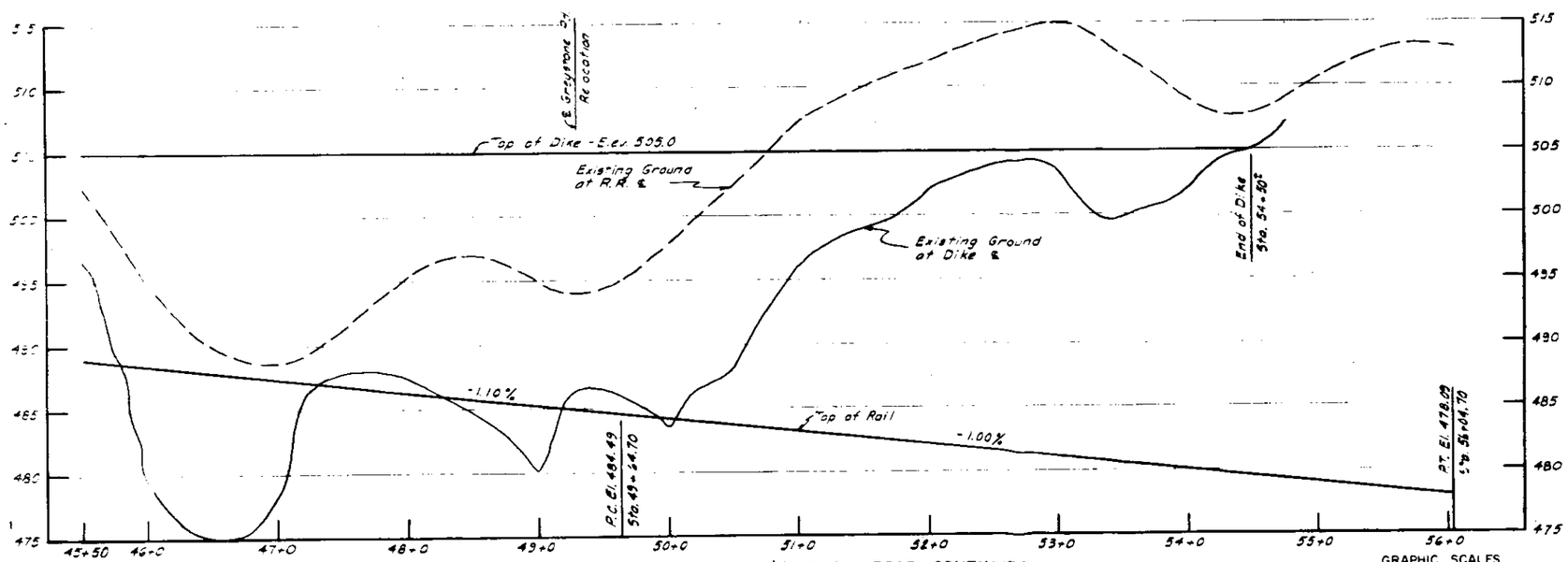
HANCOCK BROOK, CONNECTICUT

PLATE NO. 6-16



PROFILE ALONG ℄ OF RAILROAD

SCALE: HOR. 1"=50' VERT. 1"=5'



PROFILE ALONG ℄ OF RAILROAD CONTINUED

SCALE HOR 1" = 50' VERT 1" = 5'

GRAPHIC SCALES

1" = 5' 5' 0 5' 10'

1" = 50' 50' 0' 50' 100'

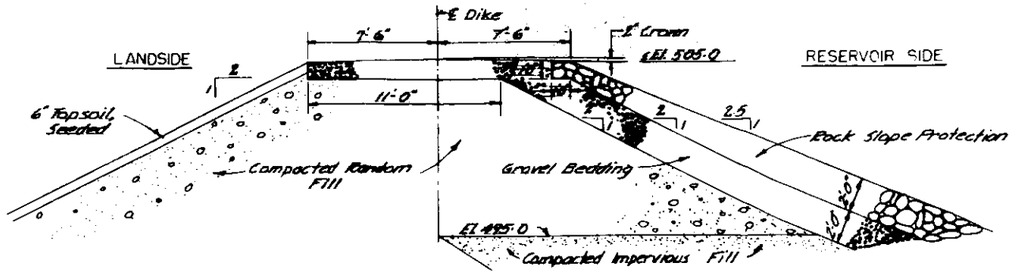
NOTES:

1. All Elevations refer to mean sea level datum.
2. Stationing refers to R.R. centerline

HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
DIKE

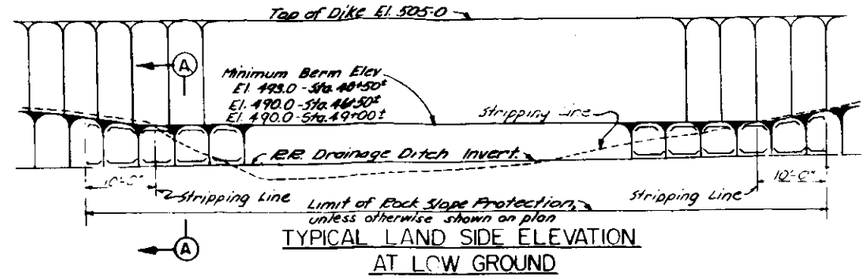
PROFILES

HANCOCK BROOK, CONNECTICUT

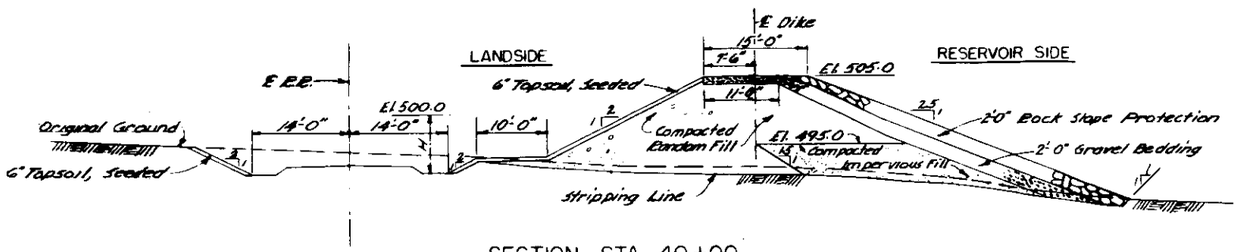


TOP OF DIKE DETAIL

SCALE = 1" = 4'-0"

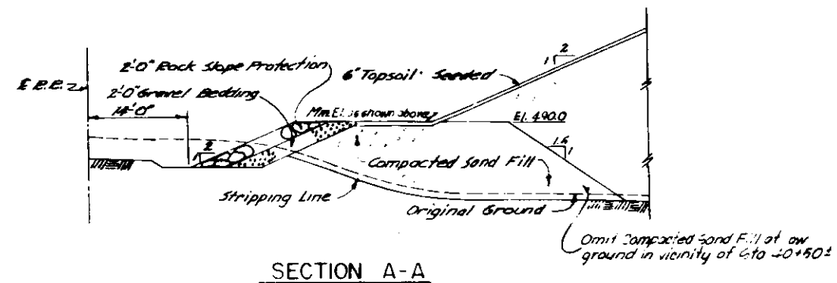


TYPICAL LAND SIDE ELEVATION AT LOW GROUND

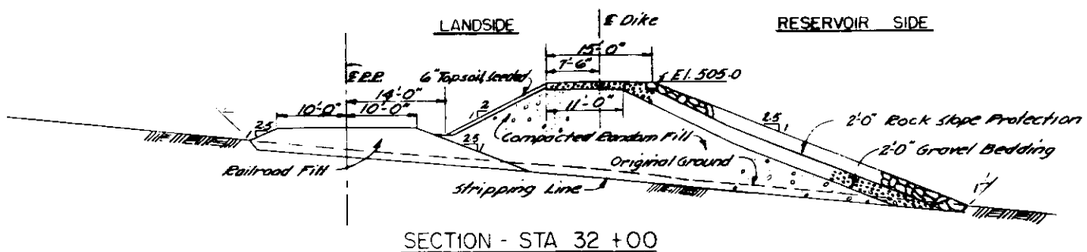


SECTION - STA 40+00

(TYPICAL FROM STA 36+00 TO STA 41+00)



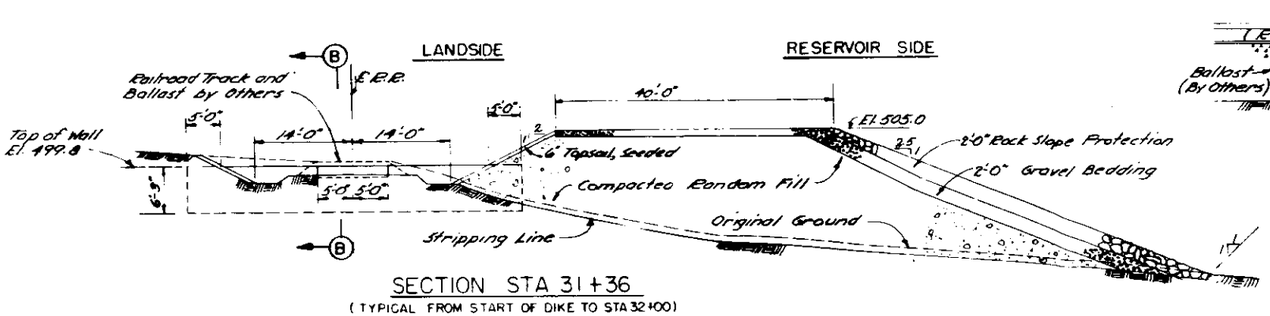
SECTION A-A



SECTION - STA 32+00

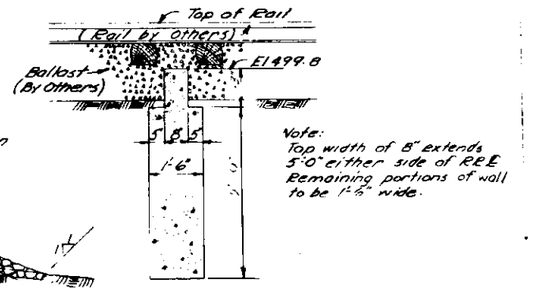
(TYPICAL FROM STA 32+00 TO STA 36+00)

Notes:
All Elevations refer to Mean Sea Level Datum
Stationing refers to Railroad Center Line



SECTION STA 31+36

(TYPICAL FROM START OF DIKE TO STA 32+00)
SHOWING CUT-OFF WALL AT STA 31+36



SECTION B-B

SCALE 1/2" = 1'-0"

GRAPHIC SCALES

1/2" = 1'-0"

1" = 10'

HOUSATONIC RIVER FLOOD CONTROL

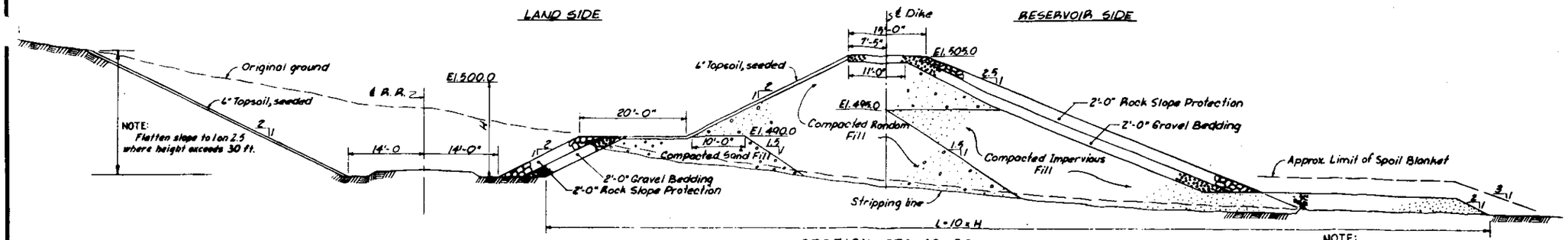
HANCOCK BROOK DAM

DIKE

TYPICAL EMBANKMENT SECTIONS

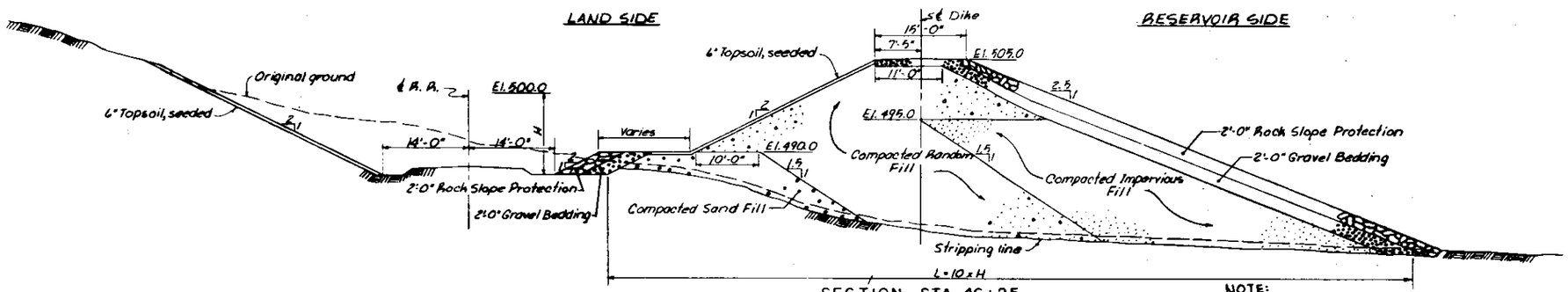
NO. 1

HANCOCK BROOK, CONNECTICUT



SECTION - STA. 49+00
(TYPICAL FROM STA. 46+50 TO STA. 54+50)
SCALE 1" = 10'

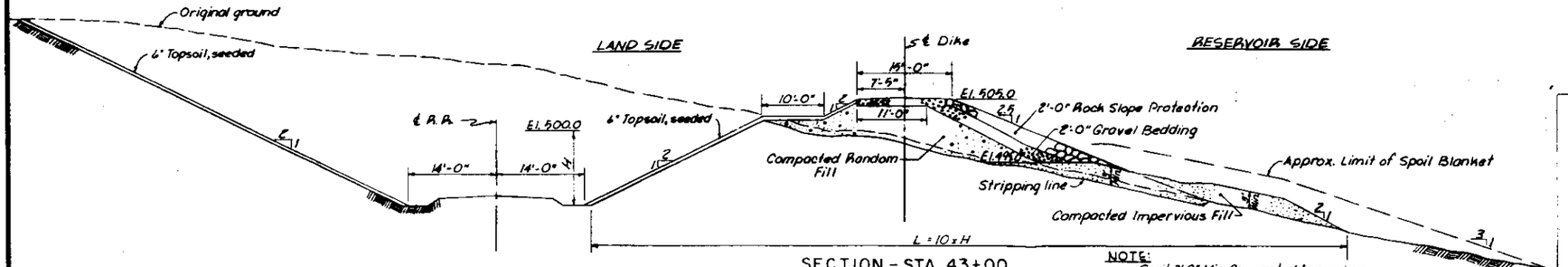
NOTE:
Omit 3'-0" Min. Compacted Impervious Fill blanket under highway embankment and beyond Sta. 51+00.



SECTION - STA. 46+25
(TYPICAL FROM STA. 46+00 TO STA. 46+50)
SCALE 1" = 10'

NOTE:
Omit 3'-0" Min. Compacted Impervious Fill blanket where Distance L does not extend outside toe of dike, and between Stas. 46+00 and 46+75.

NOTES:
All elevations refer to Mean Sea Level Datum.
Stationing refers to Railroad Centerline.



SECTION - STA. 43+00
(TYPICAL FROM STA. 41+00 TO STA. 46+00)
SCALE 1" = 10'

NOTE:
Omit 3'-0" Min. Compacted Impervious Fill blanket where Distance L does not extend outside toe of dike.

GRAPHIC SCALE
1" = 10'
10' 0 10' 20'

HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
DIKE
TYPICAL EMBANKMENT SECTIONS
NO. 2
HANCOCK BROOK, CONNECTICUT

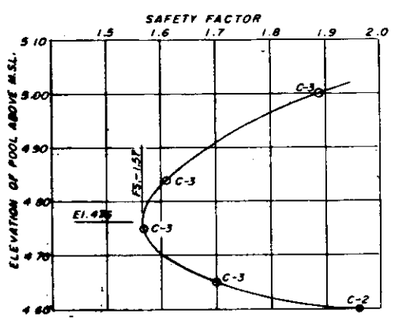
SUMMARY OF STABILITY ANALYSES

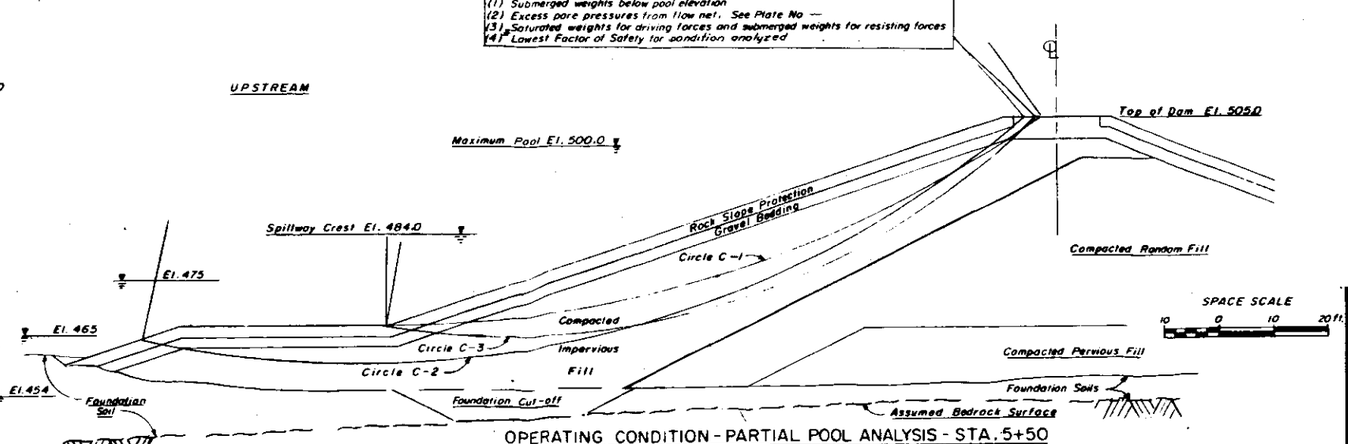
CASE	PORE PRESSURE ASSUMPTION	COMPUTED SAFETY FACTOR: Upstream Slope ARC	Upstream Slope FS	Downstream Slope ARC	Downstream Slope FS
1. CONSTRUCTION CONDITION					
Q Strength					
a. Sta. 6+60	–	—	—	A-1	1.71
				A-2	1.65 *
				A-3	1.81
				A-4	1.67
b. Sta. 6+40	–	B-1	2.44	—	—
		B-2	2.88		
		B-3	2.10		
		B-4	2.09		
2. OPERATING CONDITION					
a. Partial Pool Analysis					
R Strength		C-1	1.75 (El. 477)	—	—
(1) Sta. 5+50	(1)	C-2	1.82 (El. 474) *		
		C-3	1.57 (El. 475)		
(2) Sta. 6+40	(1)	D-1	1.64 (El. 465)	—	—
		D-2	1.74 (El. 470)		
		D-3	1.61 (El. 462)		
		D-4	1.72 (El. 460)		
b. Steady Seepage Analysis From Maximum Pool S and R Strengths				E-1	S=1.55, R=1.52 } 1.54
				E-2	S=1.54, R=1.46 } 1.50
(1) Sta. 6+60	(2)	—	—	E-3	S=1.50, R=1.46 } 1.48*
				E-4	S=1.52, R=1.44 } 1.48*
				E-5	S=1.51, R=1.47 } 1.49
				E-6	S=1.50, R=1.49 } 1.50
3. SUDDEN DRAWDOWN					
R Strength					
a. From Maximum Pool (El. 500.0 to El. 454.0)		F-1	1.27	—	—
(1) Sta. 5+50		F-2	1.41 *		
		F-3	1.07		
		F-4	1.10		
(2) Sta. 6+40	(3)	G-1	1.22	—	—
		G-2	1.24		
		G-3	1.36		
		G-4	1.12		
		G-5	1.29		
(3) Sta. 7+70		H 1	1.15	—	—
		H 2	1.16		
		H 3	1.15		
		H 4	1.18		
		H 5	1.24		
		H 6	1.17		
b. From Spillway Crest (El. 484.0 to El. 454.0)					
(1) Sta. 5+50		F-1	1.43	—	—
		F-2	1.58		
		F-3	1.27		
		F-4	1.35		
(2) Sta. 6+40	(3)	G-1	1.32	—	—
		G-2	1.32		
		G-3	1.44		
		G-4	1.31		
		G-5	1.43		
(3) Sta. 7+70		H-1	1.18 *	—	—
		H-2	1.23		
		H-3	1.18 *		
		H-4	1.22		
		H-5	1.35		
		H-6	1.29		

(1) Submerged weights below pool elevation
(2) Excess pore pressures from flow net. See Plate No —
(3) Saturated weights for driving forces and submerged weights for resisting forces
(4) * Lowest Factor of Safety for condition analyzed

DESIGN VALUES

MATERIAL	UNIT WEIGHT (PCF) γ_{Sat}	γ_{Moist}	γ_{Dry}	γ_{Sub}	SHEAR STRENGTH CD (S) φ	CD (S) C,TSF	CU (R) φ	CU (R) C,TSF	UU (Q) φ	UU (Q) C,TSF
Rock Slope Protection	140	–	120	78	35	–	–	–	–	–
Gravel Bedding	145	140	135	83	35	0.0	–	–	–	–
Compacted Sand Fill	138	132	120	76	32	0.0	–	–	–	–
Drainage Blanket	138	132	120	76	32	0.0	–	–	–	–
Compacted Pervious Fill	145	140	130	83	32	0.0	32	0.0	32	0.0
" Impervious Fill	145	140	130	83	34.6	0.0	22.4	0.1	21.3	0.4
" Random Fill	145	140	130	83	34.6	0.0	22.4	0.1	21.3	0.4
Foundation Soil	140	135	125	78	30	0.0	30	0.0	30	0.0





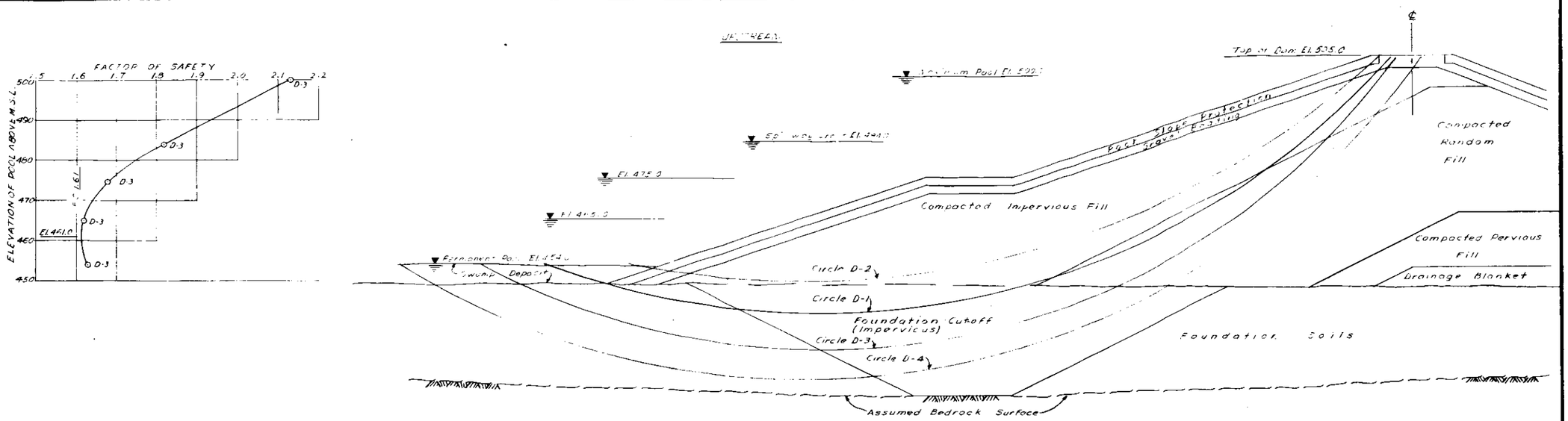
OPERATING CONDITION - PARTIAL POOL ANALYSIS - STA. 5+50

HOUSATONIC RIVER FLOOD CONTROL

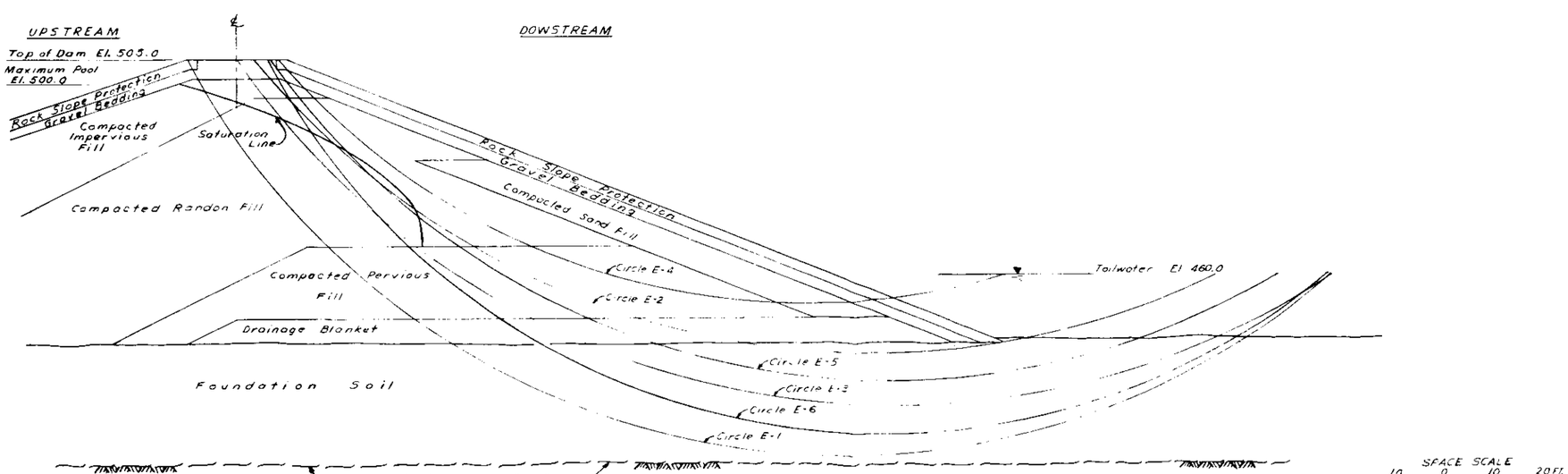
HANCOCK BROOK DAM
DAM

SUMMARY OF STABILITY ANALYSES

HANCOCK BROOK, CONNECTICUT



OPERATING CONDITION — PARTICAL POOL ANALYSIS – STA. 6+40



OPERATING CONDITION – STEADY SEEPAGE ANALYSIS – STA. 6+60

SPACE SCALE
10 0 10 20 FT.

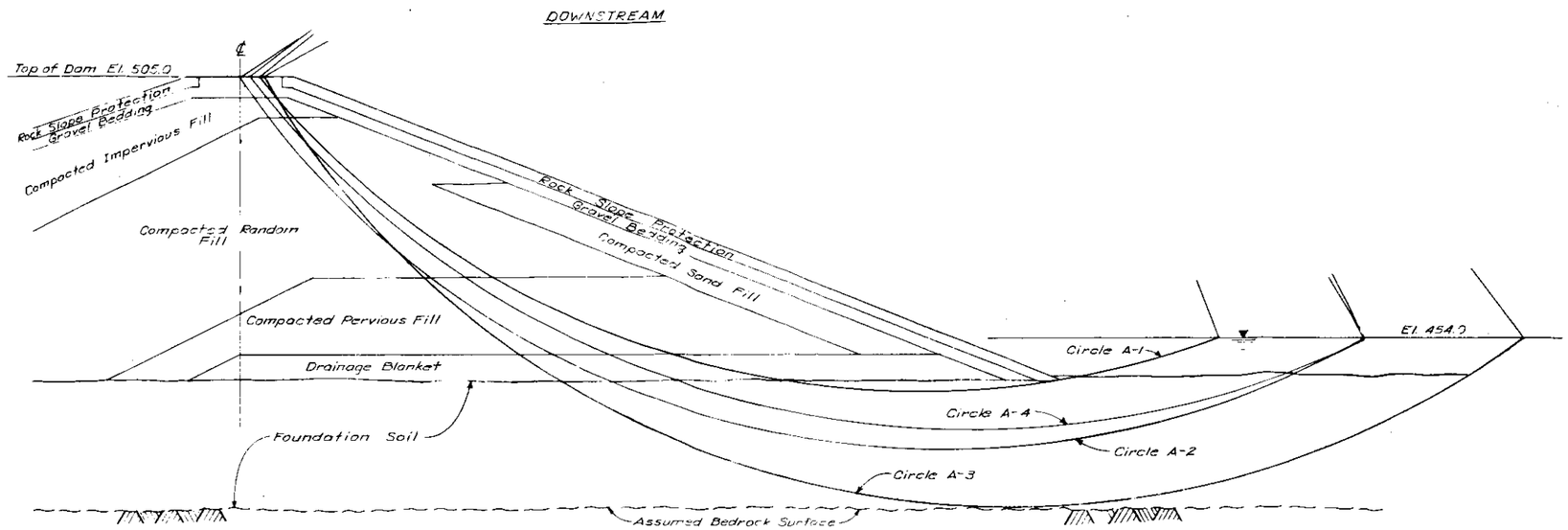
HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM
DAM

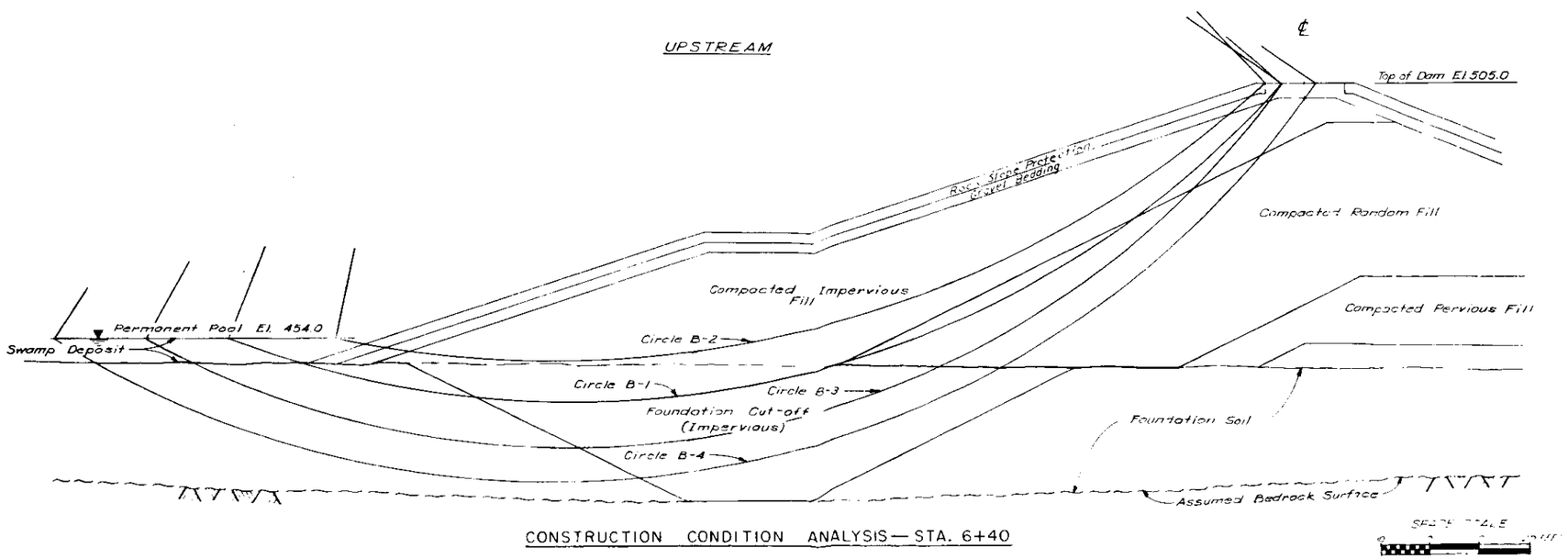
SUMMARY OF STABILITY ANALYSES

HANCOCK BROOK, CONNECTICUT

PLATE NO. 6 - 21



CONSTRUCTION CONDITION ANALYSIS — STA. 6+60



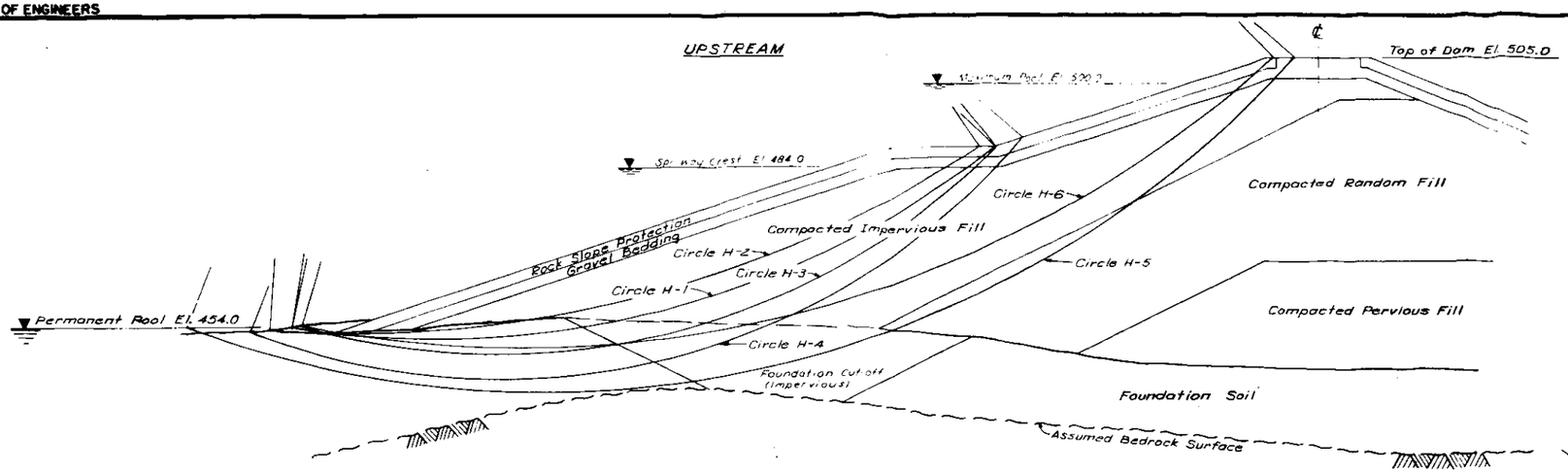
CONSTRUCTION CONDITION ANALYSIS — STA. 6+40

HOUSATONIC RIVER FLOOD CONTROL

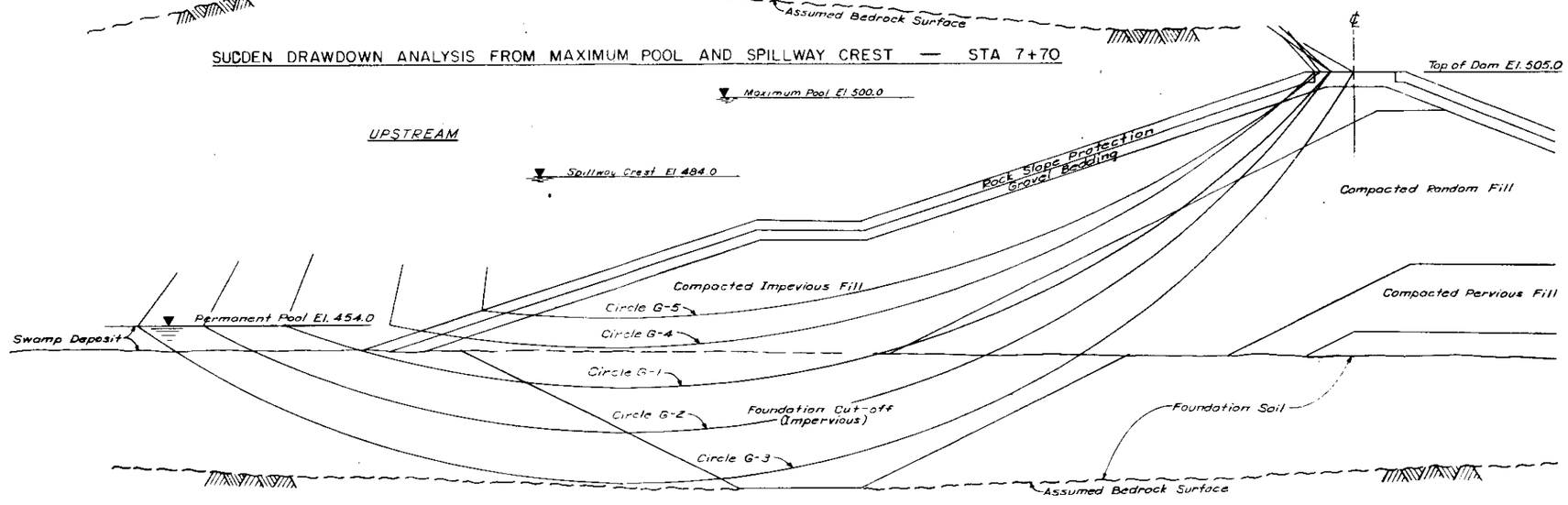
HANCOCK BROOK DAM
DAM

SUMMARY OF STABILITY ANALYSES

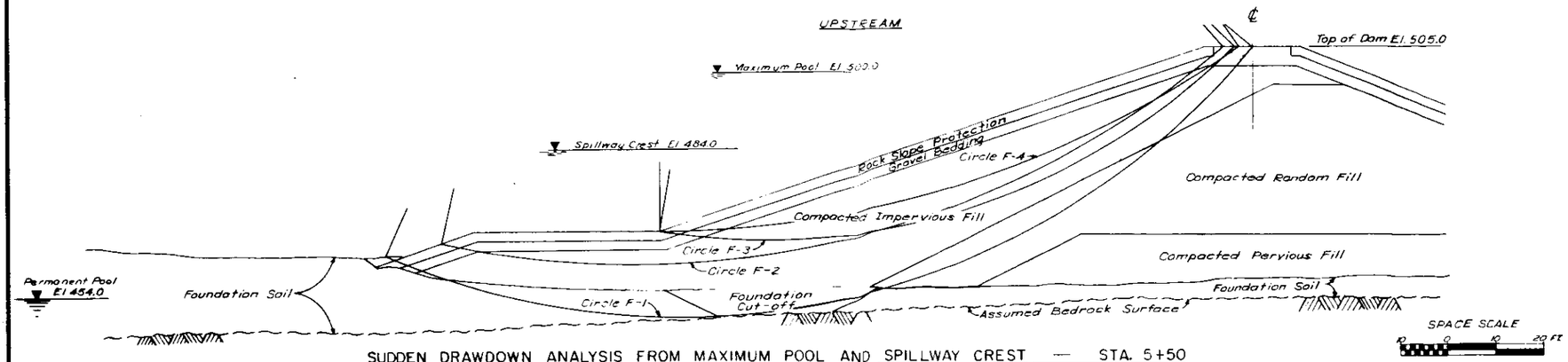
HANCOCK BROOK, CONNECTICUT



SUDDEN DRAWDOWN ANALYSIS FROM MAXIMUM POOL AND SPILLWAY CREST — STA 7+70



SUDDEN DRAWDOWN ANALYSIS FROM MAXIMUM POOL AND SPILLWAY CREST — STA 6+40



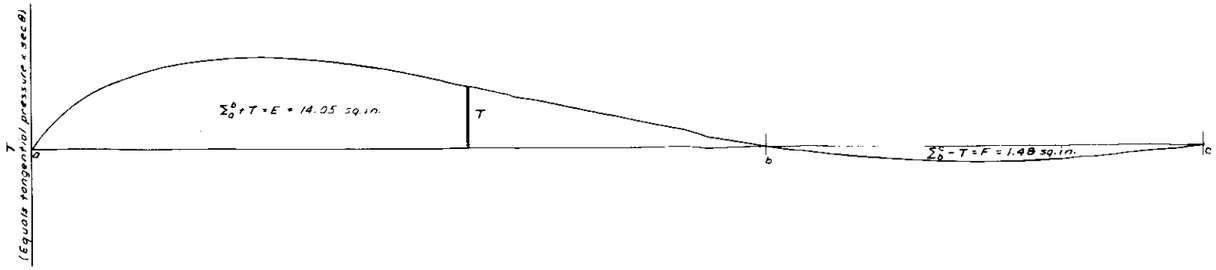
SUDDEN DRAWDOWN ANALYSIS FROM MAXIMUM POOL AND SPILLWAY CREST — STA. 5+50

HOUSATONIC RIVER FLOOD CONTROL

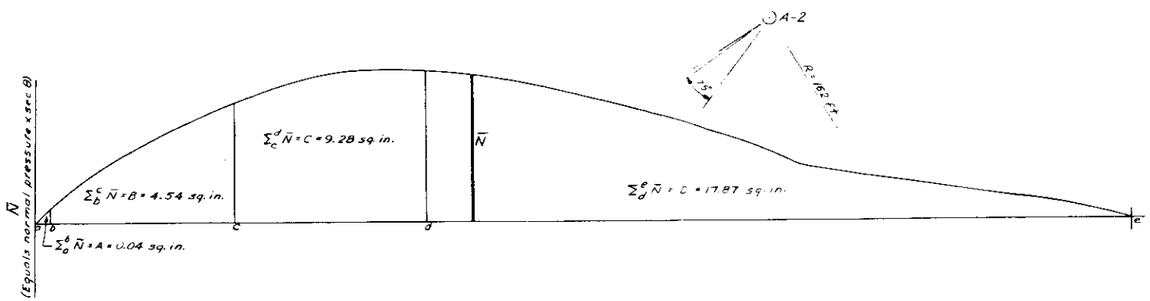
HANCOCK BROOK DAM
DAM

SUMMARY OF STABILITY ANALYSES

HANCOCK BROOK, CONNECTICUT



WEIGHT VECTOR RATIOS 140 LBS = 1.000			
MATERIAL		VECTOR RATIO (V_R)	
Rock Slope Protection	(Dry)	120 ÷ 140	= 0.857
Rock Slope Protection	(Sat)	140 ÷ "	= 1.000
Gravel Bedding	(Moist)	140 ÷ "	= 1.000
Gravel Bedding	(Sat)	145 ÷ "	= 1.036
Sand Fill, Drainage Blanket	(Moist)	132 ÷ "	= 0.945
Sand Fill, Drainage Blanket	(Sat)	138 ÷ "	= 0.985
Compacted Pervious Random Fill	(Moist)	140 ÷ "	= 1.000
Compacted Pervious Random Fill	(Sat)	145 ÷ "	= 1.036
And Impervious Fill	(Sat)	140 ÷ "	= 1.000
Foundation Soil	(Sat)	125 ÷ "	= 0.447
Water			



K = vector scale - inversion factor

$K = 10 \frac{Ft}{In} \times 10 \frac{Ft}{In} \times 140 \frac{Lbs}{Ft^2} \times \frac{1\ kip}{1000\ Lbs} = \frac{14 \times psi}{Sq\ In.}$

RESISTING FORCE = Summation $\bar{N} \tan\phi + \bar{C}L$

$\int_a^e \bar{N} \tan\phi = [A \tan 25° + B \tan 21.3° + C \tan 32° + D \tan 30°]K$

$= [(0.04)(0.70) + (4.54)(0.39) + (9.28)(0.624) + (17.87)(0.577)]14 = 251$ kips

$\bar{C}L = (C + F)\ 40 \ldots\ldots\ldots\ldots = 39$ "

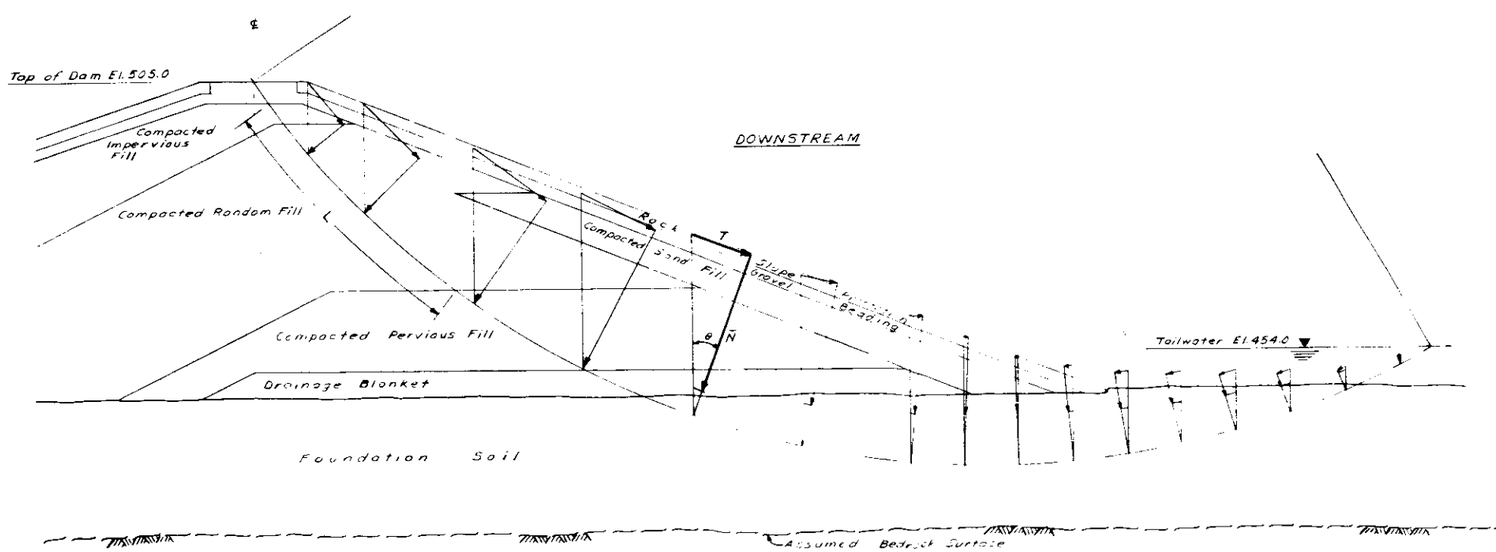
Total Resisting Force, Ft. Dam ... = 290 kips

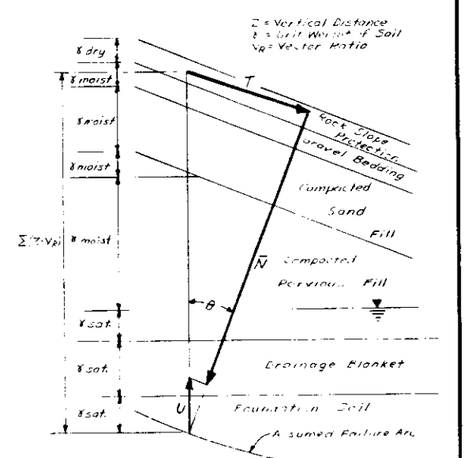
DRIVING FORCE = Summation tangential forces

$\int_a^e T = (E - F)K = (14.05 - 1.48)14 = 176$ kips

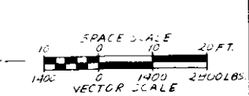
FACTOR OF SAFETY

$F.S. = \frac{\int \bar{N} \tan\phi + \bar{C}L}{\int T} = \frac{290}{176} = 1.65$





TYPICAL VECTOR DIAGRAM



HOUSATONIC RIVER FLOOD CONTROL

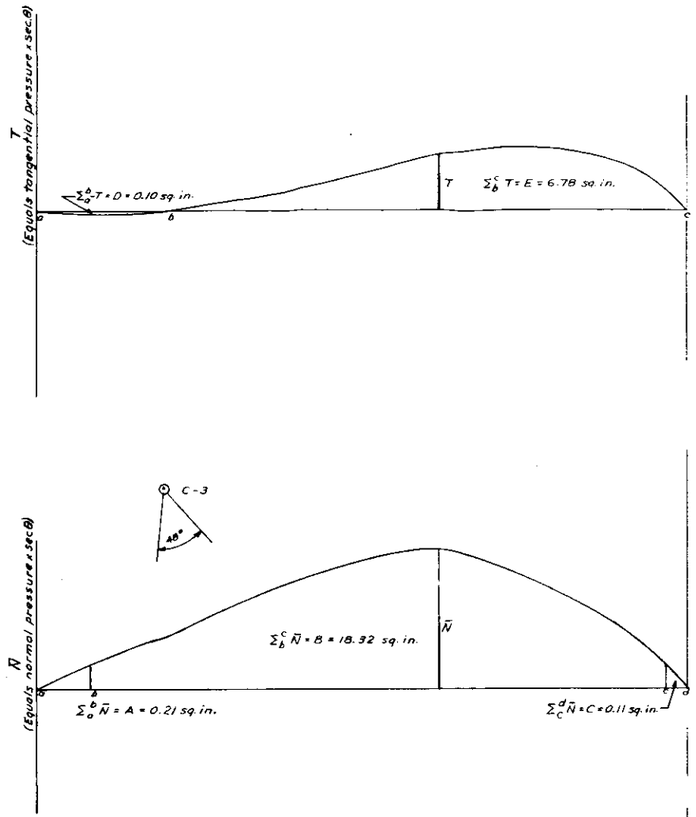
HANCOCK BROOK DAM

DAM

TYPICAL STABILITY ANALYSIS

CONSTRUCTION CONDITION - CIRCLE A-2

HANCOCK BROOK, CONNECTICUT



WEIGHT VECTOR RATIOS 83 LBS. = 1000	
MATERIAL	VECTOR RATIO (V_R)
Rock Slope Protection (Dry)	120 ÷ 83 = 1.446
Rock Slope Protection (Sub)	76 ÷ 83 = 0.916
Gravel Bedding (Moist)	140 ÷ 83 = 1.688
Gravel Bedding (Sub)	83 ÷ 83 = 1.000
Compacted Impervious Fill (Moist)	140 ÷ 83 = 1.688
Compacted Impervious Fill (Sub)	83 ÷ 83 = 1.000

K = Vector Scale Conversion Factor

$K = 10\frac{Ft}{In} \times 10\frac{Ft}{In} \times 83\frac{Lbs}{Sq.Ft.} \times \frac{1\ Kip}{1000\ Lbs} = 8.3\ ^K/sq.in.$

RESISTING FORCE = Summation $\bar{N} \tan\phi + \bar{C}L$

$\int_a^d N \tan\phi = [(A+C)\tan 35° + B \tan 22.4]K$

$= [(0.21+0.11)0.700 + 18.32 \times 0.412]8.3 = \underline{64.5^K}$

$\bar{C}L = 0.2 \times 114 = \underline{22.8^K}$

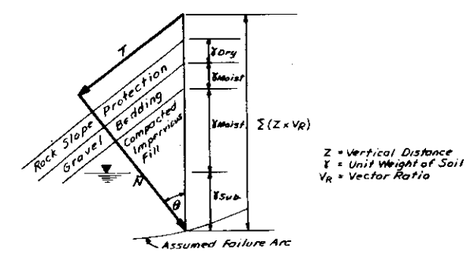
Total Resisting Force/Ft. Dam = 64.5 + 22.8 = $\underline{87.3^K}$

DRIVING FORCE = Summation Tangential Force

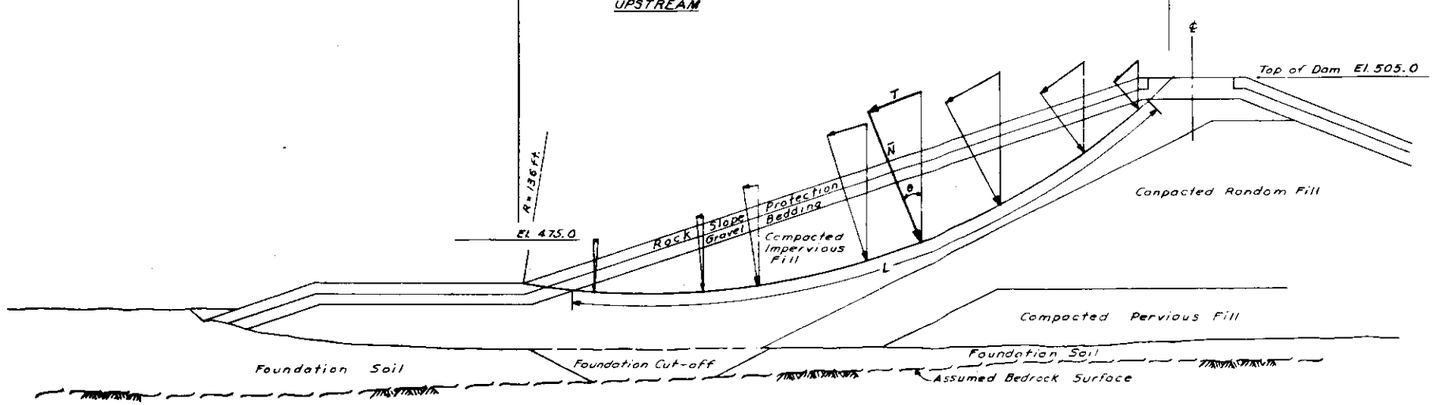
$\int_a^c T = (E-D)K = (6.78-0.10)8.3 = \underline{55.5^K}$

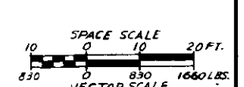
FACTOR OF SAFETY

$F.S. = \frac{\text{Resisting Force}}{\text{Driving Force}} = \frac{87.3}{55.5} = \underline{1.57}$



TYPICAL VECTOR DIAGRAM



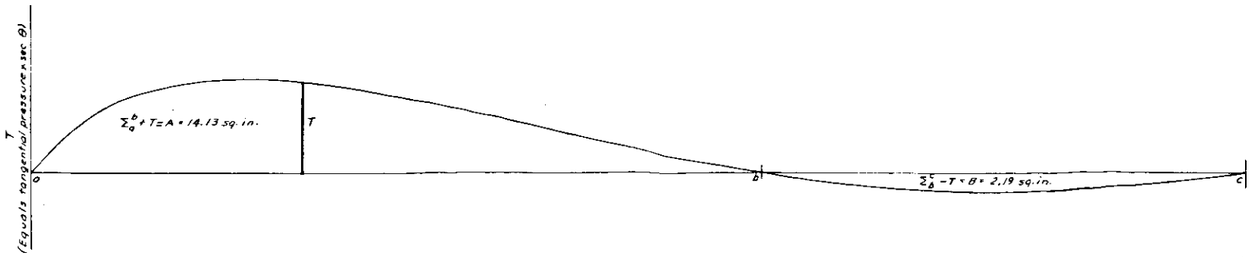


HOUSATONIC RIVER FLOOD CONTROL

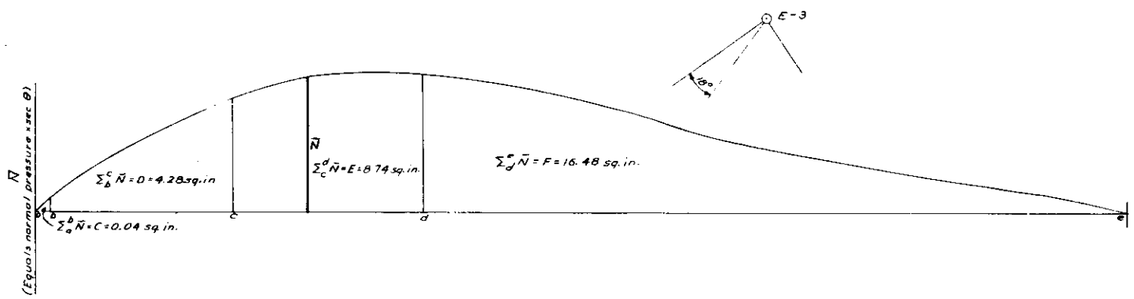
HANCOCK BROOK DAM
DAM

TYPICAL STABILITY ANALYSIS
PARTIAL POOL – CIRCLE C-3

HANCOCK BROOK, CONNECTICUT



WEIGHT VECTOR RATIOS 140 LBS = 1.00				
MATERIAL		VECTOR RATIO (V_R)		
Rock Slope Protection	(Dry)	120	÷ 140	= 0.858
Rock Slope Protection	(Sat.)	140	÷ 140	= 1.000
Gravel Bedding	(Moist)	140	÷ 140	= 1.000
Gravel Bedding	(Sat.)	145	÷ 140	= 1.036
Sand Fill, Drainage Blanket	(Moist)	132	÷ 140	= 0.944
Sand Fill, Drainage Blanket	(Sat.)	138	÷ 140	= 0.985
Impervious, Random, Pervious	(Moist)	140	÷ 140	= 1.000
Impervious, Random, Pervious	(Sat.)	145	÷ 140	= 1.036
Foundation Soil	(Sat.)	140	÷ 140	= 1.000
Water		62.5	÷ 140	= 0.447



"S" STRENGTH

RESISTING FORCE - Summation $\bar{N} \tan \phi$

$\int_a^e \bar{N} \tan\phi = C \tan 35° + D \tan 34.6° + E \tan 32° + F \tan 30°$
$= (0.04)(0.70) + (4.28)(0.69) + (8.74)(0.625) + (16.48)(0.577) = 17.93 \text{ in}^2$

DRIVING FORCE

$\int_a^c T = (A - B) = (14.13 + 2.19) = 11.94 \text{ in}^2$

FACTOR OF SAFETY

$F.S. = \frac{17.93 \text{ in}^2}{11.94 \text{ in}^2} = 1.50$

"R" STRENGTH

RESISTING FORCE - Summation $\bar{N} \tan\phi + CL$

k = Vector Scale Conversion Factor

$\int_a^e \bar{N} \tan\phi = [C \tan 35° + D \tan 22.4° + E \tan 32° + F \tan 30°] k$
$= [(0.04)(0.7) + (4.28)(0.412) + (8.74)(0.625) + (16.48)(0.577)] \ 14.0 = 244 \text{ kips}$

Cohesion $L = \frac{\pi r \theta}{180°} = \frac{\pi \ 161 \times 18°}{180°} = 50 \text{ ft.}$

$CL = 0.2 \times 50 = 10 \text{ kips}$

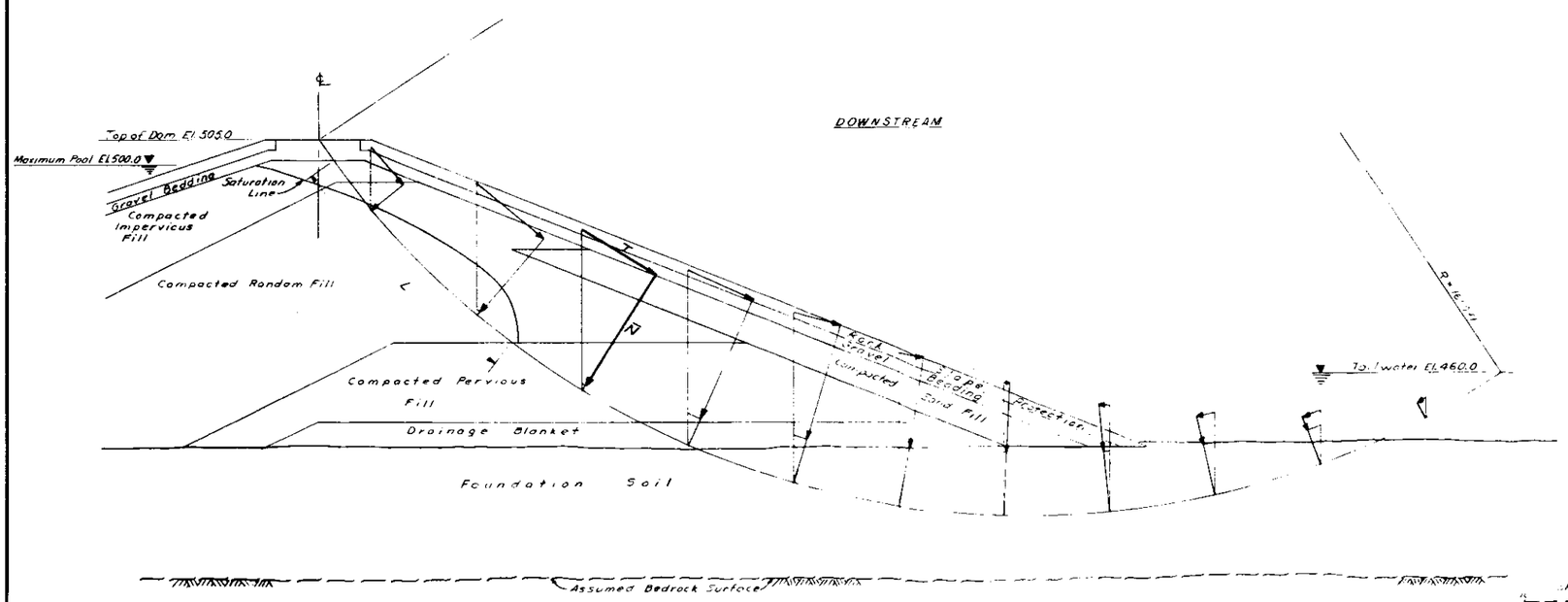
Total Resisting Force/ft. Dam = 244 kips

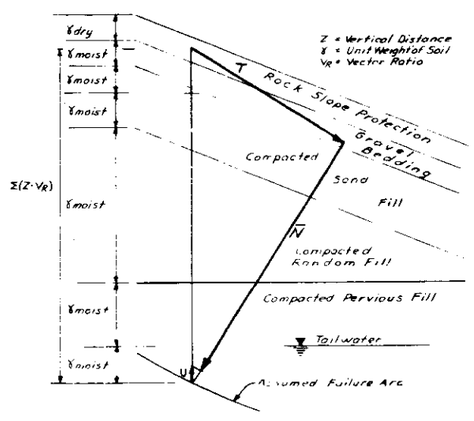
DRIVING FORCE

$\int T = (A - B) k = (14.13 - 2.19) \ 14.0 = 167 \text{ kips}$

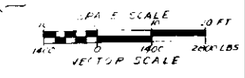
FACTOR OF SAFETY

$F.S. = \frac{244}{167} = 1.46$





TYPICAL VECTOR DIAGRAM



HOUSATONIC RIVER FLOOD CONTROL

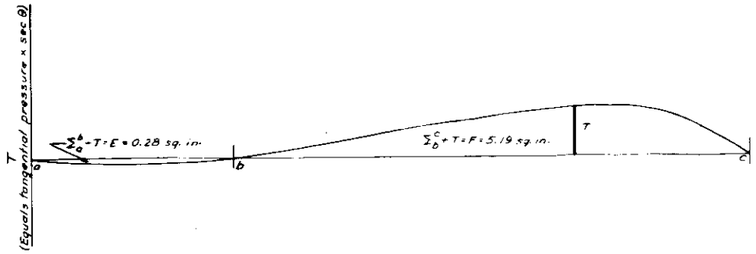
HANCOCK BROOK DAM

DAM

TYPICAL STABILITY ANALYSIS

STEADY SEEPAGE CONDITION - CIRCLE E-3

HANCOCK BROOK, CONNECTICUT



WEIGHT VECTOR RATIOS 145 LBS = 1.000		
MATERIAL		VECTOR RATIO (V_R)
Rock Slope Protection	(Sat)	140 ÷ 145 = 0.965
Rock Slope Protection	(Dry)	120 ÷ " = 0.823
Gravel Bedding	(Sat)	145 ÷ " = 1.000
Gravel Bedding	(Moist)	140 ÷ " = 0.965
Random, Impervious Fills	(Sat)	145 ÷ " = 1.000
Random, Impervious Fills	(Moist)	140 ÷ " = 0.965
Foundation Soil	(Sat)	140 ÷ " = 0.965
Swamp Deposit	(Sat)	100 ÷ " = 0.690
Water		62.5 ÷ " = 0.431

K = Vector Scale Conversion Factor

RESISTING FORCE = Summation $\bar{N} \tan\phi + \bar{C}L$

$$\int_a^e \bar{N} \tan\phi = [A \tan 15^\circ + B \tan 30^\circ + C \tan 22.4^\circ + D \tan 35^\circ]K$$

$$= [(0.05)(0.268) + (3.74)(0.577) + (6.14)(0.412) + (0.07)(0.7)]14.5 = 68.8 \text{ Kips}$$

$$\bar{C}L = (77)(0.2) \text{ ---------- } = 15.4 \text{ Kips}$$

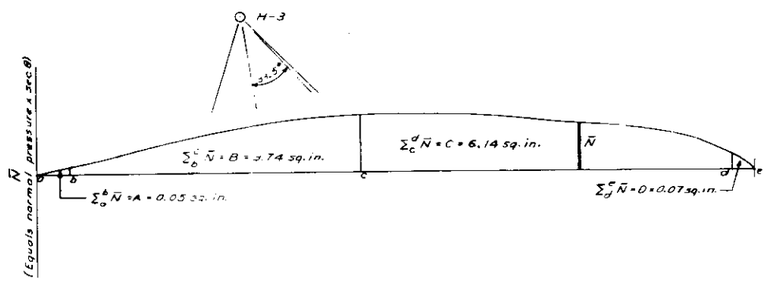
Total Resisting Force/Ft. Dam ---------- = 84.2 Kips

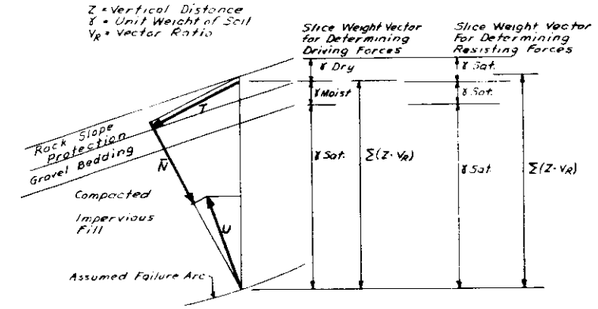
DRIVING FORCE = Summation Tangential Force

$$\int_a^c T = (F - E)K = (5.19 - 0.28)14.5 = 71.2 \text{ Kips}$$

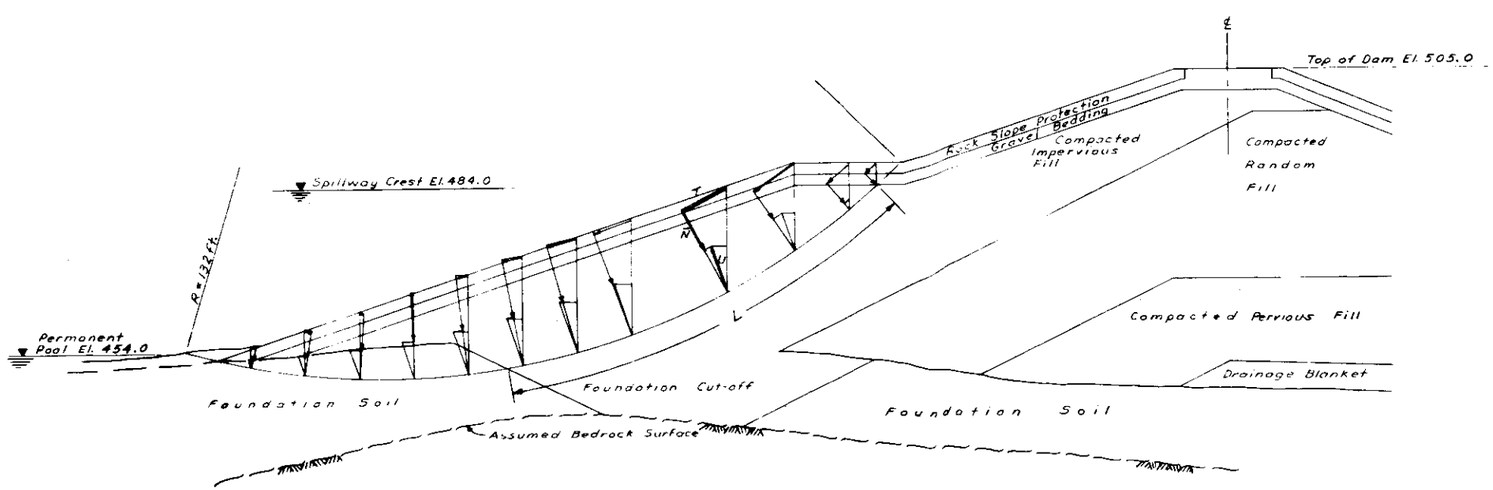
FACTOR OF SAFETY

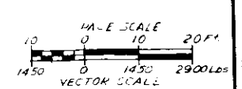
$$F.S. = \frac{\int \bar{N} \tan\phi + \bar{C}L}{\int T} = \frac{84.2}{71.2} = 1.18$$





TYPICAL VECTOR DIAGRAM





HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

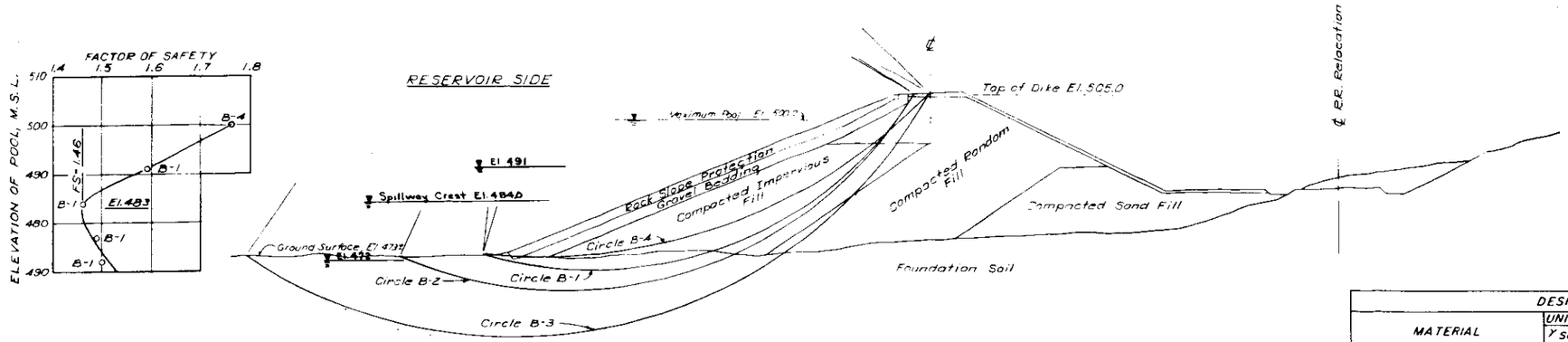
DAM

TYPICAL STABILITY ANALYSIS

SUDDEN DRAWDOWN FROM SPILLWAY CREST

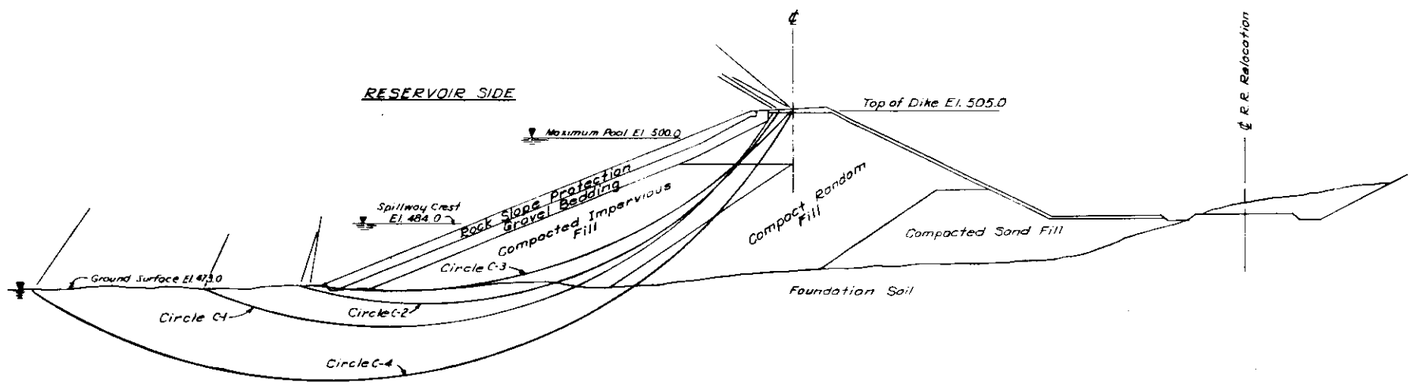
CIRCLE H-3

HANCOCK BROOK, CONNECTICUT



OPERATING CONDITION - PARTIAL POOL ANALYSIS - STA. 46+50

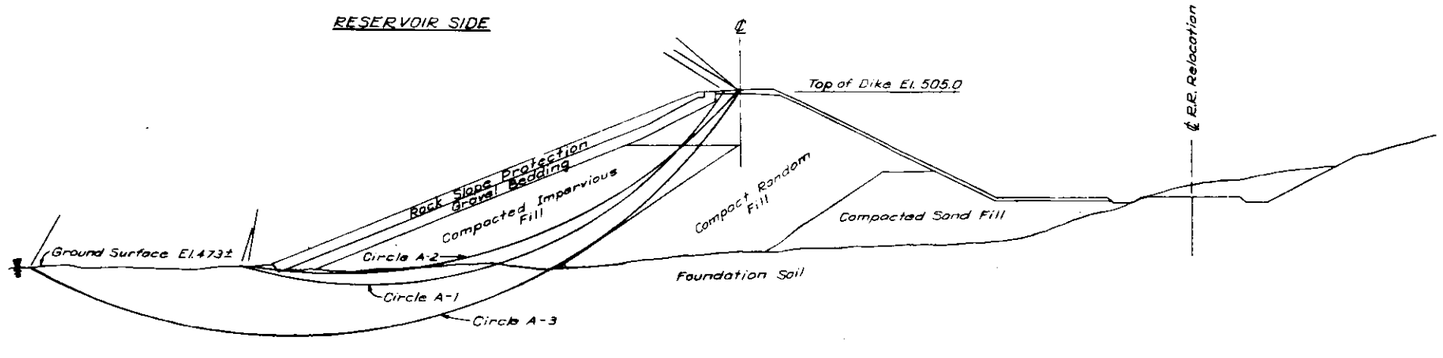
DESIGN VALUES										
MATERIAL	UNIT WEIGHTS (PCF)				SHEAR STRENGTH					
					CD (S)		CU (R)		UU (O)	
	γ Sat.	γ Moist.	γ Dry	γ Sub.	φ	C PSF	φ	C PSF	φ	C PSF
Rock Slope Protection	140	—	120	78	35	—	—	—	—	—
Gravel Bedding	145	140	135	83	35	0.0	—	—	—	—
Compacted Sand Fill	138	132	120	76	32	0.0	—	—	—	—
Compacted Impervious Fill	145	140	130	83	34.6	0.0	22.4	0.1	21.3	0.4
Compacted Random Fill	145	140	130	83	34.6	0.0	22.4	0.1	21.3	0.4
Foundation Soil	140	135	125	78	34.6	0.0	22.4	0.1	21.3	0.4



SUDDEN DRAWDOWN FROM MAXIMUM POOL AND SPILLWAY CREST—STA. 46+50

SUMMARY OF STABILITY ANALYSES			
CASE	PORE PRESSURE ASSUMPTION	COMPUTED SAFETY FACTOR Reservoir Side Slope	
		ARC	F.S.
1. CONSTRUCTION CONDITION Q Strength a. Sta. 46+50	——	A-1 A-2 A-3	3.00 3.06 2.80*
2. OPERATING CONDITION R Strength a. Partial Pool (1) Sta. 46+50	(1)	B-1 B-2 B-3 B-4	1.46 (El. 482)* 1.51 (El. 477) 1.69 (El. 472) 1.57 (El. 481)
3. SUDDEN DRAWDOWN R Strength a. From Maximum Pool (1) Sta. 46+50	(2)	C-1 C-2 C-3 C-4	1.12 1.08* 1.14 1.26
b. From Spillway Crest (1) Sta. 46+50	(2)	C-1 C-2 C-3 C-4	1.31* 1.33 1.43 1.46

(1) Submerged weights below pool elevation.
(2) Saturated weights for driving forces and submerged weights for resisting forces.
(3)* Lowest Factor of Safety for condition analized.



CONSTRUCTION CONDITION ANALYSIS-STA 46+50

SPACE SCALE
10 0 10 20 ft.

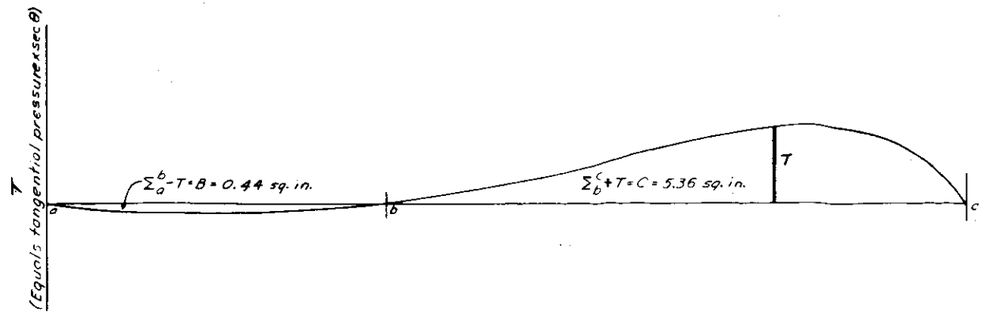
HOUSATONIC RIVER FLOOD CONTROL

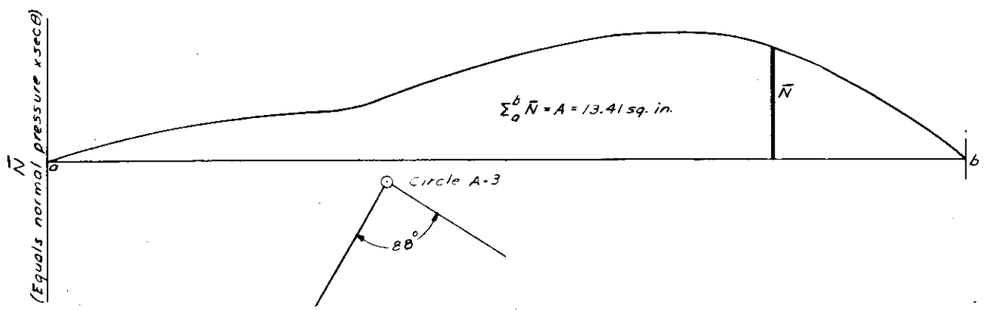
HANCOCK BROOK DAM

DIKE

SUMMARY OF STABILITY ANALYSES

HANCOCK BROOK, CONNECTICUT





WEIGHT VECTOR RATIOS 140 LBS = 1.000	
MATERIAL	VECTOR RATIO (V_R)
Rock Slope Protection (Dry)	120 ÷ 140 = 0.856
Gravel Bedding (Moist)	140 ÷ 140 = 1.000
Impervious, Random Fills (Moist)	140 ÷ 140 = 1.000
Foundation Soil (Sub)	78 ÷ 140 = 0.557

K = Vector Scale Conversion

$K = 100 \frac{Ft.^2}{In^2} \times 140 \frac{Lbs.}{Ft.^2} \times \frac{1 Kip}{1000 Lbs} = 140 \frac{Kips}{In^2}$

RESISTING FORCE - Summation $\int \bar{N} \tan \phi + \bar{C}L$

$\int_a^b \bar{N} \tan \phi = [A \tan 21.3°]k$

$= [(13.4)(0.39)]14.0 = 73.2$ Kips

$\bar{C}L = (0.8)(149) = 119.0$ Kips

Total Resisting Force/Ft. Dike = 192.2 Kips

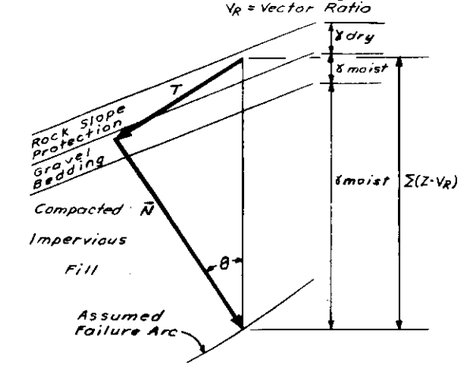
DRIVING FORCE = Summation Tangential Forces

$\int_a^c T = (C-B)K = [(5.36-0.44)]14.0 = 68.9$ Kips

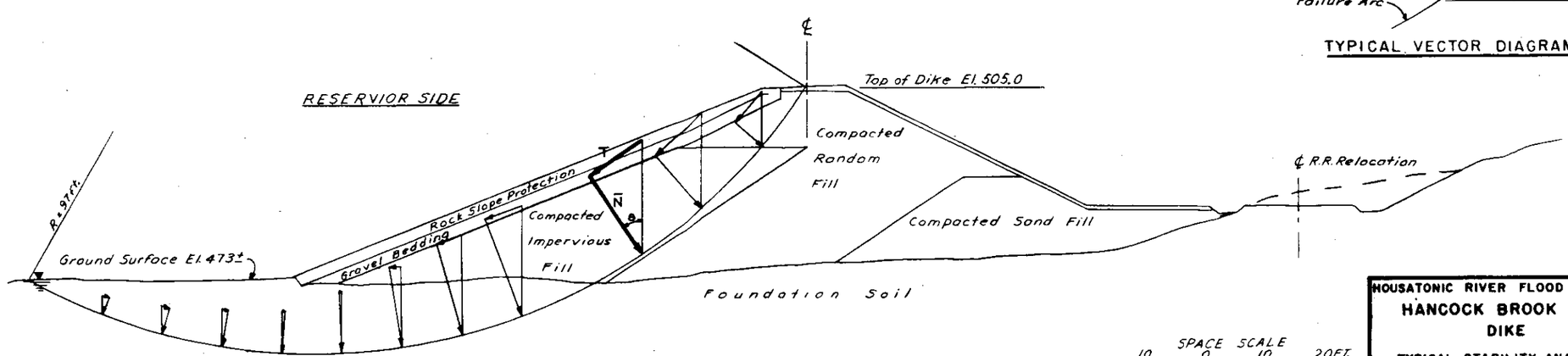
FACTOR OF SAFETY

$F.S. = \frac{\int \bar{N} \tan \phi + \bar{C}L}{\int T} = \frac{192.2}{68.9} = 2.80$

Z = Vertical Distance
γ = Unit weight of Soil
V_R = Vector Ratio

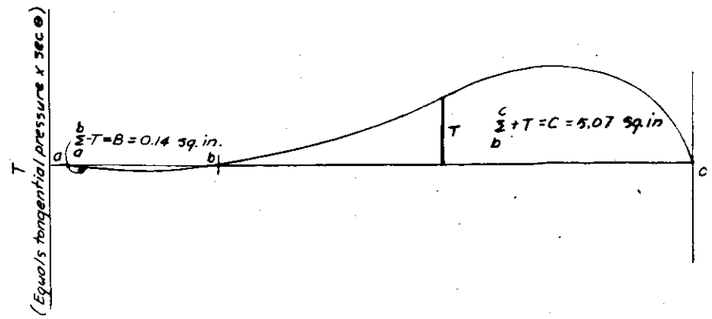


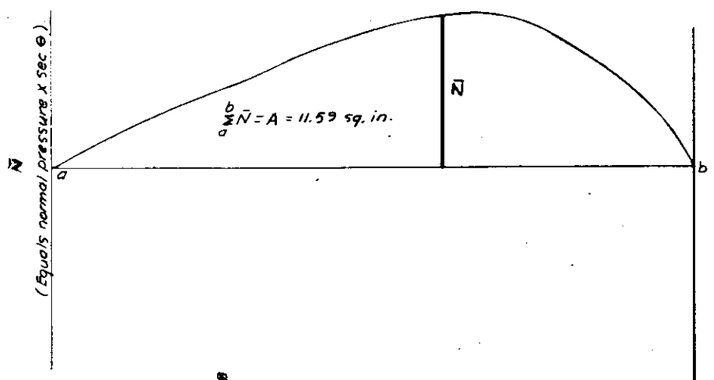
TYPICAL VECTOR DIAGRAM



SPACE SCALE
10 0 10 20 FT.
1400 0 1400 2800 LBS.
VECTOR SCALE

HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
DIKE
TYPICAL STABILITY ANALYSIS
CONSTRUCTION CONDITION - CIRCLE A-3
HANCOCK BROOK, CONNECTICUT





K = Vector Scale Conversion Factor

$K = 100\ ft^3/in^2 \times 83.0\ lbs/ft^3 \times 1\ Kip/1000\ lbs = 8.3\ kips/in^2$

Resisting Forces – Summation $\bar{N} \tan\phi + \hat{CL}$

$\int_a^b \bar{N} \tan\phi = [A \tan 22.4°]K$

$= [(11.59)(0.412)]8.3 = 39.6$ kips

$\hat{CL} = (0.2)(100) = 20.0$ kips

Total Resisting Forces/ft. Dike $= 59.6$ kips

Driving Forces – Summation Tangential Forces

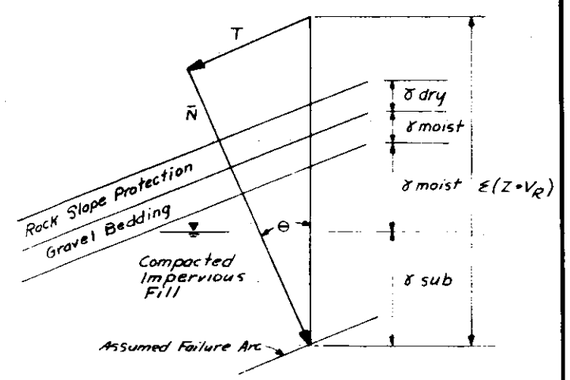
$\int_a^c T = (C - B)K = (5.07 - 0.14)\,8.3 = 40.9$ kips

Factor of Safety

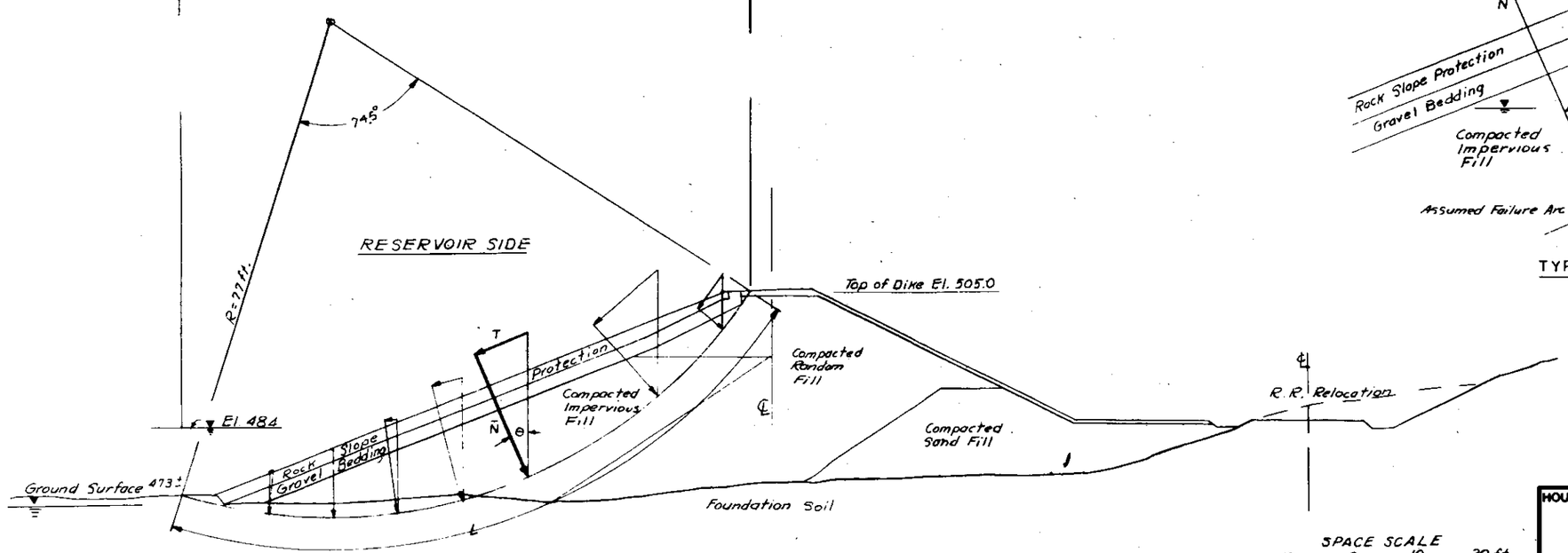
$F.S. = \frac{\text{Resisting Forces}}{\text{Driving Forces}} = \frac{59.6}{40.9} = 1.46$

WEIGHT VECTOR RATIOS 83.0 lbs. = 1.000		
MATERIAL		VECTOR RATIO (VR)
Rock Slope Protection	(Dry)	120 ÷ 83 = 1.45
Rock Slope Protection	(Sub)	78 " = 0.94
Gravel Bedding	(Moist)	140 " = 1.69
Gravel Bedding	(Sub)	83 " = 1.00
Impervious, Random Fills	(Moist)	140 " = 1.69
Impervious, Random Fills	(Sub)	83 " = 1.00
Foundation Soil	(Sat.)	140 " = 1.69
Foundation Soil	(Sub)	78 " = 0.94

Z = Vertical Distance
V_R = Vector Ratio
γ = Unit Weight of Soil

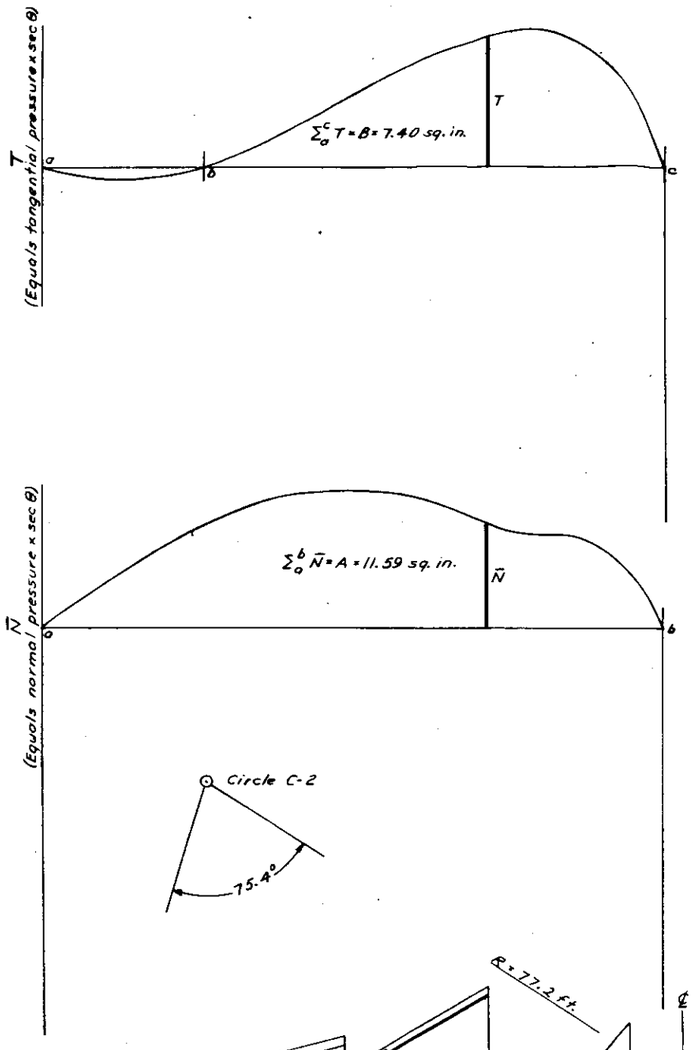


TYPICAL VECTOR DIAGRAM



SPACE SCALE
10 0 10 20 ft.
830 0 880 1660 lbs
VECTOR SCALE

HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
DIKE
TYPICAL STABILITY ANALYSIS
PARTIAL POOL – CIRCLE B-1
HANCOCK BROOK, CONNECTICUT



k = Vector Scale Conversion Factor

$K = 100 \frac{Ft^2}{In^2} \times 625 \frac{Lbs}{Ft^2} \times \frac{1\ Kip}{1000\ Lbs} = 6.25 \frac{Kips}{In^2}$

RESISTING FORCE = Summation $\int N \tan + \phi \bar{C}L$

$\int_a^b \bar{N} \tan \phi = [A \tan 22.4] K$

$= [(11.59)(0.412)] 6.25 = 29.8$ Kips

$\bar{C}L = (0.20)(100.20) = 20.0$ Kips

Total Resisting Force/Ft. Dike = 49.8 Kips

DRIVING FORCE - Summation Tangential Force

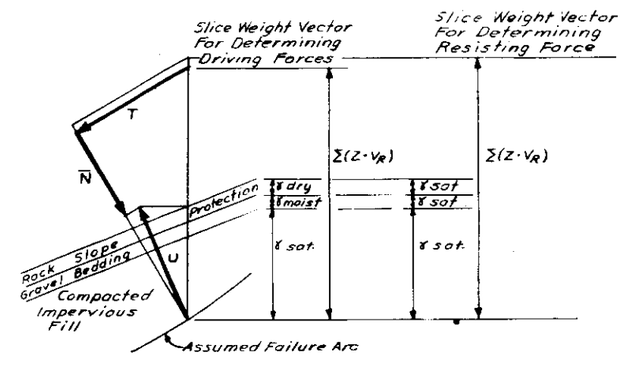
$\int_a^c T = (B)K = (7.40)(6.25) = 46.2$ Kips

FACTOR OF SAFETY

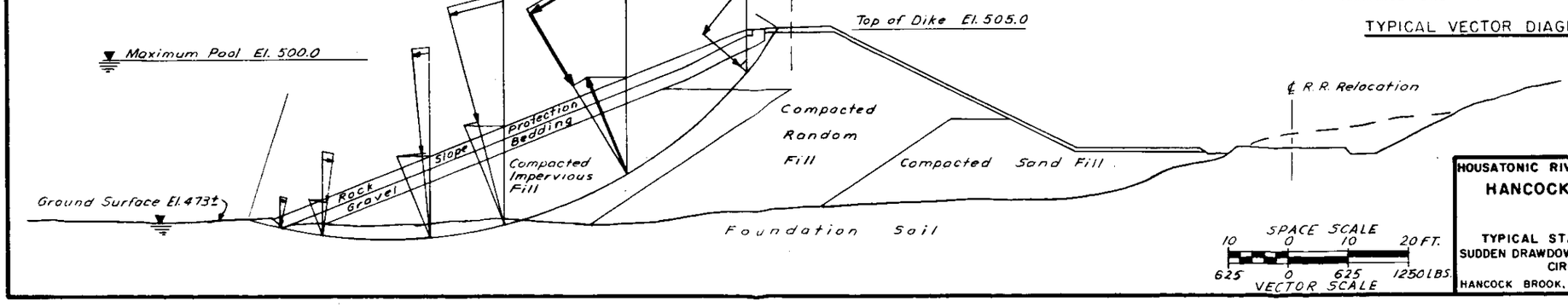
$$F.S. = \frac{\int \bar{N} \tan + \bar{C}L}{\int T} = \frac{49.8}{46.2} = 1.08$$

WEIGHT VECTOR RATIOS 62.5 LBS = 1.000				
MATERIAL		VECTOR RATIO (V_R)		
Rock Slope Protection	(Sat.)	140 ÷	62.5 =	2.24
Rock Slope Protection	(Dry)	120 ÷	" =	1.92
Gravel Bedding	(Sat.)	145 ÷	" =	2.32
Gravel Bedding	(Moist)	140 ÷	" =	2.24
Impervious, Random Fills	(Sat.)	145 ÷	" =	2.32
Impervious, Random Fills	(Moist)	140 ÷	" =	2.24
Foundation Soil	(Sat.)	140 ÷	" =	2.24
Water		62.5 ÷	" =	1.00

Z = Vertical Distance
γ = Unit Weight of Soil
V_R = Vector Ratio



TYPICAL VECTOR DIAGRAM

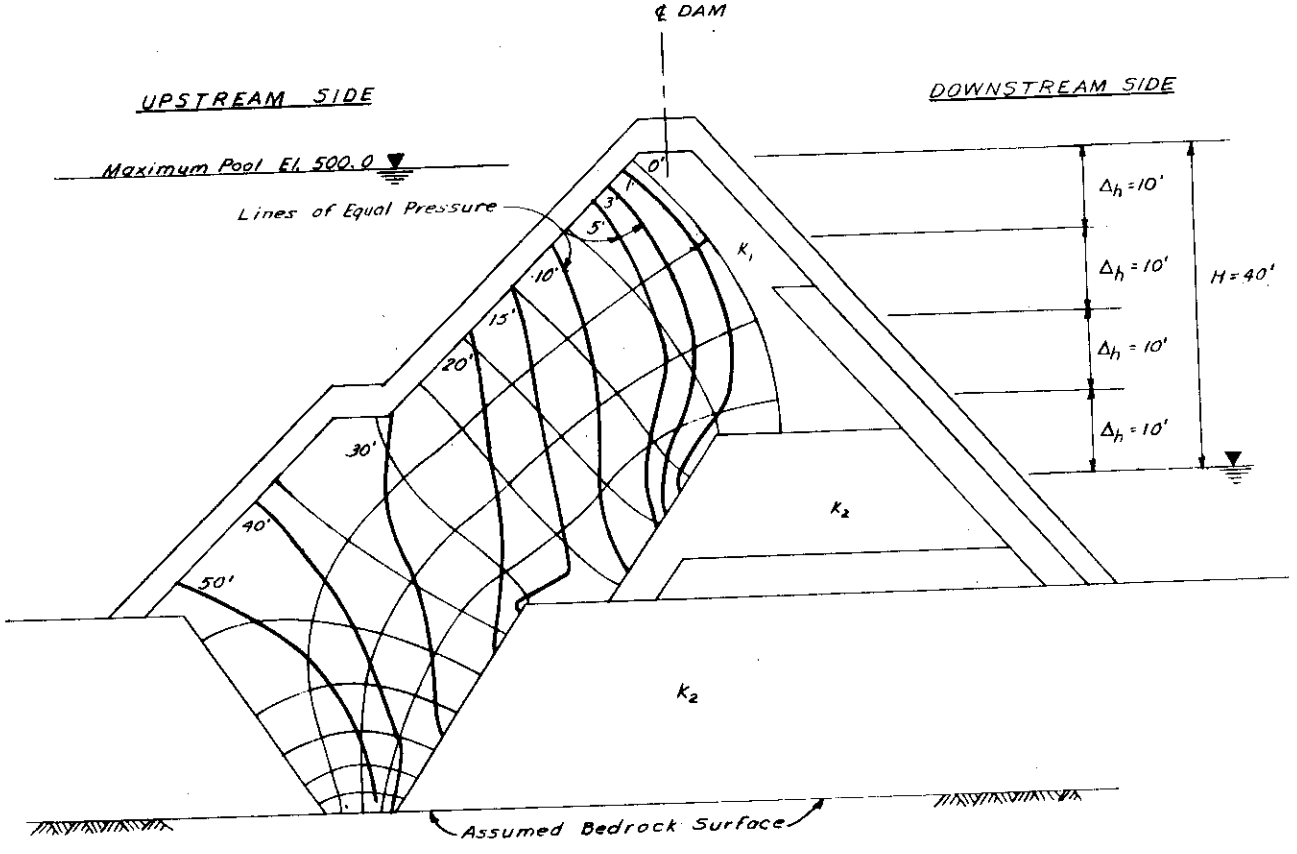


HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
DIKE

TYPICAL STABILITY ANALYSIS
SUDDEN DRAWDOWN FROM MAXIMUM POOL
CIRCLE C-2
HANCOCK BROOK, CONNECTICUT

Horizontal Dimension reduced by $\sqrt{\frac{K_V}{K_H}} = \sqrt{\frac{1}{9}} = \frac{1}{3}$

$K_2 = 100K_1$



TRANSFORMED SECTION. ℄ DAM AT STA 6+60

NOTE

Flow net applicable only to stability analysis of failure by shear movement

SCALE IN FEET

Vertical 10' 0' 10' 20'

Horizontal 30' 0' 30 60'

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

DAM

STEADY SEEPAGE FLOW NET

HANCOCK BROOK, CONNECTICUT

TABLE NO. 1

EXCAVATION	TOTAL QUANTITY CY	DISPOSITION	QUANTITY CY	BALANCE FACTOR	FILL QUANTITY	MATERIAL
Earth, Dam & Dike	75,000	To Dam	30,000	0.7	21,000	Pervious Fill, Dam
		To Spoil	45,000	-	-	Stripping
Rock - Conduit & Spillway	19,000	To Dam	13,000	1.0	13,000	Rock Slope Protection, Dam
		To Spoil	6,000	-	-	Poor Quality Rock
Earth, Relocations	303,000	To Stockpile, Random	60,000	0.9*	41,000	Random Fill, Dam
		To Stockpile, Impervious	28,000	0.7*	20,000	Impervious Fill, Dam
		To Dike	30,000	0.8	24,000	Random Fill, Dike
		To Dike	22,000	0.9	20,000	Impervious Fill, Dike
		To Relocations	98,000	0.8	78,000	Embankment Fill, Railroad & Highway
		To Spoil	32,000	-	-	Excess Random or Embankment Fill
		To Spoil	43,000	-	-	Stripping
Rock, Relocations	67,000	To Dike	6,000	1.0	6,000	Rock Slope Protection, Dike
		To Relocations	9,000	1.0	9,000	Rock Slope Protection, R.R. & Hwy
		To Relocations	52,000	1.0	52,000	Embankment Fill, R.R. & Hwy
Earth, Borrow	35,000	To Dam	30,000	0.9	27,000	Impervious Fill, Dam
		To Spoil	5,000	-	-	Stripping

* Denotes balance factor reflecting losses and volume changes before and after stockpiling.

TABLE NO. 2

FILL	FILL QUANTITY CU. YDS.	SOURCE
Impervious Fill, Dam	47,000 Total	
	20,000	Stockpile, Impervious
	27,000	Borrow
Pervious Fill, Dam	21,000	Earth Excavation, Dam
Random Fill, Dam	41,000	Stockpile, Random
Rock Slope Protection, Dam	13,000	Rock Excavation - Conduit and Spillway
Gravel Bedding, Dam	12,000	Furnished by Contractor
Gravel Fill & Sand Fill, Dam	14,000	Furnished by Contractor
Impervious Fill, Dike	20,000	Earth Excavation, Relocations
Random Fill, Dike	24,000	Earth Excavation, Relocations
Rock Slope Protection, Dike	6,000	Rock Excavation, Relocations
Gravel Bedding, Dike	5,000	Furnished by Contractor
Sand Fill, Dike	1,000	Furnished by Contractor
Embankment Fill, Relocations	130,000 Total	
	78,000	Earth Excavation, Relocations
	52,000	Rock Excavation, Relocations
Rock Slope Protection, Relocations	9,000	Rock Excavation, Relocations
Gravel Bedding, Relocation	9,000	Furnished by Contractor

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

MATERIALS USAGE CHART

PRELIMINARY

HANCOCK BROOK, CONNECTICUT

APPENDIX A

SUMMARY OF LABORATORY TEST RESULTS

HANCOCK BROOK DAM & RESERVOIR

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA STND AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL	PERM
FD-1	455±	J-2	0.6- 5.0	SM	30	55	15	0.0049													
		J-6	10.0-15.0	GP-GM	49	44	7	0.011													
FD-2	518±	J-2	0.4- 5.0	GM	67	21	12	0.05													
FD-3	454±	J-2	1.4- 5.0	ML	0	47	53	0.01													
		J-5	11.5-13.0	GP-GM	56	38	6	0.15													
		J-7	15.5-20.0	GP-GM	58	37	5	0.16													
FD-5	484.0	J-2	1.9- 5.0	SM	36	51	13	0.048													
		B-5	7.2-10.0	SP-SM	46	47	7	0.11													
FD-6	487.2	J-2	1.0- 3.8	SP-SM	16	76	8	0.10													
		J-5	5.2- 7.4	SP-SM	12	77	11														
FD-7	496.5	J-3	3.0- 5.0	SM	14	48	38	0.0076													
		J-4	5.0- 7.0	SP-SM	34	56	10	0.075													
FD-8	498.4	J-2	0.8- 3.8	SM	8	45	47	0.003													
		J-4	5.0- 7.0	SP-SM	34	55	11														
FD-9	500.2	J-6	10.0-13.9	SP	13	83	4	0.010													
FD-12	448.7	B-9	10.0-15.0	GP-GM	55	39	6	0.22													
		B-11	15.0-18.5	SP-SM	42	51	7	0.13													
FD-15	454.0	B-6	5.0- 9.1	ML	0	18	82	0.0016	30	25		29.0									
		B-8	9.3-14.0	GP-GM	60	34	6	0.22													
		B-12	19.0-23.4	SM	22	50	28	0.03													

* PROVIDENCE VIBRATED DENSITY TEST.

HANCOCK BROOK DAM

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT. TOTAL	-No4	COMPACTION DATA STND AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-No4	OTHER TESTS SHEAR	CONSOL	PERM.
FD-19	463.8	B-5	2.2- 5.0	SM	3	61	36	0.032													
		B-12	6.5-10.0	SW-SM	29	60	11														
FD-22	481.2	B-7	10.0-15.0	SM	10	65	25	0.032													
FD-24	452.7	J-2	1.0- 2.0	ML								44.9	44.9								
		B-3	1.0- 2.0	ML	1	48	51	0.009	Nonplastic												
		J-4	2.0- 4.0	ML								33.0	33.0								
		B-11	9.0-14.0	SM	2	77	21	0.027													
		B-16	16.5-19.0	SP-SM	4	90	6	0.20													
		B-19	20.0-23.5	SP-SM	44	47	9	0.09													
FD-25	460.8	J-2	2.7- 5.0	SM								25.2	26.8								
		B-3	2.7- 5.0	SM	10	46	44	0.009													
		B-5	5.0-10.0	SP-SM	33	60	7	0.17													
		J-8	15.0-20.0	ML								29.1	29.1								
		B-9	15.0-20.0	ML	4	14	82	0.016	Nonplastic												
FD-27	452.7	J-1	0.0- 5.0	ML								40.7	40.7								
		B-2	0.0- 5.0	ML	0	47	53	0.007	Nonplastic												
		J-3	5.0- 6.0	ML								45.4	45.4								
		J-5	6.0- 8.0	ML								65.5	65.5								
		B-12	15.0-20.0	GP-GM	55	35	10	0.074													
FD-28	452.0	B-5	5.0-10.0	SM	16	71	13														
		B-9	11.1-15.0	SP-SM	19	73	8	0.12													
		J-13R	20.0-21.5	SP-SM	39	53	8	0.20													
		B-17	25.0-28.0	SP-SM	39	52	9	0.16													

* PROVIDENCE VIBRATED DENSITY TEST.

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D10 mm	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO4	COMPACTION DATA STND AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU.FT.	* PVC LBS/CU.FT.	NAT. DRY DENSITY LBS/CU.FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL	PERM.
FD-29	456.8	B-8	10.0-15.5	SM	18	64	18	0.047													
FD-30	512.7	B-5	5.0-10.0	SM	4	56	40	0.0024				7.5	10.4								
		B-9	15.0-17.7	SM	15	52	33	0.0039				10.0	10.2								
		B-13	20.0-25.0	SM	17	55	28	0.006	16	14											
		J-14	20.0-25.0	SM								7.0	7.7								
FD-31	514.0	S-5	10.0-15.0	SM	32	54	14	0.032				8.74	8.9								
		B-9	20.0-25.0	SM	23	49	28	0.0066	16	15		7.6	9.2								
		B-13	27.8-30.0	SM	35	41	24	0.007	16	14											
		J-16	30.0-35.0	SM								9.5	10.2								
FD-32	512.8	B-5	5.0-10.0	SM	3	52	45	0.0049				18.2	18.8								
		B-9	13.0-15.0	ML	0	31	69	0.001	36	26											
		B-13	20.0-25.0	SM	9	52	39	0.0015	30	27											
FD-33	499.4	B-3	2.3- 5.0	SP-SM	18	73	9	0.092													
		B-9	10.7-15.0	SP-SM	47	48	5	0.018													
FD-34	533.4	B-2	1.0- 5.0	SM	32	56	12														
FD-35	516.2	B-4	5.0-10.0	GP-GM	59	35	6	0.017													
FD-36	516.4	B-4	5.0-10.0	GP-GM	50	38	12														

* PROVIDENCE VIBRATED DENSITY TEST.

HANCOCK BROOK DAM

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT TOTAL	-NO.4	COMPACTION DATA STND AASHO OPT. WATER % DRY WT	MAX DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO.4	OTHER TESTS SHEAR	CONSOL.	PERM.
FD-37	500.2	J2R	2.6- 5.0	SM								23.1	23.3								
		J4	5.0-10.0	SM					21	18											
		J4R	5.0-10.0	SM								13.5	13.8								
		B5	5.0-10.0	SM	8	52	40	0.0035													
		J6	10.0-13.7	SM								12.1	13.1								
FD-38	500.1	J3	2.8- 4.6	SM								15.8	16.4								
		J5	4.6- 6.8	SM								15.5	17.1								
		J6	6.8-11.8	ML								16.9	17.1								
		J10	13.6-25.0	SM								10.8	11.1								
FD-39	477.4	J2R	0.7-4.1.	SM								25.8	25.8								
		J4	4.1-4.7	SM								13.5	14.0								
		J6R	10.0-13.0	SM								10.3	11.9								
		B7	10.0-13.0	SM	17	50	33	0.0055	18	15											
		J8R	13.1-15.0	SM								9.9	11.2								
FD-40	487.4	J7	15.0-17.9	SM	21	56	23	0.017													
		J8	17.9-20.0	SM	3	53	44	0.0018													
		J8R	17.9-20.0									11.2	11.4								

* PROVIDENCE VIBRATED DENSITY TEST.

HANCOCK BROOK DAM

EXPL. NO.	TOP ELEV FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS: GRAVEL %	SAND %	FINES %	[illegible]	ATT LIMITS		SPECIFIC GRAVITY	NAT WATER CONTENT % DRY WT: TOTAL	NO 4	COMPACTION DATA: STD AASHO: OPT WATER % DRY WT	MAX DRY DENS LBS/CU FT	PVD LBS/CU FT	NAT DRY DENSITY LBS/CU FT: TOTAL	NO 4	OTHER TESTS: SHEAR	CONSOL	PERM
[illegible]-41	504.3	J1	1.3-5.0	ML	8	31	61	<0.001				15.1	15.4								
		J1R	1.3-5.0	ML																	
		J3	10.0-13.7	SM	6	53	41	0.0022				12.7	13.3								
		J3R	10.0-13.7	SM																	
[illegible]-42	483.5	J1R	1.[illegible]-5.0	SM								13.4	14.4								
		J3R	[illegible].0-10.0	SM								12.[illegible]	15.2								
		B4	5.0-10.0	SM	12	49	39	0.0055				15.5	15.3								
		J8R	15.0-20.0	ML																	
		P9	15.0-20.0	ML	8	28	64	<0.001				11.0	12.0								
		J10R	20.0-25.0	ML																	

* PROVIDENCE VIBRATED DENSITY TEST

HANCOCK BROOK DAM

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA			NAT. DRY DENSITY LBS/CU FT		OTHER TESTS		
														STND. AASHO		*					
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO 4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL	PERM.
FTT-1	475.0	B-2	1.1- 3.5	ML	0	16	84	0.0039													
		B-4	3.5- 6.1	GP	50	48	2	0.25													
		B-10	8.0-10.8	SP	23	73	4	0.14													
FTT-2	468.3	B-4	3.3-11.0	SP	37	62	1	0.29													
FTT-4	495.1	B-4	2.4- 3.6	SM	33	46	21	0.028													
FTT-5	490.5	B-4	1.8- 4.2	GP	53	45	2	0.37													
FTT-7	481.3	B-6	2.9- 5.6	SM	15	65	20	0.[illegible]25													
FTT-8	493.3	B-4	2.7-11.0	GP	65	33	2	0.38													

* PROVIDENCE VIBRATED DENSITY TEST.

HANCOCK BROOK DAM

EXPL. NO.	TOP ELEV. FT.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm.	ATT. LIMITS LL	PL	SPECIFIC GRAVITY	NAT WATER CONTENT % DRY WT TOTAL	- NO4	COMPACTION DATA STND AASHO OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	- NO4	OTHER TESTS SHEAR	CONSOL	PERM.
BD-1	525.5	B-4	5.0-10.0	SM	7	54	39	0.007	Nonplastic												
		J-5R	10.0-15.0	SM								10.3	10.3								
		B-6	10.0-15.0	SM	8	57	35	0.0081	Nonplastic												
		B-14	25.0-30.0	SM-SC	38	43	19	0.018	21	16											
BD-2	540.0	B-3	2.2- 5.0	SM	10	58	32	0.0058	Nonplastic												
		J-7R	10.0-15.0	SM								9.5	9.8								
		B-8	10.0-15.0	SM	6	62	32	0.0048	Nonplastic												
BD-4	580.2	B-5	5.0-10.0	SP-SM	23	65	12	0.0061													
		B-7	10.0-14.0	SM	33	54	13														
		B-19	30.0-35.0	SM	10	53	37	0.0033	18	16		7.7	8.1								
		B-23	38.8-40.0	SP-SM	0	88	12														
BD-5	549.9	B-2	0.9- 5.0	SM	38	49	13														
		B-4	7.8-10.0	SM	16	47	37	0.0032	Nonplastic												
		J-5R	7.8-10.0	SM								13.0	13.2								
		B-10	20.0-25.0	SM	8	62	30	0.008	Nonplastic												
		J-11R	20.0-25.0	SM								8.6	8.9								
		B-16	35.0-40.0	SM	9	56	35	0.0045	Nonplastic												
		J-17R	35.0-40.0	SM								8.3	8.7								

* PROVIDENCE VIBRATED DENSITY TEST.

EXPL NO.	TOP ELEV. FT	SAMPLE NO.	DEPTH FT	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D10 FT	ATT. LIMITS L.L.	P.I.	SPECIFIC GRAVITY	NAT WATER CONTENT % DRY WT TOTAL	NO4	COMPACTION DATA STND AASHO OPT WATER % DRY WT	MAX DRY DENS LBS/CU FT	PVD LBS/CU FT	NAT DRY DENSITY LBS/CU FT TOTAL	NO4	OTHER TESTS SHEAR	CONSOL	PERM
BT-2	550±	B-1	1[illegible]-1[illegible].0	SM	13	50	37	0.0033	Nonplastic												
BT-3	517±	J-2	0.[illegible] - 1.8	SM								15.3	16.3								
		B-3	1.[illegible] - 3.9	SM	4	61	35	0.0068			2.73			10.8	123.0						
		J-4	1.[illegible] - 3.9	SM								14.4	14.7								
		B-5	3.[illegible] - 5.8	SM	4	59	37	0.008			2.73			11.0	122.5						
		J-6	3.[illegible] - 5.8	SM								13.8	14.1								
		UF-7	3.[illegible] - 5.8	SM								10.1					11[illegible].7				
		J-10	5.[illegible] - 7.2	SM								9.7	1[illegible]								
		B-11	7.[illegible] - 9.4	SM	4	55	41	0.019			2.74			11.8	1[illegible]						
		J-12	7.[illegible] - 9.4	SM								15.3	16.2								
		J-14	9.4-11.8	SP-SM								11.1	1[illegible]								
BT-3	477±	B-2	1.[illegible] - 3.0	SM	26	56	13	0.033													
		B-12	[illegible] - 9.7	SM	57	40	3	[illegible].30													
		B-15	11.3-12.3	SP	3[illegible]	58	[illegible]	[illegible].15													
BT-4	514.0	B-1	0.[illegible] - [illegible].3	SM	18	63	1[illegible]	[illegible].039													
		B-2	2.[illegible] - 3.1	SM	15	60	25	[illegible].03													
		B-3	3.1- 5.0	SM	6	55	39	[illegible].0059													
		B-4	5.[illegible] - [illegible].9	SM	18	65	17	[illegible].035													
		B-5	5.[illegible] - 9.1	ML	3	42	55	[illegible].0039													
		B-6	9.1-11.3	SP-SM	24	68	8	[illegible].092													
BT-4A N.3		B-1	1[illegible].4-17.0	SM	7	54	39	[illegible].0047	Nonplastic		2.74			9.4	130.8				x		x
		BT-4A is a continuation of BT-4																			
		Chunk densities 126.7, 130.1, 132.4, 126.1, lbs/cu. ft.																			
BT-5	487±	B-5	3.[illegible] - [illegible].8	SM	6	55	39	[illegible].0026													
		B-7	[illegible].[illegible]-11.1	GP	63	33	4	[illegible].026													

* PROVIDENCE VIBRATED DENSITY TEST

HANCOCK BROOK DAM

EXPL NO	TOP ELEV FT	SAMPLE NO	DEPTH FT	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D10 mm	ATT LIMITS	SPECIFIC GRAVITY	NAT WATER CONTENT % DRY WT TOTAL	NAT WATER CONTENT % DRY WT NOAA	COMPACTION DATA AASHO WATER % DRY WT	MAX DRY DENSITY LB/CU FT	* PVC LBS/SQ FT	NAT DRY DENSITY LB/CU FT TOTAL	NAT DRY DENSITY LB/CU FT NOAA	OTHER TESTS SHEAR	CONSOL	PERM
BT-6	540.0	J-2R	2.1- 5.0	SM							12.1	13.5								
		B-4	2.1- 5.0	SM	17	57	26	0.0092	nonplastic				12.1	121.6				Y		
	UC-1	(1)	4.0- 5.0	SM							5.54					119.1				
		(2)	4.0- 5.0								12.6					11[illegible].8				
		(3)	4.0- 5.0								15.1					114.4				
		J5-R	5.0-10.0	SM							17.5	17.7								X
		P-7	5.0-10.0	SM	7	62	31	0.012	nonplastic				11.7	122.4						
		UC-6	8.0-10.0	SM																
		(1)	8.0-10.0								22.4					104.8				
		(2)	8.0-10.0								20.1					103.9				
		(3)	8.0-10.0								12.3					117.8				
		(4)	8.0-10.0								13.2					116.9				

* PROVIDENCE VIBRATED DENSITY TEST

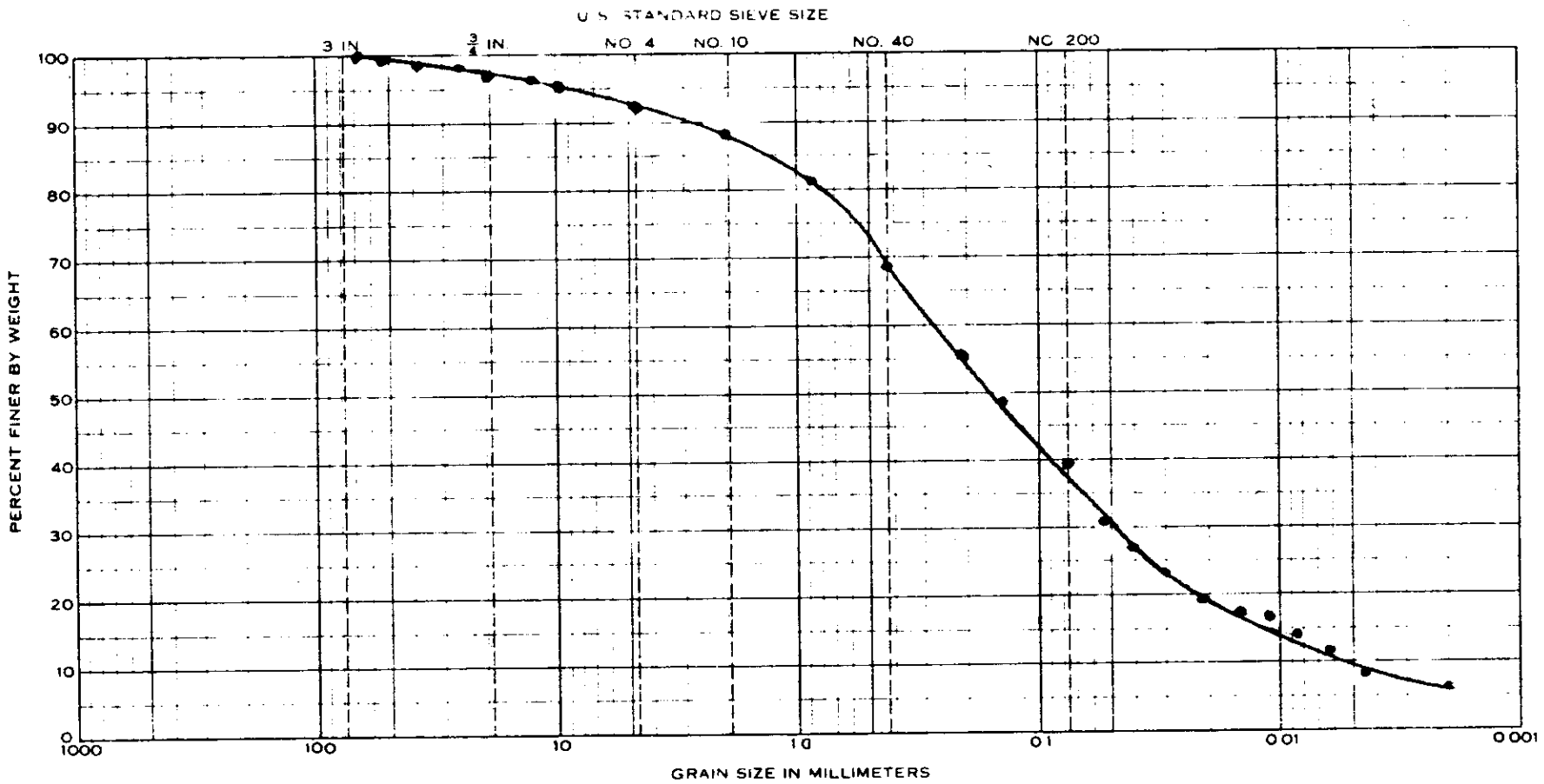
APPENDIX B

DETAILED SHEAR TEST DATA

HANCOCK BROOK DAM

PLATE NO.	TITLE
	IMPERVIOUS EMBANKMENT MATERIALS FROM REQUIRED EXCAVATIONS
	BT-4A, B-1
B - 1	Gradation Curve
B - 2	Compaction Test Report
B - 3	S Triaxial Test - Optimum +2%
B - 4	S Triaxial Test - Optimum
B - 5	S Triaxial Test - Optimum -2%
B - 6	R Triaxial Test - Optimum +2%
B - 7	R Triaxial Test - Optimum
B - 8	R Triaxial Test - Optimum -2%
B - 9	Q Triaxial Test - Optimum +2%
B - 10	Q Triaxial Test - Optimum
B - 11	Q Triaxial Test - Optimum -2%
	IMPERVIOUS EMBANKMENT MATERIALS - AREA A
	BT-6, B-4
B - 12	Gradation Curve
B - 13	Compaction Test Report
B - 14	S Triaxial Test - Optimum +2%
B - 15	S Triaxial Test - Optimum
B - 16	S Triaxial Test - Optimum -2%
B - 17	R Triaxial Test - Optimum +2%
B - 18	R Triaxial Test - Optimum

PLATE NO.	TITLE
	IMPERVIOUS EMBANKMENT MATERIALS - AREA A
	BT-6, B-4
B - 19	R Triaxial Test - Optimum -2%
B - 20	Q Triaxial Test - Optimum +2%
B - 21	Q Triaxial Test - Optimum
B - 22	Q Triaxial Test - Optimum -2%
	BT-6, B-7
B - 23	Gradation Curve
B - 24	Compaction Test Report
	RANDOM EMBANKMENT MATERIALS
	BT-2, B-3, 5, 11
B - 25	Compaction Test Report, B - 3
B - 26	Compaction Test Report, B - 5
B - 27	Compaction Test Report, B - 11
	FOUNDATION MATERIALS - DAM
	Composite LB-1 (FD-24 & FD-28)
B - 28	Gradation Curves
B - 29	S Direct Shear Test
	SPECIAL - FAULT GOUGE
B - 30	Gradation Curve
B - 31	Compaction Test Report
B - 32	R - Triaxial Test



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI
B-1	12.4-17.0	silty m-f SAND (SM)		NP	NP	NP

Project HANCOCK BROOK RESERVOIR

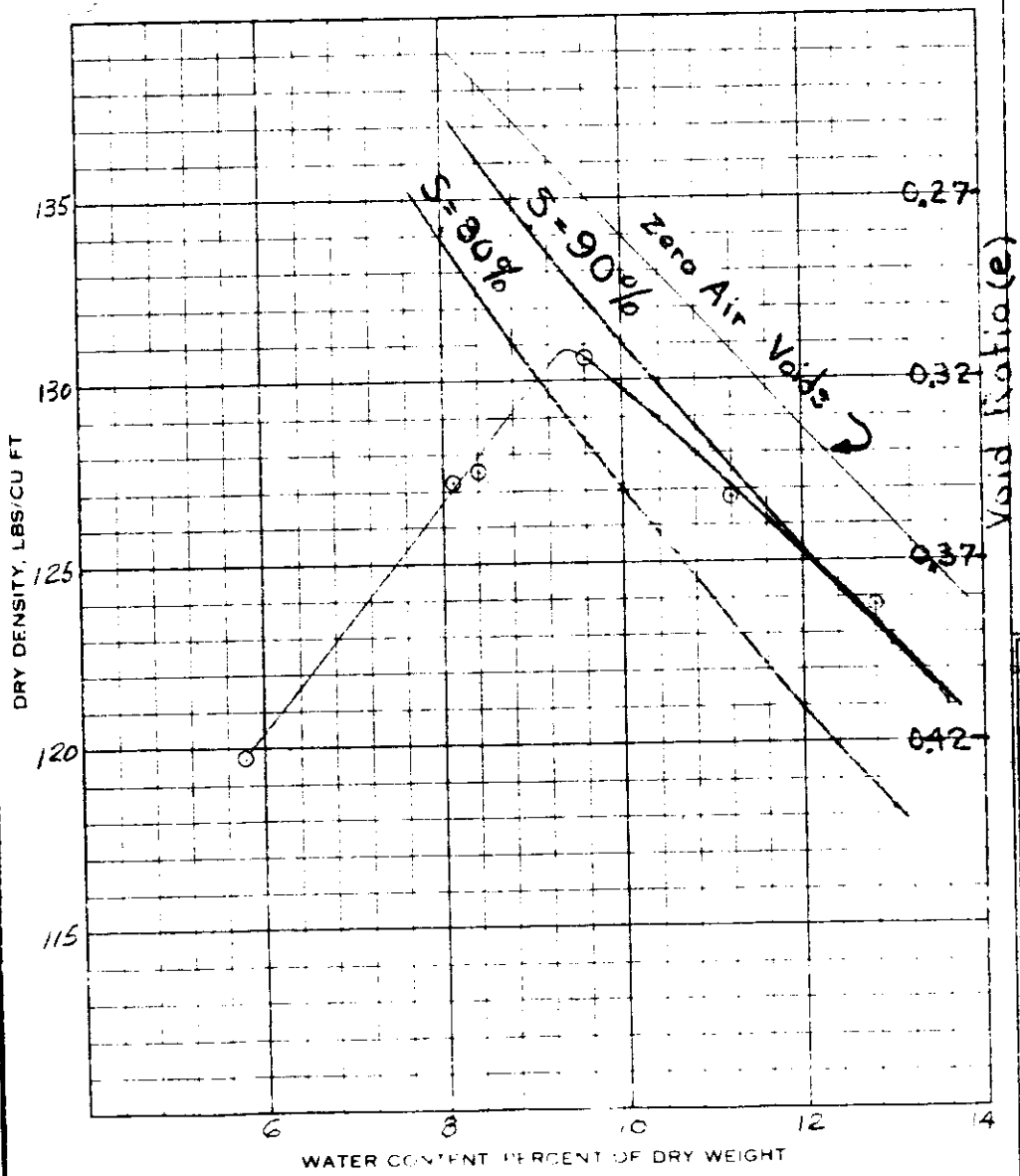
Area Railroad Relocation

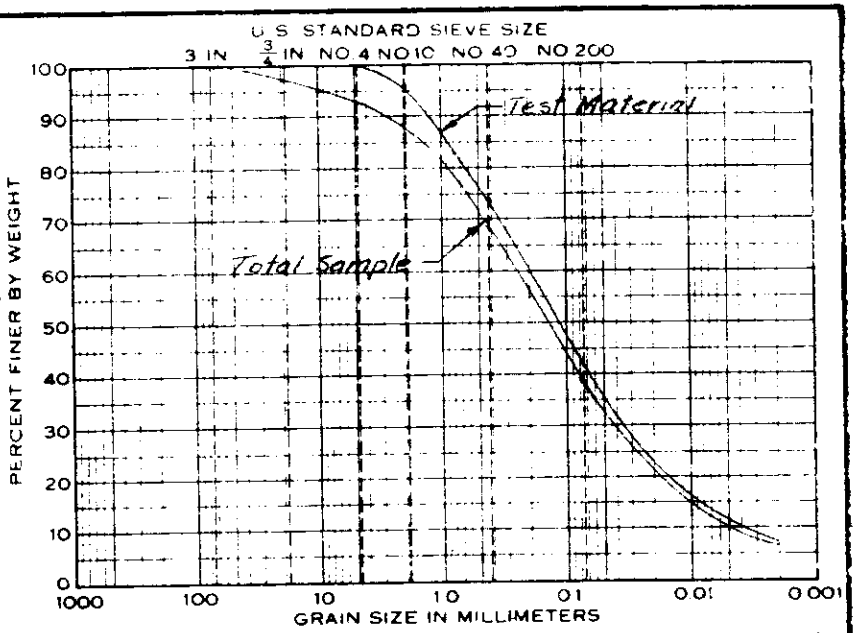
Boring No. BT-4A

Date 9 Feb. 1962

GRADATION CURVES

ENG FORM 2087





COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	G	LL	PL
B-1	12.4'-17.0'	Silty fine SAND (SM)	2.74	N.P.	NP

Sample No.		B-1			
Optimum Water Content	%	9.4			
Max Dry Density	Lbs/Cu Ft	130.8			
Optimum Water Content Corr for +	%				
Max Density Corr for +	Lbs/Cu Ft				

Project Hancock Brook

Area R.R. Relocation

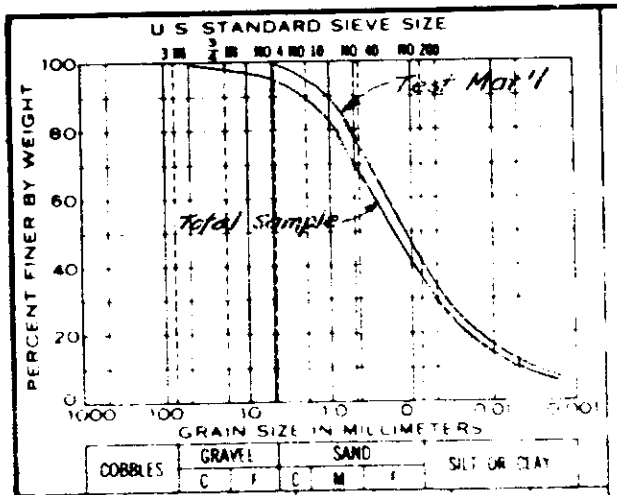
Boring No. BT-4A | Sample No. B-1

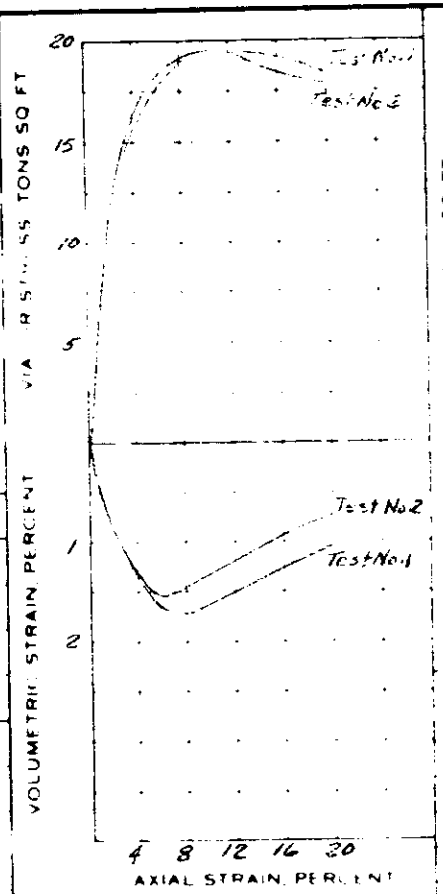
~~Elev or~~ Depth 12.4'-17.0' | Date 9 February 1962

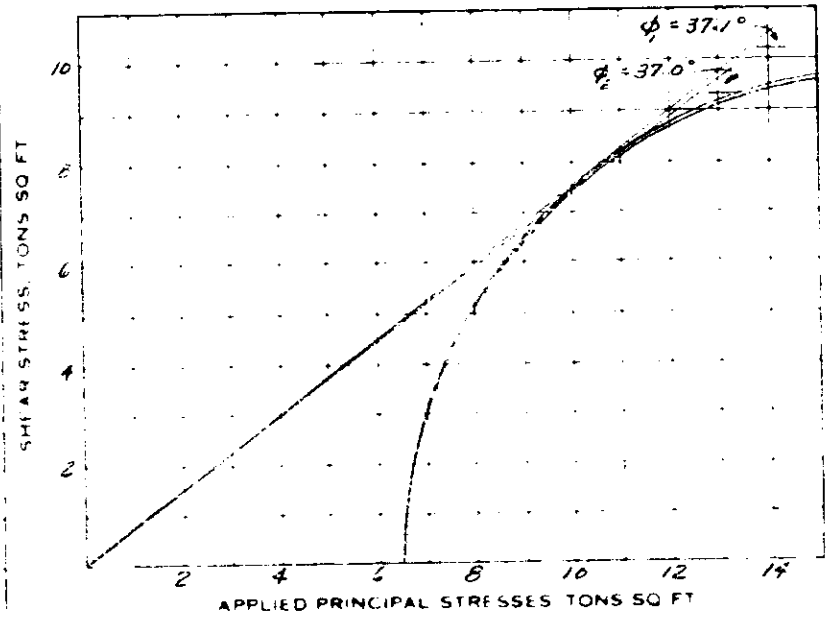
COMPACTION TEST REPORT

PLATE NO. B-2

ENG 2091







		Test No 1	Test No 2
INITIAL	Water Content W_0 %	11.4	11.6
	Dry Density Lbs/Cu Ft	126.6	126.4
	Void Ratio, e_0	.350	.352
	Saturation, S_0 %	89	90
BEFORE TEST	W C after Saturation, W_s %	12.2	12.1
	Saturation, S %	95	94
	Consol Pressure T/SqFt	6.48	6.48
	W C after Consol, W_c %	10.8	10.6
	Void Ratio after Consol e_c	.313	.310
AT FAILURE	Maj Prin Stress, σ_I T/Sq Ft	26.23	[illegible]
	Min Prin Stress, σ_{III} T/Sq Ft	6.48	[illegible]
	Water Content, W_f %	[illegible]	[illegible]
	Void Ratio, e_f	[illegible]	[illegible]
Specimen Diameter Inches		2.80	2.80
Initial Height Inr		6.30	6.30
Test Time to Failure Min		233	200

Type of Test
Constant Strain, 0.003 in/min
Control
x Consolidated x Drained

Type of Specimen *Remolded*

Ø 37.0°	Tan Ø .754	c = 0 T/Sq Ft

Classification *silty m-f SAND (SM)*

LL	N.P.	G	2.74
PL	N.P.	D_{10}	0.0045

Remarks *Samples remolded at approx. water content of 11.4% and an approx. dry density of 126.6 pcf as determined from standard compaction curve.*

Optimum moisture + 2%

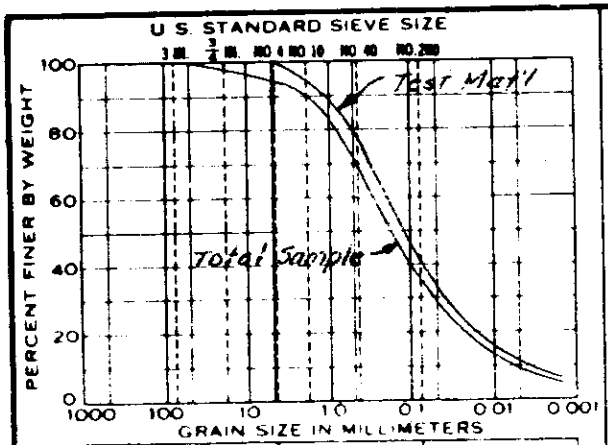
Project *Hancock Brook Reservoir*

Area *Railroad Relocation Area "A"*

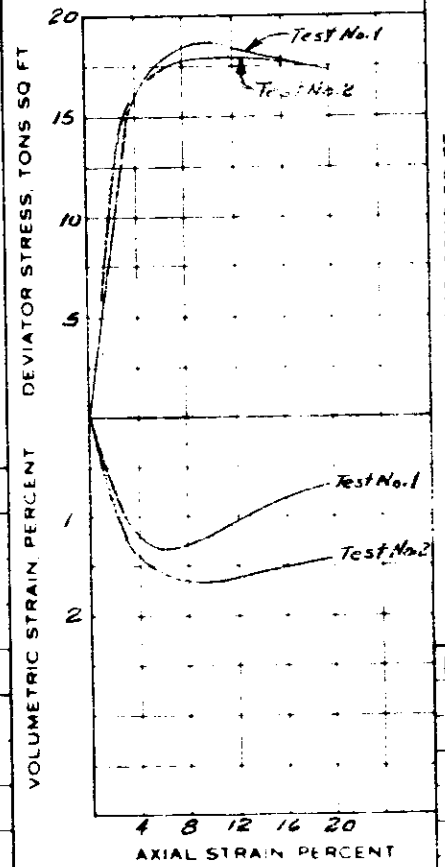
Boring No. *BT-4A* Sample No. *B-1*

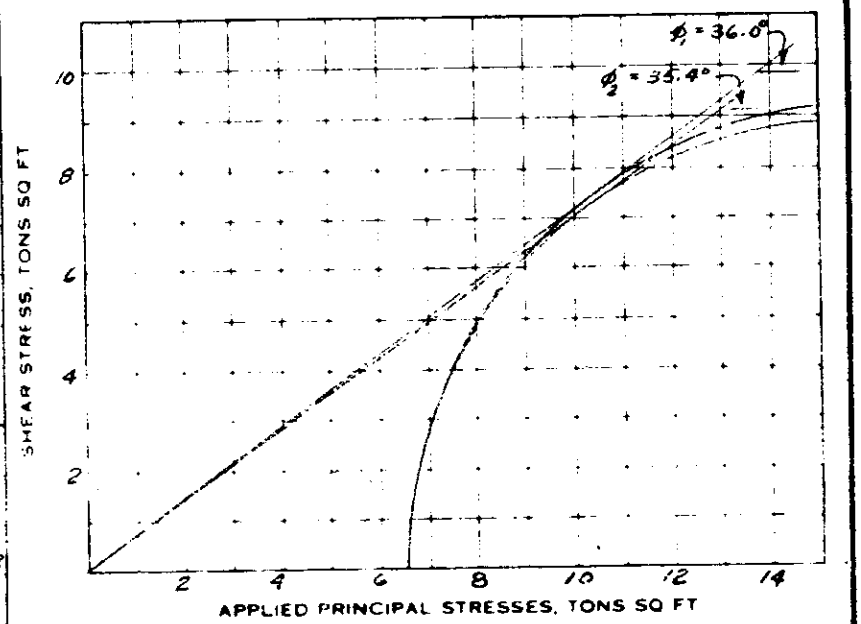
~~Elev or~~ Depth *12.4'-17.0'* Date *1 May 1962*

TRIAXIAL COMPRESSION TEST REPORT



	Test No.	1	2
INITIAL	Water Content, W_o %	9.6	9.5
	Dry Density Lbs/Cu Ft	130.6	130.7
	Void Ratio, e_o	.310	.309
	Saturation, S_o %	85	85
BEFORE TEST	W.C. after Saturation, W_s %	11.4	11.2
	Saturation, S %	100	99
	Consol Pressure T/Sq Ft	6.48	6.48
	W.C. after Consol, W_c %	10.8	10.9
	Void Ratio after Consol e_c	.295	.301
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	25.05	24.56
	Min Prin Stress, σ_{III} T/Sq Ft	6.48	6.48
	Water Content, W_f %	10.0	10.2
	Void Ratio, e_f	.273	.288
Specimen Diameter Inches		2.80	2.80
Initial Height Inc		6.30	6.50
Test Time to Failure Min		185	222





Remarks: Samples remolded at approx water content of 9.4% and an approx. dry density of 130.8 pcf as determined from standard compaction curve.

Optimum moisture

Type of Test
Constant Strain, 0.003 in./min
Control
X Consolidated, X Drained

Type of Specimen Remolded

Ø 35.4°	Tan Ø .710	C 0 T/Sq Ft	
Classification silty med SAND (SM)			
LL N.P.		G 2.74	
PL N.P.		D_{10} 0.0045	

Project Hancock Brook Dam

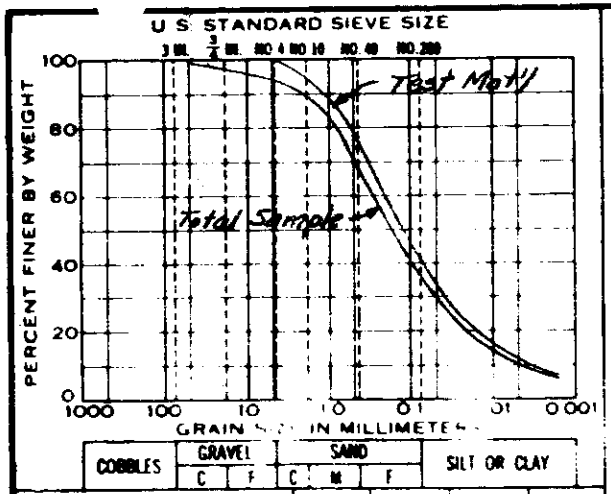
Area Railroad Relocation Area "A"

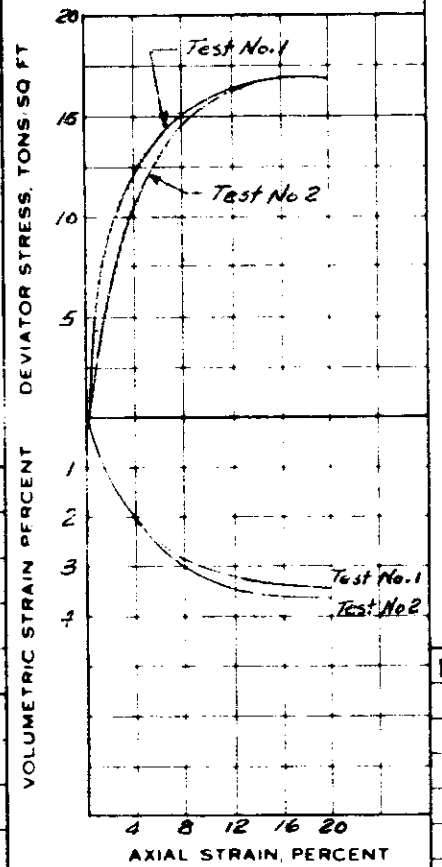
Boring No. ST-4A | Sample No. B-1

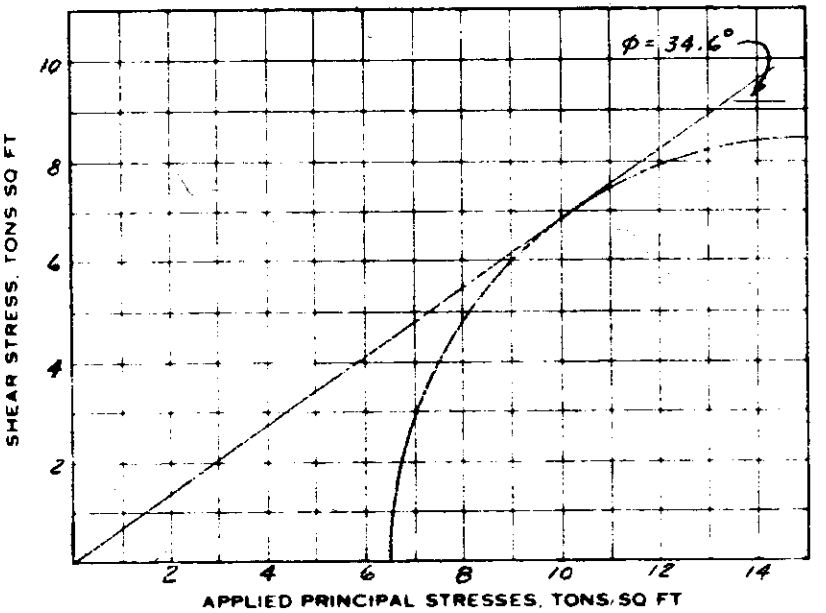
~~Elev or~~ Depth 12.4'-17.0' | Date 1 May 1962

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 2089







		Test No. 1	Test No. 2
INITIAL	Water Content, W_o %	7.6	7.4
	Dry Density Lbs/Cu Ft	124.5	124.4
	Void Ratio, e_o	.374	.374
	Saturation, S_o %	55	56
BEFORE TEST	W.C. after Saturation, W_s %	13.4	13.7
	Saturation, S %	98	100
	Consol Pressure T/Sq Ft	6.48	6.48
	W.C. after Consol, W_c %	11.8	11.8
	Void Ratio after Consol e_c	.328	.323
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	23.45	23.36
	Min Prin Stress, σ_m T/Sq Ft	6.48	6.48
	Water Content, W_f %	9.8	10.1
	Void Ratio, e_f	.274	.278
Specimen Diameter Inches		2.80	2.80
Initial Height Inr		6.30	6.30
Test Time to Failure Min		333	367

Type of Test
Constant Strain; 0.003 in/min
Control
X Consolidated, X Drained

Type of Specimen Remolded

φ = 34.6°	Tan φ = .690	c = 0 T/Sq Ft

Classification silty m-f SAND (SM)

LL N.P.	G 2.74
PL N.P.	D_{10} 0.0045

Remarks: Samples remolded at approx. water content of 7.4% and approx. dry density of 124.7 pcf as determined from standard compaction curve.

Optimum moisture - 2%

Project Hancock Brook Reservoir

Area

Boring No. BT-4A

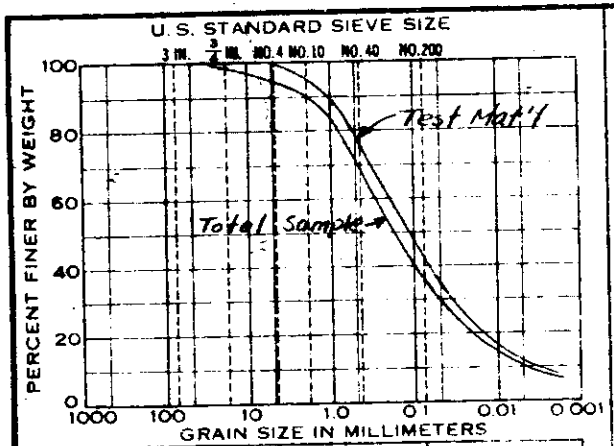
Sample No. B-1

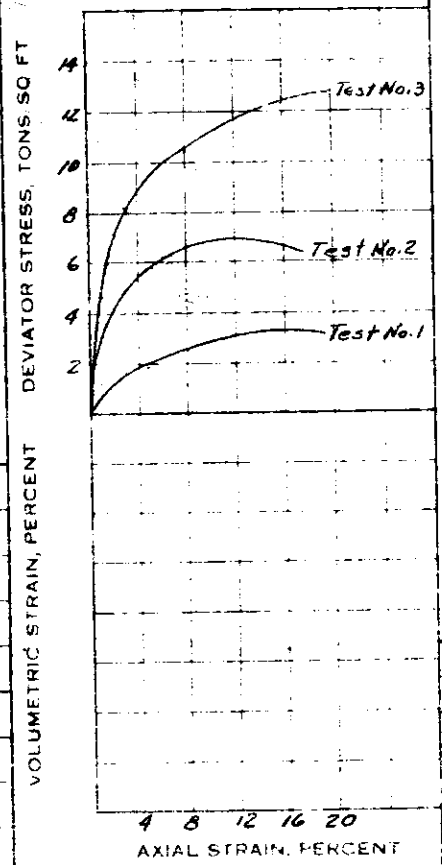
~~Elev or~~ Depth 12.4'-17.0

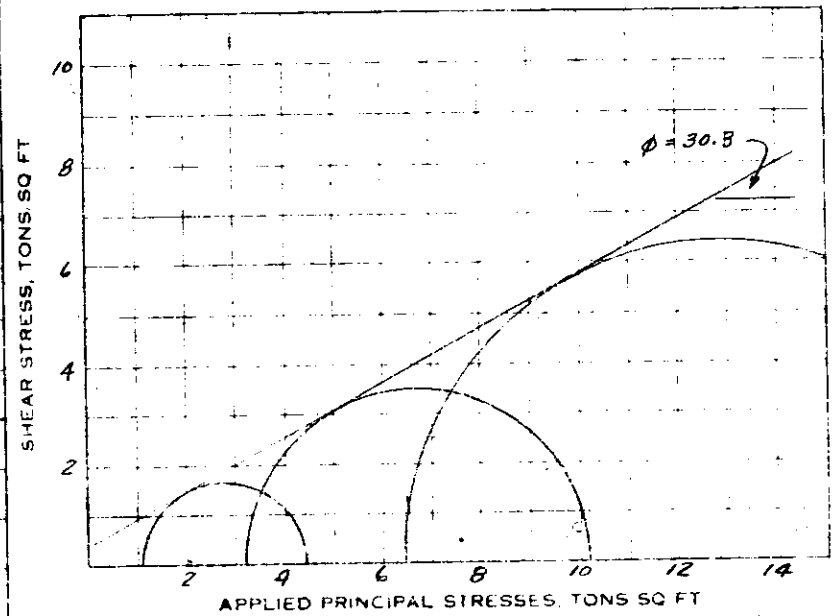
Date 30 April 1962

TRIAXIAL COMPRESSION TEST REPORT

Plate No. R-5







	Test No.	1	2	3
INITIAL	Water Content, W_0 %	11.5	11.5	11.5
	Dry Density Lbs/Cu Ft	126.5	126.5	126.5
	Void Ratio, e_0	.351	.351	.351
	Saturation, S_0 %	90	90	90
BEFORE TEST	W.C. after Saturation, W_s %	12.3	12.8	12.5
	Saturation, S %	96	100	98
	Consol Pressure T/SqFt	1.08	3.24	6.48
	W.C. after Consol. W_c %	12.0	12.0	11.1
	Void Ratio after Consol e_c	.340	.329	.313
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	4.40	10.16	19.20
	Min Prin Stress, σ_{3} T/Sq Ft	1.08	3.24	6.48
	Water Content, W_F %	12.0	12.0	11.1
	Void Ratio, e_F	.340	.329	.313
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inches		6.30	6.30	6.30
Test Time to Failure Min		42.0	25.0	50.0

Type of Test
Constant Strain 0.025 in/min.
Control
X Consolidated Un Drained

Type of Specimen Remolded.

φ = 30.3° Tan φ = .589, c = 6.4 T/Sq Ft

Classification [illegible]

LL NP G [illegible]

PL NP D [illegible]

Remarks: Samples remolded at approx. water content of 11.4 % and approx. dry density of 126.6 pcf as indicated by standard compaction curve.

Optimum moisture + 2%

Project Hancock Brook Reservoir

Area Railroad Relocation. ~~Area A~~"

Boring No BT-4A

Sample No B-1

~~Elev or~~ Depth 12.4'-17.0

Date 10 April 1962

TRIAXIAL COMPRESSION TEST REPORT

Plate No. 56

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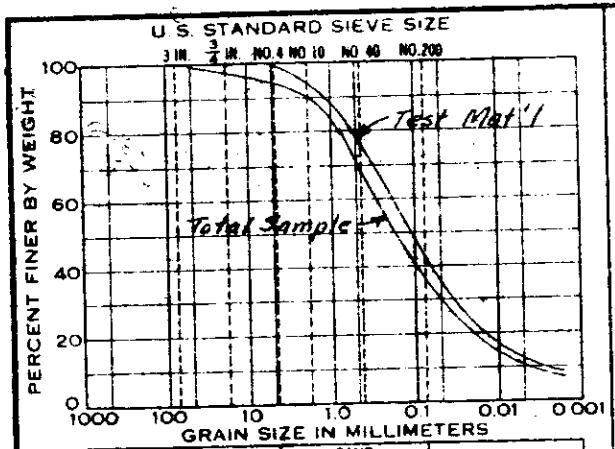
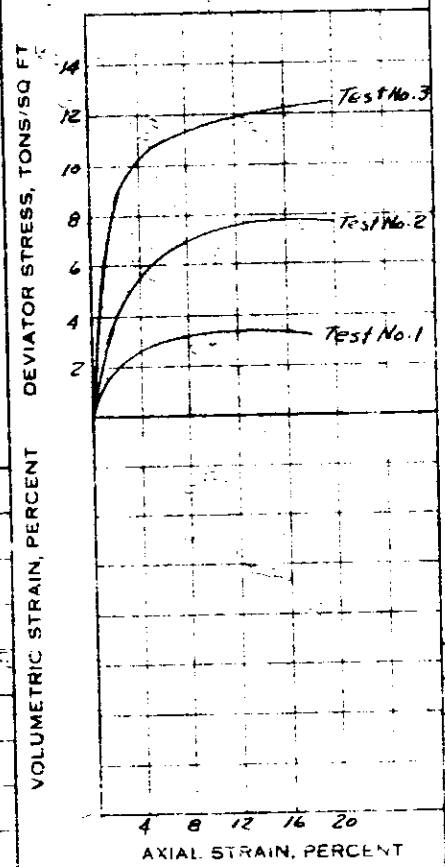
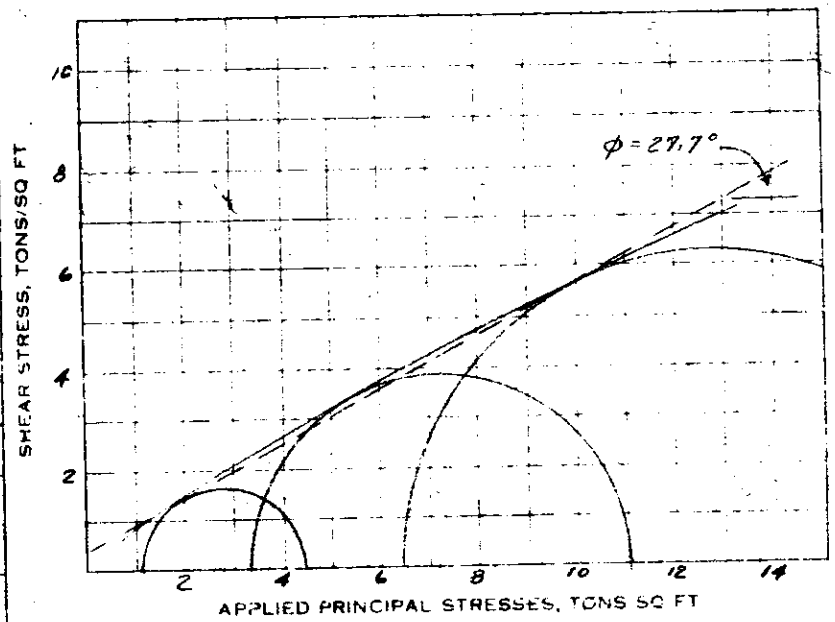


COBBLES	GRAVEL C	GRAVEL F	SAND C	SAND M	SAND F	SILT OR CLAY

	Test No.	1	2	3
INITIAL	Water Content, W_0 %	9.5	9.5	9.3
	Dry Density Lbs/Cu Ft	130.7	130.7	130.9
	Void Ratio, e_0	.309	.309	.306
	Saturation, S_0 %	85	85	83
BEFORE TEST	W.C. after Saturation, W_s %	12.0	11.4	11.5
	Saturation, S %	100	100	100
	Consol Pressure T/SqFt	1.08	3.24	6.48
	W.C. after Consol, W_c %	11.9	10.9	10.6
	Void Ratio after Consol e_c	.305	.293	.281
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	4.45	11.04	19.01
	Min Prin Stress, σ_m T/Sq Ft	1.08	3.24	6.48
	Water Content, W_f %	11.9	10.9	10.6
	Void Ratio, e_f	.305	.293	.281
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inc		6.30	6.30	6.30
Test Time to Failure Min		28.0	40.0	50.0





Remarks: Samples remolded at approx. water content of 9.4% and approx. dry density of 130.8 pcf as indicated by standard compaction curve.

Optimum moisture

Type of Test
Constant Strain; 0.025 in/min
Control
x Consolidated. Un Drained

Type of Specimen Remolded

φ = 27.7°	Tan φ = .525	c = 0.4 T/Sq Ft

Classification silty m-f SAND (SM)

LL N.P.	G 2.74
PL N.P.	D_{10} 0.0045

Project Hancock Brook Reservoir

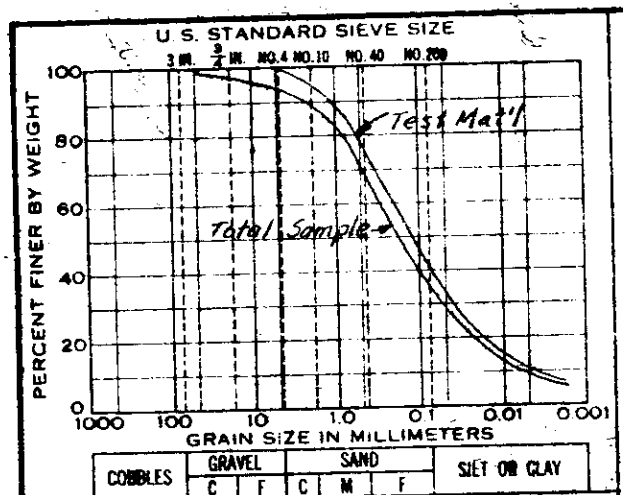
Area Railroad Relocation ~~Area A~~"

Boring No. BT-4A	Sample No. B-1
Elev or Depth 12.4'-17.0'	Date 10 April 1962

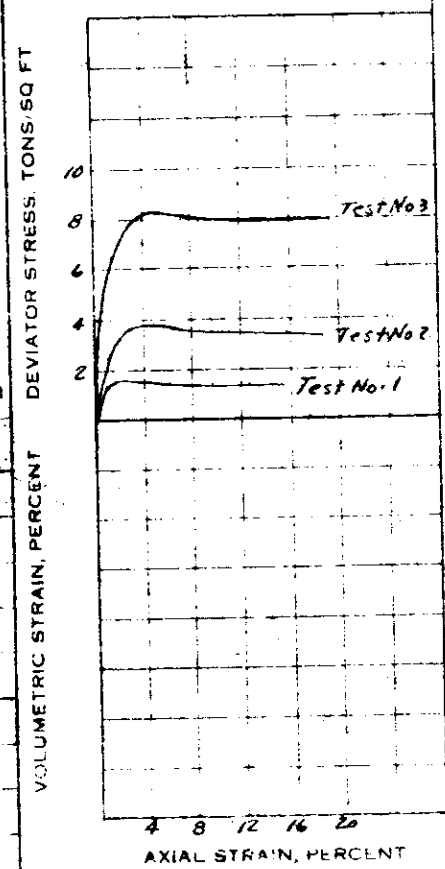
TRIAXIAL COMPRESSION TEST REPORT

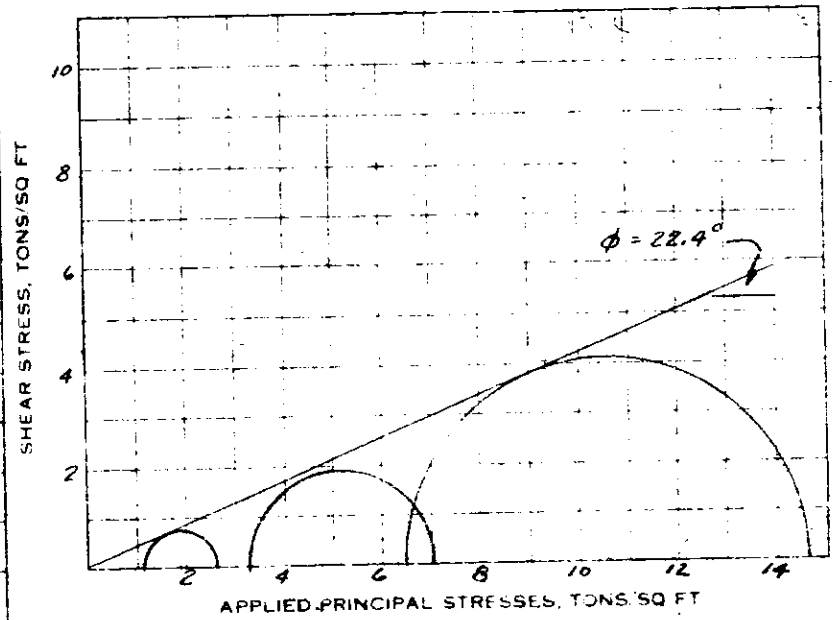
Plate No. B-1

CRB 2089



	Test No.	1	2	3
INITIAL	Water Content, W_0 %	7.4	7.2	7.5
	Dry Density Lbs/Cu Ft	124.7	125.9	124.6
	Void Ratio, e_0	.372	.369	.373
	Saturation, S_0 %	55	54	55
BEFORE TEST	W.C. after Saturation, W_s %	13.3	12.7	13.5
	Saturation, S %	98	94	99
	Consol Pressure T/Sq Ft	1.08	3.24	6.48
	W.C. after Consol, W_c %	13.1	11.8	11.3
	Void Ratio after Consol e_c	.366	.344	.313
AT FAILURE	Maj Prin Stress, σ_I T/Sq Ft	2.59	7.01	14.66
	Min Prin Stress, σ_{III} T/Sq Ft	1.08	3.24	6.48
	Water Content, W_f %	13.1	11.8	11.3
	Void Ratio, e_f	.366	.344	.313
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inc		6.30	6.30	6.30
Test Time to Failure Min		4.0	11.2	11.2





Remarks: Samples remolded at approx. water content of 7.4% and approx. dry density of 124.7 pcf as determined from standard compaction curve.

Optimum moisture - 2%

Type of Test
Constant Strain; 0.025 in/min. Control
X Consolidated, Un Drained

Type of Specimen Remolded

ϕ = 22.4°	Tan ϕ = .412	c = 0.1 T/Sq Ft

Classification Silty m-f SAND (SM)

LL	N.P.	G	2.74
PL	N.P.	D_{10}	0.0045

Project Hancock Brook Reservoir

Area Railroad Relocation ~~Area "A"~~

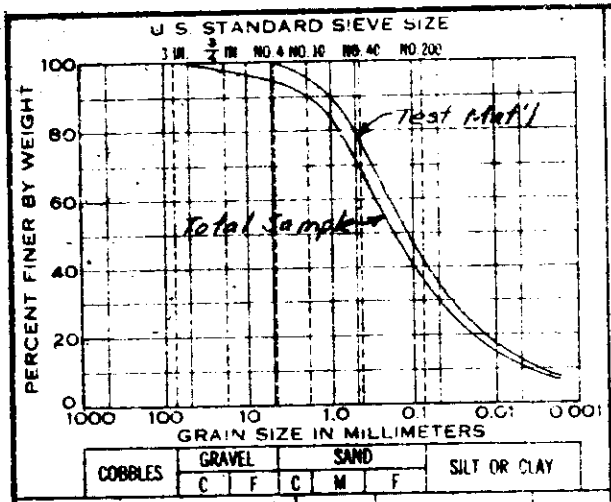
Boring No. BT-4A | Sample No. B-1

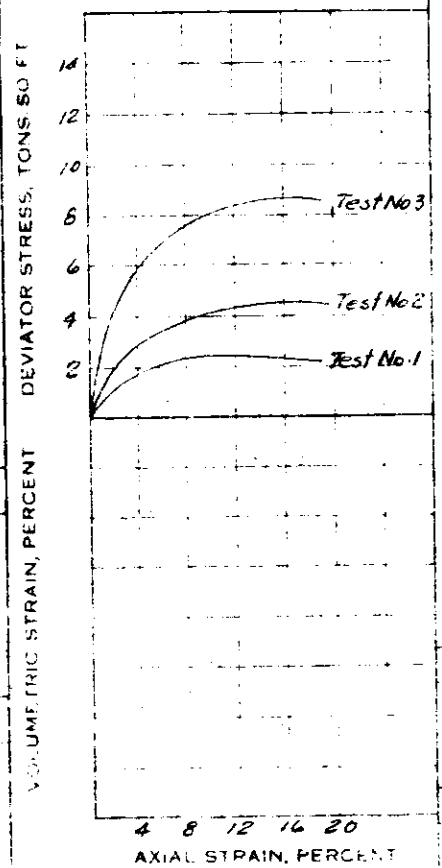
~~Elev or~~ Depth 12.4'-17.0' | Date 9 April 1962

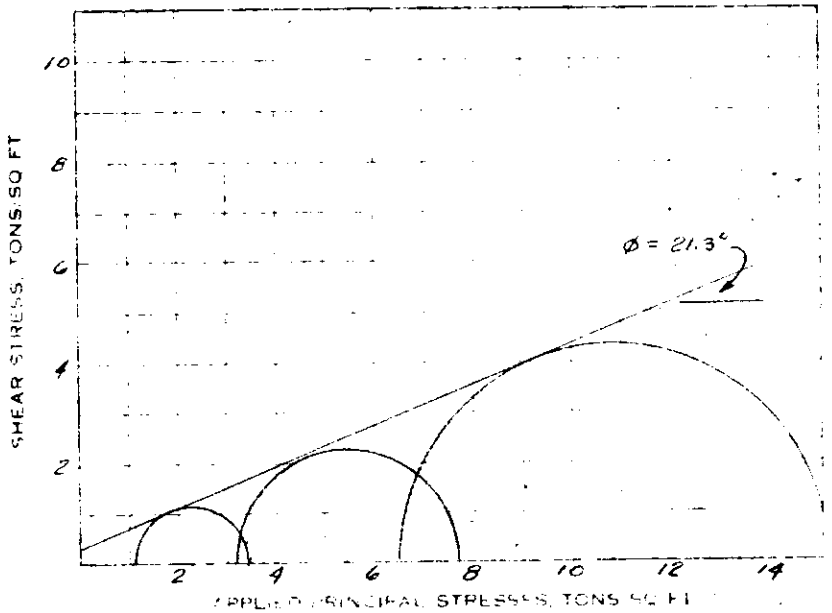
TRIAXIAL COMPRESSION TEST REPORT

Plate No. B-8

2089







	Test No.	1	2	3
INITIAL	Water Content, W_o %	11.4	11.5	11.3
	Dry Density Lbs/Cu Ft	126.5	126.5	126.5
	Void Ratio, e_o	.351	.351	.351
	Saturation, S_o %	89	90	88
BEFORE TEST	W.C. after Saturation, W_s %	—	—	—
	Saturation, S %	—	—	—
	Consol Pressure T/Sq Ft	—	—	—
	W.C. after Consol, W_c %	—	—	—
	Void Ratio after Consol e_c	—	—	—
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	3.48	7.66	15.12
	Min Prin Stress, σ_m T/Sq Ft	1.08	3.24	6.48
	Water Content, W_f %	11.4	11.5	11.3
	Void Ratio, e_f	.351	.351	.351
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inc		6.30	6.30	6.30
Test Time to Failure Min		30.0	44.0	44.0

Type of Test
Constant Strain; 0.025 in/min.
Control
Un Consolidated, Un Drained

Type of Specimen Remolded

Ø 21.3° | Tan Ø = .390 | c = 0.41 Sq Ft

Classification silty m-f SAND (SM)

LL N.P. | G 2.74
PL N.P. | D 0.0045

Remarks. Samples remolded at approx. water content of 11.4% and approx. dry density of 126.6 p.c.f. as indicated by standard compaction curve.

Optimum moisture + 2%

Project Hancock Brook Reservoir

Area Railroad Relocation, ~~Area~~ "A"

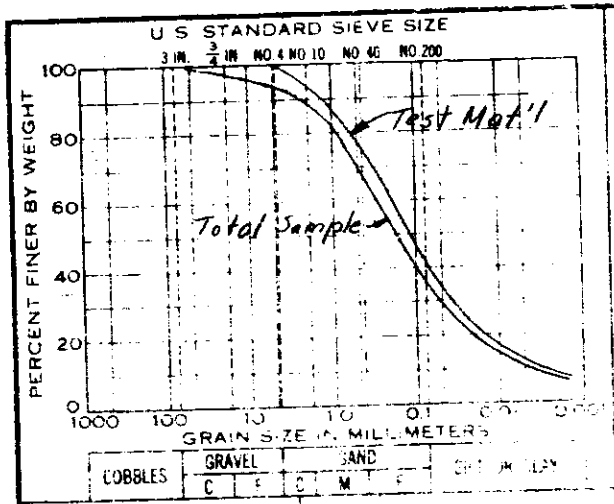
Boring No. BT-4A | Sample No. B-1

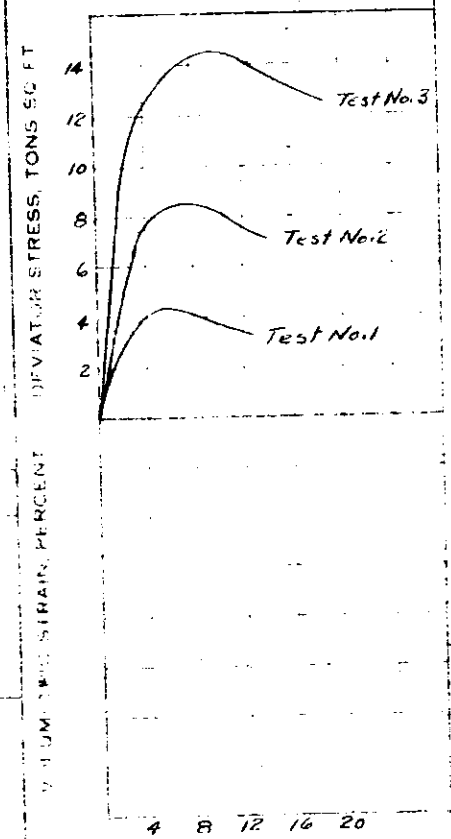
~~Elev or~~ Depth 12.4' - 17.0' | Date 23 March 1962

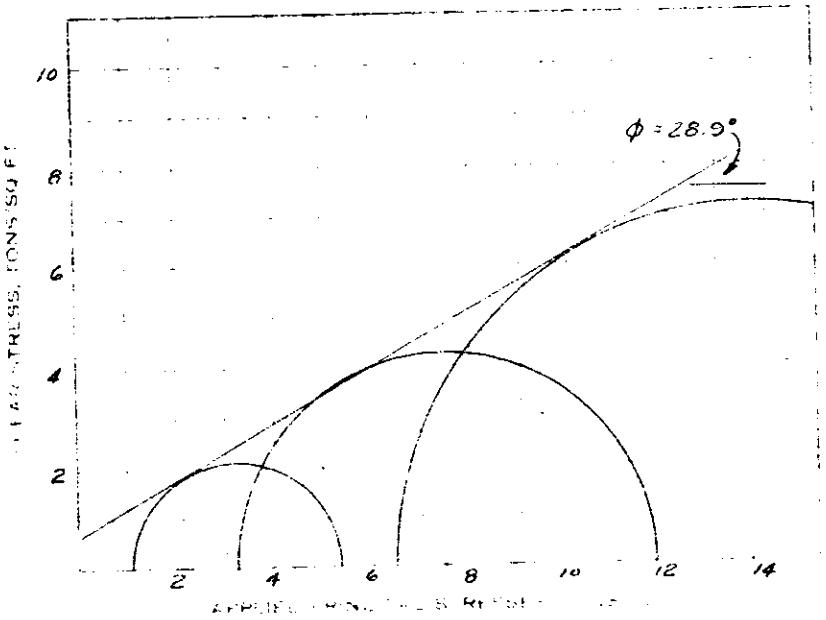
TRIAXIAL COMPRESSION TEST REPORT

Plate No. B-9

2089







	Test No.	1	2	3
INITIAL	Water Content, W_0 %	9.8	9.5	9.5
	Dry Density Lbs/Cu Ft	130.8	130.8	130.9
	Void Ratio, e_0	.308	.308	.306
	Saturation, S_0 %	87	85	85
BEFORE TEST	W.C. after Saturation W_s %	–	–	–
	Saturation, S %	–	–	–
	Consol Pressure T/Sq Ft	–	–	–
	W.C. after Consol. W_c %	–	–	–
	Void Ratio after Consol. e_c	–	–	–
AT FAILURE	Max Pipe Stress T/Sq Ft	5.39	11.73	20.87
	Min Pipe Stress T/Sq Ft	1.08	3.24	6.48
	Water Content, W_f %	9.8	9.5	9.5
	Void Ratio, e_f	.308	.308	.306
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inches		6.30	6.30	6.30
Test Time to Failure Min		14.0	20.0	24.0

Remarks: Samples remolded at approx. water content of 9.4% and approx. dry density of 130.8 p.c.f as indicated by standard compaction curve.

Optimum moisture

Type of Test: Strain; 0.025 in./min.

Consolidated: Unconsolidated, Undrained

Type of Specimen: Remolded

ϕ = 28.9 Tan ϕ .552 c = 0.7 T/Sq Ft

Classification: Silty fine SAND (SM)

LL N.P. G 2.74

PL N.P. D 0.0045

Project: Hancock Brook Reservoir

Area: Railroad Relocation Area "A"

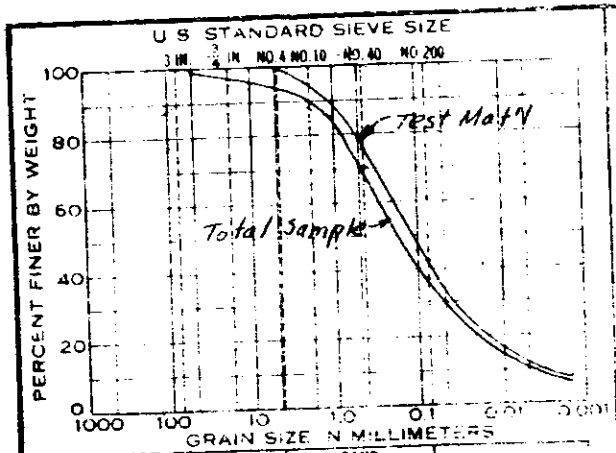
Boring No. BT-4A Sample No. B-1

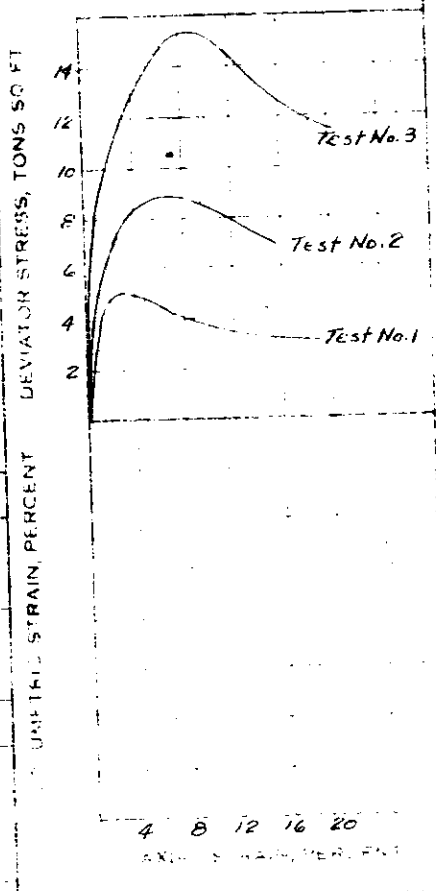
Elev. Depth 12.4'-17.0' Date 23 March 1962

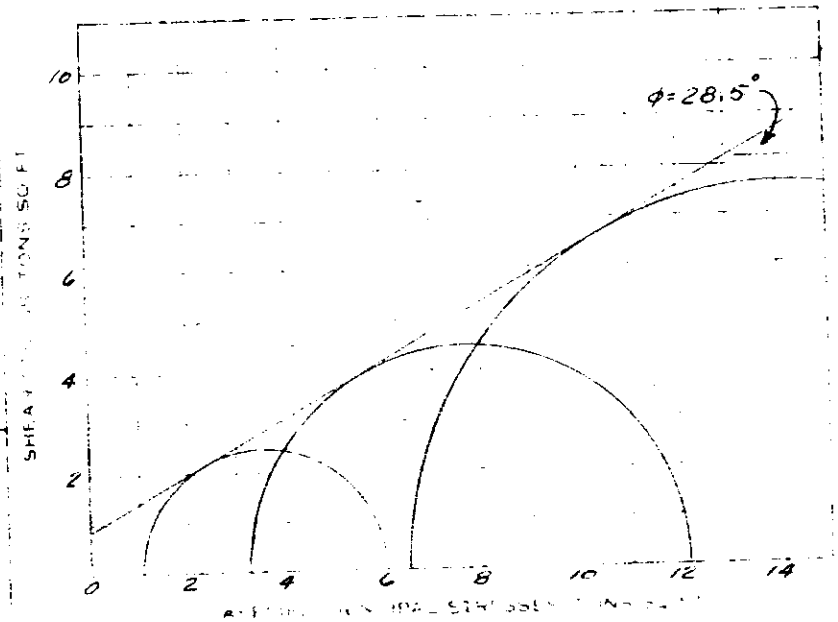
TRIAXIAL COMPRESSION TEST REPORT

Plate No. UT-10

ENG FORM 2080







	Test No.	1	2	3
INITIAL	Water Content, W_c %	7.5	7.9	7.7
	Dry Density Lbs/Cu Ft	124.6	124.6	124.5
	Void Ratio e_c	.373	.373	.374
	Saturation, S_c %	55	58	56
BEFORE TEST	W.C. after Saturation W_s %	–	–	–
	Saturation, S %	–	–	–
	Consol Pressure T/Sq Ft	–	–	–
	W.C. after Consol, W_c %	–	–	–
	Void Ratio after Consol e_c	–	–	–
AT FAILURE	Maj Prin Stress σ_1 T/Sq Ft	6.04	12.14	21.72
	Min Prin Stress σ_{III} T/Sq Ft	1.08	3.24	6.48
	Water Content W_f %	7.5	7.9	7.7
	Void Ratio e_f	.373	.373	.374
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inches		6.30	6.30	6.30
Test Time to Failure Min		7.2	18.0	22.0

Remarks: Samples remolded at approx. water content of 7.4% and approx. dry density of 124.7 pcf as determined from standard compaction curve.

Optimum moisture minus 2.0%

Type of Test: Constant Strain; 0.025 in/min
Control: Un Consolidated Un Drained

Type of Specimen: Remolded

D 28.5" Ht 6.3" Wt .543 lb 0.9 lb

Classification: Silty m-f SAND (SM)

LL N.P. G 2.74

PI N.P. .0045

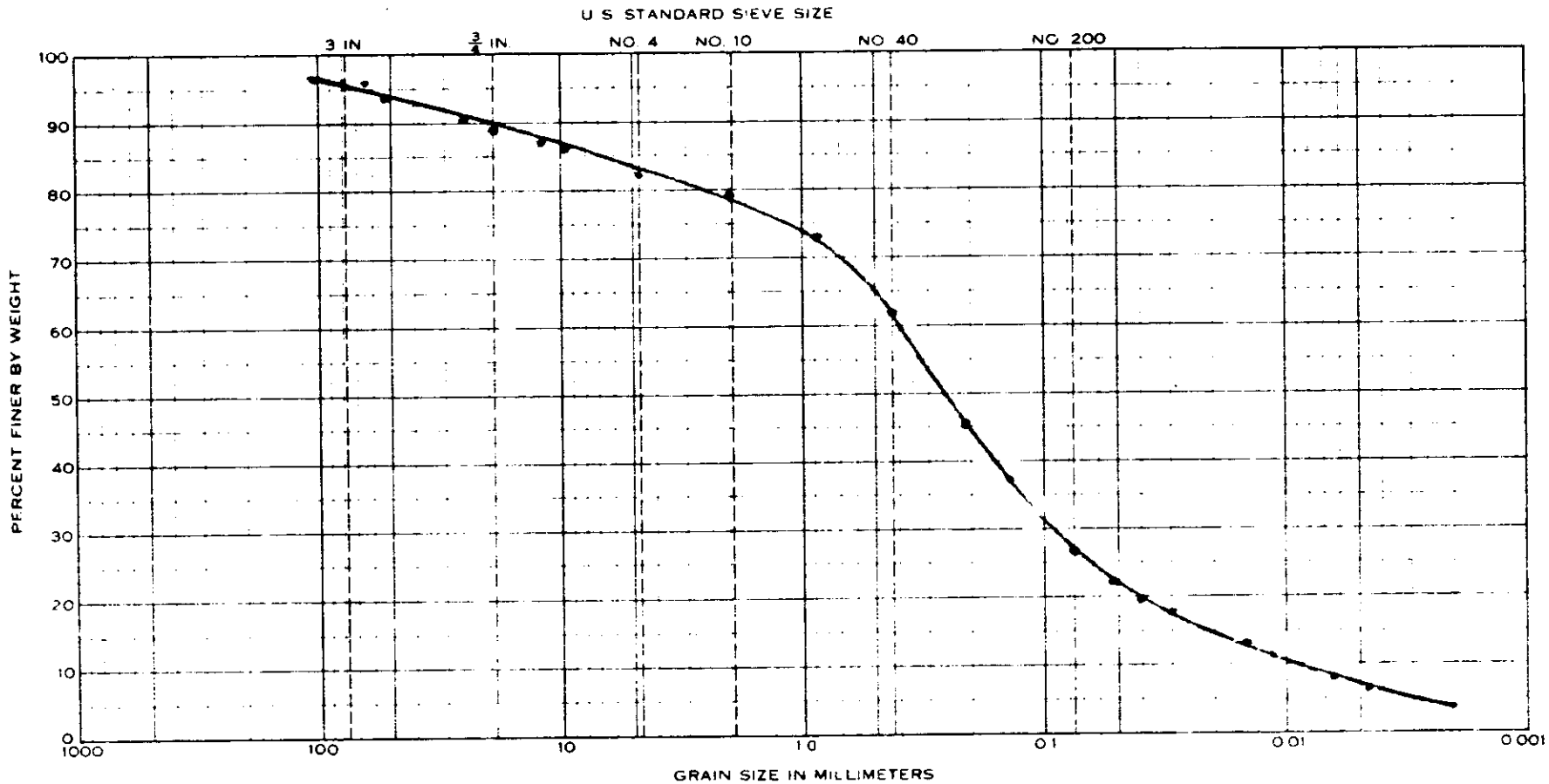
Project: Hancock Brook Reservoir

Area: Railroad Relocation Area "A"

Boring No. BT-4A Sample No. B-1

Depth 12.4'-17.0' Date 22 March 1962

TRIAXIAL COMPRESSION TEST REPORT



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI
B 4	2.1 - 5.0	gravelly silty SAND (SM)		NP	NP	NP

Project HANCOCK BROOK RESERVOIR

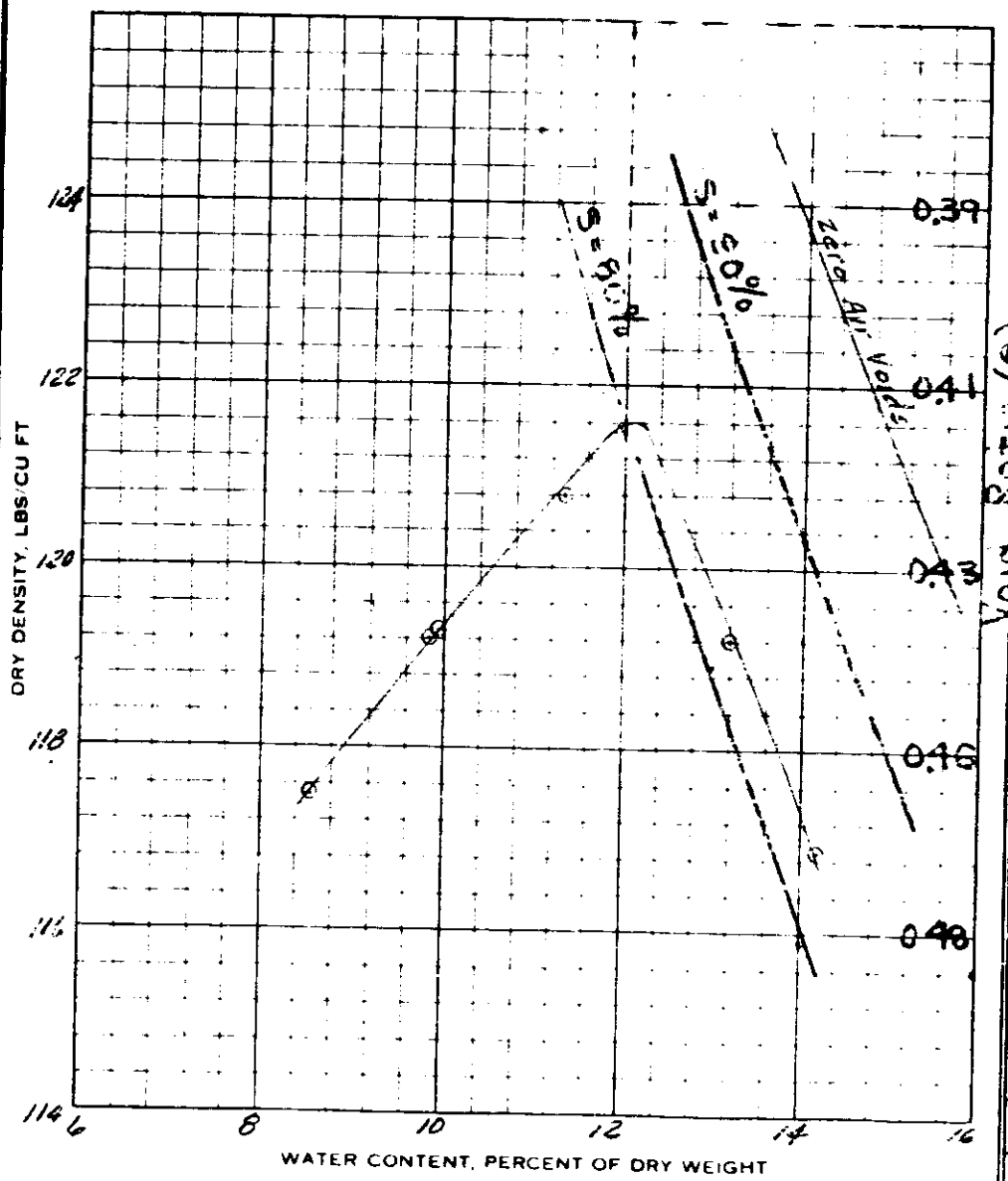
Area "A"

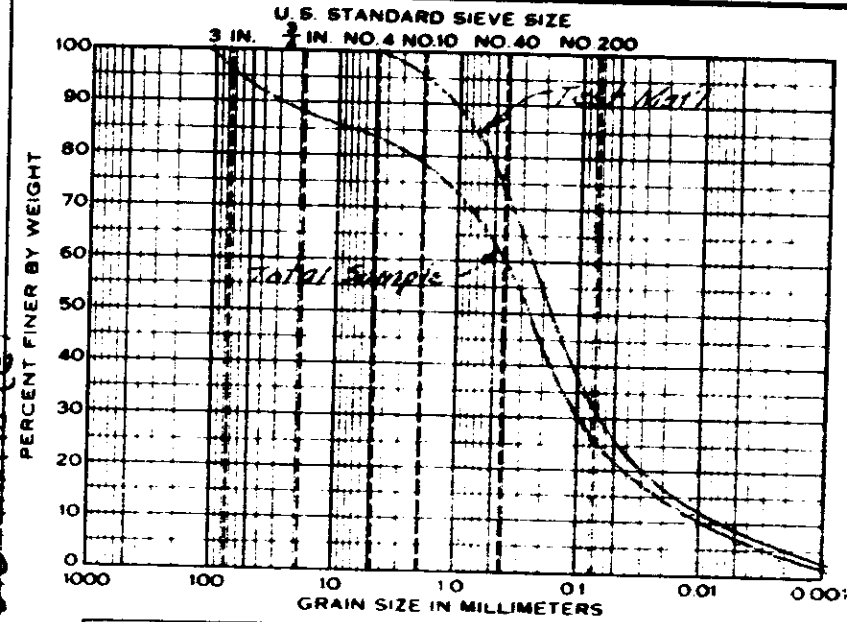
Boring No. BT-6

Date 20 April 1962

GRADATION CURVES

2087





COBBLES	GRAVEL Coarse	GRAVEL Fine	SAND Coarse	SAND Medium	SAND Fine	SILT OR CLAY

Sample No	Elev or Depth	Classification	G	LL	PI
B-4	2.1'-5.0'	gravelly silty SAND (SM)	2.75	N.P.	N.P.

Sample No.	B-4			
Optimum Water Content %	12.1			
Max Dry Density Lbs/Cu Ft	121.6			
Optimum Water Content Corr for + %				
Max Density Corr for - Lbs/Cu Ft				

Project Hancock Creek Reservoir

Area

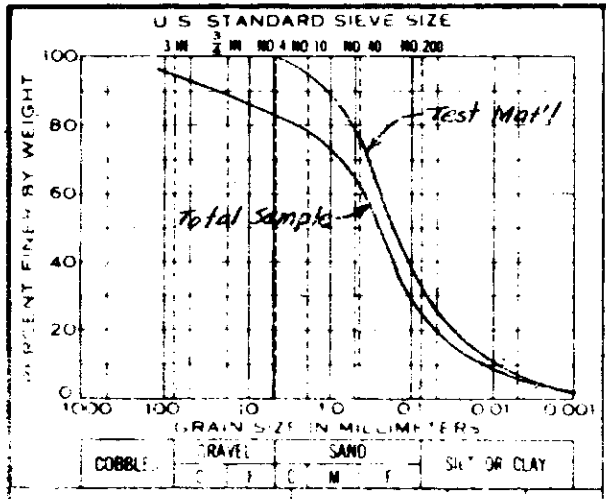
Boring No. BT-6 | Sample No. B-4

Elev or Depth 2.1'-5.0' | Date 8 May 1962

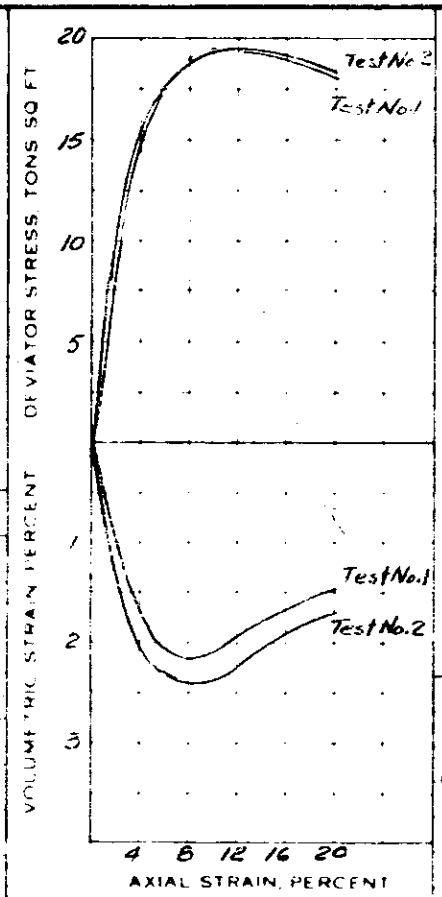
COMPACTION TEST REPORT

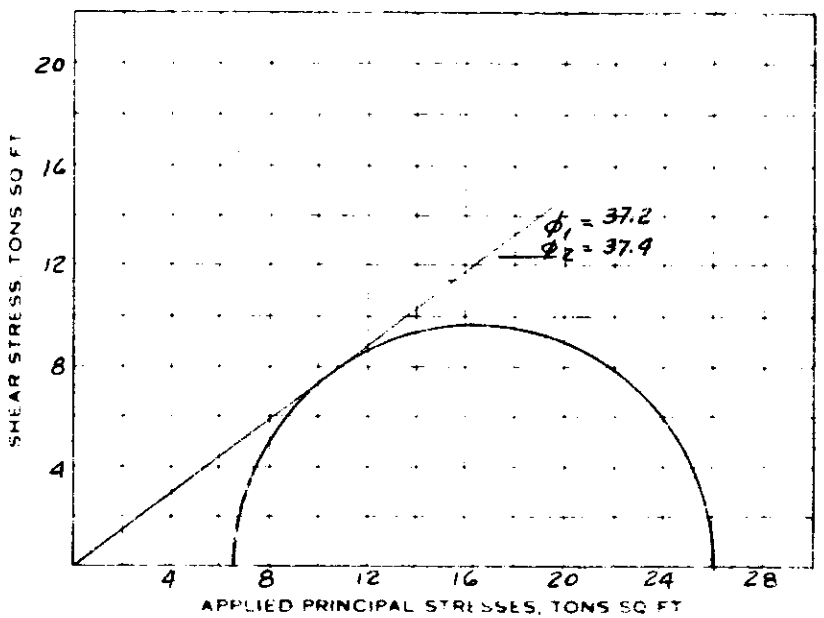
PLATE NO. B-13

EM 2091



	Test No	1	2
INITIAL	Water Content W_0 %	13.9	13.5
	Dry Density Lbs/Cu Ft	117.3	117.7
	Void Ratio, e_0	.463	.458
	Saturation, S_0 %	83	81
BEFORE TEST	W C after Saturation, W_s %	15.7	15.1
	Saturation, S %	96	95
	Consol Pressure T/Sq Ft	6.48	6.46
	W C after Consol, W_c %	14.7	13.9
	Void Ratio after Consol e_c	.423	.403
AT FAILURE	Maj Prin Stress σ_1 T/Sq Ft	26.00	26.05
	Min Prin Stress, σ_{III} T/Sq Ft	6.48	6.48
	Water Content, W_f %	13.9	13.0
	Void Ratio, e_f	.402	.379
Specimen Diameter Inches		2.80	2.80
Initial Height Inc		6.30	6.30
Test Time to Failure Min		217	250





Remarks: Specimens molded at an approx. water content of 14.1 % and an approx. dry density of 117.1 pcf as indicated by standard compaction curve. Optimum + 2% water content.

Type of Test

Constant Strain; 0.003 in/min

Control

X Consolidated X Drained

Type of Specimen Remolded

Ø 31.2°	Tan Ø .760	c-0 T/Sq Ft

Classification gravelly silty SAND (SM)

LL	N.P.	G	2.75
PL	N.P.	D_{10}	0.0095

Project Hancock Brook Reservoir

Area "A"

Boring No BT-6 | Sample No. B-4

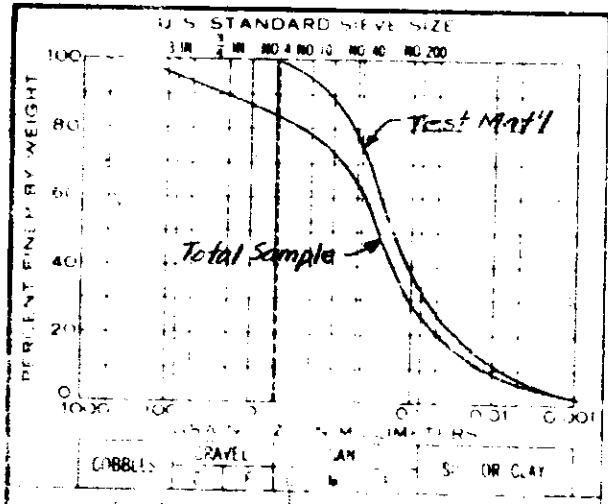
Elev or Depth 2.1'-5.0' | Date 23 August 1962

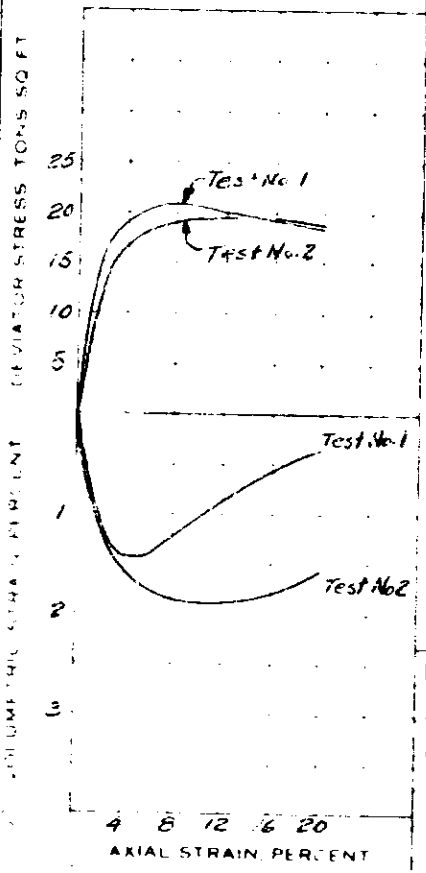
TRIAXIAL COMPRESSION TEST REPORT

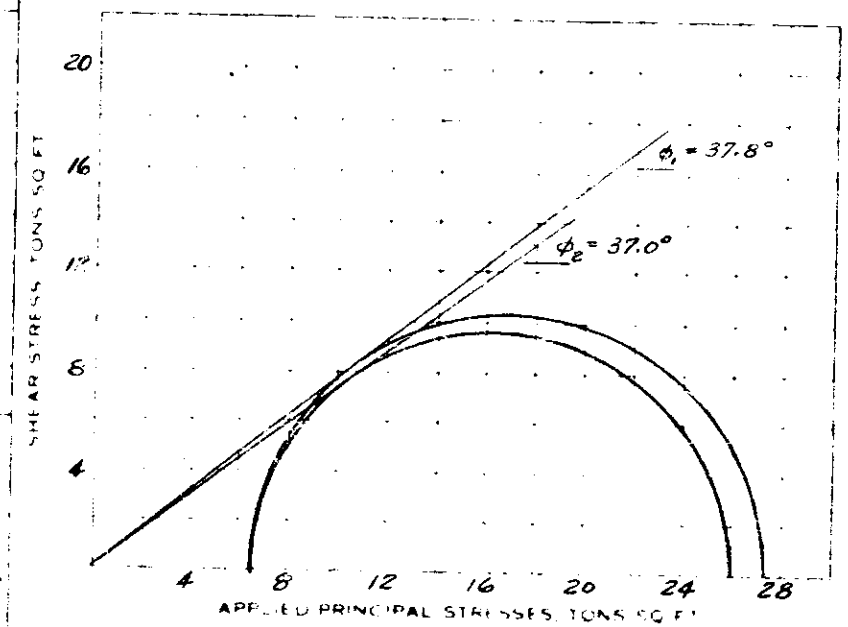
Hancock Brook Dam

Plate No. B-14

2089







	Test No.	1	2
BEFORE TEST	Water Content W_c %	12.2	12.2
	Dry Density lbs/Cu Ft	121.5	121.5
	Void Ratio, e_c	.412	.412
	Saturation, S_c %	81	81
	W C after Saturation, W_s %	14.4	14.5
	Saturation, S %	96	97
	Consol Pressure T/Sq Ft	6.48	6.48
	W C after Consol, W_c %	13.6	13.8
	Void Ratio after Consol e_c	.369	.393
AT FAILURE	Maj Prin Stress σ_1 T/Sq Ft	27.26	25.98
	Min Prin Stress σ_m T/Sq Ft	6.48	6.48
	Water Content W_f %	13.4	13.6
	Void Ratio, e_f	.385	.372
Specimen Diameter	Inches	2.80	2.80
Initial Height	Inc	6.30	6.30
Test Time to Failure	Min	167	267

Remarks: Specimens molded at an approx. water content of 12.1% and an approx. dry density of 121.6 pcf as indicated by standard compaction curve. Optimum water content

Type of Test
Constant Strain; 0.003 in./min.
Control
X Consolidated X Drained

Type of Specimen Remolded

ϕ 37.0° | Tan ϕ .753 | c - 0 T/Sq Ft

Classification gravelly silty SAND(SM)

LL	NP	G	2.75
PL	NP	D_{10}	0.0095

Project Hancock Brook Reservoir

Area "A"

Boring No. BT-6 | Sample No. B-4

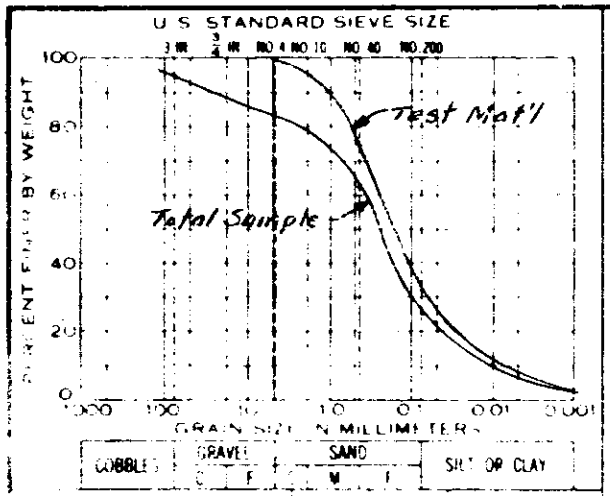
Elev or Depth 2.1'-5.0' | Date 23 August 1962

TRIAXIAL COMPRESSION TEST REPORT

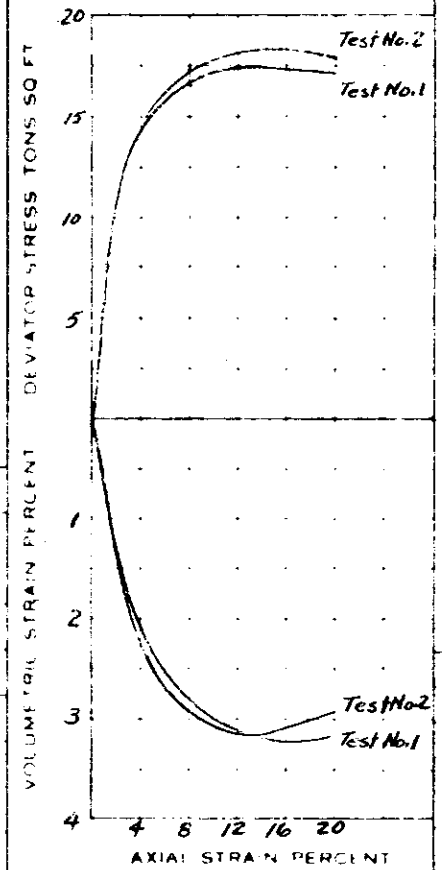
Hancock Brook Dam

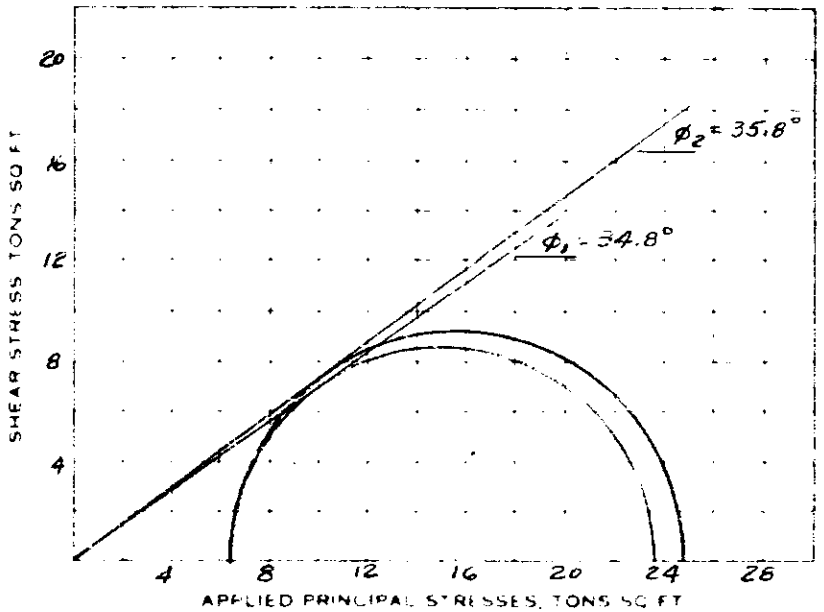
Plate No. B-15

2089



		Test No	1	2
INITIAL		Water Content W_0 %	10.9	10.4
		Dry Density lbs/Cu Ft	118.4	119.1
		Void Ratio, e_0	.449	.441
		Saturation, S_0 %	67	65
BEFORE TEST		W.C after Saturation W_s %	16.3	15.7
		Saturation, S %	100	98
		Consol Pressure T/Sq Ft	6.48	6.48
		W.C after Consol W_c %	16.1	14.7
		Void Ratio after Consol e_c	.441	.415
AT FAILURE		Maj Prin Stress σ_1 T/Sq Ft	23.77	24.78
		Min Prin Stress σ_{III} T/Sq Ft	6.48	6.48
		Water Content W_f %	14.5	13.3
		Void Ratio, e_f	.398	.375
Specimen Diameter		Inches	2.80	2.80
Initial Height		Inc	6.30	6.30
Test Time to Failure		Min	300	300





Remarks: Specimens molded at an approx. water content of 10.1% and an approx. dry density of 119.4 pcf as indicated by standard compaction curve. Optimum water content - 8%

Type of Test

Constant Strain, 0.003 in/min

Control

X Consolidated X Drained

Type of Specimen Remolded

Ø 34.8° Tan Ø .695 c - 0 T/Sq Ft

Classification gravelly silty SAND (SM)

LL	NP	G	2.75
PL	NP	D_{10}	0.0095

Project Hancock Brook Reservoir

Area "A"

Boring No. BT-6 Sample No. B-4

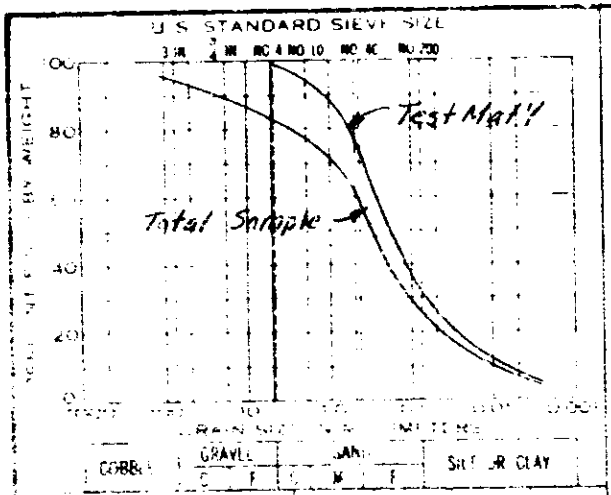
Elev or Depth 2.1'-5.0' Date 23 August 1962

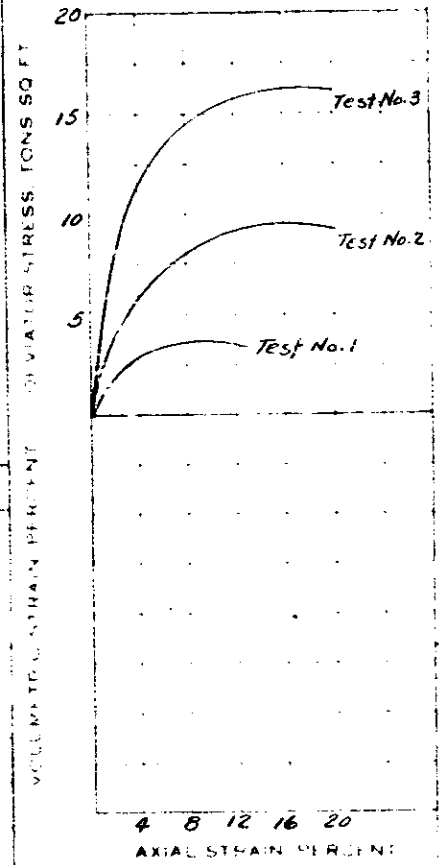
TRIAXIAL COMPRESSION TEST REPORT

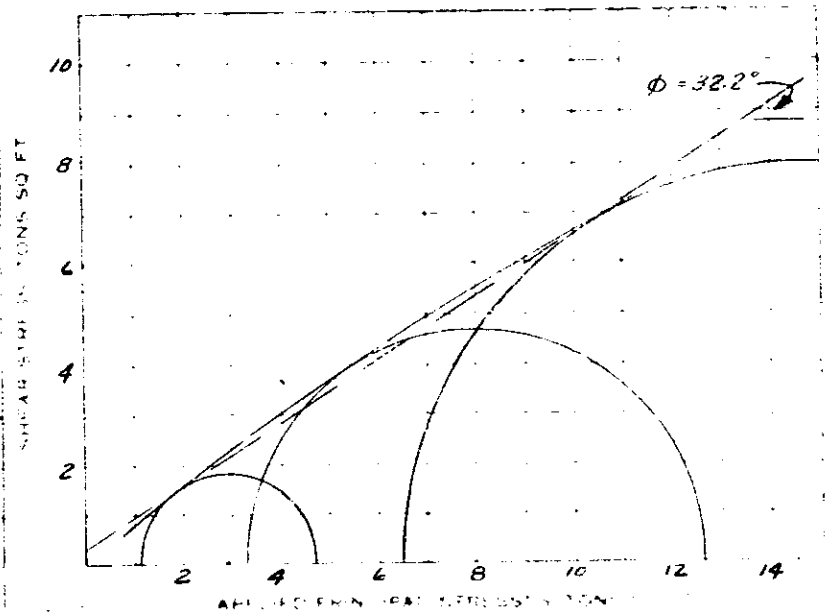
Hancock Brook Dam

Plate No. B-16

ENG 2089







	Test No.	1	2	3
BEFORE TEST	Water Content W_c %	14.4	14.2	13.9
	Dry Density Lbs/Cu Ft	116.8	117.0	117.3
	Void Ratio, e_c	.469	.467	.463
	Saturation, S_c %	84	84	83
	W.C. after Saturation W_s %	15.6	15.4	15.3
	Saturation, S_s %	95	96	95
	Consol Pressure T/Sq Ft	1.08	3.24	6.48
	W.C. after Consol W_c %	15.0	14.3	13.7
	Void Ratio after Consol e_c	.436	.413	.401
AFTER TEST	Max Prin Stress T/Sq Ft	4.67	12.70	22.57
	Min Prin Stress σ_m T/Sq Ft	1.08	3.24	6.48
	Water Content W_f %	15.0	14.3	13.7
	Void Ratio e_f	.436	.413	.401
	Specimen Diameter Inches	2.80	2.80	2.80
	Initial Height In.	6.30	6.30	6.30
	Test Time to Failure Min	20.0	38.0	38.0

Type of Test
Constant Strain; 0.025 in/min.
Control
X Consolidated Un Drained

Type of Specimen Remolded

Ø 32.2° Tan Ø .630 [illegible] T/Sq Ft

Classification gravelly silty SAND (SM)

LL N.P. G 2.75

PL N.P. D_{10} 0.0095

Remarks Samples remolded at an approx. water content of 14.1% and an approx. dry density of 117.1 pcf as determined from the standard compaction curve.

Optimum moisture +2%

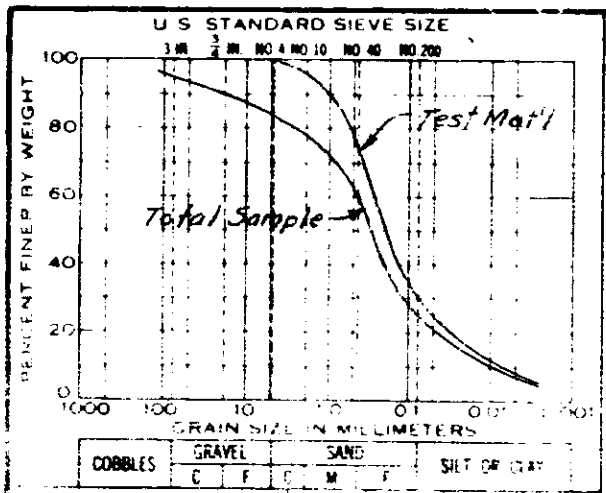
Project Hancock Brook Reservoir

Area "A"

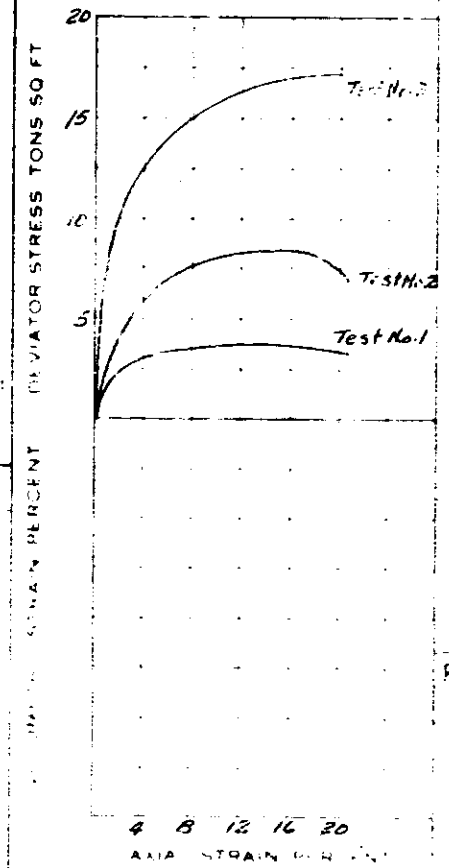
Boring No BT-6 Sample No B-4

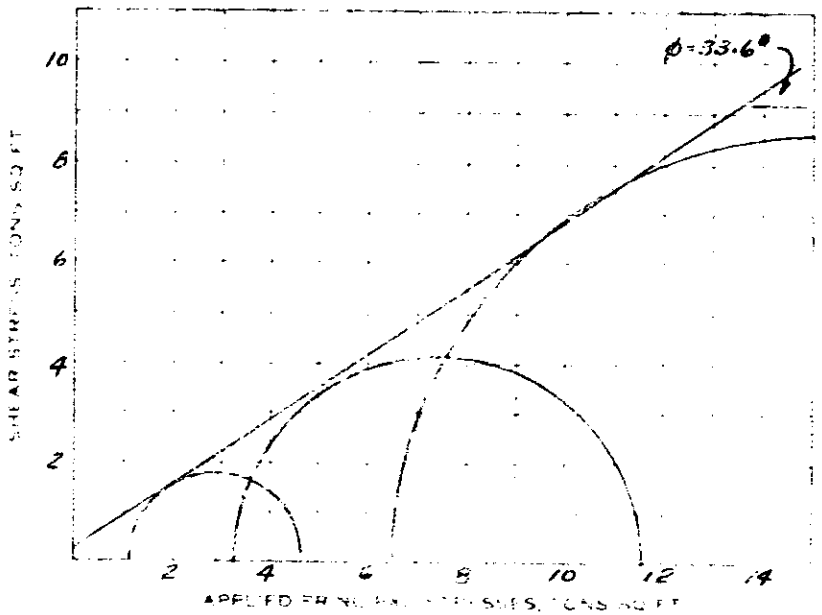
Elev or Depth 2.1' - 5.0' Date 26 June 1962

TRIAXIAL COMPRESSION TEST REPORT



	Test No	1	2	3
INITIAL	Water Content, W_0 %	12.0	11.9	11.8
	Dry Density Lbs/Cu Ft	121.7	121.8	123.0
	Void Ratio, e_0	.410	.409	.407
	Saturation, S_0 %	81	80	80
BEFORE TEST	W.C. after Saturation W_s %	14.6	14.3	14.1
	Saturation, S %	98	96	95
	Consol. Pressure T/Sq Ft	1.08	3.24	6.48
	W.C. after Consol, W_c %	14.4	13.7	13.1
	Void Ratio after Consol e_c	.406	.392	.380
AT FAILURE	Max Prin Stress σ_1 T/Sq Ft	4.71	11.58	23.76
	Min Prin Stress σ_{III} T/Sq Ft	1.08	3.24	6.48
	Water Content W_f %	14.4	13.7	13.1
	Void Ratio e_f	.406	.392	.380
Specimen Diameter	Inches	2.50	2.80	2.80
Initial Height	Inc	6.30	6.30	6.30
Test Time to Failure	Min	32.0	42.0	50.0





Remarks: Samples remolded at approx. water content of 12.1 % and an approx. dry density of 121.6 pcf as determined from standard compaction curves.

Optimum Moisture

Type of Test
Constant Strain, 0.025 in/min
Control
X Consolidated Un Drained

Type of Specimen Remolded

φ 33.6 Tan φ .665 (c=.25) (Sq ft)

Classification gravelly silty SAND (SM)

LL N.P. G 2.75

PL N.P. D_{10} 0.0095

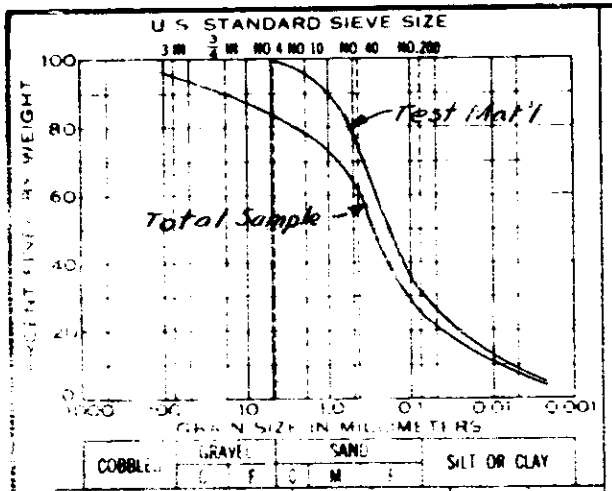
Project Hancock Brook Reservoir

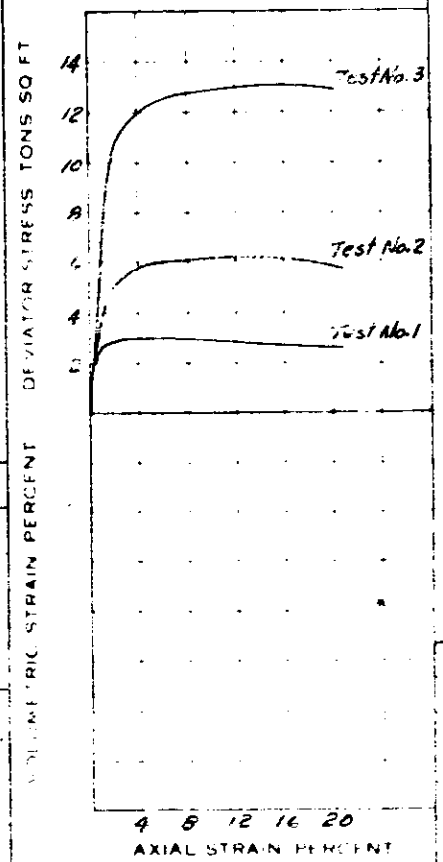
Area "A"

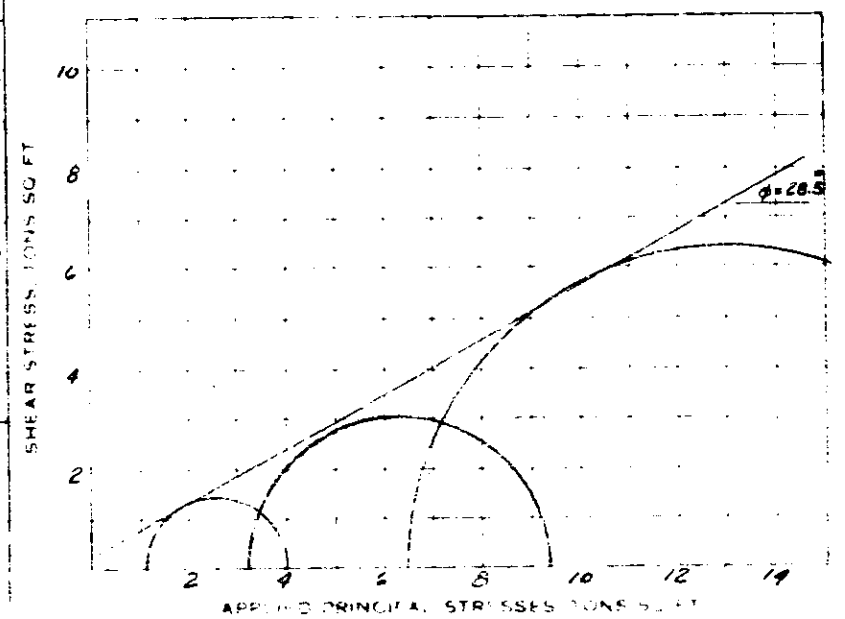
Boring No BT-6 Sample No B-4

Elev or Depth 2.1' - 5.0' Date 25 June 1962

TRIAXIAL COMPRESSION TEST REPORT







	Test No.	1	2	3
INITIAL	Water Content W_0 %	10.3	10.0	10.1
	Dry Density Lbs/Cu Ft	119.2	119.6	119.4
	Void Ratio, e_0	.440	.436	.438
	Saturation, S %	64	63	64
BEFORE TEST	W.C. after Saturation W_s %	15.1	15.2	15.4
	Saturation, S %	95	96	97
	Consol. Pressure T/Sq Ft	1.08	3.24	6.48
	W.C. after Consol. W_c %	15.0	14.4	14.2
	Void Ratio after Consol. e_c	.437	.412	.404
AT FAILURE	Maj. Prin. Stress σ_1 T/Sq Ft	3.99	9.24	14.46
	Min. Prin. Stress σ_{III} T/Sq Ft	1.08	3.24	6.48
	Water Content W_f %	15.0	14.4	14.2
	Void Ratio, e_f	.437	.412	.404
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height In		6.30	6.30	6.30
Test Time to Failure Min		5.6	34.0	38.0

Remarks: Samples remolded at approx water content of 10.1 % and an approx dry density of 119.4 pcf as determined from standard compaction curve

Optimum moisture - 2%

Type of Test
Constant Strain; 0.025 in/min
Control
X Consolidated Un Drained

Type of Specimen Remolded

Ø 28.5 | Tan Ø .542 | c = .2 T/Sq Ft

Classification gravelly silty SAND (SM)

LL N.P. | G 2.75

PL N.P. | D_{10} 0.0095

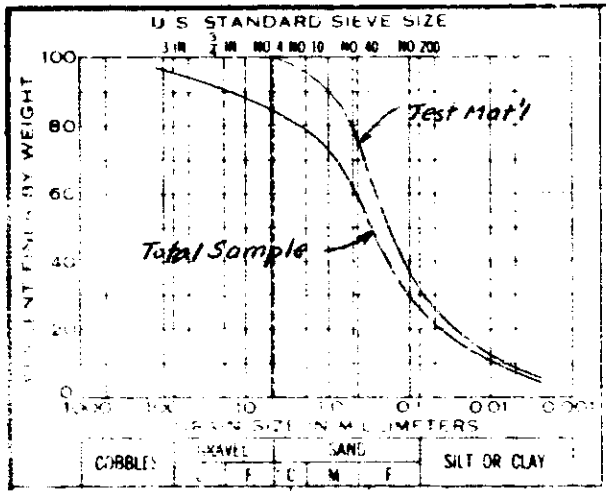
Project Hancock Brook Reservoir

Area "A"

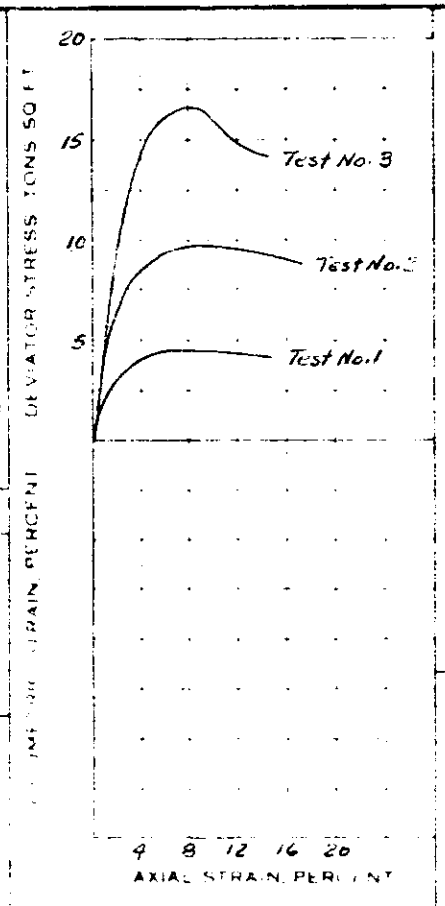
Boring No. ET-6 | Sample No. B-4

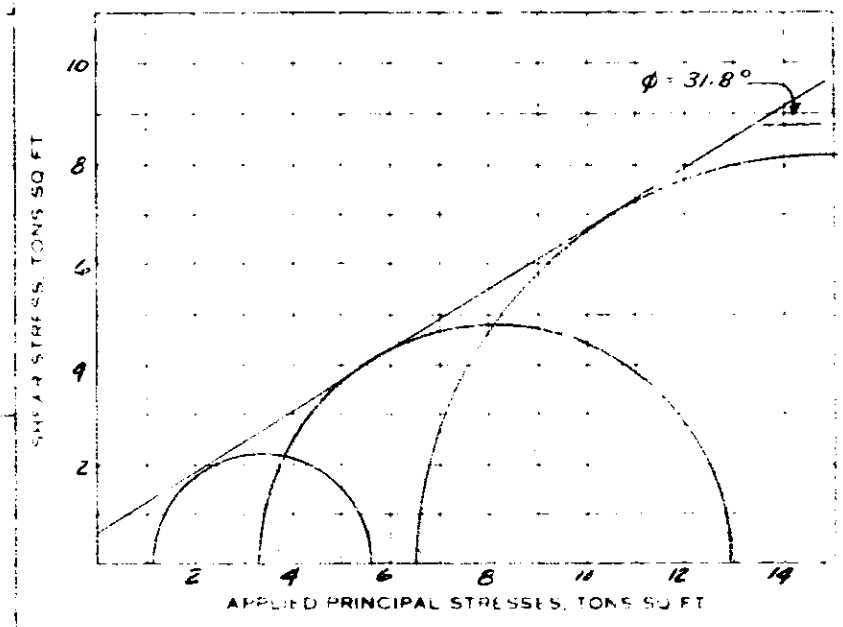
Elev or Depth 2.1' - 5.0' | Date 25 June 1962

TRIAXIAL COMPRESSION TEST REPORT



Test No		1	2	3
INITIAL	Water Content, W_0 %	12.1	11.8	11.9
	Dry Density Lbs/Cu Ft	121.6	121.9	121.9
	Void Ratio, e_0	.411	.407	.407
	Saturation, S_0 %	81	80	80.0
BEFORE TEST	W C after Saturation W_c %	–	–	–
	Saturation, S %	–	–	–
	Consol Pressure T/Sq Ft	–	–	–
	W C after Consol W_c %	–	–	–
	Void Ratio after Consol e_c	–	–	–
AT FAILURE	Max Principal Stress σ_1 T/Sq Ft	5.62	12.69	23.08
	Min Principal Stress σ_3 T/Sq Ft	1.08	3.24	6.48
	Water Content W_f %	–	–	–
	Void Ratio e_f	–	–	–
Specimen Diameter Inches		2.80	2.80	2.80
Initial Height Inc		6.30	6.30	6.30
Test Time to Failure Min		16.0	24.0	22.0





Remarks: Samples remolded at approx. water content of 12.1 % and an approx. dry density of 121.6 pcf as determined from standard compaction curve.

Optimum moisture

Type of Test
Constant Strain; 0.025 in/min
Control
Un Consolidated Un Drained

Type of Specimen Remolded

φ 31.8° | Tan φ .620 | c .6 T/Sq Ft

Classification gravelly silty SAND (SM)

LL	N.P.	G	2.75
PL	N.P.	D_{10}	0.0095

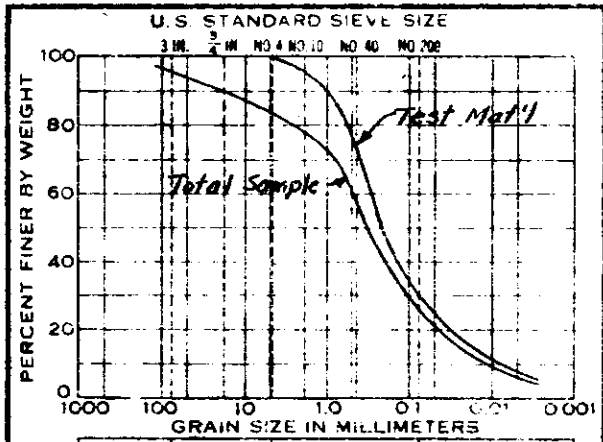
Project Hancock Brook Reservoir

Area "A"

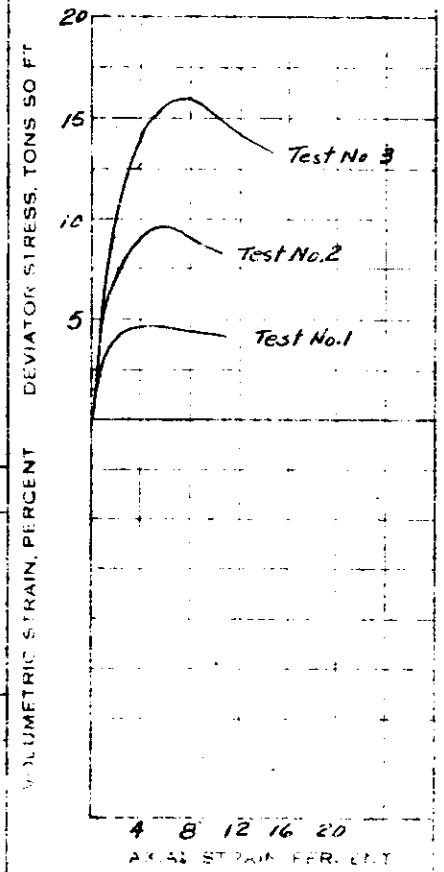
Boring No. BT-6 | Sample No. B-4

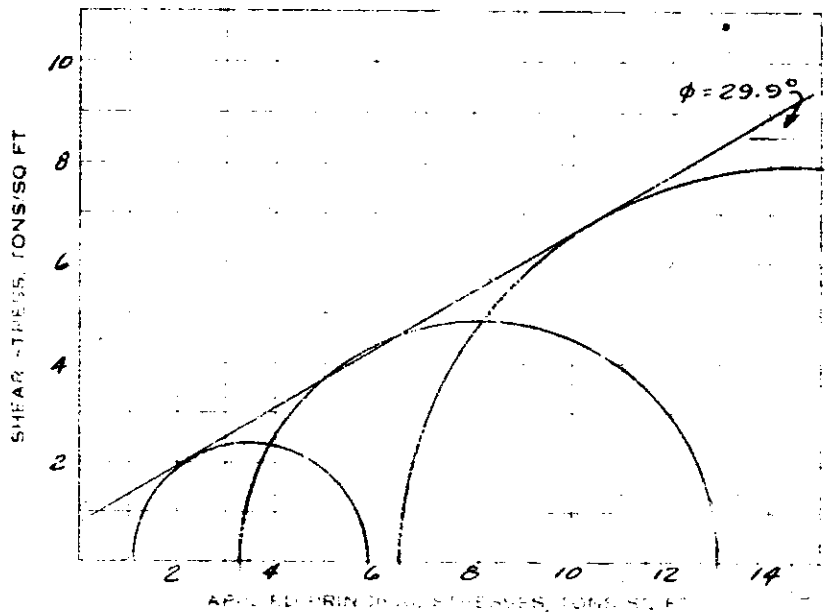
Elev or Depth 2.1' - 5.0' | Date 26 June 1962

TRIAXIAL COMPRESSION TEST REPORT



	Test No.	1	2	3
INITIAL	Water Content, W_o %	9.9	9.9	10.1
	Dry Density Lbs/Cu Ft	119.7	119.6	119.4
	Void Ratio, e_o	.434	.435	.438
	Saturation, S_o %	62	63	64
BEFORE TEST	W.C. after Saturation W_s %	–	–	–
	Saturation, S %	–	–	–
	Consol Pressure T/Sq Ft	–	–	–
	W.C. after Consol, W_c %	–	–	–
	Void Ratio after Consol e_c	–	–	–
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	5.91	12.97	22.49
	Min Prin Stress, σ_3 T/Sq Ft	1.08	3.24	6.48
	Water Content W_f %	–	–	–
	Void Ratio, e_f	–	–	–
Specimen Diameter	inches	2.80	2.80	2.80
Initial Height	inc	6.30	6.30	6.30
Test Time to Failure	Min	12.0	14.0	20.0





Remarks: Samples remolded at an approx. water content of 10.1% and an approx. dry density of 119.4 p.c.f. as determined from standard compaction curve.

Optimum moisture - 2%

Type of Test: Constant Strain; 0.025 in/min
Consolidated: Unconsolidated Undrained

Type of Specimen: Remolded

φ 29.9 | Tan φ .575 | c .8 Sq Ft

Classification: gravelly silty SAND (SM)

LL N.P. | G 2.75
PL N.P. | D 0.0095

Project: Hancock Brook Reservoir

Hole: "A"

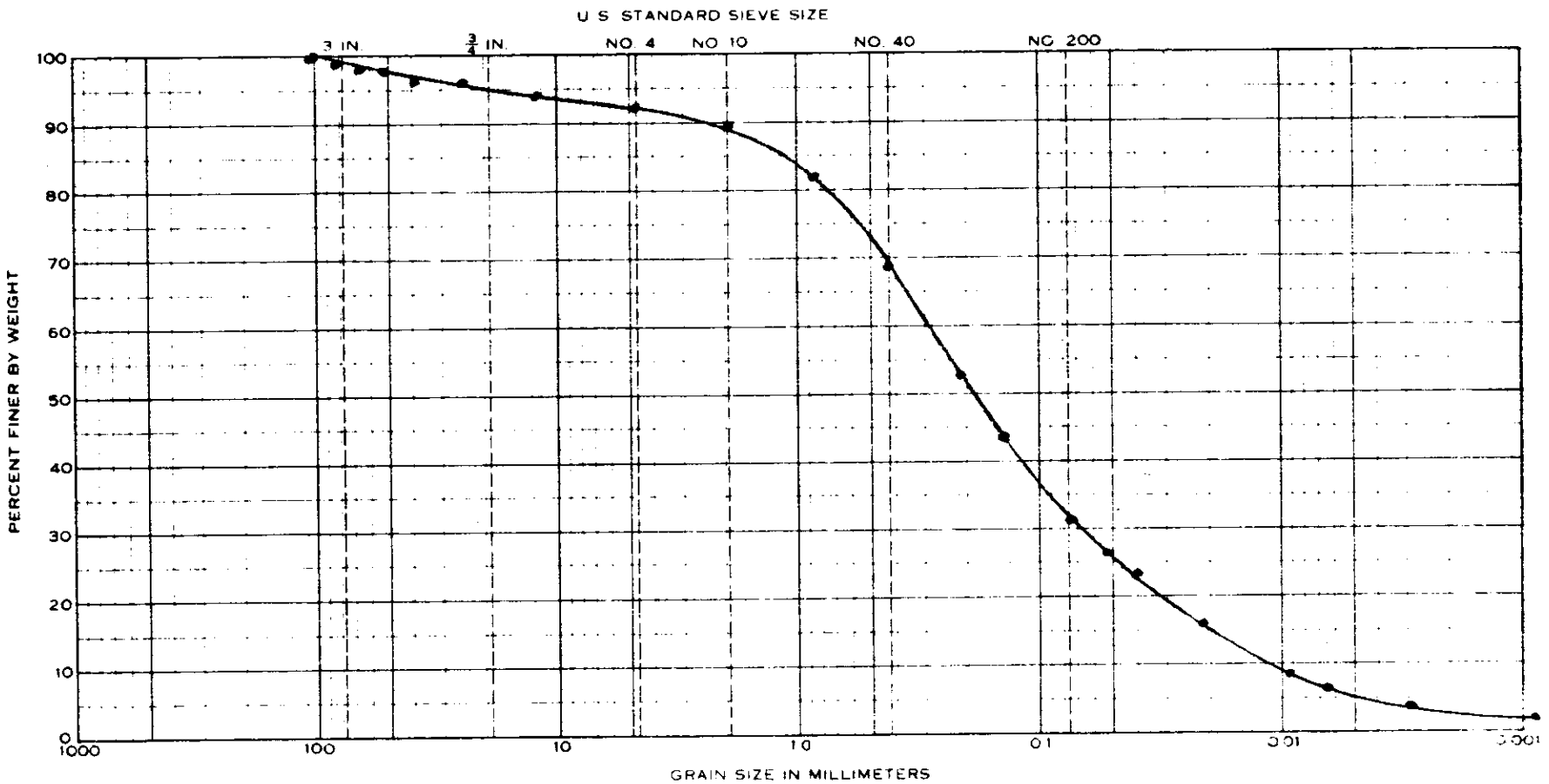
Boring No. BT-6 | Sample No. B-4

Elev or Depth 2.1' - 5.0' | Date 26 June 1962

TRIAXIAL COMPRESSION TEST REPORT

Plate No. B-22

FM 2089



Sample No.	~~Elev.~~ or Depth	Classification	Nat WC	LL	PL	PI
B-7	5.0-10.0	silty m-f SAND (SM)		NP	NP	NP

Project HANCOCK BROOK RESERVOIR

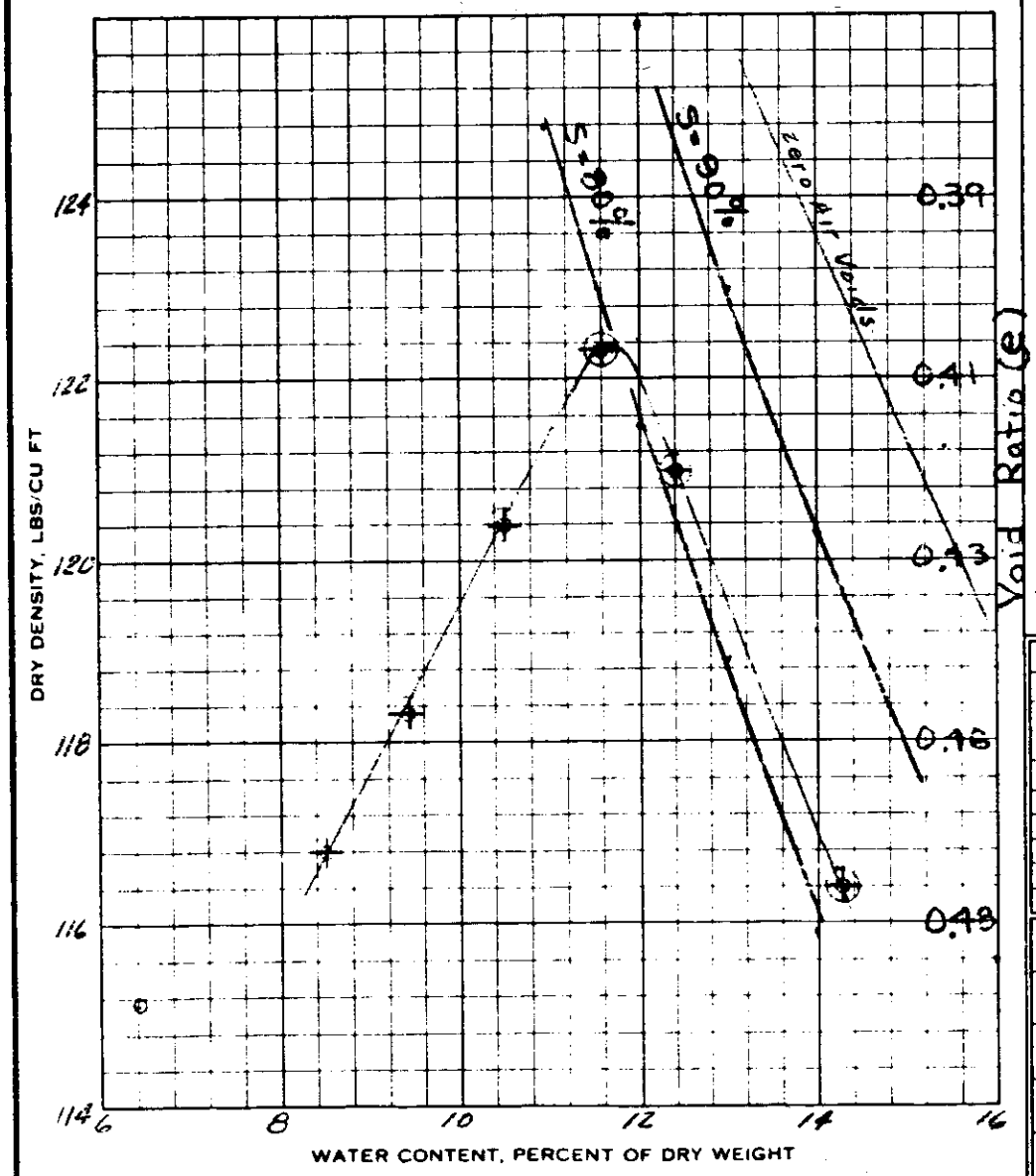
Area "A"

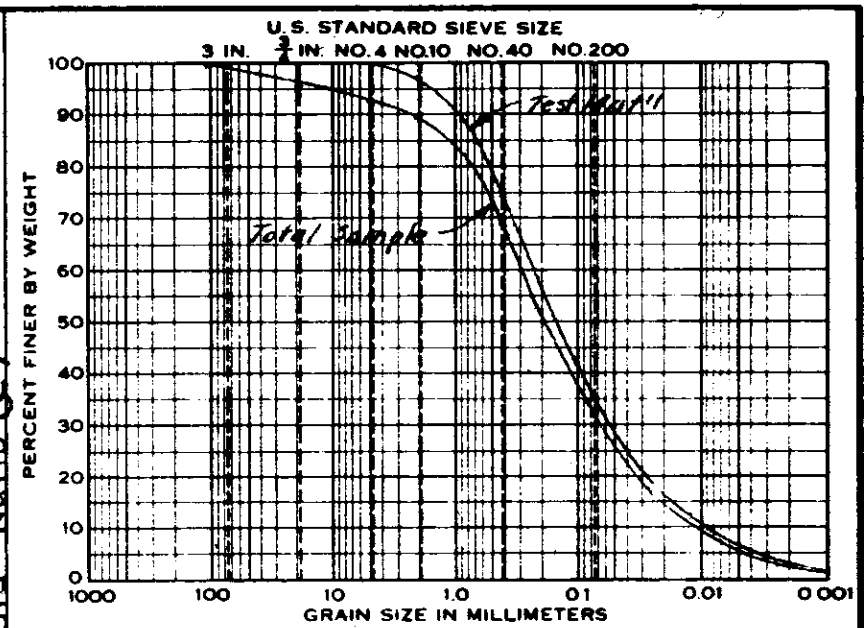
Boring No. BT-6

Date 20 April, 1962

GRADATION CURVES

ENG 2087





COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	G	LL	PL
B-7	5.0'-10.0'	silty m-f SAND (SM)	2.75	N.P.	N.P.

Sample No.		B-7			
Optimum Water Content	%	11.7			
Max Dry Density	Lbs/Cu Ft	122.4			
Optimum Water Content Corr for +	%				
Max Density Corr for +	Lbs/Cu Ft				

Project Hancock Brook Reservoir

Area

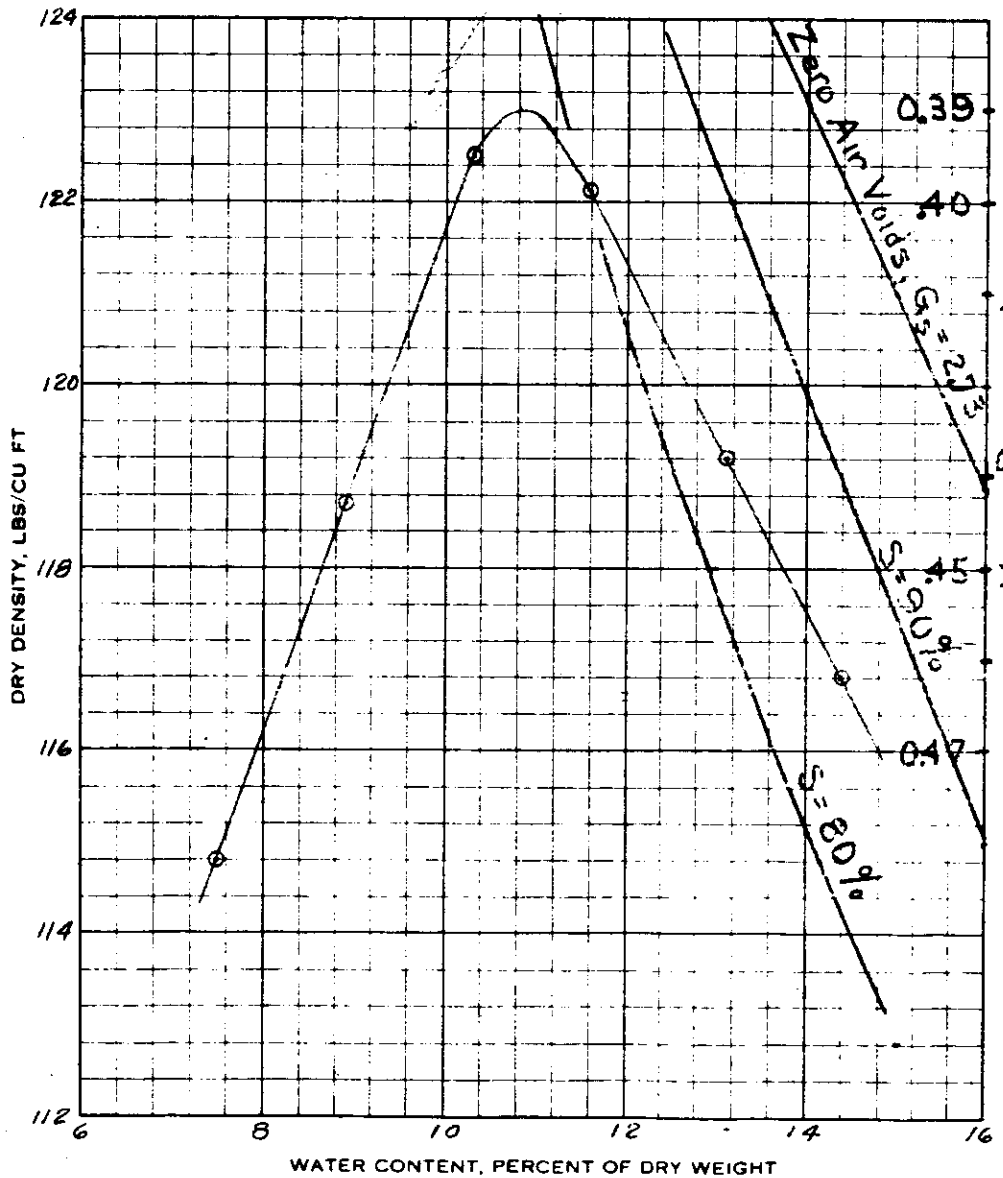
Boring No. BT-6 | Sample No. B-7

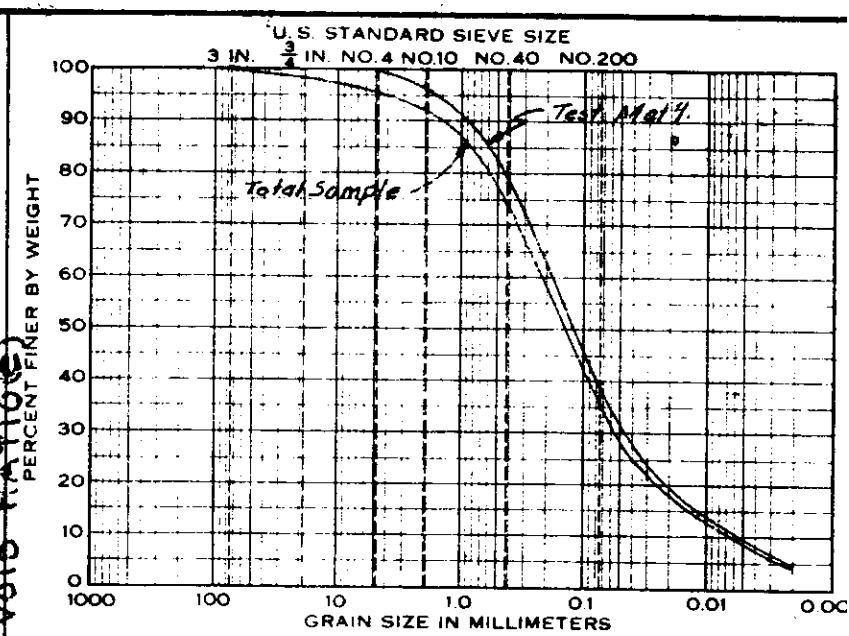
~~Elev or~~ Depth 5.0'-10.0' | Date 8 May 1962

COMPACTION TEST REPORT

PLATE NO. B-24

2091





COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	G	LL	PL
B-3	1.8'-3.9'	silty m-f SAND (SM)	2.73		

Sample No.		B-3			
Optimum Water Content	%	10.8			
Max Dry Density	Lbs/Cu Ft	123.0			
Optimum Water Content Corr for +	%				
Max Density Corr for +	Lbs/Cu Ft				

Project Hancock Brook Reservoir

Area

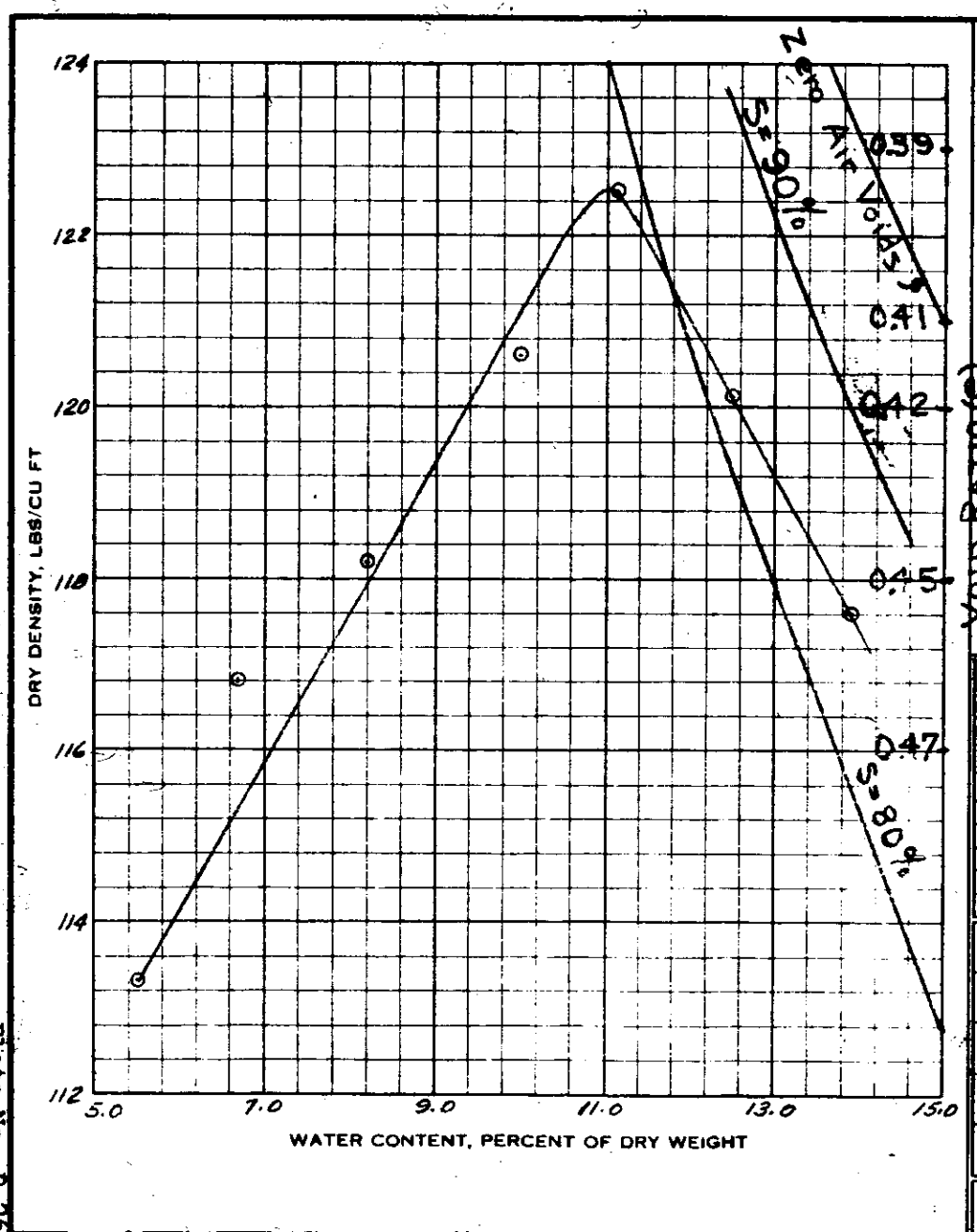
Boring No. BT-2 | Sample No. B-3

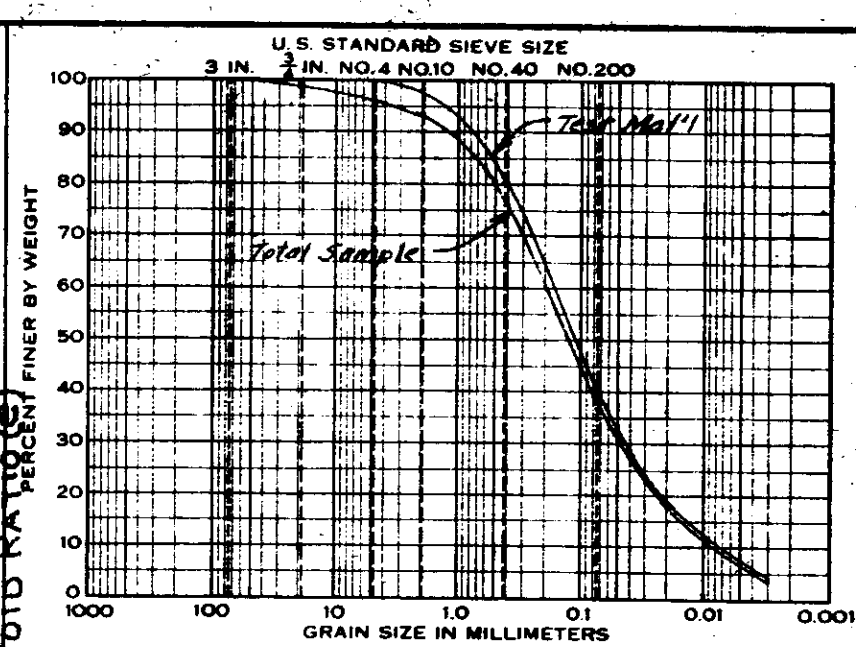
Elev or Depth 1.8'-3.9' | Date 14 March 1962

COMPACTION TEST REPORT

Plate No. B-25

2091





COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	G	LL	PL
B-5	3.9'-5.8'	silty m-f SAND (SM)	2.73		

Sample No.		B-5			
Optimum Water Content	%	11.0			
Max Dry Density	Lbs/Cu Ft	122.5			
Optimum Water Content Corr for +	%				
Max Density Corr for +	Lbs/Cu Ft				

Project Hancock Brook Reservoir

Area

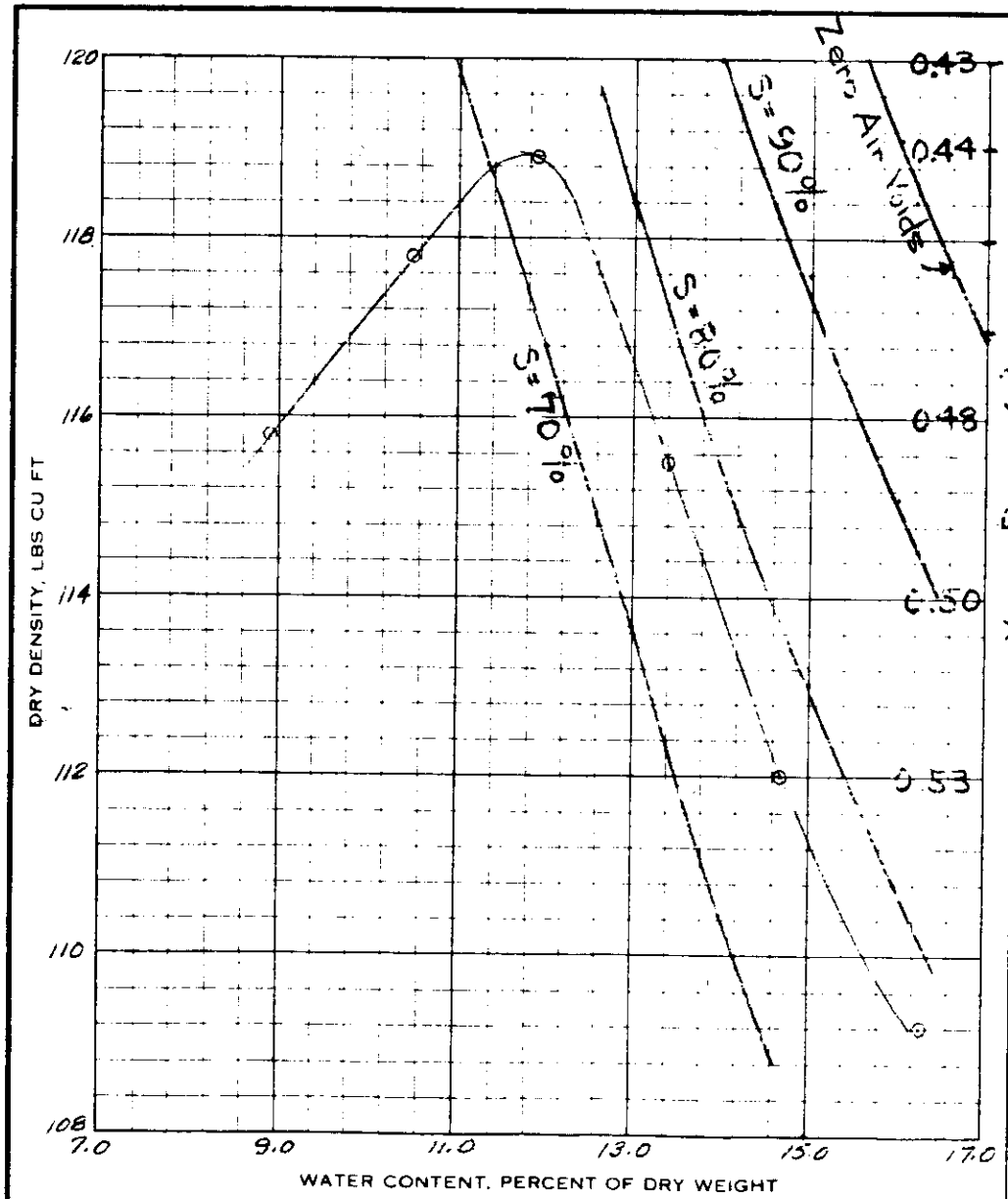
Boring No. BT-2 | Sample No. B-5

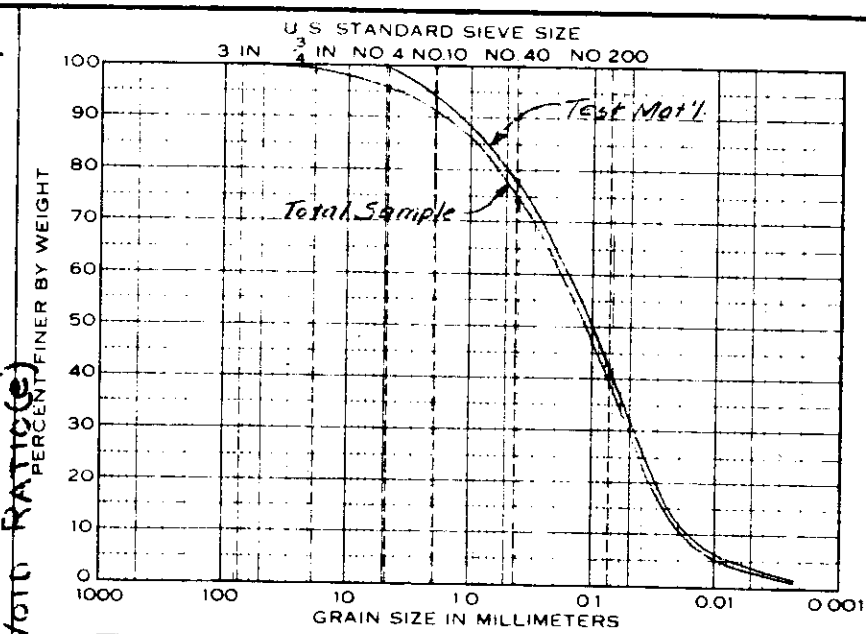
~~Elev or~~ Depth 3.9' - 5.8' | Date 14 March 1962

COMPACTION TEST REPORT

Plate No. B-26

ENG FORM 2091





COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	G	LL	PL
B-11	7.2-9.4'	silty m-f SAND (SM)	2.74		

Sample No.		B-11			
Optimum Water Content	%	11.5			
Max Dry Density	Lbs Cu Ft	118.3			
Optimum Water Content Corr for +	%				
Max Density Corr for +	Lbs Cu Ft				

Project Hancock Creek Reservoir

Area

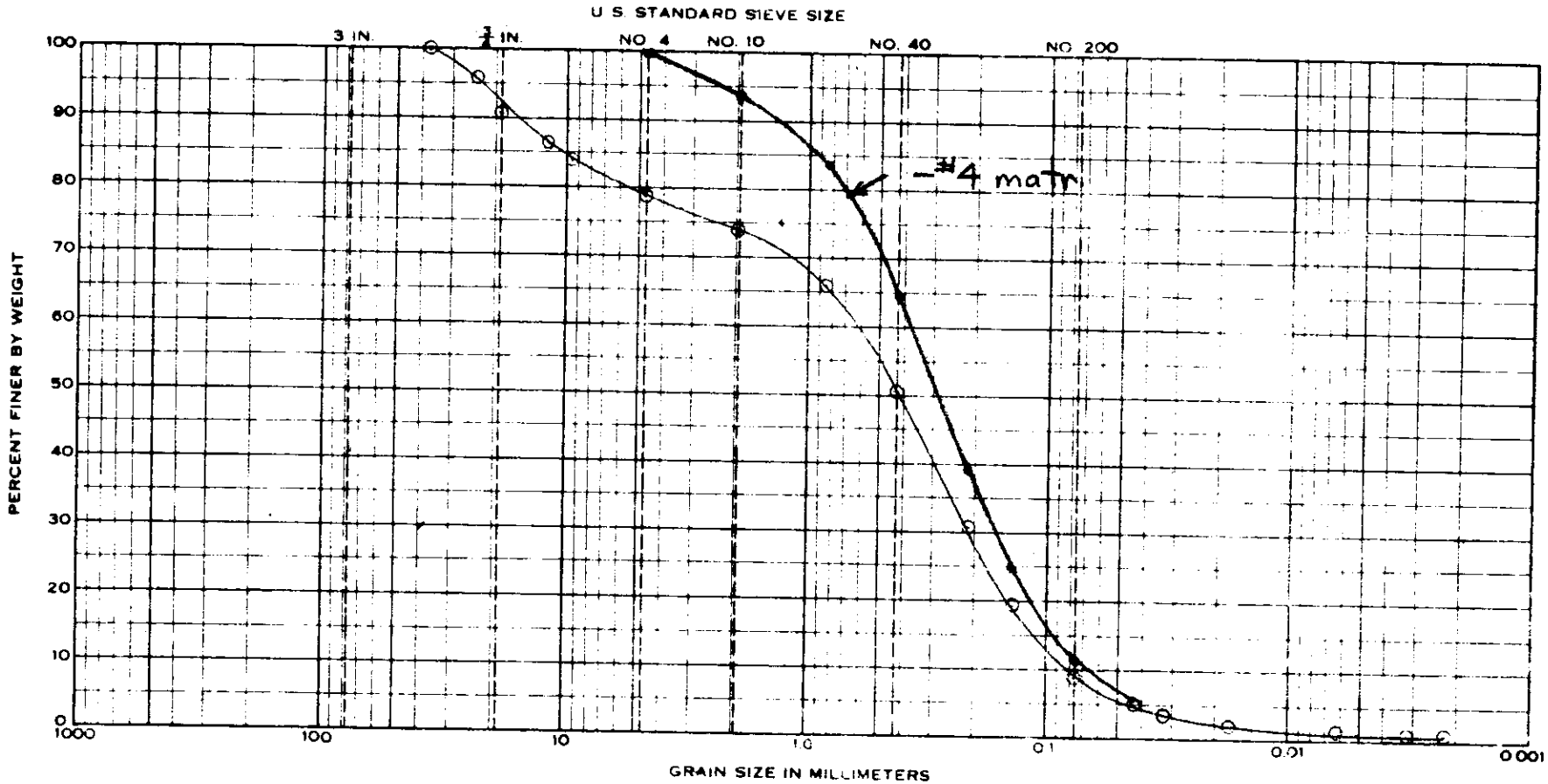
Boring No. BT-2 | Sample No. B-11

~~Elev or~~ Depth 7.2'-9.4' | Date 14 March 1962

COMPACTION TEST REPORT

Plate No. E-27

ENG FORM 2091



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	D_{10}
LB-1		silty gravelly m-f SAND (SPSM)	16.3	N.P.	N.P.	N.P.	0.062
—	—	—	—	—	—	—	LB-1 = FD-24, J6 & FD-28, J6 + J-12

Project Hancock Brook Reservoir

Area Foundation - Dam

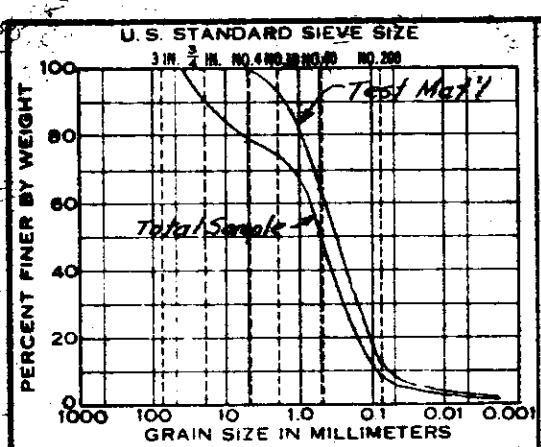
Composite Boring No. (FD-24 & FD-28)

Date 6 March 1962

GRADATION CURVES

Plate No. B-28

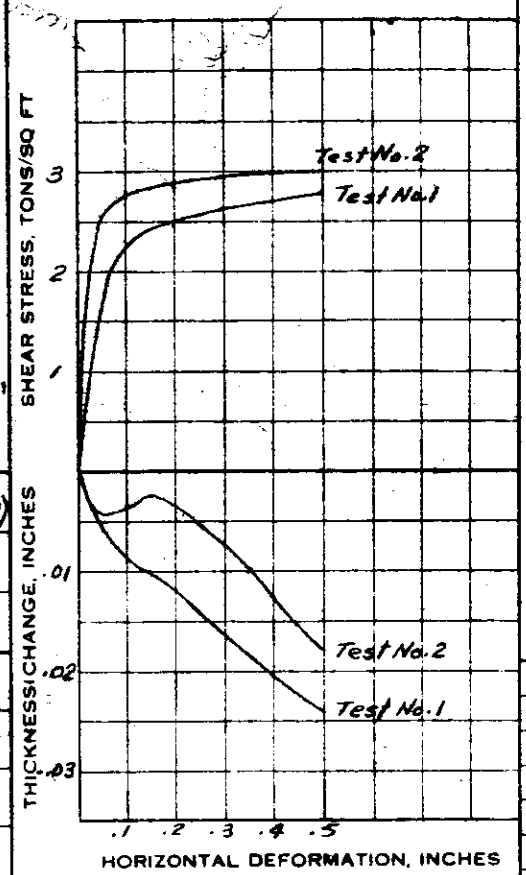
ENG FORM 2087 (Translucent) (EM 1110-2-1803)

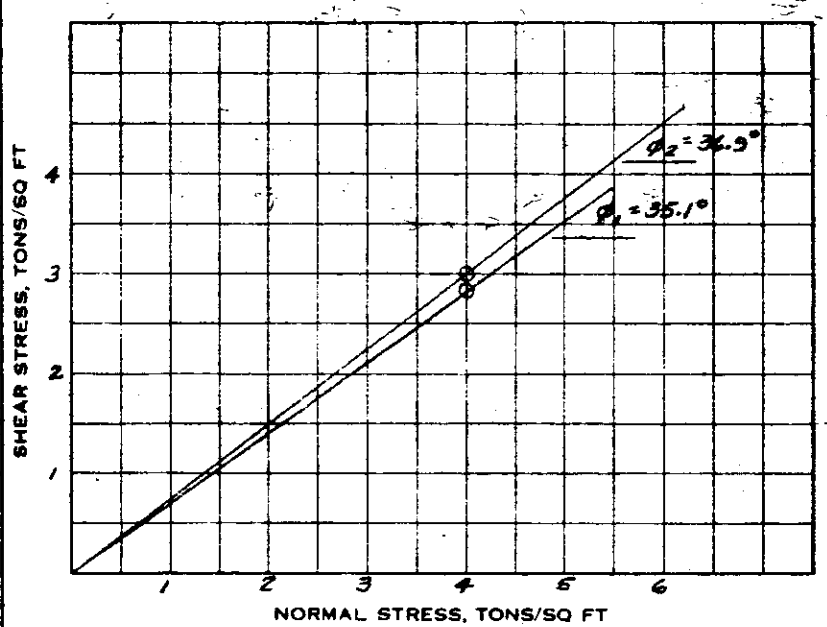


Classification *silty gravelly m-f SAND (SP-SM)*

LL	*N.P.*	G	*2.75*
PL	*N.P*	D_{10}	*0.082*

Test No.	1	2		
Initial Water Content, W_0 %	16.9	16.9		
Dry Density Lbs/Cu Ft	109.0	108.8		
Void Ratio, e_0	.574	.584		
Saturation, S_0 %	81	80		
Duration of Test min.	24.3	24.0		
WC after Test, W_f %	18.6	19.9		
Normal Stress, σ T/Sq Ft	4.0	4.0		
Max. Shear Stress, τ T/Sq Ft	2.81	3.00		





Remarks: 1. Specimens from LB-1 which was composed of FD-24, sample J-6 and FD-28, samples J-6 and J-12.

2. Specimens were moderately compacted.

Foundation - Dam

Type of Test	Type of Specimen
Strain - Control *0.02 in./min.*	*Remolded*
X Consolidated	*3.0* in. square
X Drained	*0.50* in. thickness

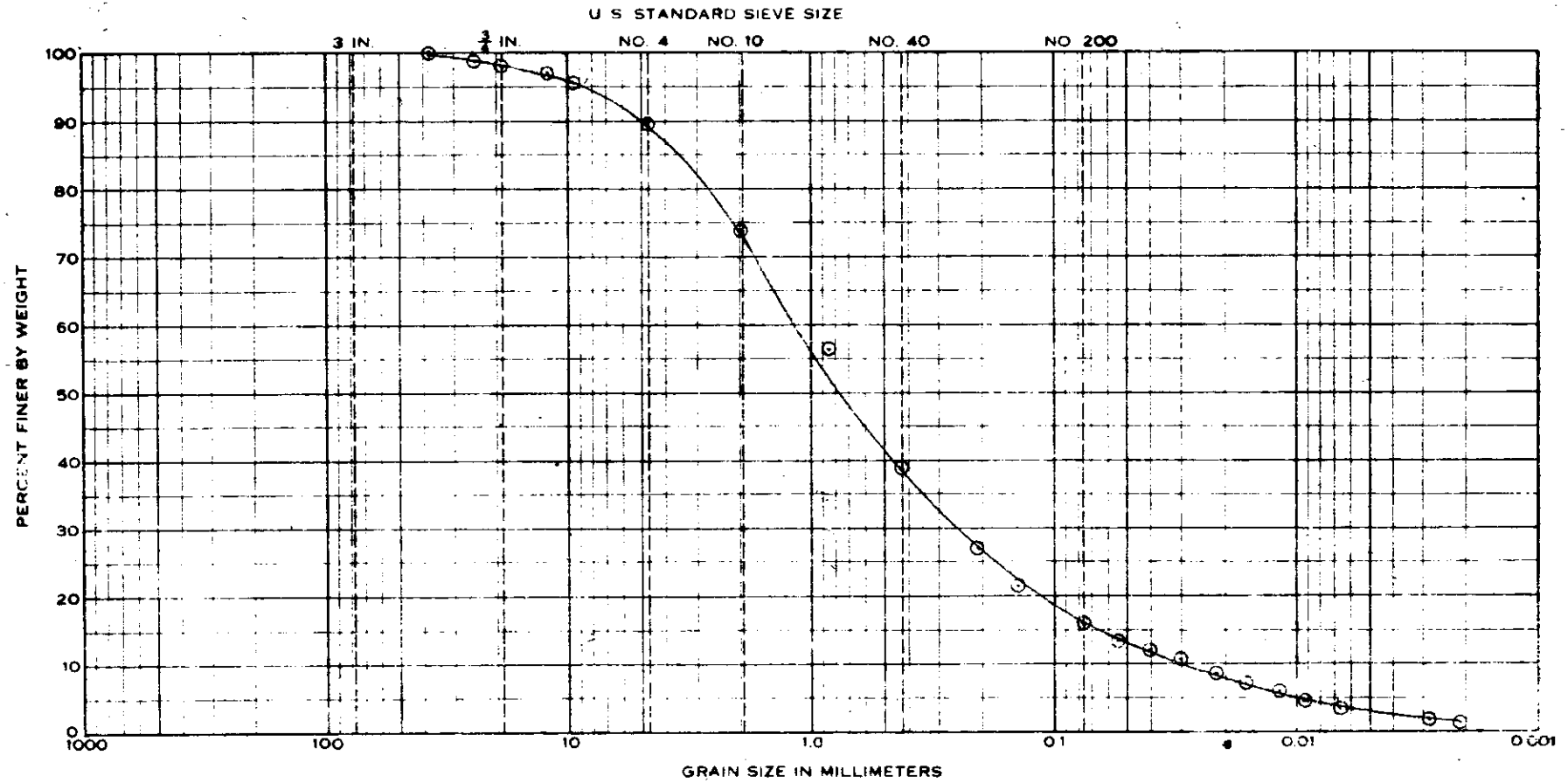
SHEAR VALUES	ϕ	TAN ϕ	C, T/SQ FT
Maximum	*35.1*	*0.703*	*0*
Ultimate			

Project *Hancock Brook*	
Area *Dam Foundation*	
Boring No.	Composite Sample No. *LB-1*
Elev or Depth	Date *7 February 1962*

DIRECT SHEAR TEST REPORT

Plate No. B-29

ENG FORM 2092



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI
LB-2		Decomposed Rock (Mica)				

Project Hancock Brook Reservoir

Area Fault Gouge

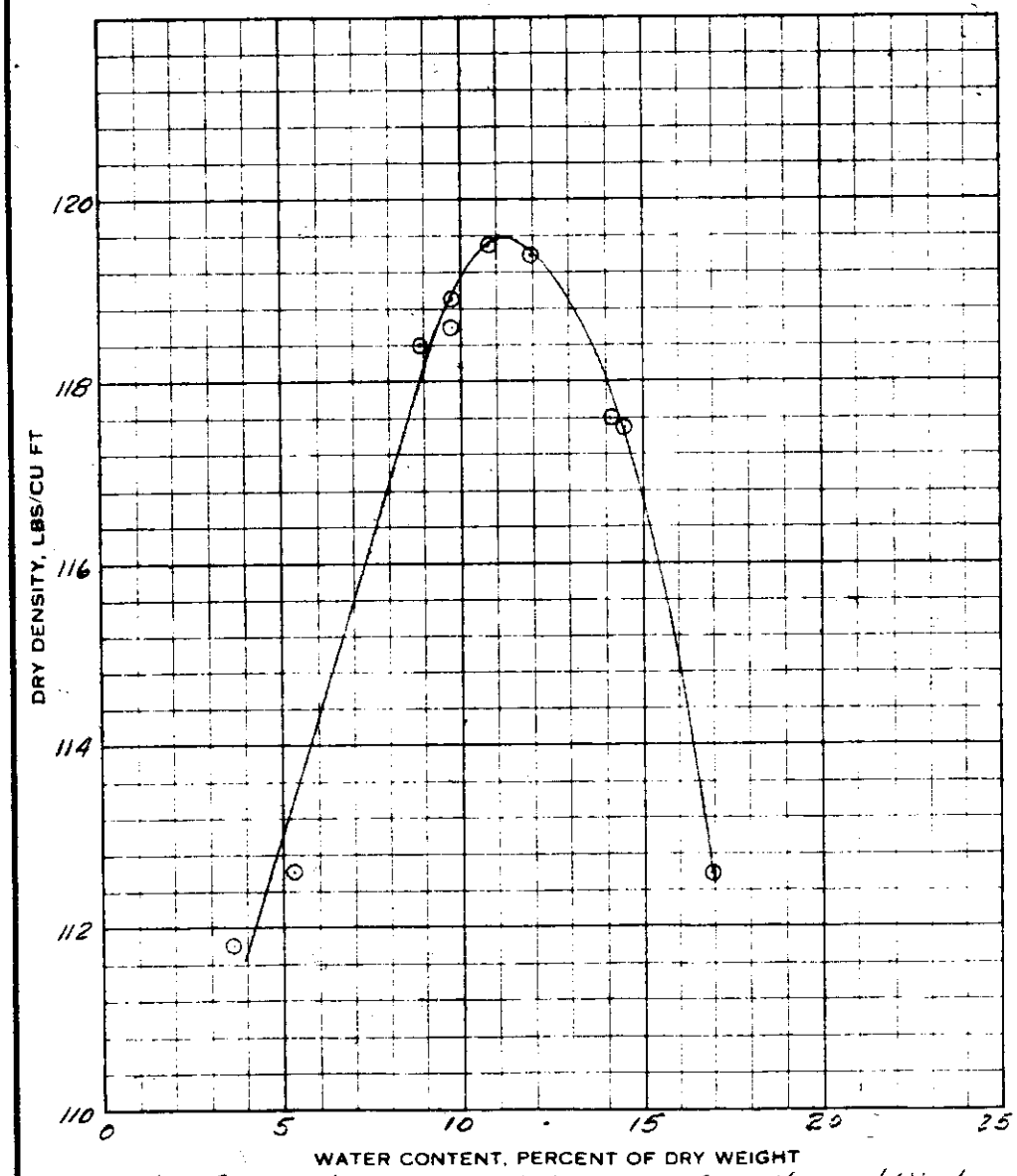
Boring No. FD-5 thru FD-9

Date 19 April 1968

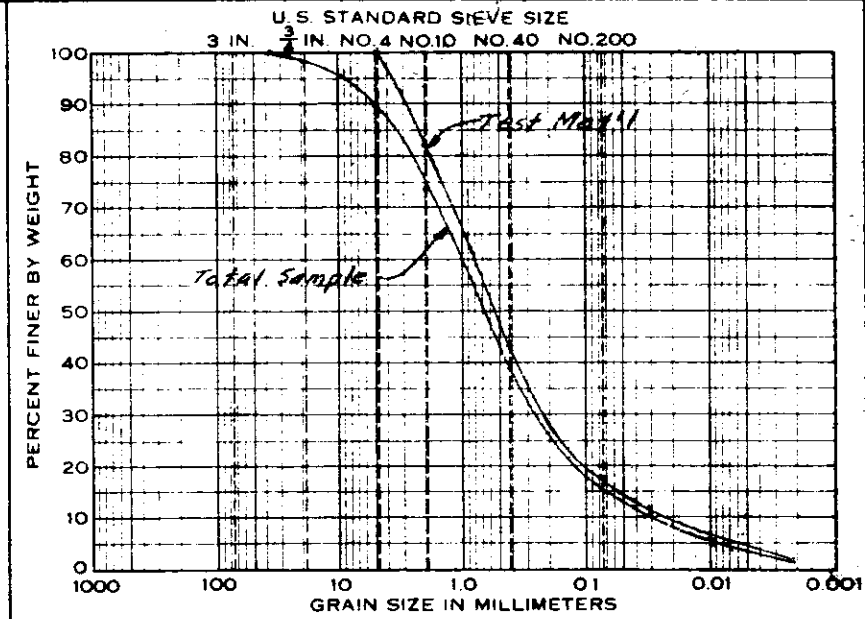
GRADATION CURVES

Plate No. B-30

ENG FORM 2087 (Translucent) (EM 1110-2-1803)



Note: Compaction Curve determined from Harvard Miniature Compaction Test. Cylinder volume 1/454 cu.ft. Material compacted in 3 layers, 25 ramps per layer with 40 lb spring in tamper.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	G	LL	PL
LB-2			2.81		

Sample No.		LB-2			
Optimum Water Content	%	11.2			
Max Dry Density	Lbs/Cu Ft	119.6			
Optimum Water Content Corr for +	%				
Max Density Corr for +	Lbs/Cu Ft				

Project Hancock Brook Reservoir

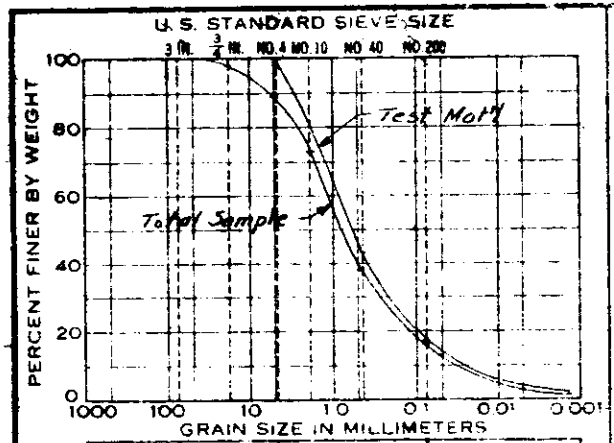
Area Fault Gouge

Boring No. FD-5 thru FD-9 | Sample No. LB-2

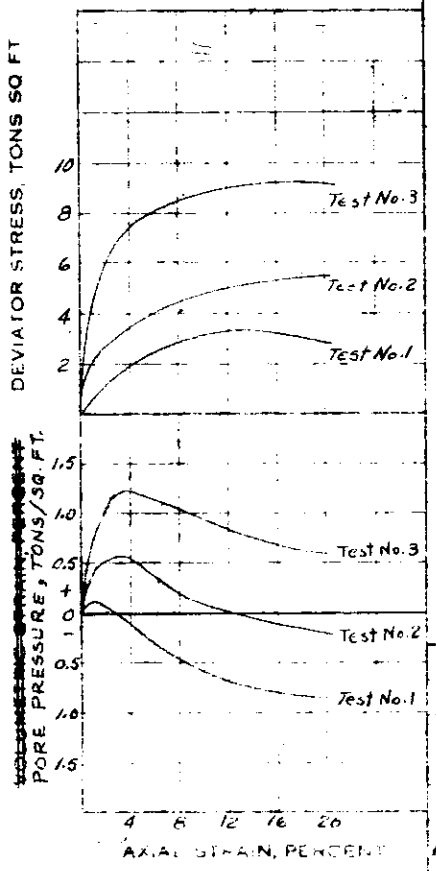
Elev or Depth | Date 29 March 1962

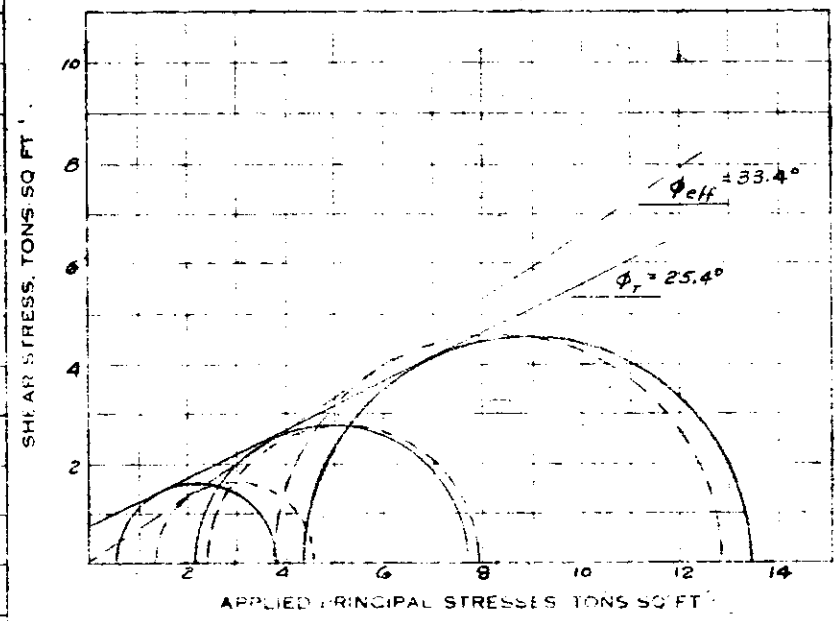
COMPACTION TEST REPORT

ENG FORM 2091



	Test No.	1	2	3
INITIAL	Water Content, W_0 %	11.0	12.0	9.9
	Dry Density Lbs/Cu Ft	117.9	116.9	119.0
	Void Ratio, e_0	.487	.501	.473
	Saturation, S_0 %	63	67	59
BEFORE TEST	W.C. after Saturation W_s %	18.4	17.0	17.7
	Saturation, S %	100	96	100
	Consol Pressure T/Sq Ft	0.54	2.16	4.32
	W.C. after Consol, W_c %	17.4	16.2	15.1
	Void Ratio after Consol e_c	.459	.475	.398
AT FAILURE	Maj Prin Stress, σ_1 T/Sq Ft	3.81	7.67	13.44
	Min Prin Stress, σ_{III} T/Sq Ft	0.54	2.16	4.32
	Water Content W_f %	17.4	16.2	15.1
	Void Ratio, e_f	.459	.475	.398
Specimen Diameter Inches		1.4	1.4	1.4
Initial Height Inc		3.2	3.2	3.2
Test Time to Failure Min		22.5	32.5	30.0





Remarks: 1. Samples remolded at an approx. water content of 11.2% and an approx. dry density of 119.6 pcf as indicated by standard compaction curve.

2. Dashed Mohr circles and envelop based on effective stresses determined from total stresses and pore pressure measurements.

Type of Test
Constant Strain, 0.02 in./min.
Control
X Consolidated Unconsolidated

Type of Specimen Remolded

ϕ 25.4° | tan ϕ .475 | c .75 T/Sq Ft

Classification Decomposed Rock (Mica)

LL | G 2.81

PL | D_{10}

Project Hancock Brook Reservoir

Area Fault Gouge

Boring No. | Sample No. LB-2

Elev or Depth | Date 13 April 1962

TRIAXIAL COMPRESSION TEST REPORT

Plate No. B-32

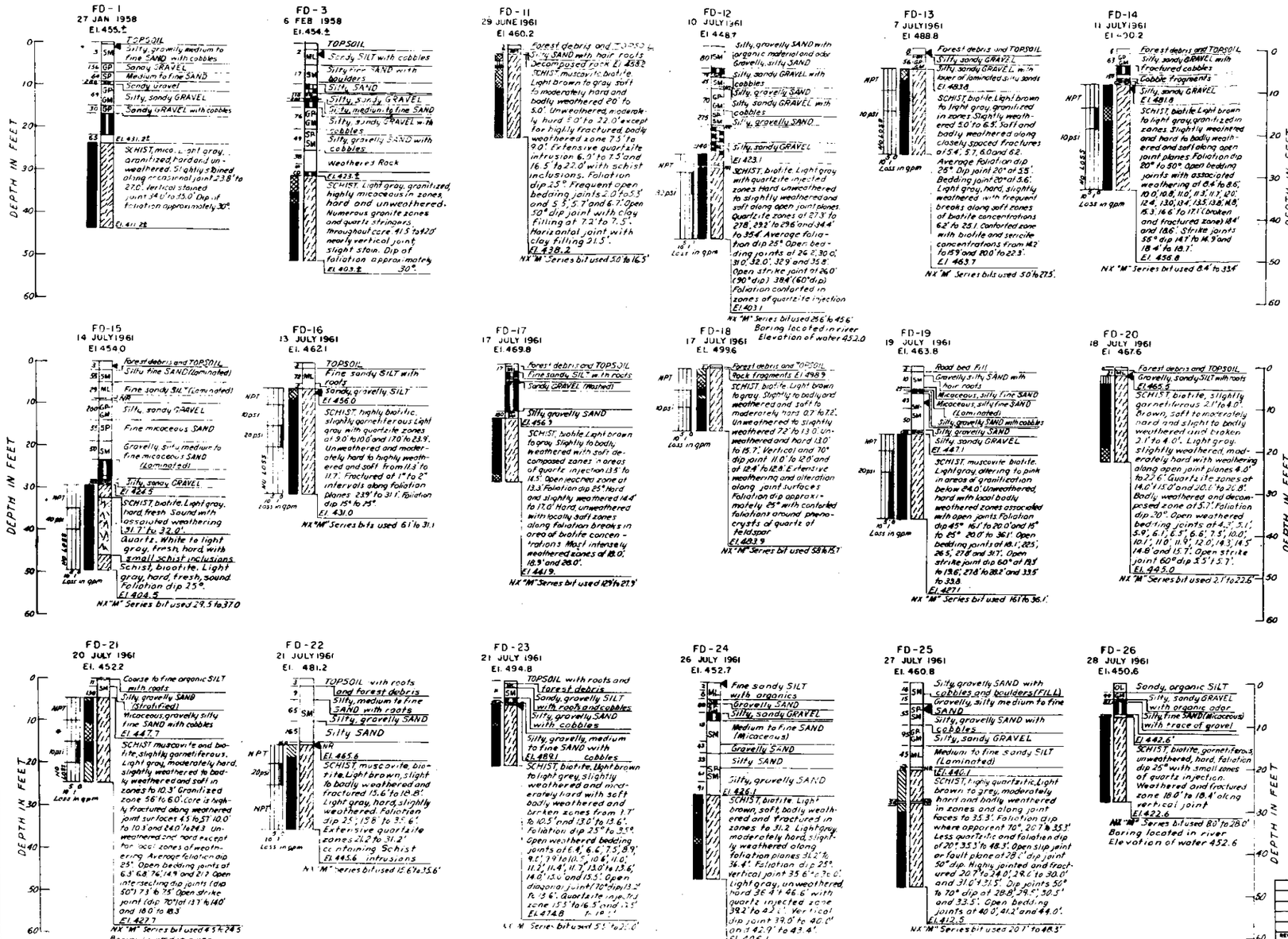
APPENDIX C

Record of Explorations

HANCOCK BROOK DAM & RESERVOIR

CORPS OF ENGINEERS

U. S. ARMY



LEGEND FOR GRAPHIC LOGS

FTT-1	Foundation Test Trench
FD-3	Foundation Test Boring
(OW)	Observation well installed
6 FEB. 1958	Date exploration completed
El 454.0	Elevation of ground surface during time of exploration
	Maximum artesian head
	Subsurface water level in boring at time of exploration
	Range of subsurface water during period of observation
	Artesian flow encountered
SP	Group letter symbol according to Unified Soil Classification System
NR	No recovery or unsatisfactory soils samples recovered
NS	Not sampled. Hole advanced by Core-drilling, blasting and/or wash boring due to operational difficulty
	Bottom of observation well
CD	Sampling in overburden by Core-drill method.
76	Blows per foot of penetration considered most representative for each sample drive using a 350 pound hammer with a free fall of about 18" on 0.15" I.D or 2" O.D, 2" I.D or 2.5" O.D; 2.5" I.D or 3" O.D size sample spoon equipped with a beveled and sharpened drive shoe.
*	Blow count not recorded or not considered representative
	Cobble or boulder (Core-drilled)
	Cobbles and boulders, continuous or nested (Core-drilled and/or blasted and chopped)
El. 423.0	Elevation of Bedrock surface
	Rock symbol
NPT	Rock core recovery 0 - 25%
	Rock core recovery 25 - 50%
	Rock core recovery 50 - 75%
	Rock core recovery 75 - 90%
	Rock core recovery 90 - 100%
El. 403.0	Elevation of bottom of exploration
NPT	No pressure test performed. Asterisk denotes that section could not be sealed for testing.
30 psi	Constantly maintained pressure for 1 to 3 minutes
	Volume loss in gallons per minute under constant pressure, tested continuously in 5-foot sections.
	Scale extended from 0 gpm to 1 gpm for clarification of low pressure losses.

NOTES

Elevations refer to Mean Sea Level Datum

For location of Foundation Explorations, see Plate No. 2-2

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES BY E.A.R. | DR BY H.C.S. | CK BY R.C.S.

SUBMITTED
HEAD, GEOLOGY SECTION
PROJECT ENGINEER

APPROVAL RECOMMENDED
CHIEF, F.D.'S GEOLOGY BRANCH

APPROVAL RECOMMENDED
CHIEF, P.D.P. BRANCH

HOUSATONIC RIVER FLOOD CONTROL

HANCOCK BROOK DAM

RECORD OF FOUNDATION EXPLORATIONS NO. 1

HANCOCK BROOK, CONNECTICUT

DATE FEB 1962

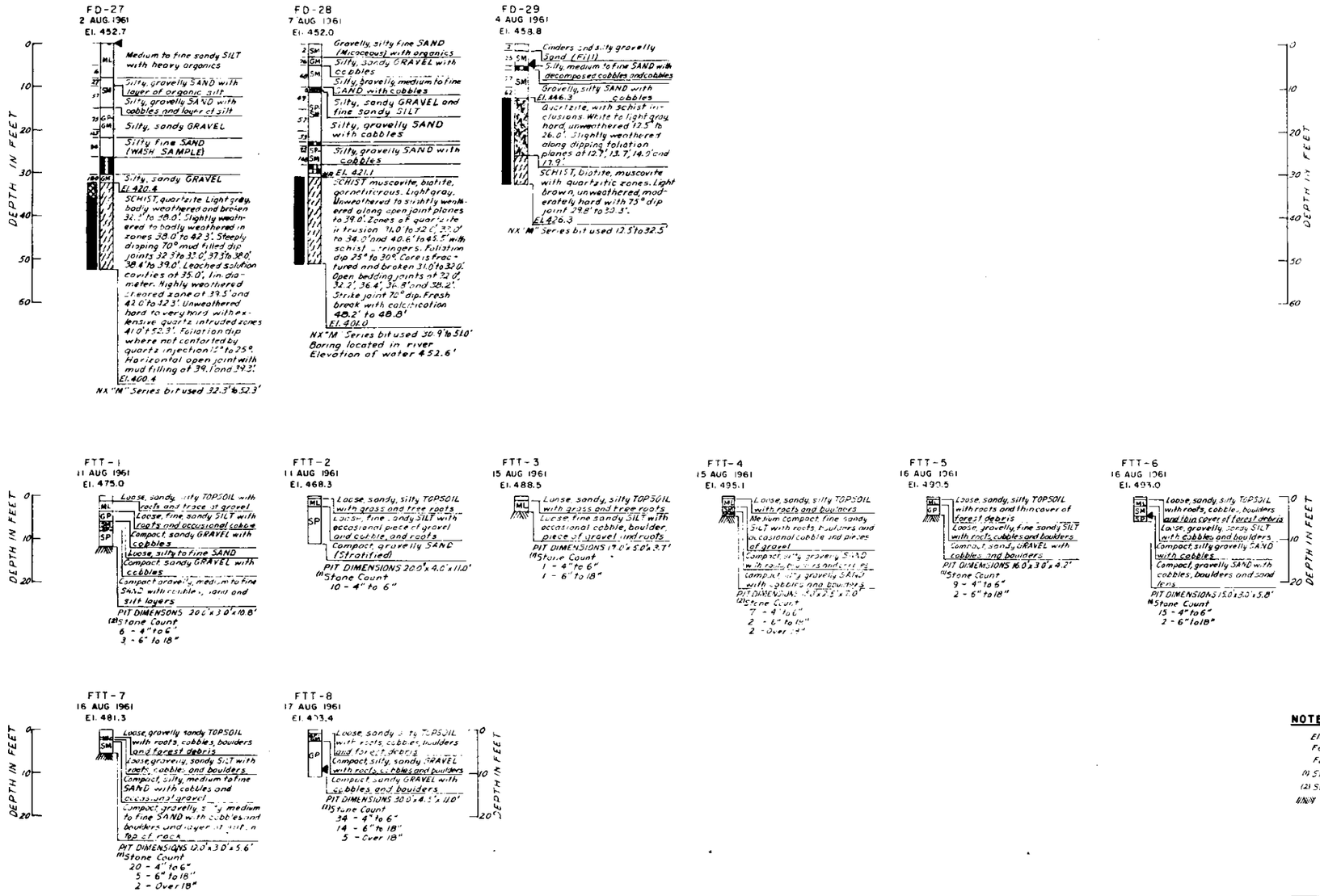
APPROVED
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN SPEC. NO. CN. ENG.-19-016-

DRAWING NUMBER

SHEET

PLATE NO. C-1



NOTES

Elevations refer to Mean Sea Level Datum
For Location of Foundation Explorations, see Plate No. 2-2
For Legend of Graphic Logs, see PLATE No. 2-6
(1) Stone Count for 6'-0" Section of 1 Wall of Foundation Test Trench
(2) Stone Count for 1 Wall of Foundation Test Trench
Apparent Bedrock

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY E.A.B. | DR. BY H.C.S. | CK. BY R.C.G.

SUBMITTED: HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED: CHIEF, F.D.B. & DIVISIONS BRANCH
APPROVAL RECOMMENDED: CHIEF, F.D.B. BRANCH

HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
RECORD OF FOUNDATION EXPLORATIONS
NO. 2
HANCOCK BROOK, CONNECTICUT
APPROVED: CHIEF, ENGINEERING DIVISION
DATE FEB 1962
SCALE: AS SHOWN | SPEC. NO. CIV ENG-19-016
DRAWING NUMBER
SHEET

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U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
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SUBMITTED: HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED: CHIEF, F.&B.R. BRANCH
APPROVAL RECOMMENDED

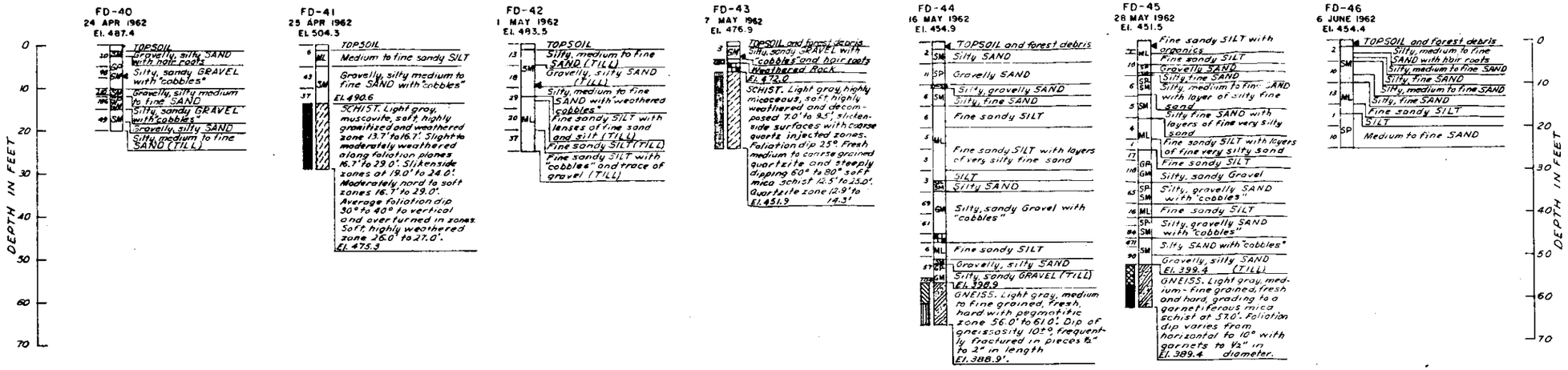
HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
RAILROAD AND HIGHWAY RELOCATION
RECORD OF FOUNDATION EXPLORATIONS NO. 1

HANCOCK BROOK, CONNECTICUT

APPROVED: CHIEF, ENGINEERING DIVISION
DATE FEB 1962

SCALE AS SHOWN | SPEC. NO. CIV. ENG.-19-016-
DRAWING NUMBER
SHEET

PLATE NO. C-3



U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
HANCOCK BROOK DAM
RAILROAD AND HIGHWAY RELOCATION
RECORD OF FOUNDATION EXPLORATIONS
NO. 2
HANCOCK BROOK, CONNECTICUT

DES. BY E.A.B. | DR. BY H.C.S. | CK. BY R.C.G.
SUBMITTED
HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, FDN. & MAT'LS BRANCH
APPROVAL RECOMMENDED
CHIEF, PLANN. & RPTS BRANCH
APPROVED
CHIEF, ENGINEERING DIVISION
DATE
SCALE
SPEC. NO CIV. ENG.-19-010
DRAWING NUMBER
SHEET

PLATE NO. C-4

APPENDIX D

ENGINEERING LOGS OF SOILS EXPLORATIONS

HANCOCK BROOK DAM

LEGEND

mod.	moderately
v.	very
comp.	compact
w/	with
occ.	occasional
f.	fine
m.	medium
c.	coarse
m-f	medium to fine
SM	soil symbol, unified soil classification system
W_n	natural water content of sample except for certain soils containing gravel for which W_n represents the water content of that part of the sample from which portions of the coarse gravel sizes have been removed
W_4	natural water content determined for that portion of the soil passing the No. 4 U. S. Standard Sieve
d	natural dry density (pcf)
D_{10}	effective grain size in millimeters
LL	Atterberg liquid limit
PI	Atterberg plasticity index
G_s	specific gravity

LEGEND (Continued)

26	a single numeral following a soil component in the description of a soil represents the percentage, by weight, of that component in the soil as determined by a mechanical analysis
(25-35)	a range of numbers in parentheses following a soil component in the description of a soil, represents the estimated limits between which lies the percentage, by weight, of that component in the soil as determined by visual inspection
(.04)	single numeral in parentheses represents estimated values of D_{10}, LL, and PI

FD-1 Elev. 455±

0.0' - 0.6'	Topsoil
0.6' - 5.0'	Brown, loose to comp., gravelly 30 silty 15 m-f sand, SP, w/cobbles D_{10} = 0.0049
5.0' - 7.1'	Brown, comp., silty (5-15) sandy (35-45) gravel, GP-GM
7.1' - 9.2'	Brown, comp., m-f sand, SP
9.2' - 15.0'	Brown, comp., silty 7 sandy 44 gravel, GP-GM, D_{10} = 0.011
15.0' - 22.0'	Brown, comp., sandy (35-45) gravel, GP, w/boulders
22.0' - 23.8'	Gray brown, comp., sandy (35-45) gravel, GP
23.8'	Top of bedrock

FD-2 Elev. 518±

0.0' - 0.4'	Topsoil
0.4' - 5.0'	Brown, loose, silty 12 sandy 21 gravel, GM, w/cobbles & boulders D_{10} = 0.05
5.0' - 10.0'	Brown, mod. comp., silty (15-25) sandy (25-35) gravel, GM, Till w/boulders
10.0' - 15.4'	Decomposed schist w/occ. rock fragments
15.4'	Top of bedrock

FD-3 Elev. 454±

0.0' - 1.4'	Topsoil
1.4' - 5.0'	Brown, loose, sandy 47 silt ML, w/cobbles, D_{10} = 0.01
5.0' - 9.0'	Brown, mod. comp., silty (25-35) f. sand, SM
9.0' - 9.5'	Brown, comp., silty (15-25) m-f sand, SM
9.5' - 13.0'	Brown, comp., silty 6 sandy 38 gravel, GP-GM, w/cobbles & boulders D_{10} = 0.15
13.0' - 13.5'	Brown, comp., silty (5-15) m-f sand, SP-SM

FD-3 Continued

13.5' - 20.0'	Brown, mod. comp., silty 5 sandy 37 gravel GP-GM, W/ boulders & cobbles, D_{10} = 0.16
20.0' - 25.0'	Brown, comp., gravelly (15-25) silty (5-15) sand, SP-SM
25.0' - 30.2'	Decomposed rock, w/weathered rock fragments
30.2'	Top of bedrock

FD-4 Elev. 510±

0.0' - 0.6'	Topsoil
0.6' - 5.0'	Badly weathered & decomposed schist
5.0' - 8.7'	Weathered rock
8.7'	Top of bedrock

FD-5 Elev. 484.0

0.0' - 1.9'	Black, soft, organic silt, OL w/roots
1.9' - 5.0'	Gray, mod. comp., gravelly 36 silty 13 sand, SM, w/mica particles & weathered gravel sizes, D_{10} = 0.048
5.0' - 7.2'	Brown, mod. comp., gravelly (15-25) sand, SP, w/some mica particles
7.2' - 10.0'	Gray brown, comp., gravelly 46 silty 7 sand, SP-SM, w/mica & weathered rock fragments, D_{10} = 0.11
10.0' - 12.0'	Weathered rock fragments
12.0'	Top of bedrock

FD-6 Elev. 487.2'

0.0' - 1.0'	Black, Topsoil
1.0' - 3.8'	Brown, loose, gravelly 16 silty 8 m-f sand, SP-SM, D_{10} = 0.10
3.8' - 5.0'	Gray, mod. comp., gravelly (15-25) silty (35-45) sand, SM, w/mica particles & silt layers

FD-6 Continued

5.0' - 5.2'	Gray brown, comp. silty, (25-35) sand, SM
5.2' - 7.4'	Brown, comp., gravel 12 silty 11 sand, SP-SM
7.4' - 7.7'	Weathered rock fragments
7.7'	Top of bedrock

FD-7 Elev. 496.5

0.0' - 0.6'	Topsoil
0.6' - 3.0'	Brown, loose, silty (20-30) m-f sand, SM, w/roots & organics
3.0' - 5.0'	Brown, loose, gravelly 14 silty 38 m-f sand, SM, w/occ. mica particles, D_{10} = 0.0075
5.0' - 13.0'	Brown, comp., gravelly 34 to (10-20) silty 10 to (15-25) sand, SP-SM & SM w/mica particles & cobbles, D_{10} = 0.075
13.0'	Top of bedrock

FD-8 Elev. 498.4

0.0' - 0.8'	Topsoil
0.8' - 3.8'	Brown, loose gravelly 8 silty 47 sand, SM w/roots, D_{10} = 0.003
3.8' - 7.0'	Brown, mod. comp., gravelly (20-30) to 34 silty (10-20) to 11 sand, SM & SP-SM
7.0' - 10.0'	Stratified, gray-brown, mod. comp., silty (20-30) sand, SM & sandy f.(30-50) silt, ML
10.0' - 11.5'	Gray, mod. comp., silty (5-15) sandy (25-35) gravel, GM
11.5	Top of bedrock

FD-9 Elev. 500.2

0.0' - 1.8'	Topsoil
1.8' - 2.3'	Gray, loose, silty (20-30) sandy (25-35) gravel, GM, w/stratum of sandy (0-20) clay, CL
2.3' - 5.0'	Stratified, gray, loose, sandy f. (20-30) silt, ML, & silty (10-30) f. sand, SM, w/organic odor

FD-9 Continued

5.0' - 9.6'	Gray, mod. comp., silty (5-15) sandy (20-30) gravel, GP-GM w/micaceous decomposed cobbles
9.6' - 10.0'	Brown, mod. comp., silty (20-30) m-f sand, SM
10.0' - 13.9'	Brown, mod. comp., gravelly 13 m-f sand, SP, D_{10} = 0.01
13.9' - 15.0'	Brown, comp., silty (5-15) m-f sand, SP-SM
15.0' - 15.4'	Gray, brown, comp., silty (15-25) sandy (25-35) gravel, GM
15.4'	Top of bedrock

FD-10 Elev. 503.0

0.0' - 0.4'	Topsoil
0.4' - 3.3'	Brown, loose to mod. comp., gravelly (25-35) silty (15-25) sand, SM
3.3' - 4.0'	Weathered rock
4.0'	Top of bedrock

FD-11 Elev. 460.2

0.0' - 0.8'	Topsoil
0.8' - 1.7'	Brown, loose, silty (25-35) sand, SM, w/roots
1.7' - 2.0'	Weathered rock
2.0'	Top of bedrock

FD-12 Elev. 448.7

0.0' - 1.0'	Dark brown, loose, gravelly (25-35) silty (15-25) sand, SM, w/organics & occ. mica particles
1.0' - 6.0'	Brown, loose to mod. comp., gravelly (10-20) silty (10-20) sand, SM, w/cobbles
6.0' - 7.4'	Brown, loose to mod. comp., silty (10-20) sandy (25-35) gravel, GM, w/cobbles
7.4' - 10.0'	Brown, loose to mod. comp., gravelly (0-10) silty (5-15) sand, SP-SM, w/occ. mica particles

FD-12 Continued

10.0' - 15.0'	Brown, mod. comp., silty 6 sandy 39 gravel, GP-GM, w/occ. mica particles, D_{10} = 0.22
15.0' - 21.0'	Brown, comp., gravelly 42 silty 7 sand, SP-SM, w/cobbles, boulders & mica particles, D_{10} = 0.13
21.0' - 25.6'	Brown, comp., silty (15-25) sandy (25-35) gravel, GM, w/cobbles & boulders
25.6'	Top of bedrock

FD-13 Elev. 488.8

0.0' - 1.6'	Topsoil
1.6' - 2.0'	Dark brown, loose, silty (15-25) sandy (25-35) gravel, GM
2.0' - 5.0'	Brown, loose to mod. comp., silty (5-15) sand (25-35) gravel, GP-GM, w/layer of laminated silty sand, SM
5.0'	Top of bedrock

FD-14 Elev. 490.2

0.0' - 1.0'	Topsoil
1.0' - 8.4'	Brown, loose to mod. comp., silty (5-15) sandy (25-35) gravel, GP-GM, w/cobbles & boulders
8.4'	Top of bedrock

FD-15 Elev. 454.0

0.0' - 2.0'	Black, soft topsoil
2.0' - 5.0'	Laminated brown, loose to mod. comp., silty (25-35) f. sand, SM & gray sandy (20-40) silt, ML
5.0' - 9.3'	Dark gray, stiff, sandy f. 18 silt, ML w/occ. clay, Cl laminae LL = 30, PI = 5, W_n = 29

FD-15 Continued

9.3' - 14.0'	Brown, comp., silty 6 sandy 35 gravel, GP-GM, w/occ. decomposed gravel particles, D_{10} = 0.22
14.0' - 19.0'	Brown, mod. comp., m-f sand, SP w/occ. mica particles
19.0' - 25.0'	Laminated brown, mod. comp. to comp micaceous, gravelly (15-25) sand,SP, silty (25-45) f. sand, SM & sandy f. (30-40) silt, ML, w/cobbles & boulders
25.0' - 29.5'	Brown, comp., silty (5-15) sandy (25-35) gravel, GP-GM, w/cobbles & boulders
29.5'	Top of bedrock

FD-16 Elev. 462.1

0.0' - 1.5'	Topsoil w/roots
1.5' - 5.0'	Brown, loose, sandy, f. (30-40) silt, ML, w/roots & some mica particles
5.0' - 6.1'	Brown, comp., gravelly (20-30) sandy f. (15-25) silt, ML
6.1'	Top of bedrock

FD-17 Elev. 469.8

0.0' - 0.6'	Topsoil
0.6' - 2.0'	Brown, loose, sandy f. (35-50) silt, ML, w/roots & organics
2.0' - 11.2'	Cobbles & boulders embedded in soil
11.2' - 12.9'	Brown, comp., micaceous, gravelly (15-25) silty (5-15) sand, SP-SM
12.9'	Top of bedrock

FD-18 Elev. 499.6

0.0' - 0.5'	Topsoil
0.5'	Top of bedrock

FD-19 Elev. 463.8

0.0' - 1.2'	Fill, loose, silty, gravelly sand, w/coal fragments & roots
1.2' - 2.2'	Dark brown, loose, gravelly (15-25) silty (20-30) sand, SM w/roots & some mica particles
2.2' - 5.7'	Brown, loose, micaceous gravelly 3 silty 36 f. sand, SM, w/silt layers, D_{10} = 0.032
5.7' - 6.0'	Brown, comp., gravelly (10-20) silty (5-15) sand, SP-SM
6.0' - 15.0'	Brown, mod. comp., gravelly 29 to (15-25) silty 11 sand SW-SM, w/some mica particles & cobbles
15.0' - 16.1'	Brown, comp., silty (5-15) sandy (30-40) gravel, GP-GM
16.1'	Top of bedrock

FD-20 Elev. 467.6

0.0' - 0.7'	Topsoil
0.7' - 2.1'	Brown, loose, gravelly (10-20) sandy, (20-30) silt, ML, w/roots
2.1'	Top of bedrock

FD-21 Elev. 452.2

0.0' - 0.3'	Black, soft, sandy f. (20-30) organic silt, OL, w/roots & debris
0.3' - 2.0'	Stratified brown, loose, gravelly (30-40) silty (20-30) sand, SM, w/mica
2.0' - 4.5'	Brown, mod. comp., micaceous gravelly (20-30) silty (20-30) sand SM w/cobbles & rock fragments
4.5'	Top of bedrock

FD-22 Elev. 481.2

0.0' - 1.8'	Topsoil
1.8' - 5.0'	Brown, loose, gravelly (0-10) silty (30-40) sand, SM w/roots
5.0' - 10.0'	Brown, mod. comp., gravelly (20-30) silty (5-15) sand, SP-SM w/some mica particles
10.0' - 15.6'	Brown, comp., gravelly 10 silty 25 sand, SM w/some mica particles & 1/2" layer of sandy f.(30-40) silt, D_{10} = 0.032
15.6'	Top of bedrock

FD-23 Elev. 494.8

0.0' - 0.5'	Topsoil
0.5' - 1.5'	Brown, loose, gravelly (20-30) sandy (10-20) silt, ML w/roots
1.5' - 5.1'	Brown, mod. comp., gravelly (30-40) silty (10-20) sand, SM, w/cobbles & boulders
5.1' - 5.7'	Brown, comp., gravelly (10-20) silty (10-20) m-f sand, SM w/mica
5.7'	Top of bedrock

FD-24 Elev. 452.7

0.0' - 1.0'	Black, v.soft, sandy(10-20) organic silt, OL
1.0' - 2.0'	Black, soft, sandy 48 silt, ML, w/organics & mica W_n = 44.9 nonplastic, D_{10} = 0.009
2.0' - 4.0'	Gray brown, soft, micaceous sandy f.(30-40) silt, ML, w/organics W_n = 33.0
4.0' - 5.0'	Gray brown, loose, gravelly (25-35) silty (15-25) sand, SM, w/mica
5.0' - 9.0'	Gray brown, mod.comp, silty (5-15) sand (20-30) gravel, GP-GM, w/boulders & 1/4" silt layer

FD-24 Continued

9.0' - 14.5'	Brown, loose, silty 21 m-f sand, SM, w/mica, D_{10} = 0.027
14.5' - 16.5'	Brown, mod. comp., gravelly (10-20) silty (20-30) sand, SM
16.5' - 20.0'	Brown, mod. comp., gravelly 4 silty 6 sand, SP-SM D_{10} = 0.2
20.0' - 26.6	Brown, mod. comp. to comp., gravelly 44 to (20-30) silty 9 to (5-15) sand, SP-SM, w/mica, D_{10} = 0.09
26.6'	Top of bedrock

FD-25 Elev. 460.8

0.0' - 2.7'	Brown, loose, gravelly (20-30) silty (15-25) sand, SM, w/cobbles & boulders
2.7' - 5.0'	Brown, loose, gravelly 10 silty 44 m-f sand, SM w/some mica W_n = 25.2, W_L = 26.8, D_{10} = 0.009
5.0' - 10.0'	Brown, mod. comp., gravelly 33 silty 7 sand, SP-SM w/cobbles D_{10} = 0.17
10.0' - 15.0'	Brown, comp., silty, (5-15) sandy (30-40) gravel, GP-GM w/mica
15.0' - 20.7'	Stratified, brown, comp., gravelly 4 sandy m-f 14 silt, ML W_n = 29.1, nonplastic, D_{10} = 0.016
20.7'	Top of bedrock

FD-26 Elev. 450.6

0.0' - 2.0'	Black, soft, sandy (10-20) organic silt, OL
2.0' - 3.8'	Gray, comp., silty (10-25) sandy (25-35) gravel, GM, w/organics
3.8' - 8.0'	Orange brown, comp., silty (15-25) sand, SM, w/boulders
8.0'	Top of bedrock

FD-27 Elev. 452.7

0.0' - 6.0'	Gray, soft, micaceous sandy, f. 47 silt, ML, w/organics W_n = 40.7, 45.4, nonplastic
6.0' - 8.0'	Gray, soft, micaceous, sandy f. (35-45) silt, ML, w/heavy organics, grass & wood fibers W_n = 65.5
8.0' - 10.0'	Brown, loose, gravelly (30-40) silty (15-25) sand, SM, w/roots & a layer of organic silt 0.1"
10.0' - 15.0'	Brown, loose to mod. comp., gravelly (30-40) silty (10-20) sand, SM, w/cobbles, some mica & 0.1" silt layer
15.0' - 22.0'	Brown, comp., silty 10 sandy 35 gravel, GP-GM, w/mica, D_{10} = 0.074
22.0' - 26.5'	Gray brown, mod. comp., silty (10-20) f. sand, SM w/mica (wash sample)
26.5' - 32.3'	Brown, comp., silty (15-25) sandy (30-40) gravel, GM, w/some mica & cobbles
32.3'	Top of bedrock

FD-28 Elev. 452.0

0.0' - 0.4'	Black, soft, sandy f.(10-30) organic silt, OL
0.4' - 3.0'	Black, loose, micaceous, gravelly (10-20) silty (30-40) f. sand, SM, w/organics
3.0' - 5.0'	Brown, mod. comp., silty (10-20) sandy (30-40) gravel, GM, w/cobbles
5.0' - 10.0'	Brown, mod. comp., gravelly 16 silty 13 m-f sand, SM, w/mica
10.0' - 10.5'	Brown, mod. comp., silty (20-30) sandy (30-40) gravel, GM
10.5' - 11.1'	Gray brown, mod. comp., sandy f. (30-40) silt, ML, w/mica
11.1' - 21.5'	Brown, mod. comp., gravelly 19 to 39 silty 8 sand, SP-SM, w/mica & cobbles, D_{10} = 0.12, 0.2

FD-28 Continued

21.5' - 22.7	Brown, mod. comp., gravelly (20-30) silty (5-15) m-f sand, SP-SM, w/mica
22.7' - 25.0'	Brown, comp., gravelly (5-15) silty (5-15) sand, SP-SM, w/cobbles
25.0' - 30.9'	Gray brown, comp., gravelly 39 silty 9 sand, SP-SM, w/cobbles & mica, D_{10} = 0.16
30.9'	Top of bedrock

FD-29 Elev. 458.8

0.0' - 1.4'	Black, loose, (fill) cinders & gravelly silty sand
1.4' - 5.0'	Brown, loose, silty (25-35) m-f sand, SM, w/cobbles & decomposed cobbles & mica particles
5.0' - 12.5'	Brown to gray brown, mod. comp., gravelly 18 silty 18 sand, SM, w/cobbles, boulders & mica, D_{10} = 0.047
12.5'	Top of bedrock

FD-30 Elev. 512.7

0.0' - 0.2'	Topsoil & forest debris
0.2' - 3.7'	Brown, loose, silty (10-20) m-f sand, SM, w/roots
3.7' - 5.0'	Brown, loose, gravelly (10-20) silty (30-40) m-f sand, SM w/weathered gravel sizes
5.0' - 6.0'	Brown, comp., silty (5-15) sandy (30-40) gravel, GP-GM
6.0' - 10.0'	Brown, comp., micaceous silty 40 m-f sand, SM W_n = 7.5 W_4 = 10.4, D_{10} = 0.0023
10.0' - 17.7'	Gray brown, [illegible], comp., gravelly ([illegible]) to 15 silty 33 m-f [illegible], SM, Till, w/cobbl[illegible]. W_n = 10.0, W_4 = 10.2, D_{10} = 0.0039
17.7' - 25.2'	Gray, comp., gravelly (0-10) to 17 silty 28 sand, SM, Till w/cobbles. W_n = 7.0, W_4 = 7.7, LL = 16, PI = 2, D_{10} = 0.008
25.2' - 27.1'	Decomposed & weathered rock
27.1'	Top of bedrock

FD-31 Elev. 514.0

0.0' - 0.6'	Topsoil & forest debris
0.6' - 5.0'	Brown, loose to mod. comp., gravelly (20-30) silty (15-25) m-f sand, SM, w/roots
5.0' - 10.0'	Brown, mod. comp., gravelly (10-20) silty (15-25) m-f sand, SM, w/thin layers of silty (20-40) f. sand
10.0' - 14.0'	Gray brown, mod. comp., gravelly 32 silty 14 sand, SM, Till w/cobbles. $W_n = 8.7$, $W_4 = 8.9$ $D_{10} = 0.039$
14.0' - 25.0'	Gray, comp., gravelly (10-20) to 23 silty 28 sand, SM, Till, w/cobbles $W_n = 7.6$, $W_4 = 9.2$ LL = 16, PI = 1, $D_{10} = 0.0066$
25.0' - 37.7'	Gray, comp. to mod. comp., gravelly (10-20) to 35 silty (25-35) to 24 m-f sand, SM, Till, w/cobbles & sand seams from 30.0' - 37.7', $W_n = 9.5$, $W_4 = 10.2$, LL = 16, PI = 2, $D_{10} = 0.007$
37.7' - 40.0'	Stratified gray, med. clay, silt & silty f. sand
40.0'	Bottom of exploration

FD-32 Elev. 512.8

0.0' - 0.8'	Topsoil
0.8' - 2.9'	Brown, soft, sandy, f. (30-40) silt, ML, w/roots & organics
2.9' - 10.0'	Brown, mod. comp. to comp., silty (35-45) to 45 m-f sand, SM w/gray silt layers, $D_{10} = 0.0049$, $W_n = 18.2$, $W_4 = 18.8$
10.0' - 13.0'	Brown, comp., silty (35-45) m-f sand, SM
13.0' - 15.0'	Gray brown, comp., sandy m-f 31 silt, ML, Till, w/cobbles LL = 36, PI = 10, $D_{10} = < 0.001$. $W_n = 11.9$, $W_4 = 12.1$
15.0' - 25.4'	Gray, comp., gravelly 9 to (10-20) silty 39 m-f sand, SM, Till w/cobbles. LL = 30, PI = 3, $D_{10} = 0.0015$, $W_n = 12.5$, $W_4 = 13.2$
25.4'	Top of bedrock

FD-33 Elev. 499.4

0.0' - 0.8'	Topsoil
0.8' - 2.3'	Brown, loose, silty (30-40) m-f sand, SM, w/roots
2.3' - 5.4'	Brown, loose to mod. comp., gravelly 18 silty 9 sand, SP-SM, w/occ. roots & cobbles increasing w/depth. D_{10} = 0.092
5.4' - 10.0'	Nested boulders in soil
10.0' - 15.0'	Brown, mod. comp., gravelly 47, silty 5 sand, SP-SM w/cobbles D_{10} = 0.18
15.0'	Bottom of exploration

FD-34 Elev. 533.4

0.0' - 0.4'	Topsoil & forest debris
0.4' - 1.3'	Brown, loose, gravelly (10-20) silty (10-20) m-f sand, SM, w/roots
1.3' - 5.0'	Gray brown, loose, gravelly 32 silty 12 sand, SM, w/cobbles
5.0' - 11.3'	Gray brown, mod. comp., silty (5-15) sandy (30-40) gravel, GP-GM w/cobbles increasing w/depth
11.3'	Top of bedrock

FD-35 Elev. 516.2

0.0' - 1.0'	Topsoil & forest debris
1.0' - 2.3'	Brown, loose, silty (20-30) m-f sand, SM, w/roots
2.3' - 5.0'	Brown, loose, gravelly (35-45) silty (5-15) sand, SP-SM, w/cobbles
5.0' - 10.0'	Brown, loose silty 6 sandy 35 gravel GP-GM w/cobbles D_{10} = 0.017
10.0' - 11.1'	Brown, loose, gravelly (15-25) silty (10-20) sand, SM
11.1' - 14.1'	Brown, loose, weathered rock mixed w/micaceous silty (15-25) sand
14.1 - 15.0'	Weathered rock
15.0'	Top of bedrock

FD-36 Elev. 516.4

0.0' - 0.6'	Topsoil & forest debris
0.6' - 2.3'	Brown, loose, gravelly (15-25) silty (30-40) sand, SM w/roots
2.3' - 5.0'	Gray, loose to mod. comp., silty (5-15) sandy (30-40) gravel, GP-GM, w/cobbles

FD-36 Continued

5.0' - 10.0'	Brown, mod. comp., silty 12 sandy 38 gravel, GP-GM w/cobbles
10.0' - 11.0'	Brown, comp., silty (15-25) sandy (30-40) gravel, GM
11.0'	Top of bedrock

FD-37 Elev. 500.2

0.0' - 2.6'	Topsoil
2.6' - 5.0'	Gray brown, mod. comp., silty (20-40) m-f sand, SM, W_n = 23.1 W_L = 23.2
5.0' - 13.7'	Gray brown, mod. comp. to comp., gravelly 8 silty 40 to (30-40) m-f sand, SM, Till. W_n = 13.5, 12.1, W_L = 13.8, 13.1 LL = 21, PI = 3, D_{10} = 0.0035
13.7' - 15.8'	Weathered rock
15.8'	Top of bedrock

FD-38 Elev. 500.1

0.0' - 0.6'	Topsoil
0.6' - 2.8'	Brown, loose, gravelly (10-20) silty (30-40) m-f sand, SM, w/cobbles & roots
2.8' - 4.6'	Gray brown, mod. comp., silty (30-40) m-f sand, SM, W_n = 15.8, W_L = 16.4
4.6' - 6.8'	Brown, mod. comp., silty (30-40) m-f sand, SM w/occ. layers of gray silt, W_n = 15.5, W_L = 17.1
6.8' - 11.8'	Gray, stiff, sandy f. (20-30) silt, ML, w/occ. layers of brown silty (20-30) f. sand SM & sandy clay, CL
11.8' - 13.6'	Brown, mod. comp., gravelly (10-20) silty (20-30) m-f sand, SM w/ weathered & decomposed cobbles
13.6' - 25.0'	Gray, comp., gravelly (10-20) silty (30-40) m-f sand, SM, Till, W_n = 10.8, W_L = 11.1
25.0'	Bottom of exploration

FD-39 Elev. 477.4

0.0' - 0.7'	Topsoil
0.7' - 4.1'	Brown, loose, silty (35-45) f. sand, SM, w/roots & cobbles
4.1' - 4.7'	Brown gray, loose to mod comp., silty (25-35) m-f sand, SM, w/occ. silt layers
4.7' - 10.0'	Stratified, gray brown, mod. comp., sandy f. (10-30) silt, ML & silty (30-40) f. sand, SM
10.0' - 25.0'	Gray, mod. comp., gravelly 17 silty 33 to (35-45) m-f sand, SM, Till, W_n = 10.3, 9.9, W_4 = 11.9, 11.2, LL = 18, PI = 3, D_{10} = 0.0055
25.0'	Bottom of exploration

FD-40 Elev. 487.4

0.0' - 1.6'	Topsoil
1.6' - 2.8'	Brown, loose, gravelly (10-20) silty (25-35) sand, SM, w/hair roots
2.8' - 10.2'	Brown, mod. comp. to comp., silty (5-15) sandy (30-40) gravel, GP-GM, w/cobbles & weathered cobbles & gravels
10.2' - 11.5'	Brown, comp., gravelly (10-20) silty (10-20) m-f sand, SM, w/gray brown, silty (25-35) m-f sand layers
11.5' - 15.0'	Brown, comp., silty (5-15) sandy (30-40) gravel, GP-GM, w/cobbles & occ. silt layers
15.0' - 17.9'	Brown, comp., gravelly 21 silty 23 sand, SM, D_{10} = 0.017
17.9' - 20.0'	Gray, comp., gravelly 3 silty 44 m-f sand, SM, Till W_n = 11.2, W_4 = 11.4, D_{10} = 0.0018
20.0'	Bottom of exploration

FD-41 Elev. 504.3

0.0' - 1.3'	Topsoil
1.3' - 5.0'	Gray brown, soft to medium gravelly 8 sandy m-f 31 silt, ML, D_{10} = < 0.001
5.0' - 13.7'	Gray brown, mod. comp. to comp., gravelly 6 silty 41 m-f sand, SM, Till, w/cobbles W_n = 12.7, W_4 = 13.3, D_{10} = 0.0022
13.7	Top of bedrock

FD-42 Elev. 483.5

0.0' - 1.4'	Topsoil
1.4' - 12.1'	Gray brown, mod. comp., gravelly (0-10) to 12 silty (30-40) to 39 m-f sand, SM, Till, w/thin lenses of brown silty sand w/weathered cobbles from 10.0' to 12.1', W_n = 13.4, 12.9, W_4 = 14.4, 15.2, D_{10} = 0.0055
12.1' - 15.0'	Gray brown, stiff, sandy F (30-40) silt, ML, Till w/thin lenses of brown, silty (40-50) f. sand, SM
15.0' - 25.0'	Gray, stiff, gravelly 8 sandy f. 28 to (30-40) silt, ML, Till, w/cobbles from 20.0' to 25.0' W_n = 15.5, 11.0, W_4 = 15.8, 12.0, D_{10} = 0.001
25.0'	Bottom of exploration

FD-43 Elev. 476.9

0.0' - 1.1'	Topsoil & forest debris
1.1' - 4.0'	Brown, loose, silty (20-30) sandy (20-30) gravel, GM, w/cobbles & hair roots
4.0' - 4.9'	Weathered rock
4.9'	Top of bedrock

FTT-1 Elev. 475.0

0.0' - 1.1'	Topsoil
1.1' - 3.5'	Brown, loose, sandy F. 16 silt, ML, w/roots & cobbles, D_{10} = 0.0039
3.5' - 6.1'	Brown, comp., sandy 48 gravel, GP, w/cobbles, D_{10} = 0.25
6.1' - 7.4'	Gray brown, loose, silty (20-30) f. sand, SM
7.4' - 8.0'	Brown, comp., sandy (30-40) gravel, GP, w/cobbles
8.0' - 10.8'	Brown, comp., gravelly 23 silty 4 sand, SP, w/cobbles w/0.1" silt layer & 0.5" sand layer
10.8'	Top of bedrock

FTT-2 Elev. 468.3

0.0' - 0.6'	Topsoil
0.6' - 3.3'	Brown, loose, sandy f. (20-30) silt, ML, w/roots & cobbles
3.3' - 11.0'	Brown, comp., gravelly 37 sand, SP, w/ 0.2" sand layer D_{10} = 0.29
11.0'	Botton of exploration

FTT-3 Elev. 489.3

0.0' - 1.0'	Topsoil
1.0' - 3.7'	Brown, loose, sandy f. (20-30) silt, ML, w/occ. roots, cobbles & boulders
3.7'	Top of bedrock

FTT-4 Elev. 495.1

0.0' - 0.6'	Topsoil
0.6' - 2.7'	Dark brown, loose, sandy f. (20-30) silt, ML, w/cobbles & boulders
2.7' - 3.6'	Brown, comp., gravelly 33 silty 21 sand, SM, w/roots, boulders & cobbles, D_{10} = 0.028

FTT-4 Continued:

3.6' - 4.7'	Brown, comp., gravelly (10-20) silty (5-15) sand, SP-SM, w/cobbles & boulders
4.7'	Top of bedrock

FTT-5 Elev. 490.5

0.0' - 0.6'	Forest debris & Topsoil
0.6' - 1.8'	Brown, loose gravelly (10-20) sandy, f. (20-30) silt, ML, w/roots, cobbles & boulders
1.8' - 4.2'	Brown, comp., silty 2 sandy 45 gravel, GP, w/cobbles & boulders, D_{10} = 0.37
4.2'	Top of bedrock

FTT-6 Elev. 493.0

0.0' - 0.7'	Forest debris & topsoil, w/ cobbles & boulders
0.7' - 2.2'	Brown, loose, gravelly (10-20) sandy (30-40) silt, ML, w/cobbles, boulders & roots
2.2' - 4.4'	Brown, comp., gravelly (20-30) silty (5-15) sand, SP-SM, w/cobbles
4.4' - 5.8'	Brown, comp., gravelly (20-30) sand, SP, w/cobbles, boulders & sand lense to 0.5'
5.8'	Refusal

FTT-7 Elev. 481.3

0.0' - 1.9'	Forest debris & topsoil w/cobbles & boulders
1.9' - 2.4'	Brown, loose, gravelly (10-20) sandy (25-35) silt, ML, w/roots, cobbles & boulders
2.4' - 2.9'	Brown, mod. comp., silty (10-20) m-f sand, SM, w/cobbles
2.9' - 5.6'	Gray, comp., gravelly 15 silty 20 sand, SM, w/cobbles, boulders & silt layer from 5.4'-5.6' D_{10} = 0.025
5.6'	Top of bedrock

FTT-8 Elev. 493.3

0.0' - 0.8'	Forest debris & topsoil w/cobbles & boulders
0.8' - 2.7'	Brown, comp., silty (5-15) sandy (25-35) gravel, GP-GM w/roots, cobbles & boulders
2.7' - 11.0'	Brown, comp., silty 2 sandy 33 gravel, GP, w/cobbles & boulders. $D_{10} = 0.38$
11.0'	Bottom of exploration

BD-1 Elev. 525.5

0.0' - 5.0'	Brown, mod. comp.gravelly (10-20) silty (25-35) m-f sand, SM, Till, w/cobbles
5.0' - 25.0	Brown to gray brown, comp. to v. comp.,gravelly 8, 7 silty 35, 39 m-f sand, SM, Till, w/cobbles & clay strata from 19.0' to 20.0' nonplastic W_n = 10.3, W_4 = 10.3, D_{10} = 0.007, 0.0081
25.0' - 30.0'	Gray brown, comp. to v. comp., gravelly 38 silty 19 m-f sand, SM-SC Till LL = 21, Pl = 5, D_{10} = 0.018
30.0'	Bottom of exploration

BD-2 Elev. 540.0

0.0' - 1.1'	Topsoil
1.1' - 2.2'	Brown, loose, gravelly (10-20) silty (25-35) m-f sand, SM
2.2' - 20.0'	Gray brown, mod. comp. to comp., gravelly (10-20) to 6, 10 silty 32 m-f sand, SM, Till, w/cobbles, nonplastic, W_n = 9.5, W_4 = 9.8, D_{10} = 0.0057, 0.0048
20.0'	Bottom of exploration

BD-3 Elev. 570.6

0.0' - 0.8'	Topsoil
0.8' - 5.0'	Brown, loose to mod comp., gravelly (25-35) silty (5-15) sand, SP-SM w/cobbles
5.0' - 7.4'	Brown, comp., gravelly (10-20) silty (5-15) sand, SP-SM, w/cobbles
7.4' - 10.0'	Brown, comp., gravelly (25-35) silty (10-20) sand, SM, w/cobbles
10.0' - 10.4'	Brown, comp., silty (5-15) sandy (30-40) gravel, GP-GM
10.4'	Top of bedrock

BD-4 Elev. 580.2

0.0' - 0.9'	Topsoil
0.9' - 9.1'	Brown, mod. comp., gravelly 22 silty 12 sand, SP-SM, w/cobbles, D_{10} = 0.0061
9.1' - 15.0'	Brown, mod. comp. to comp., gravelly (10-20) to 33 silty 13 sand, SM, w/cobbles, decomposed stone & occasional silt laminae
15.0' - 17.3'	Brown, comp., silty (10-20) sand, SM
17.3' - 22.2'	Stratified, brown, v. comp., gravelly (10-20) silty (10-20) sand, SM & sandy f. (20-50) silt, ML
22.2' - 24.1'	Gray, v. comp., silty (25-35) sand, SM, Till
24.1' - 25.0'	Brown, comp., gravelly (10-15) silty (5-15) sand, SP-SM
25.0' - 38.8'	Gray, comp. to v. comp., gravelly 10 silty 37 m-f sand, SM, Till, LL = 18, PI - 2, W_n = 7.7, W_4 = 8.1, D_{10} = 0.0033
38.8' - 45.5'	Stratified, brown, mod. comp., silty 12 m-f sand, SM & gray, silty (30-40) m-f sand, SM Till
45.5'	Top of bedrock

BD-5 Elev. 549.9

0.0' - 0.9'	Topsoil
0.9' - 5.0'	Brown, loose, gravelly 38 silty 13 sand, SM, w/cobbles
5.0' - 7.0'	Brown, mod. comp., silty (10-20) sand, SM
7.0' - 20.0'	Gray brown to gray, comp. to v. comp., gravelly 16 silty 36 m-f sand, SM Till, non-plastic, W_n = 13.0, W_4 = 13.2, D_{10} = 0.0032
20.0' - 40.0'	Gray, comp. to v. comp., gravelly 8, 9 silty 30, 35 m-f sand, SM Till, nonplastic, W_n = 8.6, 8.3, W_4 = 8.9, 8.7 D_{10} = 0.008, 0.0045
40.0'	Bottom of exploration

BT-2 Elev. 517±

0.0' - 0.7'	Topsoil
0.7' - 1.8'	Brown, loose, gravelly (10-20) silty (15-25) m-f sand, SM, w/small roots
1.8' - 3.9'	Gray brown, comp., silty 35 m-f sand, SM, W_n = 14.4, W_4 = 14.7, D_{10} = 0.0062, G_s = 2.73 $_d$ = 123.0
3.9' - 5.8'	Gray, comp., silty 37 m-f sand, SM w/sand seams to ½", W_n = 13.8, W_4 = 14.1, D_{10} = 0.008, G_s = 2.73, $_d$ = 122.5
5.8' - 7.2'	Brown, mod. comp., gravelly (10-20) silty (10-20) m-f sand, SM, W_n = 9.7, W_4 = 10.8
7.2' - 9.4'	Brown, mod. comp., silty 41 sand SM, W_n = 15.3, W_4 = 16.2, D_{10} = 0.019, G_s = 2.74, $_d$ = 118.9
9.4' - 11.8'	Gray brown, comp., silty (5-15) sand, SP-SM
11.8' - 12.2'	Red brown, sandy gravel, GP
12.2'	Bottom of exploration

BT-3 Elev. 500±

0.0' - 0.5'	Topsoil
0.5' - 1.2'	Brown, loose, gravelly (10-20) silty (30-40) sand, SM, w/roots
1.2' - 3.1'	Brown, loose, gravelly 26 silty 18 sand, SM, D_{10} = 0.033
3.1' - 3.9'	Brown, mod. comp., silty (5-15) sandy (30-40) gravel, GP-GM, w/cobbles
3.9' - 5.3'	Brown, loose,gravelly (10-20) silty (15-25) sand, SM
5.3' - 5.9'	Stratified, brown, loose, gravelly (10-20) sandy (30 -40) silt, ML

BT-3 Continued

5.9' - 9.7'	Brown comp., sandy 40 gravel, GP, w/cobbles D_{10} = 0.3
9.7' - 12.3'	Brown, mod. comp., gravelly 38 sand SP w/cobbles D_{10} = 0.16
12.3'	Bottom of exploration

BT-4 Elev. 514.0

0.0' - 0.9'	Topsoil & forest debris
0.9' - 3.1'	Brown, loose to mod. comp. gravelly 18, 15 silty 19, 25 m-f sand, SM, D_{10} = 0.039, 0.03
3.1' - 5.0'	Gray brown, comp., gravelly 6 silty 39 m-f sand, SM D_{10} = 0.0059
5.0' - 5.9'	Brown, mod. comp., gravelly 18 silty 17 m-f sand, SM D_{10} = 0.035
5.9' - 9.1'	Stratified, brown, mod. comp., m-f sandy 42 silt, ML, D_{10} = 0.0039
9.1' - 11.3'	Brown, comp., gravelly 24 silty 8 sand, SP-SM, D_{10} = 0.002
11.3' - 17.0'	Gray brown, comp., gravelly 7 silty 39 m-f sand, SM, Till, nonplastic, D_{10} = 0.0047
17.0'	Bottom of exploration

BT-5 Elev. 490±

0.0' - 0.6'	Topsoil and forest debris
0.6' - 2.2'	Brown, loose, sandy f. (30-40) silt, ML, w/roots
2.2' - 3.3'	Brown gray, loose, silty (20-30) m-f sand, SM
3.3' - 5.8'	Stratified, mod. comp. gray, sandy f. (30-40) silt, ML, 1/4" to 1/2" and Orange Br. silty (15-25) f. sand, SM 1/4" to 1/2"

BT-5 Continued

5.8' - 11.1'	Brown, comp., sandy 33 gravel, GP, w/cobbles & boulders D_{10} = 0.026
11.1'	Bottom of exploration

BT-6 Elev. 540±

0.0' - 0.8'	Topsoil
0.8' - 2.1'	Brown, loose, gravelly (10-20) silty (20-30) sand, SM, w/cobbles & roots
2.1' - 10.0'	Gray, comp., gravelly 17, 7 silty 26, 31 sand, SM, Till, w/cobbles & thin lenses of f. sand, W_n = 12.1, 17.5 W_L = 13.5, 17.7, nonplastic D_{10} = 0.0092, 0.012
10.0'	Bottom of exploration