From: Bachand, Michael L NAE
To: Sneeringer, Paul J NAE
Cc: Keegan, Michael F NAE; Michalak, Scott C NAE; Schmidt, Rosemary A NAE
Subject: New Bedford HB - Design Memorandums 2 & 5 (UNCLASSIFIED)
Date: Tuesday, August 21, 2012 2:38:36 PM
Attachments: DM2.pdf
New Bedford-Fairhaven Barrier No.5.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Paul,
As discussed during today's meeting, here are the two original project Design Memorandums.

Design Memorandum 2 - Site Geology

Design Memorandum 5 - Embankment and Foundations

Thanks - Mike

Michael L. Bachand, P.E.
Levee Safety Program Manager

United States Army Corps of Engineers
New England District
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Classification: UNCLASSIFIED
Caveats: NONE

HURRICANE PROTECTION PROJECT

NEW BEDFORD-FAIRHAVEN
HURRICANE BARRIER

NEW BEDFORD HARBOR, MASSACHUSETTS

DESIGN MEMORANDUM NO. 2
SITE GEOLOGY

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

FEBRUARY 1960

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

RESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO. NEDGW

29 February 1960

SUBJECT: New Bedford-Fairhaven Hurricane Protection, New Bedford, Massachusetts - Design Memorandum No. 2, Site Geology

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

1. In accordance with EM 1110-2-1150, there is submitted herewith for review and approval, Design Memorandum No. 2, "Site Geology", for the New Bedford-Fairhaven Hurricane Protection Project, New Bedford, Massachusetts.

2. The portions of graphic logs of subsurface explorations showing rock core recoveries do not conform with guide presentation in EM 1110-1-1806. The logs will be revised in accordance with the Manual for presentation on contract drawings.

FOR THE DIVISION ENGINEER:

John Wm Leslie

JOHN WM. LESLIE
Chief, Engineering Division

Incl (10 cys)
Des Memo No. 2,
Site Geology - New Bedford-
Fairhaven Hurricane Protection

NEW BEDFORD-FAIRHAVEN HURRICANE PROTECTION
NEW BEDFORD, MASSACHUSETTS
DESIGN MEMORANDUM NO. 2
SITE GEOLOGY

Index to Design Memoranda

No.	Title	Submission Date	Approved
1	Hydrology and Hydraulics		
2	Site Geology		
3	General Design		
4	Sewer Modifications		
5	Embankments and Foundations		
6	Concrete Materials		
7	Detail Design, Walls and Miscellaneous Structures		
8	Detail Design, Navigation Gates and Appurtenances		

NEW BEDFORD - FAIRHAVEN HURRICANE PROTECTION

DESIGN MEMORANDUM NO. 2

SITE GEOLOGY

CONTENTS

NEW BEDFORD - FAIRHAVEN HURRICANE PROTECTION

DESIGN MEMORANDUM NO. 2

SITE GEOLOGY

LIST OF PLATES

NEW BEDFORD - FAIRHAVEN HURRICANE PROTECTION

NEW BEDFORD HARBOR

MASSACHUSETTS

DESIGN MEMORANDUM NO. 2

SITE GEOLOGY

FEBRUARY 1960

A. GENERAL.

1. The purpose of this memorandum is to provide a geologic background for the design of a complex barrier structure to prevent the entrance of hurricane tidal surges into New Bedford - Fairhaven Harbor and to provide protection to the harbor area from the action of high waves that occur with hurricanes and other storms. The principal structure is an earth-filled rock-faced barrier, 4,500 feet long, which will extend across the harbor mouth, and have a gated opening 150 feet wide at the existing navigation channel and two gated conduits to maintain tidal circulation. A by-pass channel will be dredged to maintain vessel traffic while the gate is under construction. Other structures will include dikes and walls to prevent flanking of the main barrier in the Clark Cove Area of New Bedford and in Fairhaven, and a pumping station at Clark Cove to remove excess water from run-off and wave overtopping. A relief sewer line is being considered for construction on the New Bedford side to divert sewage from the city's principal interceptor outfall into the harbor behind the main barrier during storms.

B. GEOGRAPHY AND PHYSIOGRAPHY.

2. New Bedford - Fairhaven Harbor is bounded by the peninsulas of Clark Point on the west, and Sconticut Point on the east. The outer harbor, about two miles wide at Buzzards Bay to the south, is generally shallow with maximum natural depths of about 30 feet at the harbor mouth. The inner harbor, which lies in the estuary of the Acushnet River to the north, is about 2/3 mile wide. Its mouth is marked on the east by Fort Phoenix, a bedrock headland, on the west by a low industrial flat, and in the middle by Palmer Island, an irregular series of rock hummocks joined by sandy shoals running parallel to the harbor axis. The ship channel passes into a dredged anchorage serving commercial harbor facilities, largely fishing. The area is of moderately low relief with the relatively low-lying southern parts of New Bedford on the west and Fairhaven on the east ranging from zero to 50 feet above sea level. West of the Clark Point peninsula is an embayment, Clark Cove, about 1-1/2 miles long, whose bayhead is separated from the inner harbor by a rather low, heavily populated 1/2-mile strip. East of Fort Phoenix, in Fairhaven, a broad shallow embayment borders a salt marsh drained by two small tidal creeks.

C. SITE GEOLOGY.

3. The area lies on the seaboard lowland, the submerged fringe of an old hardrock peneplane surface. It is somewhat of an outlying segment of the old crystalline mass, since it is separated from it by the Carboniferous soft rock Narragansett Basin on the west, and on the north by the Narragansett Basin (which arcs around) and the Norfolk Basin. Bedrock is concealed to the east by thick glacial sediments and to the south by the ocean. An arc bounding the northwest quadrant of a compass rose and having a 15-mile radius would approximate the boundary between the soft rocks and the older igneous and metamorphic complex on which New Bedford rests.

4. Bedrock at the site is granitic gneiss, the product of the intrusion of Lower or pre-Paleozoic schist by granitic magma. Surface exposures are largely pegmatitic with frequent schistose phases and distinct schist intercalations.

5. Principal soils are glacial sands and gravels, overlain in part by alluvial materials, generally redeposited glacial sediments and, in the case of the harbor, an accumulation of mud.

6. Pre-glacial drainage relief appears relatively small in the New Bedford - Fairhaven vicinity. The most conspicuous erosional feature is the bedrock valley between Palmer Island and Fort Phoenix which extends only to about elevation minus 70 feet, M.S.L., in contrast with the Sakonnet River Valley to the west, which attains depths probably in the vicinity of elevation minus 400 feet, and the Cape Cod area, to the east, where comparable bedrock depths appear to exist.

7. Post-glacial surficial drainage is poor, consisting of numerous small ponds, winding streams and marshes.

8. Shoreline features are bayhead and baymouth bars, spits and tombolos. Beaches are somewhat under-nourished because of thin overburden cover. Ocean exposure is rather severe in the outer harbor area, although longer fetches are restricted by the Elizabeth Islands chain lying about 10 miles to the south.

D. FOUNDATION INVESTIGATIONS.

9. One hundred and five foundation borings have been made for the project. Nine borings were made on upstream alignments in the Acushnet River and forty borings were made on or near the present alignment during survey report studies made in 1955-1956. The rest of the borings were made in 1959. Forty-three borings determined foundation conditions for the gate and barrier, 14 for the Rodney French Boulevard Dike, 10 for the Fairhaven Dike, 11 for the Clark Cove Dike, and 3 for the street gate structures. In addition, 11 borings were made in the bypass channel and 3 borings in Blackmer Street, New Bedford, to determine the character of materials to be encountered in excavation of

the bypass channel and sewer relocation, respectively. Undisturbed sampling using the Hvorslev fixed piston with split cone clamp and Shelby tubes, and bedrock diamond drilling were involved in the investigations. Other explorations included 14 hand dug test pits and 1 test trench for the dikes, a street gate structure, and the sewer relocation; 57 drill rod probings washed and hammered to refusal, to more closely define bedrock surface for the gate and bypass channel; and 8 borings in the outer harbor and 6 in Clark Cove, to determine the availability of dredge borrow. The locations are shown on Plates 2 and 3.

E. FOUNDATION CONDITIONS FOR THE HARBOR BARRIER.

10. Bearing conditions for the main harbor barrier are largely favorable, involving from zero to four feet of partially displaceable organic silts and sands west of Palmer Island and from zero to seven feet of similar material east of Palmer Island. A thick soft organic silt pocket occurs east of the gate structure, but dredging of the bypass navigation channel and placement of cofferdam cells will involve removal and replacement of much of these undesirable materials (See geologic section on Plate 3).

11. Western Section. Bedrock is shallow west of Palmer Island attaining a maximum depth to about elevation minus 31 feet, M.S.L., 300 feet west of boring FD-95. Maximum water depth is attained in the area of borings FD-95, FD-96 and FD-97 which represent the former site of a large conduit now replaced for improved flushing reasons by two smaller conduits as shown on Plate 3. Bedrock is assumed to lie slightly below elevation minus 25 feet at these two structures. With water depths of less than 10 feet, less than 5 feet of sandy organic silt is indicated for the structure nearest New Bedford, while little or no harbor mud is expected beneath the eastern structure. The remaining overburden materials are granular largely sandy glacial till beneath the structure near Palmer Island and some till-like material underlying silty gravelly sand beneath the western structure. Bedrock in general, in the western section, is overlain by granular materials capped by 1 to 4 feet of organic silts and organic silty sands.

12. Eastern Section. A bedrock depression with maximum depth along the alignment to about elevation 65 feet lies between the existing 32 foot, M.S.L., navigation channel and Fort Phoenix. Maximum overburden thickness occurs there since the water depth is only about 5 feet, M.S.L. Immediately above the bedrock there, and directly on much of the bedrock east of the existing channel, is a deposit of silts and sands, largely rock flour, attaining its maximum thickness of about 35 feet directly beneath the bypass channel. The top of this bed will be exposed in the bottom of the bypass channel excavation, if carried to existing channel grade, possibly warranting a gravel blanket to protect against scour. Overlying this is a layer 3 to 10 feet thick of variably silty gravelly sands and sandy gravels (its continuation west of the existing channel is partially till-like). Above this layer, east of the ship channel, is a wedge of organic silts which are sandy in part, thin at the east shore but thickening to about 12 feet at the existing ship channel.

These are the materials previously mentioned as partially being removed during excavation of the bypass channel. A layer of sands and silty sands, for the most part 6 or 7 feet thick, covers the organic wedge and is overlain by a thin layer of sandy harbor mud. East of the bedrock depression, bedrock rises rapidly to outcrop at Fort Phoenix. It rises more gently west of the depression to outcrop on Palmer Island. Between Palmer Island and the existing channel, and between Fort Phoenix and the bedrock depression, the bedrock is overlain by a deposit of variably silty sandy gravels and gravelly sands, attaining a maximum thickness of about 10 feet. This is overlain between the island and the ship channel by a thin continuation of the rock flour horizon, a few feet of the partially till-like material mentioned above, and a thin cover of organic silty sands and sandy silts, with maximum water depth at the top of slope of the ship channel of about 20 feet.

13. Gate Area. The 150-foot navigation opening will be provided with sector gates that close during a hurricane. They will be contained in recesses in the abutments during normal periods. The gates consist of two similar leaves with radii of 90 feet and overall height of 61 feet. The sill elevation will be minus 39 feet, M.S.L. The gate structure will be constructed in the dry on sound granitic gneiss, involving little or no removal of weathered rock, ranging in elevation from approximately minus 50 feet, M.S.L., to about elevation minus 60 feet (See Plate 2). Unconfined compression tests of rock samples from boring FD-77, located beneath the center of the gate structure required an average breaking load slightly under 12,000 psi. Probings on 100-foot centers indicate a fairly regular surface averaging approximately elevation minus 55 feet. Reliability of the bedrock contours on Plate 3 is limited to the area covered by the probings indicated. Final design and location of the cofferdam may require additional explorations to further configure the rock surface. Some bedrock removal will be involved in excavating the bypass channel (See Plate 3). The existing navigation channel required considerable rock removal along its western edge in the vicinity of Palmer Island light. Explorations for this project, however, did not indicate rock above grade north of the barrier in the proposed bypass channel.

F. FOUNDATION CONDITIONS FOR THE DIKES AND WALLS.

14. Most of the dikes and walls will be on firm granular soils. Exceptions include the dike on the north side of Clark Cove where the eastern half will involve the removal of trash fill and the western half may require a cut-off through riprap fill. Another small area of trash and earth fill will require partial removal on the east side of Clark Cove. Parts of the Rodney French Boulevard Dike toe will rest on thin harbor mud deposits, and an alternate alignment of the Fairhaven Dike crosses an area of salt marsh involving about 2 feet of peaty organic silt. The present alignment of Fairhaven Dike is mostly along an abandoned railroad bed. Both alignments also involve the removal of some trash fill. Additional borings are needed for detail on the marsh crossing, the character of the Clark Cove fills, and the foundations for the street gates, Clark Cove pumping station and the harbor barrier conduits.

G. AVAILABILITY OF CONSTRUCTION MATERIALS.

15. An approximate dividing line can be drawn longitudinally through New Bedford - Fairhaven Harbor west of which can be found relatively impervious glacial tills accompanied by sands and gravels, while east of that line, toward Cape Cod, only sands and washed tills containing little or no silt or clay occur. The best source of land borrow, therefore, lies a few miles west of the harbor. Dredging of the bypass channel, however, will involve the removal of large quantities of mostly granualr material suitable for placement within the structures and, supplemented with other materials dredged from the immediate vicinity, will provide the bulk of earthen borrow requirements.

16. The coast from Duxbury on Cape Cod Bay, to Buzzards Bay, is devoid of bedrock exposures. Elevations gradually increase west of Mattapoisett with occasional exposures until the bedrock appears conspicuously at Fort Phoenix in Fairhaven. Higher land inshore from Fort Phoenix, therefore, provides the easternmost nearshore quarry site of appreciable reserve where a large operating quarry exists in Acushnet, 3-1/2 miles north of Fort Phoenix.

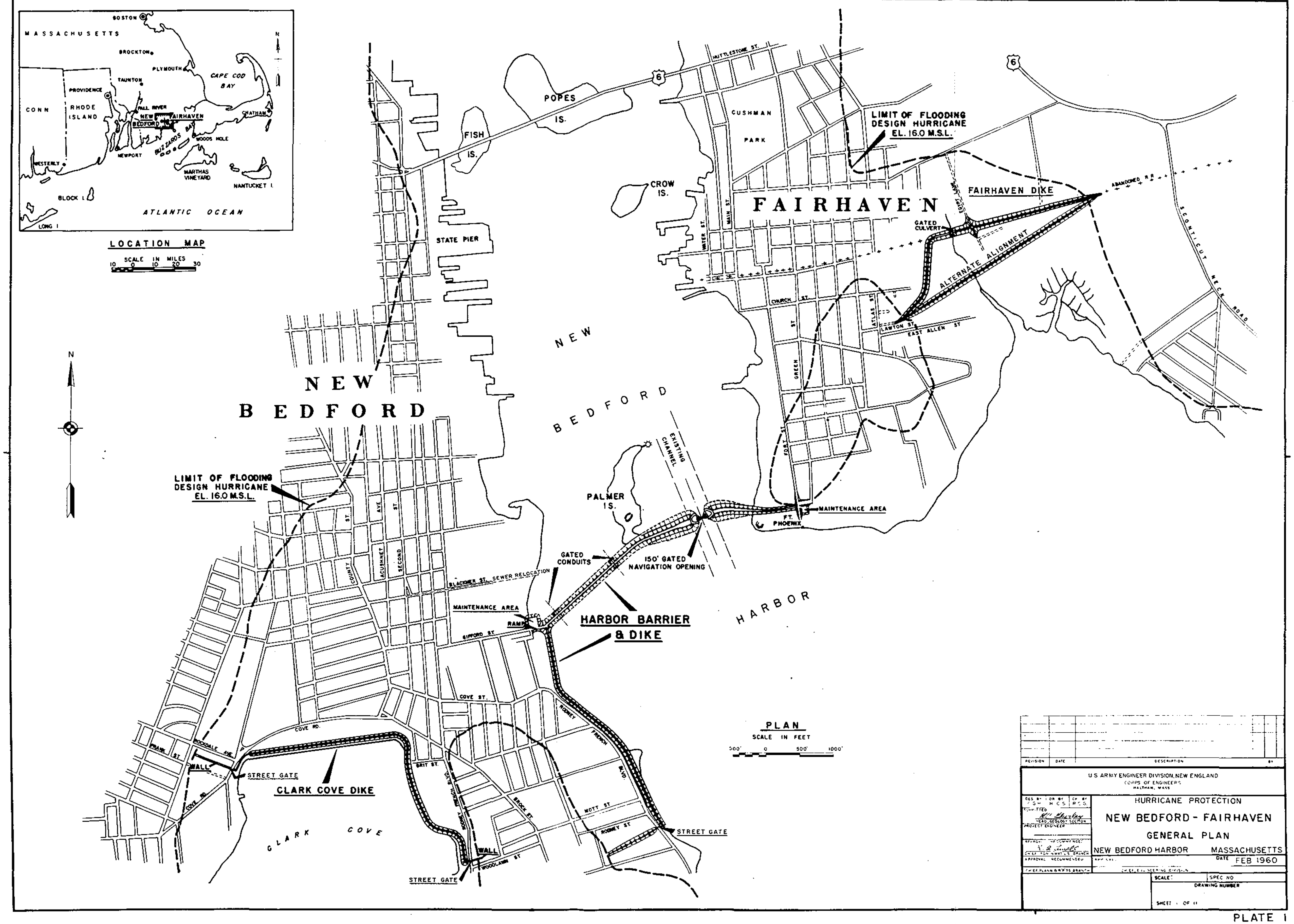
17. Earthen Borrow for Barriers and Dikes. Materials dredged from the bypass channel will consist essentially of variable sands and silty sands with silt pockets. They will provide most of the fill for the barriers and dikes, provided dredging is carried to the same grade as the existing navigation channel. Direct hydraulic placement is not considered practical because of the excessively flat slopes resulting from a hydraulic operation. It is planned, therefore, to stockpile materials on the New Bedford shore adjacent to the western abutment of the harbor barrier. Stockpiling will permit the drainage and examination with respect to possible selection or mixing of materials prior to placement within the structures. In addition, a limited dredge borrow area containing largely medium to fine sands will be provided about 1,500 feet south of the barrier, west of Palmer Island, to provide the balance of materials required. A large reserve dredge borrow area containing sand will be available in Clark Cove. Its use, however, is not anticipated at this time. Gravel requirements will depend on the selection of a final barrier section and will be obtained from land sources. Two sectional schemes are under consideration, one involving inshore side rock toes and the other utilizing natural gravel toes. Requirements for the former scheme involve relatively small gravel quantities and the materials probably would be provided by the contractor. The latter scheme involves larger quantities inasmuch as the section utilizes flatter slopes. The nearest sources of natural gravel are located in Dartmouth, 5 to 8 miles haul distance from the site.

18. Rock Borrow for Barriers and Dikes. Rock requirements are upwards of one-half million cubic yards, ranging in size from filter stone to 4-ton rough dimension stone. Cover stone for the barriers and dikes must meet rigid specifications, particularly with respect to durability. Fortunately, the nature of the underlying rock throughout this area is such that almost any exposure suitable for quarrying could produce good revetment. Bluestone quarry (in Acushnet), the only operating

quarry in the vicinity, is removing granitic gneiss and gneissoid granodiorite for road metal. It is expected that stone from this source would meet specifications, but it is not known if they will be interested in opening a new face to provide dimension stone at competitive prices. Local quarries have operated on a very small scale in East Freetown and South Dartmouth, both areas offering major quarry possibilities. The Freetown area, 11 miles north of Palmer Island, consists of holocrystalline true granite, grading northward to granite porphyry, both excellent cover stone types. The Dartmouth area, 6 miles west of the site, consists of massive granitic gneiss and appears suitable for the production of large cover stone. Both areas possess favorable relief for the opening of major working faces. A possible smaller source convenient to the Fairhaven Dike and east side of the harbor barrier, exists in Mattapoisett, about 5 miles east of Fort Phoenix. The rock is exposed as a long narrow rib possessing considerable relief. It is at least partially fine-grained (aplitic) and appears suitable as a secondary source of rock fill and, possibly, cover sizes. It is possible, however, that the larger quarries of Connecticut and southwestern Rhode Island which produce, respectively, true trap rock and granite in large quantities and of any dimension may offer competitive prices at the site.

19. Concrete Aggregates. Three commercial aggregate sources within 20 miles haul distance have been sampled for testing and are expected to meet approval. Several processed crushed gravel and one quarry source of concrete aggregates are located within a four to nine-mile truck haul distance range from the site. Most of the sources are equipped with crushers and screens and range in production capacity from 600-1600 tons per day. The quarry source is rated at 800 tons per day. A detailed discussion of concrete aggregates will appear in Design Memorandum No. 6, Concrete Materials.

CORPS OF ENGINEERS U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

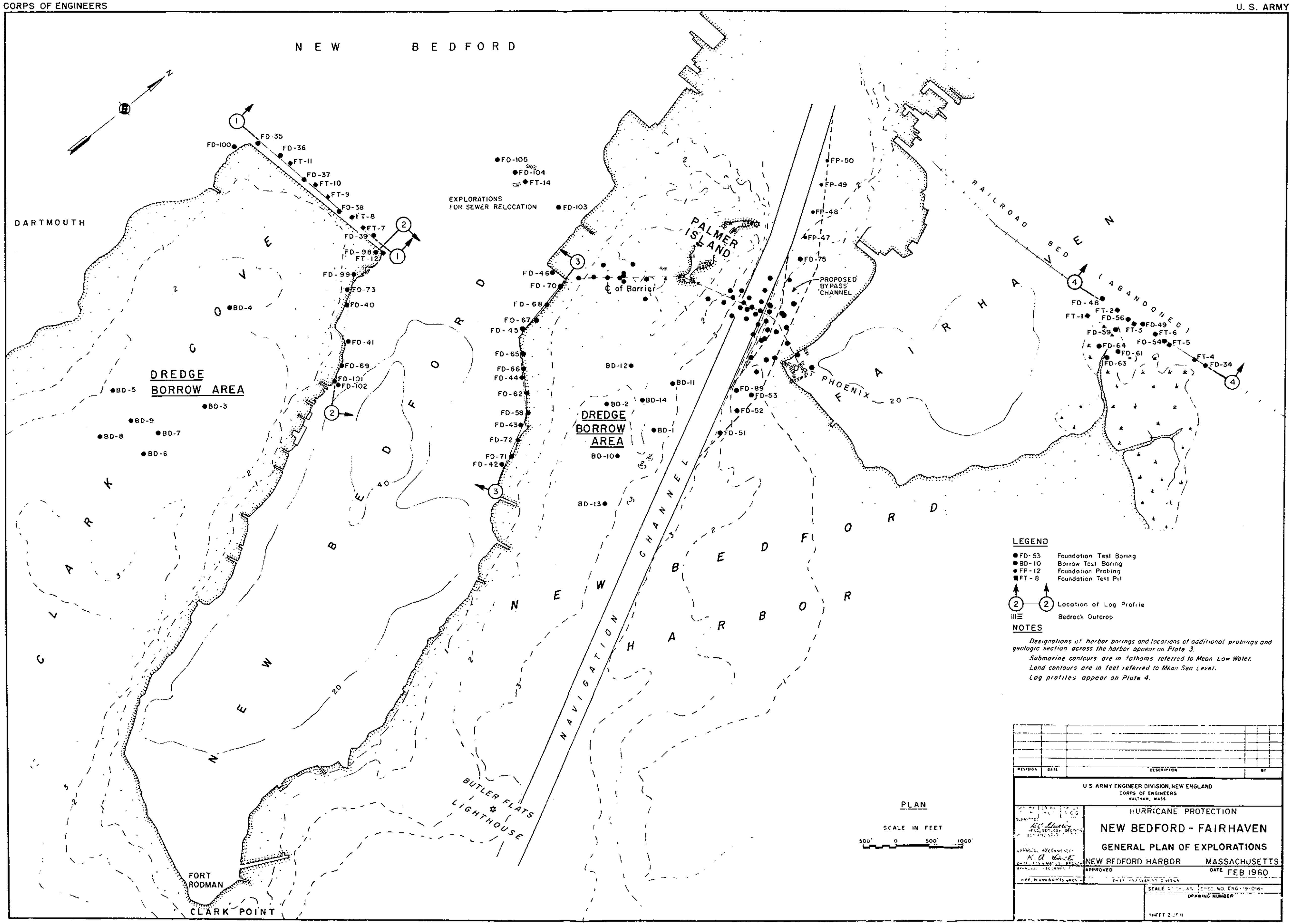
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY YGH · DR. BY HCS · CK. BY RCG.
SUBMITTED
HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, FOUNDATIONS BRANCH
APPROVAL RECOMMENDED
CHIEF, PLANNING REPORTS BRANCH
APPROVED
CHIEF, ENGINEERING DIVISION

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
GENERAL PLAN
NEW BEDFORD HARBOR MASSACHUSETTS
DATE FEB 1960

SCALE: SPEC NO.
DRAWING NUMBER
SHEET 1 OF 11

PLATE 1



LEGEND

● FD-53	Foundation Test Boring
● BD-10	Borrow Test Boring
● FP-12	Foundation Probing
■ FT-8	Foundation Test Pit
② — ②	Location of Log Profile
⫼	Bedrock Outcrop

NOTES

Designations of harbor borings and locations of additional probings and geologic section across the harbor appear on Plate 3.

Submarine contours are in fathoms referred to Mean Low Water.

Land contours are in feet referred to Mean Sea Level.

Log profiles appear on Plate 4.

REVISION	DATE	DESCRIPTION	BY

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

SUBMITTED
R.C. Sheetz
HEAD, GEOLOGY SECTION

APPROVAL RECOMMENDED
K. A. Smith
CHIEF, SOILS & MATLS. BRANCH

APPROVAL RECOMMENDED
CHIEF, PLANN. & RPTS. BRANCH

HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

GENERAL PLAN OF EXPLORATIONS

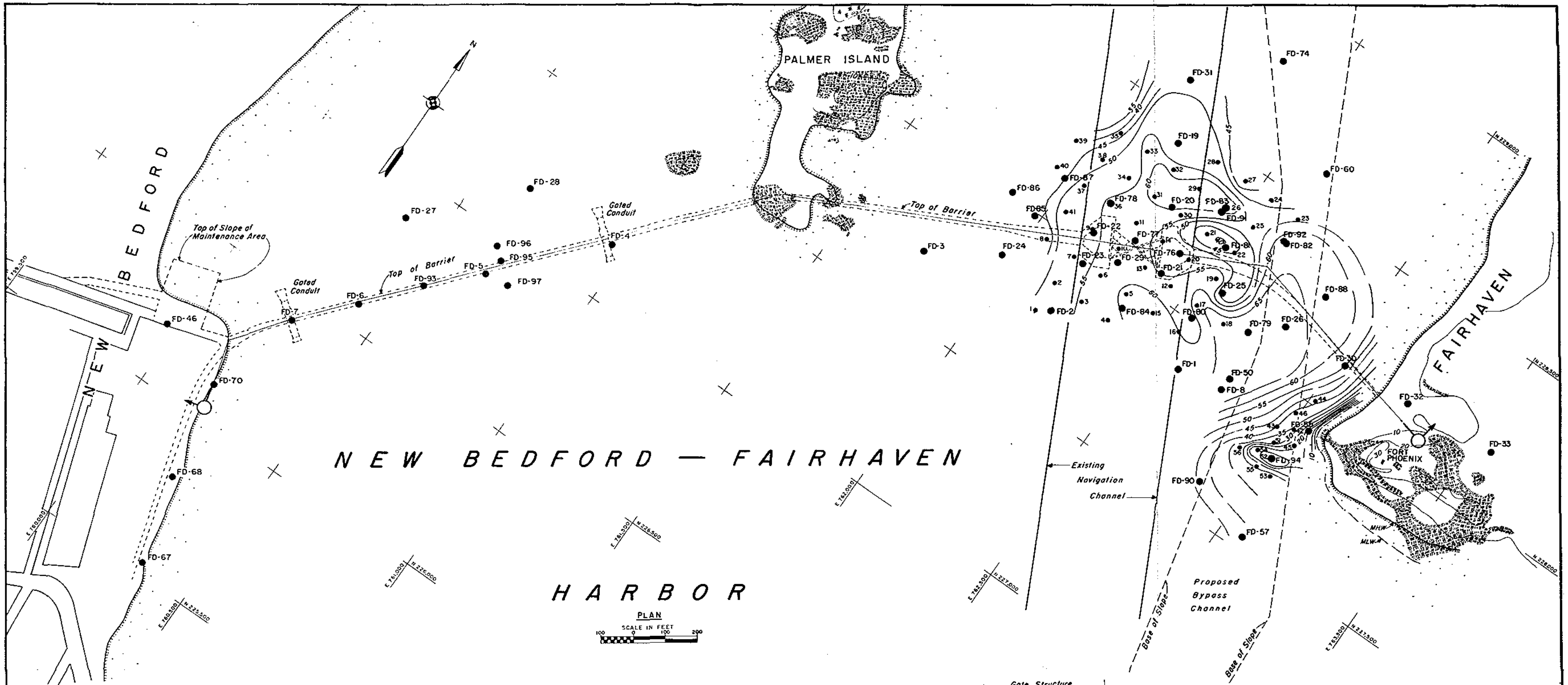
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION

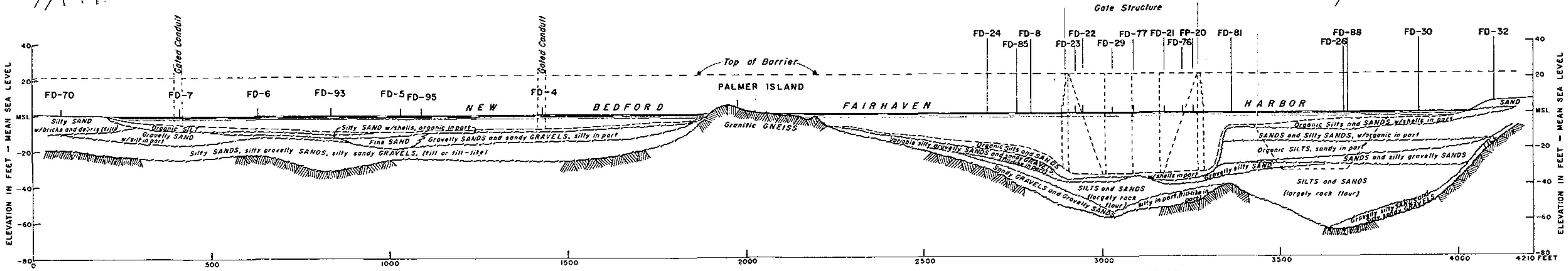
DATE FEB 1960

SCALE AS SHOWN
SPEC. NO. ENG-19-016-
DRAWING NUMBER
SHEET 2 OF 11

PLATE 2



PLAN



GEOLOGIC SECTION - HARBOR ALIGNMENT
(LOOKING NORTH)

LEGEND

●	FD-8	Foundation Test Boring
•	22	Foundation Test Probing
▥		Bedrock Outcrop
⁎ ⁎		Marsh

Location and Orientation of Geologic Section

NOTES

Contours within the harbor represent assumed bedrock surface referred to Mean Sea Level.

Coordinates refer to the Massachusetts Grid System.

FD-91 and FD-92 are undisturbed sample borings.

REVISION	DATE	DESCRIPTION	BY

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

DES. BY C.G.H. | DR. BY H.C.S. | CK. BY R.C.G.

SUBMITTED
HEAD, GEOLOGY SECTION

PROJECT ENGINEER

APPROVAL RECOMMENDED
K. A. Linell
CHIEF, FDN & MAT'LS BRANCH

APPROVAL RECOMMENDED
CHIEF, PLANNING & REPTS BRANCH

HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN
PLAN OF HARBOR EXPLORATIONS
AND GEOLOGIC SECTION
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION

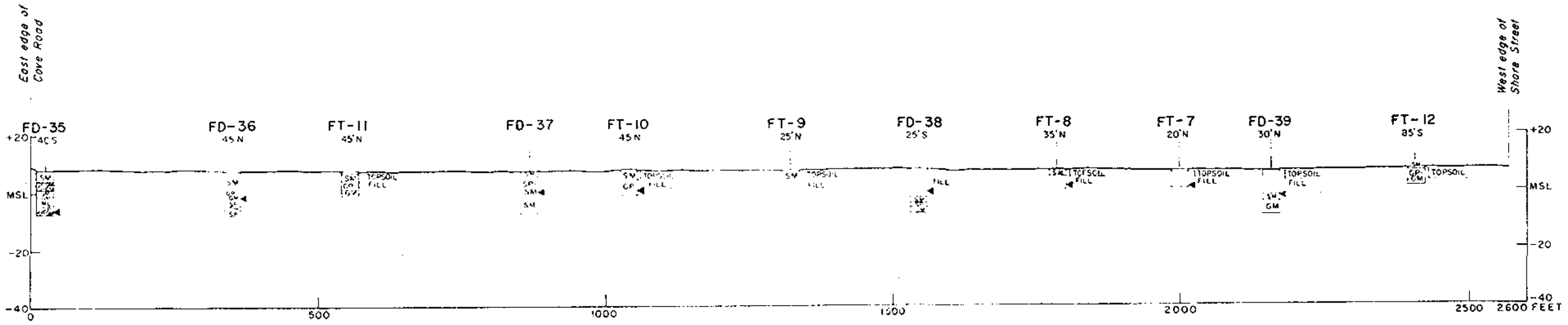
DATE FEB 1960

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

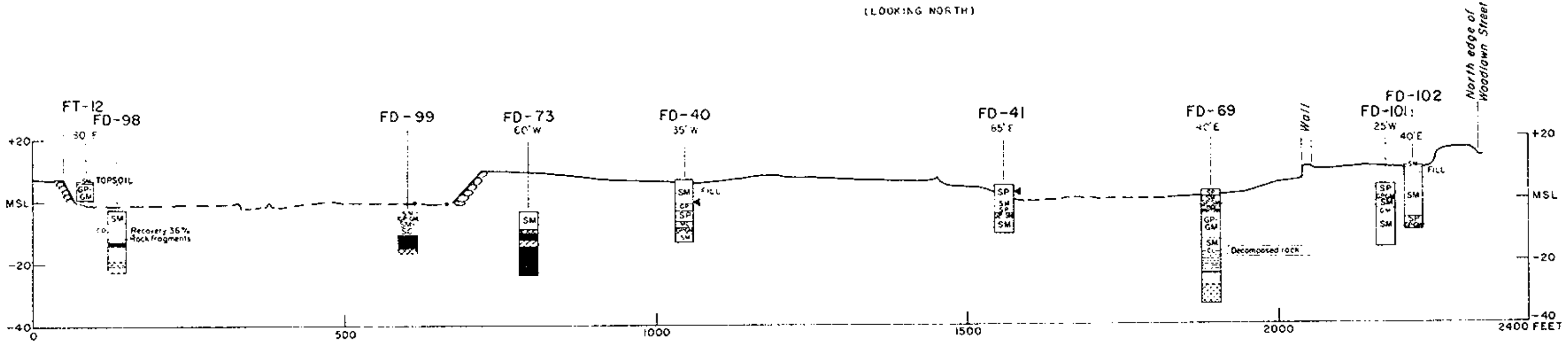
SHEET 3 OF 11

PLATE 3

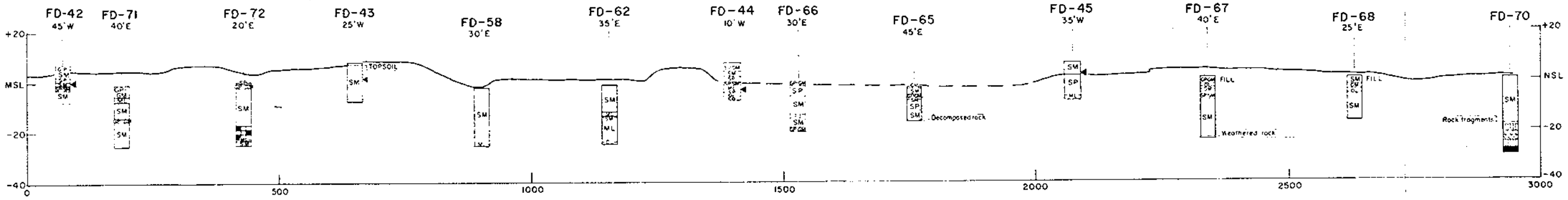
ELEVATION IN FEET — MEAN SEA LEVEL



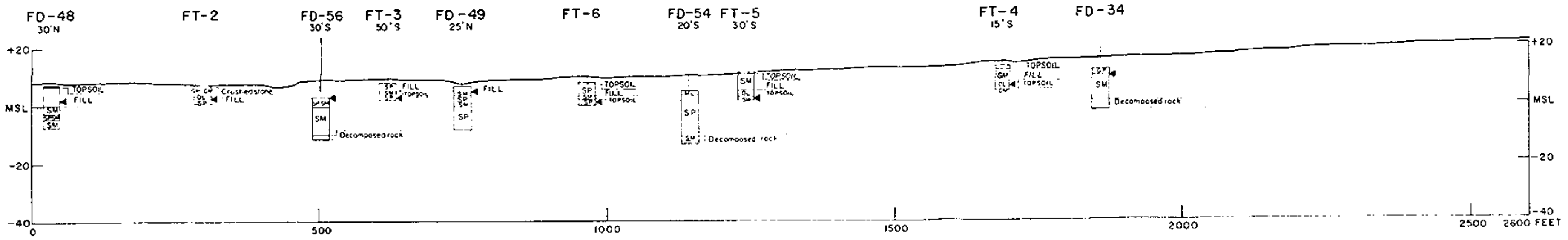
NORTH SHORE OF CLARK COVE, LOG PROFILE 1-1
(LOOKING NORTH)



EAST SHORE OF CLARK COVE, LOG PROFILE 2-2
(LOOKING EAST)



WEST SHORE OF NEW BEDFORD HARBOR, LOG PROFILE 3-3
(LOOKING WEST)



ABANDONED RAILROAD EMBANKMENT-FAIRHAVEN, LOG PROFILE 4-4
(LOOKING NORTH)

LEGEND FOR GRAPHIC LOGS

FD-69	Foundation Test Boring
FT-12	Foundation Test Pit
40'E	Offset from Profile Line
CD	Core-drilled in overburden
◀	Subsurface water level in boring at time of exploration
SP	Group letter symbol according to Unified Soil Classification System
▚	Cobbles or boulders continuous or nested (Core-drilled and/or blasted and chopped)
▤	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 %

NOTES

Locations of Log Profiles are shown on Plate 2

Graphic Logs showing details of the explorations appear on Plates 5 through 9

Subsurface water levels in the explorations are subject to tidal fluctuations

REVISION	DATE	DESCRIPTION	BY

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

DES. BY C G H | DR. BY R A W | CK. BY R C G
SUBMITTED H C Hurley HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED K. A. CHIEF, FDN & MAT'LS BRANCH
APPROVAL RECOMMENDED CHIEF, PLANN & RPTS BRANCH

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
LOG PROFILES ALONG DIKES
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION
DATE FEB 1960
SCALE
SPEC NO ENG 19 016-
DRAWING NUMBER
SHEET 4 OF 11

CORPS OF ENGINEERS

U. S. ARMY

LEGEND FOR GRAPHIC LOGS

FD-5	Foundation Test Boring
BD-6	Borrow Test Boring
(OW)	Observation Well Installed
29, NOV. 1955	Date exploration completed
El.-9.4	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 soil samples recovered
U	Bottom of observation well
NS	Not Sampled. Hole advanced by Core-drilling, blasting, and/or wash boring due to operational difficulty
CD	*Sampling in overburden by the Core-drill Method*
25	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 a 1 ½" I.D. or 2" O.D., 2" I.D. or 2½" O.D and/or 2½" I.D. or 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe
*	Blow counts not recorded or not considered representative
■	Cobble or boulder (Core-drilled)
▚	Cobbles or boulders, continuous or nested (Core-drilled and/or blasted and chopped)
El.-24.6	Elevation of bedrock surface
▤	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.-29.1	Elevation of bottom of exploration

NOTES

Locations of subsurface explorations are shown on Plate 2

Borings FD-9 through FD-18 were made on upstream alignments and are shown on Plate 11

REVISION	DATE	DESCRIPTION	BY

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

DES. BY C.G.H. | DR. BY H.C.S. | CK. BY R.C.G.

SUBMITTED K.C. Judkins
HEAD, GEOLOGY SECTION

PROJECT ENGINEER

APPROVAL RECOMMENDED K.A. Lall
CHIEF, FDN. & MAT'LS BRANCH

APPROVAL RECOMMENDED
CHIEF, PLANN. & RPTS BRANCH

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
RECORD OF FOUNDATION EXPLORATIONS
NO. 1
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION

DATE FEB 1960

SCALE | SPEC NO
DRAWING NUMBER
SHEET 5 of 11

PLATE 5

NOTES

Locations of subsurface explorations are shown on Plate 2

Legend for graphic logs appears on Plate 5

Subsurface water levels in the explorations may be subject to tidal fluctuation.

REVISION	DATE	DESCRIPTION	BY

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

DES. BY	DR. BY	CK. BY
C G H	H A W	R C G

SUBMITTED
H C Hurley
HEAD, GEOLOGY SECTION

PROJECT ENGINEER

APPROVAL RECOMMENDED
K. A. Linell
CHIEF, FDN & MAT'LS BRANCH

APPROVAL RECOMMENDED
CHIEF, PLANS & SPECS BRANCH

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
RECORD OF FOUNDATION EXPLORATIONS
NO. 2
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION

DATE FEB 1960

SCALE
SPEC. NO
DRAWING NUMBER
SHEET 6 OF 11

PLATE 6

CORPS OF ENGINEERS

U. S. ARMY

NOTES

Locations of subsurface explorations are shown on Plate 2

Legend for graphic logs appears on Plate 5

Subsurface water levels in the explorations may be subject to tidal fluctuation.

REVISION	DATE	DESCRIPTION	BY

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

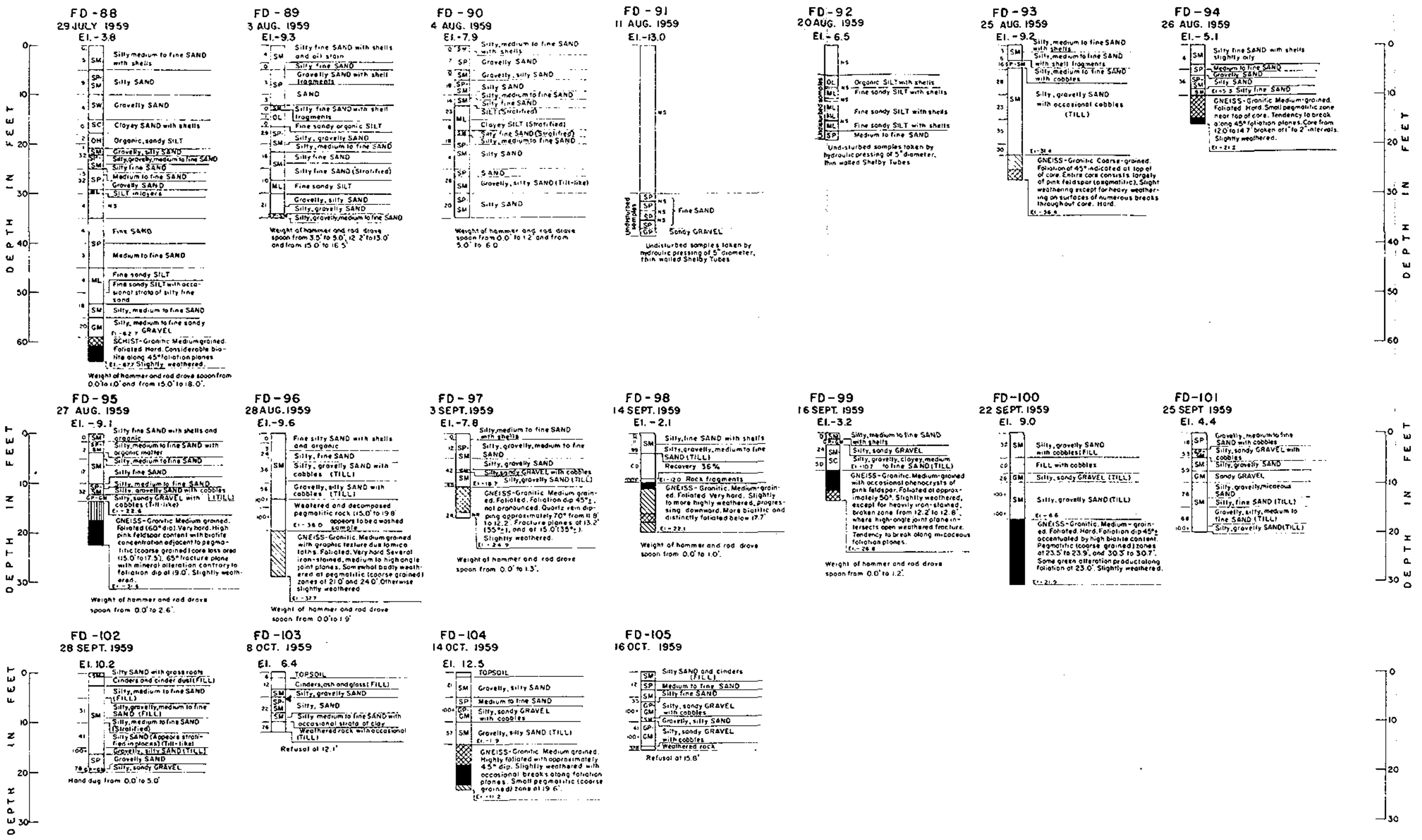
HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
RECORD OF FOUNDATION EXPLORATIONS
NO. 3
NEW BEDFORD HARBOR MASSACHUSETTS

DATE FEB 1960

SHEET 7 OF 11

PLATE 7

CORPS OF ENGINEERS U. S. ARMY



NOTES

Locations of subsurface explorations are shown on Plate 2

Legend for graphic logs appears on Plate 5

Subsurface water levels in the explorations may be subject to tidal fluctuation.

REVISION	DATE	DESCRIPTION	BY

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

DES. BY C.G.H. DR. BY R.A.W. CK. BY R.C.G.

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APPROVAL RECOMMENDED
CHIEF, PLANN & R'PTS BRANCH

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
RECORD OF FOUNDATION EXPLORATIONS NO. 4
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION
DATE FEB 1960

SCALE
SPEC NO. -
DRAWING NUMBER
SHEET 8 OF 11

CORPS OF ENGINEERS

U. S. ARMY

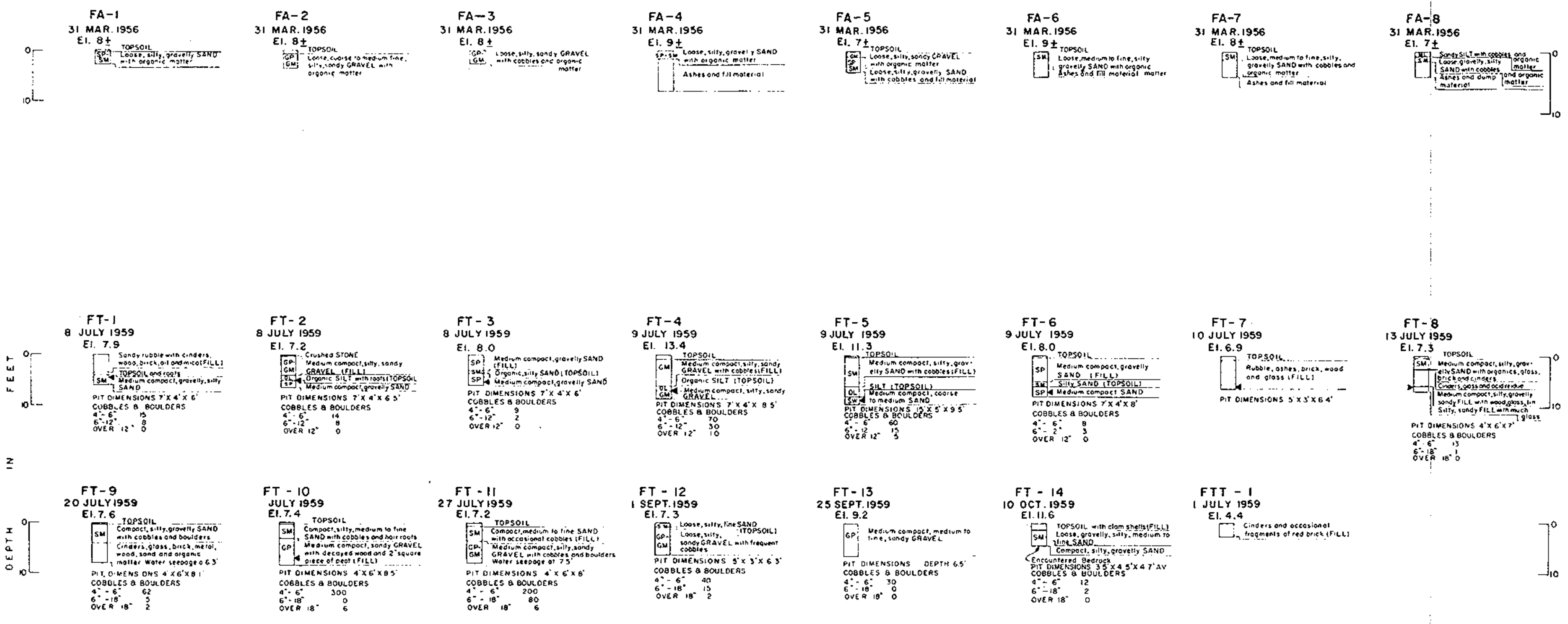

TABLE OF PROBINGS

PROBING DESIGNATION	WATER DEPTH CORRECTED TO (M.S.L.)	BOTTOM THICKNESS PROBED (FT.)	REMARKS
FP - 1	24.3	27.3	Refusal El. -51.6
FP - 2	24.5	28.1	" El. -52.6
FP - 3	33.5	22.2	" El. -55.7
FP - 4	32.8	23.2	" El. -56.0
FP - 5	32.4	29.6	" El. -62.0
FP - 6	32.7	24.0	" El. -56.7
FP - 7	28.7	25.6	" El. -54.3
FP - 8	19.6	23.6	" El. -43.2
FP - 9	31.9	22.9	" El. -54.8
FP - 10	31.2	28.1	" El. -59.3
FP - 11	32.8	22.7	" El. -55.5
FP - 12	31.4	26.5	" El. -57.9
FP - 13	31.0	25.8	" El. -56.8
FP - 14	31.6	22.8	" El. -54.4
FP - 15	30.8	32.6	" El. -63.4
FP - 16	32.6	27.8	" El. -60.4
FP - 17	24.9	39.6	" El. -64.5
FP - 18	5.6	60.1	" El. -65.7
FP - 19	5.7	52.3	" El. -58.0
FP - 20	30.8	21.0	" El. -51.8
FP - 21	20.6	21.6	" El. -42.2
FP - 22	7.4	38.1	" El. -45.5
FP - 23	6.3	47.2	" El. -53.5
FP - 24	7.4	41.5	" El. -48.9
FP - 25	8.0	45.6	" El. -53.6
FP - 26	11.5	52.6	" El. -64.1
FP - 27	11.0	33.3	" El. -44.3
FP - 28	19.9	32.7	" El. -52.6
FP - 29	22.1	41.5	" El. -63.6
FP - 30	33.3	25.0	" El. -58.3
FP - 31	34.7	25.8	" El. -60.5
FP - 32	34.8	20.2	" El. -55.0
FP - 33	35.7	22.6	" El. -58.3
FP - 34	34.5	17.7	" El. -52.2
FP - 35	35.8	8.2	" El. -44.0
FP - 36	34.0	23.3	" El. -57.3
FP - 37	29.5	20.9	" El. -50.4
FP - 38	33.9	14.4	" El. -48.3
FP - 39	18.2	25.9	" El. -44.1
FP - 40	17.0	23.2	" El. -40.2
FP - 41	23.8	28.1	" El. -51.9
FP - 42	4.4	25.9	" El. -30.3
FP - 43	5.0	38.3	" El. -43.3
FP - 44	3.5	37.6	" El. -41.1
FP - 45	3.8	18.3	" El. -22.1
FP - 46	3.8	33.7	" El. -37.5
FP - 47	29.5	20.6	" El. -50.1
FP - 48	31.3	16.5	" El. -47.8
FP - 49	28.8	16.5	No Refusal
FP - 50	27.6	18.0	Refusal El. -45.6
FP - 51	5.3	27.8	" El. -33.1
FP - 52	5.0	9.8	" El. -14.8
FP - 53	7.3	24.5	" El. -31.8
FP - 54	6.6	9.5	" El. 16.1
FP - 55	7.7	21.2	" El. -28.9
FP - 56	7.0	25.3	" El. -32.3
FP - 57	5.0	19.2	" El. -24.2

NOTES

Locations of subsurface explorations are shown on Plate 2.

Legend for graphic logs appears on Plate 5.

Subsurface water levels in the explorations may be subject to tidal fluctuation.

Probings accomplished by jetting $1\frac{5}{8}$" O.D. drillrods to refusal and hammering with a 350 lb. drop hammer falling freely an average distance of about 18 inches. Refusal is defined as 300 hammer blows without appreciable further penetration.

REVISION	DATE	DESCRIPTION	BY

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

DES BY C.G.H. | DR BY R.A.W. | CK BY R.C.G.
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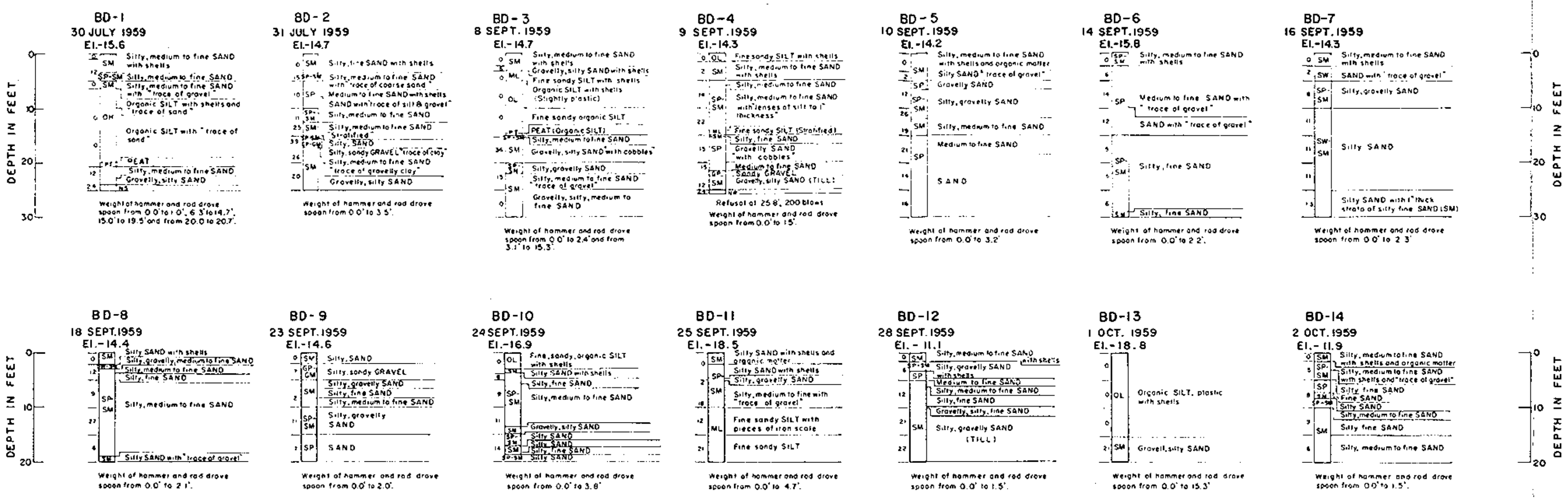
CHIEF, FDN & MAT'LS BRANCH
APPROVAL RECOMMENDED
CHIEF, PLANN & RP'TS BRANCH

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
RECORD OF FOUNDATION EXPLORATIONS
NO. 5
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION
DATE FEB 1960

SCALE
SPEC NO.-
DRAWING NUMBER
SHEET 9 OF 11



NOTES

Locations of subsurface explorations are shown on Plates 2 and 3

Legend for graphic logs appears on Plate 5

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
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HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

RECORD OF BORROW EXPLORATIONS

NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
CHIEF, ENGINEERING DIVISION

DATE FEB 1960

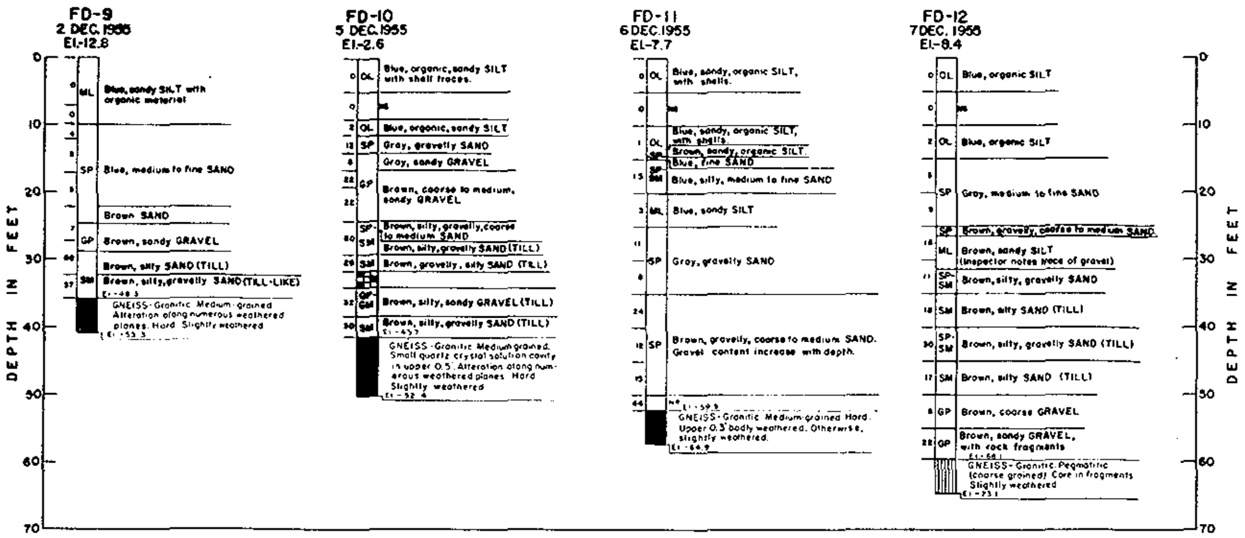
SCALE

SPEC NO

DRAWING NUMBER

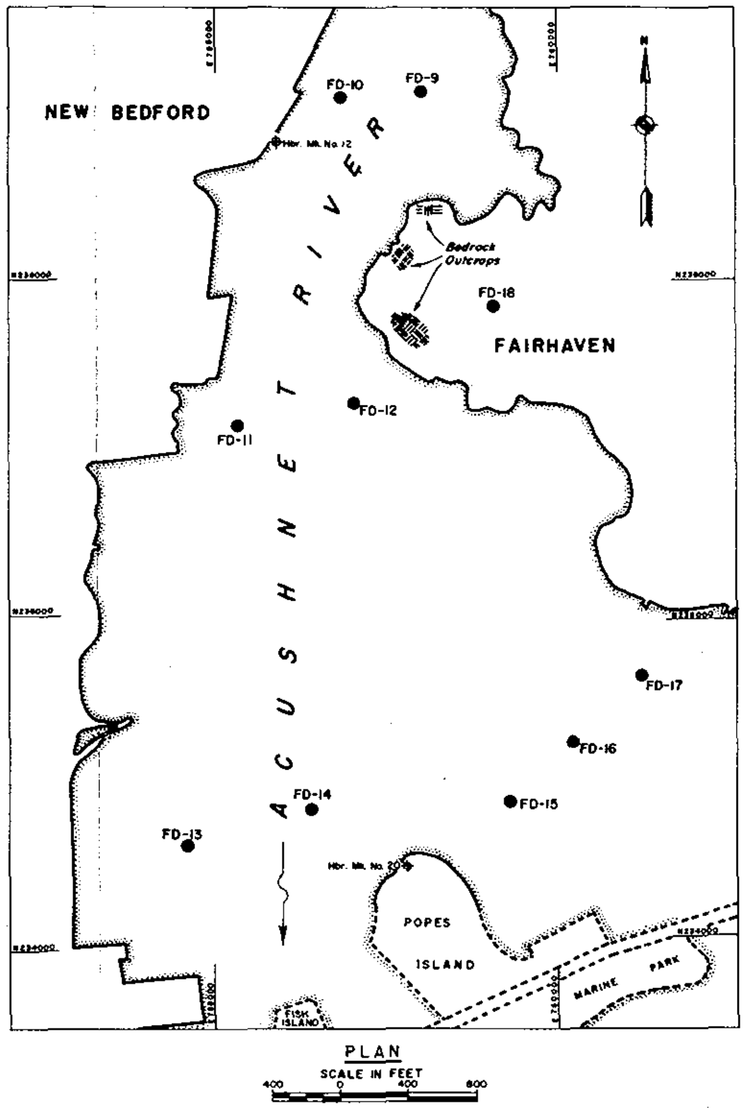
SHEET 10 OF 11

PLATE 10

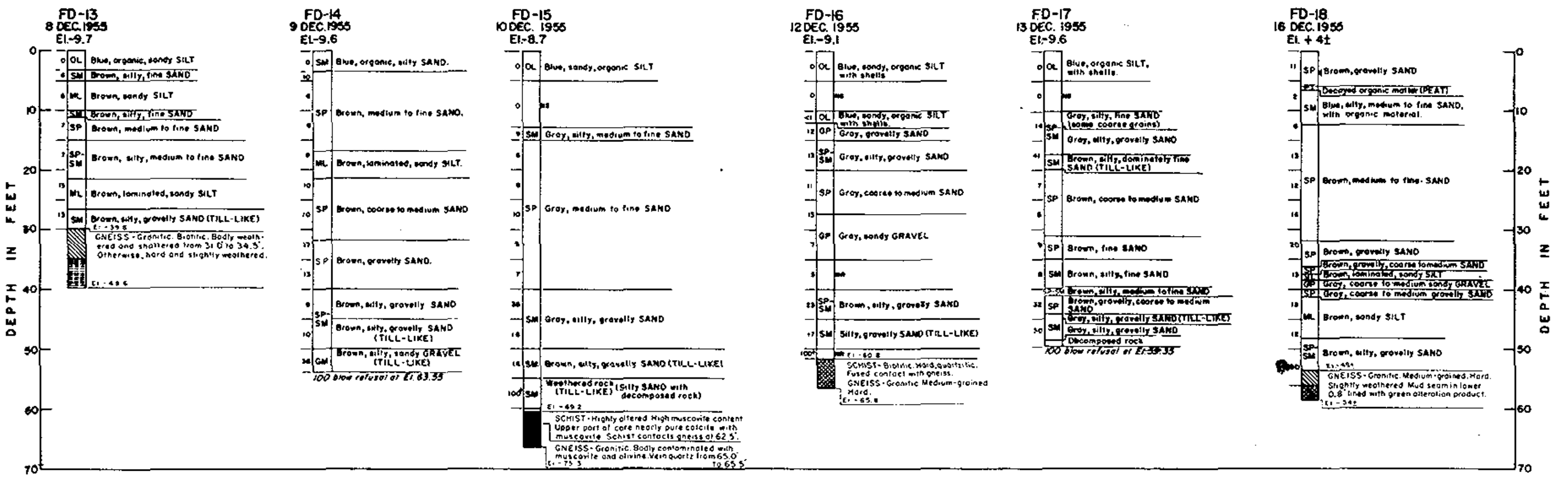


LEGEND FOR GRAPHIC LOGS

FD-10 Foundation Test Boring
5 DEC 1955 Date exploration completed.
El.-2.65 M.S.L. elevation of ground or river bottom at time of exploration.
◄ Subsurface water level in boring at time of exploration.
SM Group letter symbol according to Unified Soil Classification System.
NR No Recovery or unsatisfactory soil samples recovered.
NS Not Sampled (Core-drilled, blasted and/or wash-bored).
80 Blows per foot of penetration considered most representative, usually within a 5-foot sample drive using a 350 pound hammer with a free fall of about 18 inches on a 2" O.D. or $1\frac{1}{2}$" I.D. size sample spoon equipped with beveled and sharpened drive shoe. $2\frac{1}{2}$" O.D. sample spoon used for FD-18.
Blow count not recorded or not considered representative.
Cobbles or boulders (Core-drilled).
Cobbles or boulders continuous or nested. (Core-drilled and/or blasted and chopped.)
El-43.75 Elevation of bedrock surface.
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-52.45 Elevation at bottom of exploration.



PLAN



REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
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DES. BY C.G.H.	DR. BY H.C.S.	CK. BY R.C.G.

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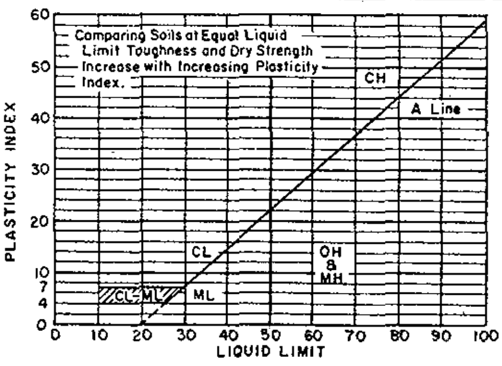
HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
PLAN AND RECORD OF
UPSTREAM EXPLORATIONS
NEW BEDFORD HARBOR MASSACHUSETTS

APPROVED
DATE FEB 1960
CHIEF, ENGINEERING DIVISION

SCALE
SPEC. NO.
DRAWING NUMBER
SHEET 11 OF 11

PLATE 11

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions			Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weight).			Laboratory Classification Criteria			
Coarse-grained Soils More than half of material is larger than No. 200 sieve size	Gravels More than half of coarse fraction is larger than No. 4 sieve size.	Clean Gravels (Little or no fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows:	Less than 5% GW, GP, SW, SP, More than 12% GM, GC, SM, SC, 5% to 12% Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly graded gravels, or gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.					Not meeting all gradation requirements for GW	
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixture.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).					Atterberg limits below "A" line with PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixture.	Plastic fines (for identification procedures see CL below).					Atterberg limits above "A" line with PI greater than 7	
	Sands More than half of coarse fraction is smaller than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.					$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly graded sands or gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.					Not meeting all gradation requirements for SW	
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).					Atterberg limits above "A" line or PI less than 4	Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).					Atterberg limits above "A" line with PI greater than 7	
Fine-grained Soils More than half of material is smaller than No. 200 sieve size The No. 200 sieve size is about the smallest particle visible to the naked eye.					Identification Procedures on Fraction Smaller than No. 40 Sieve Size						
					Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)				
	Silts and Clays Liquid limit is less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None				
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium				
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight				
	Silts and Clays Liquid limit is greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium				
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High				
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to Medium				
Highly Organic Soils			PT	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			PLASTICITY CHART For laboratory classification of fine-grained soils			

(1) Boundry classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder.
(2) All sieve sizes on this chart are U. S. standard.

NOTE

For further information on Unified Soil Classification, refer to "The Unified Soil Classification System," Volumes 1 and 2, Technical Memorandum No. 3-357, published by U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. File copies may be examined at Headquarters, U. S. Army Engineer Division, New England, 424 Trapelo Road, Waltham, Massachusetts., Building 141, Foundation and Materials Branch.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

PLATE 12

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

NEDGW

3 November 1961

SUBJECT: New Bedford, Fairhaven and Acushnet Hurricane Protection Project - New Bedford, Massachusetts - Design Memorandum No. 5 - Embankments and Foundations

TO:
Chief of Engineers
ATTN: ENGCW-E
Department of the Army
Washington 25, D. C.

In accordance with EM 1110-2-1150, there are submitted herewith for review and approval, ten (10) copies of Design Memorandum No. 5 - Embankments and Foundations for the New Bedford, Fairhaven and Acushnet Hurricane Protection Project, New Bedford, Massachusetts.

FOR THE DIVISION ENGINEER:

John Wm Leslie

JOHN WM. LESLIE
Chief, Engineering Division

Incl (10 cys)
Design Memo No. 5

HURRICANE PROTECTION PROJECT

NEW BEDFORD - FAIRHAVEN BARRIER

NEW BEDFORD HARBOR, MASSACHUSETTS

DESIGN MEMORANDUM NO. 5

EMBANKMENTS AND FOUNDATIONS

INDEX TO DESIGN MEMORANDA

No.	Title	Submitted	Approved
1	Hydrology and Hydraulics	30 June 1961	7 Aug 1961
2	Site Geology	29 Feb 1960	22 Mar 1960
3	General Design	15 Sept 1961	24 Oct 1961
4	Sewer Modifications	10 Mar 1961	6 Apr 1961
5	Embankments and Foundations	3 NOV 1961	
6	Concrete Materials	14 Mar 1960	6 Apr 1960
7	Detail Design, Walls & Miscellaneous Structures		
8	Detail Design, Navigation Gates & Appurtenances	29 Apr 1960	24 Oct 1961
9	Cathodic Protection	10 Feb 1961	27 Mar 1961
10	Real Estate	30 Dec 1960	10 Feb 1961
11	Pumping Station		

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION

HURRICANE PROTECTION PROJECT

NEW BEDFORD - FAIRHAVEN BARRIER

NEW BEDFORD HARBOR
MASSACHUSETTS

DESIGN MEMORANDUM NO. 5

EMBANKMENTS AND FOUNDATIONS

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APPENDICES

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION

HURRICANE PROTECTION PROJECT

NEW BEDFORD - FAIRHAVEN BARRIER

NEW BEDFORD HARBOR
MASSACHUSETTS

DESIGN MEMORANDUM NO. 5

EMBANKMENTS AND FOUNDATIONS

A. INTRODUCTION

1. Location and Description of Project. The New Bedford-Fairhaven Hurricane Project is located in the vicinity of New Bedford and Fairhaven, Massachusetts. The City of New Bedford and the Towns of Fairhaven and Acushnet, Massachusetts are located in Bristol County, about 50 miles south of Boston, Massachusetts and about 30 miles southeast of Providence, Rhode Island. They are situated on the west shore of Buzzards Bay which opens to the Atlantic Ocean. The purpose of the project is to provide a barrier and dikes which will prevent the entrance of tidal surges into the New Bedford-Fairhaven Harbor and inundation of commercial and residential property during periods of hurricanes. The locations, arrangement and pertinent details of the structures are shown on Plates 5-1 and 5-13 through 5-18.

2. General. Programs of subsurface investigations and soils and coastal engineering studies were undertaken for the design of the embankments forming the Harbor Barrier and the supplemental dikes, for the foundation design of concrete structures to be founded on soil, and to determine the character and quantities of materials to be excavated. The subsurface investigations included explorations and laboratory tests for determining the distribution and characteristics of foundation and construction materials and for determining soil conditions pertinent to the design and construction of embankments and excavation slopes. Soils and coastal engineering studies were made to assist in the development of the designs for certain concrete structures and to develop adequate dike and barrier embankments utilizing earth materials from required excavations and rock and gravel materials available from sources in the vicinity of the project.

B. SUBSURFACE INVESTIGATIONS

3. Subsurface Explorations. Subsurface explorations were made in accordance with current criteria and practices as described in the pertinent sections of the Engineering Manual for Civil Works Construction. Explorations were made in the foundation areas of all structures, in the

area of the temporary Bypass Channel, and in the Ponding Area adjacent to the Pumping Station. In addition, explorations were made in two bay areas to explore for possible earth borrow materials. No explorations were made for rock materials, gravel, and land earth borrow, except reconnaissance and the taking of gravel samples from exposed faces. The majority of the explorations were drive sample borings, machine probings and hand auger borings. Where necessary to determine the depth and character of bedrock, bore holes were extended by core boring. A few test pits were excavated in the foundation area of Clark Cove Dike to determine the character of man-made fills. Two explorations, FD-91 and FD-92, in the embankment foundation area immediately east of the Sector Gate Structure were made to obtain 5-inch diameter undisturbed samples of silts and organic silts. The completed subsurface exploration program for foundations, materials to be excavated, and construction materials is considered adequate for design purposes and construction control. The locations, types and general purposes of the foundation explorations completed prior to January 1960 are described in Design Memorandum No. 2, "SITE GEOLOGY". Since that date, the following explorations have been made:

a. Additional probings and borings in the area of the Bypass Channel to obtain pre-bidding subsurface data and additional data for quantity estimates.

b. Borings at the location of the Pumping Station and the revised location of Street Gate Structure No. 2 to determine the characteristics of the foundation soils and depths to bedrock.

c. Auger holes in the Ponding Area at the Pumping Station to determine the characteristics of the materials to be excavated.

d. Test pits in the foundation area of Clark Cove Dike between Stations 44+00 and 54+00 to determine the characteristics of the existing fill materials.

The locations of all subsurface explorations, exclusive of recent probings for the Bypass Channel, pertinent to the project are shown on Plates 5-3 through 5-7. In all, 141 drill holes, 145 probes, 33 test pits, 1 test trench, and 21 auger holes were made during the exploration program in addition to the sampling of exposed gravel sources.

4. Laboratory Tests. 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 in the laboratory in conformance with the Unified Soil Classification System. Grain size analyses and determinations of Atterberg Limits and organic contents were performed on selected samples to control and confirm visual classification and to provide more precise data where considered necessary. Specific gravities were determined for selected samples and the samples used in shear and consolidation tests. Natural moisture contents were determined for selected specimens of fine-grained soils and the specimens used for shear and consolidation tests. No permeability

tests were made on foundation soils or those soils to be used for the construction of the embankment since the relative characteristics can be judged with sufficient accuracy by visual inspection and from grain size distribution curves. Natural density tests were limited to samples selected for shear and consolidation tests.

5. Consolidation Tests. The consolidation characteristics were determined on test specimens of 100 cm^2 area from sample UC-1 of boring FD-91 and from samples UC-5 and UC-9 of boring FD-92. The sample selected from FD-91 is considered typical of the zones of ML-material containing little or no fine sand. The samples selected from FD-92 were considered to be the most uniform and compressible of those obtained from the soft zone containing organic silts and soils with high organic content.

6. Shear Tests. Shear tests were made on undisturbed foundation samples from drill holes FD-91 and FD-92. The intention was to determine the Q-, R-, and S-shearing strength of the material by testing specimens from the same samples used for consolidation tests. However, this was not possible due to the variation in the samples and the loss of satisfactory specimens during their preparation. At the conclusion of the program, all three shear test series had been made on sample UC-3 from FD-91 which was ML-material interspersed with thin layers of silty fine sand, and the three series on basic OL-material from FD-92 had been made on specimens from UC-5 and UC-9. The moisture contents and unit weights for all the specimens of OL-material from FD-92 were sufficiently close to permit the use of the results as representative of one material. Considering the granular nature of the materials and the size of the structures, no shear tests were made on earth embankment fill material or on other foundation soils.

7. Presentation of Data. Plates showing laboratory soil test results and summaries of these results are included in this memorandum. Detailed shear and consolidation test data and results of other tests are presented on Plate 5-26 and in Appendices A and B. Pertinent test data, representative for soils in certain foundation or excavation areas, are shown on Plates 5-23 and 5-24. Plates of "Record of Explorations", of explorations completed prior to January 1960, are shown in Design Memorandum No. 2 "SITE GEOLOGY." These plates of "Record of Explorations" will be revised to include explorations made after January 1960, for inclusion in the contract drawings. Soil profiles based on engineering soil logs are shown on Plates 5-8 through 5-12. These logs were prepared for all pertinent explorations by the designing soils engineer with the aid of test data and an experienced classifier. These logs include descriptions of the soils and soil strata based on the engineer's examination of the samples and his interpretation of all test results and exploration data. The descriptions include the state or consistency of the material, estimated or tested percentages of the soil components, color, details regarding stratification, existence of foreign material, geological names and other data considered significant to judge the characteristics of the materials needed for design and construction control problems involved. Also included with the description are test values of

the percentages of the soil components, effective sizes, water contents, specific gravities, Atterberg Limits and unit dry weights.

C. CHARACTERISTICS OF EMBANKMENT FOUNDATION SOILS

8. General. The purpose of this part is to describe the characteristics of the foundation soils in general for the Harbor Barrier and all dike embankments. In certain foundation reaches, the characteristics of the foundation soils vary from the general descriptions given below. The characteristics of the soils in these reaches and more details required for design are given under the heading of the design feature in Parts H, J, K, and L.

9. Distribution and Description. The distribution of overburden soils in the embankment foundation areas is shown by the engineering log profiles on Plates 5-8 through 5-12, and by the geological and soil profiles in Design Memorandum No. 2 "SITE GEOLOGY". The pertinent natural soils in all foundation areas are variable clean sands, gravelly sands, silty sands, and sandy non-plastic glacial till. Sandy glacial till occurs in the higher foundation areas at the ends of all dikes and to a certain extent in the foundation area of the Harbor Barrier west of Palmer Island. In all other foundation areas, the pertinent natural soils are variable sands, generally underlain by glacial till deposits. The foundations for most of the Clark Cove Dike and the Harbor Barrier Dike are in existing or previous beach areas. No typical grain size curves are shown in this memorandum for the natural foundation soils since no soils can be considered as typical. The gradations of the soils are indicated by the data on the engineering log profiles shown on Plates 5-8 through 5-12. In much of the foundation area for the Clark Cove Dike and a portion of the foundation area for the Harbor Barrier Dike, the variable sands are covered with man-made fill which will be the upper foundation material for the embankments. The variable sands may be interspersed with thin beds of material containing a high percentage of organics as a result of former salt water marsh deposits. The only significant organic deposits and silt deposits occur in the vicinity of the proposed Bypass Channel. In the foundation areas for the Harbor Barrier, the sandy glacial till and the variable sand deposits are overlain by thin deposits of very loose or soft sandy silts and silty sands containing some organics. In the foundation area of the Fairhaven Dike, the natural sand deposits are overlain by 1 to 4 feet of organic salt marsh deposit material.

10. Shearing Strength. No shear tests were made on specimens of foundation soils and fill, except as discussed in Part B, since these materials are basically granular and will have ample shearing strength to insure stable embankments of design heights and dimensions. Except as discussed in Part L, the thin surface deposits of loose or soft sandy material in the Harbor Barrier foundation area will either be displaced during the placement of embankment materials or will consolidate sufficiently during the construction period to produce a material with a high shearing strength.

11. Permeability. The permeability characteristics of the foundation soils vary widely. Permeability values were not assigned since the quantities

of seepage through the foundation soils are not pertinent to the design. The measures incorporated in the design to control seepage pressures at the toes of the embankment due to pertinent variability of permeability characteristics are discussed in Part K.

12. Consolidation. The consolidation characteristics of the foundation soils were not determined except as discussed in Part B. Any settlement due to consolidation or displacement of loose or soft surface foundation soil will take place during construction. The probable magnitudes of settlements due to consolidation, displacement of foundation soils and penetration of rock into the foundation soils are presented in Part K.

D. CHARACTERISTICS OF FOUNDATION BEDROCK

13. Bedrock Foundations for Embankments. Portions of the Harbor Barrier embankment will be constructed on bedrock at Fort Phoenix and at Palmer Island. Segments of the Clark Cove Dike near Station 39+00 and near Station 47+00 also will be constructed on bedrock. The exposed rock at these locations is sound, massive, glacially-smoothed granitic gneiss, relatively free from close jointing and excessive weathering.

14. Bedrock Foundations for Concrete Structures. The navigation gate structure is located between outcroppings on Palmer Island and at Fort Phoenix and will be founded on bedrock lying at elevations ranging from 50 to 60 feet below mean sea level. Subsurface explorations applicable to the construction cofferdam and gate areas consisted of 19 standard drive sample and core borings of which 5 borings cored bedrock in the foundation for the gate structure. Additionally, 41 probings were made in the general area by driving and washing uncased drill rods to solid refusals of 300 blows using a 350 pound drop weight. The probing refusals correlate sufficiently well with the core borings for development of rock contours giving a reasonable assumption of the configuration of the rock surface as presented on PLATE 3 in DESIGN MEMORANDUM No. 2, "SITE GEOLOGY". Core samples indicate that rock to be encountered in the gate structure is generally a sound granitic gneiss with evidence of local schistose and coarse pegmatitic phases. The cores exhibit a consistent dip of foliation at about 45°. Unconfined compression tests on 2-1/8-inch diameter core samples of the typical rock gave an average breaking strength of about 12,000 p.s.i.

E. DISTRIBUTION, TYPES AND USE OF EARTH MATERIALS TO BE EXCAVATED

15. General. Construction of the project requires the excavation of large quantities of natural earth materials for the Bypass Channel and the Sector Gate Structure and lesser quantities of natural earth materials and man-made fills for the Ponding Area, the drainage ditch along the toe of the Harbor Barrier Dike and in the foundation areas of the Harbor Barrier and all dikes. A portion of the natural earth materials was selected for use in the construction of all earth fill sections of embankments and other earth fills as stated Parts E

and H. Natural earth materials not utilized in the construction of the embankments, stripping material in excess of that salvaged for use as topsoil, and most of the man-made fill material containing ashes, cinders, trash, organics and debris will be spoiled in areas selected by the contractor.

16. Bypass Channel. The excavation of the Bypass Channel will involve the dredging of approximately 651,000 cubic yards to the neat lines. For two feet over depth it would be 730,000 cubic yards. The soil to be excavated ranges from gravelly sand to silt with little or no sand sizes and in part consists of organic silt and fine sand containing organics. The variation, distribution, and types of materials in the Bypass Channel Area are shown by the log profiles on Plate 5-10. The distribution of the various types of material is extremely variable, both laterally and vertically. Typical grain size curves are shown on Plate 5-24. As stated in Section H, the greater portion of earth fill material for the project will be obtained by special treatment of the material excavated from the Bypass Channel.

17. Harbor Barrier Gate Structure. The distribution and types of soils to be excavated for the construction of the Harbor Barrier Gate Structure are indicated by the data shown on Plate 5-9. The soils vary from gravelly silty sand (glacial till) to uniform silt. At the east end of the area, deposits of organic silt and soils containing a high percentage of organics exist between approximate elevations -18 M.S.L. and -29 M.S.L. The greatest portion of the materials to be excavated are silt with fine sand, silt with thin layers of fine sand, and silt. In general, the very silty zone is overlain with fine sand containing minor quantities of organics. Underlying the silty zone is a zone, varying in thickness from about 5 to 15 feet, of brown silty gravelly sand, silty sand and silty sandy gravel. These soils are generally more pervious than the soils in the overlying silt zone and contain from 10 to 20 percent fines. The soil profile in the area to the east is more complex than in other areas.

18. Ponding Area. The material to be excavated to form the Ponding Area is man-made fill placed over a previous shore area. East of approximate dike Station 22+00, the fill material is mainly rubbish or granular material containing rubbish, metal, and ashes. The material west of this station is mainly gravelly silty sand (apparently glacial till type material) containing between 40 and 20 percent fines in the component passing the No. 4 U. S. Sieve. Taking advantage of the uniformity of the fill in this western portion and the relatively impervious nature of the material, it will be specifically used for the construction purposes stated in Paragraph 36. This fill material contains numerous cobbles and boulders either placed with the earth fill or buried by fill.

19. Clark Cove Dike. The distribution and types of materials to be excavated in the foundation area of the Clark Cove Dike and appurtenant concrete structures are indicated by the data on Plate 5-11. The material to be excavated west of Street Gate Structure No. 1 are limited in quantity and are extremely variable but probably consist mainly of man-made granular fill. Between Street Gate Structure No. 1 and about Station

12+00 there are layers and zones of surface and buried riprap stone. Between Stations 10+30 and 22+00, the materials to be excavated consist mainly of about 10 feet of man-made fill and a few feet of underlying very pervious gravelly sands. The man-made fill is variable, consisting of zones of silty sandy gravels and silty sands. It is estimated that if the materials on a vertical face in this reach are mixed, the resulting mixture would contain between 15 and 25 percent fines. The materials to be excavated to the east and south of Station 22+00 consist mainly of man-made fill material. The fill material is cinders, ashes, trash and debris and granular soil containing ashes and debris. In this reach, limited quantities of silty sands, sandy gravels and sands containing little or no fines will be excavated.

20. Harbor Barrier Dike and Drainage Ditch. The distribution and types of materials to be excavated in the foundation area of the Harbor Barrier Dike and adjoining drainage ditch are indicated by the data on Plate 5-8. Very little data are available relative to the soils to be excavated to construct the ocean side rock-fill section between Stations 9+60 and 22+50, but it is expected that the soils in this area are variable sands with little or no silt content. The materials to be excavated between Stations 9+60 and 22+50 for the drainage ditch and dike foundation drainage toe are variable sands and silty sands. They are either natural or man-made fill. It is estimated that if these materials are excavated to the full depth in one operation, the resulting mixture will be a silty sand containing at least 10 percent fines. The materials to be excavated north of Station 36+70 consist mainly of ashes, cinders, and trash. The materials in all other excavations for this dike are granular and variable and consist largely of sands with little or no fines.

21. Harbor Barrier. The material to be excavated in the foundation areas of the Harbor Barrier (other than in reaches of Bypass Channel and cofferdam for Gate Structure) and the dike to the east will be limited in quantity. The materials between Stations 83+65 and 86+00 are mainly beach sands and gravels containing little or no silt. East of Station 86+00, the required excavations are shallow and the materials to be excavated will be gravelly silty sand containing more than 15 percent fines.

22. Fairhaven Dike. The distribution and types of materials to be excavated in the foundation area of the Fairhaven Dike are indicated by the data on Plate 5-12. The dike extends across a salt marsh area where stripping between 12 inches and 4 feet will be required to remove the surface material containing a high percentage of organics. The materials to be excavated below the stripping line for the drainage toe range from silty sand to sands with little or no fines. It is estimated that when these materials are mixed by the excavation operation, the resulting mixture will generally contain from zero to 10 percent silt. The materials to be excavated below the stripping line for placement of the ocean side stone protection consists mainly of silty sand with a silt content of about 20 percent. Due to the limited depth to which these materials will be excavated on the ocean side, it is considered impractical to separate them from the overlying stripping materials by separate excavation operations.

F. AVAILABILITY AND CHARACTERISTICS OF EMBANKMENT MATERIALS FROM OFF-SITE SOURCES

23. Earth Fill Material. The present design utilizes material from required excavations for the project for embankments and other earth fills and no off-site borrow sources are required. During the early stages of the investigations and studies, two submerged areas were explored as possible sources for earth fill material. The investigation of these two sources and the data obtained are described in Design Memorandum No. 2 "SITE GEOLOGY".

24. Gravel Materials. Natural bank run gravel materials are available from several large deposits located in the Freetown-Assonet area. Materials are being taken from these sources at the present time. The results of tests on samples taken from existing exposed faces were used in the selection of filter and gravel bedding materials as stated in Part J. The deposits containing the selected materials are within 20 miles of the project.

25. Rock Materials. Sources of rock suitable for rock fill, armor stone, protection stone and bedding stone and other rock products are described in Design Memorandum No. 2 "SITE GEOLOGY". It is anticipated that the contractor will develop a quarry for most of the project needs either in South Dartmouth, about 6 miles from the site, or in Freetown, about 11 miles from the site.

G. DESIGN OF EMBANKMENTS - GENERAL

26. General. The embankments for the dikes and barrier are part of a hurricane protection project. These embankments will be subjected to the effects of hurricane tides and waves, and to overtopping. The still water level for design storm conditions is taken at Elevation +16 M. S. L. The significant wave heights for the design storm and the characteristics of the tidal surges and waves are presented in Design Memorandum No. 1 "HYDROLOGY AND HYDRAULICS". The maximum significant wave height is 9.0 feet which will occur against the central east-west portions of the Harbor Barrier and of Clark Cove Dike. During a storm, water will accumulate behind portions of the Harbor Barrier and dikes as a result of surface run-off and overtopping. As a result of these accumulations, the design elevations of the water surfaces on the land or harbor side of the embankments during design storm donditions are assumed to +7.0, 0.0, and +5.0 M.S.L. for the Clark Cove Dike, the Harbor Barrier and Dike, and the Fairhaven Dike, respectively.

27. Design Criteria. The embankments were designed to produce reasonably stable structures for design hurricane conditions and construction conditions in accordance with pertinent sections of the Engineering Manual for Civil Works Construction and other current Corps of Engineers Publications. Some of the data and criteria in these manuals and publications, applicable for flood control structures, were adjusted for conditions produced by hurricanes. For some reaches, the embankments were not designed for the factors of safety for stability against shear failures generally accepted in the design of flood control structures. The

embankments were designed to utilize the earth materials obtained from the Bypass Channel and the silty sands from required excavations in the dike foundation areas and from the Ponding Area. In the design, consideration was given to feasible and economical construction procedures.

28. The major problem in design of the embankments was to obtain adequate seepage control, utilizing materials to be dredged from the Bypass Channel. These materials generally range from silt with little or no fine sand to gravelly sands containing no fines. Portions of the embankments are not designed for the usual conservative control of seepage through the foundations and embankments and are not designed with conservative filter material requirements. It is anticipated that minor settlements may occur during major storms in limited reaches due to movement of materials by seepage forces. Such settlement will not significantly decrease the effectiveness of the embankment since major overtopping is anticipated.

29. <u>Sections Selected</u>. The embankment sections for the various reaches of the dikes and barrier, developed as a result of design studies, are shown on Plates 5-19 through 5-24. These structures consist mainly of an earth fill central section flanked by layers of gravel and rock and in some reaches by rock-fill sections. The rock and gravel layers on the ocean side are required to prevent erosion due to wave action. The rock and gravel layers on the land and harbor sides are required to control seepage and to prevent erosion due to overtopping. The rock-fill toe sections are incorporated for construction purposes. The designs for the various reaches of the embankments vary according to foundation conditions, significant wave heights, foundation seepage control requirements and construction conditions in each reach.

30. <u>Construction Considerations</u>. The major portion of the Harbor Barrier and Dike and a limited portion of the Clark Cove Dike will be constructed off-shore and will be subject to attack by wave action and storms during construction. In these reaches, rock-fill toe sections were incorporated in the embankment. They will prevent destruction of earth fill and filter layers during construction, eliminate the necessity of constructing temporary protective measures, and will permit the economical placement of all embankment materials by using land-operated equipment. The rock-fill toe was not incorporated in limited off-shore reaches of the Clark Cove Dike where it is considered practical to readily construct the entire width of the embankment with land-based equipment. The elevation and top width of the rock-fill toe sections was selected to permit the placement of the rock-fill material by end-dumping from trucks. It is anticipated that the dumped earth fill portion of the embankments below Elevation +2 M.S.L. will be constructed concurrently with the adjoining rock-fill sections or section, except for the lag required for protection of the earth fill and filter layers as construction progresses. Placing the earth fill concurrently with the rock-fill will provide ample area for hauling rock-fill materials without excessive backing of the hauling equipment. Also, this operation will permit equipment used for placing filter materials to operate from the earth fill section without interfering with the placement of rock fill material. Special provisions will be made in the

specifications for placement of embankment materials in the vicinity of Gated Conduits Numbers 1 and 2 to avoid displacement of these structures.

H. EMBANKMENT EARTH FILL SECTIONS

31. General. The earth fill sections of the embankments were designed to reduce seepage through the structures, control seepage through the foundations and to utilize only earth materials from required excavations. The dimensions of the earth fill sections of the dike embankments and above Elevation +2 M.S.L. of the Harbor Barrier (except for the earth wrap-around at the Gate Structure) are those required for the minimum quantity of armor protection and bedding stone, the cost of which greatly affects the cost of the project. These dimensions are adequate to provide a creep ratio at the contact of the earth fill sections of at least 2 along the wall of the Sector Gate Structure and also along the foundation of the Harbor Barrier embankment where two rock fill toes are provided. The earth fill sections provide foundation cut-offs for foundation seepage control in reaches where cut-offs are considered necessary and practical to construct. The dikes and barrier designs requiring the minimum quantity of stone protection are considered to be the most economical. The use, however, of small earth fill sections in the structure make the problem of seepage control critical as discussed in Part J and requires special treatment of the materials to be excavated from the Bypass Channel for use as earth fill. Homogeneous earth fill sections, except as stated in Paragraph 36 for the Fairhaven Dike, were provided in lieu of zoned sections utilizing materials from a stock pile in which materials are placed by uncontrolled hydraulic methods. It is considered impractical to zone sections due to their limited dimensions and to control the placement of materials from a variable stock pile. Earth fill material, to be satisfactory for seepage control, must: (a) be less pervious than the materials adjacent to it, which act as seepage filter zones, (b) not contain fines which will clog the filters, (c) be as homogeneous as practicable, (d) be more impervious than the pervious zones intercepted by foundation cut-offs.

32. Mixing, Control, and Characteristics of Earth Fill Materials from Bypass Channel. The major portion of the required earth fill material will be obtained by hydraulic dredging from the Bypass Channel. To make this material meet the criteria stated in Paragraph 31 above and to make it suitable for the selected design will require thorough mixing, control and inspection. To thoroughly mix the materials will require:

a. Careful control of hydraulic dredging operations

b. Dredging to full depth in one operation

c. Formation of land stock piles of dredged materials with heights greater than 8 feet above the final stock pile area grades

d. Construction of stock piles in a manner that permits mixing of materials during excavation operations of the stock piles

e. Excavating stock-piled materials on vertical faces to produce mixing of layered materials

f. Spreading the unsuitable materials encountered during excavation of the stock piles in thin layers over the top of the remaining portion of the stock piles. As a result of this operation, these materials will be mixed with other materials during subsequent excavation operations.

g. Possibly, mixing by disc harrows, pulverizers, blades and similar equipment

In addition, "drying back" of stock piled materials and washing away of organics may be necessary. The above stated operations, although not usual, are considered practicable and necessary to produce a satisfactory end product.

33. The variation and distribution of the soils to be excavated for the Bypass Channel are described in Part E. There appears to be no uniformity in the distribution of the various soils to be excavated. Besides specifying methods of dredging, careful control will be required of the formation of stock piles to produce a suitable end product. A study of the quantities of the different soils to be excavated indicates that if all the soils in the Bypass Channel could be thoroughly mixed at one time, the resulting material would be a well graded silty sand with about 10 percent of particles retained on the No. 4 sieve and about 15 percent by dry weight of particles passing the No. 200 sieve. In the study it was assumed that all soil particles smaller than 0.005 millimeter would be washed away during the mixing operations. Considering all factors, it is concluded that the following specifications can be met for embankment earth fill material obtained by mixing the materials from the Bypass Channel excavation:

a. 80 percent of the fill material of every load being placed in the earth fill section shall contain between 5 and 40 percent by weight of particles passing the No. 200 U. S. Standard Sieve and shall contain at least 15 percent by weight of particles retained on the No. 40 U. S. Standard Sieve.

b. The percentage of material meeting the above gradation requirements shall be determined by the areal distribution of the soils of various gradations at the surface of a layer of material 12 inches thick after it is spread by one pass of a bulldozer, or after it has been processed by disc harrows or other equipment.

With this specification, the fill material as placed, will vary from homogeneous to heterogeneous and the gradation of the material or zones and pockets of material making up the total will have a gradation, generally within the limits shown on Plate 5-27.

34. The contractor will be responsible for mixing soils from the Bypass Channel excavation to produce earth fill materials meeting the above requirements, except as stated in Paragraph 37. The government will provide stock pile areas, one on the shore at the west end of the Harbor Barrier and another near the future location of the Fairhaven Dike. These locations are shown on Plate 5-1. All material excavated

for the Bypass Channel will be placed in the stock piles. The Government will specify the quantity in each stock pile after the Contractor's plan of operations becomes known. The quantities in the stock piles will be adequate to take care of all earth fill material contingencies and borrow will not be required. Stock-piled materials not used in construction will be leveled and left in the stock pile areas to the extent possible in accordance with the Government agreement with the land owners. Additional excess material will be spoiled in areas selected by the contractor. Provisions will be made so that material from stock piles may be wasted in the Bypass Channel below Elevation -12 M.S.L. by extending the fill areas within specified limits.

35. Utilization of Materials Excavated for the Sector Gate Structure. The soils to be excavated for the construction of the Sector Gate Structure are described in Paragraph 17. The only soil in this excavation that is suitable for earth fill in the selected embankment sections without mixing with other soils is the gravelly silty sand in the lower stratum overlying bedrock. A portion of the other soils could be utilized if placed in the hydraulic fill stock piles and mixed with the sands from the excavation for the Bypass Channel. From a design standpoint, it is desirable that several thin layers of the very silty soils from the intermediate zone of this excavation be placed in the stock piles so that the fill material from the stock piles will be more impervious and the specified end product can be more readily produced. To utilize any of these materials, however, would require definite timing and methods of excavation operations. Since it is considered advisable to control the contractor's operation for this excavation and since there is an ample quantity of earth fill material from the Bypass Channel and land excavations, the utilization of material from the Gate Structure will not be required. However, permission will be granted if the contractor desires to utilize some of these materials to aid in his producing the specified earth fill material from stock piles.

36. Utilization of Materials from Land Excavations. Consideration was given to the utilization as earth fill in the embankment, of earth materials which do not contain organics, ashes, cinders or debris to be excavated in areas other than the Bypass Channel and the Sector Gate Structure. These earth materials to be excavated in the various reaches are described in Part E. Since there is an adequate quantity of suitable earth fill material from these and other excavations, all of the earth materials from these excavations will not be utilized. To utilize all of these earth materials would require zoning of the embankment, specific routing of materials, detailed inspection, the testing of small quantities of materials and the separation of the earth materials in shallow excavation from overlying unsuitable materials. Earth materials to be utilized in the earth fill sections will be obtained from specified areas and will be placed at specific locations as follows:

a. The Ponding Area. The earth material excavated west of approximately Station 22+00 for the Ponding Area is the most suitable earth fill material which can be obtained from required excavation for use in the foundation cut-off of the Clark Cove Dike. This material, therefore, will be utilized as dumped earth fill in the Clark Cove Dike below elevation +2 M.S.L., extending eastward from Street Gate Structure No. 1 to Station 36+20. A study of the quantities reveals that more than an adequate quantity of material will be available for this purpose. The remaining material will be placed to the extent possible between Station 36+20 and Street Gate Structure No. 2.

b. Clark Cove Dike Foundation Area. The only material that will be utilized as earth fill from the excavation within the foundation area of the Clark Cove Dike and appurtenant structures will be that excavated between Station 10+30 and approximate Station 22+00. The specifications will require that excavation within this reach be accomplished by methods that will mix the materials on a nearly vertical face. The resulting material, which will be equivalent to that specified as earth fill material from the hydraulically placed stock piles will be used in the construction of Clark Cove Dike above and beyond the limits of the fills made of materials excavated for the Ponding Area, as defined in the preceding subparagraph.

c. Harbor Barrier Dike, Stations 1+80 to 36+80. The earth materials to be excavated in the foundation area for the Harbor Barrier Dike for the construction of Street Gate Structure No. 3, and for the drainage ditch along the toe of the dike, all between Stations 1+80 and 36+80, may be more pervious than the required earth fill material from the hydraulically placed stock piles. Therefore, these materials will be used as earth fill in the area of the drainage ditch adjacent to the toe of the dike, in the construction of the upper portion of Maintenance Area No. 1, and in the construction of the Harbor Barrier Dike west of Station 7+00. These materials are considered satisfactory for the construction of this reach of the dike which is less than 10 feet in height and is less exposed to hurricane waves.

d. Harbor Barrier, Stations 86+00 to 91+00. The earth fill material excavated in the foundation area of the Harbor Barrier east of Station 86+00 and Maintenance Area No. 2 will be equivalent to the specified earth fill material from the hydraulically placed stock piles and will be utilized in the construction of the Harbor Barrier.

e. Fairhaven Dike. The specifications will require that the excavation, after stripping, for the construction of the foundation drainage toe for the Fairhaven Dike will be by methods which will mix the earth materials on a nearly vertical face. The resulting material will have a permeability in the order of the most pervious earth fill material permissible from the hydraulically placed stock piles. To permit the use of this material in the embankment by direct casting and spreading, the earth fill section has been zoned as shown on Plate 5-22. This material will be placed in the land side portion of the earth fill section.

37. Bypass Channel Earth Fill. The details of the embankment section selected for the Harbor Barrier in the reach of the Bypass Channel is shown on Plate 5-20. The design requires the placement of dumped earth fill below Elevation -12 M.S.L. to form a foundation for the rock fill portions of the embankment. The dumped earth fill

section below Elevation -12 M.S.L. will have a top extending 132 feet beyond the limits of the rock toes of the superimposed structure and has end slopes of 1 on 3. These dimensions and slopes were selected to provide sufficient material to insure that currents and wave action will not cause undermining of the rock toes of the superimposed structure. There is adequate material for the formation of slopes of 1 on 15 beyond the limits of the rock fill toes of the superimposed structure.

38. The earth fill material to be placed below Elevation -12 M.S.L. in the Bypass Channel will be obtained from one of the hydraulically placed stock piles. All or a portion of this fill material may be placed directly from the stock pile. It is anticipated that the contractor may desire to use material from the stock pile containing less than 10 percent silt for cellular cofferdam construction prior to its placement in the Bypass Channel below Elevation -12 M.S.L. To provide for the use of the cellular fill material obtained from the stock pile, which, when placed in the Bypass Channel fill, may contain less silt than required for earth fill materials from the stock piles, the specifications will provide for the utilization of two types of fill material in the Bypass Channel fill as follows:

a. The earth fill for a distance of 100 feet, centered about a line located 32 feet north of the centerline of the Harbor Barrier, will be composed of earth fill materials specified for earth embankments in Paragraph 33 above.

b. The earth fill beyond the central zone, defined in paragraph (a) above, will be composed of earth fill material as specified above for the central zone except that the lower percentage of fines may be zero.

These requirements for Bypass Channel fill material below Elevation -12 M.S.L. will also permit the use of about 70,000 cubic yards of stock-piled material which does not contain the minimum required percentage of fines.

39. Placement and Compaction. The design provides for all earth fill material in embankments below Elevation +2 M.S.L. to be placed without compaction, except for the earth wrap-arounds at the Sector Gate Structure. This eliminates the necessity for cofferdams and dewatering and permits the construction of earth fill sections concurrently with rock fill toe sections. Except for the placement of earth fill material below Elevation -12 M.S.L. in the Bypass Channel and possibly in the vicinity of Conduits Nos. 1 and 2, the dumped earth fill material will be placed without dropping freely through water by end-dumping and pushing with a bulldozer. This method will prevent detrimental segregation and produce some mixing of the fill material during placement. Fill material in the Bypass Channel below Elevation -12 M.S.L. will be placed by dumping from scows or barges. Hydraulic placement will not be permitted as it might produce detrimental zoning or stratification relative to foundation seepage control or zones of low shear strength soils in the foundation area for the embankment. Tractor or roller compaction will be required above the top elevation of the dumped earth fill. If the surface of the dumped earth fill is not sufficiently stable for the operation of

rollers, the fill material will be compacted by tractors only until the fill becomes stable for roller operation. The tractors will be operating on a ramp type slope. All earth fill material other than dumped fill will be compacted by tractors or small rollers to attain, generally, a density greater than 95 percent of Standard Proctor density, except that all earth fill material placed within the cofferdam for the construction of the Sector Gate Structure will be compacted with heavy equipment. All earth fill adjacent to concrete structures will be carefully compacted by special means to produce a tight contact with the wall and to obtain a high degree of density in the zones where rolling compaction equipment cannot or should not operate. Earth fill placed along the sides of gated conduits Nos. 1 and 2 and the gated culvert below elevations of adjoining dumped earth fill will be similarly compacted for widths of 5 and 3 feet, respectively. Special provisions will be made in the specifications for placement, selection and compaction of fill around and above buried utilities in the foundation areas of the embankment to prevent settlement of the fill and to provide a compacted condition in the vicinity of the utility. Both provisions are necessary to insure adequate seepage control.

I. EMBANKMENT ROCK SECTIONS

40. Rock Fill Toes. The rock fill toes for certain reaches of the embankments in inundated areas are provided mainly for economical construction. They also serve to insure a stable embankment condition during construction in areas where a thin surficial layer of soft or very loose soils exists in the foundation area. The rock fill material will be any quarry type rock fragments of less than 2/3 of a cubic yard, except that no load of material shall contain more than 20 percent by weight of material passing the 6-inch screen. It is intended to prepare the specification so that all of the rock from a rock quarry operation producing armor stone and slope protection stones may be utilized in the structure.

41. Ocean Side Rock Sections and Gravel Bedding. Layers of armor stone, bedding stone and gravel bedding are provided on the ocean side slopes and tops of the dike and barrier embankments to produce a structure that will be stable under the action of hurricane waves. The minimum theoretical weights of the armor stone protection on the ocean side of the dikes and barrier have been determined for the wave heights as stated in Design Memorandum No. 1 - "HYDROLOGY AND HYDRAULICS", using the modified Iribarren formula in Technical Report No. 4 of the Beach Erosion Board. The maximum weights were made 1.5 times the minimum weights. The final weights selected vary from the theoretical ones for practical reasons. The specifications will allow 20 percent of the armor stone to be slightly larger and 20 percent to be slightly smaller than the range of stone weights shown on the plates. The thickness of an armor stone layer on a slope is approximately twice the thickness of a cube shaped rock of the required minimum weight. The armor stone on the slopes will be placed "pell mell" with an outer slope tolerance of zero to plus 18 inches above water and zero to plus 36 inches below water. The layers on the slopes will not be chinked. The armor stone layer forming the top of a structure has a thickness equal to approximately

the thickness of a cube-shaped rock of the required minimum weight. The armor stone on the top will be laid individually and chinked to provide a tight layer with fairly smooth top.

42. Where the armor stone is not placed on the rock fill, the usual successive layers of bedding stone and filter stone beneath the armor stone were replaced by a single layer of well-graded quarry run rock. This layer is noted on the drawings as "bedding stone". It was provided for reasons of economy. The material for the bedding stone layer will be well-graded up to a maximum size rock with a maximum dimension of 2 feet and shall not contain more than 5 percent by weight of particles passing the 2-inch sieve. This range of material will require rock fragments in the layer of sizes required for "bedding layers" and "rock filters" by the criteria in the above reference for armor stone for slope protection. Where armor stone is placed against rock fill sections, the rock fill material serves as bedding stone. The bedding stone layer on the tops and slopes is underlain by a 2-foot layer of gravel bedding composed of bank run sandy gravel. This material will be well-graded with the component passing the 4-inch sieve containing at least 45 percent of particles retained on the No. 4 sieve and with the component passing the No. 4 sieve containing less than 10 percent of particles passing the No. 200 sieve. This gravel bedding material is considered adequate to prevent significant movement of the gravel and underlying soil due to pore pressures and erosion developed as a result of wave action.

43. At locations and to the extent considered necessary, provisions are made at the toe of the slopes to reduce possible erosion of the foundation soils due to the action of normal and storm waves, to prevent detrimental displacement of the slope protection materials and costly maintenance. No provisions are considered necessary where the armor stone is underlain by a rock fill toe with base at or below Elevation -3 M.S.L. The provisions are as follows:

a. A 10-foot berm of armor stone over a layer of bedding stone with a base at or below Elevation -3 M.S.L. is provided on the ocean side at the foot of slopes along beaches and in the existing harbor and bay areas where the base of a rock fill toe is at or below Elevation -3 M.S.L. This protection is considered necessary mainly to prevent erosion by normal wave action.

b. A small berm of armor stone, overlying gravel bedding, with the top at the adjoining ground surface elevation, is provided on the ocean side at the base of the slopes of end reaches of dikes which are on high ground.

c. The slope protection layers of rock and gravel extend down to a base Elevation of -3 M.S.L. on the ocean side of Clark Cove Dike in the reach where the embankment toe is set back 50 feet from the existing shore line. This provision is made to afford protection in case the shore material is partially washed away during a storm period. The water side slope of the existing fill is protected with heavy riprap which will be left in place.

d. A 10-foot berm of armor stone overlying a layer of bedding stone is provided on the ocean side at the base of the slope of the valley reach of Fairhaven Dike where erosion effects due to wave action during storms will be great.

44. Land Side Slope Protection. Layers of rock and gravel have been provided on the land or harbor side slopes of the dikes and barrier embankments to prevent erosion by overtopping. These layers are also required for seepage control as described in Part J. The outer layers of stone on the slopes, which must withstand the full effect of overtopping, will be composed of stone ranging in size between 500 and 1500 pounds. The effect and magnitude of overtopping upon these layers are unknown and the range of stone sizes has been selected on the basis of engineering judgment. The successive layers of bedding stone and gravel bedding beneath the protection stone on the slope are the same as under the armor stone described in Paragraphs 41 to 43 above, except that for certain dikes the gravel bedding material will contain more cobbles and gravel sizes as described in Part J. On the flat berm of the Harbor Barrier, the layer of protection stone is omitted. A surface layer of bedding stone on this berm is considered adequate to withstand the effects of overtopping.

45. Erosion of the embankment due to wave action on the harbor side of the Harbor Barrier will be prevented by the rock fill material in the toe section and the slope protection provided to withstand the effects of overtopping. No additional provisions are considered necessary.

J. EMBANKMENT SEEPAGE CONTROL

46. General. The dike and barrier embankments were designed to control seepage through the embankments and foundations soils in order to prevent the movement of a significant amount of foundation, filter, and earth fill materials. The selection of relatively small earth fill sections and the use of the variable and pervious materials from the Bypass Channel and other excavations make the control of seepage a critical problem. The maximum head conditions assumed for design are based on head water conditions of still water level and significant wave heights and on tailwater conditions at the ground elevation or at the minimum water elevation, all as defined in Part G. The details of the features provided in the designs to control seepage are described in the following paragraphs in this part. The structures were not designed with as high a factor of safety as is usually provided for in the design of flood control structures to insure that no movement of the materials will occur. Considering, however, the control that is provided and the fact that maximum hydraulic head conditions will occur only for a few hours, any movement of material will result only in minor settlement which will not impair the effectiveness or the stability of the structure. Settlements occurring in the area of the harbor side rock toe of the Harbor Barrier will not affect the top of the structure. The cost of more adequate seepage control to prevent possible minor settlements is considered not justified. The features that were incorporated to control seepage to prevent the movement of materials are considered sufficient,

to produce adequately low seepage pore pressures which affect the shearing strengths of the foundation and earth fill materials in place. Since the quantity of seepage through any embankment including the upper rock layers and the foundation overburden will be insignificant as compared to the quantity of water that gets inside the structure due to overtopping, no additional provisions were made in the design to reduce the quantity of seepage through the earth fill sections and the foundation soils.

47. Earth Fill Sections and Filters. The control of seepage through the embankments below the top of the earth fill section is provided by successive layers or zones of gravel and different size rock on the land or harbor side of the earth sections. The adequacy of these layers depends upon the characteristics of the material in the earth fill section. The materials in these layers were selected on the basis that the earth fill material, in general, will meet the requirements stated in Paragraph 33 for earth fill material from the hydraulically placed stock piles and thus will contain between 5 and 40 percent by weight of fines. It should be noted that the layers will not be adequate if the entire width of an earth fill section is composed of material which is more pervious than indicated by the above gradation except in reaches described below. Earth fill material not meeting the above requirements will be utilized only in the construction of limited reaches of certain dikes on land where the dikes are less than 10 feet in height and in the land side portion of the earth fill section of the Fairhaven Dike as described in Part H. To insure adequate control of seepage through the Fairhaven Dike, where more pervious material may be incorporated in the earth fill section, filter material was selected as stated in Paragraph 50. Special provisions will be made in the specifications, as stated in Paragraph 39, for the selection, placement and compaction of earth fill adjacent to and in the vicinity of concrete structures and utilities to provide a tight contact with the structure and utilities and good compaction where rolling equipment cannot or should not operate.

48. Two materials, noted on the drawings as "filter material" and "gravel bedding", have been selected to act as filters adjacent to the earth fill material. They are provided to prevent movement of the particles of the earth fill materials and the development of detrimental seepage pressures on the harbor side or land side slope of the earth fill section. These materials will be bank run sandy gravels available within 20 miles of the project site, having the following gradation requirements:

a. Filter Materials. The filter material shall be well-graded with a maximum size equal to one-half the thickness of the layer in which it is placed. The component of the material passing a 9-inch screen shall contain between 65 and 85 percent by weight of particles retained on the No. 4 sieve. The component of the material passing the No. 4 sieve shall contain not more than 10 percent by dry weight of particles passing the No. 200 sieve and less than 70 percent by dry weight of particles passing the No. 40 sieve.

b. Gravel Bedding Material. Material meeting the above requirements for filter material may be used as gravel bedding material. Other gravel bedding material shall meet the maximum size and gradation for the minus No. 4 sieve component as required for filter material. In addition, the component of the material passing the 4-inch screen shall contain at least 45 percent by dry weight of particles retained on the No. 4 sieve.

49. The above requirements are established on the basis of filter requirements and the gradations of materials in existing natural gravel deposits. The gradation of samples taken from exposed faces in deposits that meet the above criteria are shown on Plate 5-28. Natural materials were selected to avoid processing and layered construction. If processed materials were to be used, two layers in lieu of one layer would be required to insure proper filter action. However, due to the large quantity of filter and gravel bedding material required, consideration will be given, prior to the preparation of specifications, to permit the use of crushed rock materials as an alternate. Specifications for filter material below Elevation +2 M.S.L. and for layers only 12-inches thick will remain as stated above.

50. A study of the materials in the probable sources for "gravel bedding material" and "filter material" shows that it may be assumed for design purposes that, in general, these materials will contain between 2 and 6 percent by weight of silt particles of the component passing the No. 4 sieve. The specifications will set a corresponding maximum of 10 percent for control purposes. It is concluded from a study of the gradations of these materials and those of the earth fill material that the materials acting as a filter, in general, will be about four times as pervious as the average earth fill material and will have a coefficient of permeability slightly in excess of the most pervious earth fill materials specified. Although these materials are not as pervious as required by standard criteria for filters, they are considered satisfactory for the proposed structures. To obtain a more adequate design, "filter material" is designated to be used: (a) for the Harbor Barrier below water where the seepage is downward and where the adjacent rock-fill toe material may be segregated, (b) on the harbor side of the earth wrap-arounds at the Sector Gate Structure, and (c) for the north-south reach of the Harbor Barrier Dike where the seepage gradients will be large and will occur over a longer period of time compared to other structures. Filter material will also be used on the land side slope of the earth fill section of the valley reach of the Fairhaven Dike to permit the use of possibly more pervious earth fill material obtained from required excavation as discussed in Part H and to provide a layer of the same material across the top of the toe drain and up the slope. Owing to its very boney nature, the advantage of the use of "filter material" at these locations is to provide more assurance that the "filter material" will not move into the adjacent bedding stone or rock fill material in case large seepage pressures develop at the outer surface of the earth fill section. The requirements of the gradation of bedding stone, as stated in Paragraph 42, were established with the thought in mind that it may have to act as a filter adjacent to the "filter material" and the "gravel bedding material".

51. "Filter material" is provided between the earth fill sections and the ocean side rock fill toe sections of the structures. The adequacy of this material to act as a suitable filter at this location depends upon the effect of wave action and the character of the rock fill. The material is considered adequate on the assumption that there will be little if any pulsating action by waves because of the dampening effect of the large rock fill section. Some movement of filter and earth fill materials may occur if the rock fill materials become greatly segregated during placement. It is anticipated that more settlement due to wave action will occur as a result of the foundation soils moving into the voids of the rock fill material. Transition material is not provided at the base of the rock fill toe. Considering the construction difficulties of placing such a layer and the type of structures, its cost is not warranted.

52. Earth Fill Contact with Concrete Structures. The earth fill sections of the dikes and barrier abut the Clark Cove Pumping Station and various gate structures. Considering the heights of the embankments and the hydraulic heads involved, no changes in the embankment sections in the vicinity of the structures are necessary for seepage control along the contact of the embankment and structures. The maximum hydraulic heads involved for the Street Gate Structures and the Pumping Station, based on design still water levels are 7 and 9 feet, respectively. Due to the height and location of the earth fill wrap-arounds for the Sector Gate Structure, the design provides for conservative hydraulic gradients in the contact zones to insure adequate seepage control. At this structure, the maximum design hydraulic head conditions are approximately 16 and 25 feet, based on still water level and significant wave height, respectively. The earth fill section at the contact has 1 on 2 side slopes and a top width at Elevation +12 M.S.L. of 30 feet. The creep ratios of the earth fill sections at Elevation +12 M.S.L. and -32 M.S.L., based on still water condition, are approximately 1.9 and 7.0, respectively. Based on significant wave height, they are approximately 1.2 and 4.4, respectively. These creep ratios are adequate considering the protection provided by the adjoining filter and rock layer on the harbor side, and also considering that all of the earth fill at the contact zones will be well compacted and placed in the dry.

53. Foundation Seepage - General. The seepage through the foundation soils of the embankments is controlled by the incorporation of toe drains and foundation earth cut-offs where such features are required. The designs are based on the assumption that maximum seepage pressures in the foundation soils will be developed with the water on the ocean side at the design still water level at Elevation +16 M.S.L. The purpose and details of these features for the various reaches of the embankments and the foundation conditions pertinent to seepage control are described in Paragraphs 54 through 59 below. These features are considered adequate to prevent the formation of seepage pressures that will detrimentally affect the stability of the structures and to prevent, in general, the movement by seepage forces of a significant quantity of foundation soils. Except in the vicinity of the Sector Gate Structure, some movement of foundation soils might occur in limited reaches, particularly in reaches where toe drains only are provided. This movement is due to the narrow base widths of the earth fill sections, the variability of the foundation soils, and the high seepage gradients that may develop.

54. Harbor Barrier Foundation. The control of seepage through the foundation soils of the Harbor Barrier between Stations 46+80 and 83+65 is provided for by making the foundation contact width of the foundation soil equal to about twice the probable maximum seepage head that will occur. In this reach, the lower portion of the earth fill section is flanked by rock fill sections as shown on Plate 5-20, except between Stations 62+40 and 65+00 on Palmer Island where the top of the bedrock is at or near the present ground surface. On Palmer Island, the harbor side zones of protection stone, bedding stone and gravel bedding extend to the bedrock surface to form a drain at the bedrock surface. No provisions are made for the grouting of the bedrock. The criterion stated above for reaches other than on Palmer Island does not insure conservative seepage control. No filter layer is provided between the foundation soil and the base of the harbor side rock fill toe. It is anticipated that some foundation soil may move into the voids of the rock fill, causing settlement of the surface of the harbor side berm in the area of the rock fill toe. If such settlement does occur, it will not affect the top of the main portion of the barrier.

55. The harbor side rock toe of the embankment terminates at Station 83+65 and the Harbor Barrier extends up on to high ground to the east in the form of a dike embankment section. The ocean side rock fill toe extends eastward beyond Station 83+65 until it abuts the steep bedrock surface at Fort Phoenix. Between Stations 83+65 and 84+85, the foundation area consists in part of an existing beach and in part of an off-shore area. The foundation soils in this reach are mainly fine to medium sand with little or no inorganic silt but containing shells and organics in limited zones. A wide thin foundation drainage blanket is provided, as shown on Plate 5-20, to control seepage and to provide a filter zone beneath the harbor side rock protection layers. This blanket will be composed of filter material and will extend up the slope at the end of the rock toe section to form a filter layer. The blanket has a width of 30 feet at the toe of the end of the rock fill section at Station 83+65, and uniformly decreases in width to 12 feet at Station 84+25. In this reach the wide foundation drainage blanket is provided in lieu of a deep toe drain or a deep foundation cut-off since deep excavation in the area would be difficult and the blanket type drain facilitates a transition with the barrier section to the west.

56. The dike foundation area between Stations 84+85 and 87+20, forming part of the Harbor Barrier, lies on a slope with the toe of the slope to the north. In this reach, the height of the embankment is greater than 10 feet, measured from the ground surface at the land side toe. The overburden in the western and northern portions of this foundation area consists of a zone less than 5 feet thick, of medium to fine sand overlying unstratified gravelly silty sand. Bedrock is at or near the ground surface in portions of the area. In the remaining portions, the foundation soil is gravelly silty sand. The foundation gravel drain, 12 feet wide and 3 feet deep, west of Station 84+85, extends eastward throughout this reach to Station 87+20 to provide seepage control through the various foundation soils and a drain on the bedrock surface.

No features are provided for foundation seepage control for the embankment east of Station 87+20 since the height of the embankment is less than 10 feet and the foundation soil is mainly unstratified gravelly silty sand.

57. Clark Cove Dike Foundation. The features provided to control seepage through the foundations for the various reaches of Clark Cove Dike are shown on Plate 5-21. In general, the features consist of an earth fill foundation cut-off and a zone of gravel bedding beneath the rock sections on the land side of the embankment. The zone of gravel is provided to prevent vertical movement of the foundation soils beneath the toe either by acting as a pervious foundation toe drain or as a filter zone. Provisions are made to place gravel bedding material on excavation slopes where necessary to prevent the earth fill foundation cut-off material from moving into open zones of trash fill. The foundation conditions pertinent to seepage control and the details and purposes for the foundation earth cut-offs in various reaches are as follows:

a. Stations 0+00 to 4+08. No cut-off is provided since the embankment is essentially a low rock structure.

b. Station 4+08 to Street Gate Structure No. 1. As foundation conditions are not known and depend upon previous and existing use and construction in this area for residential and commercial purposes, a cut-off is provided to disconnect any existing pipes and drains and to form a water barrier in any pervious or open man-made fill.

c. Street Gate Structure No. 1 to Station 10+30. The foundation materials in the land side portion of the area are mostly man-made granular fill above approximately Elevation -2 M.S.L. overlying previous shore line deposits. The present slope of the fill is protected by heavy riprap. Zones of stone with some voids, apparently forming previous riprap protection with the top near the edge of the pavement of Clark Cove Road, is buried in the fill. The present riprap protection and any stone immediately beneath it will be removed prior to placement of earth fill. It is not planned to remove the buried riprap zone from the foundation area as this might require shoring to prevent undermining of the existing pavement.

The bay side portion of the foundation area is inundated and the soils are mainly sands and gravelly sands with apparently very pervious gravelly sand at the surface. Provisions are made to remove these very pervious surface soils above Elevation -6 M.S.L. in the foundation area beyond the toe of the existing riprap to provide a partial foundation cut-off.

d. Stations 10+30 to approximately 22+00. The foundation soils are man-made fill of silty sand and silty sandy gravel above approximate Elevation -3 M.S.L. overlying previous shore line deposits. The subsurface data and photographs of previous conditions indicate that the soils immediately beneath the fill are very pervious gravelly sands with little or no fines. These soils were at the surface of a previous shore-line area and are apparently continuous beneath the foundation and adjoining storage areas. A cut-off is provided to Elevation -6 M.S.L. to form a water barrier in the zone of very pervious gravelly sand. The foundation cut-off below

Elevation +2 M.S.L. will be composed of silty gravelly sand with more than 20 percent fines to insure a relatively impervious barrier. This material will be obtained from the required excavation for the Ponding Area. The prevention of "boils" forming along the west edge of the Ponding Area and the landside toe of the dike depends upon the adequacy of this cut-off. Without the cut-off, the escape gradients at these two locations might be in the order of 2.3 and 1.3 respectively.

e. Stations 22+00 to 36+70. The foundation materials and materials in the area of the adjoining Ponding Area are mainly trash, ashes, debris and granular soils containing ashes and debris. Much of this area was at one time used as a city dump. Explorations, however, indicate that the materials in the dike foundation are mainly granular soil and ashes containing very little trash and that the fill material between Stations 35+00 and 36+70 is mainly sandy gravel containing no debris. The fill materials were placed in an inundated area at the edge of the Cove. The depth of the fill material at the land side toe of the embankment is approximately 10 feet. The fill material overlies a sand deposit, the top of which is probably composed of relatively pervious gravelly sands. A cut-off is provided to Elevation -6 M.S.L. to provide a water barrier in the man-made fill and to effect at least a partial cut-off in the underlying sands. Silty gravelly sand, containing more than 20 percent finer, from the required excavation for the Ponding Area will be used as earth fill below Elevation +2 M.S.L.

f. Stations 36+70 to 39+55. The bay side portion of the foundation area is inundated. The foundation soils in this portion are sands of a shore-line deposit. The surface soils are gravelly sands with little or no silt. The land side portion of the foundation area is composed of a beach area, a filled area with stone retention walls, and an area of exposed bedrock. Several rock groins exist in the beach and adjoining areas. Prior to placement of earth fill material, the rock groins and the remains of timber walls and piers will be removed. It is planned not to remove the rock retention walls or the fill which is mainly stones and other stable material. In the bedrock area, the embankment sections of rock and gravel at the land side toe extend to form a drain on the bedrock surface. No provisions are made for the grouting of the bedrock. A foundation cut-off is provided on the water side of the embankment section to Elevation -3 M.S.L. to form a barrier in the more pervious surface sands.

g. Stations 39+55 to 44+10. The materials in the land side portion of the foundation area are mainly industrial fill and trash and, in general, are not "solid" fill materials. The existing fill materials are protected by large riprap stones. In general, the fill extends to about Elevation -3 M.S.L. The soils in the inundated portion of the foundation area comprise a surface layer of gravelly sand overlying silty sands, which in turn overlie sandy glacial till. The pervious surface layer probably varies in thickness from about one foot at the bay side toe to about 3 feet at the toe of the existing fill material. In view of the nature of the fill material, provisions are made to remove it from the foundation area to provide seepage control and reduce settlement of the embankment. A foundation cut-off is provided to Elevation -4 M.S.L. Excavation for this cut-off can readily be accomplished as a result of the protection provided by the bay side rock-fill toe of the embankment.

h. Stations 44+10 to 53+15. The foundation material is mainly very pervious cinder fill with limited zones of other industrial waste. It is known that in some areas, trenches in this cinder fill were filled with various industrial wastes. A cut-off is provided to form a water barrier through this very pervious cinder fill and these zones of unknown waste materials. The depth of the cut-off trench will vary up to a maximum of about 14 feet. In the vicinity of Station 47+70, the surface of bedrock is at the ground surface.

i. Stations 53+15 to Street Gate Structure No. 2. The foundation area is comprised in part of an existing beach area and in part of an existing gravel parking area. The parking area is about 60 feet wide between the beach and Rodney French Boulevard. The soil in the parking area is mainly silty, gravelly sand containing more than 15 percent silt with zones of cinders. The fill material, which is about 5 feet deep, is retained by a concrete wall and overlies, in general, silty gravelly sand (sandy till-like material) containing more than 15 percent silt. A cut-off is provided through the fill to form a water barrier in the cinders and possibly other pervious fill material.

j. East of Street Gate Structure No. 2. The foundation soil is a gravelly silty sand (glacial till) except possibly in the immediate vicinity of the structure where a thin surface zone of man-made fill exists. In most of the area, excavations were made to obtain earth fill material for previous projects. The man-made fill is gravelly silty sand containing more than 15 percent fines. Considering the impervious nature of all foundation soils and the seepage heads involved, seepage control features are not provided.

58. Harbor Barrier Dike Foundation. The features provided to control seepage through the foundations for the various reaches of the Harbor Barrier Dike are shown on Plate 5-19. In general, seepage control is provided by incorporating a foundation toe drain. The material in the lower portion of the drain termed "Drainage Trench Material" will be concrete fine aggregate to insure that it is as pervious as the soils being tapped by the drain. A layer of filter material with gradation as defined in Paragraph 48 is provided between the drainage trench material and overlying layers of bedding stone and stone protection. The filter material is slightly more impervious than the underlying drainage trench material and, therefore, is not an ideal material. However, it contains a large percentage of gravel sizes and cobbles and should be satisfactory to prevent movement of materials into the overlying rock. The foundation conditions pertinent to seepage control and the details and purposes of the seepage control features are as follows:

a. Stations 0+00 to 7+00. As determined by field reconnaisance and existing open excavations, the foundation soil is mainly an unstratified gravelly silty sand. No special features are provided to control seepage since the foundation soil is uniform and relatively impervious and the height of the embankment is less than 10 feet.

b. Station 7+00 to Street Gate Structure No. 3. The foundation soil is mainly as described above between Stations 0+00 and 7+00, except that some shallow man-made fill exists in the vicinity of the Street Gate Structure. Any fill materials found unsatisfactory for seepage control as revealed by excavations for the Street Gate Structure and rock slope protection, will be removed from the foundation area. A small toe drain with a bottom width of 12 feet is provided since the height of the embankment is greater than 10 feet. This toe drain will be composed of gravel bedding material with gradation as described in Paragraph 49. The toe drain is considered adequate for foundation seepage control since the foundation soils are quite impervious and uniform.

c. Street Gate Structure No. 3 to Station 22+50. The pertinent foundation soils range in general from silty sand to uniform sand without silt content. There are minor zones or lenses of sandy gravel and sands with organics. The soils are in haphazard zones and layers of limited extent. Some of the soils in the foundation area apparently are man-made beach fills. Other soils are those of beach and shore sand deposits. In general, the soils contain more than 10 percent silt content except possibly the upper soils in the vicinity of the ocean side of the foundation areas. Portions of the ocean side of the area are inundated. An ocean side rock toe fill is provided for the full length of the reach to aid in construction and to provide adequate slope protection without excessive excavation. The use of this toe decreases the seepage path through the foundation soils and toe drain to about 2 times the maximum seepage head. A ditch for surface drainage is located along the landside toe of the dike with a bottom grade varying between approximate Elevations +3 and +2 M.S.L. To reduce seepage pressures beneath the toe of the dike and the bottom of the drainage ditch, a foundation toe drain has been provided. This toe drain will extend between 7 and 6 feet below the bottom grade of the drainage ditch. The toe drain is selected in lieu of a foundation cut-off since foundation conditions would permit only a partial cut-off unless a very deep costly one were constructed.

d. Stations 22+50 to 36+70. The foundation area is inundated and adjacent to a surface area within the tidal range. In general, the foundation soils range from clean sands to silty sands. The explorations indicate that the more pervious zones or the tops of more pervious zones are above Elevation -4 M.S.L. A ditch for surface drainage is located at the toe of the dike with bottom elevation at approximately +1 M.S.L. An ocean side rock toe is provided in the embankment for construction purposes. It reduces the path of foundation seepage to about twice the maximum seepage head. To reduce seepage pressures beneath the toe of the dike and the bottom of the drainage ditch, a foundation toe drain is provided. A bottom elevation of -4 M.S.L. for the toe drain was selected to insure that the drain will extend across or into the more pervious zones of foundation sands. This elevation was selected for all other reaches of the dike to permit uniform construction. A toe drain was selected in this reach in lieu of a foundation cut-off since it would be necessary to extend the cut-off to Elevation -10 M.S.L. to insure a complete barrier through the most pervious zones.

e. Stations 36+70 to 45+80. The conditions and design for this reach are similar to those described above for the reach between Stations 22+50 and 36+70, except as stated herein. In this reach, the natural soils of sands and silty sands are generally overlain by thin deposits of organic silts and sands containing organics. Over the entire foundation area, the natural soils were covered with man-made fill composed of ashes and granular soil containing brick, glass and other debris. From visual observations of the site, it is assumed that the fill in the foundation area is free of waste with large voids. In addition to the foundation toe drain, a cut-off which forms a water barrier through the fill material, is provided in this reach.

59. Fairhaven Dike Foundation. The features incorporated into the dike section to control seepage through the foundation are shown on Plate 5-22. The overburden in the foundation area between Stations 2+00 and 25+00 consists of a surface layer of salt marsh organic material, overlying, in general, a layer of silty sand with variable silt and organic content with a bottom depth of less than 6 feet below the ground surface. In general, a zone of relatively pervious medium to fine sand and gravelly sand lies below the silty sand zone. To prevent the development of detrimental seepage pressures at the toe of the dike, a foundation toe drain is provided to a depth of 6 feet. It extends to the underlying relatively pervious zone. The materials in the foundation toe drain will be as described in Paragraph 58 for other drains. Except for a filter blanket beneath the land side toe stone protection, no seepage control features are considered necessary beyond the foundation area between Stations 2+00 and 25+00, since the foundation soil is, in general, non-stratified gravelly silty sand. Where the dike is more than 10 feet in height, the filter blanket thickness is two feet while at other locations, it is one foot thick.

K. EMBANKMENT SETTLEMENTS AND FOUNDATION DISPLACEMENTS

60. General. The settlements due to consolidation of the foundation materials and the quantity of additional embankment materials required as a result of surface foundation soil being penetrated or displaced will vary throughout the project, depending upon the character of the foundation materials, the embankment sections, and the construction methods. Due to the character and variability of the foundation soils and the limited magnitudes of the settlements and the quantity of additional materials required, no computations are deemed warranted. Consequently, all values stated herein are estimates made after considering pertinent factors. Considering the pervious nature of the foundation soils and the limited thicknesses of highly compressible foundation soils, it is concluded that all settlements and displacements will occur during construction and that no provisions are required to compensate for post construction movements.

61. The occurrence of settlements and displacements will require additional material for the construction of the embankments. Since rock type materials of the embankments will be measured for payment on the basis of unit weight, the actual volumes of the additional required rock type materials need not be measured directly. It is estimated that the quantity of additional earth fill material required on the entire project as a result of these settlements and displacements will be less than 2 percent and, therefore, it is planned not to make direct measurement or to apply assumptions for payment measurements.

62. The foundation materials for the Clark Cove Dike, the Harbor Barrier Dike between Stations 0+00 and 36+70 and the Fairhaven Dike are, in general, natural sands, silty sands, cinders and trash fill. No thick layer of very loose surface soils, which might be displaced by construction, exists in the inundated foundation areas. It is anticipated that no foundation settlement or displacement will occur at the ends of the dikes where the dike sections are low and the bases will be on high ground. In other reaches, it is estimated that due to consolidation and displacement of the foundation soils, the average maximum settlement will be less than 3 inches during construction of the earth fills and that the total settlement and displacement at the centerline of the embankment will average less than 6 inches. In these reaches, the lower materials for rock fill and slope protection on the ocean side of the embankments will generally be placed in water and penetration of these materials into the foundation soils is anticipated. In addition, displacement of the foundation soils is anticipated in some reaches. It is estimated that the total settlement, the penetration of the rock type materials into their surface foundation soils and the displacement of the surface layers will be in the order of 12 inches in existing bay and harbor areas and 6 inches in other areas.

63. Harbor Barrier Dike, Stations 36+70 to 45+80. The pertinent foundation materials in the reach of the Harbor Barrier Dike between approximate Stations 36+70 and 45+80 are mainly trash and ashes, varying in thickness up to 10 feet, which overlie natural sandy soils in some areas and a thin layer of organic silt in other areas. In this reach, it is estimated that the total settlement and displacement of foundation materials and penetration of rock materials into the foundation materials in base areas of the ocean side rock fill and slope protection sections may average 2 feet. In the remaining portion of the entire foundation embankment area, no displacement of foundation materials or penetration of embankment materials are anticipated. However, in this portion it is estimated that the maximum average settlement of the foundation soil will be less than 12 inches and that the greater part of this settlement will occur after completion of the earth fill section and during the placement of the various layers of gravel and rock.

64. Harbor Barrier. The foundation soils of the Harbor Barrier east of Station 83+50, within the area of the cofferdam for the Sector Gate Structure, on and in the vicinity of Palmer Island, are sand, silty sand, dense sandy silt and bedrock. It is anticipated that no displacement of foundation soils will occur in these reaches and that settlement due to consolidation of the foundation materials will be

negligible. The foundation soils of the Harbor Barrier in reaches other than stated above consist mainly of sand fill (Bypass Channel Area), clean sands and compact silty sands. With the exception of the Bypass Channel these soils are overlain by a thin layer of very loose or soft silty sand or sandy silt with variable organics content, up to 5 feet but generally less than 18 inches thick. The additional embankment materials required in these reaches will be due to (a) the consolidation and displacement of the surface layer of loose material, (b) the penetration of rock materials into the loose surface layer, (c) the consolidation of the dumped fill in the Bypass Channel area, and (d) the consolidation of the zones of natural loose and soft soils, containing organics and organic silt within the limits stated below. The extent to which penetration, consolidation and displacement will occur cannot be determined on the basis of available data. In the embankment reach between the Bypass Channel and the east side of the cofferdam and in a reach of about 100 feet to the east of the Bypass Channel there exists a soft stratified zone of silty fine sand and organic silt between approximately -20 and -30 M.S.L. Computations indicate that the maximum settlement due to consolidation of this stratified zone will be on the order of 12 inches in locations where the zone is about 10 feet thick. The consolidation test data shown on Plate 5-26 were assumed to be applicable to the computations. The actual settlements in the foundation area that will occur due to the consolidation of this zone cannot be determined due to the wide variation in soil conditions. Considering the soil conditions in all reaches of the Harbor Barrier covered by this paragraph, it is expected that the average settlement, displacement and penetration of the initially placed materials of the rock-fills and armor stone may be as great as 2 feet and of the dumped earth fill as great as 12 inches.

L. EMBANKMENT STABILITY

65. General. Consideration was given in the selection of sections and certain provisions were made to insure that the embankments will be stable from the standpoint of shear failure. The outer portions of the embankments consist of relatively large sections of rock and gravel materials which permit the use of steeper exterior slopes. These slopes were selected on the basis of stability and economy of the outer protection materials. In general, the pertinent foundation soils for the embankments consist of sands, silty sands and granular type fill materials. These materials have a sufficient angle of internal friction to insure against a foundation shear failure for the selected embankment sections. In the bay and harbor areas where a surficial layer of very loose or soft silty sand or sandy silt exists, rock toes are provided. These will assure ample stability. It is anticipated that any surficial material that does not have initial adequate strength to insure against a foundation shear failure will either be (a) penetrated by the rock fill material and armor stone, (b) displaced during construction of the rock fill sections, or (c) adequately consolidated as construction progresses to produce the required strengths.

66. The special provisions planned to insure stability in certain reaches are as follows:

a. The surface layer of the salt water marsh deposit in the foundation area of the Fairhaven Dike will be stripped.

b. In portions of the foundation area of the Harbor Barrier Dike, between approximate Stations 36+70 and 45+80, there exists a zone of soft organic silt and soils containing organics, underlying recently placed fill. This zone apparently is the remains of a surficial deposit of a previous salt marsh area. To insure ample consolidation of this zone, the construction of the embankment above Elevation -12 M.S.L. will be deferred for a period of 2 months. If the embankment in this reach is not stable, signs of movement will occur during the construction period.

c. Between Stations 45+80 and 50+00 of the Harbor Barrier, there exists a surficial deposit of very loose or soft silty sand or sandy silt containing minor quantities of organics. This material will have ample strength to withstand the imposed stresses providing it is amply consolidated during construction. To insure that no failure will occur during construction, construction of the embankment above Elevation +4 M.S.L. will be deferred for a period of 60 days.

d. Foundation soils of low shear strength immediately east of the Sector Gate Structure will be removed within the cofferdam area above Elevation -30 M.S.L. prior to the placement of earth fill within the cofferdam.

67. Harbor Barrier in Vicinity of Bypass Channel. Analyses were made to determine the stability of the embankment section at Station 77+50 of the Harbor Barrier which is considered most critical for the embankment reach between the Bypass Channel fill and the east side of the cofferdam for the Sector Gate Structure and for a reach of about 100 feet to the east of the Bypass Channel fill. In this area, there exists a soft stratified zone of silty fine sand and organic silts approximately between Elevations -20 and -30 M.S.L. between zones of sands, silty sands, and silts as indicated by Borings Nos. FD-26, FD-81, FD-82, FD-83 and FD-88. The zone is variable both in characteristics and thickness. The soils with the least strength and the greatest thickness occur in the north portion of the foundation area. The characteristics of these weakest soils are considered equal to those of the undisturbed samples from Boring FD-92. The results of shear tests and consolidation tests made on samples from Boring FD-92 are shown on Plate 5-26. The results of shear and consolidation tests on samples of variable sandy silts (ML) from Boring FD-91 are also shown on this Plate. These results are not applicable to the analyses of the embankment as they represent more rigid soils lying below the pertinent zone of soft foundation soils.

68. The upstream and downstream slopes were analyzed for the construction condition. The analyses, results, and data used are shown on Plate 5-29. These results show that the minimum factor of safety for the harbor side, based on the results of Q-Tests is 1.36. This factor of safety for the harbor side, where the weakest foundation soils exist, is considered ample and insures that this slope will be stable under

all conditions. The factor of safety for the ocean side, based on Q-Tests is 1.19, which is considered ample since the foundation conditions are considerably more favorable than assumed in the analyses. However, to insure greater stability during the construction period, the construction of the embankment above Elevation +4 M.S.L. will be deferred for a period of 30 days, during which time the strength of the weak soils will increase by consolidation. Considering the actual soil conditions, the soil assumptions used in the analyses, and the results of the analyses, the factor of safety for the ocean side slope will be greater than 1.33 after consolidation.

69. East Portion of Cofferdam Area. The zone of low strength foundation soils described in the above, apparently extends into the area toward the Sector Gate Structure. If the east wall of the cofferdam is located west of Station 77+00 provisions will be made during construction to provide a layer of sand over the low strength material to the east of the cofferdam to provide conditions similar to those used in the analyses of the section at Station 77+50.

70. It is anticipated that the low strength foundation soil will be removed in the foundation areas for cellular type cofferdam construction. However, if it is not, the zone should consolidate sufficiently under the cofferdam loads to provide ample strength.

71. Embankments Adjoining Sector Gate Structure. The east and west wrap-around embankment sections for the Sector Gate Structure are shown on Plate 5-20 and have side slopes of 1 on 2. All of the earth fill in these sections placed within the cofferdam will be compacted in accordance with guide specifications for earth dams. The foundation soils of these sections are variable ranging from compact gravelly silty sand (glacial till) to compact stratified silt. The existing soils above Elevation -30 M.S.L. within the foundation and cofferdam areas to the east of the structure will be excavated to insure the removal of the deposits of low strength soils described in Paragraph 68 above. The compact, stratified silt deposit is considered the most critical from the standpoint of stability. The material in this deposit is mainly compact, nonplastic, sandy (fine) silt, interspersed with layers of silty fine sand. Based on examination of undisturbed samples taken from Boring FD-91 the sandy silt soil contains from 10 to 30 percent by weight of fine sand particles and the silty fine sand contains 25 to 45 percent by weight of silt particles. The sand strata vary in thickness from 1/4-inch to 12-inches. Undisturbed sample UC-3 from Boring FD-91 of this material was tested and results of shear tests are shown on Plate 5-26. It is concluded from a study of all exploration data and these test results that the foundation soils for these wrap-around sections will have an angle of internal friction of at least 33 degrees which is sufficient to provide an ample factor of safety against shear failure for these reaches of the embankment.

M. MISCELLANEOUS EARTHWORK

72. Bypass Channel. The construction of the Bypass Channel requires the hydraulic dredging of approximately 651,000 cubic yards of material measured in place to the neat lines. For two feet over depth the quantity

would be increased to 730,000 cubic yards. The location and widths of the channel are shown on Plates 5-2 and 5-15. The channel is approximately 4500 feet long with widths varying from 150 to 350 feet. The channel will have bottom neat line grade at -32 M.S.L. and excavation side slopes of 1 on 3. The types and distribution of the soils in the Bypass Channel area are described in Paragraph 16. To provide mixing of the soils as stated in Paragraph 32, the excavation will be made to the full depth in one operation. All materials from the Bypass Channel excavation will be placed hydraulically in stock piles as stated Paragraph 32 in a manner which will produce mixing of the materials during stock pile excavation operations. Channel excavation side slopes of 1 on 3 were selected in accordance with the usual practice in this coastal area where underwater dredging is required for this type of material. Provisions will be made for the maintenance of the proposed full depth and width of the channel during its use. Some of the soils in the finished side slopes will be non-plastic silt with 5 to 30 percent fine sand particles, and silty fine sand. These soils may be sufficiently sensitive to vibration so that slides may occur during the driving of piling for the Sector Gate Structure in portions of reaches where zones of these materials exist.

73. Sector Gate Structure. The design details as well as construction of the cofferdam, including the stability of the earth slopes required for the excavation to bedrock for the Sector Gate Structure will be the responsibility of the Contractor. The types and distribution of the materials in the excavation and cofferdam areas are as described in Paragraph 17. Detailed descriptions of the undisturbed samples taken from the silt zone are given in Paragraph 71. Since there is a possibility that the soils in the silt zone will become unstable during the driving of piling for the cofferdam, the contractor will be alerted to this effect in the specifications. The material excavated will be spoiled in areas provided by the contractor, except as stated in Paragraph 17.

74. Maintenance Area No. 1. Maintenance Area No. 1 to be located at the west end of the Harbor Barrier will require the construction of a fill up to 22 feet in height. The foundation material consists of beach sands, man-made sand fill, and fill up to a depth of 10 feet of cinders, bricks and debris. The fill material for the maintenance area will be sands and silty sands obtained from portions of the excavations required for the Harbor Barrier Dike as stated in Paragraph 36, and silty sands from the hydraulically placed stock pile on the New Bedford shore. All fill material for the maintenance area will be compacted using heavy rollers.

75. Maintenance Area No. 2. The construction of Maintenance Area No. 2 at the east end of the Harbor Barrier will require both excavation and the placement of earth fill. The earth fill material will be obtained from the excavation for the Harbor Barrier between Stations 83+65 and 86+00. This material is mainly beach sands and gravels containing little or no fines and is considered too pervious for use in the higher portions of the embankments. The fill material will be compacted as required for the earth fill in the adjoining dike.

N. CONCRETE STRUCTURES - EARTH FOUNDATIONS AND SEEPAGE CONTROL

76. Pumping Station. The Pumping Station will be constructed at the toe of the Clark Cove Dike at approximate Station 18+12. The structure is approximately 32 feet wide and 62 feet long with a foundation elevation of about -12.5 M.S.L., exclusive of exterior intake and discharge chambers. The foundation materials for the structure are indicated by the data of Borings FD-123, FD-124, and FD-125 shown on Plate 5-11. The elevation of top of bedrock in the area varies between -18 M.S.L. and -24 M.S.L. In general, the foundation below Elevation -12.5 M.S.L. consists of a loose to moderately compact silty, fine to medium sand layer, about six inches thick. This layer overlies glacial till which extends to bedrock. The glacial till consists of compact to moderately compact gravelly silty sands. The soils below Elevation -12.5 M.S.L. are considered adequate for the foundation of the structure. No special provisions are considered necessary for foundation seepage control.

77. Street Gate Structure No. 1. The design details for Street Gate Structure No. 1, which will be included in Design Memorandum No. 7, "Detail Design, Walls and Miscellaneous Structures", will be similar to those for Street Gate Structure No. 2. The overburden and fill materials in the area of the structure are indicated by the data of Borings FD-100 and FD-107 on Plate 5-11. Much of the material above approximate Elevation +1 M.S.L. consists of man-made fill of silty gravelly sand and gravelly sand containing cobbles and boulders. At the eastern edge of the foundation area, there exist blocks of rock of previous riprap which were buried by the placement of more recent fill toward the bay area. Below about Elevation +1 M.S.L., the overburden is compact glacial till or till-like material consisting of gravelly silty sand and silty sandy gravel. At the present time, the final design for the structure is not completed. Due to the unknown nature of the man-made foundation fill material and type of structure, it will be either placed on steel H-piling or founded on material within the firm soil zone below the man-made fill. The material in the firm soil zone is considered adequately stable for the foundation of the structure. No special provisions will be required for seepage control if the structure is founded on earth. If the structure is placed on piles, a steel sheet pile cut-off will be provided above Elevation +1 M.S.L. to control seepage through the man-made fill and to prevent detrimental seepage between the base and the underlying soil.

78. Street Gate Structure No. 2. The design details for Street Gate Structure No. 2 will be included in Design Memorandum No. 7. The overburden and fill materials in the area of the structure are indicated by the data of Boring FD-126 and FD-127 on Plate 5-11. Above elevations about +1 M.S.L. at FD-126 and +4 M.S.L. at FD-127, the material is man-made fill composed of moderately compact silty gravelly sand. Below these elevations, the foundation soil is compact glacial till composed mainly of silty gravelly sand with about 30 percent fines. Due to the existence of high quality stable fill material, the foundation elevations for the structure were set in the fill zones. The thickness of the fill below the base varies from about 1 to 5 feet. The fill and the underlying

till are considered very competent as foundation soils for the structure. No special provisions are considered necessary for foundation seepage control.

79. Street Gate Structure No. 3. The design details of Street Gate Structure No. 3 will be similar to those for Street Gate Structure No. 2 and will be included in Design Memorandum No. 7. The overburden and fill materials in the area of the structure are indicated by the data of Borings Nos. FD-119 and FD-118 on Plate 5-8. Most or possibly all of the soil above about Elevation +2.0 M.S.L. is man-made fill. In general, this fill material is medium to fine sand and gravelly silty sand with various amounts of organics, shells and cinders. Below this fill material exists a layer, about 2 feet thick, of moderately pervious silty gravelly sand containing about 11 percent silt particles. Below approximate Elevation 0.0 M.S.L. the overburden soil is compact gravelly silty sand (glacial till) containing from 30 to 45 percent fines. Bedrock in the area is at approximate Elevation -15 M.S.L. The final design of the structure is not completed. The fill material is considered unsuitable for a foundation for the structure. The structure will be founded on piles or in the glacial till zone which is considered as a competent foundation material. Provisions for foundation seepage control will be as described in Paragraph 77 for Street Gate Structure No. 1.

80. Gated Conduits Nos. 1 and 2. The design details of the Gated Conduits to be constructed at Stations 47+61 and 57+64 of the Harbor Barrier will be included in Design Memorandum No. 7, "Detail Design, Walls and Miscellaneous Structures". Conduit No. 1 has an invert Elevation of -7.0 M.S.L. and a foundation Elevation of -8.5 M.S.L. The Gate Structure for Conduit No. 1 has a foundation Elevation of -10.0 M.S.L. The corresponding grades for Conduit No. 2 are one foot lower than those stated above. The pertinent soils in the foundation areas are indicated by the data of Borings Nos. FD-7 and FD-4 shown on Plate 5-8. Both of these borings indicate the top of a moderately compact till-like or till zone at about Elevation -12 M.S.L. In general, the material in this zone which extends at least to Elevation -25 M.S.L., is a brown gravelly silty sand containing about 25 percent fines. Immediately above the till or till-like zones there are deposits, a few feet thick, of either gravelly silty sand with about 10 percent silt, or sandy gravel. At the location of the borings, the top of these zones are at about Elevation -10.0 M.S.L. Above these deposits are zones, a few feet thick, of very loose or soft organic silts or fine to medium sand containing shells. Final designs of the conduit are not completed. In the areas of the earth fill sections, provisions will be made to found the conduits on piling or on the compact gravelly silty sand and the upper sand and gravel layers containing less than 10 percent fines. In the rock toe embankment section areas, the structure will be founded directly on the soil below the surficial deposits of soft and loose material, or on piling, or on a concrete slab extending below the top of the compact silty sand zone. Detailed explorations to determine the exact foundation conditions throughout the length of each structure were not performed. If the structure is to bear directly on the foundation soil, it may become necessary to excavate soft material inside the cofferdam after dewatering and to backfill with concrete.

The silty gravelly sand or silty sandy soils are considered satisfactory for the foundation of these structures and for piling resistance.

81. Twin Barrel Concrete Box Culvert. The design details of the Twin Barrel Concrete Box Culvert to be constructed in the drainage ditch area between Maintenance Area No. 1 and the west end of the Harbor Barrier will be included in Design Memorandum No. 7 "Detail Design, Walls and Miscellaneous Structures". The culvert has a top elevation of +20 M.S.L. and will be about 50 feet wide with an invert elevation at 0.0 M.S.L. Explorations were not made at the location of this structure to determine foundation conditions. On the basis of subsurface data of the two nearest Borings Nos. FD-46 and FD-70, it is expected that the material in the foundation area above about Elevation -7.0 M.S.L. is man-made fill composed of ashes, cinders, debris and varying quantities of earth. Below the man-made fill, there are deposits of alluvial sands and silty sands which probably overlie glacial till or till-like soils. Based on data of all explorations in the vicinity there is a possibility that a thin zone of organic silt or soil, containing organics, may exist immediately below the man-made fill. The final design of this structure is not completed. The base will be either on wood piling or on firm natural soil.

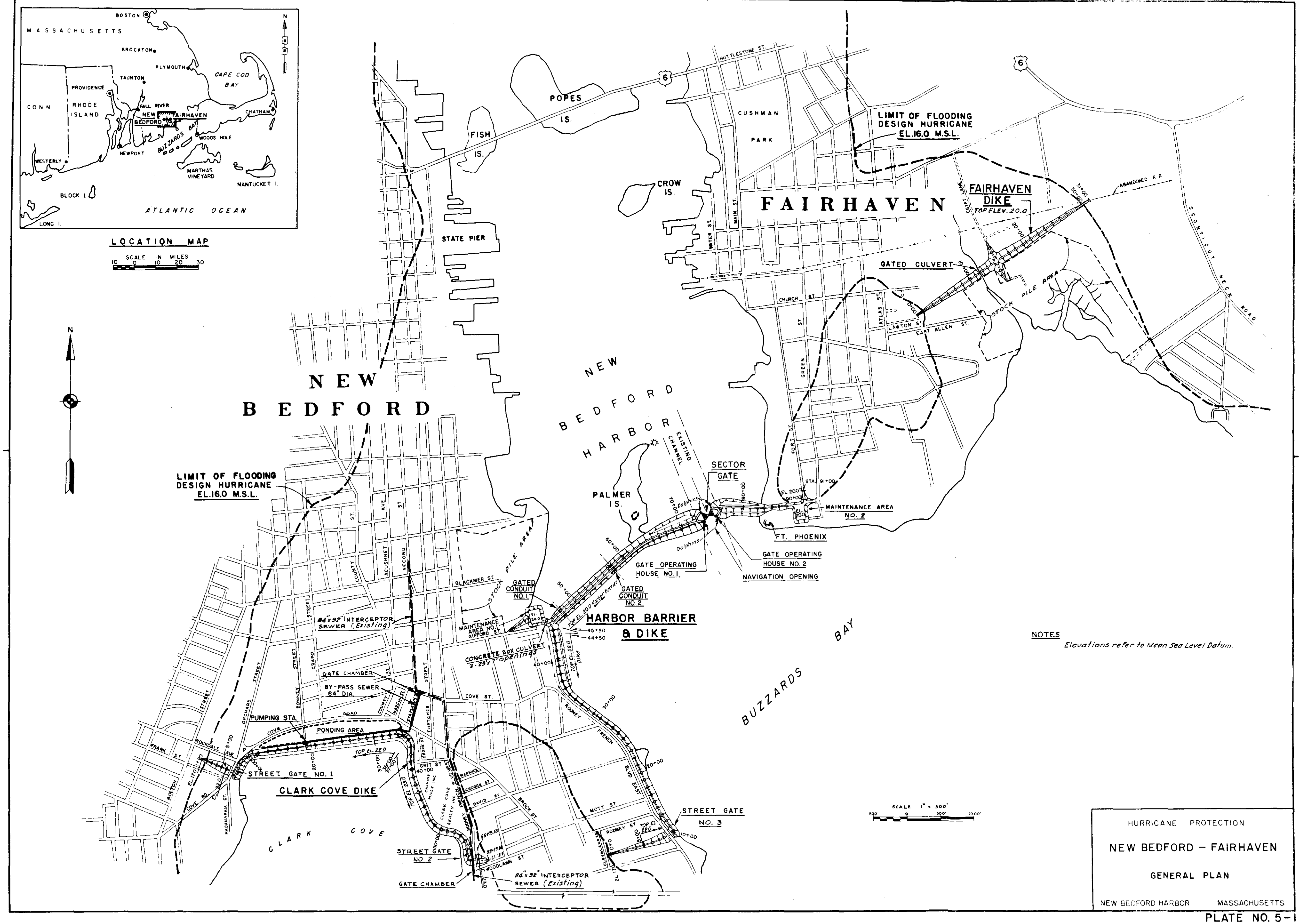
82. Gated Culvert. The design details of the Gated Culvert Structure, to be constructed in the foundation area of the Fairhaven Dike at approximate Station 12+00, will be included in Design Memorandum No. 7 "Detail Design, Walls, and Miscellaneous Structures". The conduit will be made of reinforced concrete pipe with 4 feet inside diameter and with an invert elevation varying from -1.0 to -0.5 M.S.L. The foundation soils are indicated by the data for Boring FD-63, shown on Plate 5-12. The surface layer is a salt marsh deposit of muck and material containing organics. Below the surface layer are deposits of sands and silty sands which overlie a glacial till deposit. The conduit and base of the gate structure will be founded on the sands below the surficial salt water marsh deposit. Only minor differential settlement is anticipated.

O. EARTHWORK QUANTITIES

83. The estimated quantities of materials from required excavation to be utilized in the construction and to be wasted are shown on Plate 5-31. The quantities of material to be used in the structures are based on the information given in Section H. It is planned to stock-pile all material excavated from the Bypass Channel. The Government will specify the quantity in each stock pile after the Contractor's plan of operation becomes known. The exact quantities required from the stock piles depend on many factors including settlement, displacement, losses during storms, losses in stock pile foundation areas, accuracy of surveys, tolerances used in construction and the Contractor's plan of operation. It is anticipated that all or most of the excess material in the stock piles may be spread and left in the stock pile areas. The maximum quantities that can be left depend on the final agreements with the land owners.

84. Computations based on available topographical data and neat lines of the embankment sections indicate that there will be available about 20 percent additional material in the stock piles to compensate for settlement, foundation displacement, shrinkage, overexcavations, incorrect

topography, more stripping than assumed, losses due to storms and in transportation. Immediately prior to the bidding period, detailed surveys will be made in underwater areas to obtain up to date topographic data upon which recomputed quantities of excavation and fill will be based. If it is determined that there is insufficient material from the required excavation outlined in Part H to insure that no borrow will be required, further consideration will be given to the use of other materials from the required excavation in some of the other areas.



HURRICANE PROTECTION

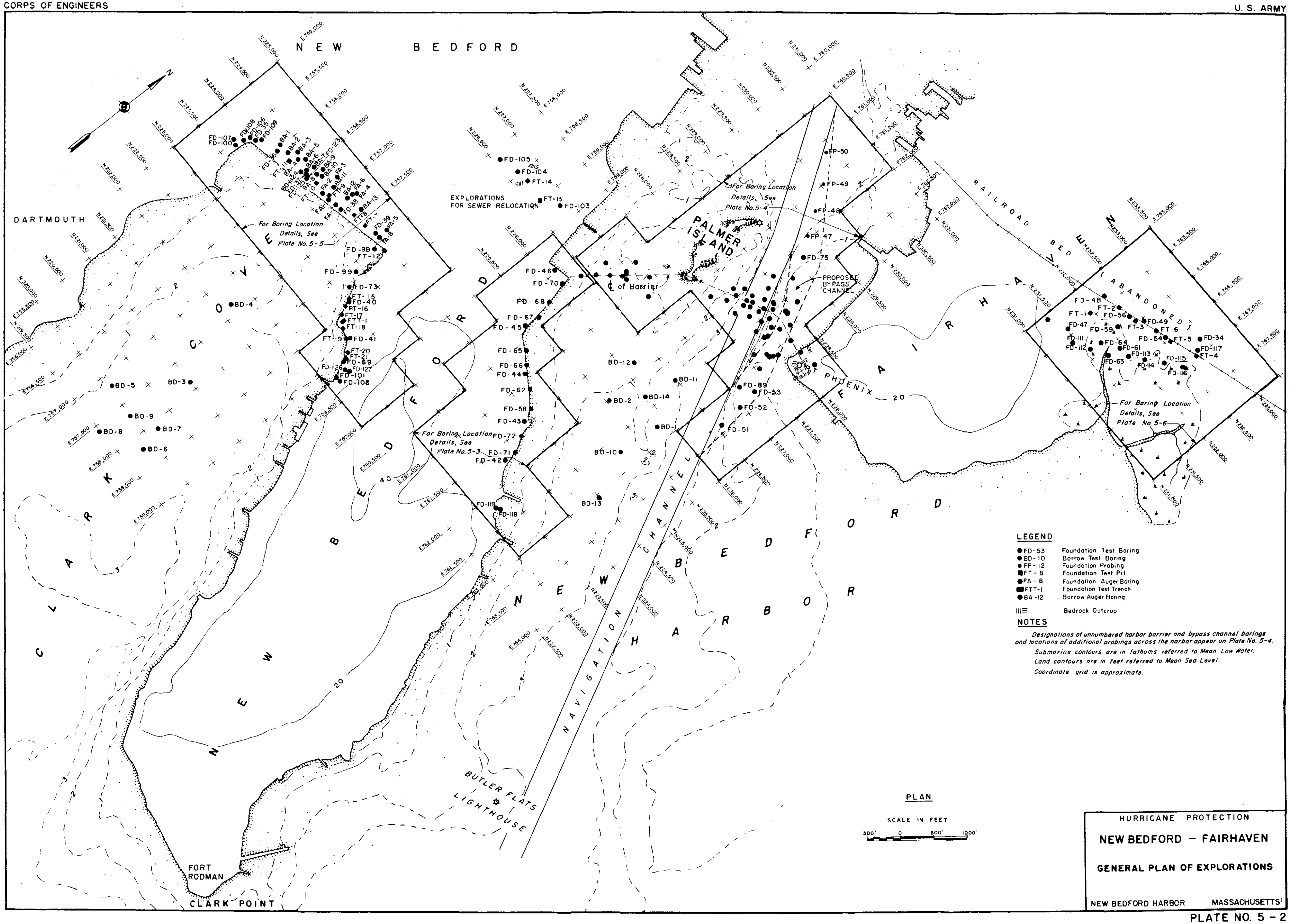
NEW BEDFORD – FAIRHAVEN

GENERAL PLAN

NEW BEDFORD HARBOR MASSACHUSETTS

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

●FD-53	Foundation Test Boring
●BD-10	Borrow Test Boring
•FP-12	Foundation Probing
■FT-8	Foundation Test Pit
●FA-8	Foundation Auger Boring
▬FTT-1	Foundation Test Trench
●BA-12	Borrow Auger Boring
III☰	Bedrock Outcrop

NOTES

Designations of unnumbered harbor barrier and bypass channel borings and locations of additional probings across the harbor appear on Plate No. 5-4.

Submarine contours are in fathoms referred to Mean Low Water.

Land contours are in feet referred to Mean Sea Level.

Coordinate grid is approximate.

PLAN

SCALE IN FEET

500' 0 500' 1000'

HURRICANE PROTECTION

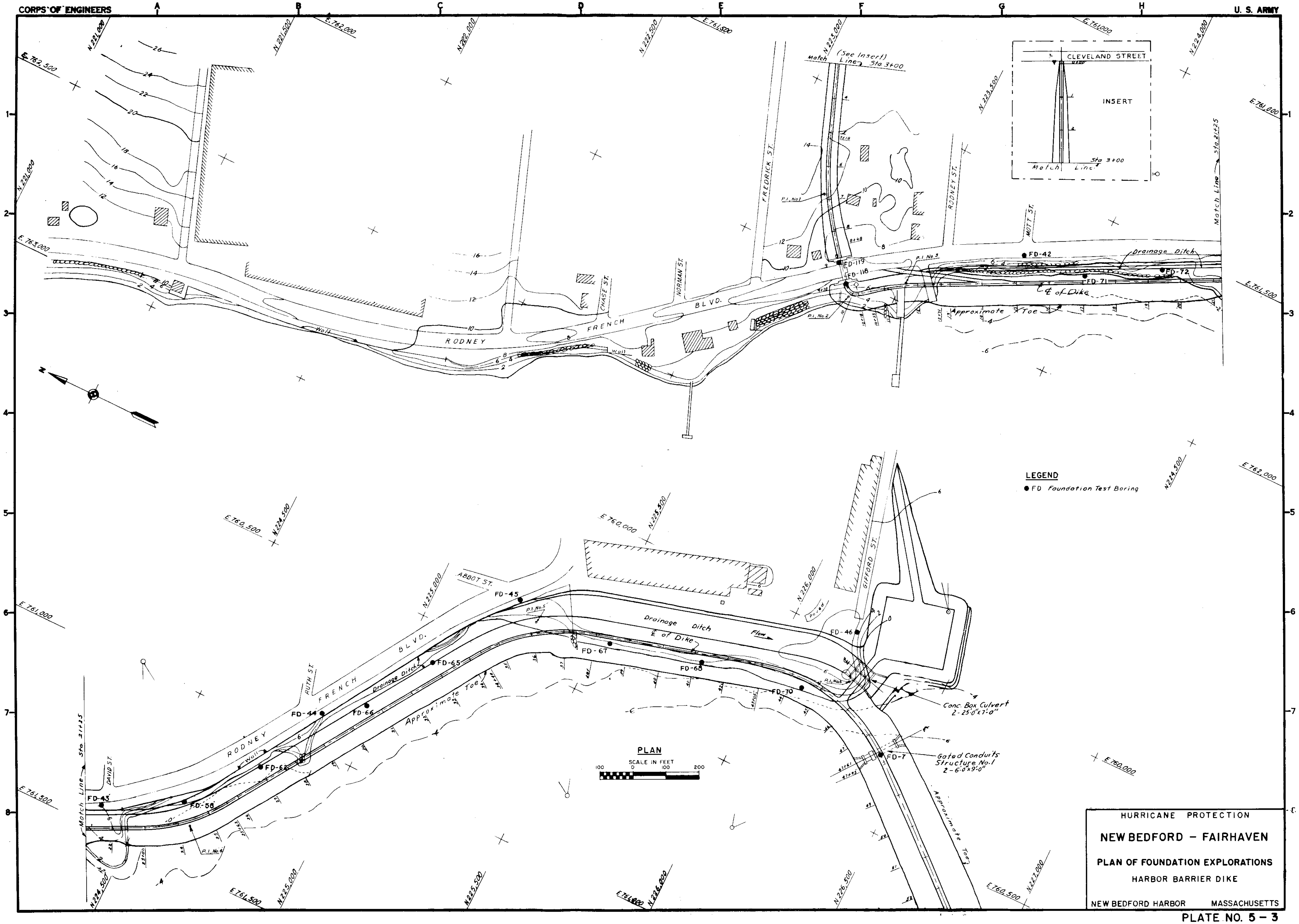
NEW BEDFORD – FAIRHAVEN

GENERAL PLAN OF EXPLORATIONS

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5 – 2

CORPS OF ENGINEERS **U. S. ARMY**



HURRICANE PROTECTION

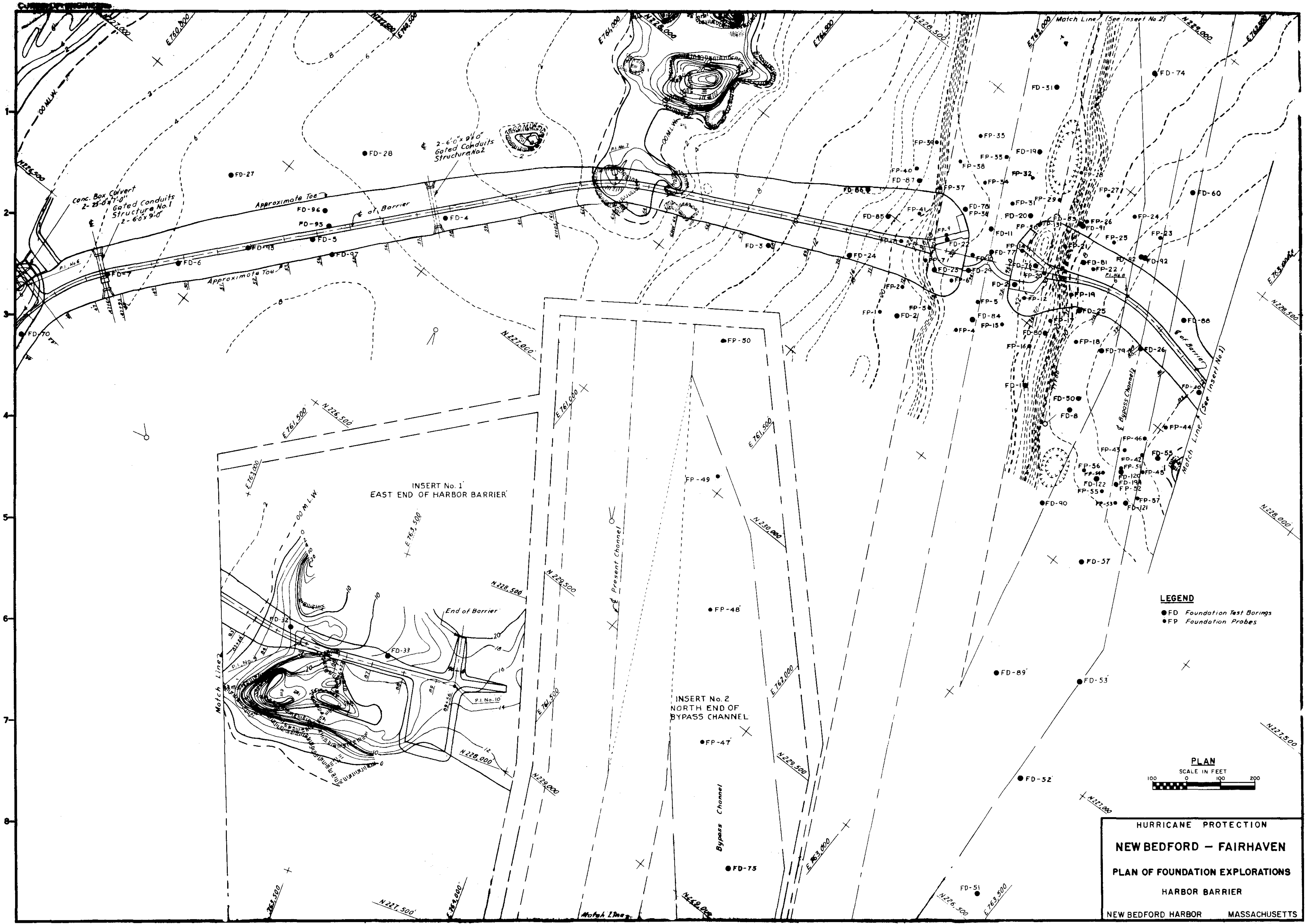
NEW BEDFORD – FAIRHAVEN

PLAN OF FOUNDATION EXPLORATIONS

HARBOR BARRIER DIKE

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5 – 3



HURRICANE PROTECTION

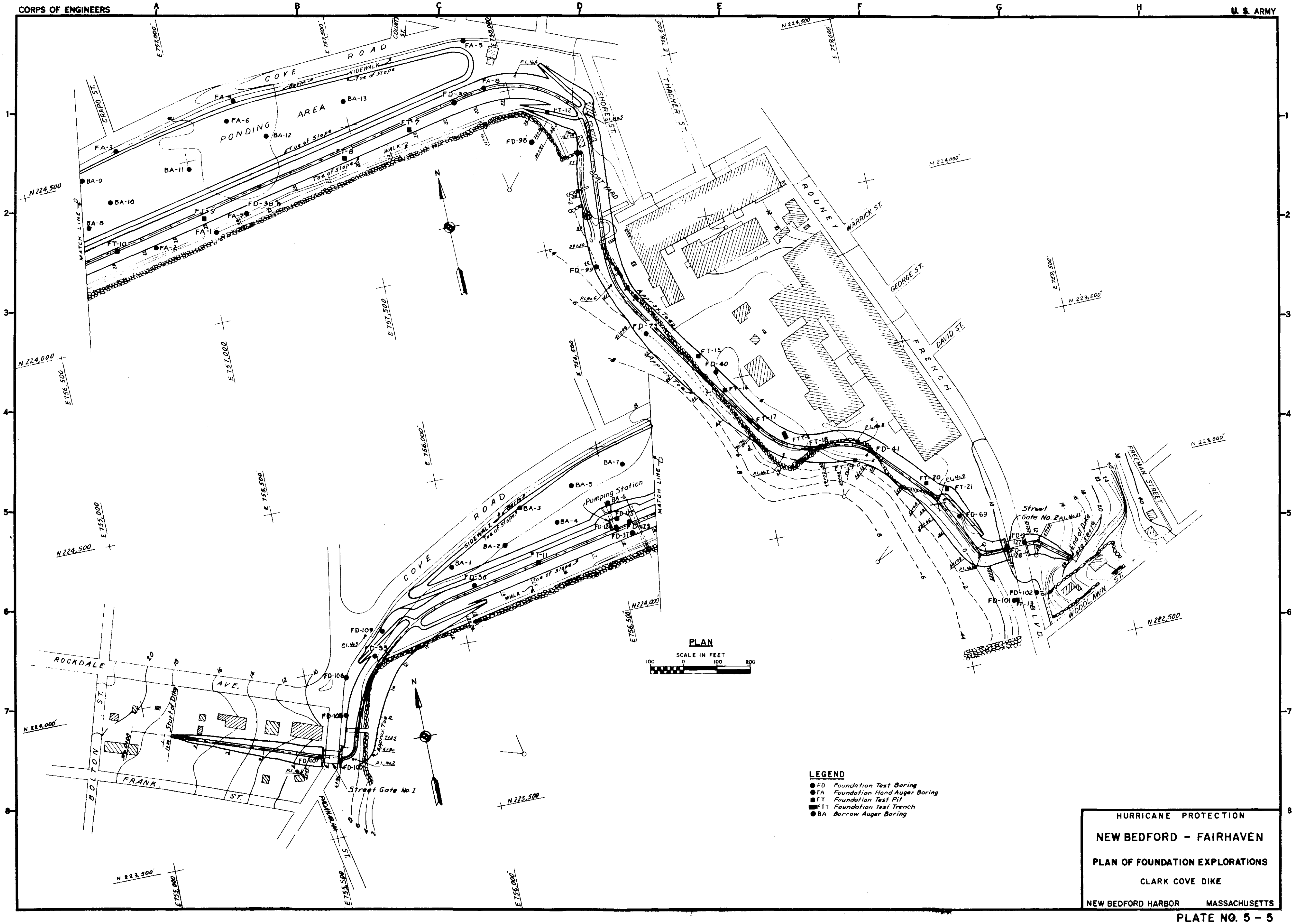
NEW BEDFORD – FAIRHAVEN

PLAN OF FOUNDATION EXPLORATIONS

HARBOR BARRIER

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5 – 4



HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

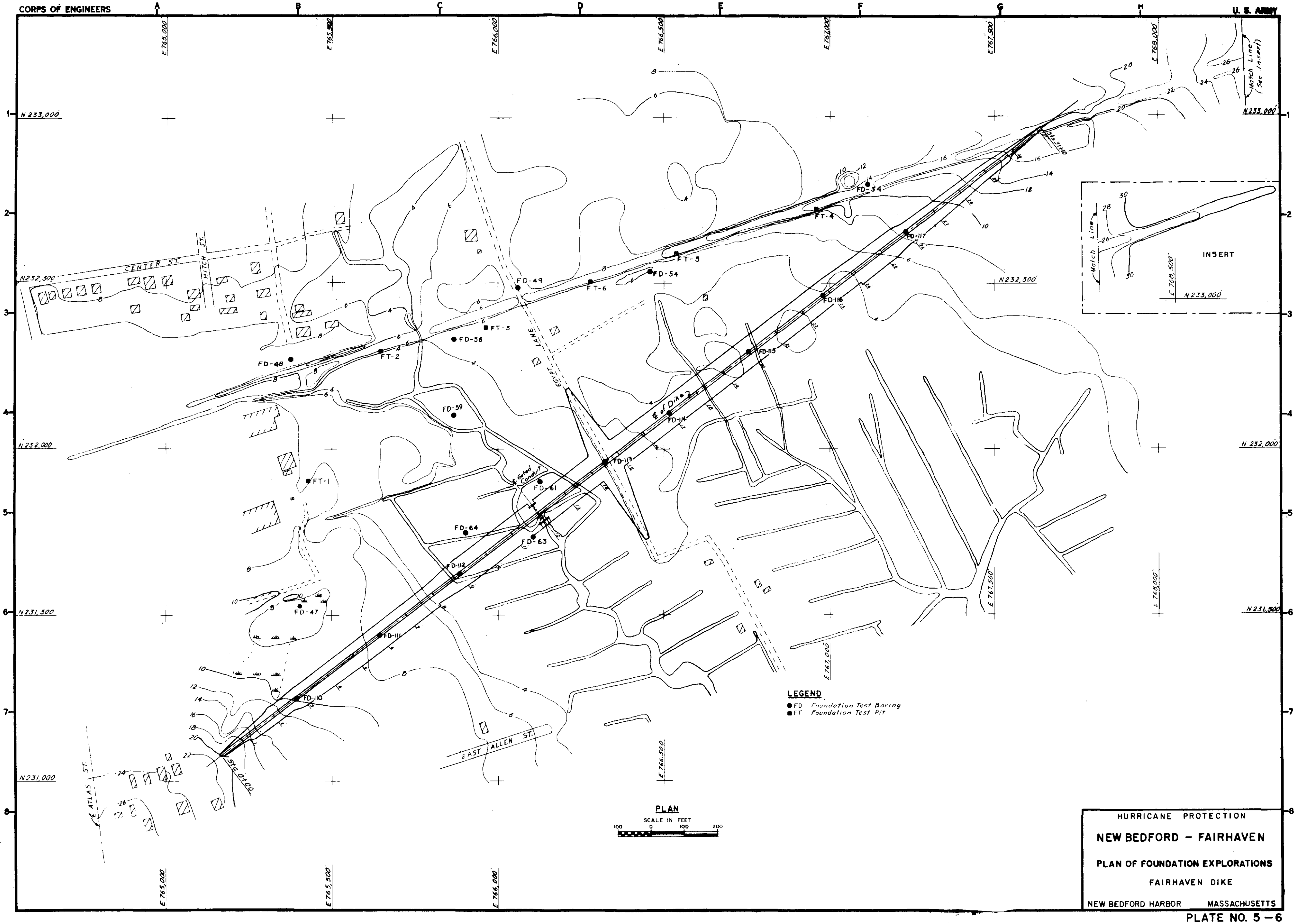
PLAN OF FOUNDATION EXPLORATIONS

CLARK COVE DIKE

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5 - 5

CORPS OF ENGINEERS U. S. ARMY



LEGEND

● FD Foundation Test Boring

■ FT Foundation Test Pit

HURRICANE PROTECTION

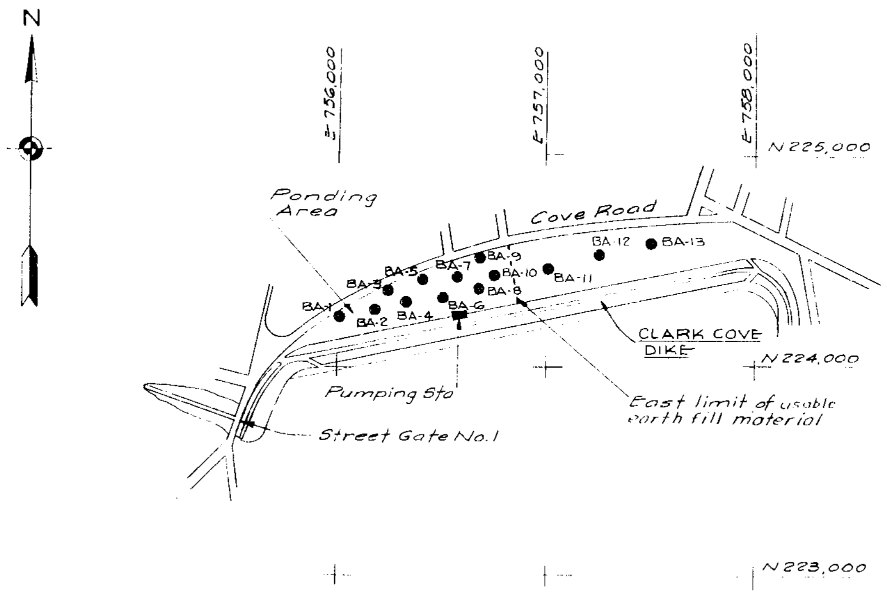
NEW BEDFORD - FAIRHAVEN

PLAN OF FOUNDATION EXPLORATIONS

FAIRHAVEN DIKE

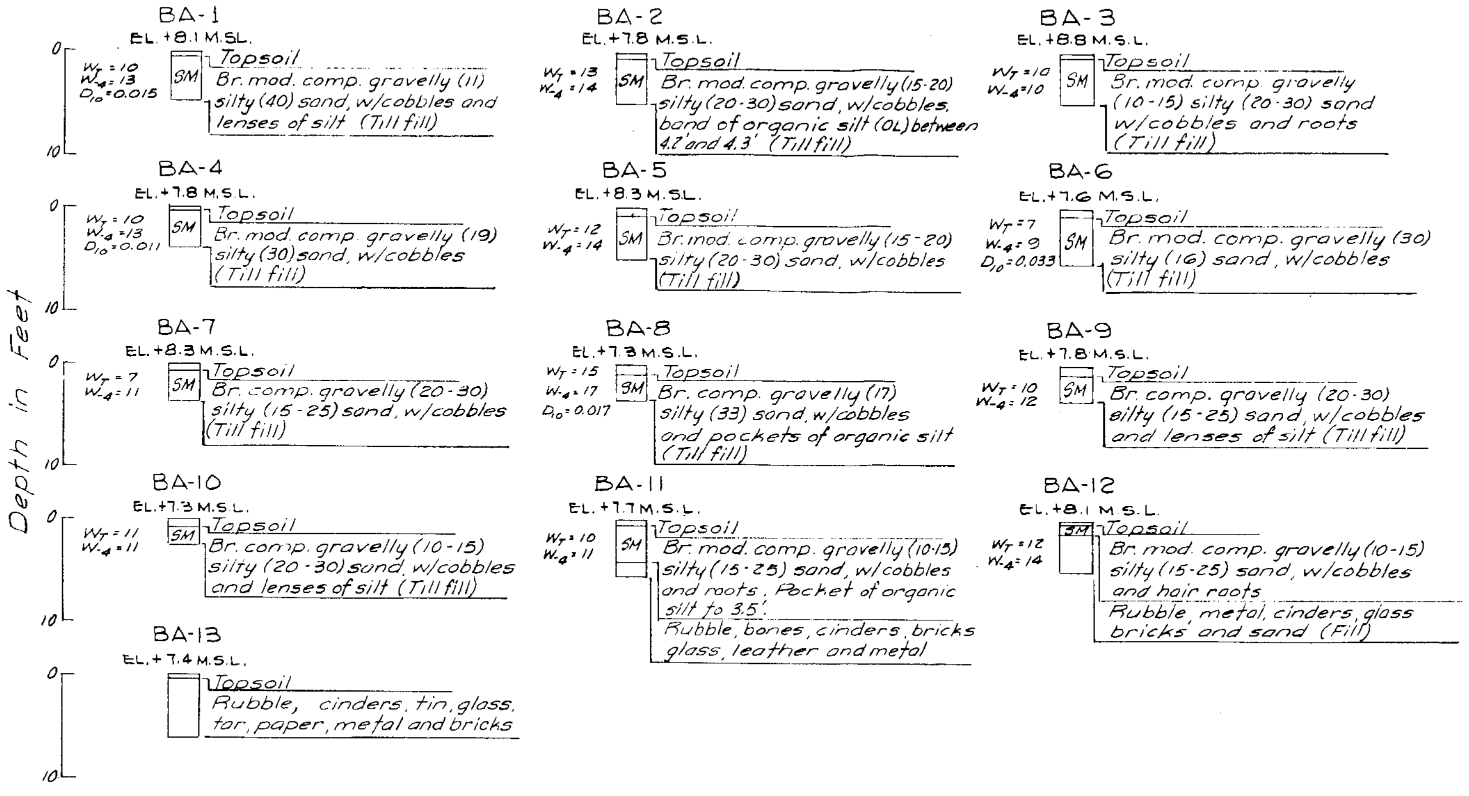
NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-6



AREA EXPLORED FOR EARTH FILL MATERIAL

SCALE IN FEET
500' 0 500 1000



LEGEND

● BA Borrow Test Auger

ω_T Moisture content determined on total sample.

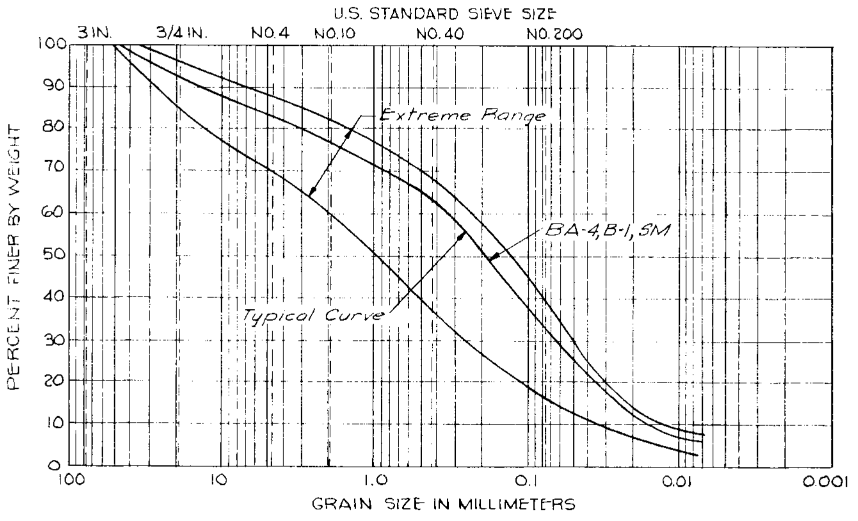
ω_{-4} Moisture content determined on portion of sample passing No. 4 sieve.

NOTE

For Legend of Engineering Logs, see Plate No. 5-11

BORING NO.	SAMPLE NO.	DEPTH IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS				NATURAL WATER CONTENT	
				GRAVEL %	SAND %	FINES %	D_{10} mm	ω_T	ω_{-4}
BA-1	J-1R	0.6-4.6	SM					10	13
	B-1	0.6-4.6	SM	11	49	40	0.015		
BA-2	J-1R	0.4-4.8	SM					13	14
BA-3	J-1R	0.6-5.1	SM					10	10
BA-4	J-1R	0.3-4.2	SM					10	13
	B-1	0.3-4.2	SM	19	51	30	0.011		
BA-5	J-1R	0.8-5.1	SM					12	14
BA-6	J-1R	0.7-5.4	SM					7	9
	B-1	0.7-5.4	SM	30	54	16	0.033		
BA-7	J-1R	0.8-3.5	SM					7	11
BA-8	J-1R	0.9-3.4	SM					15	17
	B-1	0.9-3.4	SM	17	50	33	0.017		
BA-9	J-1R	0.9-3.6	SM					10	12
BA-10	J-1R	0.8-2.7	SM					11	11
BA-11	J-1R	0.6-4.2	SM					10	11
BA-12	J-1R	0.4-1.6	SM					12	14

SUMMARY OF TEST DATA



GRADATION RANGE

HURRICANE PROTECTION

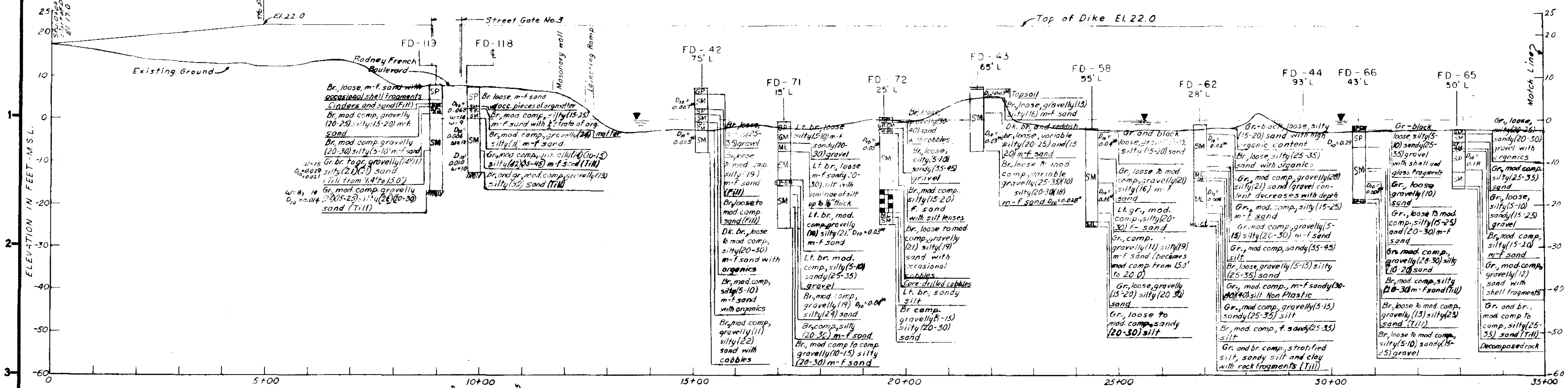
NEW BEDFORD - FAIRHAVEN

PLAN OF EXPLORATIONS AND SUMMARY
OF TEST DATA

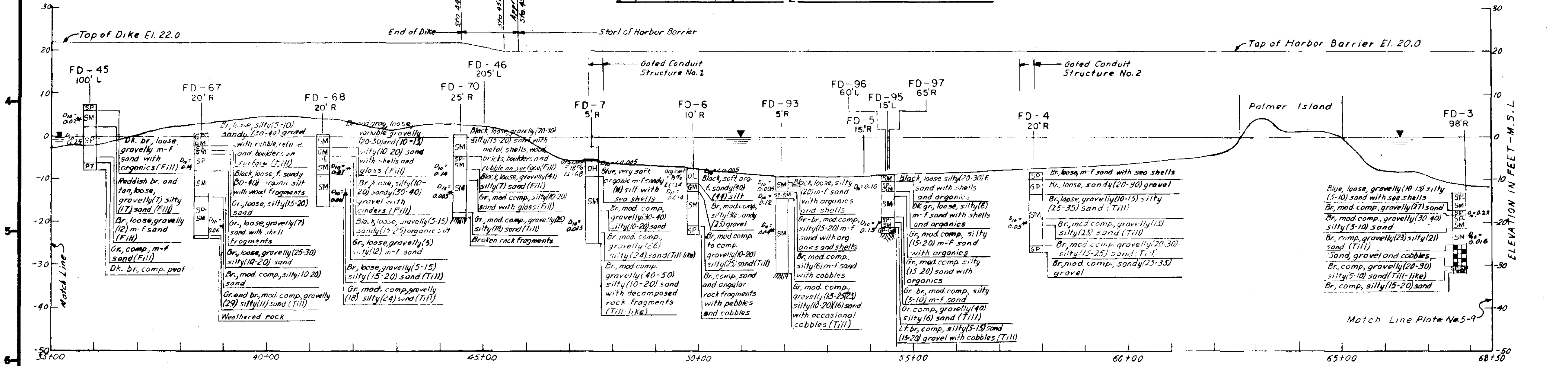
PONDING AREA

NEW BEDFORD HARBOR, MASSACHUSETTS

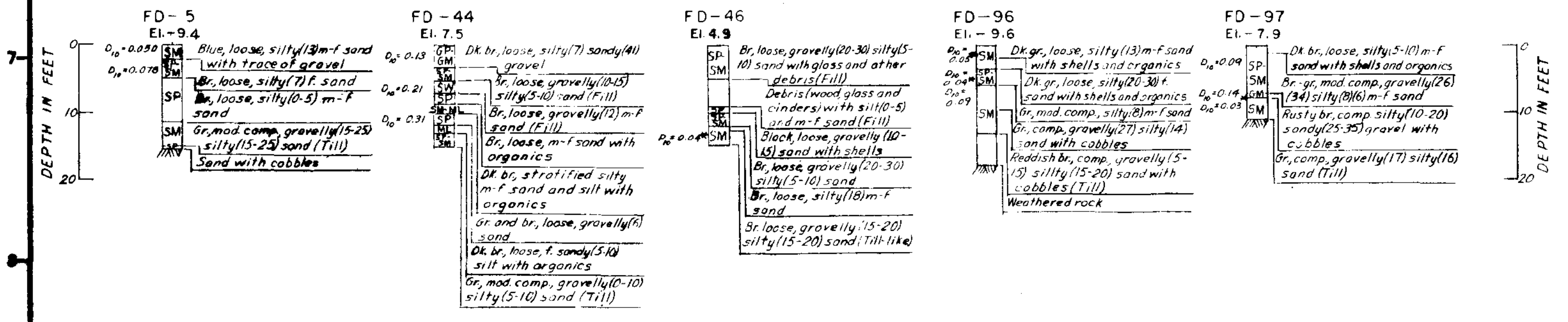
PLATE NO. 5-7



LOG PROFILE NO. 1, ALONG ¢ OF DIKE AND HARBOR BARRIER



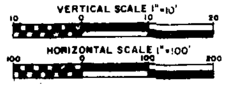
LOG PROFILE NO. 1, ALONG ¢ OF DIKE AND HARBOR BARRIER (CONTINUED)



NOTES

For location of explorations, see Plates Nos. 5-2, 5-3, 5-4

For legend of engineering logs, see Plate No. 5-11



HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

ENGINEERING LOG PROFILE NO. 1

HARBOR BARRIER AND DIKE

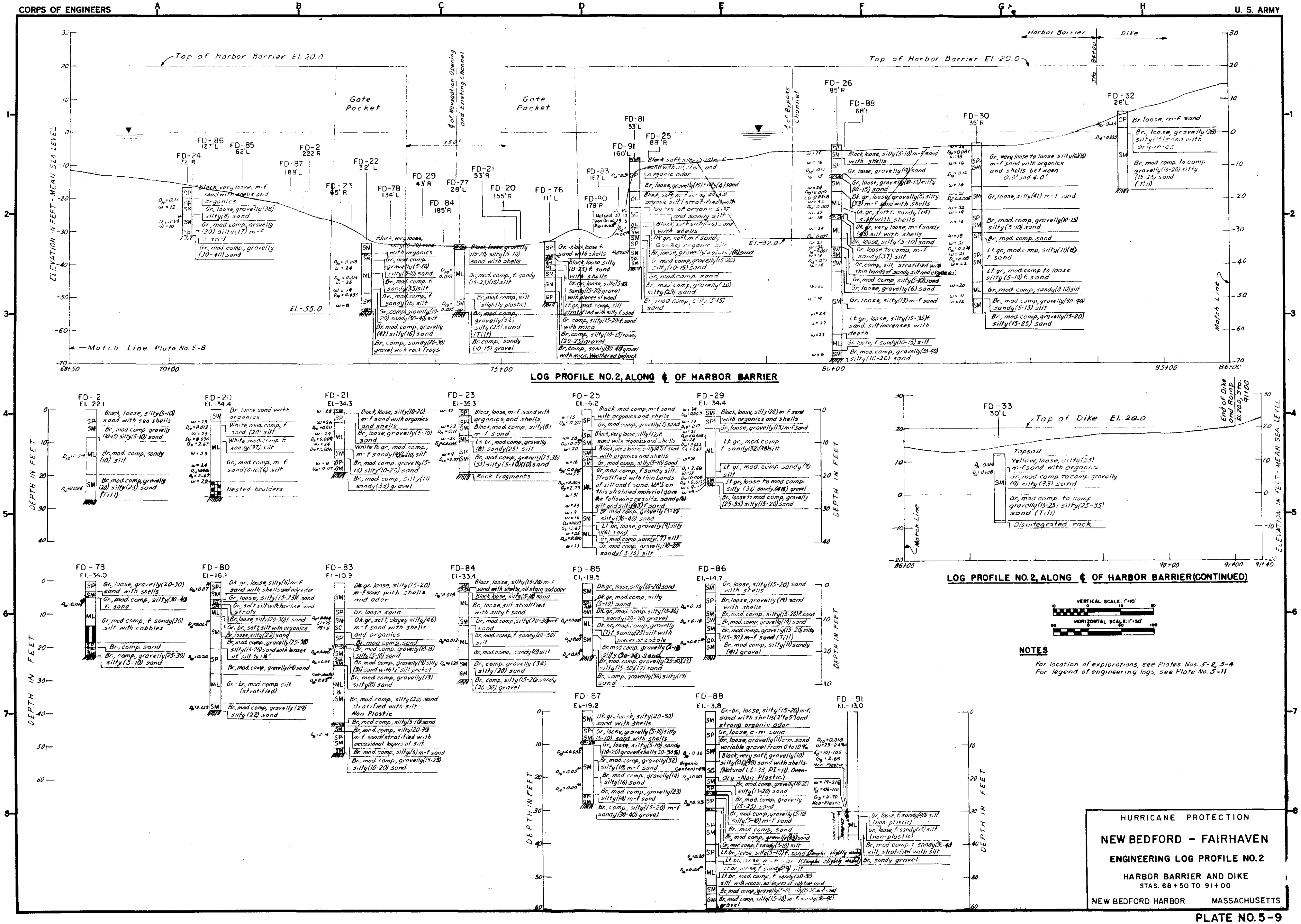
STAS. 0+00 TO 68+50

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-8

CORPS OF ENGINEERS

U. S. ARMY



LOG PROFILE NO. 2, ALONG ℄ OF HARBOR BARRIER

LOG PROFILE NO. 2, ALONG ℄ OF HARBOR BARRIER (CONTINUED)

NOTES

For location of explorations, see Plates Nos. 5-2, 5-4

For legend of engineering logs, see Plate No. 5-11

HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

ENGINEERING LOG PROFILE NO. 2

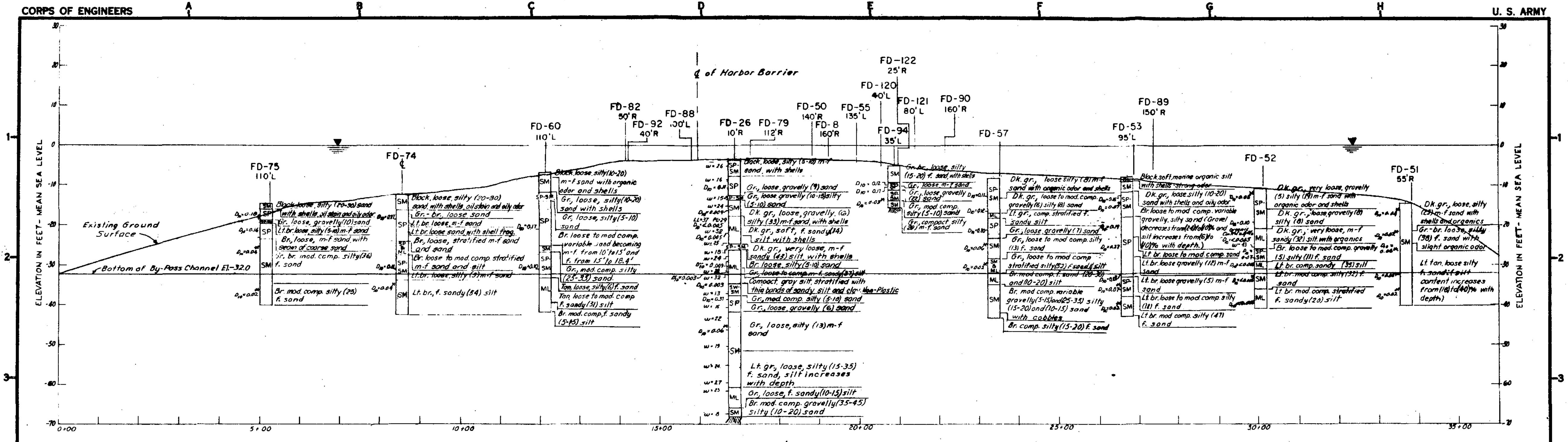
HARBOR BARRIER AND DIKE

STAS. 68+50 TO 91+00

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-9

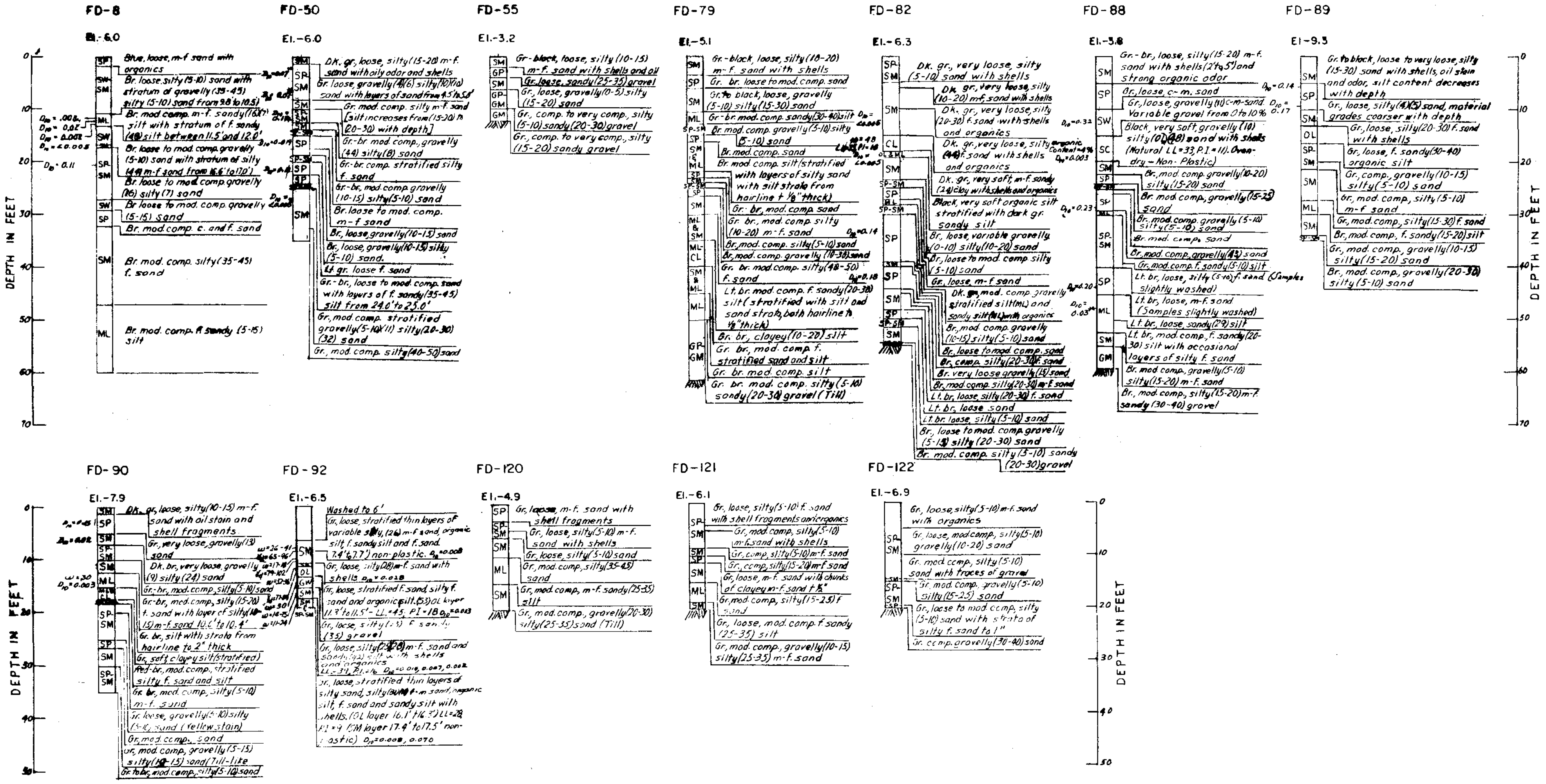
CORPS OF ENGINEERS U. S. ARMY



LOG PROFILE NO. 3, ALONG ℄ OF BY-PASS CHANNEL

VERTICAL SCALE 1"=10'

HORIZONTAL SCALE 1"=100'



NOTES

For location of explorations, see Plates Nos. 5-2 and 5-4

For legend of engineering logs, see Plate No. 3-11

HURRICANE PROTECTION

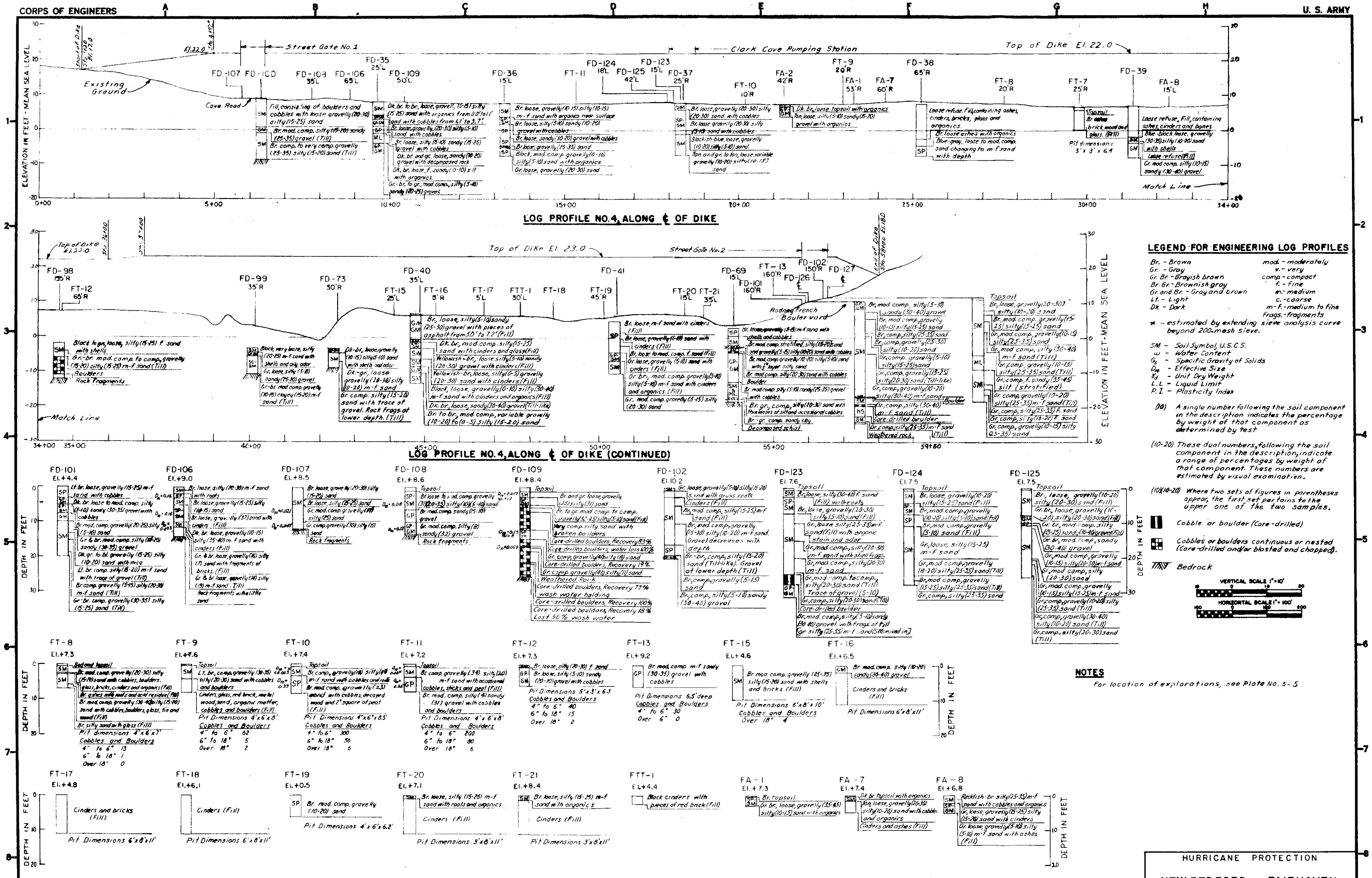
NEW BEDFORD - FAIRHAVEN

ENGINEERING LOG PROFILE NO. 3

BYPASS CHANNEL
STAS. 0+00 TO 36+00

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-10



LEGEND FOR ENGINEERING LOG PROFILES

Br. - Brown	mod. - moderately
Gr. - Gray	v. - very
Gr. Br. - Grayish brown	comp. - compact
Br. Gr. - Brownish gray	f. - fine
Gr. and Br. - Gray and brown	m. - medium
Lt. - Light	c. - coarse
Dk. - Dark	m-f. - medium to fine
	frags. - fragments

* - estimated by extending sieve analysis curve beyond 200-mesh sieve.

SM - Soil Symbol, U.S.C.S.
ω - Water Content
G_s - Specific Gravity of Solids
D_{10} - Effective Size
γ_d - Unit Dry Weight
L.L. - Liquid Limit
P.I. - Plasticity Index

(10) A single number following the soil component in the description indicates the percentage by weight of that component as determined by test

(10-20) These dual numbers, following the soil component in the description, indicate a range of percentages by weight of that component. These numbers are estimated by visual examination.

(10)(10-20) Where two sets of figures in parentheses appear, the first set pertains to the upper one of the two samples.

▮ Cobble or boulder (Core-drilled)

▦ Cobbles or boulders continuous or nested (Core-drilled and/or blasted and chopped).

Bedrock

VERTICAL SCALE 1" = 10'
10 0 10 20

HORIZONTAL SCALE 1" = 100'
100 0 100 200

NOTES

For location of explorations, see Plate No. 5-5

HURRICANE PROTECTION

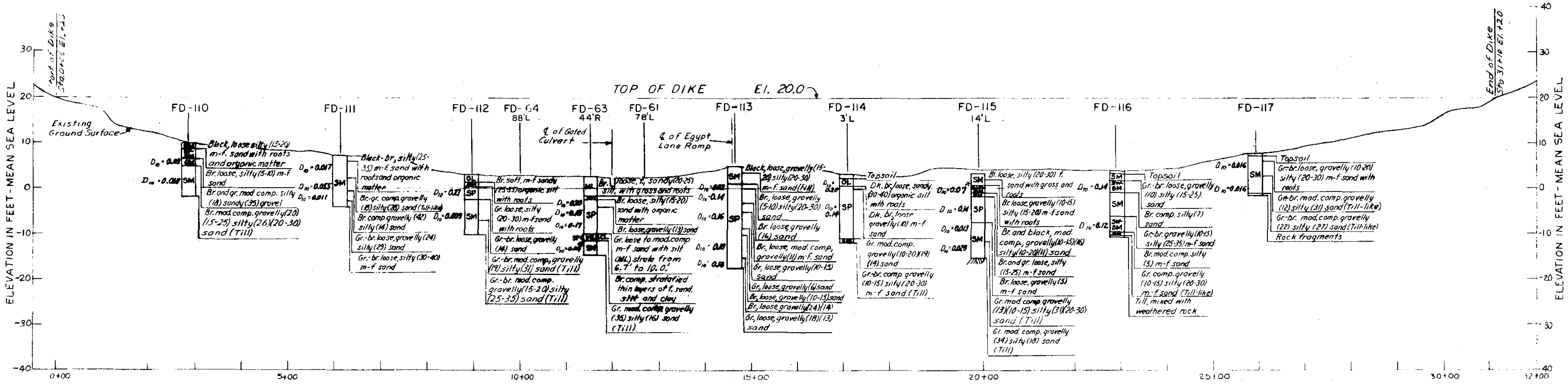
NEW BEDFORD – FAIRHAVEN

ENGINEERING LOG PROFILE NO. 4

CLARK COVE DIKE
STAS. 1 + 20 TO 58 + 00

NEW BEDFORD HARBOR MASSACHUSETTS

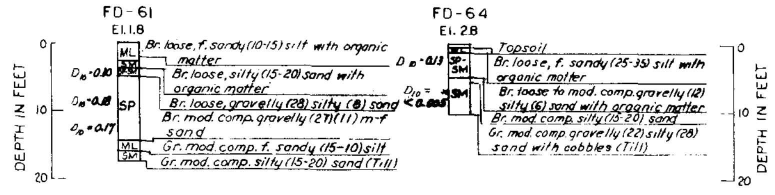
PLATE NO. 5-11



LOG PROFILE NO. 5, ALONG ℄ OF DIKE

VERTICAL SCALE 1" = 10'
10 0 10 20

HORIZONTAL SCALE 1" = 100'
100 0 100 200



NOTES

For location of explorations, see Plate No. 5-6

For legend of engineering logs, see Plate No. 5-11

HURRICANE PROTECTION

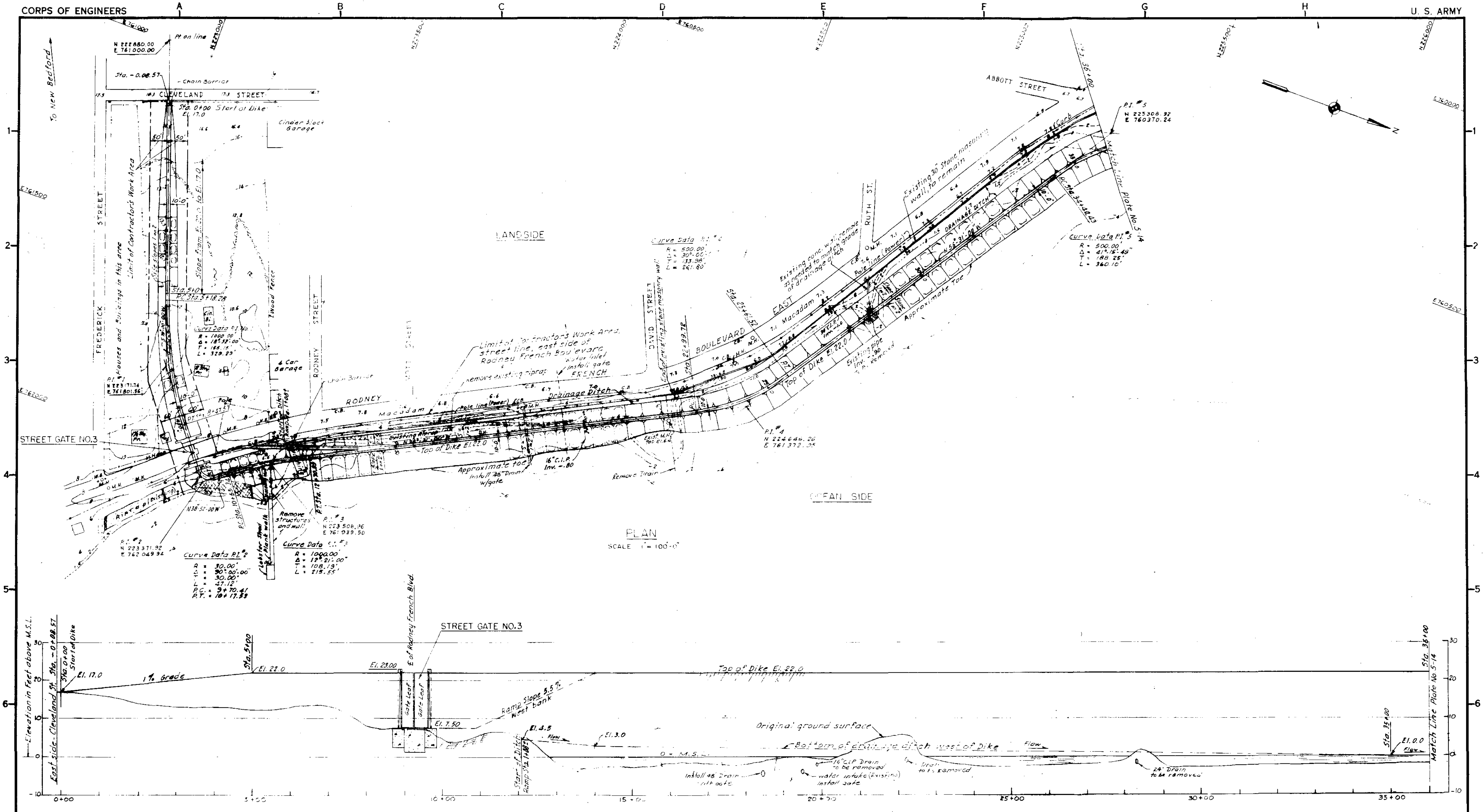
NEW BEDFORD - FAIRHAVEN

ENGINEERING LOG PROFILE NO. 5

FAIRHAVEN DIKE
STAS. 0+00 TO 31+10

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-12



PROFILE ON ℄ OF DIKE

HORIZONTAL SCALE: 1"=100'

100 0 100 200

VERTICAL SCALE: 1"=10'

10 0 10 20

NOTES

Elevations refer to Mean Sea Level Datum.

For Typical Sections of Harbor Barrier Dike & Drainage ditch see Plate No. 5-19

All elevations are plus elevations unless otherwise noted.

All spot elevations are existing.

HURRICANE PROTECTION

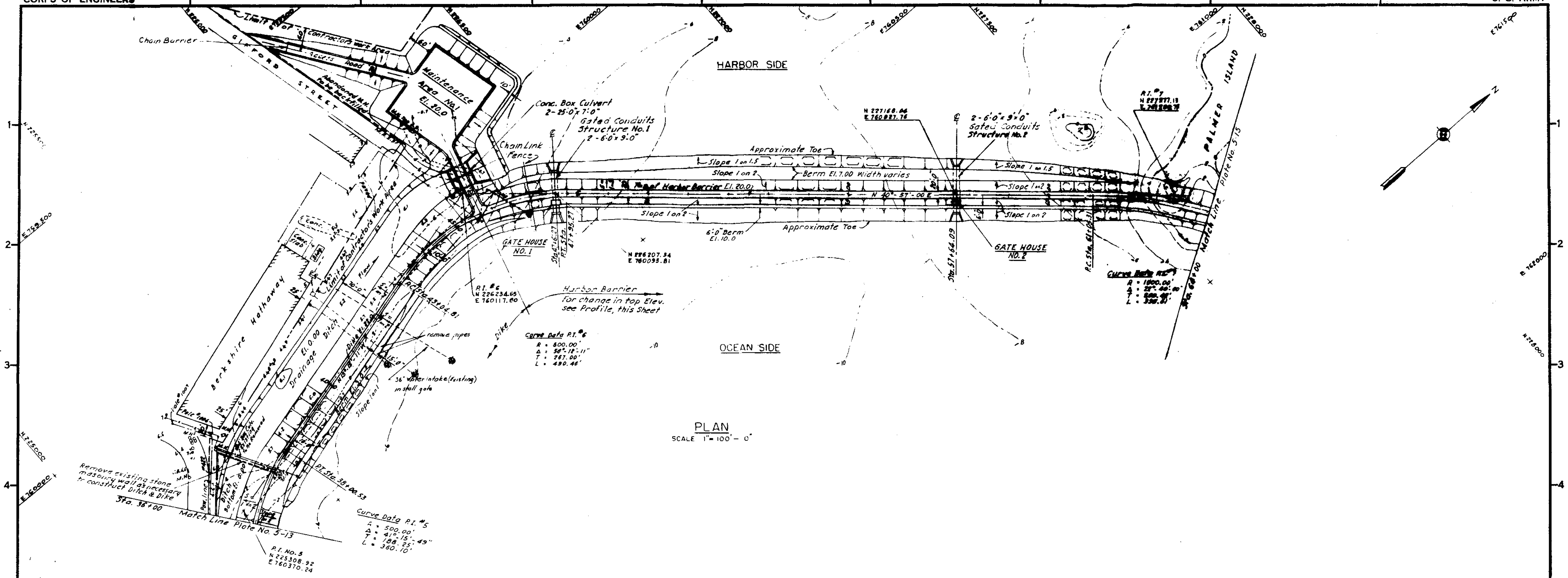
NEW BEDFORD – FAIRHAVEN

PLAN AND PROFILE NO. 1

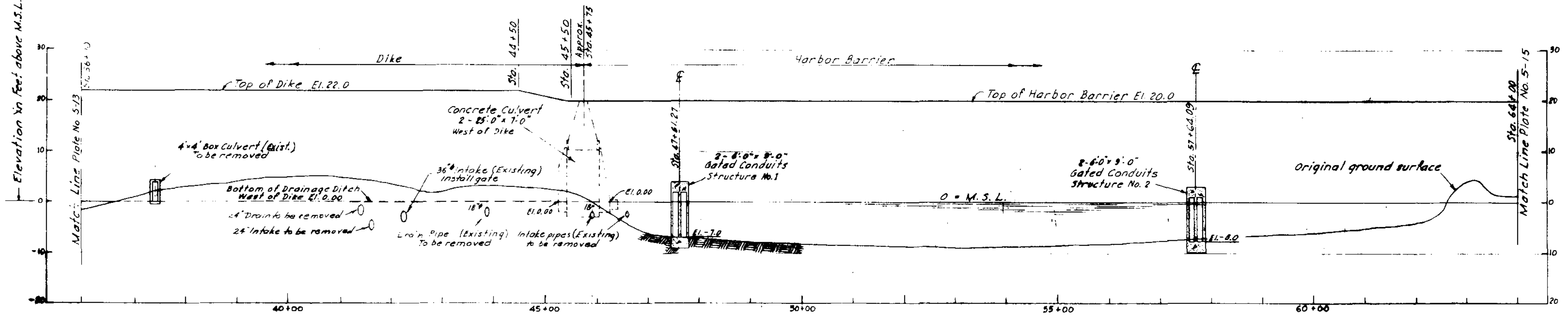
HARBOR BARRIER AND DIKE
STAS. 0+00 TO 36+00

NEW BEDFORD HARBOR MASSACHUSETTS

CORPS OF ENGINEERS U. S. ARMY



PLAN
SCALE 1" = 100' - 0"



PROFILE ON ℄ OF DIKE AND HARBOR BARRIER

HORIZONTAL SCALE 1"=100'
100 0 100 200

VERTICAL SCALE 1"=10'
10 0 10 20

NOTES

Elevations refer to Mean Sea Level Datum.

For Typical Sections of Dike and Harbor Barrier see Plates Nos. 5-19, 5-20

All Elevations are plus elevations except as otherwise noted

All Spot elevations are existing

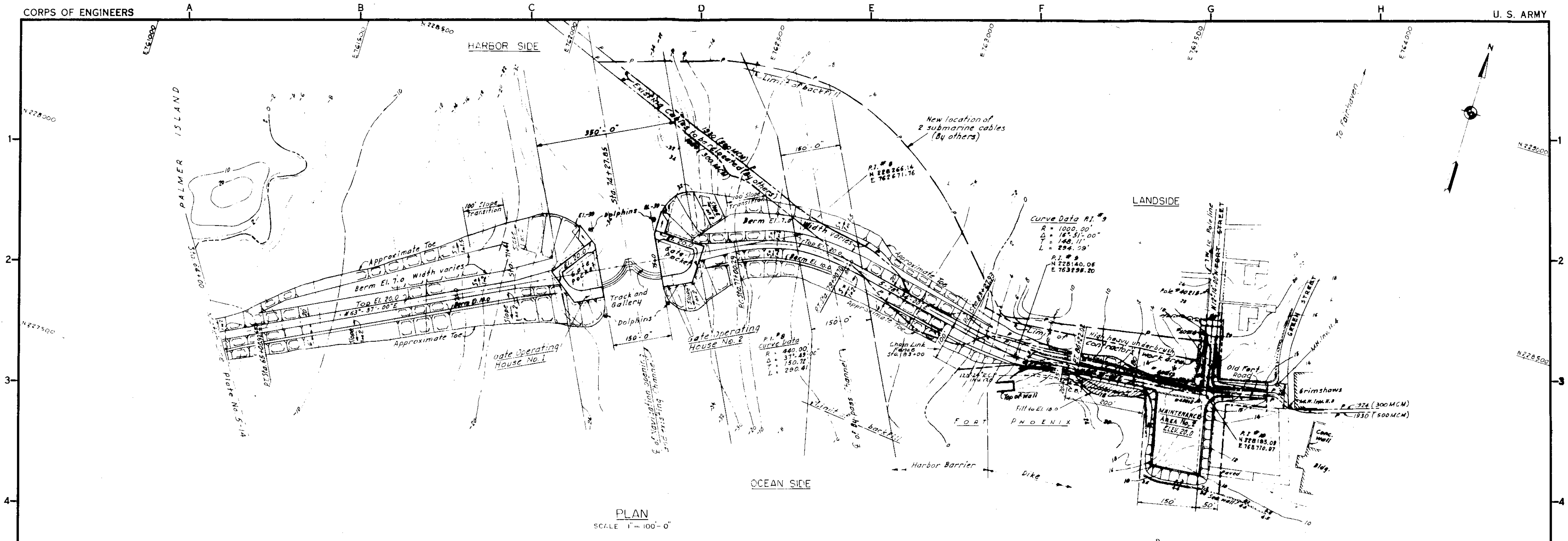
HURRICANE PROTECTION

NEW BEDFORD – FAIRHAVEN

PLAN AND PROFILE NO. 2
HARBOR BARRIER AND DIKE
STAS. 36+00 TO 64+00
NEW BEDFORD HARBOR MASSACHUSETTS

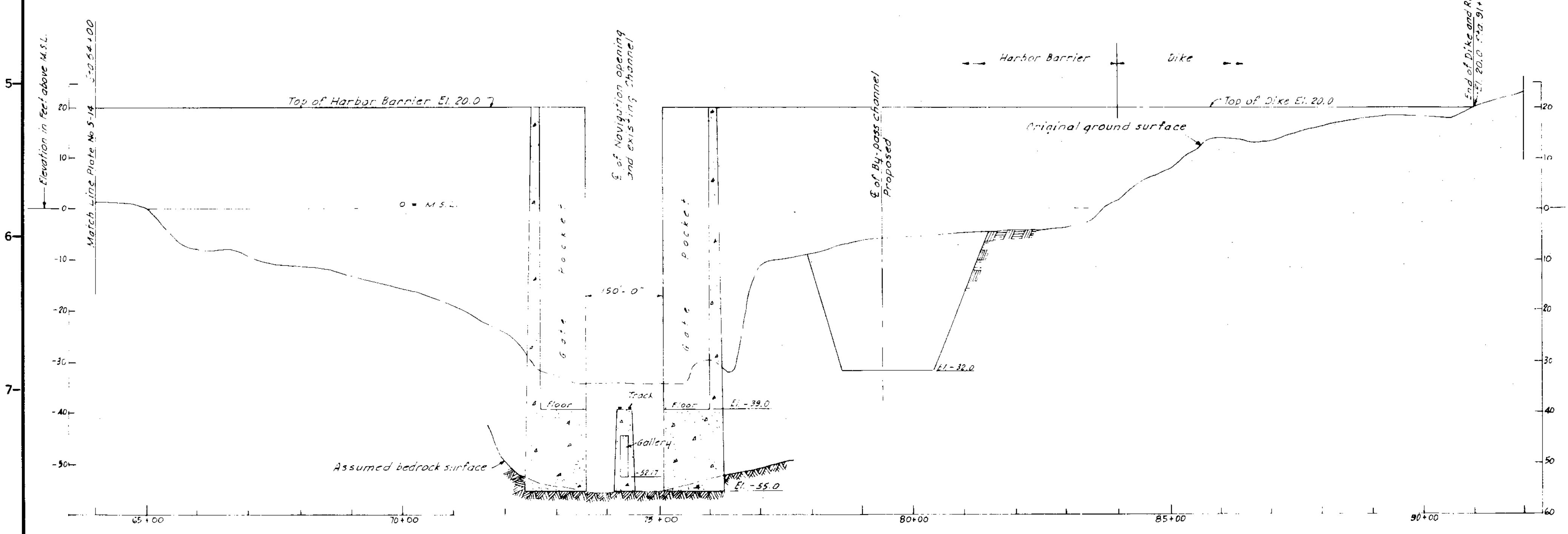
CORPS OF ENGINEERS

U. S. ARMY



PLAN

SCALE 1" = 100'-0"



PROFILE ON ℄ OF DIKE AND HARBOR BARRIER

HORIZONTAL SCALE: 1" = 100'

100 0 100 200

VERTICAL SCALE: 1" = 10'

10 0 10 20

NOTES

Elevations refer to Mean Sea Level Datum.

For Typical Sections of Dike and Harbor Barrier see Plate No. 5-20.

All elevations are plus elevations unless otherwise noted. All spot elevations are existing.

HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

PLAN AND PROFILE NO. 3

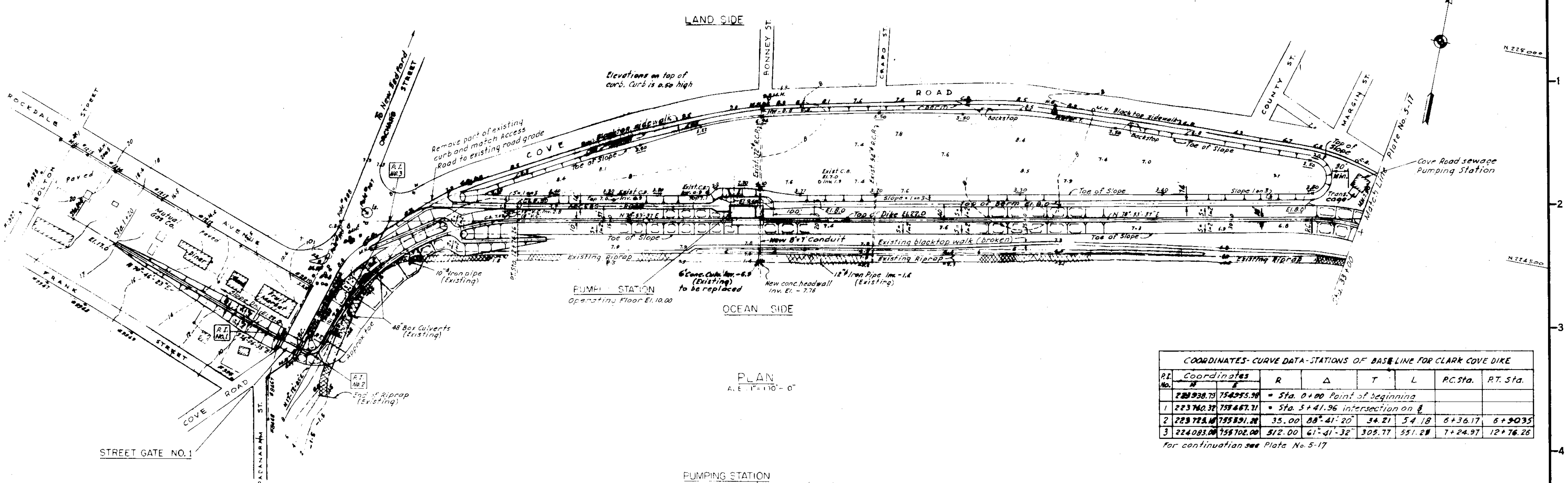
HARBOR BARRIER AND DIKE

STAS. 64+00 TO 91+00

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-15

CORPS OF ENGINEERS U. S. ARMY



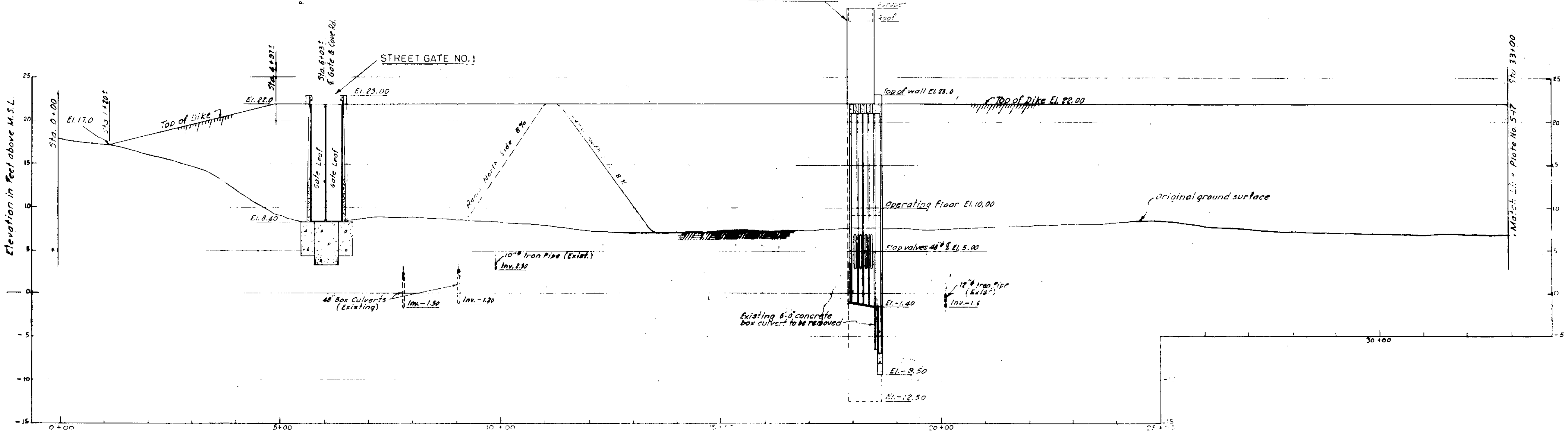
PLAN
SCALE 1"=100'-0"

STREET GATE NO. 1

P.I. No.	Coordinates N	Coordinates E	R	Δ	T	L	P.C. Sta.	P.T. Sta.
	223938.79	754955.98	• Sta. 0+00 Point of beginning					
1	223760.37	755467.71	• Sta. 5+41.96 intersection on ℄					
2	223725.16	755891.28	35.00	88°-41'-20"	34.21	54.18	6+36.17	6+90.35
3	224083.00	756702.00	512.00	61°-41'-32"	305.77	551.28	7+24.97	12+76.26

COORDINATES- CURVE DATA-STATIONS OF BASE LINE FOR CLARK COVE DIKE

For continuation see Plate No. 5-17



PROFILE ON ℄ OF DIKE

HORIZONTAL SCALE: 1"=100'
100 0 100 200

VERTICAL SCALE: 1"=5'
5 0 5 10

NOTES

Elevations refer to Mean Sea Level Datum.

All elevations are plus except as noted. Spot elevations are existing.

Elevations underlined 3.50 denote new grades.

For Typical Embankment Sections of Dike see Plate No. 5-21

HURRICANE PROTECTION

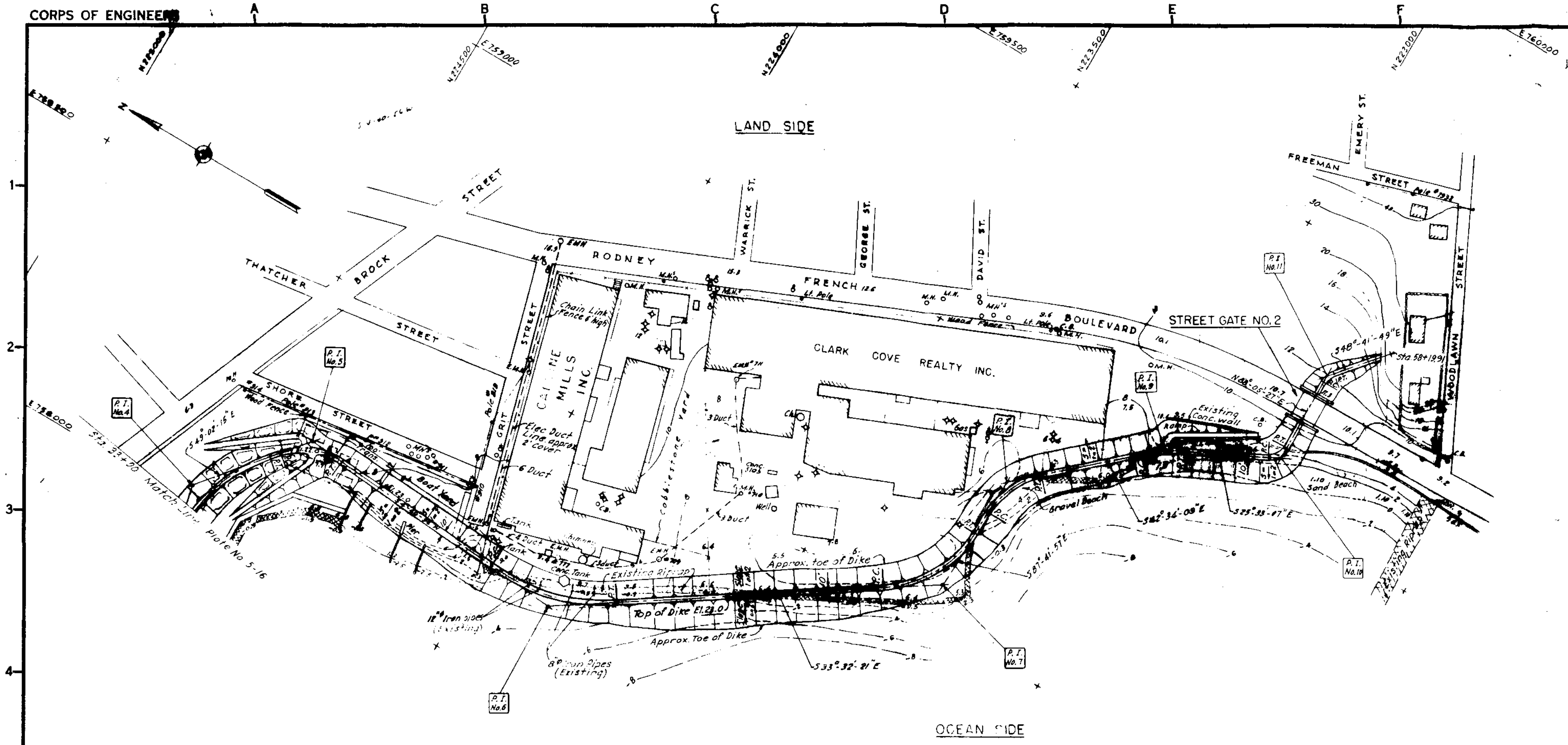
NEW BEDFORD - FAIRHAVEN

PLAN AND PROFILE NO. 4

CLARK COVE DIKE
STAS. 1+20 TO 33+00

NEW BEDFORD HARBOR, MASSACHUSETTS

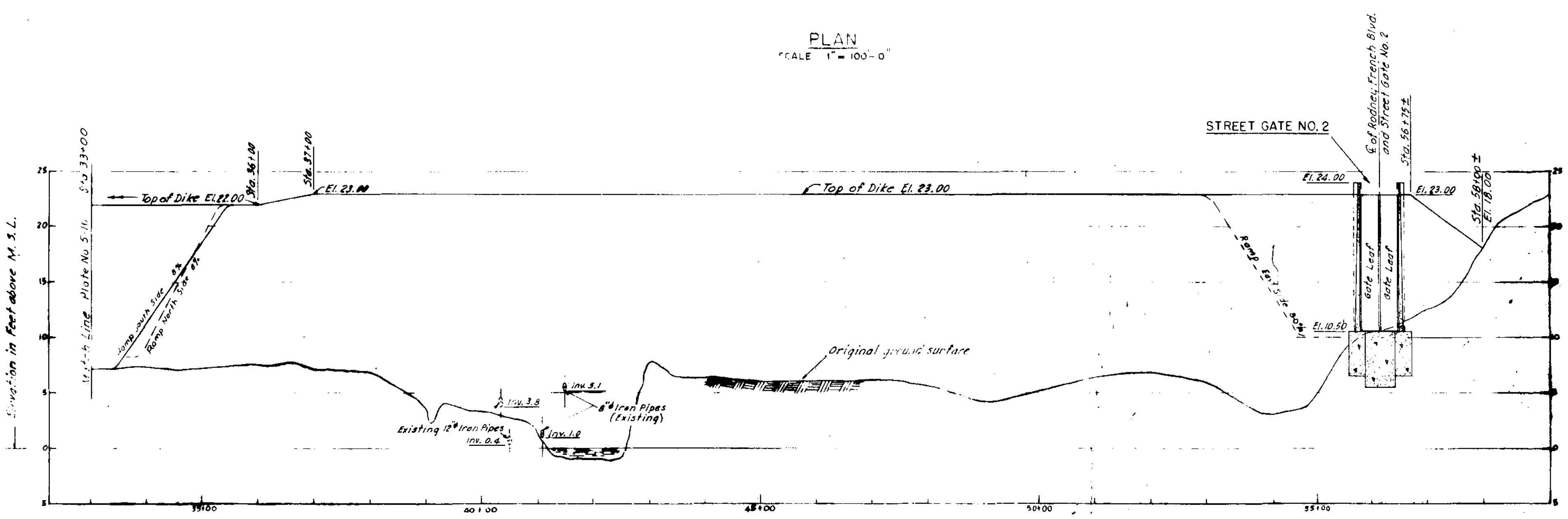
PLATE NO. 5-16



COORDINATES - CURVE DATA - STATIONS OF BASE LINE FOR CLARK COVE DIKE								
P.I. No.	Coordinates		R	Δ	T	L	P.C. Sta.	P.T. Sta.
	N	E						
4	224540	758030	312.00'	52°-04'-08"	152.40'	283.54'	31+90.52	34+74.06
5	224382	758212	130.00'	53°-43'-11"	65.84'	121.89'	34+96.84	36+18.73
6	223851	758169	373.00'	38°-13'-17"	129.24'	248.82'	39+50.42	41+99.24
7	223243	758576	220.00'	54°-09'-06"	112.48'	207.96'	46+94.16	49+02.12
8	223234	758800	158.00'	45°-07'-48"	65.66'	124.45'	49+48.16	50+72.61
9	223013	759003	263.00'	17°-01'-02"	39.35'	78.11'	52+67.68	53+45.79
10	222,823.54	759,093.58	30.00'	66°-21'-26"	19.62'	34.74'	54+96.82	55+31.56
11	222,829.44	759,270.48	40.00'	43°-12'-44"	15.84'	30.17'	56+73.10	57+03.27
	222742	759370	End Station of Base Line					58+19.91

For Data of P.I. Nos. 1, 2 and 3 see Plate No. 5-16

PLAN
SCALE 1" = 100'-0"



PROFILE ON ℄ OF DIKE

HORIZONTAL SCALE: 1" = 100'
100 0 100 200
VERTICAL SCALE: 1" = 5'
5 0 5 10

NOTES

Elevations refer to Mean Sea Level Datum.
For Typical Sections of Dike see Plate No. 5-21

HURRICANE PROTECTION

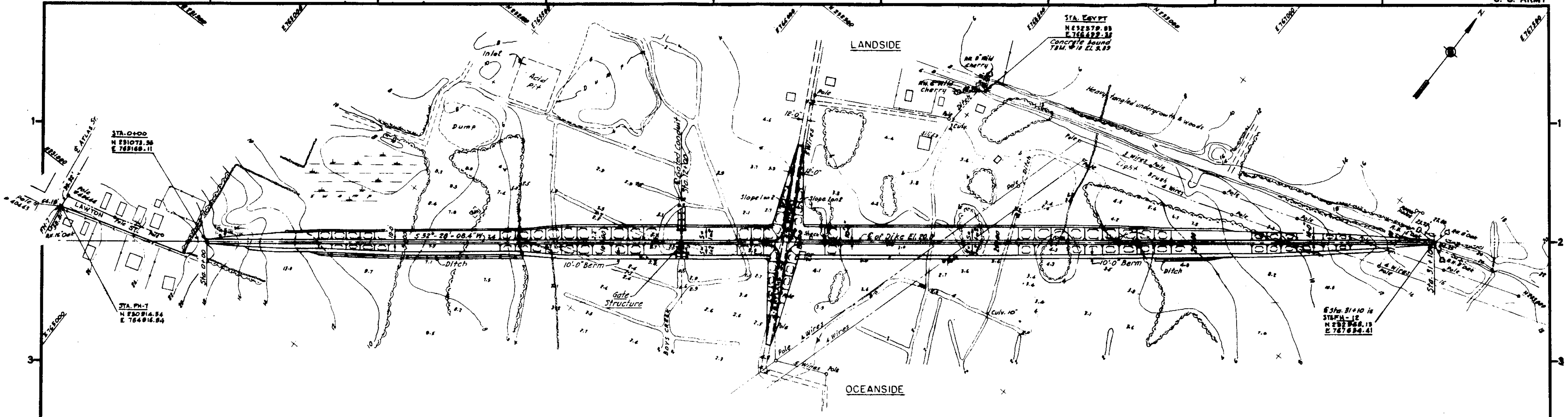
NEW BEDFORD – FAIRHAVEN

PLAN AND PROFILE NO. 5
CLARK COVE DIKE
STAS. 33+00 TO 58+00

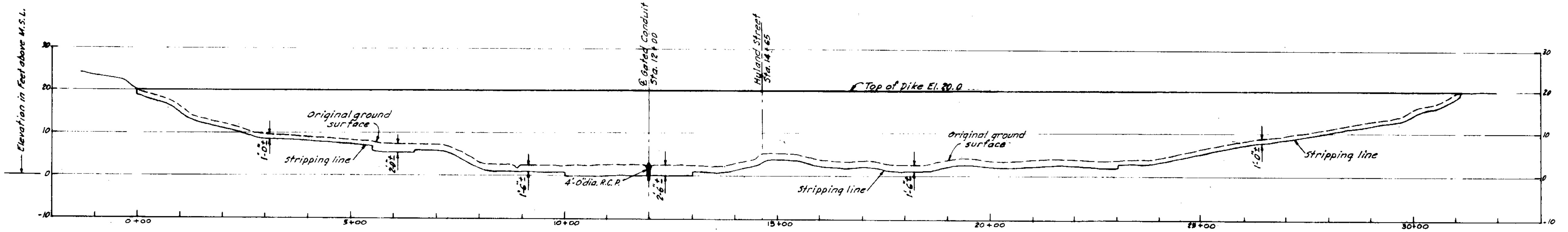
NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-17

CORPS OF ENGINEERS U. S. ARMY



PLAN
SCALE 1"=100'-0"



PROFILE ON ℄ OF DIKE

HORIZONTAL SCALE: 1"=100'
100 0 100 200

VERTICAL SCALE: 1"=10'
10 0 10 20

NOTES

Elevations refer to Mean Sea Level Datum.
For Typical Sections of Dike see Plate No. 5-22

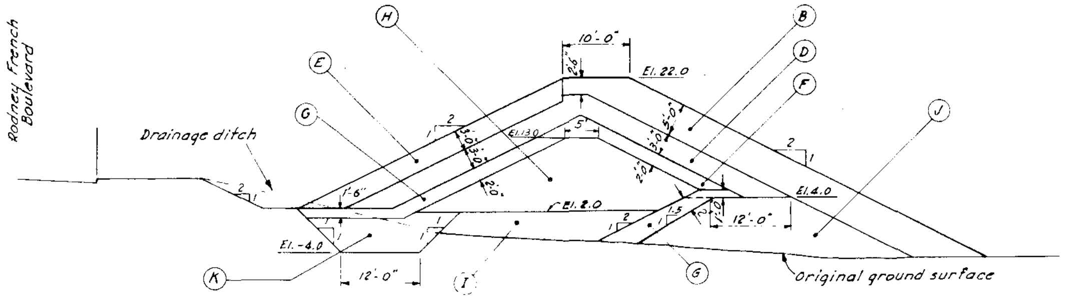
HURRICANE PROTECTION

NEW BEDFORD – FAIRHAVEN

PLAN AND PROFILE NO. 6
FAIRHAVEN DIKE
STAS. 0+00 TO 31+10

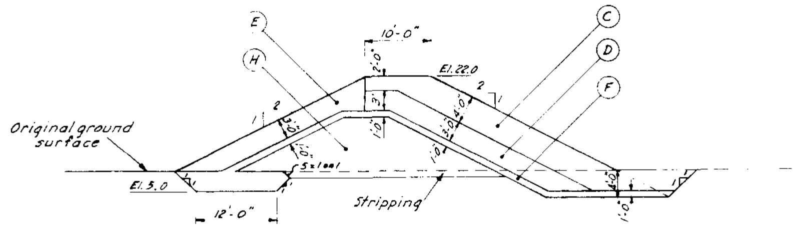
NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5 –18



STA. 17+80

From Sta. 12+20 to Sta. 21+30



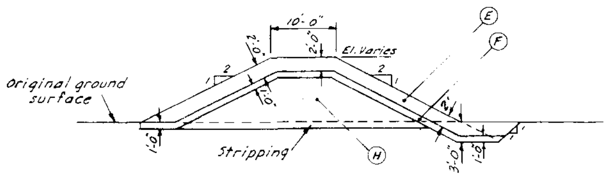
STA. 8+60

From Sta. 7+20 to Sta. 9+05±

Transition occurs between Sta. 7+00 and Sta. 7+20

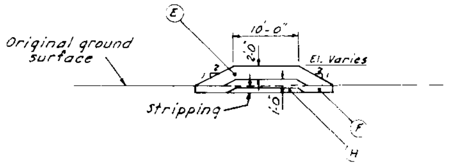
LANDSIDE

OCEANSIDE



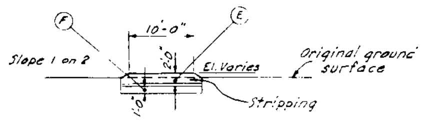
STA. 4+55

From Sta. 1+80 to Sta. 7+00



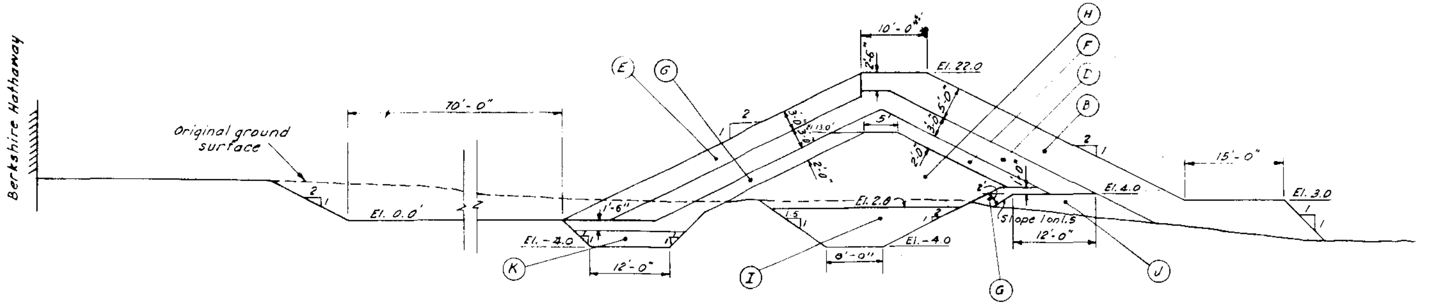
STA. 1+15

From Sta. 0+50 to Sta. 1+80



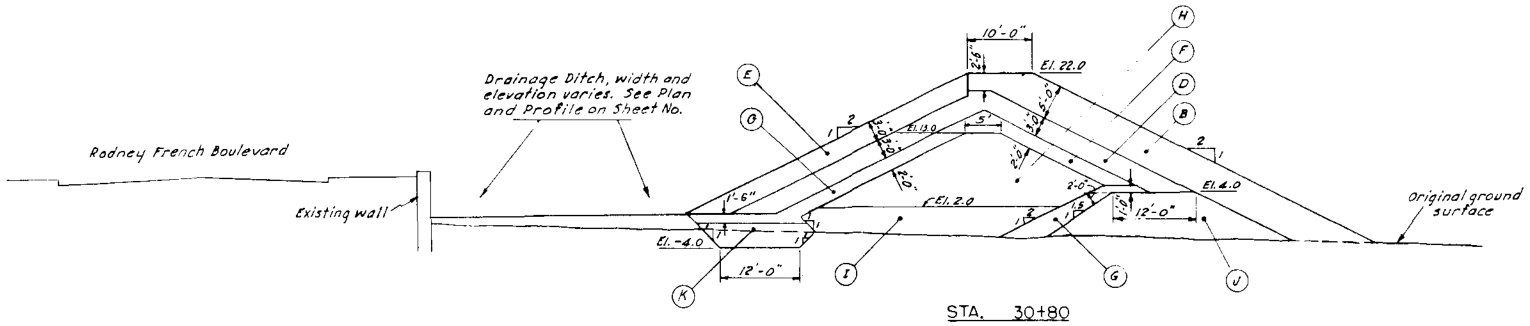
STA. 0+25

From Sta. 0+00 to Sta. 0+50



STA. 39+75

From Sta. 36+70 to Sta. 45+80

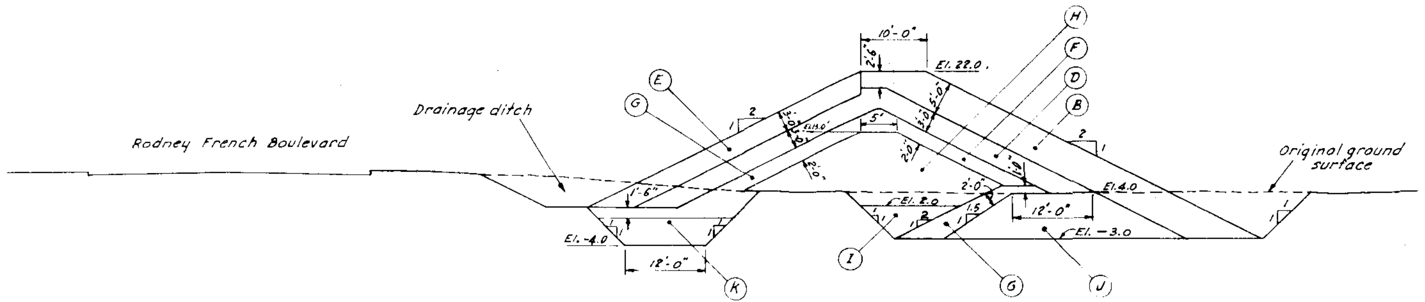


STA. 30+80

From Sta. 22+50 to Sta. 36+70

LANDSIDE

OCEANSIDE



STA. 21+78

From Sta. 9+60 to Sta. 12+20 & From Sta. 21+30 + Sta. 22+50

NOTES

Elevations refer to Mean Sea Level Datum.

All elevations are plus elevations, unless otherwise noted.

Within the foundation area of the proposed dike along Rodney French Boulevard (East) remove all exposed boulders, cobbles and stones above low water. Remove all existing riprap and bedding and strip area as directed by the Contracting Officer.

For locations of Sections see Plan on Plates Nos 5-13 and 5-14

LEGEND

Ⓐ Armor Stone, 4.5 to 2.75 Tons (See Sheet No.
Ⓑ Armor Stone, 3.0 to 2.0 Tons
Ⓒ Armor Stone, 2.0 to 1.0 Tons
Ⓓ Bedding Stone, Quarry run
Ⓔ Protection Stone, 1500 to 500 Lbs.
Ⓕ Gravel Bedding
Ⓖ Filter Material
Ⓗ Compacted Earth Fill
Ⓘ Dumped Earth Fill
Ⓙ Rock Fill
Ⓚ Drainage Trench Material

TYPICAL SECTIONS
SCALE: 1" = 10'
10 0 10 20

HURRICANE PROTECTION

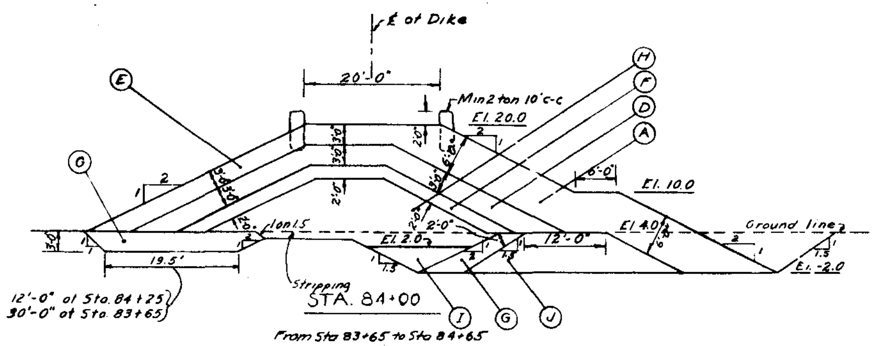
NEW BEDFORD - FAIRHAVEN

TYPICAL SECTIONS NO. 1

HARBOR BARRIER AND DIKE
STAS. 0+00 TO 45+80

NEW BEDFORD HARBOR MASSACHUSETTS

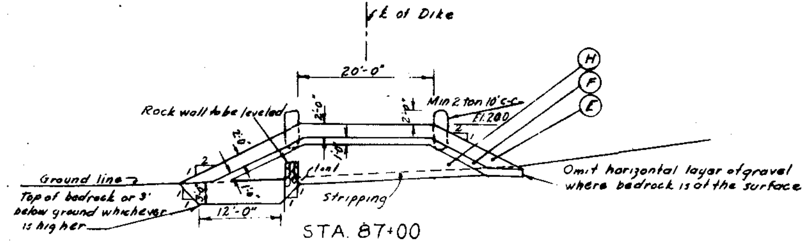
PLATE NO. 5 - 19



STA. 84+00

From Sta 83+65 to Sta 84+65

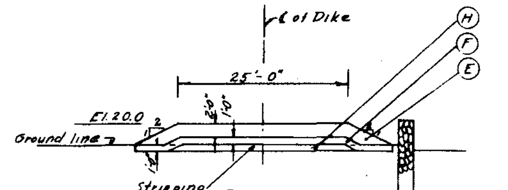
Transition occurs between Sta 83+20 and Sta 83+65



STA. 87+00

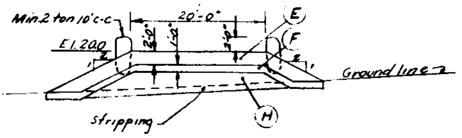
From Sta 84+85 to Sta 87+20

Transition occurs between Sta 84+65 and Sta 84+85



STA. 90+20

From Sta 89+90 to End of Dike



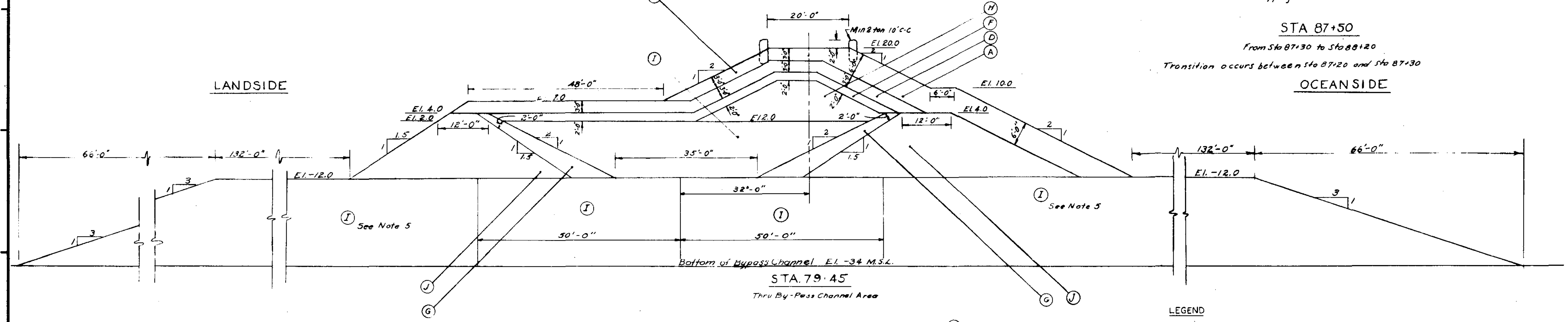
STA 87+50

From Sta 87+30 to Sta 88+20

Transition occurs between Sta 87+20 and Sta 87+30

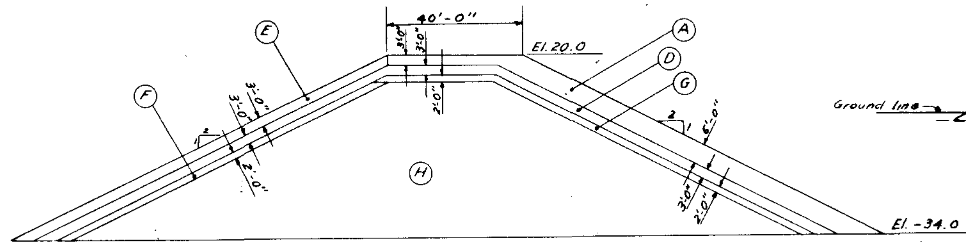
LANDSIDE

OCEANSIDE



STA. 79+45

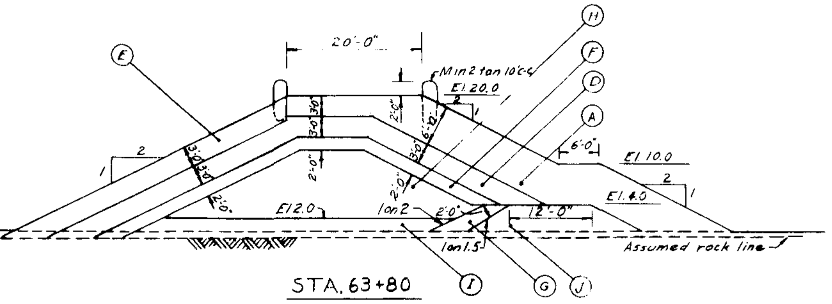
Thru By-Pass Channel Area



STA. 72+41

Typical for wrap-arounds at East and West Gate Pockets

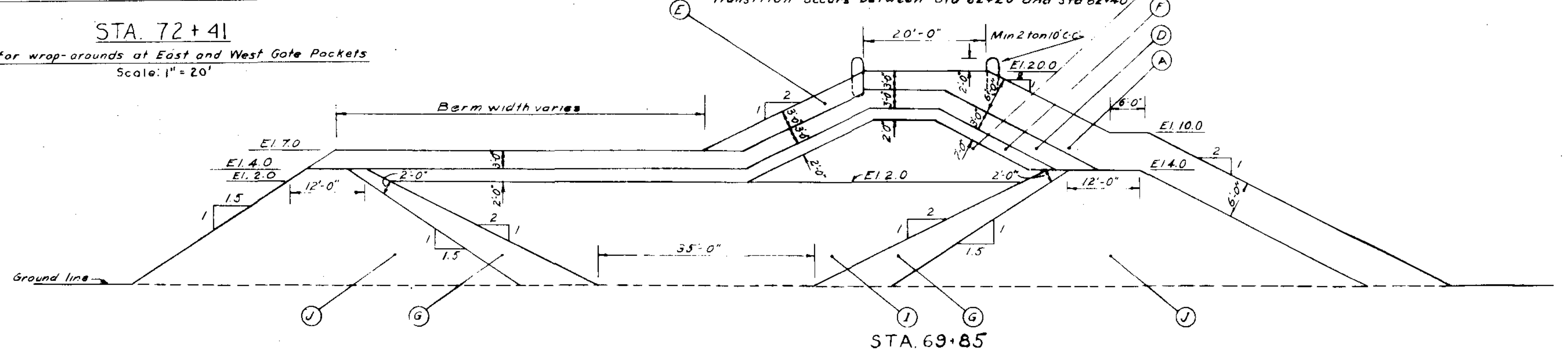
Scale: 1" = 20'



STA. 63+80

From Sta 62+40 to Sta 65+00

Transition occurs between Sta 62+20 and Sta 62+40



STA. 69+85

From Sta 46+80 to Sta 62+20, From Sta 65+20 to Sta 71+44 and From Sta 77+02 to Sta 83+20 except thru By-Pass Channel area

Transition occurs between Sta 45+80 and Sta 46+80 and between Sta 65+00 and Sta 65+20

TYPICAL SECTIONS

SCALE: 1" = 10'

10 0 10 20

LEGEND

- (A) Armor Stone, 4.5 to 2.75 Tons.
- (B) Armor Stone, 3.0 to 2.0 Tons. (see Sheet No
- (C) Armor Stone, 2.0 to 1.0 Tons. (see Sheet No
- (D) Bedding Stone, Quarry-run
- (E) Protection Stone, 1500 to 500 Lbs.
- (F) Gravel Bedding
- (G) Filter Material
- (H) Compacted Earth Fill
- (I) Dumped Earth Fill
- (J) Rock Fill

NOTES

Elevations refer to Mean Sea Level Datum.

All elevations are plus elevations except as otherwise noted.

For locations of Sections, see Plan on Plates Nos. 5-14 and 5-15

Within the foundation area of the proposed dike, strip as directed by the Contracting Officer.

Below El.-12 and beyond the 100-foot wide central zone, earth fill material may contain less than 5% fines

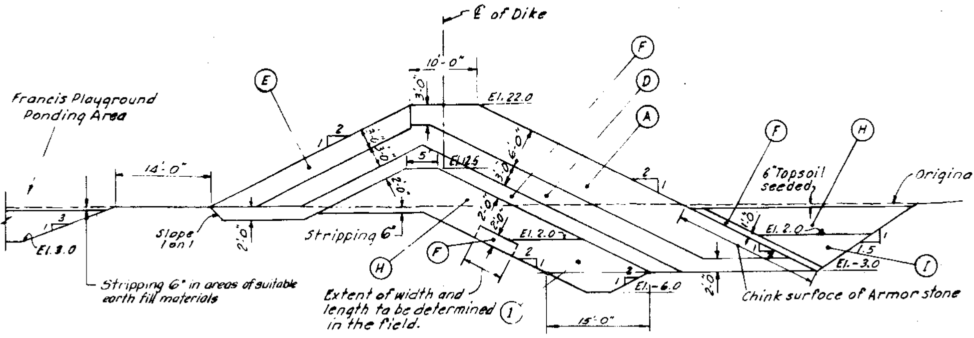
HURRICANE PROTECTION

NEW BEDFORD – FAIRHAVEN

TYPICAL SECTIONS NO. 2

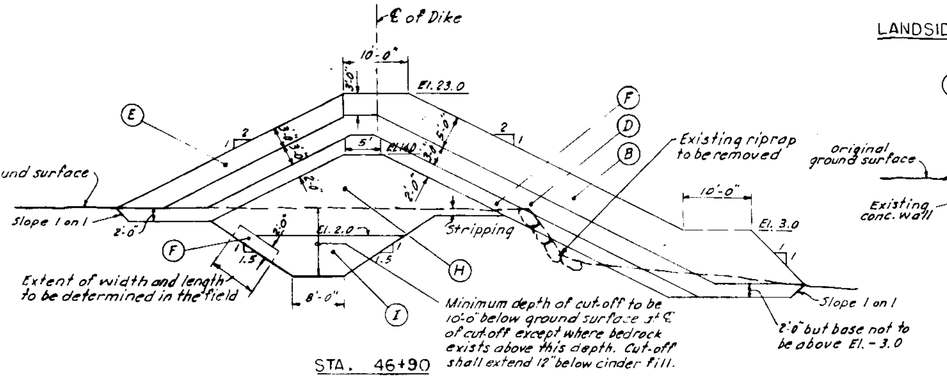
HARBOR BARRIER AND DIKE
STAS. 45+80 TO 91+00

NEW BEDFORD HARBOR MASSACHUSETTS



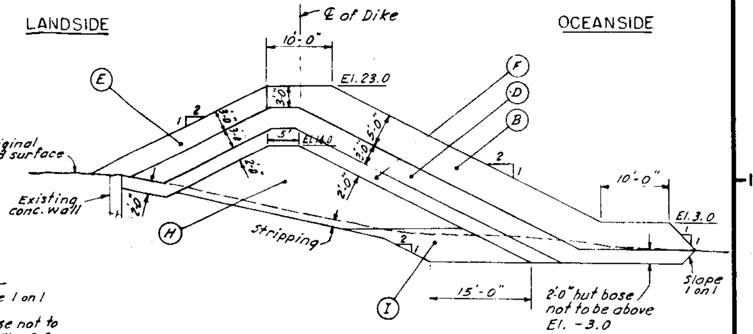
STA. 31+00

From Sta. 10+30 to Sta. 36+70



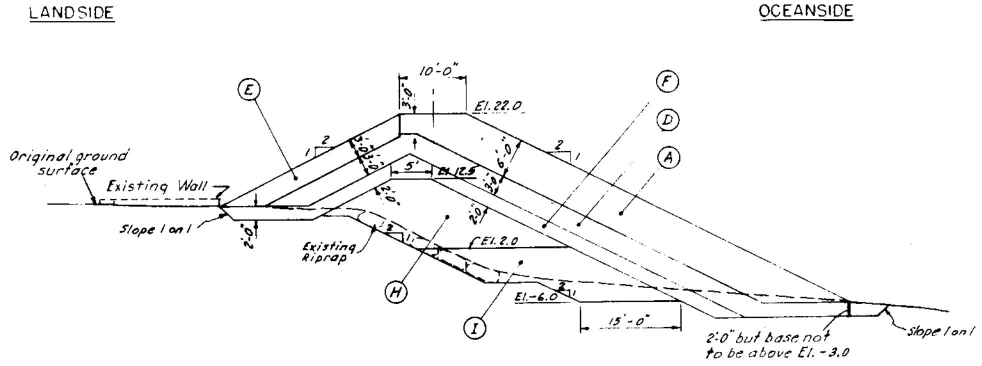
STA. 46+90

From Sta. 44+10 to Sta. 53+15



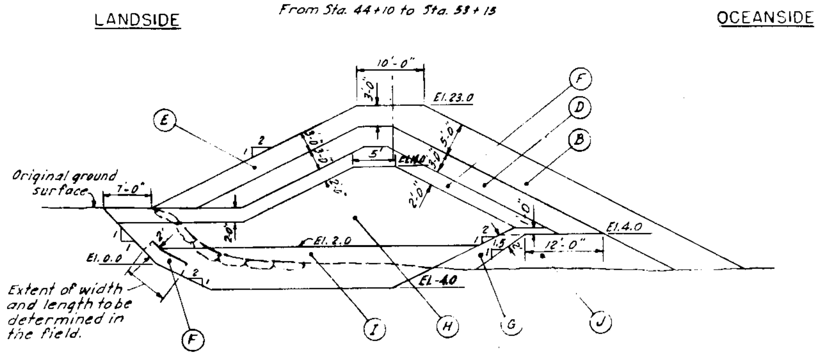
STA. 55+00

From Sta. 53+15 to Wall



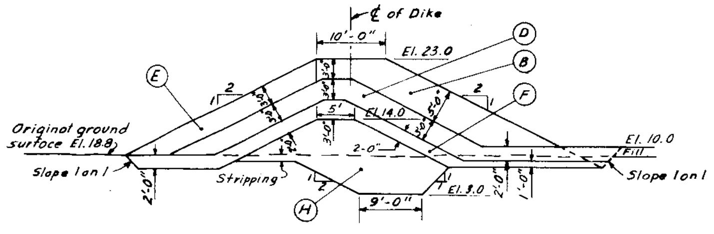
STA. 8+85

From Sta. 6+34± (Street Gate) to Sta. 10+30



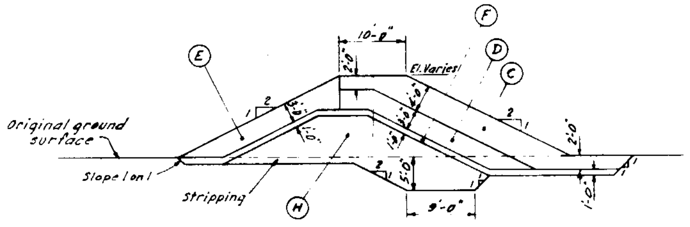
STA. 42+30

From Sta. 39+55 to Sta. 44+10



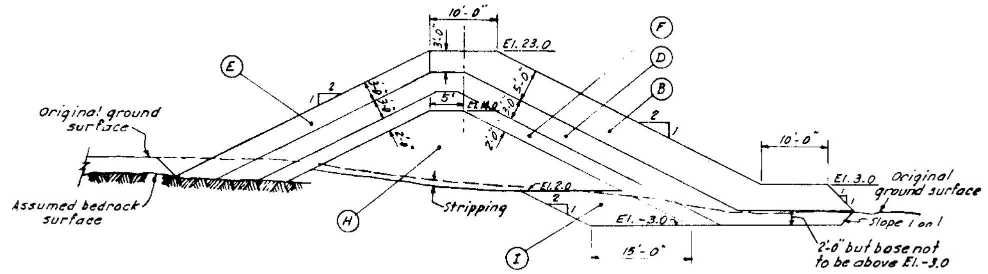
STA. 55+50

This section is typical from Wall to West side, Street Gate Structure No. 2



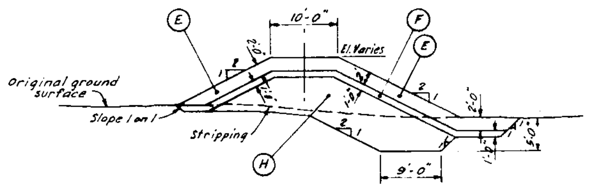
STA. 5+08

From Sta. 4+58 to Sta. 5+68± (Street Gate No. 1)



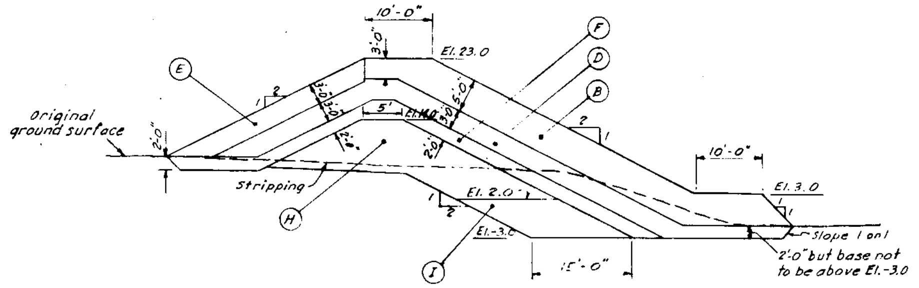
STA. 39+10

From Sta. 38+80 to Sta. 39+55



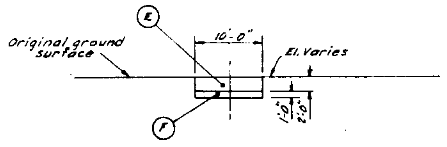
STA. 4+33

From Sta. 1+28 to Sta 4+58 Cut-off trench starts at Sta 4+08
also
From Sta 56+55± to Sta. 57+90 Omit cut-off trench



STA. 37+00

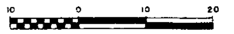
From Sta. 36+70 to Sta. 38+80



STA. 1+25

From Sta. 1+20± (start of dike) to Sta. 1+28
also
From Sta. 57+90 to 58+00 (end of dike)

TYPICAL SECTIONS
SCALE: 1"=10'



LEGEND

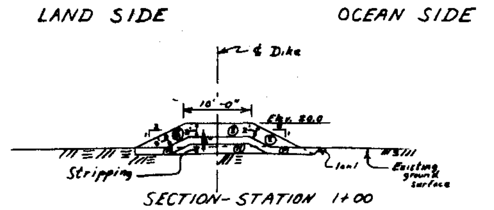
Ⓐ Armor Stone, 4.5 to 2.75 Tons
Ⓑ Armor Stone, 3.0 to 2.0 Tons
Ⓒ Armor Stone, 2.0 to 1.0 Tons
Ⓓ Bedding Stone, Quarry-run
Ⓔ Protection Stone, 1500 to 500 Lbs.
Ⓕ Gravel Bedding
Ⓖ Filter Material,
Ⓗ Compacted Earth Fill
Ⓘ Dumped Earth Fill
Ⓙ Rock Fill

NOTES

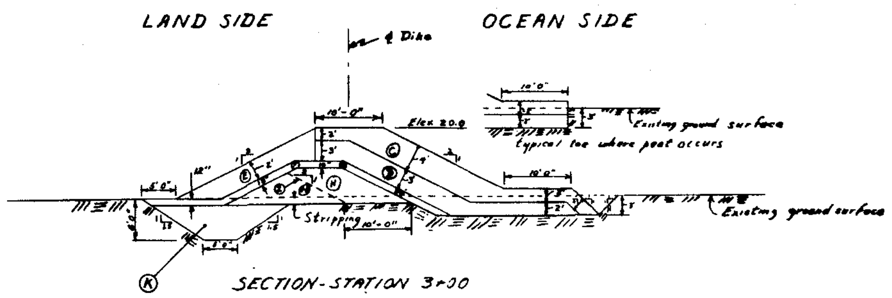
Elevations refer to Mean Sea Level Datum.
All elevations are plus elevations, except as noted.
Within the foundation area of the proposed dike at Clark Cove, remove all exposed boulders, cobbles and stones above low water, also remove all existing riprap and bedding and strip the area as directed by the Contracting Officer.
For locations of Sections see Plan on Plates Nos. 5-16 and 5-17
No excavation will extend below bedrock surface.

HURRICANE PROTECTION
NEW BEDFORD – FAIRHAVEN
TYPICAL SECTIONS NO. 3
CLARK COVE DIKE
STAS. 1+20 TO 58+00
NEW BEDFORD HARBOR MASSACHUSETTS

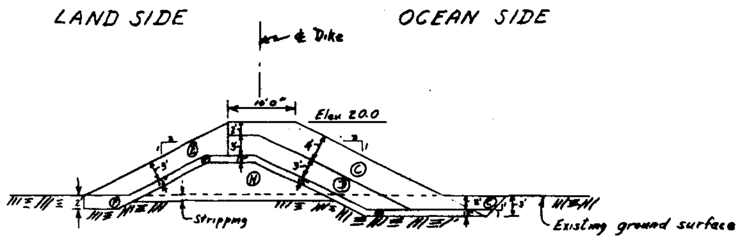
PLATE NO. 5 – 21



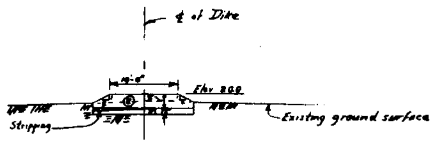
SECTION- STATION 1+00
Typical from Sta 0+40 to Sta 1+10
Sta 30+00 to Sta 30+80±



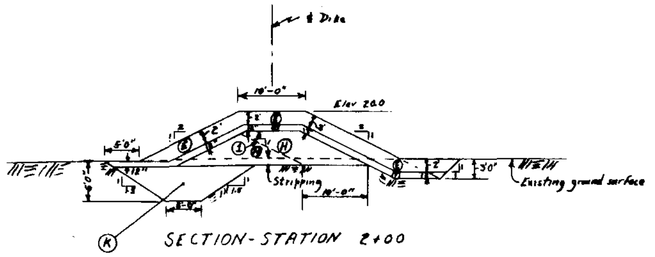
SECTION-STATION 3+00
Typical from Sta 3+00 to Sta 4+70
Note - Transition Sta 4+70 to Sta 5+50



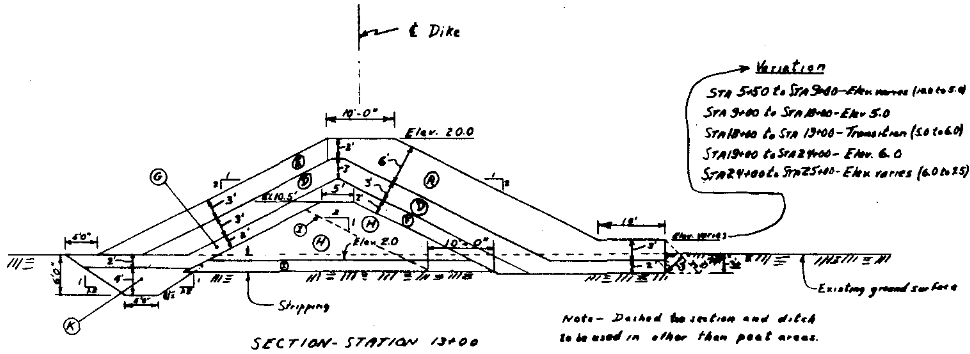
SECTION- STATION 27+00
Typical from Sta 25+80 to Sta 27+90
Note - Transition Sta 27+90 to Sta 28+10



SECTION-STATION 0+40
Typical from Sta 0+05± to Sta 0+40
and Sta 30+80± to Sta 31+00±



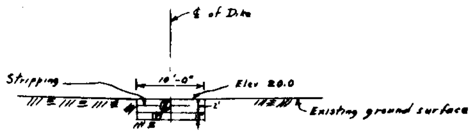
SECTION-STATION 2+00
Typical from Sta 2+00 to Sta 2+50
Note-Transition Sta 2+50 to Sta 3+00



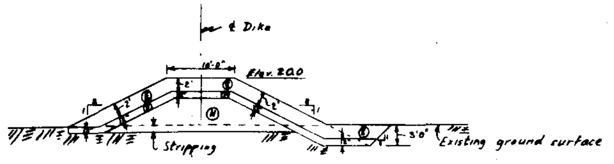
Variation
STA 5+50 to STA 9+00 - Elev. varies (4.0 to 5.0)
STA 9+00 to STA 18+00 - Elev 5.0
STA 18+00 to STA 19+00 - Transition (5.0 to 6.0)
STA 19+00 to STA 24+00 - Elev. 6.0
STA 24+00 to STA 25+00 - Elev varies (6.0 to 7.5)

Note - Dashed toe section and ditch to be used in other than peat areas.

SECTION- STATION 13+00
Typical from Sta 5+50 to Sta 25+00
Note - Transition Sta 25+00 to Sta 25+80



SECTION- STATION 0+00
Typical from Sta 0+00 to Sta 0+05±
and Sta 31+00± to Sta 31+10



SECTION-STATION 1+80
Typical from Sta 1+10 to 1+80
and Sta 28+10 to 29+80
Note - Transition Sta 29+80 to Sta 30+00
Sta 1+80 to Sta 2+00

Notes
Elevations refer to Mean Sea Level Datum
All elevations are plus elevations, except as noted
For locations of Sections, see Plan on Plate No. 5-18
① Material used from excavations for drainage trench shall be placed north of this line and prior to placement of other earth fill material north of this line

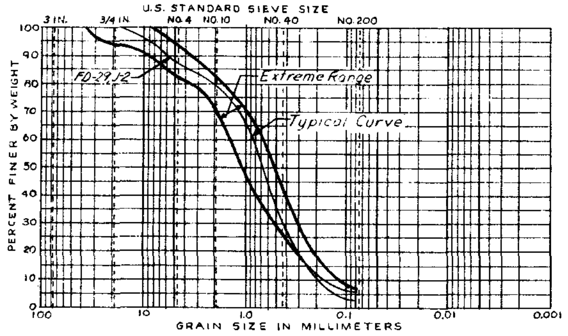
DEPTH OF STRIPPING	
STATION	APPROXIMATE DEPTH - INCHES
0+00-5+50	12±
5+50-6+50	24±
6+50-10+00	18±
10+00-13+00	30±
13+00-23+00	18±
23+00-31+10	12±

LEGEND		
Symbol	Material	Weight
Ⓐ	Armor Stone	4.5 to 2.75 Tons
Ⓒ	Armor Stone	2.0 to 1.0 Tons
Ⓓ	Bedding Stone	Quarry-Run
Ⓔ	Protection Stone	1500 to 500 Lbs.
Ⓕ	Gravel Bedding	—
Ⓗ	Compacted Earth Fill	—
Ⓘ	Dumped Earth Fill	—
Ⓚ	Drainage Trench Material	—

TYPICAL SECTIONS
SCALE: 1" = 10'
10 0 10 20

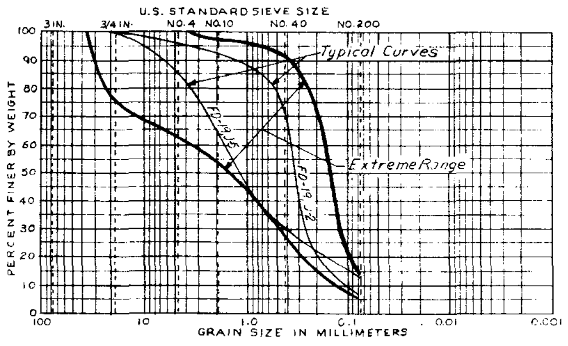
HURRICANE PROTECTION
NEW BEDFORD – FAIRHAVEN
TYPICAL SECTIONS NO. 4
FAIRHAVEN DIKE
STAS. 0+00 TO 31+10
NEW BEDFORD HARBOR MASSACHUSETTS

BORING NO.	SAMPLE NO.	DEPTH IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS				ATTERBERG LIMITS		SPECIFIC GRAVITY G_s	NATURAL WATER CONT. %	NATURAL DRY DENSITY LB/CU.FT.	ORGANIC CONT. %
				GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL				
FD-3	J-2	4.3- 5.0	SP	27	70	3	0.220						
FD-20	J-7	21.7-26.2	SP								14		
FD-23	J-4	10.0-13.0	SP								9		
FD-25	J-1	0- 2.0	SP								23		
	J-2	2.0- 6.0	SP	7	91	2	0.200				15		
FD-29	J-2	2.0- 5.5	SW	13	83	4	0.170				15		
FD-80	J-10	20.0-25.0	SP	14	85	1	0.200						
FD-81	J-2	1.2- 5.0	SP	15	81	4	0.310						
FD-86	J-3	5.0- 8.2	SP	19	77	4	0.150						



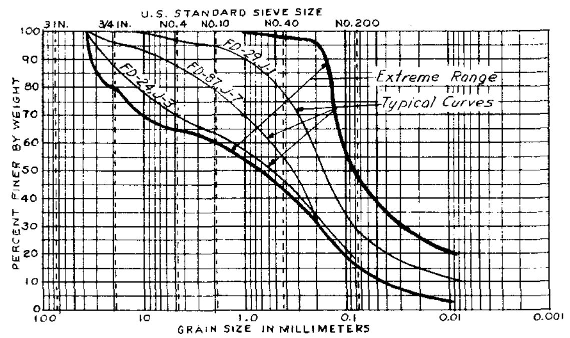
SP MATERIAL

BORING NO.	SAMPLE NO.	DEPTH IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS				ATTERBERG LIMITS		SPECIFIC GRAVITY G_s	NATURAL WATER CONT. %	NATURAL DRY DENSITY LB/CU.FT.	ORGANIC CONT. %
				GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL				
FD-19	J-5	13.0-18.0	SP-SM	15	73	12	0.060						
FD-23	J-2	2.0- 7.0	SP-SM	2	90	8	0.110				22		
	J-5	13.0-18.0	SP-SM	35	55	10	0.070				9		
FD-24	J-2	3.0- 8.0	SP-SM	38	54	8	0.110				12		
FD-25	J-3	6.0-12.0	SP-SM	2	86	12	0.070				28		
	J-5	14.0-17.0	SP-SM								16		
FD-80	J-1	0.0- 5.0	SP-SM	3	86	11	0.070						
FD-81	J 10	21.1-23.4	SP-SM	24	65	11							
FD-83	J-10	22.5-25.0	SW-SM	13	79	8	0.090						
	B-19	45.0-50.0	SP-SM	—	94	6	0.140						



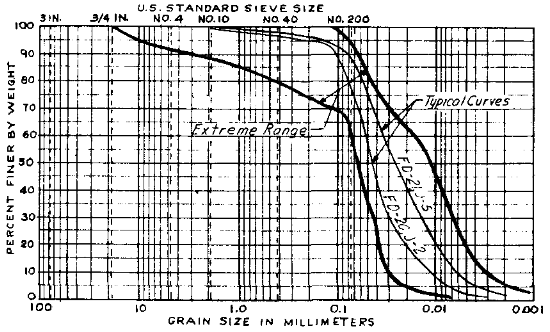
SP-SM AND SW-SM MATERIAL

BORING NO.	SAMPLE NO.	DEPTH IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS				ATTERBERG LIMITS		SPECIFIC GRAVITY G_s	NATURAL WATER CONT. %	NATURAL DRY DENSITY LB/CU.FT.	ORGANIC CONT. %
				GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL				
FD-2	J-7	22.0-27.0	SM	20	57	23	0.024						
FD-3	J-4	6.4-11.0	SM	23	56	21	0.016						
FD-21	J-1	0- 1.0	SM								28		
FD-22	J-6	15.0-19.0	SM	43	41	16	0.035				8		
FD-23	J-1	0- 2.0	SM								32		
FD-24	J-3	8.0-11.0	SM	30	53	17					10		
FD-25	J-4	12.0-14.0	SM								20		
	J-6	17.0-22.0	SM	0	53	47					22		
	J-9	31.0-32.0	SM								9		
	J-10	32.0-35.0	SM	9	75	16	0.022			2.67	16		
FD-29	J-1	0- 2.0	SM	3	67	28	0.007				34		
	J-3	22.0-22.9	SM								9		
FD-77	J-8	16.5-20.0	SM	32	45	23	0.025						
FD-80	J-7	10.0-15.0	SM	0	78	22							
	J-14	36.2-38.7	SM	29	48	23	0.025						
FD-81	J-14	27.5-30.0	SM	20	51	29	0.011						
FD-83	J-4	10.0-15.0	SM-SC	2	52	46	0.004	25	20				
	J-9	20.0-22.5	SM	9	60	31							
	B-12	25.0-30.0	SM	0	80	20		NON-PLASTIC					
FD-84	J-9	22.7-25.0	SM	34	46	20	0.020						
FD-85	J-7	15.6-20.0	SM	23	60	17							
	J-8	20.0-21.9	SM	36	45	19							
FD-87	B-6	10.0-15.0	SM	32	50	18	0.010						
	J-7	15.0-20.0	SM	14	70	16							
	B-8A	20.0-25.0	SM	23	63	14							



SM MATERIAL

BORING NO.	SAMPLE NO.	DEPTH IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS				ATTERBERG LIMITS		SPECIFIC GRAVITY G_s	NATURAL WATER CONT. %	NATURAL DRY DENSITY LB/CU.FT.	ORGANIC CONT. %
				GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL				
FD-2	J-4	12.0-17.0	ML	0	10	90	0.014						
FD-20	J-2	3.5- 5.0	ML	0	20	80	0.012				23		
	J-3	5.0-10.0	ML	0	37	63	0.030			2.67	25		
	J-4	10.0-15.0	ML								25		
	J-5	15.0-20.0	ML	0	6	94	0.012			2.67	24		
	J-6	20.0-21.7	ML								28		
FD-21	J-3	4.0- 5.0	ML	0	9	91	0.011				26		
	J-4	5.0-10.0	ML	0	6	94	0.009				24		
	J-5	10.0-12.0	ML	0	10	90	0.006				24		
FD-22	J-3	5.0- 8.0	ML	0	35	65	0.018				24		
	J-4	9.0-14.0	ML	0	16	84	0.014				25		
	J-5	14.0-15.0	ML								19		
FD-23	J-3	8.0-10.0	ML	8	25	67					20		
FD-25	J-7	22.0-27.0	ML	0	6	94	0.003			2.73	31		
	J-8	27.0-31.0	ML								34		
	J-11	35.0-37.0	ML	0	6	94	0.010				26		
	J-12	39.0-41.7	ML								21		
FD-24	J-3	5.5- 7.0	ML	0	38	62					23		
	J-4	7.0-12.0	ML	0	32	68	0.022			2.67	24		
	J-5	13.0-18.0	ML								23		
	J-6	19.0-20.5	ML	0	8	92	0.008			2.68	23		
FD-77	J-3	5.0-10.0	ML	0	15	85	0.013						
FD-78	B-4	5.0-10.0	ML	0	30	70							
FD-84	J-3	2.4- 5.0	ML	0	30	70	0.018						
	J-7	15.0-20.0	ML	0	8	92	0.012						
FD-85	J-4	10.0-13.8	ML	7	23	70							

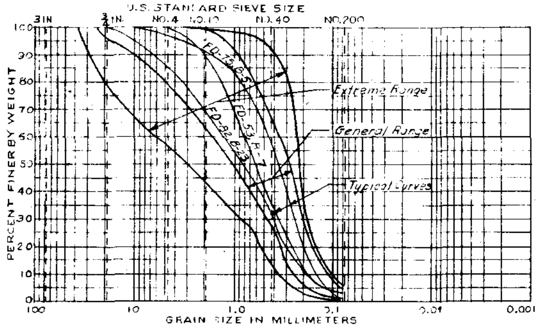


ML MATERIAL

HURRICANE PROTECTION
NEW BEDFORD - FAIRHAVEN
SUMMARY OF TEST DATA
SECTOR GATE STRUCTURE
NEW BEDFORD HARBOR MASSACHUSETTS

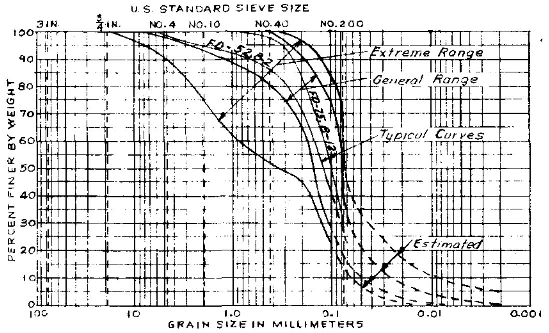
CORPS OF ENGINEERS **U. S. ARMY**

BORING NO	SAMPLE NO	DEPTH OF SAMPLE IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL	PL	SPECIFIC GRAVITY G_s	NATURAL WATER CONTENT %	NATURAL DRY DENSITY lbs/cu.ft.	ORGANIC CONT %
FD-26	J-2	4.0-9.0	SP	9	90	1	0.11				16		
	J-9	9.0-10.0	SP								15		
	J-11	31.0-34.0	SP								13		
	J-12	34.0-38.0	SP	6	94	0	0.37						
FD-50	J-10	15.0-17.5	SP	0	97	3	0.19						
	J-13	20.0-22.3	SP	0	96	4	0.11						
FD-53	B-7	10.0-15.0	SP	1	96	3	0.19						
	B-9	15.0-20.0	SP	12	86	2	0.21						
	B-12	22.5-25.0	SP	5	92	3	0.13						
FD-60	B-7	10.0-15.0	SP	2	94	4	0.17						
FD-74	J-3	5.0-7.1	SP	0	99	1	0.27						
FD-75	J-2	1.5-4.1	SP	10	88	2	0.18						
	B-5	5.0-8.8	SP	3	96	1	0.16						
FD-82	B-16	30.0-35.0	SP	1	97	2	0.14						
	J-23	40.0-44.1	SP	15	81	4	0.18						
FD-88	J-13	26.1-29.2	SP	44	52	4	0.23						
	B-17	40.0-45.0	SP	0	100	0	0.20						
FD-89	J-2	5.0-8.0	SP	11	84	5	0.14						
	J-3	8.0-10.0	SP	2	95	3	0.17						
FD-90	J-2	1.2-5.0	SP	13	84	3	0.15						
FD-94	J-2	4.0-5.0	SP	3	93	4	0.12						
	J-3	5.0-6.1	SP	22	74	4	0.17						



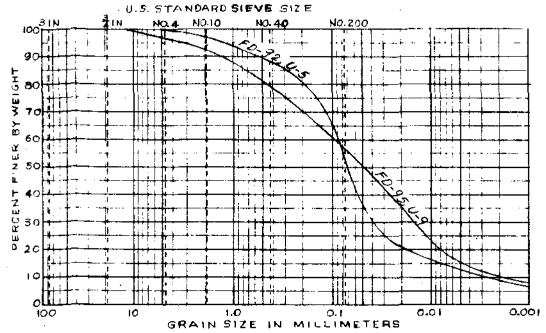
SP MATERIAL

BORING NO	SAMPLE NO	DEPTH OF SAMPLE IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL	PL	SPECIFIC GRAVITY G_s	NATURAL WATER CONTENT %	NATURAL DRY DENSITY lbs/cu.ft.	ORGANIC CONT %
FD-8	J-9	16.6-17.0	SM	1	56	43							
FD-26	J-4	10.0-14.0	SM	6	61	33	0.009				24		
	J-13	38.0-43.0	SM								2		
	J-14	43.0-48.0	SM	4	83	13					19		
FD-50	B-15A	25.0-30.0	SM	11	57	32							
FD-51	B-2	0.0-50.0	SM	2	75	23							
	B-5	6.8-10.0	SM	0	63	37							
	B-7	10.0-15.0	SM	2	82	16							
	J-8	15.0-20.0	SM	0	68	32							
	B-10	20.0-25.5	SM	0	60	40							
FD-52	B-10	20.0-25.0	SM	0	68	32							
FD-53	J-15	30.0-35.0	SM	0	53	47							
FD-57	B-9	15.0-20.0	SM	0	87	13							
	B-11	20.0-23.9	SM	0	68	32							
FD-74	B-13	21.4-25.0	SM	0	54	46							
FD-75	B-8	10.0-15.0	SM	0	64	36							
	B-12	20.0-25.5	SM	0	75	25							
FD-82	B-6	10.0-15.0	SM	3	53	44	0.003	NON-PLASTIC					
FD-90	J-3	5.0-7.0	SM	9	66	25	0.02						
FD-94	J-5	8.8-10.2	SM	1	79	20							



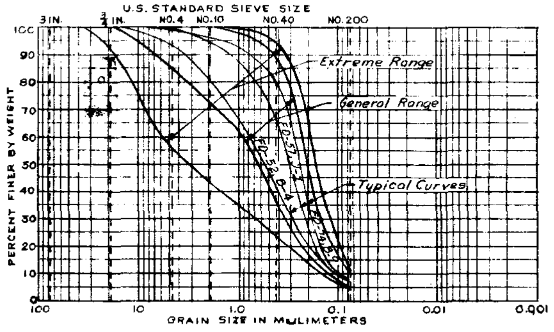
SM MATERIAL

BORING NO	SAMPLE NO	SAMPLE DEPTH IN FEET	DEPTH OF TEST IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL	PL	SPECIFIC GRAVITY G_s	NATURAL WATER CONTENT %	NATURAL DRY DENSITY lbs/cu ft	ORGANIC CONT %
FD-92	UC-5	11.3-11.6		OL	0	47	53	0.003	45	26	2.65	38	83	
	UC-9	11.2-16.7		OL	0	53	42	0.002	28	19	2.68	47	77	



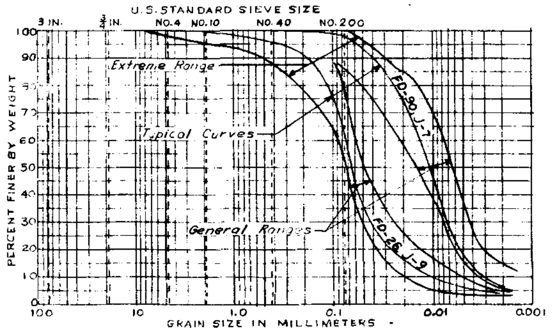
OL MATERIAL

BORING NO	SAMPLE NO	DEPTH OF SAMPLE IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL	PL	SPECIFIC GRAVITY G_s	NATURAL WATER CONTENT %	NATURAL DRY DENSITY lbs/cu.ft.	ORGANIC CONT %
FD-8	J-10	17.0-22.0	SP-SM	16	77	7	0.11						
FD-26	J-1	0.0-4.0	SP-SM								26		
	J-7	21.0-25.0	SP-SM								18		
	J-15	48.0-52.0	SP-SM								24		
	J-16	52.0-57.0	SP-SM								27		
	J-18	62.0-64.4	SP-SM								8		
FD-50	J-2	1.2-4.5	SP-SM	4	86	10	0.075						
	J-4	5.0-8.2	SP-SM	6	84	10	0.075						
	J-7	10.0-12.4	SP-SM	44	48	8	0.12						
FD-52	B-4	5.0-10.0	SP-SM	7	86	8	0.10						
	J-7	15.0-18.2	SP-SM	5	85	10	0.07						
FD-53	J-3	3.7-5.0	SP-SM	24	70	6	0.16						
	B-5	5.0-10.0	SP-SM	10	80	10	0.07						
	B-14	25.0-30.0	SP-SM	0	89	11	0.07						
FD-57	J-1	0.0-5.0	SP-SM	2	91	7	0.11						
	B-3	5.0-8.8	SP-SM	6	87	7	0.12						
	B-6	10.0-14.0	SP-SM	7	88	5	0.20						
FD-60	B-12	20.0-25.0	SP-SM	0	94	6	0.10						
FD-74	B-9	15.0-20.0	SP-SM	0	95	5	0.11						



SP - SM MATERIAL

BORING NO	SAMPLE NO	DEPTH OF SAMPLE IN FEET	SOIL SYMBOL	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL	PL	SPECIFIC GRAVITY G_s	NATURAL WATER CONTENT %	NATURAL DRY DENSITY lbs/cu.ft.	ORGANIC CONT %
FD-8	J-5	10.5-11.5	ML	1	15	84	0.003						
	J-6	11.5-12.0	ML	2	47	51	0.020						
	J-7	12.1-13.1	ML	0	7	93	0.002						
FD-26	J-5	14.0-19.0	ML	0	14	86		37	29		52		
	J-6	19.0-21.0	ML	0	43	57	0.005				25		
	J-8	22.5-24.0	ML								24		
	J-9	24.0-27.0	ML	0	37	63	0.009	NON-PLASTIC			21		
	J-10	27.0-29.0	ML	0	2	98	0.003				32		
	J-17	57.0-61.0	ML								23		
FD-52	J-5	10.0-15.0	ML								43		4
	B-6	10.0-15.0	ML	0	32	68							
	J-8	18.2-20.0	ML	0	35	65							
	B-12	25.0-30.0	ML	0	20	80							
FD-60	B-15	26.3-30.0	ML	0	31	69							
FD-88	J-18	45.0-50.0	ML	0	29	71							
FD-90	J-7	12.3-15.0	ML	0	1	99	0.003				30		



ML MATERIAL

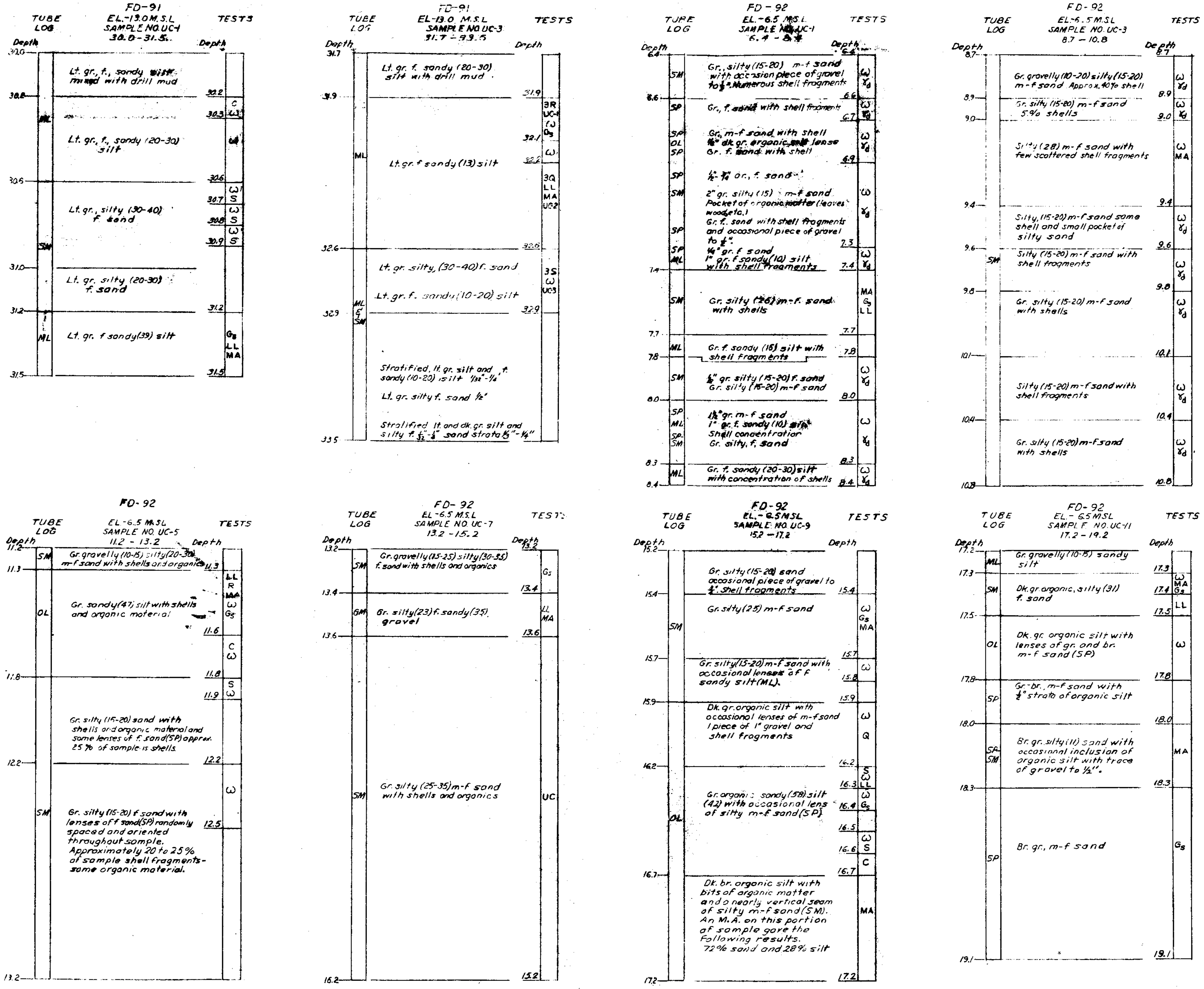
HURRICANE PROTECTION

NEW BEDFORD – FAIRHAVEN

SUMMARY OF TEST DATA
BYPASS CHANNEL

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5 - 24



LEGEND FOR TESTS

ω	Natural Water Content
MA	Mechanical Analysis
LL	Atterberg Limits
G_s	Specific Gravity of Solids
γ_d	Dry Density
C	Consolidation
Q	Unconsolidated Undrained Triaxial Compression Test
R	Consolidated Undrained Triaxial Compression Test
S	Consolidated Drained Direct Shear Test
UC	Unconfined Compression Test

NOTES

For location of explorations, see Plate No.

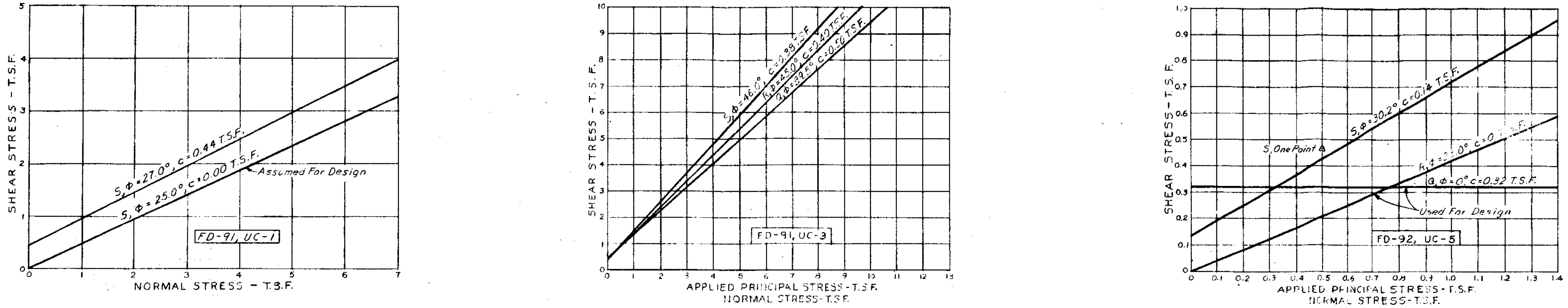
For legend of tube logs, see Plate No. 5-4

HURRICANE PROTECTION

NEW BEDFORD – FAIRHAVEN

SUMMARY OF LOGS OF UNDISTURBED SAMPLES

NEW BEDFORD HARBOR MASSACHUSETTS

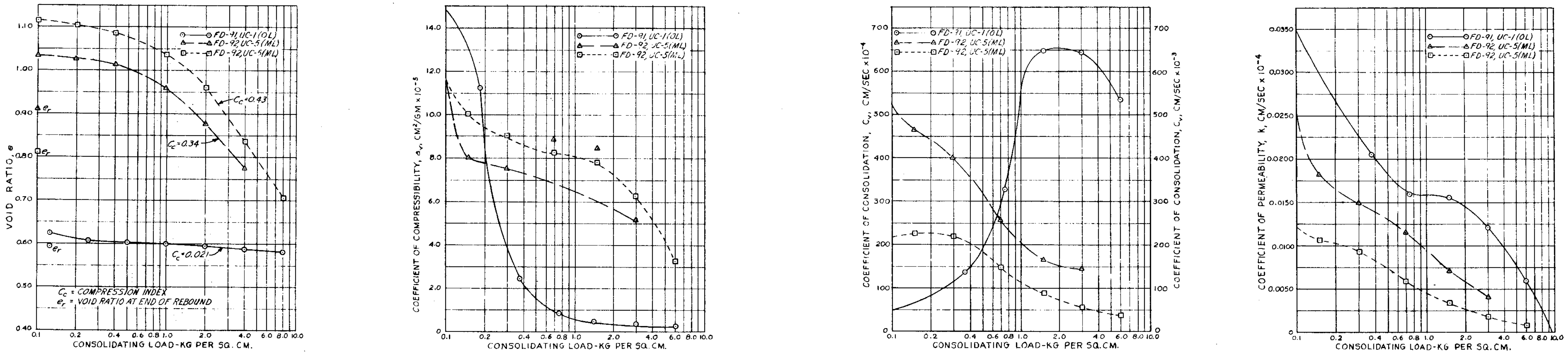


SM - MATERIAL

ML - MATERIAL

OL - MATERIAL

SHEAR STRENGTH CURVES



CONSOLIDATION CHARACTERISTICS OF THE ML AND OL MATERIAL

SOIL SYMBOL	BORING NO.	TOP ELEV. FT. M.S.L.	SAMPLE NO.	DEPTH OF SAMPLE FEET	MECHANICAL ANALYSIS				ATTERBERG LIMITS		SPECIFIC GRAVITY Gs	CONSOLIDATION DATA									SHEAR DATA													
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		SPECIMEN SIZE		INITIAL			FINAL		P_o T/SQFT	P_c T/SQFT	TEST	TYPE OF TEST	SPECIMEN SIZE IN INCHES			INITIAL			σ_{III} T/SQFT	σ_{I} T/SQFT	σ T/SQFT	τ T/SQFT	c T/SQFT	ϕ DEGREES
												H IN.	A SQ. IN.	ω %	γ lb/cu.ft.	S %	ω %	S %					H	D or L	L	ωi %	γi lb/cu.ft.	Si %						
SM	FD-91	-13.0	UC-1	30.6-30.7																	1	S	0.75	3.0	3.0	20	101	82			1.0	0.86		
				30.7-30.8																	2	S	0.75	3.0	3.0	20	104	89			2.0	1.44	0.44	27.0
				30.8-30.9																	3	S	0.75	3.0	3.0	20	103	85			4.0	2.35		
	FD-92	- 6.5	UC-7	13.6-15.2																		UC	7.09	5.0		30	91	96					0.16	0
ML	FD-91	-13.0	UC-1	30.2-30.3								1	15.50	24	102	100	23	104	0.83	1.0														
				31.2-31.5	0	39	61	0.015	NON-PLASTIC		2.68																							
			UC-3	31.9-32.1																														
																					1	R	1.40	3.0		21	108	100	1.08	7.85				
																					2	R	1.40	3.0		19	110	100	2.16	15.56			0.40	45.0
																					3	R	1.40	3.0		20	110	100	4.32	27.50				
											2.70											UC	1.40	3.0		20	108	97						
				32.2-32.6																	1	Q	1.40	3.0		20	110	100	1.08	7.86				
																					2	Q	1.40	3.0		21	108	100	2.16	16.41			0.50	39.5
																					3	Q	1.40	3.0		20	108	100	4.32	26.24				
					0	13	87	0.009	NON-PLASTIC													UC	1.40	3.0		21	108	99					0.40	0
				32.6-32.9																	1	S	1.40	3.0		20	109	100	1.08	8.05				
																					2	S	1.40	3.0		22	106	99	2.16	15.55			0.38	46.0
																					3	S	1.40	3.0		20	109	100	4.32	27.42				
																						UC	1.40	3.0		20	109	100					0.52	0
OL	FD-92	- 6.5	UC-5	11.3-11.6	0	47	53	0.003													1	R	1.44	3.01		43	77	99	0.54	1.18				
									45	26											2	R	1.41	3.03		35	86	100	1.08	2.55			0.0	23.0
											2.65										3	R	1.43	3.03		36	84	98	2.16	4.90				
				11.6-11.8								1	15.50	39	80	99	32	105	0.32	1.0														
			UC-9	15.9-16.2																	1	Q	1.44	3.03		39	82	100	0.54	1.19				
																					2	Q	1.35	3.03		40	82	100	1.08	1.72			0.32	0
																					3	Q	1.35	3.03		40	80	97	2.16	3.32				
				16.2-16.3					28	19											1	S	0.75	3.0	3.0	45	76	99			0.5	0.42		
				16.3-16.4	5	53	42	0.002			2.68										2	S	0.75	3.0	3.0	40	77	90			1.0	0.72	0.136	30.2
				16.5-16.6																	3	S	0.75	3.0	3.0	43	77	100			1.5	1.00		
				16.6-16.7								1		43	78	101	32	107	0.45	1.5														

SUMMARY OF TEST DATA

LEGEND

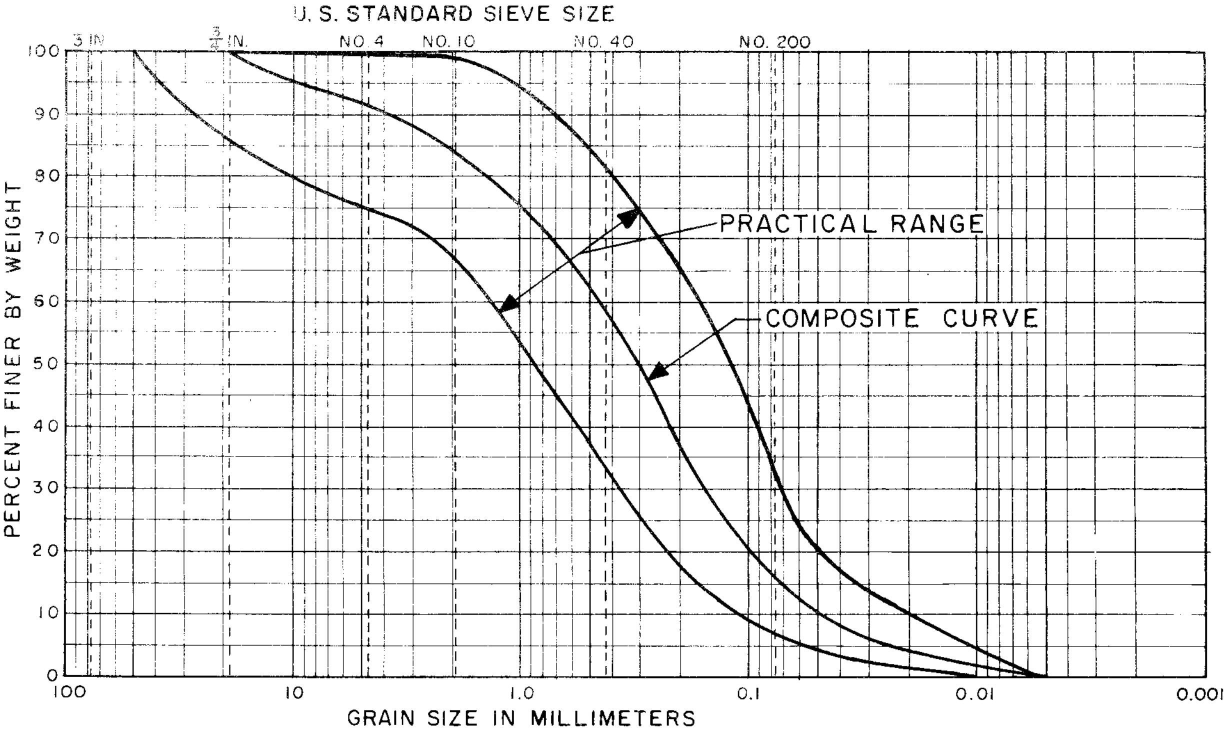
Q	Unconsolidated Undrained Triaxial Compression Test
R	Consolidated Undrained Triaxial Compression Test
S	Consolidated Drained Direct Shear Test
UC	Unconfined Compression Test

HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

SUMMARY OF TEST DATA
SHEAR AND CONSOLIDATION

NEW BEDFORD HARBOR MASSACHUSETTS



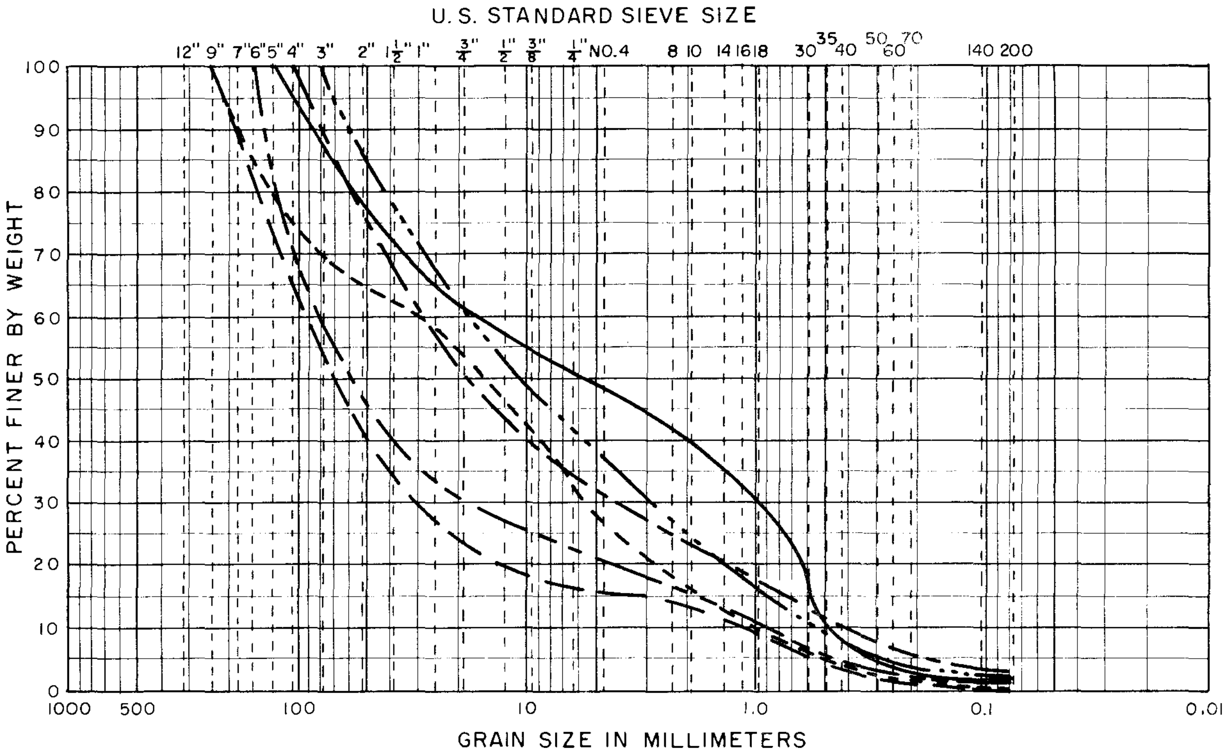
HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

COMPOSITE CURVE AND PRACTICAL RANGE OF EARTH FILL MATERIAL

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-27



LEGEND	SOURCE AND LOCATION	DISTANCE TO THE PROJECT IN MILES	TYPE OF MATERIAL
————	Assonet Sand and Gravel Co. Assonet, Mass. ENTIRE PIT	18	Ⓕ
—— —— -	Assonet Sand and Gravel Co. Assonet, Mass. COARSE PORTION OF PIT	18	Ⓕ and Ⓖ
- - - - - - -	Borge Pit Assonet, Mass.	18	Ⓕ and Ⓖ
—— - - ——	Mederios Freetown Pit No. 1 Freetown, Mass.	10	F
—— - - - ——	Mederios Freetown Pit No. 2 Freetown, Mass.	10	Ⓕ and Ⓖ
—— - - - - ——	Tri City Pit Berkley, Mass.	18	Ⓕ

NOTE

Ⓕ Represents GRAVEL BEDDING

Ⓖ Represents FILTER MATERIAL

HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

SOURCES AND GRADATIONS OF
GRAVEL BEDDING AND
FILTER MATERIALS

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5-28

OF SAFETY FACTORS FROM STABILITY ANALYSES FOR CONSTRUCTION CONDITION

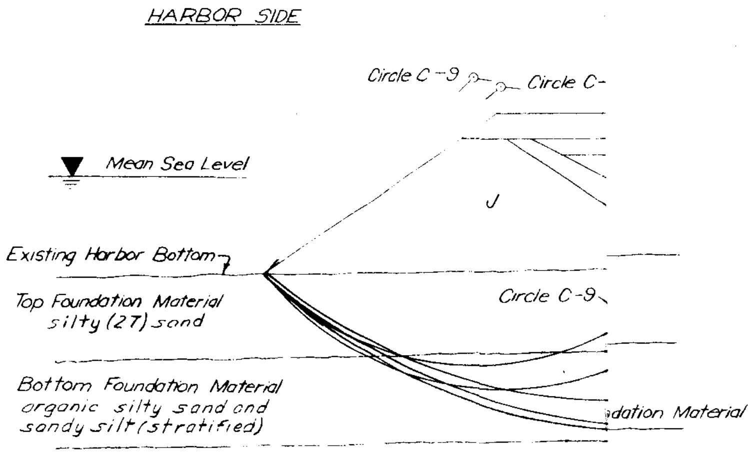
HARBOR SIDE		OCEAN SIDE	
TOP FOUNDATION LAYER Q STRENGTH			
BOTTOM FOUNDATION LAYER		BOTTOM FOUNDATION LAYER	
Q STRENGTH	R STRENGTH	Q STRENGTH	R STRENGTH
—	—	1.25	1.33
—	—	1.97	1.40
—	—	1.19	1.58
—	—	1.32	1.91
—	—	1.22	1.40
—	—	1.40 *	
1.90	2.08		
1.36	1.67		
2.00	2.07		
1.39	1.74		
1.41	1.52		

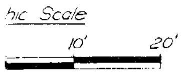
* Circle C-6 Passes Through Top Foundation Material Only

Circle C-1.

DESIGN VALUES

MATERIAL	UNIT WEIGHT(Y) PCF				SHEAR STRENGTH					
					Q		R		S	
	Y sat	Y moist	Y dry	Y sub	φ	c,TSF	φ	c,TSF	φ	c,TSF
(A) Armor Stone			110	68					40°	
(B) Bedding Stone, Quarry Run			115						40°	
(E) Protection Stone			105						40°	
(F) Gravel Bedding			115						30°	
(G) Filter Material			115	71					30°	
(H) Compacted Earth Fill	131	123	108	67					35°	
(I) Dumped Earth Fill	125	114	100	61					30°	
(J) Rock Fill			100	61					40°	
Top Foundation Material			92	56	25°					
Bottom Foundation Material			88	54		0.32	23°			





HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

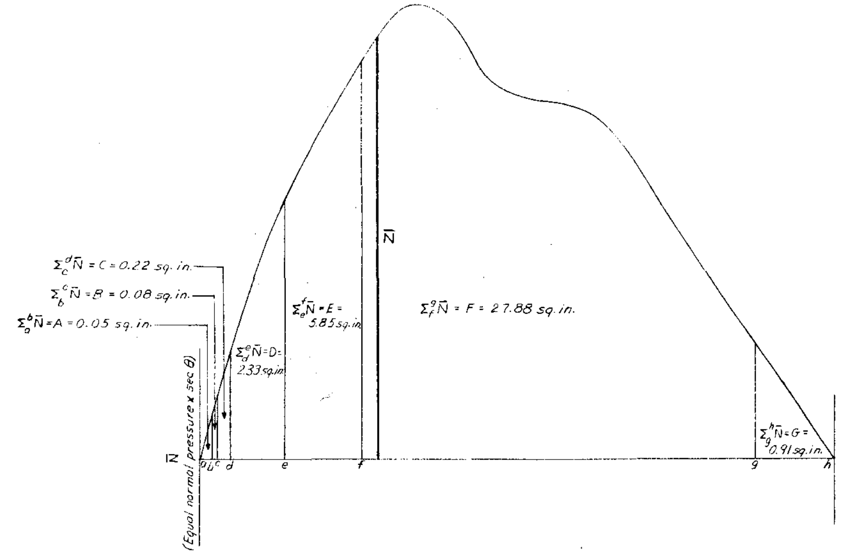
SUMMARY OF STABILITY ANALYSES

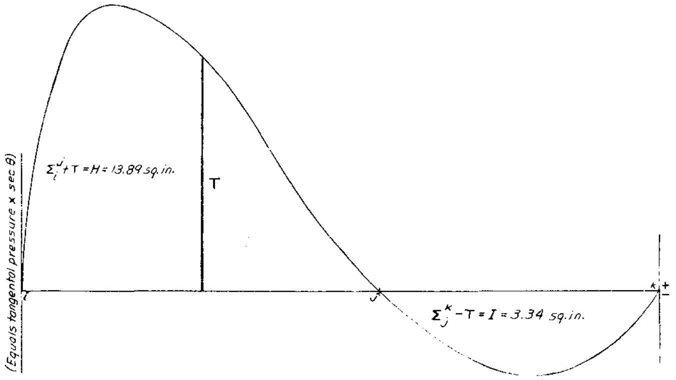
HARBOR BARRIER

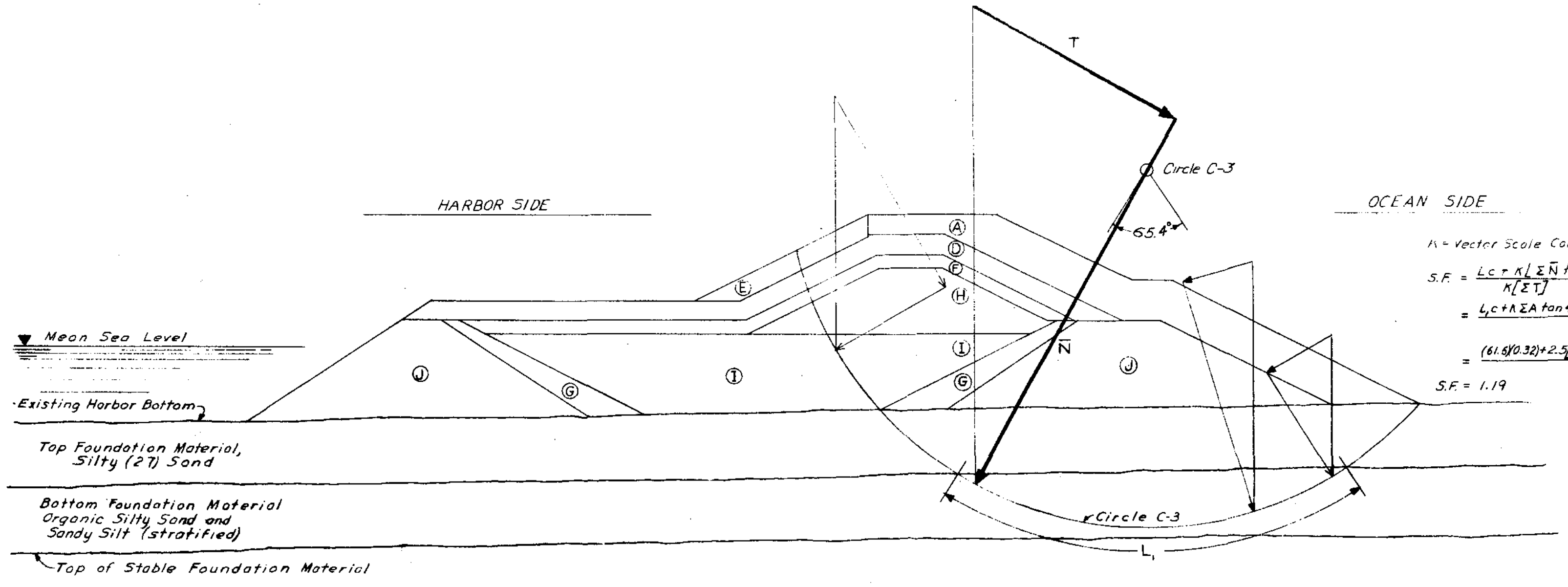
NEW BEDFORD HARBOR MASSACHUSETTS

WEIGHT VECTOR RATIOS
50 LBS = 1.00

MATERIAL		VECTOR RATIO (V_R)
Ⓐ Armor Stone	(Dry)	110 ÷ 50 = 2.20
Ⓐ Armor Stone	(Sub.)	68 ÷ 50 = 1.36
Ⓓ Bedding Stone Quarry Run	(Dry)	115 ÷ 50 = 2.30
Ⓔ Protection Stone	(Dry)	105 ÷ 50 = 2.10
Ⓕ Gravel Bedding	(Dry)	115 ÷ 50 = 2.30
Ⓖ Gravel Filter	(Dry)	115 ÷ 50 = 2.30
Ⓖ Gravel Filter	(Sub)	71 ÷ 50 = 1.42
Ⓗ Compact Earth Fill	(Moist)	123 ÷ 50 = 2.46
Ⓘ Dumped Earth Fill	(Sat.)	125 ÷ 50 = 2.50
Ⓘ Dumped Earth Fill	(Sub.)	61 ÷ 50 = 1.22
Ⓙ Rock Fill	(Dry)	100 ÷ 50 = 2.00
Ⓙ Rock Fill	(Sub.)	61 ÷ 50 = 1.22
Top Foundation Material	(Sub.)	56 ÷ 50 = 1.12
Bottom Foundation Material	(Sub.)	54 ÷ 50 = 1.08







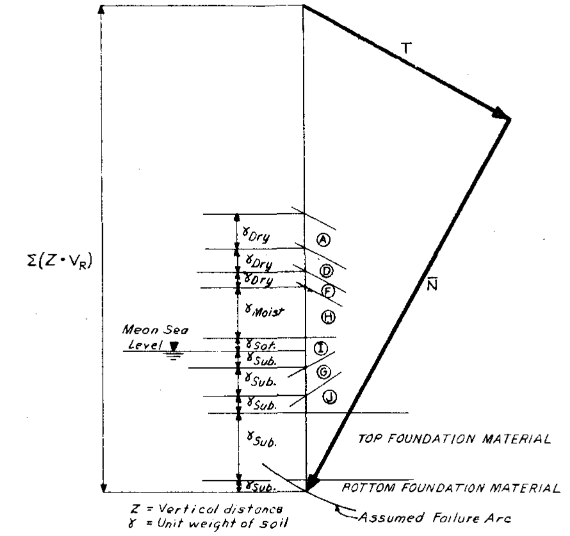
K = Vector Scale Conversion Factor

$$S.F. = \frac{Lc + K[\Sigma \bar{N} \tan \phi]}{K[\Sigma T]}$$

$$= \frac{L_1 c + K \Sigma A \tan 40^\circ + (B+D) \tan 30^\circ + C \tan 35^\circ + (E+G) \tan 25^\circ}{K[H - I]}$$

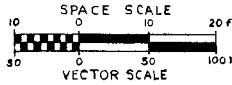
$$= \frac{(61.6)(0.32) + 2.5[(0.05)(0.839) + (0.08 + 2.33)(0.577) + (0.22)(0.700) + (5.85 + 0.91)(0.466)]}{2.5[13.89 - 3.34]}$$

S.F. = 1.19



Z = Vertical distance
γ = Unit weight of soil

TYPICAL VECTOR DIAGRAM



HURRICANE PROTECTION

NEW BEDFORD - FAIRHAVEN

TYPICAL STABILITY ANALYSIS

CONSTRUCTION CONDITION - CIRCLE C-3

HARBOR BARRIER

NEW BEDFORD HARBOR MASSACHUSETTS

STRUCTURE	REQUIRED EXCAVATION			REQUIRED EARTH FILL			REMARKS PERTAINING TO ORIGIN AND DISPOSITION OF MATERIALS SELECTED FOR USE
	A TOTAL	B SELECTED FOR USE	C WASTE =A-B	D TOTAL	E FROM EXCAVATION =0.8 B	F FROM STOCK-PILES =D-E	
Clark Cove Dike Including Ponding Area	153,000	47,700	105,700	81,600	38,200	43,400	Material excavated west of Sta. 22+00 in Ponding Area and between Stas. 10+30 and 22+00 in dike foundation area, exclusive of stripping, will be used for construction of dike.
Harbor Barrier Dike Including Drainage Ditch and Maintenance Area No. 1	49,500	17,400	32,100	93,600	13,900	79,700	Material excavated south of Sta. 36+80, exclusive of stripping, will be used for construction of dike west of Sta. 7+00, Maintenance Area No. 1 and adjoining roads, and for fill in area of drainage ditch.
Harbor Barrier, West of Assumed Limit of Cofferdam for Sector Gate Structure	1,100	-	1,100	78,300	-	78,300	
Harbor Barrier, East of Assumed Limit of Cofferdam for Sector Gate Structure, Including Maint. Area No. 2	5,600	2,200	3,400	26,700	1,800	25,000	Material excavated east of Sta. 86+00, exclusive of stripping, will be used in construction of Barrier, Maintenance Area No. 2 and adjoining roads
Harbor Barrier Sector Gate Structure within Assumed Limits of Cofferdam	140,000	-	140,000	123,000	-	123,000	
Bypass Channel Below Elev. -12 MSL	See Below			90,000 (neat lines) 93,000 (2' overdepth)	-	90,000 (neat lines) 93,000 (2' overdepth)	
Fairhaven Dike	23,500	4,500	19,000	17,100	3,600	13,500	Material excavated for landside foundation toe drain, exclusive of stripping, will be placed in landside portion of dike embankment section.
Totals						452,900 to 455,900	

Bypass Channel Excavation:

To neat lines	651,000
To lines at 2' overdepth	730,000
Limits of quantity of actual excavation	651,000 to 730,000
Losses during pumping, assumed at 5%	32,600 to 36,500
Available for stock piles (stock pile measurement)	618,400 to 693,500
Losses due to material required in stock pile areas for grading and stabilization, assumed at 10%	61,800 to 69,400
Material available for use from stock piles	556,600 to 624,100
Material required from stock piles for earth fill (embankment measurement)	452,900 to 455,900

By placing all material from Bypass Channel excavation in the stock piles, there will be about 20% additional material to compensate for settlement, foundation displacement, shrinkage, over excavation, incorrect topography, more stripping than assumed, losses due to storms, transportation etc.

HURRICANE PROTECTION

NEW BEDFORD – FAIRHAVEN

QUANTITIES AND DISTRIBUTION OF EARTH MATERIALS

NEW BEDFORD HARBOR MASSACHUSETTS

PLATE NO. 5–31

APPENDIX A
SUMMARY OF TEST DATA
OTHER THAN SHEAR AND CONSOLIDATION DATA
HURRICANE PROTECTION - NEW BEDFORD-FAIRHAVEN

Page Nos.	Exploration Numbers
A-19	FD-118 - FD-119
A-20	FT-2 - FT-6, FT-10, FT-11, FT-16, FT-18, FT-20, FT-21
A-21	BD-1 - BD-4
A-22	BD-5 - BD-8
A-23	BD-8 (Cont.) - BD-11
A-24	BD-12, BD-14
A-25	BA-1 - BA-12
A-26	BT-1 - BT-12

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENT %
					GRAVEL %	SAND %	FINES %	D10 mm.	LL	PL		TOTAL	-NO4	STND. AASHO OPT. WATER - % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	-NO4	SHEAR	CONSOL.	PERM.	
FD-2	-22.1	J-4	12.0-17.0	ML	0	10	90	0.014														
		J-7	22.0-27.0	SM	20	57	23	0.024														
FD-3	-13.1	J-2	4.3- 5.0	SP	27	70	3	0.22														
		J-4	8.4-11.0	SM	23	56	21	0.016														
FD-4	-8.4	J-4	10.7-12.0	SM	13	64	23															
FD-5	-9.4	J-1	0.0-2.2	SM	4	83	13	0.050														
		J-2	2.2-5.0	SP-SM	0	93	7	0.078														
FD-6	-7.5	J-1	0.0-1.2	OL	0	44	56		34													8
		J-2	1.2-3.2	ML	0	39	61	0.014														
FD-7	-5.1	J-1	0.0-3.8	OH	0	11	89		68													18
		J-4	12.0-17.0	SM	26	50	24	0.015														
FD-8	-6.0	J-5	10.5-11.5	ML	1	15	84	0.003														
		J-6	11.5-12.0	ML	2	47	51	0.02														
		J-7	12.1-13.1	ML	0	7	93	0.002														
		J-9	16.6-17.0	SM	1	56	43															
		J-10	17.0-22.0	SP-SM	16	77	7	0.11														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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		
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	-NO4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	-NO4	SHEAR	CONSOL.	PERM.
FD-19	-33.3	J-2	3.0- 8.0	SP-SM	5	89	6	0.13													
		J-3	8.0-11.0	ML	0	13	87	0.004				20									
		J-5	13.0-18.0	SP-SM	15	73	12	0.060													
FD-20	-34.4	J-2	3.5- 5.0	ML	0	20	80	0.012				23									
		J-3	5.0-10.0	ML	0	37	63	0.030			2.67	25									
		J-4	10.0-15.0	ML								25									
		J-5	15.0-20.0	ML	0	6	94	0.012			2.67	24									
		J-6	20.0-21.7	ML								28									
		J-7	21.7-26.2	SP								14									
FD-21	-34.3	J-1	0.0- 1.0	SM								28									
		J-3	4.0- 5.0	ML	0	9	91	0.011				26									
		J-4	5.0-10.0	ML	0	6	94	0.009				24									
		J-5	10.0-12.0	ML	0	10	90	0.006				24									
		J-7	15.0-19.1	GP-GM	56	33	11	0.07				8									
FD-22	-33.6	J-3	5.0- 8.0	ML	0	35	65	0.018				24									
		J-4	9.0-14.0	ML	-	16	84	0.014													
		J-5	14.0-15.0	ML								19									
		J-6	15.0-19.0	SM	43	41	16	0.035				8									
FD-23	-35.3	J-1	0-2.0	SM								32									
		J-2	2.0-7.0	SP-SM	2	90	8	0.11				22									
		J-3	8.0-10.0	ML	8	25	67					20									
		J-4	10.0-13.0	SP								9									
		J-5	13.0-18.0	SP-SM	35	55	10	0.07				9									

* PROVIDENCE VIBRATED DENSITY TEST.

EXPL. NO.	TOP ELEV. FT. M.S.L.	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.
FD-24	-16.6	J-2	3.0- 8.0	SP-SM	38	54	8	0.11				12									
		J-3	8.0-11.0	SM	30	53	17					10									
FD-25	- 6.2	J-1	0.0- 2.0	SP								23									
		J-2	2.0- 6.0	SP	7	91	2	0.20				15									
		J-3	6.0-12.0	SP-SM	2	86	12	0.07				28									
		J-4	12.0-14.0	SM								20									
		J-5	14.0-17.0	SP-SM								16									
		J-6	17.0-22.0	SM	0	53	47					22									
		J-7	22.0-27.0	ML	0	6	94	0.003			2.73	31									
		J-8	27.0-31.0	ML								34									
		J-9	31.0-32.0	SM								9									
		J-10	32.0-35.0	SM	9	75	16	0.022			2.67	16									
		J-11	35.0-37.0	ML	0	6	94	0.010				26									
		J-12	39.0-41.7	ML								21									
FD-26	- 3.9	J-1	0.0- 4.0	SP-SM								26									
		J-2	4.0- 9.0	SP	9	90	1	0.11				16									
		J-3	9.0-10.0	SP								15									
		J-4	10.0-14.0	SM	6	51	33	0.009				24									
		J-5	14.0-19.0	ML	0	14	86		37	29		52									
		J-6	19.0-21.0	ML	0	43	57	0.005				25									
		J-7	21.0-25.0	SP-SM								18									
		J-8	22.5-24.0	ML								24									
		J-9	24.0-27.0	ML	0	37	63	0.009	Non Plastic			21									
		J-10	27.0-31.0	ML	0	2	98	0.003				32									
		J-11	31.0-34.0	SP								13									
		J-12	34.0-38.0	SP	6	94	0	0.37				16									
		J-13	38.0-43.0	SM								22									

* PROVIDENCE VIBRATED DENSITY TEST.

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO 4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
FD-26 Continued	-3.9	J-14	43.0-48.0	SM	4	83	13					19										
		J-15	48.0-52.0	SM								24										
		J-16	52.0-57.0	SM								27										
		J-17	57.0-61.0	ML								23										
FD-27	-8.5	J-1	0.0-3.0	ML								79										
		J-2	3.0-5.0	SM								21										
FD-28	-7.3	J-1	0.0- 2.0	SM								21										
		J-2	2.0- 7.0	SP								18										
		J-3	7.0- 9.0	SP-SM								16										
		J-4	9.0-12.0	SP								12										
		J-5	12.0-14.4	SM								12										
FD-29	-34.4	J-1	0.0- 2.0	SM	3	67	28	0.007				34										
		J-2	2.0- 5.5	SW	13	83	4	0.17				15										
		J-3	5.5-7.0	ML	0	38	62					23										
		J-4	7.0-12.0	ML	0	32	68	0.022			2.67	24										
		J-5	13.0-18.0	ML								23										
		J-6	19.0-20.5	ML	0	8	92	0.008			2.68	23										
		J-7	20.5-22.0	GM	49	20	31	0.012				9										
		J-8	22.0-22.9	SM								9										

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO 4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
FD-30	-3.6	J-1	0.0- 1.5	SP-SM								24										
		J-2	1.5- 4.0	SP-SM	5	89	6	0.087				33										
		J-3	4.0- 9.0	SP-SM	2	90	8	0.12				16										
		J-4	9.0-13.0	SP-SM								16										
		J-5	13.0-18.0	SM	3	56	41					21										
		J-6	18.0-20.0	SM								22										
		J-7	20.0-23.0	SP-SM								14										
		J-8	23.0-27.0	SP-SM								14										
		J-9	27.0-29.0	SP								18										
		J-10	29.0-32.0	SP-SM	0	89	11	0.074				21										
		J-11	32.0-37.0	SP-SM	0	92	8	0.08				21										
		J-12	37.0-42.0	SP-SM								22										
		J-13	42.0-45.5	ML								20										
		J-14	45.5-47.0	SM								11										
		J-15	47.0-51.4	SM								12										
FD-31	-32.5	J-3	4.0- 6.0	ML	0	44	56	0.018														
		J-4	6.0-11.0	ML	0	31	69	0.015														
FD-32	+6.0	J-1	0.0- 5.0	SP	1	98	1	0.23														
		J-2	5.0- 7.0	SM	28	57	15	0.033														
FD-33	+12.4	J-1	0.0- 4.0	SM	0	75	25	0.024														
		J-2	4.0- 5.0	SM	9	58	33	0.008														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA STND. AASHO			NAT. DRY DENSITY LBS/CU FT		OTHER TESTS			
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-42	+7.2	J-2	1.3- 5.0	SM	3	78	19															
		J-6	10.0-15.0	SM	11	67	22															
FD-43	+7.7	J-1	0.4- 2.7	SM	13	71	16															
		J-5	10.0-15.0	SM	10	72	18															
FD-44	+7.5	J-1	0.0- 3.2	GP-GM	52	41	7	0.13														
		J-3	5.0- 7.2	SW	12	85	3	0.21														
		J-6	10.0-11.7	SP	6	93	1	0.31														
FD-45	+7.9	J-2	1.2- 3.9	SM	7	76	17															
		J-4	5.0-10.0	SP	12	85	3	0.25														
FD-46	+4.9	J-5	12.0-12.9	SM	3	79	18															
FD-47	+9.1	J-1	0.0- 4.0	GP-GM	57	35	8	0.12														
		J-6	10.0-13.0	SM	17	61	22															
FD-48	+7.8	J-3	7.1-10.0	SM	0	62	38															
		J-6	13.2-15.0	SM	36	50	14															
FD-50	-6.0	J-2	1.2- 4.5	SP-SM	4	86	10	0.075														
		J-4	5.0- 8.2	SP-SM	6	84	10	0.075														
		J-7	10.0-12.4	SP-SM	44	48	8	0.12														
		J-10	15.0-17.5	SP	0	97	3	0.19														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENT %
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	-NO4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	-NO4	SHEAR	CONSOL.	PERM.	
FD-50 Continued																						
		J-13	20.0-22.3	SP	0	96	4	0.11														
		B-16A	25.0-30.0	SM	11	57	32															
FD-51	-14.5	B-2	0.0- 5.0	SM	2	75	23															
		B-5	6.8-10.0	SM	0	63	37															
		B-7	10.0-15.0	SM	2	82	16															
		J-8	15.0-20.0	SM	0	68	32															
		B-10	20.0-25.5	SM	0	60	40															
FD-52	-10.9	B-2	0.0- 5.0	SM	5	76	19															
		B-4	5.0-10.0	SP-SM	7	85	8	0.10														
		J-5	10.0-15.0	ML								43										4
		B-6	10.0-15.0	ML	0	32	68															
		J-7	15.0-18.2	SP-SM	5	85	10	0.07														
		J-8	18.2-20.0	ML	0	35	65															
		B-10	20.0-25.0	SM	0	68	32															
		B-12	25.0-30.0	ML	0	20	80															
FD-53	- 7.6	J-3	3.7- 5.0	SP-SM	24	70	6	0.16														
		B-5	5.0-10.0	SP-SM	10	80	10	0.07														
		B-7	10.0-15.0	SP	1	96	3	0.19														
		B-9	15.0-20.0	SP	12	86	2	0.21														
		B-12	22.5-25.0	SP	5	92	3	0.13														
		B-14	25.0-30.0	SP-SM	0	89	11	0.07														
		J-15	30.0-35.0	SM	0	53	47															

* PROVIDENCE VIBRATED DENSITY TEST.

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO 4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	PVD * LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
FD-54	+4.2	B-3	1.5- 5.0	SP	14	83	3	0.19														
		B-5	5.0-10.0	SW-SM	6	86	8	0.08														
		B-7	10.0-15.0	SP	9	88	3	0.18														
FD-56	+2.5	B-6	10.0-13.2	GM	40	44	16															
FD-57	-8.4	J-1	0.0- 5.0	SP-SM	2	91	7	0.11														
		B-3	5.0- 8.8	SP-SM	6	87	7	0.12														
		B-6	10.0-14.0	SP-SM	7	88	5	0.20														
		B-9	15.0-20.0	SM	0	87	13															
		B-11	20.0-23.8	SM	0	68	32															
FD-58	-2.3	B-3	1.0- 5.0	SM	21	63	16															
		J-9	15.0-20.0	SM	11	80	19															
FD-59	+2.9	J-1	0.4- 2.5	SP-SM	22	72	6	0.17														
		B-5	5.0- 9.2	SP-SM	32	62	6	0.19														
FD-60	-6.2	B-7	10.0-15.0	SP	2	94	4	0.17														
		B-12	20.0-25.0	SP-SM	0	94	6	0.10														
		B-15	26.3-30.0	ML	0	31	69															
FD-61	+1.8	J-3	3.8- 5.0	SP-SM	28	64	8	0.10														
		B-5	5.0-10.0	SP	27	70	3	0.19														
		J-6	10.0-14.4	SP	11	86	3	0.17														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
														STND. AASHO								
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-62	-1.0	J-3	2.3- 5.0	SM	28	51	21															
		J-10	15.0-18.3	ML	4	37	59	0.006	Non	Plastic												
FD-63	+2.5	J-3	5.0- 6.7	SP	13	83	4	0.20														
		B-5	6.7-10.0	SP	1	95	4	0.15														
		B-7	10.0-12.5	SP	1	96	3	0.17														
		J-10	15.0-17.2	SM	34	50	16															
FD-64	+2.8	B-3	1.2- 4.2	SP-SM	12	82	6	0.13														
		B-7	5.8-10.0	SM	22	50	28															
FD-65	-2.4	B-6	5.0- 9.4	SP	12	84	4	0.18														
FD-66	-1.3	J-2	0.8- 5.0	SP	10	88	2	0.29														
		J-7	13.0-15.0	SM	13	64	23															
FD-67	+0.8	J-4	5.0- 8.8	SW	7	89	4	0.14														
		B-11	20.0-24.2	SP-SM	29	60	11															
FD-68	+0.5	J-5	6.5- 9.6	SM	5	83	12															
		J-7	12.5-15.0	SM	18	58	24															

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
					GRAVEL %	SAND %	FINES %	D 10 mm.	LL	PL		TOTAL	- NO4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-70	+0.5	J-2	5.0- 7.9	SP-SM	41	52	7	0.14														
		B-5	10.5-15.0	SM	25	57	18															
FD-71	-0.3	J-3	7.0-10.0	SM	10	69	21															
		J-5	15.0-17.0	SM	19	57	24															
FD-72	+0.4	B-8	5.0-10.0	SM	21	60	19															
FD-74	-12.5	J-3	5.0- 7.1	SP	0	99	1	0.27														
		B-9	15.0-20.0	SP-SM	0	95	5	0.11														
		B-13	21.4-25.0	SM	0	54	46															
FD-75	-14.5	J-2	1.5- 4.1	SP	10	88	2	0.18														
		B-5	5.0- 8.8	SP	3	96	1	0.16														
		B-8	10.0-15.0	SM	0	64	36															
		B-12	20.0-25.5	SM	0	75	25															
FD-77	-34.1	J-3	5.0-10.0	ML	0	15	85	0.013														
		J-8	16.5-20.0	SM	32	45	23	0.025														
FD-78	-34.0	B-4	5.0-10.0	ML	0	30	70															

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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	* PVD LBS/CU FT	NAT. DRY DENSITY LBS/CU FT TOTAL	-NO4	OTHER TESTS SHEAR	CONSOL.	PERM.	ORGANIC CONTENTS %
FD-80																						
	-16.1	J-1	0.0- 5.0	SP-SM	3	86	11	0.07														
		J-7	10.0-15.0	SM	0	78	22															
		J-10	20.0-25.0	SP	14	85	1	0.20														
		J-14	36.2-38.7	SM	29	48	23	0.025														
FD-81																						
	-7.9	J-2	1.2- 5.0	SP	15	81	4	0.31														
		J-7	15.0-20.0	SC	3	71	26		33	23	Natural											
									24	19	Oven Dried											
		J-10	21.1-23.4	SP-SM	24	65	11															
		J-14	27.5-30.0	SM	20	51	29	0.011														
FD-82																						
	-6.3																					
		B-6	10.0-15.0	SM	3	53	44	0.003	Non-Plastic													
		J-7	15.0-18.0	CL	0	25	75		35	19		48										
		B-16	30.0-35.0	SP	1	97	2	0.14														
		J-23	40.0-44.1	SP	15	81	4	0.18														
FD-83																						
	-10.9	J-4	10.0-15.0	SM-SC	2	52	46	0.004	25	20												
		J-9	20.0-22.5	SM	9	60	31															
		J-10	22.5-25.0	SW-SM	13	79	8	0.09														
		B-12	25.0-30.0	SM	0	80	20		Non-Plastic													
		B-19	45.0-50.0	SP-SM	0	94	6	0.14														
FD-84																						
	-33.4	J-3	2.4- 5.0	ML	0	30	70	0.018														
		J-7	15.0-20.0	ML	0	8	92	0.012														
		J-9	22.7-25.0	SM	34	46	20	0.020														

* PROVIDENCE VIBRATED DENSITY TEST

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			ORGANIC CONTENTS %
														STND. AASHO		* PVD LBS/CU FT						
	M.S.L.				GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT		TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-85	-18.5	J-4	10.0-13.8	ML	7	23	70															
		J-7	15.6-20.0	SM	23	60	17															
		J-8	20.0-21.9	SM	36	45	19															
FD-86	-14.7	J-3	5.0 -8.2	SP	19	77	4	0.15														
		J-5	10.0-11.8	SW	14	83	3	0.18														
		J-7	15.0-20.0	GP-GM	48	41	11	0.07														
FD-87	-19.2	B-6	10.0-15.0	SM	32	50	18	0.010														
		J-7	15.0-20.0	SM	14	70	16															
		B-8A	20.0-25.0	SM	23	63	14															
FD-88	-3.8	B-5	10.0-15.0	SW	11	88	1	0.32														
		J-6	15.0-20.0	SC	10	42	48	0.003	33	22												4
		J-13	26.1-29.2	SP	44	52	4	0.23														
		B-17	40.0-45.0	SP	0	100	0	0.20														
		J-18	45.0-50.0	ML	0	29	71															
FD-89	-9.3	J-2	5.0- 8.0	SP	11	84	5	0.14														
		J-3	8.0-10.0	SP	2	95	3	0.17														
FD-90	-7.9	J-2	1.2- 5.0	SP	13	84	3	0.15														
		J-3	5.0- 7.0	SM	9	66	25	0.02														
		J-7	12.3-15.0	ML	0	1	99	0.003				30										

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
					GRAVEL %	SAND %	FINES %	D 10 mm.	LL	PL		TOTAL	- NO 4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
FD-91	-13.0																					
		UC-1	30.2-30.3	ML								23					102			✓		
			30.3-30.6	ML								24										
			30.6-30.7	SM								23					101		✓			
			30.7-30.8	SM								23					104		✓			
			30.8-30.9	SM								24					103		✓			
			31.2-31.5	ML	0	39	61	0.015	Non-Plastic		2.68	23							✓			
		UC-3	31.9-32.1	ML								21					108		✓			
				ML								19					110		✓			
				ML								20					110		✓			
				ML							2.70	20					108		✓			
			32.1-32.2	ML								20										
			32.2-32.6	Strat ML&SM								20					110		✓			
				"								21					108		✓			
				"								20					108		✓			
				"	0	13	87	0.009	Non-Plastic			21					108		✓			
			32.6-32.9	Strat ML&SM								20					109		✓			
				"								22					106		✓			
				"								20					109		✓			
				"								20					109		✓			

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
														STND. AASHO								
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO4	OPT. WATER - % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-92																						
	-6.5	UC-1	6.4- 6.6	SM								28					96					
			6.6- 6.7	SP								26					90					
			6.7- 6.9	SP								29					90					
			6.9- 7.3	SP&SM								31					87					
			7.3- 7.4	ML								41					65					
			7.4- 7.8	SM	1	73	26	0.008	Non-Plastic		2.66											
			7.8- 8.0	SM								26					81					
			8.0- 8.3	SP&ML								32					94					
			8.3- 8.4	ML								38					80					
		UC-3	8.7- 8.9	SM								25					98					
			8.9- 9.0	SM								28					79					
			9.0- 9.4	SM	5	67	28	0.028				29										
			9.4- 9.6	SM								17					99					
			9.6- 9.8	SM								22					95					
			9.8-10.1	SM								24					92					
			10.1-10.4	SM								28					91					
			10.4-10.7	SM								24					102					
		UC-5	11.3-11.6	OL	0	47	53	0.003				43					77		✓			
									45	26		35					86		✓			
											2.65	36					84		✓			
			11.6-11.8	OL								37					80					
			11.8-11.9	SM								36					84					
			12.2-12.5	SM								32										

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
														STND. AASHO		* PVD LBS/CU FT						
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO 4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT		TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
FD-92	(Continued)																					
		UC-7	13.2-13.4	SM							2.70											
			13.4-13.6	GM	42	35	23	0.016	39	23												
			13.6-15.2									30					91		✓			
		UC-9	15.4-15.7	SM	7	68	25	0.014			2.67	14										
			15.7-15.8	SM								20										
			15.9-16.2	OL								39					82		✓			
				OL								40					82		✓			
				OL								40					80		✓			
			16.2-16.3	OL					28	19		45					76		✓			
			16.3-16.4	OL	5	53	42	0.002			2.68	40					77		✓			
			16.5-16.6	OL								43					77		✓			
			16.6-16.7	OL								43					78			✓		
			16.7-17.2	SM	2	70	28	0.007														
		UC-11	17.3-17.4	SM	3	66	31	0.008			2.68	24										
			17.5-17.8	OL								11										
			18.0-18.3	SP-SM	1	88	11	0.070														
			18.3-19.1	SP							2.67											

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	SAMPLE NO.	DEPTH FT.	SOIL SYMBOL	MECHANICAL ANALYSIS				ATT. LIMITS		SPECIFIC GRAVITY	NAT. WATER CONTENT % DRY WT		COMPACTION DATA STND. AASHO		COMPACTION DATA	NAT. DRY DENSITY LBS/CU FT		OTHER TESTS			ORGANIC CONTENTS %
					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.	
FD-93	-9.2	J-1	0.0- 1.5	SM	3	77	20	0.008														
		J-3	3.3- 4.8	SP-SM	5	89	6	0.12														
		J-6	10.0-15.0	SM	23	61	16															
FD-94	-5.1	J-2	4.0- 5.0	SP	3	93	4	0.12														
		J-3	5.0- 6.1	SP	22	74	4	0.17														
		J-5	8.8-10.2	SM	1	79	20															
FD-95	-9.1	J-2	1.6- 3.7	SP-SM	5	89	6	0.10														
		J-6	11.0-12.2	SP-SM	40	54	6	0.13														
FD-96	-9.6	J-1	0.0- 1.9	SM	0	87	13															
		J-3	3.4- 5.0	SP-SM	2	90	8	0.09														
		J-5	5.8- 9.5	SM	27	59	14															
FD-97	-7.8	J-2	1.3- 5.0	SP-SM	26	66	8	0.09														
		J-3	5.0- 7.3	SP-SM	34	60	6	0.14														
		J-5	7.7-10.0	SM	17	67	16															
FD-106	+9.0	J-3	1.9- 3.2	SP	37	60	3	0.16														
		J-5	5.0-10.0	SP-SM	16	78	6	0.16														
		J-6	10.0-11.5	SM	13	67	20	0.033														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	-NO4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	-NO4	SHEAR	CONSOL.	PERM.	
FD-107	+8.5	J-3	5.0-10.0	SM	17	58	25	0.21														
		J-4	10.0-12.0	SM	30	55	15	0.047														
FD-108	+8.6	B-4	1.0- 5.0	SP-SM	31	59	10	0.08														
		B-10	10.0-13.5	GP-GM	60	32	8	0.12														
FD-109	+8.4	J-2	1.2- 2.8	SM	25	44	31	0.017				13										
		J-6	12.1-13.9	SP-SM	41	51	8	0.10				8										
		J-7	17.0-17.5	SP-SM	40	49	11	0.068														
FD-110	+9.8	B-4	3.3- 5.0	GM	47	35	18	0.03														
		B-6	5.0-10.0	SM	20	54	26	0.018														
FD-111	+7.2	B-3	1.2- 5.0	SM	18	54	28	0.017														
		B-5	5.0- 7.8	SM	42	44	14	0.055														
		J-6	7.8-10.0	SM	24	47	29	0.011														
FD-112	+3.0	J-3	2.6- 5.0	SP	14	83	3	0.27														
		B-6	5.5-10.0	SM	19	50	31	0.009														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENT %
														STND. AASHO								
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FD-113	+4.9	J-3	3.8- 5.0	SP	16	80	4	0.22														
		J-4	5.0- 8.0	SP	11	86	3	0.14														
		J-8	11.5-12.0	SP	6	91	3	0.16														
		J-11	16.5-17.0	SP-SM	24	71	5	0.20														
		B-12	15.0-20.0	SP-SM	14	81	5	0.17														
		J-13	20.5-20.9	SP	18	80	2	0.18														
		B-14	20.0-22.6	SP	13	85	2	0.17														
FD-114	+3.2	J-2	2.5- 3.3	SP	10	87	3	0.20														
		J-4	5.6- 6.0	SP	19	77	4	0.14														
		B-5	5.0-10.0	SP	14	81	5	0.14														
FD-115	+3.3	J-3	2.6- 3.3	SW-SM	16	73	11	0.068														
		B-7	5.0-10.0	SP	5	91	4	0.14														
		J-9	10.7-14.4	SM	13	56	31	0.013														
		B-12	15.0-18.6	SM	34	48	18	0.028														
FD-116	+3.9	J-2	2.2- 5.0	SW-SM	6	88	6	0.14														
		B-6	10.0-13.3	SW-SM	5	90	5	0.12														
FD-117	+7.8	B-3	1.6- 5.0	SM	12	47	31	0.016														
		B-5	5.0- 8.8	SM	22	51	27	0.016														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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.	
FD-118																						
	+7.5	J-3	5.0- 7.5	SP-SM	24	65	11	0.068				14										
		J-4	7.5-10.0	SM	14	44	42	0.006				8										
		J-5R	10.0-15.0	SM								11										
		J-6	15.0-20.0	SM	13	55	32	0.010				10										
FD-119																						
	+8.3	J-5	6.7- 9.4	SM	14	65	21	0.029														
		J-7	10.0-15.0	SM	11	68	21	0.021														
		J-8	15.0-20.0	SM	24	50	26	0.014														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
FT-2	+7.2	B-2	0.2- 4.0	SP	38	58	4	0.19														
FT-3	+8.0	B-2	0.0- 3.0	SW-SM	12	81	7	0.12														
		B-5	3.5- 6.0	SP	15	83	2	0.22														
FT-4	+13.4	B-5	7.0- 8.5	SM	19	49	32	0.013														
FT-5	+11.3	B-5	8.0- 9.5	SP	8	89	3	0.25														
FT-6	8.0	B-2	0.9- 5.0	SP-SM	13	78	9	0.08														
FT-10	+7.4	B-2	0.8- 3.3	SM	19	32	49															
		B-4	3.3- 8.5	SM	23	73	4	0.27														
FT-11	+7.2	B-2	0.7- 3.7	SM	34	46	20															
		B-4	3.7- 8.0	GP	55	41	4	0.35														
FT-16	+6.5	J-2	1.7-11.0	C																		
FT-17	+4.8	J-1	0.0-11.0	I																		
FT-18	+6.1	J-1	0.0-11.0	N	57	39	4	0.29	(FT-16, J-2; FT-17, J-1; FT-18, J-1; FT-20, J-2; FT-21, J-2 were combined to form a composite sample)													
FT-20	+7.1	J-2	0.9-11.0	D																		
FT-21	+8.4	J-2	1.3-11.0	E																		
				R																		
				S																		

* PROVIDENCE VIBRATED DENSITY TEST.

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			ORGANIC CONTENTS %
														STND. AASHO								
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	-NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	-NO4	SHEAR	CONSOL.	PERM.	
BD-1	-15.6	J-4	5.0- 6.3	SP	1	95	4	0.092														
		J-5	6.3-10.0	OH	0	35	65		71	32												7
		J-7	10.0-15.0	OH	0	9	91		72	33												9
		J-9	15.0-20.0	OH	0	20	80		59	37												9
BD-2	-14.7	J-1	0.0- 3.5	SM	1	78	21	0.008														
		J-4	7.8-10.0	SP	14	82	4	0.21														
		J-6	12.5-15.0	SM	4	83	13	0.065														
BD-3	-14.7	J-1	0.0- 2.4	SM	19	77	4	0.11														
		J-2	2.4- 3.1	SP	1	83	16	0.012														
		J-3	3.1- 5.0	SM	7	65	28	0.018														
		J-4	5.0-10.0	ML	0	30	70	0.002														
		J-6	10.0-14.8	OL	0	36	64	0.002														
		J-9	15.0-15.3	SM	0	80	20	0.048														
		J-10	15.3-20.0	SP-SM	27	63	10	0.074														
BD-4	-14.3	J-1	0.0- 1.5	SM	0	71	29	0.006														
		J-2	1.5- 5.0	SM	0	79	21	0.009				27										
		J-3	5.0- 5.8	SP-SM	3	92	5	0.12														
		B-5	5.8-10.0	SP-SM	0	95	5	0.13														
		J-6	10.0-14.2	SP-SM	0	91	9	0.078														
		J-8	14.2-15.0	ML	0	33	67	0.003														
		J-9	15.0-15.2	SM	0	72	28															
		J-10	15.2-20.0	SP-SM	15	78	7	0.087														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.
BD-5	-14.2	J-1	0.0- 3.2	SM	4	76	20	0.01				24									
		J-2	3.2- 5.0	SP	7	92	1	0.16													
		J-3	5.0- 6.5	SP-SM	31	63	6	0.13													
		J-4	6.5-10.0	SP-SM	40	52	8	0.11													
		J-5	10.0-12.0	SP-SM	30	62	8	0.11													
		J-6	12.0-15.0	SM	0	78	22														
		J-7	15.0-18.7	SP-SM	0	94	6	0.09													
		J-8	18.7-20.0	SW	7	90	3	0.23													
BD-6	-15.8	J-3	5.0- 9.5	SP	7	92	1	0.26													
		B-4	5.0- 9.5	SP	2	97	1	0.26													
		J-5	9.5-10.0	SP	3	94	3	0.16													
		J-6	10.0-15.0	SP	2	97	1	0.34													
		J-8	15.0-20.0	SP-SM	0	90	10														
BD-7	-14.3	J-2	2.3- 5.0	SW	9	87	4	0.18													
		J-3	5.0-10.0	SP-SM	32	65	3	0.15													
		J-4	10.0-15.0	SW-SM	7	87	6	0.10													
		J-5	15.0-20.0	SW-SM	9	86	5	0.14													
BD-8	-14.4	J-1	0.0- 2.1	SM	4	81	15														
		J-2	2.1- 3.0	SW-SM	14	81	5	0.092													
		J-4	3.7- 5.0	SP-SM	0	94	6	0.082													
		J-5	5.0-10.0	SP	0	95	5	0.088													
		B-6	5.0-10.0	SP-SM	1	93	6	0.092													

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
BD-8	Continued																					
	-14.4	J-7	10.0-14.0	SP	0	97	3	0.089														
		J-9	14.0-15.0	SP-SM	1	92	7	0.080														
		J-10	15.0-19.0	SP-SM	0	92	8	0.080														
		J-11	19.0-20.0	SM	5	71	24															
BD-9																						
	-14.6	J-2	2.0- 5.0	GP-GM	57	36	7	0.15														
		J-3	5.0- 6.5	SM	15	72	13	0.067														
		J-4	6.5- 8.2	SM	0	86	14	0.056														
BD-10																						
	-16.9	J-1	0.0- 3.0	SM	2	74	24	0.008														
		J-2	3.0- 3.8	SM	7	81	12	0.050														
		J-3	3.8- 5.0	SP	0	97	3	0.15														
		J-5	5.7-10.0	SP-SM	1	89	10	0.073			2.68											
		J-8	15.0-17.0	SP	9	89	2	0.16														
		J-10	18.2-18.6	SM	1	54	45	0.019														
BD-11																						
	-18.5	J-1	0.0- 2.0	SM	7	79	14	0.034														
		J-2	2.0- 4.7	SP-SM	12	80	8	0.15														
		J-3	4.7- 5.0	SP	19	76	5	0.16														
		J-6	10.0-15.0	ML	0	19	81	0.011														
		J-7	15.0-20.0	ML	0	5	95	0.006														

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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			
					GRAVEL %	SAND %	FINES %	D_{10} mm.	LL	PL		TOTAL	- NO 4	STND. AASHO OPT. WATER % DRY WT	STND. AASHO MAX. DRY DENS. LBS/CU FT	* PVD LBS/CU FT	TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
BD-12																						
	-11.1	J-1	0.0- 1.5	SP	8	88	4	0.16														
		J-3	3.3- 5.0	SP-SM	2	88	10	0.074														
		J-5	6.2-10.0	SM	0	55	45															
		J-7	10.0-14.8	ML	0	36	64	0.012														
		J-9	14.8-15.0	SM	11	40	49	0.002														
BD-14																						
	-11.9	J-3	3.0- 5.0	SP-SM	0	88	12															
		J-4	5.0- 7.2	SP	0	96	4	0.11														
		J-5	7.2- 8.3	SM	5	80	15															
		J-7	10.0-15.0	SM	1	74	25															
		J-8	15.0-20.0	SM	4	81	15															

* PROVIDENCE VIBRATED DENSITY TEST

EXPL. NO.	TOP ELEV. FT. M.S.L.	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		* PVD LBS/CU FT						
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO 4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT		TOTAL	- NO 4	SHEAR	CONSOL.	PERM.	
BA-1	+8.1	J-1R	0.6-4.6	SM								10	13									
		B-1	0.6-4.6	SM	11	49	40	0.015														
BA-2	+7.8	J-1R	0.4-4.8	SM								13	14									
BA-3	+8.8	J-1R	0.6-5.1	SM								10	10									
BA-4	+7.8	J-1R	0.3-4.2	SM								10	13									
		B-1	0.3-4.2	SM	19	51	30	0.011														
BA-5	+8.3	J-1R	0.8-5.1	SM								12	14									
BA-6	+7.6	J-1R	0.7-5.4	SM								7	9									
		B-1	0.7-5.4	SM	30	54	16	0.033														
BA-7	+8.3	J-1R	0.8-3.5	SM								7	11									
BA-8	+7.3	J-1R	0.9-3.4	SM								15	17									
		B-1	0.9-3.4	SM	17	50	33	0.017														
BA-9	+7.8	J-1R	0.9-3.6	SM								10	12									
BA-10	+7.3	J-1R	0.8-2.7	SM								11	11									
BA-11	+7.7	J-1R	0.6-4.2	SM								10	11									
BA-12	+8.1	J-1R	0.4-1.6	SM								12	14									

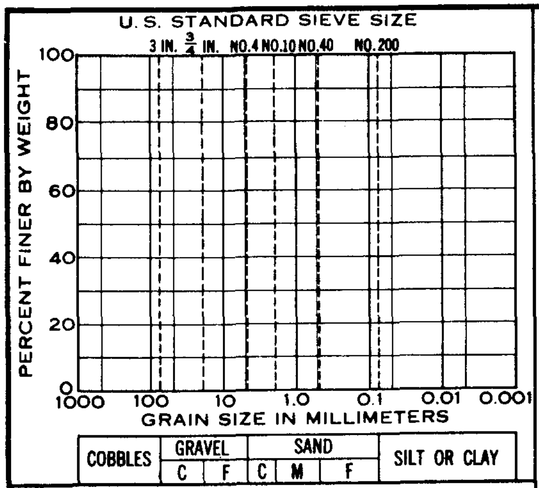
* PROVIDENCE VIBRATED DENSITY TEST.

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		* PVD LBS/CU FT						
					GRAVEL %	SAND %	FINES %	D_{10} mm	LL	PL		TOTAL	- NO4	OPT. WATER % DRY WT	MAX. DRY DENS. LBS/CU FT		TOTAL	- NO4	SHEAR	CONSOL.	PERM.	
BT-1		A	6.0-9.0	GW	64	34	2	0.44			Tri-City Borrow Pit - Berkley, Mass.											
BT-2		1	3.0-5.0	SP	29	70	1	0.18			DeMatteo's Borrow Pit - Berkley, Mass.											
BT-3		1	5.0-10.0	SP	18	81	1	0.22			DeMatteo's Borrow Pit - Berkley, Mass.											
BT-4		1	4.0-5.0	SP-SM	44	50	6	0.12			West of Route 140											
BT-5		1-A	4.0-5.0	GP	52	48	0	0.45			Assonet Sand & Gravel Co. - Assonet, Mass.											
BT-6		B-1		GP	71	25	4	0.38			Fish Pit - West Falmouth, Mass.											
BT-7		B-1		GP	68	31	1	0.53			Mill Road & Blacksmith Rd, West Falmouth, Mass.											
BT-8		B-1		GP-GM	59	33	8	0.098			Mederios-Perrys Pit - Dartmouth, Mass.											
BT-9		B-1		GW	68	29	3	0.42			Mederios-Freetown Pit No. 1 - Freetown, Mass.											
BT-10		B-1		GP	79	20	1	0.97			Mederios-Freetown Pit No. 2 - Freetown, Mass.											
BT-11		B-1		GP	84	16	0	1.2			Assonet Sand & Gravel Company - Assonet, Mass.											
BT-12		B-1		GP	72	28	0	1.0			Borge Pit - Assonet, Mass.											

* PROVIDENCE VIBRATED DENSITY TEST

APPENDIX B
SHEAR TEST DATA

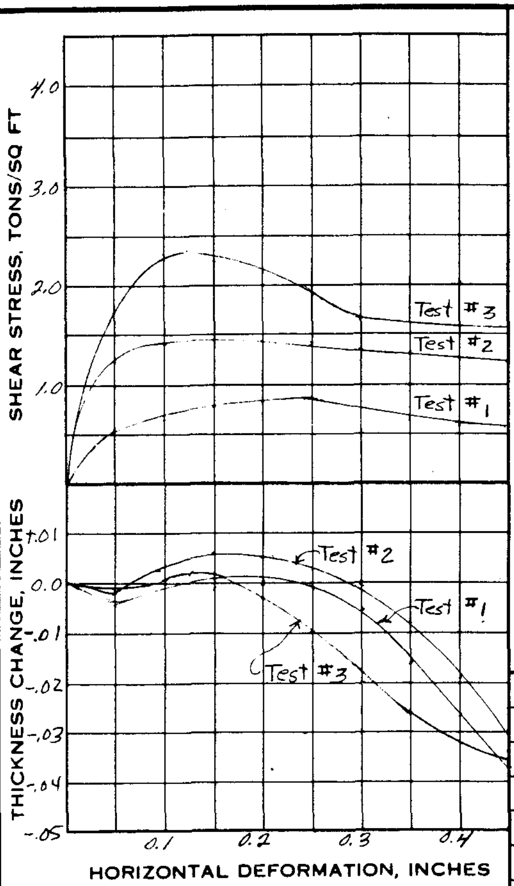
Plate No.	Hole - Sample No.	Type of Test
B-1	FD-91 - UC-1	S(CD) Direct
B-2	- UC-3	Q(UU) Triaxial
B-3	- UC-3	R(CU) Triaxial
B-4	- UC-3	S(CD) Triaxial
B-5	FD-92 - UC-5	R(CU) Triaxial
B-6	- UC-5	S(CD) Direct
B-7	- UC-9	Q(UU) Triaxial
B-8	- UC-9	S(CD) Direct



Classification silty fine SAND (SM)

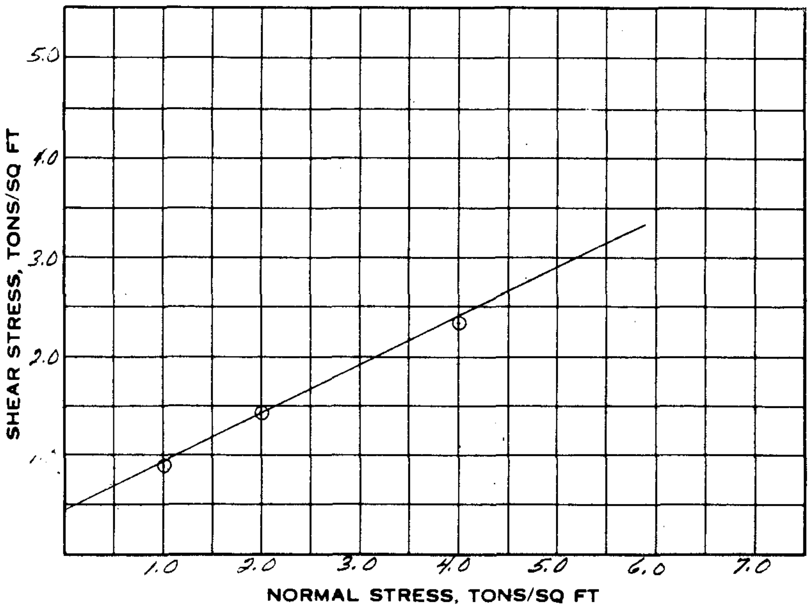
LL N.P.	G 2.68
PL N.P.	D_{10} –

Test No.	1	2	3	
Initial Water Content, W_0 %	19.9	20.3	19.5	
Dry Density Lbs/Cu Ft	101.2	104.0	103.3	
Void Ratio, e_0	.653	.610	.619	
Saturation, S_0 %	82	89	85	
Duration of Test	23'	36'	37'	
WC after Test, W_F %	20.7	21.1	19.3	
Normal Stress, σ T/Sq Ft	1.0	2.0	4.0	
Max. Shear Stress, τ T/Sq Ft	.86	1.44	2.35	



Type of Test	Type of Specimen
strain – Control .02"/min	Undisturbed
Consolidated	9.0 in. square
Drained	.75 in. thickness

SHEAR VALUES	Ø	TAN Ø	C, T/SQ FT
Maximum	27°	.506	.44
Ultimate			



Remarks:

Project New Bedford, Mass.

Area U.S. Army Engineer Division, New England

Boring No. FD-91

Sample No. UC-1

~~Elev or~~ Depth 29.98'-31.46'

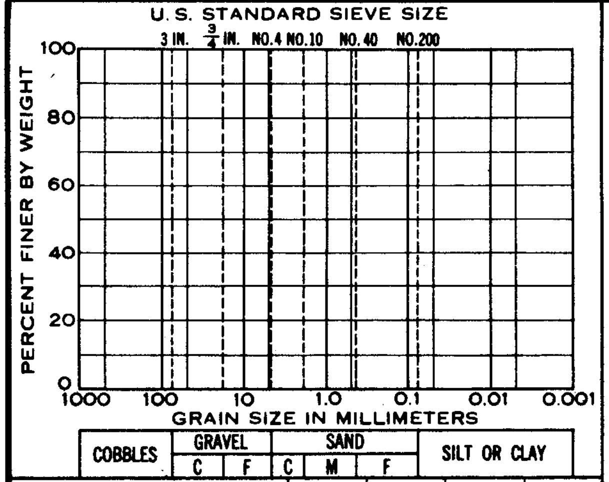
Date 24 Sept. 1959

DIRECT SHEAR TEST REPORT

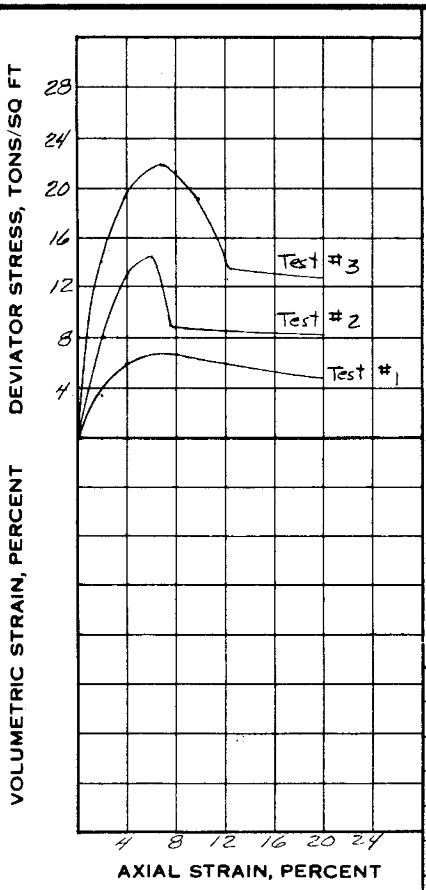
PLATE NO. B-1

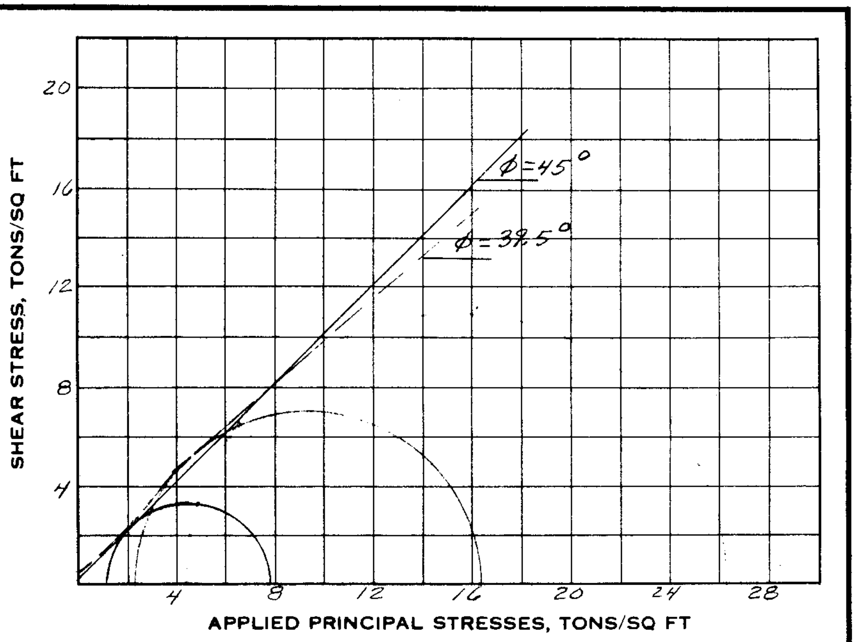
ENG FORM 1 DEC 51 2092

GPO 83-22498



	Test No.	1	2	3	
INITIAL	Water Content, W_0 %	20.3	20.9	20.3	
	Dry Density Lbs/Cu Ft	110.2	108.5	108.5	
	Void Ratio, e_0	.529	.553	.553	
	Saturation, S_0 %	100	100	100	
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_I T/Sq Ft	7.86	16.41	26.24	
	Min Prin Stress, σ_{III} T/Sq Ft	1.08	2.16	4.32	
	Water Content, W_F %				
	Void Ratio, e_F				
Specimen Diameter Inches		1.4	1.4	1.4	
Initial Height Inr		3.0	3.0	3.0	
Test Time to Failure Min		20	18	13	





Type of Test
Constant *strain, .02 in/min* Control
Un Consolidated, *Un* Drained

Type of Specimen *Undisturbed*

Ø = *39.5°*	Tan Ø = *.823*	c = *.5* T/Sq Ft

Classification *ML & SM (Stratified)*

LL *N.P.*	G *2.70*
PL *N.P.*	D_{10} *–*

Remarks:

Specimens in a very dense state.

Project *New Bedford, Mass*

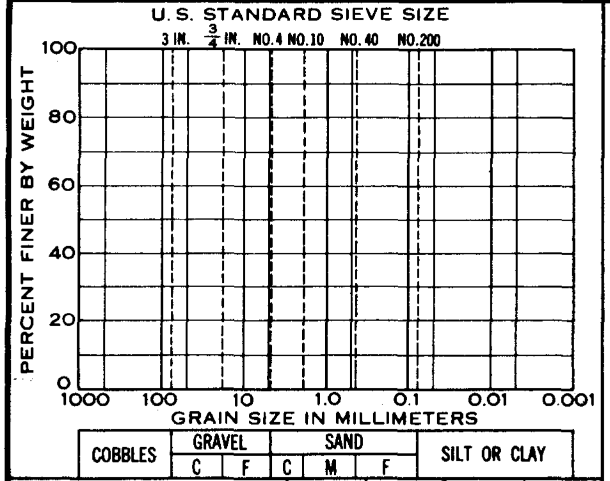
Area *U.S. Army Engineer Division, New England*

Boring No. *FD-91*	Sample No. *UC-3*
~~Elev~~ or Depth *31.65' - 33.46'*	Date *21 Sept. 1957*

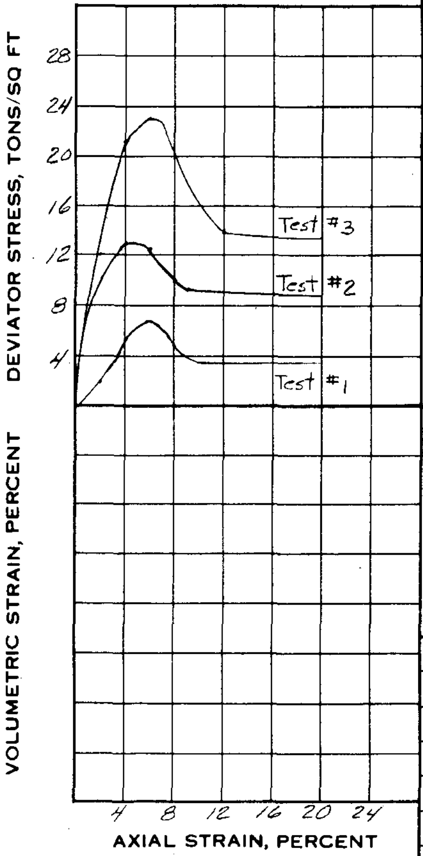
TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 DEC 51 2089

GPO 83-22462



Test No.		1	2	3	
INITIAL	Water Content, W_0 %	21.1	19.2	19.8	
	Dry Density Lbs/Cu Ft	108.2	109.6	110.1	
	Void Ratio, e_0	.557	.537	.531	
	Saturation, S_0 %	100	100	100	
BEFORE TEST	W.C. after Saturation, W_s %				
	Saturation, S %				
	Consol Pressure T/Sq Ft	1.08	2.16	4.32	
	W.C. after Consol, W_c %	20.4	18.5	18.8	
	Void Ratio after Consol, e_c	.538	.498	.504	
AT FAILURE	Maj Prin Stress, σ_I T/Sq Ft	7.85	15.56	27.50	
	Min Prin Stress, σ_{III} T/Sq Ft	1.08	2.16	4.32	
	Water Content, W_f %	20.4	18.4	18.8	
	Void Ratio, e_f	.538	.498	.504	
Specimen Diameter Inches		1.4	1.4	1.4	
Initial Height Inc		3.0	3.0	3.0	
Test Time ~~to Failure~~ Min		32	32	32	



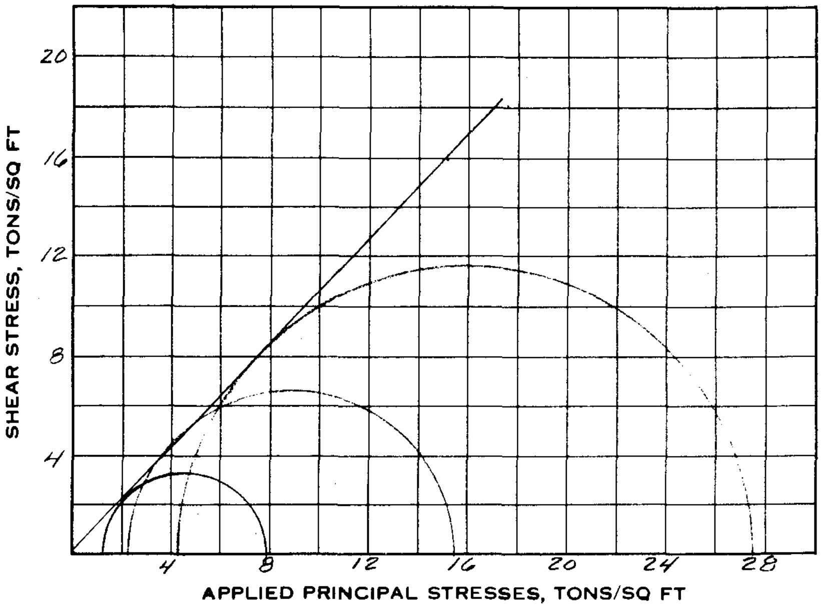
Type of Test
Constant *strain, 0.32 in/min*
Control
Consolidated, *Un* Drained

Type of Specimen *Undisturbed*

Ø = *45* °	Tan Ø = *1.00*	c = *.4* T/Sq Ft

Classification *ML*

LL *N.P.*	G *2.70*
PL *N.P.*	D_{10} *—*



Remarks:

Project *New Bedford, Mass.*

Area *U.S. Army Engineer Division, New England*

Boring No. *FD-91*

Sample No. *UC-3*

~~Elev or~~ Depth *31.65' - 33.46'*

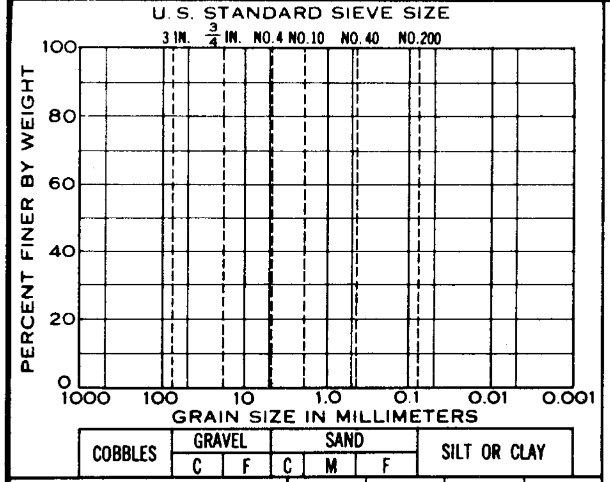
Date *18 Sept. 1959*

TRIAXIAL COMPRESSION TEST REPORT

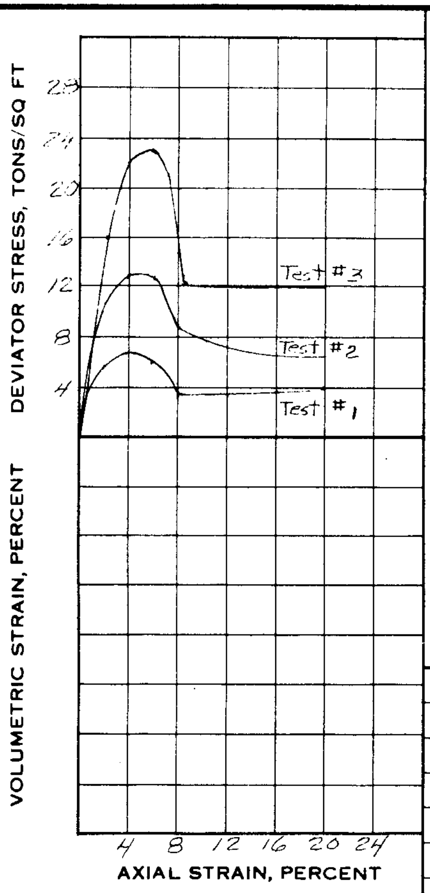
PLATE NO. B-3

ENG FORM 1 DEC 51 2089

GPO 83-22482



	Test No.	1	2	3	
INITIAL	Water Content, W_0 %	20.2	21.5	20.3	
	Dry Density Lbs/Cu Ft	108.8	106.1	108.8	
	Void Ratio, e_0	.548	.587	.549	
	Saturation, S_0 %	100	99	100	
BEFORE TEST	W.C. after Saturation, W_s %				
	Saturation, S %				
	Consol Pressure T/Sq Ft	1.08	2.16	4.32	
	W.C. after Consol, W_c %	18.0	20.4	18.8	
	Void Ratio after Consol, e_c	.488	.556	.508	
AT FAILURE	Maj Prin Stress, σ_I T/Sq Ft	8.05	15.55	27.42	
	Min Prin Stress, σ_{III} T/Sq Ft	1.08	2.16	4.32	
	Water Content, W_F %	22.0	23.2	21.5	
	Void Ratio, e_F	.596	.631	.582	
Specimen Diameter Inches		1.4	1.4	1.4	
Initial Height In		3.0	3.0	3.0	
Test Time ~~to Failure~~ Min		26	26	26	



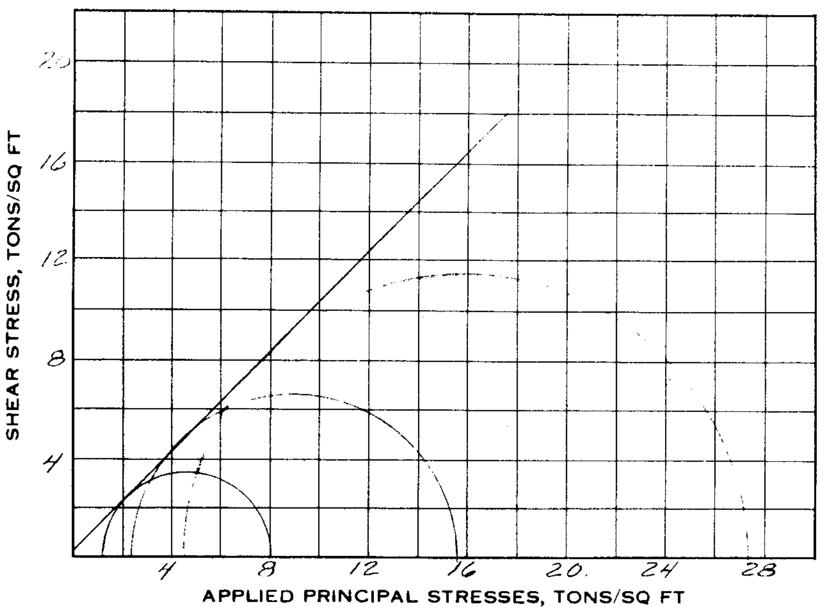
Type of Test
Constant strain, .02 in/min
Control
Consolidated, Drained

Type of Specimen Undisturbed

ϕ = 46 °	Tan ϕ = 1.036	c = .38 T/Sq Ft

Classification SM & ML (stratified)

LL N.P.	G 2.70
PL N.P.	D_{10} —



Remarks:

Project New Bedford, Mass.

Area U.S. Army Engineer Division, New England

Boring No. FD-91

Sample No. UC-3

~~Elev or~~ Depth 31.65' - 33.46'

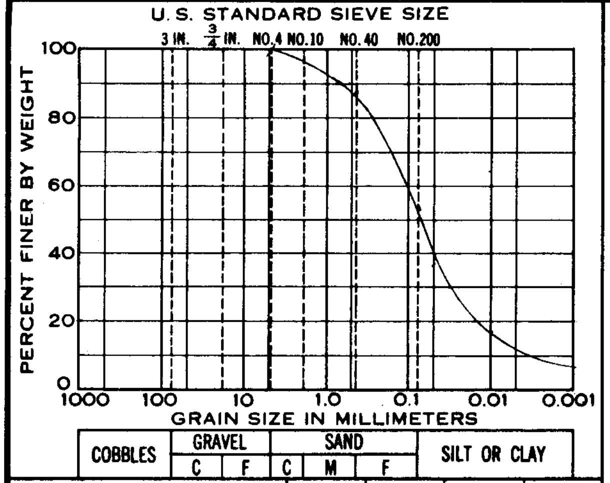
Date 18 Sept. 1959

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 1 DEC 51 2089

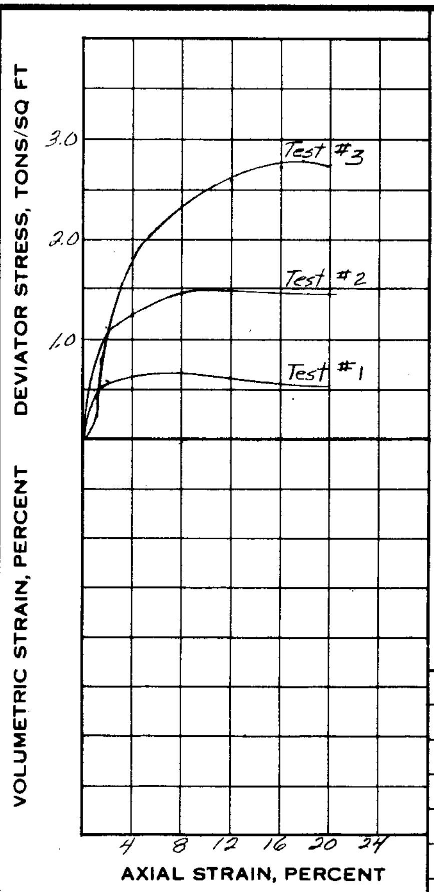
GPO 83-22462

PLATE NO. B-4



	Test No.	1	2	3	
INITIAL	Water Content, W_0 %	42.8	34.7	36.3	
	Dry Density Lbs/Cu Ft	76.94	86.42	83.62	
	Void Ratio, e_0	1.150	0.913	0.977	
	Saturation, S_0 %	98.7	100	98.5	
BEFORE TEST	W.C. after Saturation, W_s %				
	Saturation, S %				
	Consol Pressure T/Sq Ft	0.54	1.08	2.16	
	W.C. after Consol, W_c %	39.9	31.0	29.2	
	Void Ratio after Consol, e_c	1.071	0.813	0.788	
AT FAILURE	Maj Prin Stress, σ_I T/Sq Ft	1.18	2.55	4.90	
	Min Prin Stress, σ_{III} T/Sq Ft	.54	1.08	2.16	
	Water Content, W_F %	39.9	30.9	28.7	
	Void Ratio, e_F	1.071	0.811	0.776	
Specimen Diameter Inches		1.44	1.41	1.43	
Initial Height Inr		3.01	3.03	3.03	
Test Time to Failure Min		29	28	29	

ENG FORM 2089
1 DEC 51



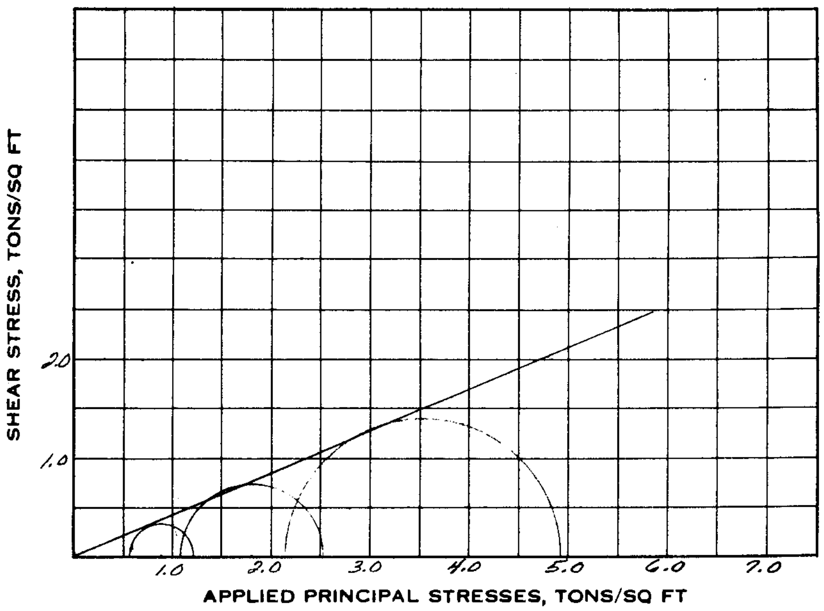
Type of Test
Constant Strain, .02 in/min
Control
Consolidated, Un Drained

Type of Specimen Undisturbed

Ø = 23 °	Tan Ø = .424	c = 0.0 T/Sq Ft

Classification Org. sandy SILT (OL)

LL 45	G 2.65
PL 27	D_{10}



Remarks:

All 3 Specimens contained several shells.

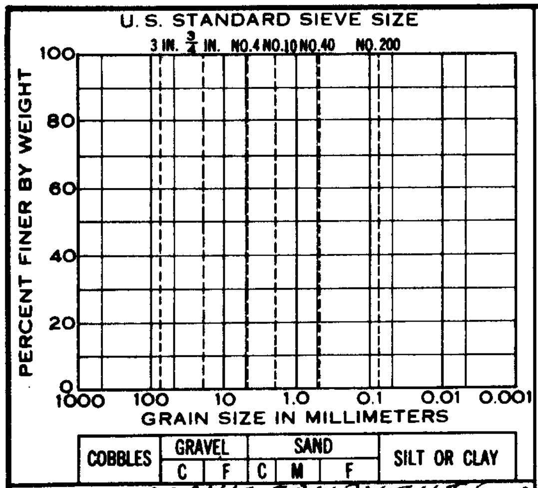
Project New Bedford Hurricane

Area U.S. Army Engineer Division, New England

Boring No. FD-92	Sample No. UC-5
~~Elev or~~ Depth 11.18' - 13.20'	Date 7 Dec. 1959

TRIAXIAL COMPRESSION TEST REPORT

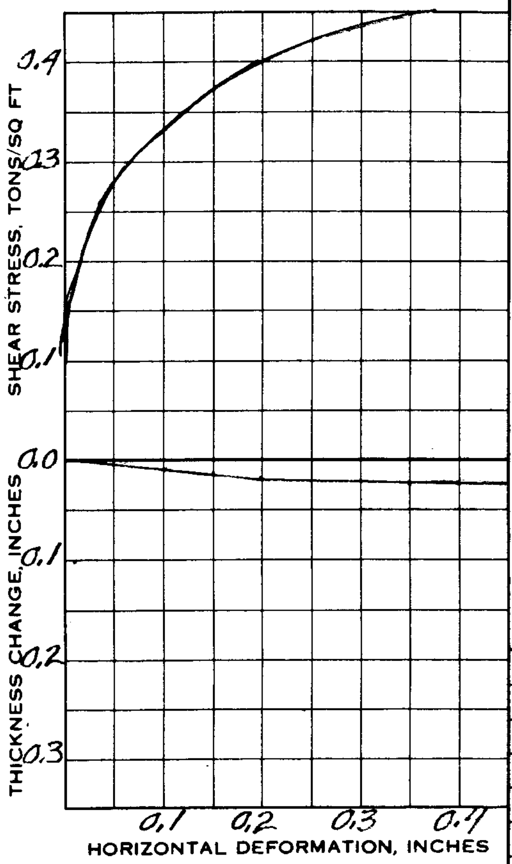
GPO 63-22462



Classification ORGANIC SANDY SILT (OL) W/SHELLS

LL 45	G 2.68
PL 27	D_{10} 0.0026

Test No.	1			
Initial Water Content, W_0 %	36.0			
Dry Density Lbs/Cu Ft	84.3			
Void Ratio, e_0	0.961			
Saturation, S_0 %	99.3			
Duration of Test Hrs	8.0			
WC after Test, W_f %	29.0			
Normal Stress, σ T/Sq Ft	0.50			
Max. Shear Stress, τ T/Sq Ft	0.46			



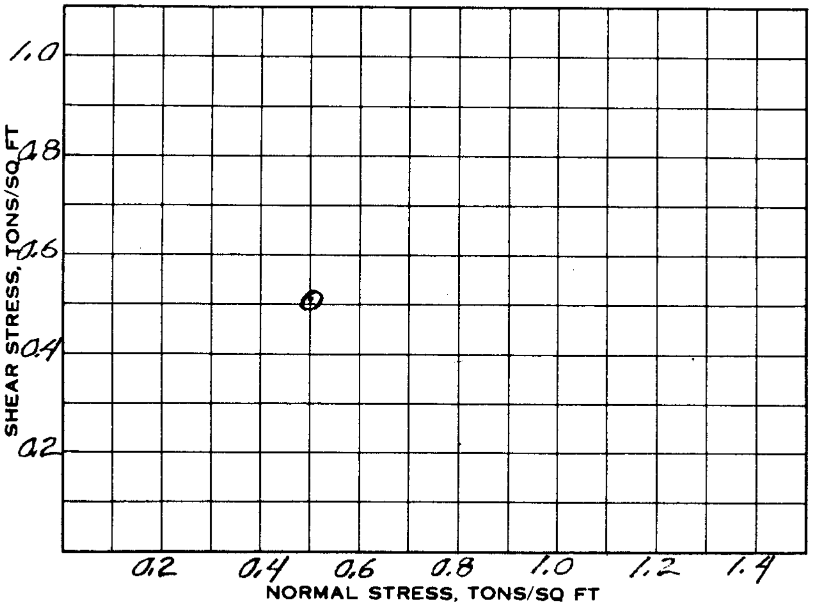
Type of Test
— Control

Consolidated

Drained

Type of Specimen
UNDISTURBED
3.0 in. square
in. thickness

SHEAR VALUES	ø	TAN ø	C, T/SQ FT
Maximum			
Ultimate			



Remarks:
INSUFFICIENT MATERIAL AVAILABLE TO COMPLETE THE TEST

Project NEW BEDFORD MASS

Area U.S. ARMY ENGINEER DIVISION NEW ENGLAND

Boring No. FD-92

Sample No. UC-5

~~Elev or~~ Depth 11.18'-13.20'

Date 2 NOV 1959

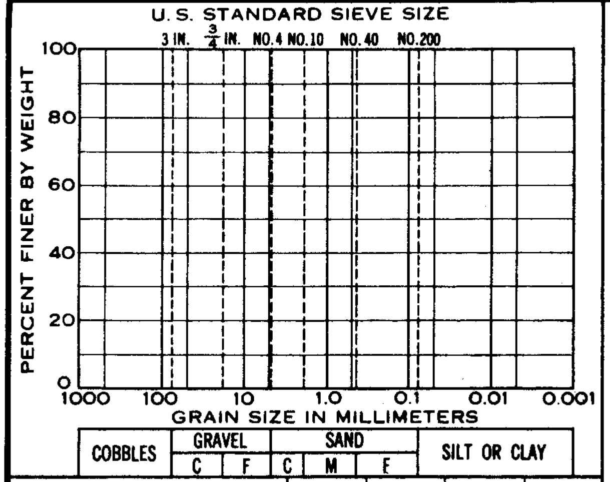
DIRECT SHEAR TEST REPORT

PLATE NO. B-6

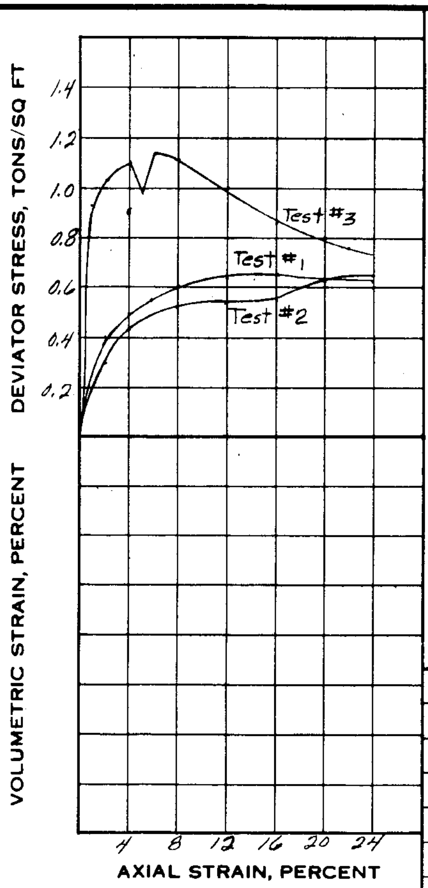
ENG FORM 1 DEC 51 2092

GPO 83-22456

PLATE NO. B-7



	Test No.	1	2	3	
INITIAL	Water Content, W_0 %	38.8	39.7	39.6	
	Dry Density Lbs/Cu Ft	82.28	81.90	80.02	
	Void Ratio, e_0	1.033	1.043	1.090	
	Saturation, S_0 %	100	100	97	
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_I T/Sq Ft	1.19	1.72	3.32	
	Min Prin Stress, σ_{III} T/Sq Ft	0.54	1.08	2.16	
	Water Content, W_F %				
	Void Ratio, e_F				
	Specimen Diameter Inches	1.44	1.35	1.35	
	Initial Height Inr	3.03	3.03	3.03	
	Test Time to Failure Min	29	31	28	



Type of Test

Constant *Strain, 0.02 in/min* Control

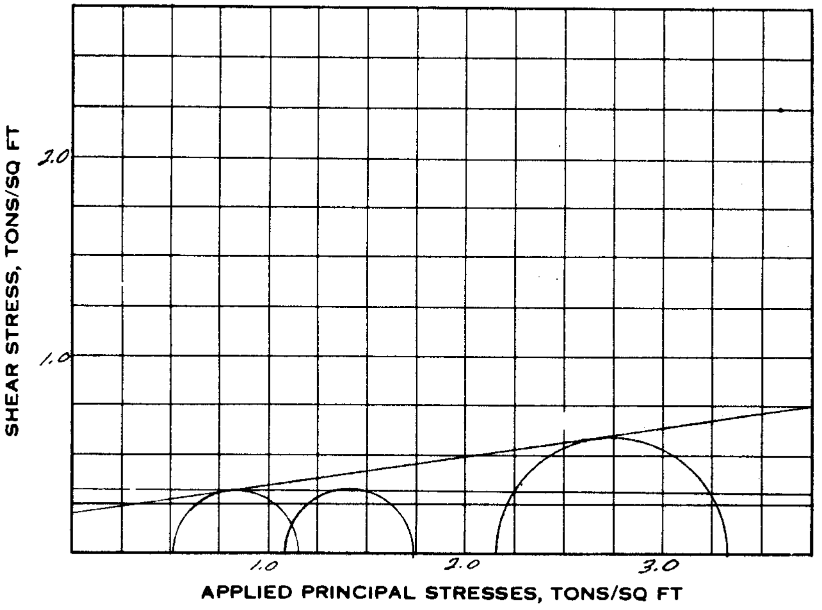
Un Consolidated, *Un* Drained

Type of Specimen *Undisturbed*

Ø = 0.0 °	Tan Ø = 0.0	c = .32 T/Sq Ft

Classification *Org SILT(OL) w/(SP)*

LL	G 2.68
PL	D_{10}



Remarks:

Specimen used for test #3 contained more sand than other specimens. It was also noted that sample tilted slightly during test. Results not considered in determination of Ø and c.

Project *New Bedford, Mass.*

Area

Boring No. *FD-92*

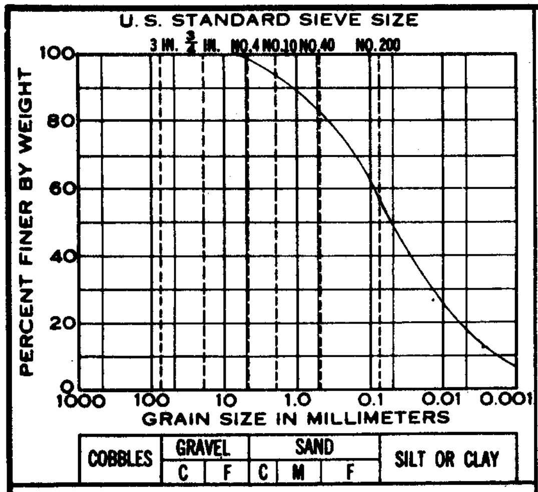
Sample No. *UC-9*

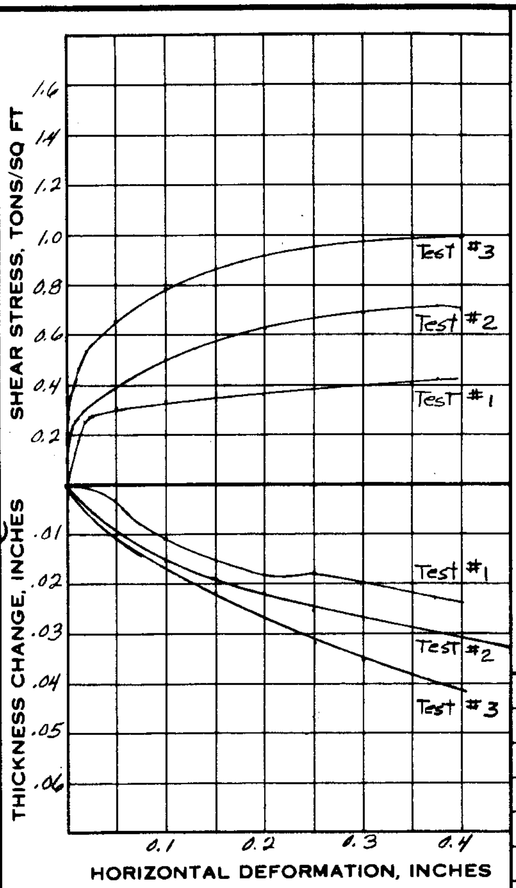
~~Elev or~~ Depth *15.23' - 17.22'*

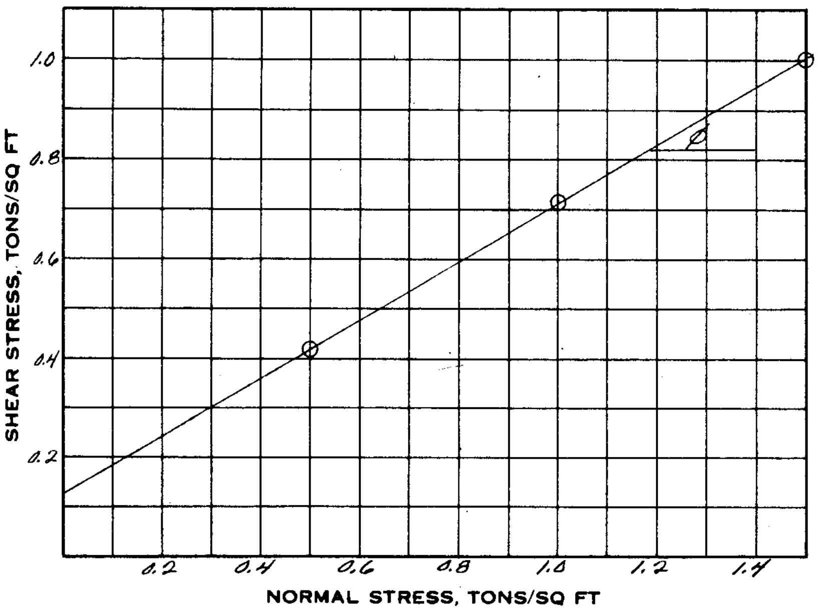
Date *15 Dec. 1959*

TRIAXIAL COMPRESSION TEST REPORT

ENG FORM 2089 1 DEC 51







Classification *Org. SILT (OL) w/lenses of SAND(SM)*

LL 28.6	**G** 2.68
PL 19.4	D_{10}

Test No.	1	2	3	
Initial Water Content, W_0 %	44.6	39.5	43.2	
Dry Density Lbs/Cu Ft	75.7	76.9	77.4	
Void Ratio, e_0	1.209	1.174	1.162	
Saturation, S_0 %	98.9	90.2	99.6	
Duration of Test hrs.	8.0	8.0	8.0	
WC after Test, W_F %	38.6	36.9	30.1	
Normal Stress, σ T/Sq Ft	0.50	1.0	1.5	
Max. Shear Stress, τ T/Sq Ft	0.42	0.72	1.00	

Type of Test	**Type of Specimen**
Strain - **Control** Rate = 0.0008 in/min	Undisturbed
Consolidated	3.0 **in. square**
Drained	0.75 **in. thickness**

SHEAR VALUES	**ø**	**TAN ø**	**C, T/SQ FT**
Maximum	30.2°	0.581	0.136
Ultimate			

Remarks:

Maximum shearing stresses selected at 0.375" Horizontal Displacement.

Project New Bedford Hurricane Protection

Area U.S. Army Engineer Division, New England

Boring No. FD-92	**Sample No.** UC-9
~~Elev or~~ Depth 15.23' - 17.22'	**Date** 11 Dec. 1959

DIRECT SHEAR TEST REPORT

PLATE NO. B-8

ENG FORM 1 DEC 51 2092

GPO 83-22486