AD-A086 878 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/13
SEABROOK LOCK COMPLEX, LAKE PONTCHARTRAIN, LOUISIANA; DESIGN FO--ETC(U)
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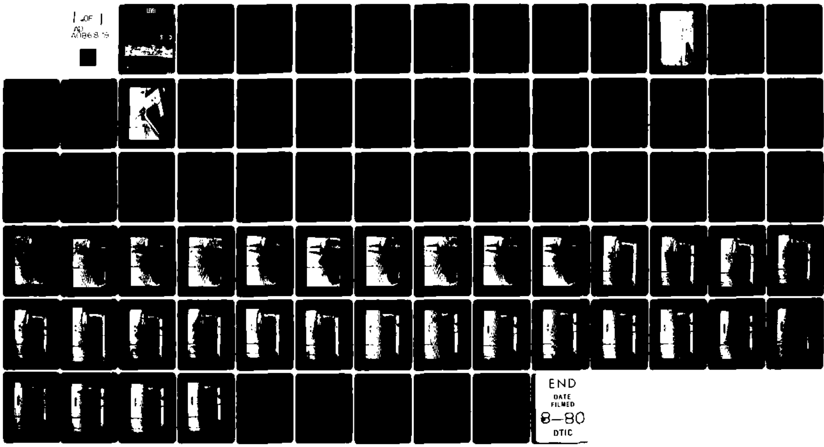

(12) LEVEL II

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TECHNICAL REPORT HL-80-8

SEABROOK LOCK COMPLEX, LAKE PONTCHARTRAIN, LOUISIANA; DESIGN FOR WAVE PROTECTION AT A TEMPORARY ENTRANCE DURING VARIOUS PHASES OF LOCK CONSTRUCTION

Hydraulic Model Investigation

by

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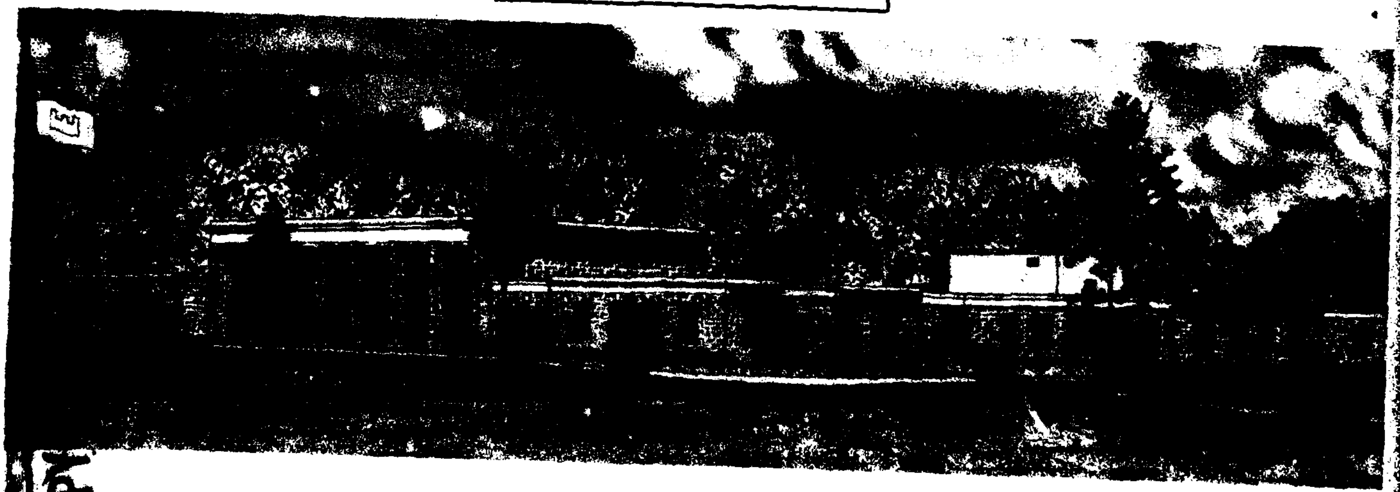
June 1980

Final Report



Prepared for U. S. Army Engineer District, New Orleans
New Orleans, Louisiana 70160

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report HL-80-8

2. GOVT ACCESSION NO.
AD-A086878

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
SEABROOK LOCK COMPLEX, LAKE PONTCHARTRAIN, LOUISIANA; DESIGN FOR WAVE PROTECTION AT A TEMPORARY ENTRANCE DURING VARIOUS PHASES OF LOCK CONSTRUCTION; Hydraulic Model Investigation

5. TYPE OF REPORT & PERIOD COVERED
Final report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Robert R. Bottin, Jr

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U. S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U. S. Army Engineer District, New Orleans
P. O. Box 60267
New Orleans, La. 70160

12. REPORT DATE
June 1980

13. NUMBER OF PAGES
72

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
(14) WES/TR/HL-80-8

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Breakwaters
Hydraulic models
Locks (Waterways)
Seabrook Lock Complex
Water wave action on maritime structures

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A 1:36-scale undistorted hydraulic model reproducing the site of the proposed Seabrook Lock Complex, the Inner Harbor Navigation Canal at its junction with Lake Pontchartrain, portions of the New Orleans Lakefront Airport, the stepped seawall adjacent to Lakeshore Drive, and sufficient offshore area in Lake Pontchartrain to permit generation of the required test waves was used to investigate the design of proposed breakwaters with respect to wave action. The proposed breakwater plans involved the placement of sheet-pile (Continued)

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Unclassified 412389

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

and floating structures arranged to provide wave protection to a temporary entrance during various phases of lock construction. An 80-ft-long wave generator and an Automated Data Acquisition and Control System (ADACS) were utilized in model operation. It was concluded from test results that:

a. With no breakwater protection, the temporary entrances of Construction Sequence Phases II, III, and IV (Plans II, III, and IV) into the Inner Harbor Navigation Canal were characterized by rough and turbulent wave conditions (wave heights in excess of 6 ft) for the waves tested, and the cofferdams for each Construction Sequence Phase were significantly overtopped.

b. Installation of a 2,150-ft-long sheet-pile breakwater lakeward of the proposed lock site (Plans II-A, III-A, and IV-A) will reduce wave heights in the respective temporary entrances of Phases II, III, and IV to within the established 2.0-ft wave-height criterion for test waves from the following directions:

Construction Sequence Phase II - NNW
Construction Sequence Phase III - N, NNW
Construction Sequence Phase IV - N, NNW

c. In addition to the 2,150-ft-long sheet-pile breakwater of Plan II-A, a 288-ft-long floating breakwater (Plan II-C) installed NE of the proposed lock site is required to meet the established wave-height criterion in the temporary entrance of Construction Sequence Phase II for test waves from N.

d. In addition to the 2,150-ft-long sheet-pile breakwater of Plans II-A, III-A, and IV-A, a 1,344-ft-long floating breakwater (Plans II-D, III-B, and IV-C) installed NW of the proposed lock site is required to meet the established wave-height criterion in the respective temporary entrances of Construction Sequence Phases II, III, and IV for test waves from NW.

e. The 2,150-ft-long sheet pile breakwater of Plans II-A, III-A, and IV-A, in conjunction with the 1,344-ft-long floating breakwater (Plans II-D, III-B, and IV-C), will substantially reduce overtopping of the cofferdams for Construction Sequence Phases II, III, and IV for test waves from all directions.

PREFACE

A request for a model investigation of wave action at the proposed Seabrook Lock, Lake Pontchartrain, Louisiana, was initiated by the District Engineer, U. S. Army Engineer District, New Orleans (LMN). Authorization for the U. S. Army Engineer Waterways Experiment Station (WES) to perform the study was granted by the Office, Chief of Engineers. Funds were authorized by LMN on 3 February 1978 and 16 August 1979.

The model study was conducted at WES during the period April 1978-October 1979 under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory; Mr. F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory; Dr. R. W. Whalin, Chief of the Wave Dynamics Division; and Mr. C. E. Chatham, Jr., Chief of the Wave Processes Branch. Testing was performed by Messrs. H. F. Acuff, civil engineering technician, and R. E. Ankeny, computer technician, under the supervision of Mr. R. R. Bottin, Jr., Project Manager. Mr. K. A. Turner, computer specialist, was responsible for obtaining wave characteristics at Seabrook by the application of hindcasting techniques. This report was prepared by Mr. Bottin.

Prior to the model investigation Messrs. Chatham and Bottin visited the LMN office and the Seabrook area to confer with representatives of LMN and to inspect the prototype site. During the course of the investigation, liaison between LMN and WES was maintained by means of conferences, telephone communications, and monthly progress reports.

Messrs. Jay Combe, Cecil Soileau, and Larry Dement of LMN visited WES to observe model operation and participate in conferences during the course of the model study.

Test results of wave conditions at the proposed lock entrance were reported in WES Technical Report HL-80-7, "Seabrook Lock Complex, Lake Pontchartrain, Louisiana; Design for Wave Protection at Lock Entrance," dated May 1980. Test results of wave conditions at a temporary entrance to be used during intermediate stages of lock construction are reported herein.

COL John L. Cannon, CE, and COL Nelson P. Conover, CE, were

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometres
square feet	0.09290304	square metres
square miles (U. S. statute)	2.589988	square kilometres

SEABROOK LOCK COMPLEX, LAKE PONTCHARTRAIN, LOUISIANA; DESIGN FOR WAVE PROTECTION AT A TEMPORARY ENTRANCE DURING VARIOUS PHASES OF LOCK CONSTRUCTION

Hydraulic Model Investigation

PART I: INTRODUCTION

Description of Project

1. The Flood Control Act approved 27 October 1965 authorized a project for hurricane flood protection on Lake Pontchartrain, Louisiana, of which Seabrook Lock (Rock Island District 1977) is a part. The lock complex is proposed for construction on the south shore of Lake Pontchartrain (Figure 1) at its junction with the Inner Harbor Navigation

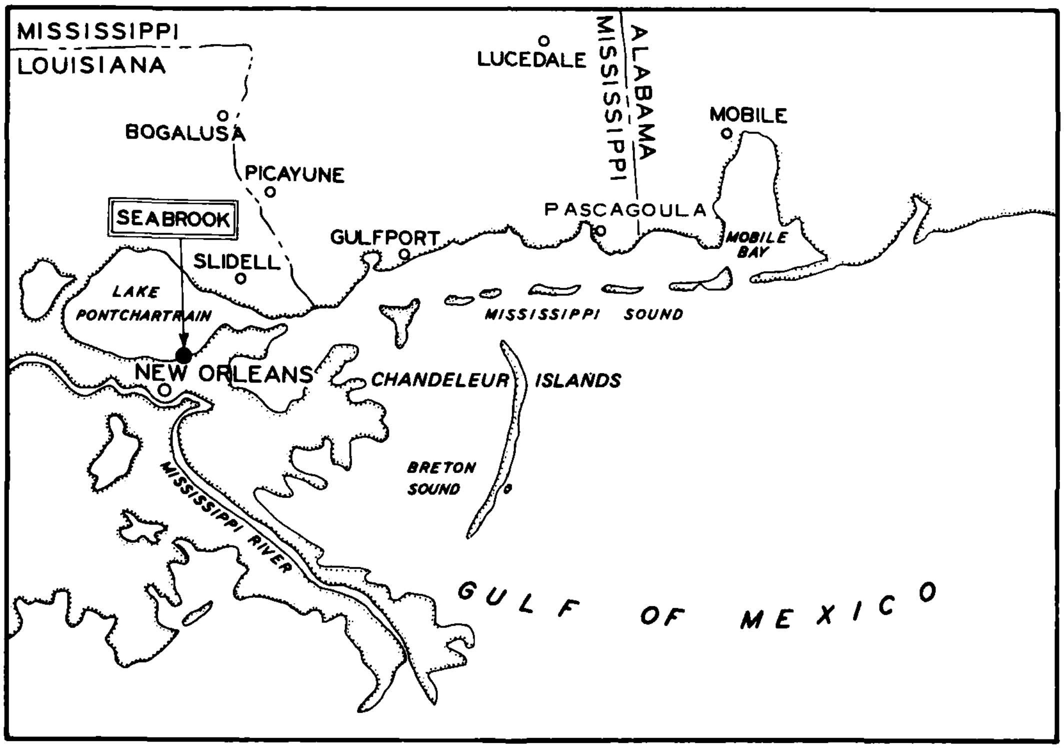

Figure 1. Project location

Canal (IHNC) and will consist of three major components: an 84-ft-wide* by 860-ft-long by 16-ft-deep navigation lock, a rock and shell dam, and an outlet structure. All waterborne vessels (recreational small-craft and commercial barge traffic) traveling between Lake Pontchartrain and the IHNC would pass through the lock.

The Problem

2. The project area (Figure 2) is subjected to storm-generated waves in Lake Pontchartrain (ranging up to 5 ft in height) approaching from north, north-northwest, and northwest. In addition, a vertical seawall on the south shore of the lake tends to reflect a high degree of wave energy back into the lake in the vicinity of the lock site. These conditions could make navigation in the lock entrance difficult and dangerous for waterborne commerce and small-boat traffic.

Previously Reported Model Tests and Conclusions

3. The Seabrook model was originally constructed to study wave conditions at the proposed lock entrance and to determine the degree of protection afforded by the various proposed breakwater plans (Bottin and Turner 1980). Conclusions derived from results of these tests were as follows:

- a. Existing conditions are characterized by very rough and turbulent waves in the vicinity of the proposed lock during periods of storm wave attack.
- b. Installation of a rock wave absorber along the vertical and stepped walls in the area will significantly calm wave conditions in the vicinity of the proposed lock.
- c. Wave heights in the proposed lock with no breakwaters installed (Plan 2) would be extremely hazardous (wave heights in excess of 8 ft).
- d. The combined 2,250-ft breakwater length (one outer and

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

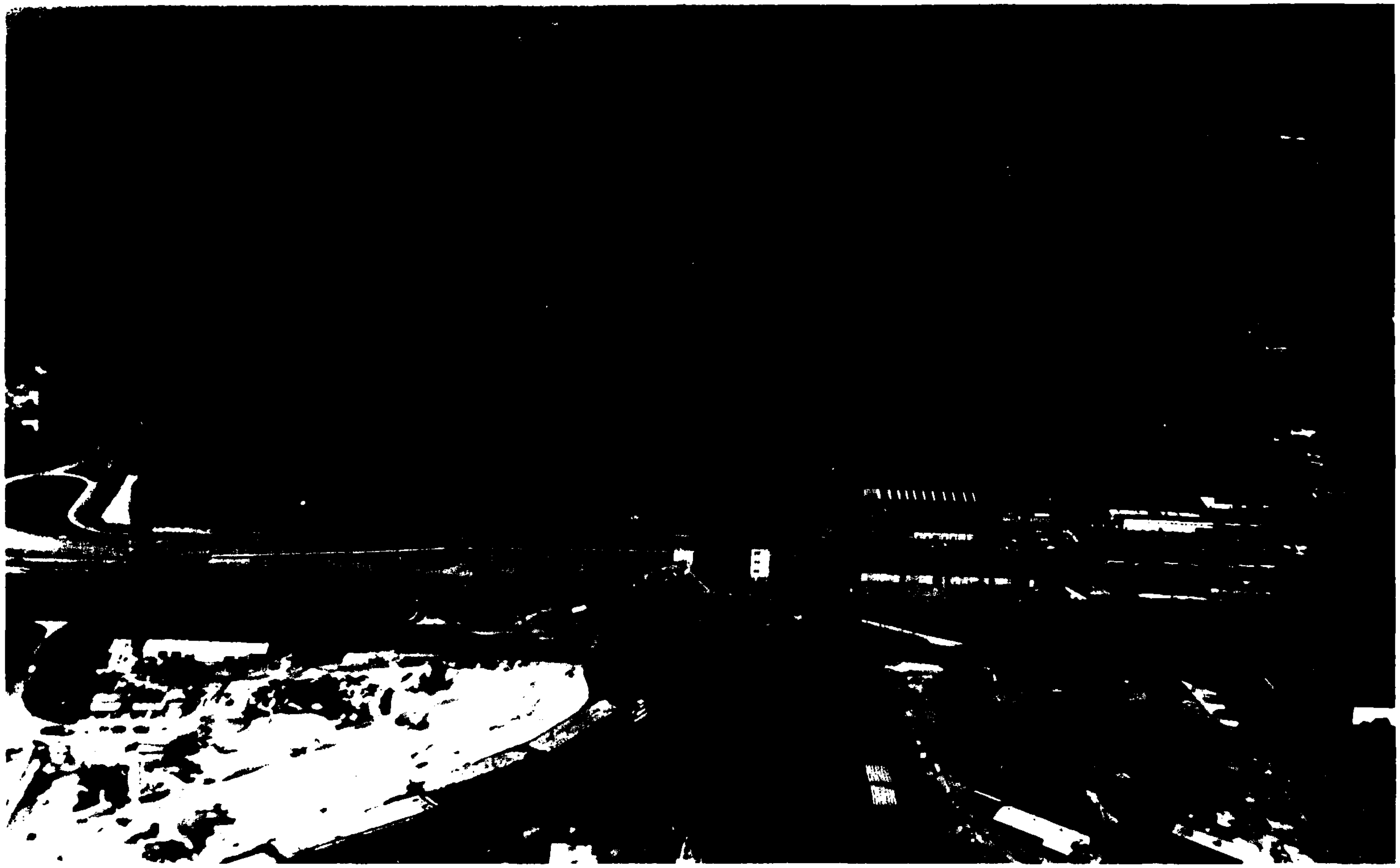

Figure 2. Aerial photograph of proposed lock site

two inner breakwaters) of Plan 8 provides wave protection that satisfies the established criterion at the lock entrance and appears to be the most economical rubble-mound breakwater plan tested.

e. The sheet-pile outer breakwater configurations of Plans 10A, 11B, 12A, and 20A, all in conjunction with two 300-ft-long rubble-mound inner breakwaters, will provide wave protection that meets the established criterion at the lock entrance.

f. To achieve the established wave-height criterion at the lock entrance with floating structures (providing 50 percent attenuation for waves approaching from a direction perpendicular to the structure), a total breakwater length of 5,088 ft is required (Plan 17C, consisting of two outer and three inner breakwaters).

Purpose of the Present Investigation

4. At the request of the U. S. Army Engineer District, New Orleans (LMN), a hydraulic model investigation was initiated by the U. S. Army Engineer Waterways Experiment Station (WES) to:

a. Determine wave conditions at the temporary entrance during intermediate stages of lock construction.

b. Determine the degree of protection afforded the temporary entrance by the installation of a 2,150-ft-long sheet-pile breakwater (outer breakwater of Plan 20A from previous test results (Bottin and Turner 1980)).

c. Develop remedial plans, as necessary, for the alleviation of undesirable wave conditions.

d. Determine if design modifications to the proposed plans could be made that would reduce construction costs significantly and still provide adequate wave protection.

Wave-Height Criterion

5. For the study reported herein, LMN specified that for an improvement plan to be acceptable, maximum wave heights in the temporary entrance should not exceed 2.0 ft.

PART II: THE MODEL

Design of Model

6. The Seabrook Lock model (Figure 3) was constructed to an undistorted linear scale of 1:36, model to prototype. Scale selection was based on such factors as:

- a. Depth of water required in the model to prevent excessive bottom friction.
- b. Absolute size of model waves.
- c. Available shelter dimensions and area required for model construction.
- d. Efficiency of model operation.
- e. Available wave-generating and wave-measuring equipment.
- f. Model construction costs.

A geometrically undistorted model was necessary to ensure accurate reproduction of short-period wave patterns. Following selection of the linear scale, the model was designed and operated in accordance with Froude's model law (Stevens et al. 1942). The scale relations used for design and operation of the model were as follows:

Characteristic	Dimension*	Model:Prototype Scale Relation
Length	L**	$L_r = 1.36$
Area	L^2	$A_r = L_r^2 = 1:1,296$
Volume	L^3	$V_r = L_r^3 = 1:46,656$
Time	T	$T_r = L_r^{1/2} = 1:6$
Velocity	L/T	$V_r = L_r^{1/2} = 1:6$

* Dimensions are in terms of length and time.
** For convenience, symbols and unusual abbreviations are listed and defined in the Notation (Appendix A).

7. Some of the proposed improvement plans for Seabrook involved

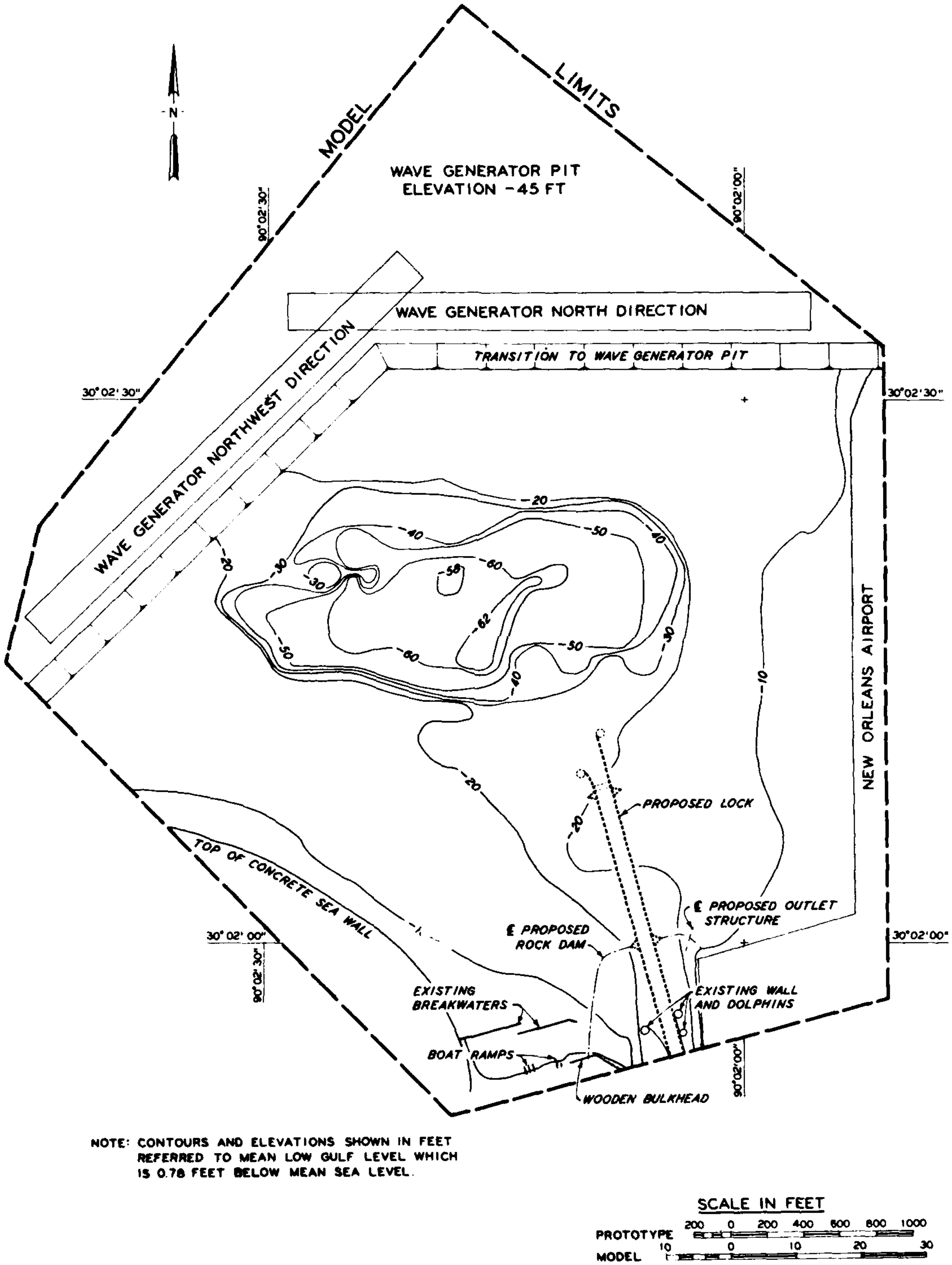

Figure 3. Model layout

the use of steel sheet-pile structures and/or 54-in. prestressed cylinders. In the model these structures were considered to be impervious and were constructed of wood.

8. Other improvement plans included the use of floating breakwater structures. Selection of floating model structures was based on the results of two-dimensional wave transmission tests conducted at a 1:36 scale using 4-sec, 4- and 5-ft waves approaching from a direction normal to the structure and a 40-ft depth. A breakwater cross section was selected that provided an approximate transmission coefficient of 0.5 (50 percent attenuation). While these structures (prototype dimensions 96 ft long by 63 ft wide by 6 ft high) were constructed of marine plywood in the model, they could represent any type of floating breakwater that gives 50 percent attenuation for 4-sec, 4- or 5-ft-high waves with normal approach.

The Model and Appurtenances

9. The model, which was molded in cement mortar, reproduced the site of the proposed Seabrook Lock Complex, the IHNC at its junction with Lake Pontchartrain, portions of the New Orleans Lakefront Airport and the stepped seawall adjacent to Lakeshore Drive, and underwater contours in Lake Pontchartrain to an offshore depth of -18 ft* (including a -62 ft dredged area formed as a result of dredging operations to obtain material for the New Orleans Lakefront Airport) with a sloping transition to the wave generator pit elevation of -45 ft. The total area reproduced in the model was approximately 14,420 sq ft, representing about 0.67 square miles in the prototype. A general view of the model is shown in Figure 4. Vertical control for model construction was based on mlg, el 0.78 ft below mean sea level (msl). Horizontal control was referenced to a local prototype grid system.

10. Model waves were generated by an 80-ft-long piston-type wave

* All elevations (el) cited herein are in feet referred to mean low gulf level (mlg) unless otherwise stated.

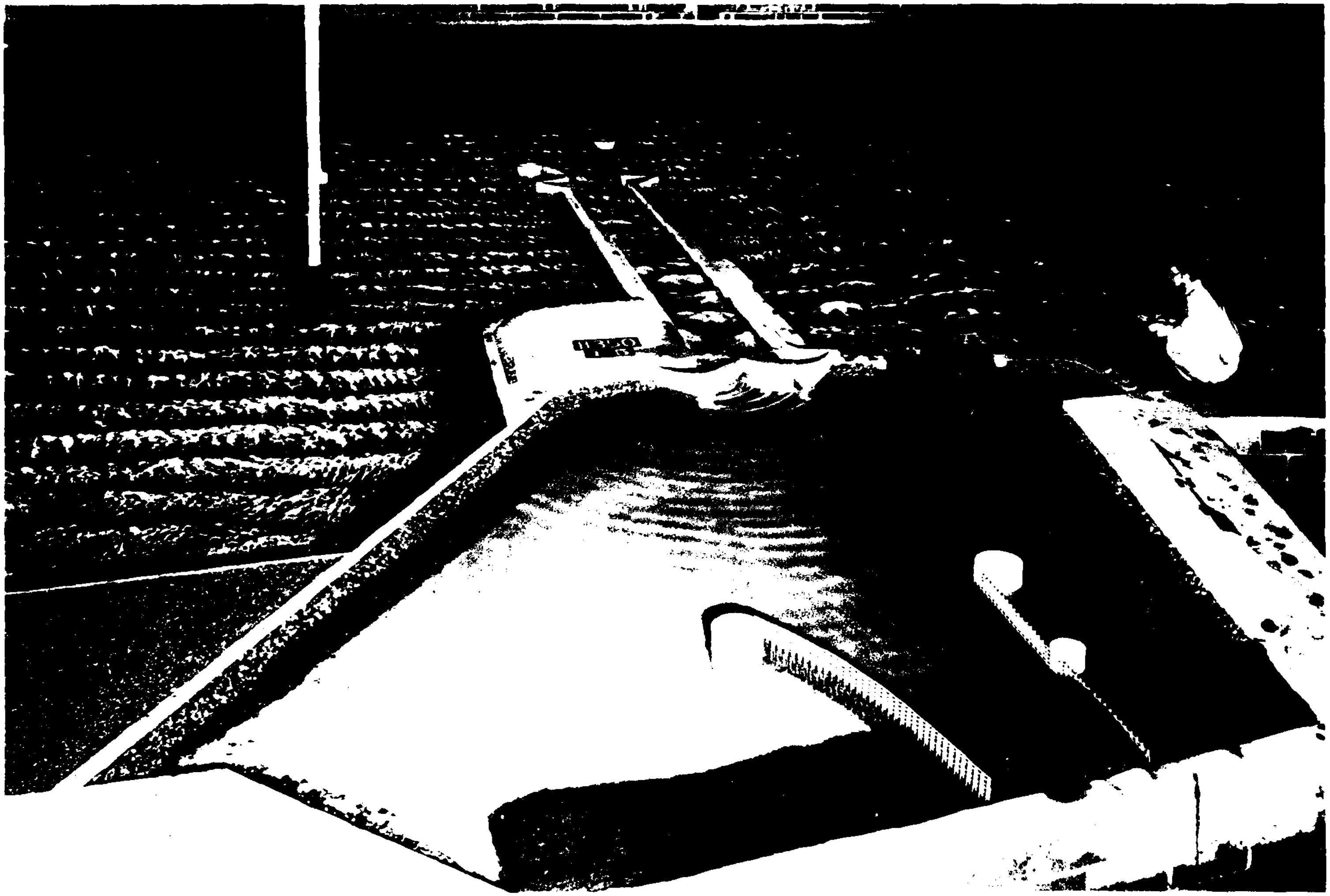

Figure 4. General view of model with lock installed

generator. The horizontal movement of the piston plate caused a periodic displacement of water incident to this motion. The length of the stroke and the frequency of the piston plate movement were variable over the range necessary to generate waves with the required characteristics. In addition, the wave generator was mounted on retractable casters which enabled it to be positioned to generate waves from the required directions.

11. An Automated Data Acquisition and Control System (ADACS), designed and constructed at WES (Figure 5), was used to secure wave-height data at selected locations in the model. Basically, through the use of a minicomputer, ADACS recorded onto magnetic tape the electrical output of parallel-wire, resistance-type wave gages that measured

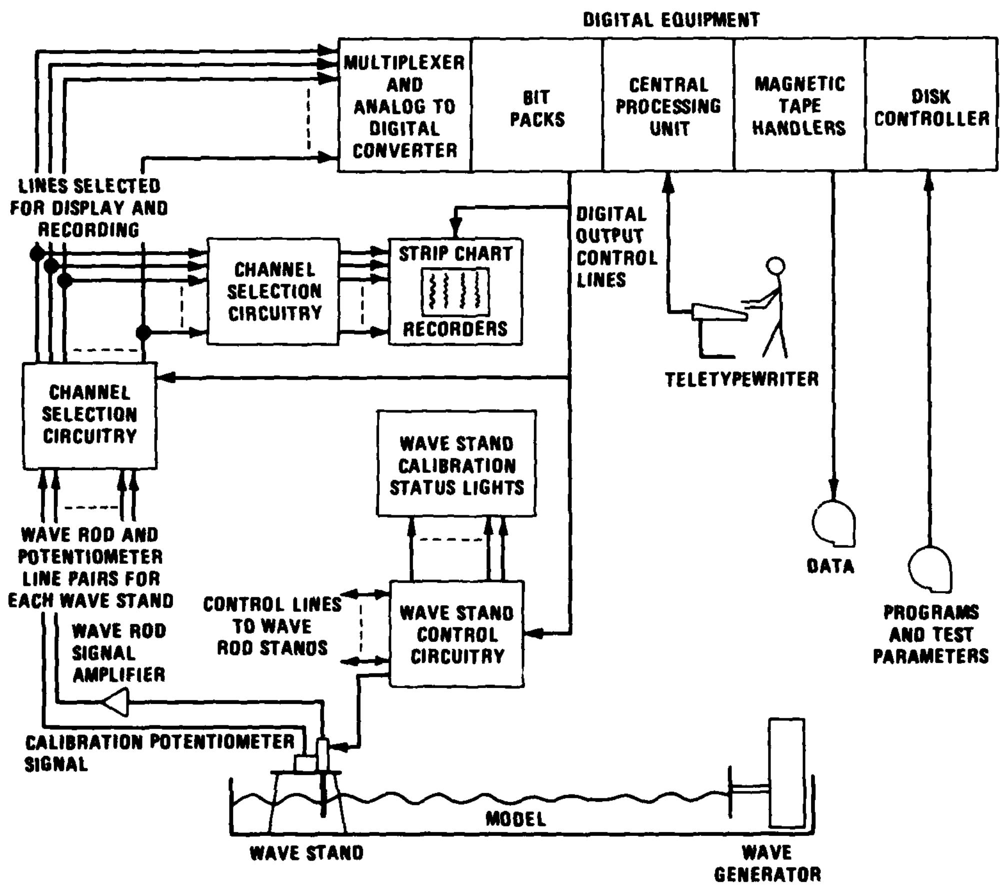

Figure 5. Automated Data Acquisition and Control System (ADACS)

the change in water-surface elevation with respect to time. The magnetic tape output of ADACS then was analyzed to obtain the wave-height data.

12. A 2-ft (horizontal) layer of fiber wave absorber was placed around the inside perimeter of the model to damp any wave energy that might otherwise be reflected from the model walls. In addition, guide vanes were placed along the wave generator sides to ensure proper formation of the wave train incident to the model contours.

PART III: TEST CONDITIONS AND PROCEDURES

Selection of Test Conditions

Still-water level

13. Still-water levels (swl's) for wave-action models are selected so that various wave-induced phenomena dependent on water depths are accurately reproduced in the model. These phenomena include the refraction of waves in the problem area, overtopping of various structures by waves, reflection of wave energy from various structures, and transmission of wave energy through porous structures.

14. It was desirable to select a model swl that closely approximated the higher water stages which normally occur in the prototype for the following reasons:

- a. The maximum amount of wave energy reaching a coastal area normally occurs during the higher water phase of the local tide cycle.
- b. Most storms moving onshore are characteristically accompanied by a higher water level due to wind tide and shoreward mass transport.
- c. The selection of a high swl helps minimize model scale effects due to viscous bottom friction.

15. Still-water levels of +1.0 and +4.0 ft msl were selected by LMN for use during model testing. The lower value (+1.0 ft) represents mean high gulf level (+0.8 ft) with a 0.2-ft short period rise in local water level due to wind tide, and the higher value (+4.0 ft) represents a lake level that occurs about once a year.

Factors influencing selection of test wave characteristics

16. In planning the testing program for a model investigation of wave-action problems, it is necessary to select dimensions and directions for the test waves that will allow a realistic test of proposed improvement plans and an accurate evaluation of the elements of the various plans. Surface wind waves are generated primarily by the interactions between tangential stresses of wind flowing over water, resonance

between the water surface and atmospheric turbulence, and interactions between individual wave components. The height and period of the maximum wave that can be generated by a given storm depend on the wind speed, the length of time that wind of a given speed continues to blow, and the water distance (fetch) over which the wind blows. Selection of test conditions entails evaluation of such factors as:

- a. The fetch and decay distances (the latter being the distance over which waves travel after leaving the generating area) for various directions from which waves can attack the problem area.
- b. The frequency of occurrence and duration of storm winds from the different directions.
- c. The window(s) from which the site is exposed to wave attack.
- d. The alignments, lengths, and locations of various reflecting surfaces at the site.
- e. The refraction of waves caused by differentials in depth in the area lakeward of the site, which may create either a concentration or diffusion of wave energy.

Wave refraction

17. When waves move into water of gradually decreasing depth, transformations take place in all wave characteristics except wave period. The most important transformations with respect to selection of test wave characteristics are the changes in wave height and direction of travel due to the phenomenon referred to as wave refraction. The change in wave height and direction can be determined by plotting refraction diagrams and calculating refraction coefficients. These diagrams are constructed by plotting the position of wave orthogonals (lines drawn perpendicular to wave crests) from deep water into shallow water. If it is assumed that waves do not break and there is no lateral flow of energy along the wave crest, the ratio between the wave height in deep water (H_o) and the wave height at any point in shallow water (H) is inversely proportional to the square root of the ratio of the corresponding orthogonal spacings (b_o and b), or $H/H_o = K_s(b_o/b)^{1/2}$ The quantity $(b_o/b)^{1/2}$ is the refraction coefficient, K_r ; K_s is the shoaling coefficient. Thus, the refraction coefficient multiplied

by the shoaling coefficient gives a conversion factor for transfer of deepwater wave heights to shallow-water values. The shoaling coefficient, which is a function of wavelength and water depth, can be obtained from the Shore Protection Manual (CERC 1977).

18. Due to the limited depth in Lake Pontchartrain (-18 ft) and the limited fetch (20 miles), a wave-refraction analysis was not conducted for the Seabrook Lock site. The magnitude and direction of winds approaching Seabrook from over the lake were considered to be the governing factors and all waves were assumed to be locally generated. For this study, critical directions of wave approach were determined to be north, north-northwest, and northwest.

Prototype wave data and selection of test waves

19. Measured prototype wave data on which a comprehensive statistical analysis of wave conditions could be based were unavailable for the Seabrook area. However, statistical wave hindcast data representative of this area were obtained by the application of hindcasting techniques from CERC (1977) to wind data acquired at the New Orleans International Airport as detailed by Bottin and Turner (1980). Model test waves selected from these data are shown in the following tabulation:

Direction	Wave Period sec	Wave Height ft
North	3	2
		4
	4	5
North-northwest	3	2
		4
	4	4
Northwest	3	2
		4
	4	4

Analysis of Model Data

20. Relative merits of the various plans tested were evaluated by:

a. Comparison of wave heights at selected locations in the model.

b. Visual observations, wave pattern photographs, and model movie footage.

In analyzing the wave-height data, the average height of the highest one third of the waves recorded at each gage location was computed. Computed wave heights were adjusted to compensate for excess model attenuation due to viscous bottom friction by application of Keulegan's equation (Keulegan 1950). From this equation, reduction of wave heights in the model (relative to the prototype) can be calculated as a function of water depth, width of wave front, wave period, water viscosity, and distance of wave travel.

PART IV: TESTS AND RESULTS

The Tests

Test plans

21. Wave-height tests were conducted for three phases of lock construction with no breakwater protection and for twelve variations in the design elements of various breakwater plans. The 2,150-ft-long sheet-pile breakwater of Plan 20A (from Bottin and Turner 1980) and floating breakwaters were tested with variations consisting of changes in the lengths and alignments of the floating structures. Wave pattern photographs and model movie footage were obtained for prebreakwater conditions and the more important breakwater plans. The three construction phases tested (Rock Island District 1977) were as follows:

Construction Sequence Phase II - Lakeward cofferdam

Construction Sequence Phase III - Landward cofferdam

Construction Sequence Phase IV - Lock walls

Since the Seabrook Lock Complex was installed in the model prior to initiation of these tests, the various construction phases were tested in reverse order (i.e. Phase IV, Phase III, Phase II). Brief descriptions of the test plans are presented in the following subparagraphs; dimensional details are shown in Plates 1-3.

- a. Plan IV (Plate 1) entailed all of the elements of Phase IV. This phase consisted of the outlet structure, the landward lock gates, and the lakeward lock gates with guidewalls and dolphins. The lock walls were constructed of cofferdams (el +8.0 ft msl); and the temporary entrance into the canal was located west of the landward lock gates.
- b. Plan IV-A (Plate 1) consisted of the elements of Plan IV with the installation of a 2,150-ft-long sheet-pile breakwater lakeward of the proposed lock site. This sheet-pile structure was 5.5 ft wide with a +6 ft crest elevation.
- c. Plan IV-B (Plate 1) involved the elements of Plan IV-A with a 1,152-ft-long floating breakwater installed northwest of the proposed lock.
- d. Plan IV-C (Plate 1) entailed the elements of Plan IV-B with 192 ft of breakwater length added to the eastern end of the floating structure, resulting in a floating breakwater length of 1,344 ft.

e. Plan IV-D (Plate 1) consisted of the elements of Plan IV-C with 192 ft of breakwater length removed from the western end of the floating structure, resulting in a floating breakwater length of 1,152 ft.

f. Plan III (Plate 2) involved the elements of Phase III. This phase consisted of the lakeward lock gates with cofferdams (el +8.0 ft msl) constructed around the landward lock gates and the outlet structure. The temporary entrance into the canal was located west of the cofferdams.

g. Plan III-A (Plate 2) entailed the elements of Plan III with the installation of a 2,150-ft-long sheet-pile breakwater lakeward of the proposed lock site.

h. Plan III-B (Plate 2) consisted of the elements of Plan III-A with a 1,344-ft-long floating breakwater installed northwest of the proposed lock site.

i. Plan III-C (Plate 2) involved the elements of Plan III-B with 192 ft of breakwater length removed from the eastern end of the floating structure, resulting in a floating breakwater length of 1,152 ft.

j. Plan II (Plate 3) entailed the elements of Phase II. This phase consisted of cofferdams (el +8.0 ft msl) constructed around the lakeward lock gates. The temporary entrance into the canal was north of the existing entrance (junction of Lake Pontchartrain and the IHNC).

k. Plan II-A (Plate 3) involved the elements of Plan II with the installation of a 2,150-ft-long sheet-pile breakwater lakeward of the proposed lock site.

l. Plan II-B (Plate 3) consisted of the elements of Plan II-A with a 480-ft-long floating breakwater connected to shore at the New Orleans Lakefront Airport northeast of the proposed lock site.

m. Plan II-C (Plate 3) entailed the elements of Plan II-B with 192 ft of structure removed from the western end of the floating breakwater, resulting in a 288-ft-long structure.

n. Plan II-D (Plate 3) consisted of the elements of Plan II-A with a 1,344-ft-long floating breakwater connected to the stepped seawall northwest of the proposed lock site.

o. Plan II-E (Plate 3) involved the elements of Plan II-D with 192 ft of structure length removed from the eastern end of the floating breakwater, resulting in a 1,152-ft-long structure.

Wave-height tests

22. Wave-height tests for prebreakwater conditions (Plans IV, III, and II) and the sheet-pile breakwater plans (Plans IV-A, III-A, and II-A) were conducted using test waves from all three directions (i.e. N, NNW, and NW). Tests involving modifications to the various floating breakwaters were limited to the most critical directions of wave approach (i.e. N and/or NW). Wave gage locations for the various test plans are shown in Plates 1-3.

Movie

23. A 20-min movie of the three construction phases and breakwater modifications was secured and forwarded to LMN for use in briefings, public meetings, etc. Included in the movie footage were the following:

a. A view of 4-sec, 5-ft test waves in the lake at the outer breakwater location with the +1 ft swl and no structure installed.

b. A view of the sheet-pile breakwater under attack by 4-sec, 4-ft test waves from N for the +1 ft swl.

c. A view of floating breakwaters under attack by 4-sec, 4-ft test waves from NW for the +1 ft swl.

d. The temporary lock entrance under attack by 4-sec, 5-ft test waves from N for the +1 and +4 ft swl's (Plans IV, IV-A, III, III-A, II, II-A, and II-C).

e. The temporary lock entrance under attack by 4-sec, 4-ft test waves form NW for the +1 and +4 ft swl's (Plans IV, IV-A, IV-C, III, III-A, III-B, II, II-A, and II-D).

Test Results

24. In evaluating test results, the relative merits of each plan were based on an analysis of measured wave heights. Model wave heights (significant wave height or $H_{1/3}$) were tabulated (Tables 1-10) to show measured values at selected locations.

Test plans

25. Wave-height measurements obtained for Plan IV are presented in Table 1. For the +1 ft swl, maximum wave heights obtained in the temporary entrance (gages 1-4) were 5.5, 5.0, and 4.0 ft for test waves from N, NNW, and NW, respectively. For the +4 ft swl, maximum wave heights in

the temporary entrance were 4.5, 5.6, and 6.1 ft for test waves from N, NNW, and NW, respectively. The established wave-height criterion of 2.0 ft in the entrance was exceeded for test waves from each direction for both swl's. Typical wave patterns obtained for Plan IV are shown in Photos 1-4.

26. Results of wave-height tests with Plan IV-A installed in the model are presented in Table 2. Maximum wave heights obtained in the temporary entrance for the +1 ft swl were 0.7, 1.4, and 3.4 ft, for test waves from N, NNW, and NW, respectively. For the +4 ft swl, maximum wave heights were 1.8, 1.5, and 6.3 ft in the temporary entrance for test waves from N, NNW, and NW, respectively. The 2.0-ft wave-height criterion was exceeded only by test waves from NW for both the +1 and +4 ft swl's. Typical wave patterns obtained for Plan IV-A are shown in Photos 5-8.

27. Results of wave-height tests conducted for Plans IV-B and IV-C, with the +1 ft swl and Plans IV-B through IV-D with the +4 ft swl for test waves from NW are presented in Table 3. Maximum wave heights obtained in the temporary entrance for the +1 ft swl were 1.9 ft and 1.5 ft for Plans IV-B and IV-C, respectively. For the +4 ft swl, maximum wave heights in the temporary entrance were 2.3, 2.0, and 2.3 ft for Plans IV-B through IV-D, respectively. The established wave-height criterion of 2.0 ft was met only by Plan IV-C. Typical wave patterns obtained for Plan IV-C are shown in Photos 9 and 10.

28. Wave heights obtained with Plan III installed in the model are presented in Table 4. Maximum wave heights obtained the in the temporary entrance (gages 1-4) for the +1 ft swl were 4.6, 3.7, and 3.5 ft for test waves from N, NNW, and NW, respectively. For the +4 ft swl, maximum wave heights in the temporary entrance were 6.2, 5.4, and 4.2 ft for test waves from N, NNW, and NW, respectively. The established wave-height criterion of 2.0 ft was exceeded for test waves from each direction for both swl's. Typical wave patterns obtained for Plan III are shown in Photos 11-14.

29. Wave-height measurements obtained for Plan III-A are presented in Table 5. For the +1 ft swl, maximum wave heights in the temporary entrance were 1.1, 1.4, and 2.9 ft for test waves from N, NNW, and NW,

respectively. For the +4 ft swl, maximum wave heights were 1.4, 1.8, and 3.8 ft in the temporary entrance for test waves from N, NNW, and NW, respectively. The 2.0-ft wave-height criterion was exceeded only by test waves from NW for both the +1 and +4 ft swl's. Typical wave patterns obtained for Plan III-A are shown in Photos 15-18.

30. Results of wave-height tests conducted for Plan III-B with the +1 ft swl and Plans III-B and III-C with the +4 ft swl for test waves from NW are presented in Table 6. The maximum wave height obtained in the temporary entrance for Plan III-B for the +1 ft swl was 1.1 ft. For the +4 ft swl, maximum wave heights in the temporary entrance were 2.0 and 3.3 ft for Plans III-B and III-C, respectively. The established 2.0-ft wave-height criterion was satisfied by Plan III-B. Typical wave patterns obtained for Plan III-B are shown in Photos 19 and 20.

31. Results of wave-height measurements with Plan II installed in the model are presented in Table 7. Maximum wave heights obtained in the temporary entrance (gages 1-3) for the +1 ft swl were 4.4, 3.9, and 3.5 ft for test waves from N, NNW, and NW, respectively. For the +4 ft swl, maximum wave heights in the temporary entrance were 3.5, 5.6, and 6.3 ft for test waves from N, NNW, and NW, respectively. The established 2.0-ft wave-height criterion at the entrance was exceeded for test waves from each direction for both swl's. Typical wave patterns obtained for Plan II are shown in Photos 21-24.

32. Wave-height data obtained for Plan II-A are presented in Table 8. For the +1 ft swl, maximum wave heights in the temporary entrance were 1.6, 1.3, and 3.6 ft for test waves from N, NNW, and NW, respectively. For the +4 ft swl, maximum wave heights were 2.1, 1.8, and 5.7 ft in the temporary entrance for test waves from N, NNW, and NW, respectively. The 2.0-ft wave-height criterion was exceeded by test waves from N for the +4 ft swl and test waves from NW for both the +1 and +4 ft swl's. Wave patterns obtained for Plan II-A are presented in Photos 25-28.

33. Results of wave-height tests conducted for Plan II-C with the +1 ft swl and Plans II-B and II-C with the +4 ft swl for test waves

from N are presented in Table 9. The maximum wave height obtained in the temporary entrance for Plan II-C for the +1 ft swl was 1.4 ft. For the +4 ft swl, maximum wave heights in the temporary entrance were 1.3 and 1.8 ft for Plans II-B and II-C, respectively. Typical wave patterns obtained for Plan II-C are shown in Photos 29-30.

34. Wave-height data obtained for Plan II-D with the +1 ft swl and Plans II-D and II-E with the +4 ft swl for test waves from NW are presented in Table 10. The maximum wave height obtained in the temporary entrance for Plan II-D for the +1 ft swl was 1.7 ft. For the +4 ft swl, maximum wave heights in the temporary entrance were 1.9 and 2.6 ft for Plans II-D and II-E, respectively. Typical wave patterns obtained for Plan II-D are shown in Photos 31-32.

Discussion of test results

35. Test results for Construction Sequence Phases II, III, and IV with no breakwater protection (Plans II, III, and IV) revealed rough and turbulent wave conditions in the respective temporary entrances with wave heights up to 6.3 ft for Phase II, 6.2 ft for Phase III, and 6.1 ft for Phase IV.

36. The installation of the 2,150-ft-long sheet-pile breakwater lakeward of the lock site (Plans II-A, III-A, and IV-A) significantly reduced wave heights in the temporary entrances of Phases II, III and IV for test waves from N and NNW. In only one instance did wave heights exceed the established criterion of 2.0 ft. For 4-sec, 5-ft test waves from N with the +4 ft swl, the maximum wave height in the temporary entrance of Phase II (Plan II-A) was 2.1 ft. A 288-ft-long floating breakwater installed northeast of the proposed lock site at the New Orleans Lakefront Airport (Plan II-C) reduced this 2.1-ft wave height to 1.8 ft.

37. Wave heights in the temporary entrances of Plans II-A, III-A, and IV-A exceeded the 2.0-ft criterion for test waves from the NW for both the +1 and +4 ft swl's. A 1,344-ft-long floating breakwater installed NW of the proposed lock site (Plans II-D, III-B, and IV-C) reduced wave heights in the temporary entrances of Phases II, III, and IV to less than 2.0 ft.

38. It should be noted that the floating breakwaters tested in the model provided 50 percent attenuation for 4-sec waves approaching from a direction perpendicular to the structure. Lengths of the structures possibly may be reduced if floating breakwaters that would provide greater than 50 percent attenuation are used.

39. Visual observations, wave pattern photographs, and model movie footage revealed substantial overtopping of the cofferdams (particularly at the +4 ft swl) for Construction Sequence Phases II, III, and IV with no breakwater protection (Plans II, III, and IV). The 2,150-ft-long sheet-pile breakwater of Plans II-A, III-A, and IV-A substantially reduced overtopping of the cofferdams for test waves from N and NNW. The addition of the 1,344-ft-long floating structure of Plans II-D, III-B, and IV-C substantially reduced overtopping of the cofferdams for test waves from NW.

PART V: CONCLUSIONS

40. Based on the results of the hydraulic model investigation reported herein, it is concluded that:

- a. With no breakwater protection, the temporary entrances of Construction Sequence Phases II, III, and IV (Plans II, III, and IV) into the IHNC were characterized by rough and turbulent conditions (wave heights in excess of 6 ft) for the waves tested, and the cofferdams for each Construction Sequence Phase were significantly overtopped.
- b. Installation of a 2,150-ft-long sheet-pile breakwater lakeward of the proposed lock site (Plans II-A, III-A, and IV-A) will reduce wave heights in the respective temporary entrances of Phases II, III, and IV to within the established 2.0-ft wave-height criterion for test waves from the following directions:

  Construction Sequence Phase II - NNW
  Construction Sequence Phase III - N, NNW
  Construction Sequence Phase IV - N, NNW
- c. In addition to the 2,150-ft-long sheet-pile breakwater of Plan II-A, a 288-ft-long floating breakwater (Plan II-C) installed NE of the proposed lock site is required to meet the established wave-height criterion in the temporary entrance of Construction Sequence Phase II for test waves from N.
- d. In addition to the 2,150-ft-long sheet-pile breakwater of Plans II-A, III-A, and IV-A, a 1,344-ft-long floating breakwater (Plans II-D, III-B, and IV-C) installed NW of the proposed lock site is required to meet the established wave-height criterion in the respective temporary entrances of Construction Sequence Phases II, III, and IV for test waves from NW.
- e. The 2,150-ft-long sheet-pile breakwater of Plans II-A, III-A, and IV-A, in conjunction with the 1,344-ft-long floating breakwater (Plans II-D, III-B, and IV-C) will substantially reduce overtopping of the cofferdams for Construction Sequence Phases II, III, and IV for test waves from all directions.

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TABLE 1

WAVE HEIGHTS FOR PLAN IV

Test Wave Direction	Test Wave Period, sec	Test Wave Height, ft	Wave Height, ft: Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
					SWL = +1 FT							
N	3.0	2.0	0.6	0.6	1.2	1.2	0.9	1.6	1.1	2.3	3.3	3.0
		4.0	1.6	1.8	2.5	2.7	3.7	4.5	3.6	4.0	4.7	5.2
	4.0	5.0	1.8	1.2	3.6	5.5	3.8	5.1	4.6	3.8	4.7	5.0
NNW	3.0	2.0	1.8	2.9	3.2	1.3	4.1	3.2	2.1	2.7	2.2	2.6
		4.0	1.8	2.5	3.3	2.5	4.5	4.1	3.3	3.1	3.3	3.2
	4.0	4.0	3.8	2.7	5.0	2.0	5.8	5.8	5.0	4.7	2.6	3.7
NW	3.0	2.0	2.0	1.5	1.7	1.9	2.4	2.6	1.7	0.8	1.2	2.4
		4.0	2.6	2.4	2.8	3.6	4.6	5.0	4.6	2.5	2.6	2.6
	4.0	4.0	4.4	3.3	2.0	4.3	5.4	4.6	5.4	3.1	3.7	2.6
					SWL = +4 FT							
N	3.0	2.0	0.9	0.8	1.1	1.5	1.3	0.7	1.2	2.2	3.0	3.3
		4.0	1.7	1.8	2.4	2.7	3.0	3.0	2.8	4.2	5.1	5.4
	4.0	5.0	3.2	2.0	2.9	4.5	3.5	3.8	3.2	3.9	4.9	6.6
NNW	3.0	2.0	1.8	2.4	2.7	3.4	4.2	3.4	3.4	1.6	1.9	1.5
		4.0	2.3	3.0	3.1	3.6	4.7	4.5	3.5	2.9	4.0	3.7
	4.0	4.0	3.8	4.2	5.6	2.3	6.5	4.4	3.1	2.6	7.3	2.7
NW	3.0	2.0	2.3	2.7	2.8	3.4	2.1	2.8	1.3	1.6	1.6	2.0
		4.0	2.7	3.0	2.6	4.3	4.7	5.4	4.2	2.9	3.3	3.7
	4.0	4.0	6.1	3.2	3.5	4.0	4.3	6.2	6.3	3.9	2.9	3.1

TABLE 2

WAVE HEIGHTS FOR PLAN IVA

Test Wave Direction	Test Wave Period, sec	Test Wave Height, ft	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
						SWL = +1 FT						
N	3.0	2.0	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.4	0.4	0.2
		4.0	0.3	0.3	0.3	0.3	0.5	0.5	0.7	1.7	2.1	1.5
	4.0	5.0	0.4	0.6	0.7	0.5	0.6	1.0	0.8	2.2	2.3	1.8
NNW	3.0	2.0	0.5	0.6	0.7	0.9	0.6	0.9	0.5	0.6	0.4	0.5
		4.0	0.6	0.8	0.8	1.1	1.1	1.3	1.0	1.0	1.5	1.3
	4.0	4.0	1.0	1.0	1.0	1.4	0.9	1.8	1.7	2.4	2.3	2.4
NW	3.0	2.0	1.2	2.0	1.3	1.7	0.9	0.6	0.7	0.3	0.4	0.2
		4.0	2.3	2.1	2.5	3.4	3.1	3.2	3.0	1.8	0.8	1.2
	4.0	4.0	2.6	2.9	2.0	3.0	3.7	3.0	3.1	0.4	0.4	0.3
						SWL = +4 FT						
N	3.0	2.0	0.1	0.3	0.3	0.4	0.4	0.4	0.4	0.6	0.7	0.7
		4.0	0.8	0.7	0.8	1.1	1.1	0.9	0.9	2.4	2.4	1.8
	4.0	5.0	1.4	1.8	1.4	1.1	1.5	1.8	1.2	2.0	2.7	3.4
NNW	3.0	2.0	0.7	0.8	1.1	1.0	1.0	1.1	0.7	0.3	1.0	0.8
		4.0	1.0	1.1	1.4	1.5	1.8	1.7	1.3	1.4	2.0	1.7
	4.0	4.0	0.7	0.5	0.8	1.3	2.1	1.8	1.1	3.0	1.4	2.0
NW	3.0	2.0	1.4	1.1	1.5	1.1	1.2	1.0	0.9	0.4	0.5	0.9
		4.0	2.7	2.8	3.0	3.9	4.0	3.5	3.1	1.9	1.9	2.7
	4.0	4.0	4.1	3.3	4.3	6.3	4.4	6.4	3.5	0.9	0.7	1.1

TABLE 3

WAVE HEIGHTS FOR PLANS IV-B - IV-D FOR

TEST WAVES FROM NORTHWEST

PLAN	TEST WAVE PERIOD SEC	TEST WAVE HEIGHT FT	WAVE HEIGHT, FT GAGE 1	GAGE 2	GAGE 3	GAGE 4	GAGE 5	GAGE 6	GAGE 7	GAGE 8	GAGE 9	GAGE 10
						SWL = +1 FT						
IV-B	3.0	2.0	0.7	0.8	0.6	0.8	1.0	1.0	0.8	0.3	0.4	0.4
		4.0	1.0	1.0	1.3	1.6	2.2	2.1	2.8	2.2	1.4	1.9
	4.0	4.0	1.8	1.9	0.8	1.2	2.0	2.8	2.9	1.0	0.6	0.2
IV-C	3.0	2.0	0.5	0.5	0.6	0.5	0.8	0.7	0.9	0.4	0.4	0.4
		4.0	1.0	0.8	1.0	1.5	1.6	1.5	2.2	1.5	0.9	2.1
	4.0	4.0	0.7	0.5	0.6	1.0	2.1	1.4	2.3	0.6	0.6	0.4
						SWL = +4 FT						
IV-B	3.0	2.0	0.4	0.7	1.0	1.2	1.3	1.5	1.6	0.4	0.7	0.8
		4.0	1.2	1.4	1.4	1.7	2.5	2.3	2.9	2.0	1.9	1.8
	4.0	4.0	2.1	2.3	1.5	1.7	3.0	2.6	3.9	0.8	0.9	1.1
IV-C	3.0	2.0	0.5	0.5	0.7	0.8	0.7	0.6	0.9	0.4	0.7	1.0
		4.0	0.8	1.0	1.0	1.7	1.6	1.6	2.6	2.2	2.1	2.0
	4.0	4.0	1.4	1.8	0.8	2.0	2.2	3.2	3.2	0.7	0.9	1.0
IV-D		4.0	1.2	2.3	0.8	1.6	2.1	2.2	2.7	0.8	0.8	0.8

TABLE 4

WAVE HEIGHTS FOR PLAN III

Test Wave Direction	Test Wave Period, Sec	Test Wave Height, Ft	Wave Height, Ft: Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
						SWL = +1 FT						
N	3.0	2.0	0.4	0.2	0.8	2.0	0.5	0.5	2.2	1.1	1.9	1.7
		4.0	0.8	0.8	1.3	2.9	0.7	4.8	4.3	3.6	4.8	2.9
	4.0	5.0	1.0	1.4	2.3	4.6	1.8	7.0	4.0	6.6	4.7	4.9
NNW	3.0	2.0	0.8	1.2	1.9	2.3	0.7	4.1	1.6	2.3	2.5	3.6
		4.0	1.1	1.1	2.0	3.5	0.8	4.4	4.8	4.1	4.3	4.2
	4.0	4.0	0.7	1.6	3.0	3.7	1.0	6.1	6.8	4.6	4.5	5.9
NW	3.0	2.0	1.2	0.9	0.8	1.9	0.9	4.4	2.1	2.8	2.1	3.8
		4.0	1.7	2.3	2.7	3.5	1.3	4.2	5.3	3.9	3.7	3.3
	4.0	4.0	2.4	2.7	1.4	2.2	1.3	6.0	6.6	3.1	6.7	4.3
						SWL = +4 FT						
N	3.0	2.0	1.0	1.2	1.1	3.1	1.1	1.8	4.1	1.3	2.9	1.6
		4.0	1.1	1.1	1.8	3.5	0.8	4.4	3.9	4.7	4.2	3.2
	4.0	1.7	1.0	1.6	4.1	6.2	2.2	8.5	3.1	7.5	6.0	3.5
NNW	3.0	2.0	0.7	0.9	1.8	2.7	0.7	2.9	2.0	3.0	3.5	1.1
		4.0	1.2	1.3	2.4	4.0	0.8	5.1	5.4	4.6	4.5	4.1
	4.0	4.0	0.8	1.2	2.3	5.4	1.0	8.0	9.4	8.1	6.0	4.7
NW	3.0	2.0	1.3	1.8	1.6	2.1	0.7	2.4	2.5	2.6	1.2	2.5
		4.0	2.7	3.4	3.5	4.2	1.7	4.7	5.5	4.3	4.3	4.2
	4.0	4.0	1.6	3.1	3.3	4.2	1.4	4.5	6.7	2.8	4.4	4.7

TABLE 5

WAVE HEIGHTS FOR PLAN IIIA

Test Wave			Wave Height, ft									
Direction	Period sec	Height ft	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
						SWL = +1 FT						
N	3.0	2.0	<0.1	0.1	0.1	0.2	<0.1	0.3	0.3	0.8	1.6	1.3
		4.0	0.2	0.3	0.3	0.7	0.2	1.3	2.0	2.4	3.6	2.7
	4.0	5.0	0.4	0.4	0.6	1.1	0.4	1.2	1.6	3.1	3.4	4.1
NNW	3.0	2.0	0.5	0.6	0.8	1.1	0.3	1.0	1.1	0.8	1.2	0.6
		4.0	0.5	0.6	1.1	1.3	0.5	2.3	2.0	1.8	2.5	1.6
	4.0	4.0	0.9	0.9	0.7	1.4	0.3	2.1	2.3	2.9	3.9	3.7
NW	3.0	2.0	1.1	1.0	0.8	1.4	0.7	2.8	0.9	2.4	1.1	0.8
		4.0	1.8	1.9	2.4	2.9	1.2	3.9	3.9	3.7	1.6	1.7
	4.0	4.0	1.9	1.5	1.3	1.4	0.9	4.6	2.9	1.0	2.2	1.3
						SWL = +4 FT						
N	3.0	2.0	0.2	0.2	0.3	0.3	0.2	0.4	0.7	0.7	1.3	2.2
		4.0	0.4	0.5	0.6	1.2	0.4	2.3	2.8	2.6	3.5	2.9
	4.0	5.0	0.9	0.8	1.3	1.4	0.7	2.6	2.5	2.7	2.8	2.2
NNW	3.0	2.0	0.4	0.6	0.9	1.1	0.4	1.1	0.8	1.0	0.7	1.3
		4.0	0.9	1.0	1.3	1.8	0.7	1.8	2.0	2.5	2.5	2.3
	4.0	4.0	0.8	1.4	1.4	1.4	0.6	1.9	3.7	3.6	2.2	2.5
NW	3.0	2.0	1.3	1.4	1.3	0.9	0.4	2.6	1.6	2.5	1.2	1.3
		4.0	2.1	2.1	2.8	3.1	1.2	3.6	4.6	2.9	2.1	2.3
	4.0	4.0	2.3	2.6	2.6	3.8	0.8	4.4	4.1	1.1	2.0	2.1

TABLE 6

WAVE HEIGHTS FOR PLANS III-B - III-C FOR

TEST WAVES FROM NORTHWEST

PLAN	TEST WAVE PERIOD SEC	TEST WAVE HEIGHT FT	WAVE HEIGHT, FT GAGE 1	GAGE 2	GAGE 3	GAGE 4	GAGE 5	GAGE 6	GAGE 7	GAGE 8	GAGE 9	GAGE 10
						SWL = +1 FT						
III-B	3.0	2.0	0.2	0.2	0.4	0.4	0.1	0.5	0.8	1.0	0.8	0.5
		4.0	0.5	0.6	0.8	1.0	0.4	1.4	2.1	1.7	1.0	1.9
	4.0	4.0	0.3	0.7	1.1	0.6	0.7	1.6	2.6	0.4	1.5	1.3
						SWL = +4 FT						
III-B	3.0	2.0	0.4	0.4	0.4	0.5	0.2	0.8	0.5	1.2	0.9	1.9
		4.0	0.7	0.8	1.0	1.4	0.5	1.3	2.9	2.5	1.9	3.9
	4.0	4.0	0.9	1.0	0.7	2.0	1.5	3.0	3.6	2.0	2.6	2.9
III-C		4.0	0.7	0.5	1.6	3.3	1.0	2.2	4.6	1.8	1.3	2.4

TABLE 7

WAVE HEIGHTS FOR PLAN II

Test Wave Direction	Test Wave Period, sec	Test Wave Height, ft	Wave Height, ft: Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
						SWL = +1 FT						
N	3.0	2.0	1.2	1.1	1.7	1.2	0.6	1.2	2.6	2.2	1.6	2.8
		4.0	2.0	2.3	2.0	2.8	2.4	2.3	3.4	6.9	5.1	4.7
	4.0	5.0	1.8	4.2	4.4	2.7	2.2	2.6	5.4	6.4	4.5	3.4
NNW	3.0	2.0	1.6	3.4	2.0	1.5	2.2	4.7	2.8	3.9	2.4	2.8
		4.0	3.0	3.6	3.0	3.1	3.5	4.1	3.3	5.4	5.8	4.2
	4.0	4.0	2.8	3.8	3.9	4.8	2.7	4.2	4.9	4.3	6.6	4.3
NW	3.0	2.0	1.4	1.6	2.0	2.7	3.6	2.6	1.8	4.2	1.3	2.4
		4.0	3.3	2.7	3.2	4.6	3.4	2.4	4.3	5.3	5.7	3.5
	4.0	4.0	2.6	2.8	3.5	3.5	7.2	4.3	4.9	3.1	3.1	4.3
						SWL = +4 FT						
N	3.0	2.0	2.7	1.8	2.4	1.9	1.7	1.2	1.8	2.3	1.6	3.7
		4.0	2.8	2.1	3.0	2.9	2.7	2.4	3.2	5.9	5.1	3.7
	4.0	5.0	2.6	3.5	3.5	3.1	3.9	1.9	6.2	7.0	7.0	3.5
NNW	3.0	2.0	1.8	2.7	3.5	1.8	2.5	3.6	3.6	3.8	2.6	3.4
		4.0	2.8	3.6	3.2	3.2	3.2	3.6	3.9	5.3	6.1	4.1
	4.0	4.0	5.2	5.6	2.6	3.5	7.4	2.3	4.3	3.6	6.6	2.8
NW	3.0	2.0	3.4	2.2	4.2	3.1	3.5	2.8	2.6	4.2	3.1	2.1
		4.0	3.9	4.0	4.7	3.6	3.6	2.3	4.7	4.6	5.3	3.7
	4.0	4.0	6.3	2.0	3.3	2.5	2.4	1.8	5.1	4.9	5.7	5.2

TABLE 8

WAVE HEIGHTS FOR PLAN II-A

Test Wave Direction	Test Wave Period Sec	Test Wave Height Ft	Wave Height, Ft Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
			SWL = +1 FT									
N	3.0	2.0	0.6	0.3	0.6	0.5	0.5	0.9	0.3	0.7	0.7	1.7
		4.0	1.4	1.3	1.6	1.8	1.6	1.7	0.9	1.6	2.1	2.7
	4.0	5.0	0.9	1.3	1.1	1.5	1.9	1.4	1.5	1.4	2.2	2.5
NNW	3.0	2.0	0.5	0.8	0.7	1.2	0.8	1.2	0.7	1.2	1.6	1.7
		4.0	1.0	1.3	1.3	1.3	1.7	1.6	1.2	1.4	1.6	2.3
	4.0	4.0	1.0	1.0	1.2	1.5	1.7	1.7	1.1	1.3	2.0	3.8
NW	3.0	2.0	1.5	2.5	2.9	1.5	2.2	1.3	1.4	1.8	1.3	0.7
		4.0	2.4	2.9	3.6	3.4	2.8	1.9	4.0	2.9	3.5	1.2
	4.0	4.0	2.7	2.3	2.5	1.1	1.5	1.0	3.7	1.7	1.9	1.8
			SWL = +4 FT									
N	3.0	2.0	0.4	0.3	0.4	0.5	0.5	1.2	0.5	0.7	0.8	1.9
		4.0	1.7	1.2	1.7	1.6	1.8	2.0	1.7	1.9	2.4	3.7
	4.0	5.0	2.0	1.8	2.1	2.1	2.3	1.1	3.1	1.5	2.8	2.4
NNW	3.0	2.0	0.8	0.8	1.5	1.0	1.3	1.3	0.8	1.5	1.7	1.1
		4.0	1.5	1.3	1.8	1.5	2.4	2.4	1.7	2.1	2.3	3.4
	4.0	4.0	1.5	1.0	1.7	1.3	2.9	1.5	1.3	1.9	2.8	5.3
NW	3.0	2.0	2.0	1.7	2.0	2.7	2.4	2.5	1.9	1.2	2.5	0.7
		4.0	3.5	3.0	3.3	4.0	3.8	2.4	5.3	3.8	4.2	2.2
	4.0	4.0	2.8	5.7	4.3	3.0	2.9	2.0	3.8	1.3	1.0	1.5

TABLE 9

WAVE HEIGHTS FOR PLANS II-B AND II-C

FOR TEST WAVES FROM NORTH

	Test Wave		Wave Height, ft									
Plan	Period sec	Height ft	Gage 1	Gage 2	Gage 3	Gage 4	Gage 5	Gage 6	Gage 7	Gage 8	Gage 9	Gage 10
					SWL = +1 FT							
II-C	3.0	2.0	0.7	0.5	0.7	0.5	0.5	1.0	0.3	0.9	1.3	1.4
		4.0	1.4	1.3	1.1	1.6	1.3	1.6	0.7	1.6	1.5	2.7
	4.0	5.0	0.5	0.7	0.9	1.1	1.4	1.1	1.5	1.5	1.8	2.2
					SWL = +4 FT							
II-B		5.0	0.8	1.3	1.1	1.5	1.3	1.5	2.5	1.2	2.6	1.9
II-C	3.0	2.0	1.0	0.6	0.9	0.6	0.7	1.3	0.5	0.7	1.4	2.1
		4.0	1.4	1.3	1.6	1.6	1.5	1.6	1.2	2.0	2.8	3.6
	4.0	5.0	0.9	1.8	1.7	1.8	2.3	1.6	2.1	1.4	2.0	2.5

TABLE 10

WAVE HEIGHTS FOR PLANS II-D AND II-E

FOR TEST WAVES FROM NORTHWEST

PLAN	TEST WAVE PERIOD SEC	TEST WAVE HEIGHT FT	WAVE HEIGHT, FT GAGE 1	GAGE 2	GAGE 3	GAGE 4	GAGE 5	GAGE 6	GAGE 7	GAGE 8	GAGE 9	GAGE 10
					SWL = +1 FT							
II-D	3.0	2.0	0.7	0.6	0.7	0.8	0.7	0.3	1.6	1.4	2.0	0.5
		4.0	0.9	1.0	1.7	1.6	1.4	1.3	2.6	1.8	2.4	1.3
	4.0	4.0	1.5	0.5	1.0	1.3	1.2	0.4	3.0	0.9	1.6	1.3
					SWL = +4 FT							
	3.0	2.0	0.6	0.5	0.9	0.8	0.4	0.4	1.1	1.5	2.2	0.7
		4.0	1.2	1.4	1.8	2.1	1.6	1.5	2.6	2.4	2.7	1.9
	4.0	4.0	1.4	1.6	1.9	2.7	1.6	0.5	2.0	1.1	2.1	0.9
II-E		4.0	2.6	2.1	1.7	1.9	1.4	1.6	5.6	1.4	1.8	1.6

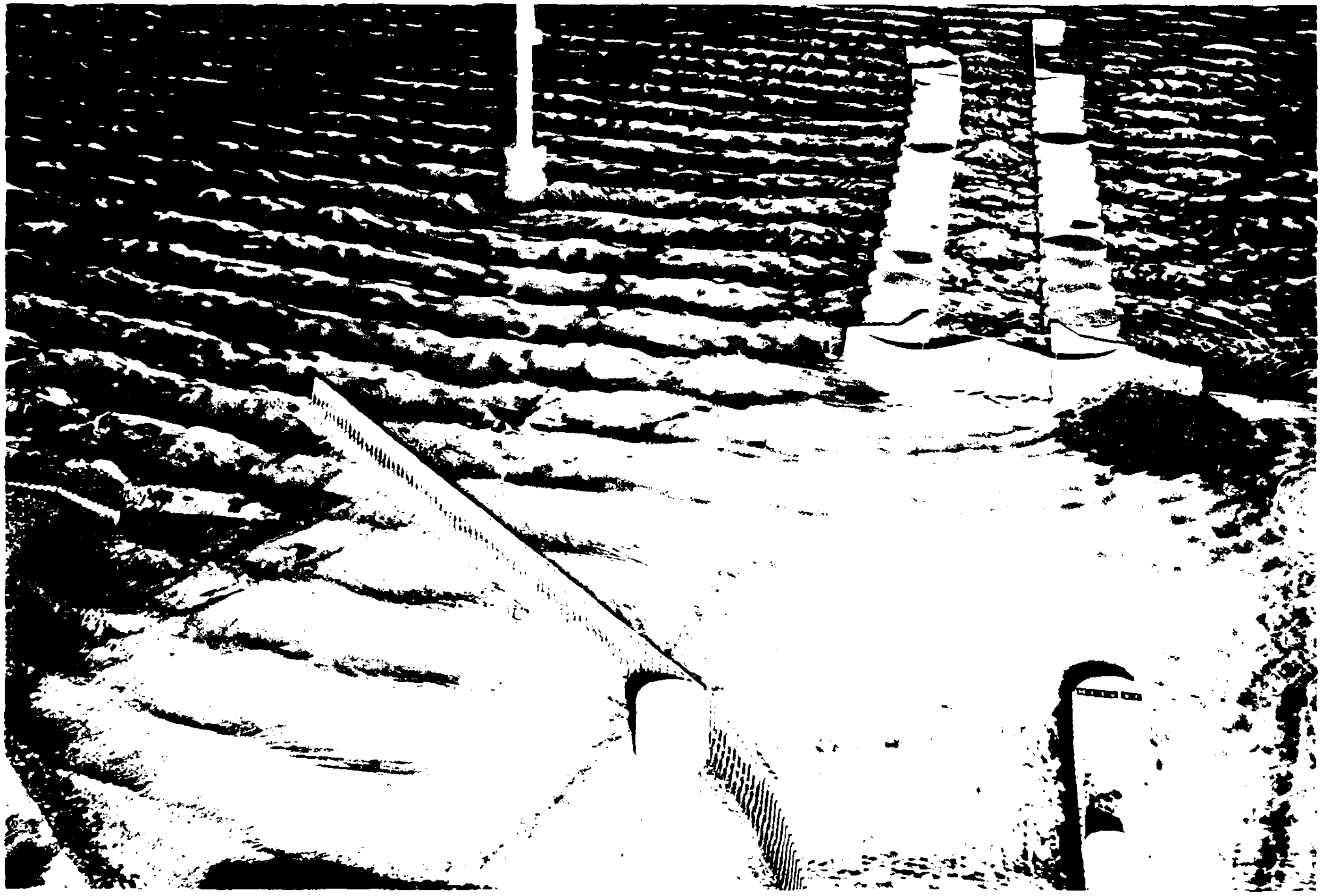


Photo 1. Typical wave patterns at temporary entrance for Plan IV; 4-sec, 5-ft waves from N; swl = +1 ft msl

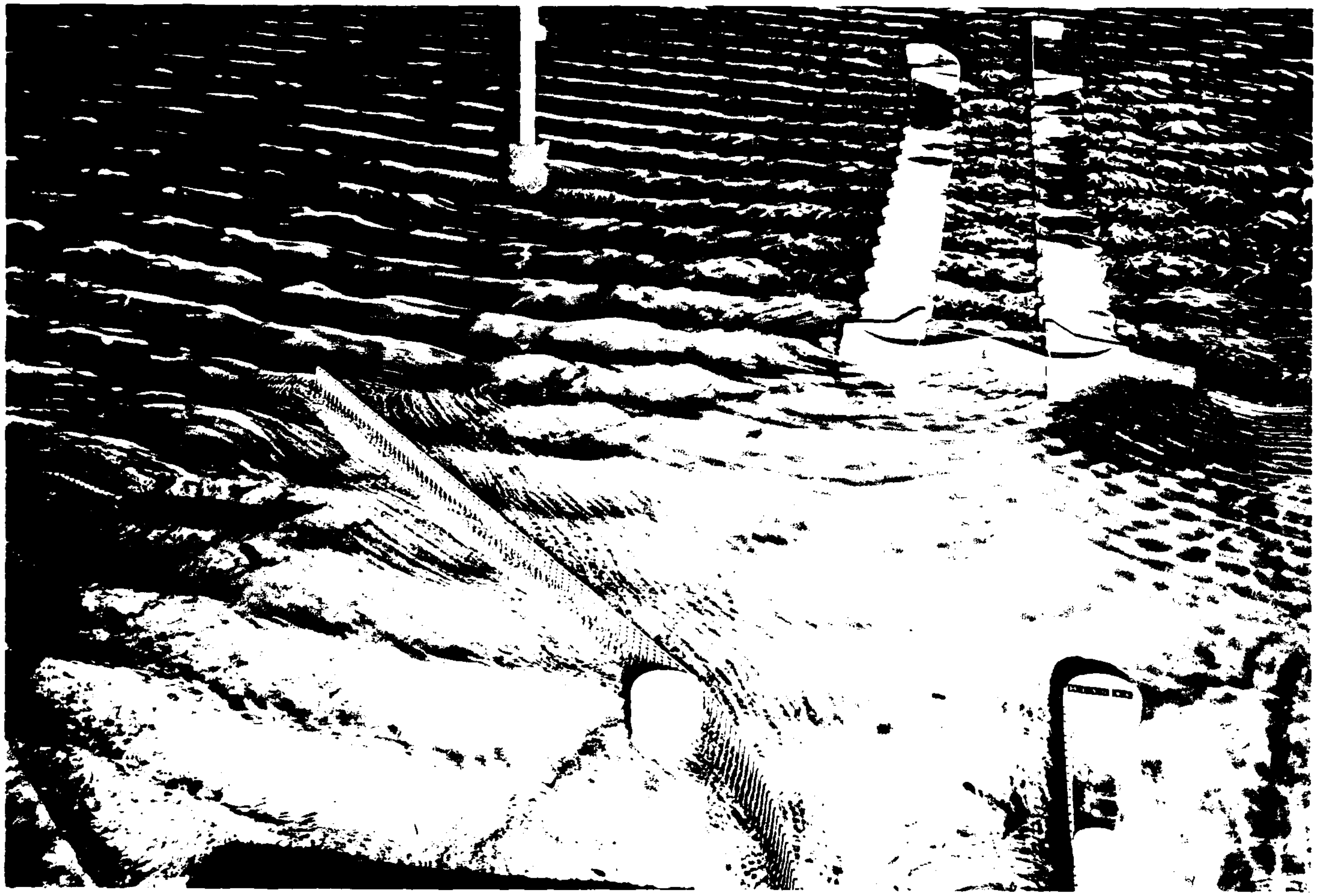


Photo 2. Typical wave patterns at temporary entrance for Plan IV; 4-sec, 5-ft waves from N; swl = +4 ft msl

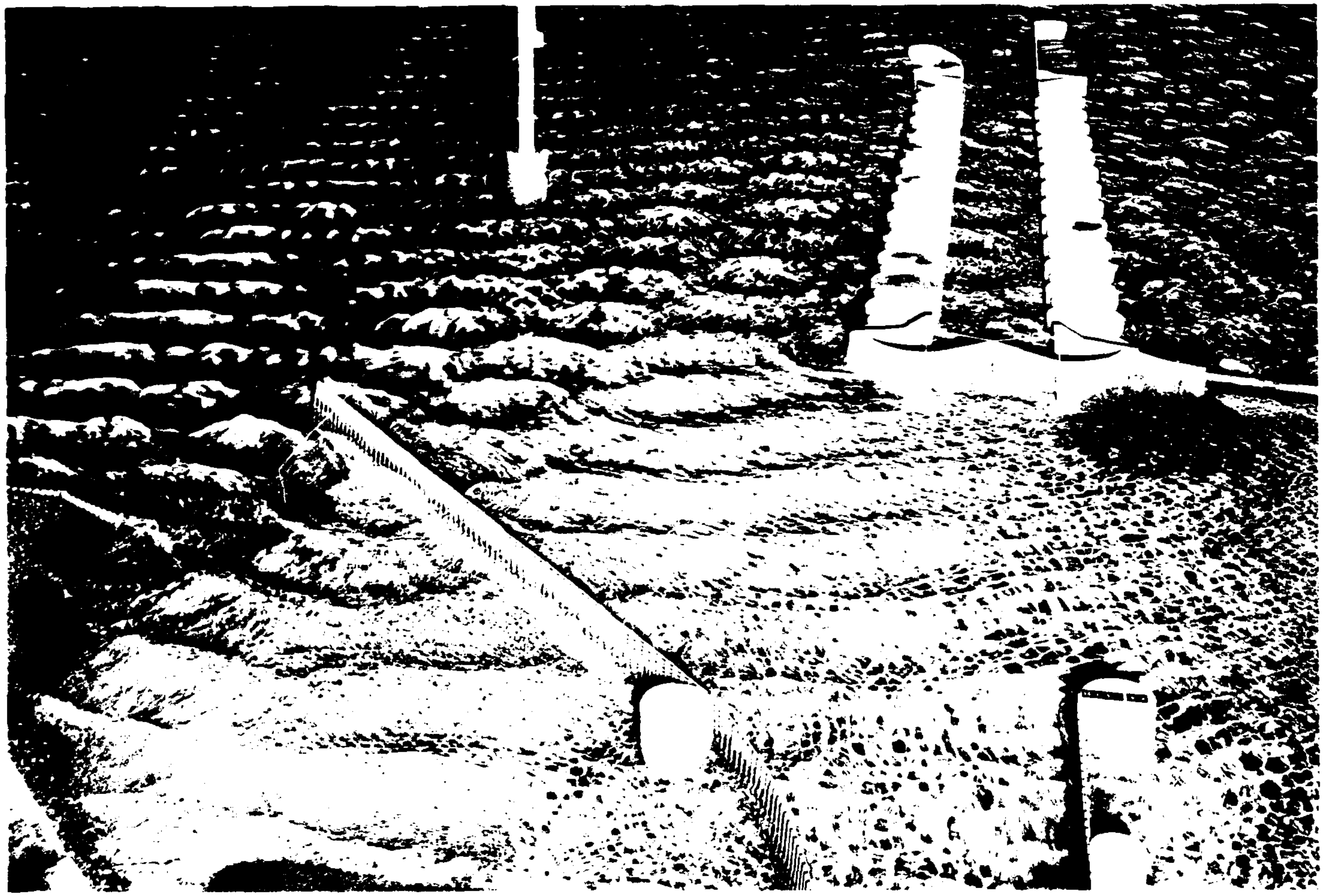


Photo 3. Typical wave patterns at temporary entrance for Plan IV; 4-sec, 4-ft waves from NW; swl = +1 ft msl

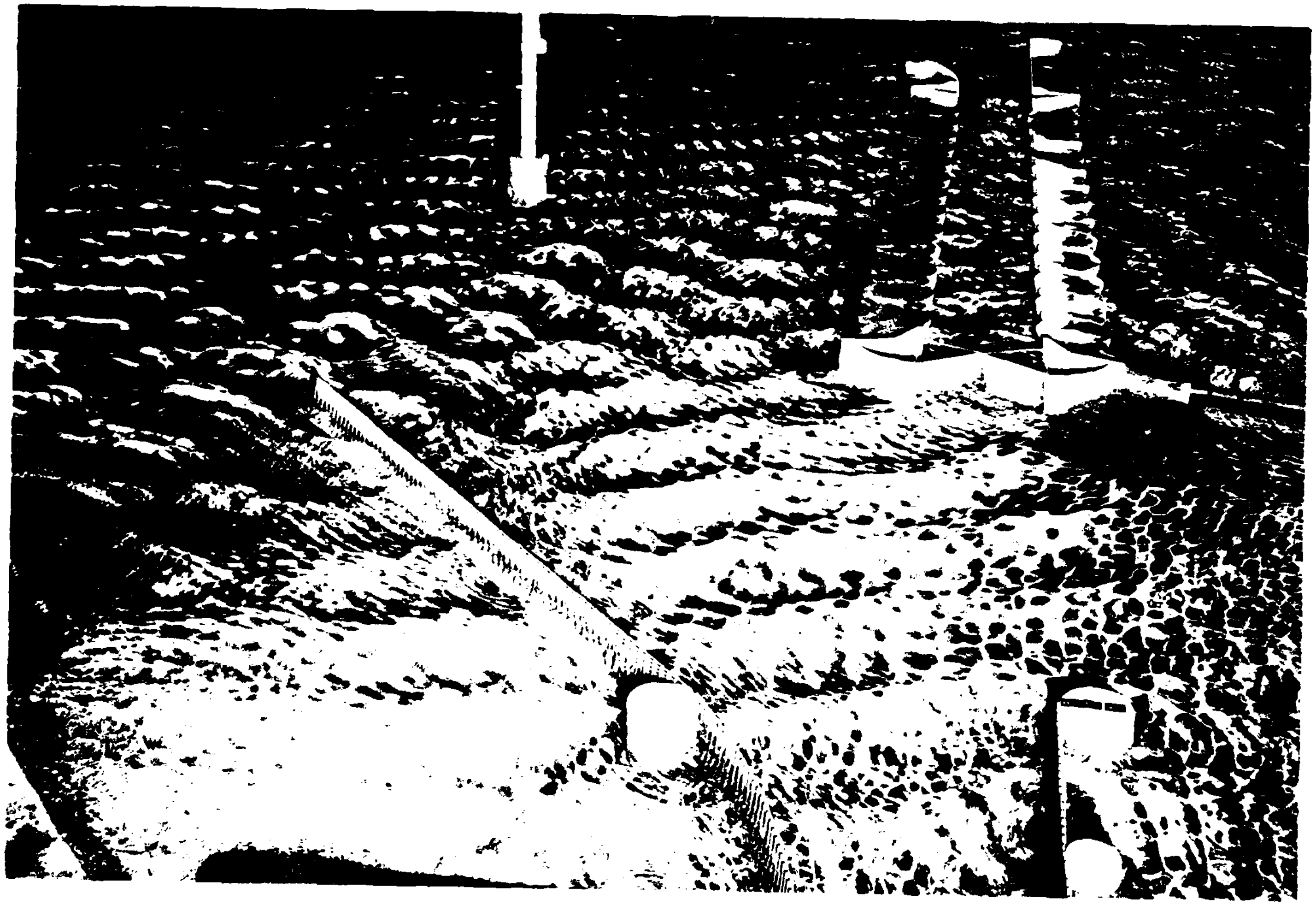


Photo 4. Typical wave patterns at temporary entrance for Plan IV; 4-sec, 4-ft waves from NW; swl = +4 ft msl

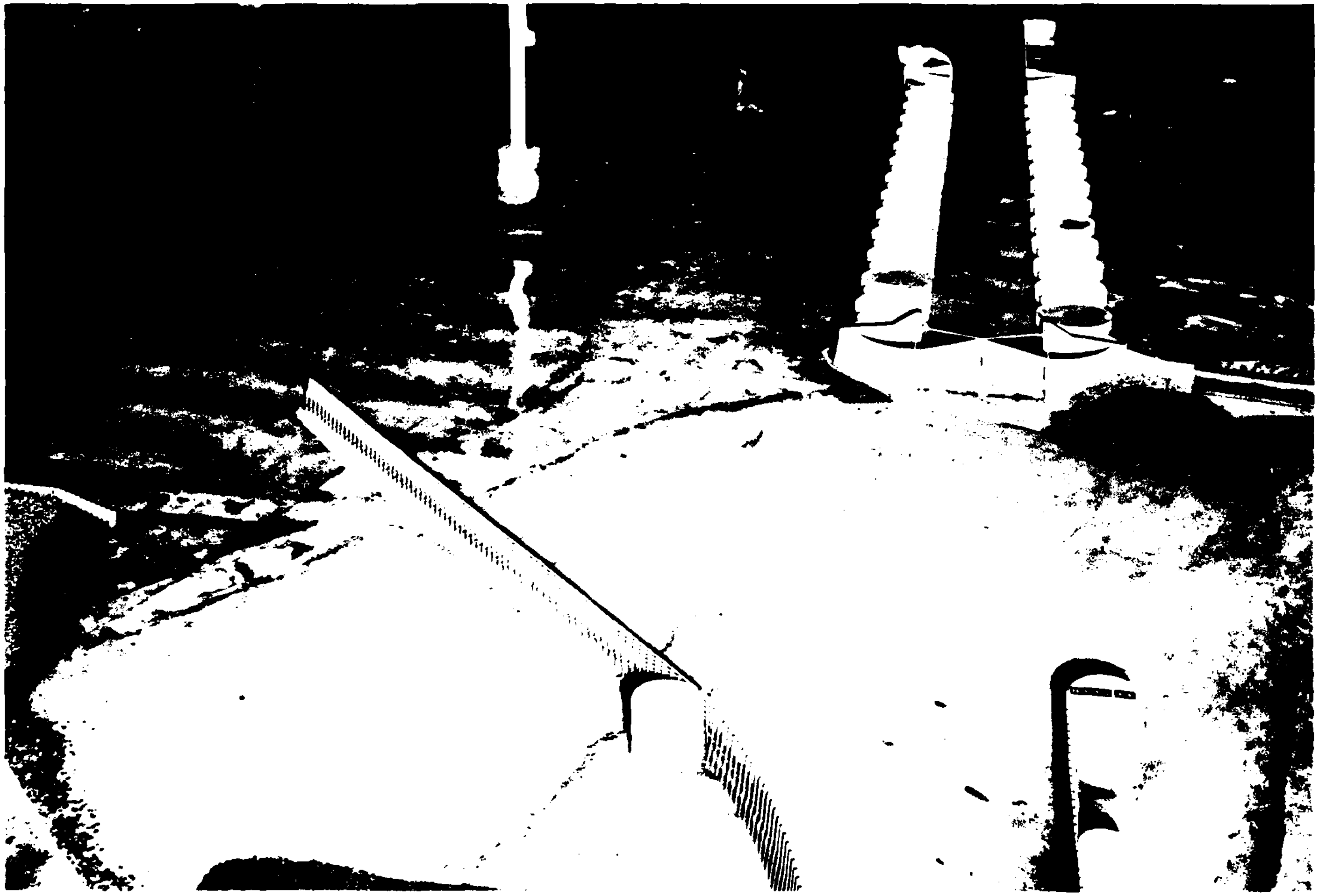


Photo 5. Typical wave patterns at temporary entrance for Plan IV-A; 4-sec, 5-ft waves from N; swl = +1 ft msl

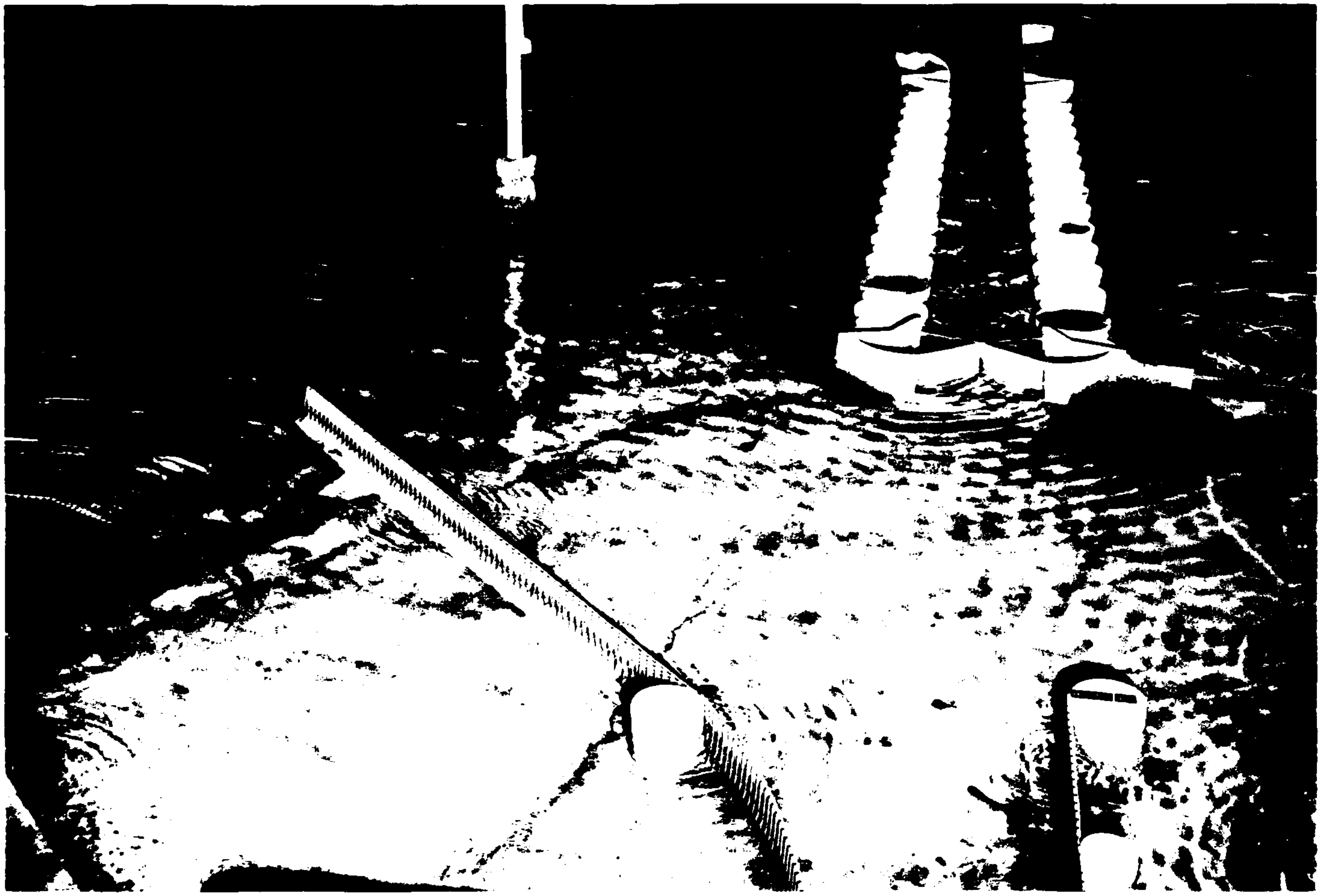


Photo 6. Typical wave patterns at temporary entrance for Plan IV-A; 4-sec, 5-ft waves from N; swl = +4 ft msl

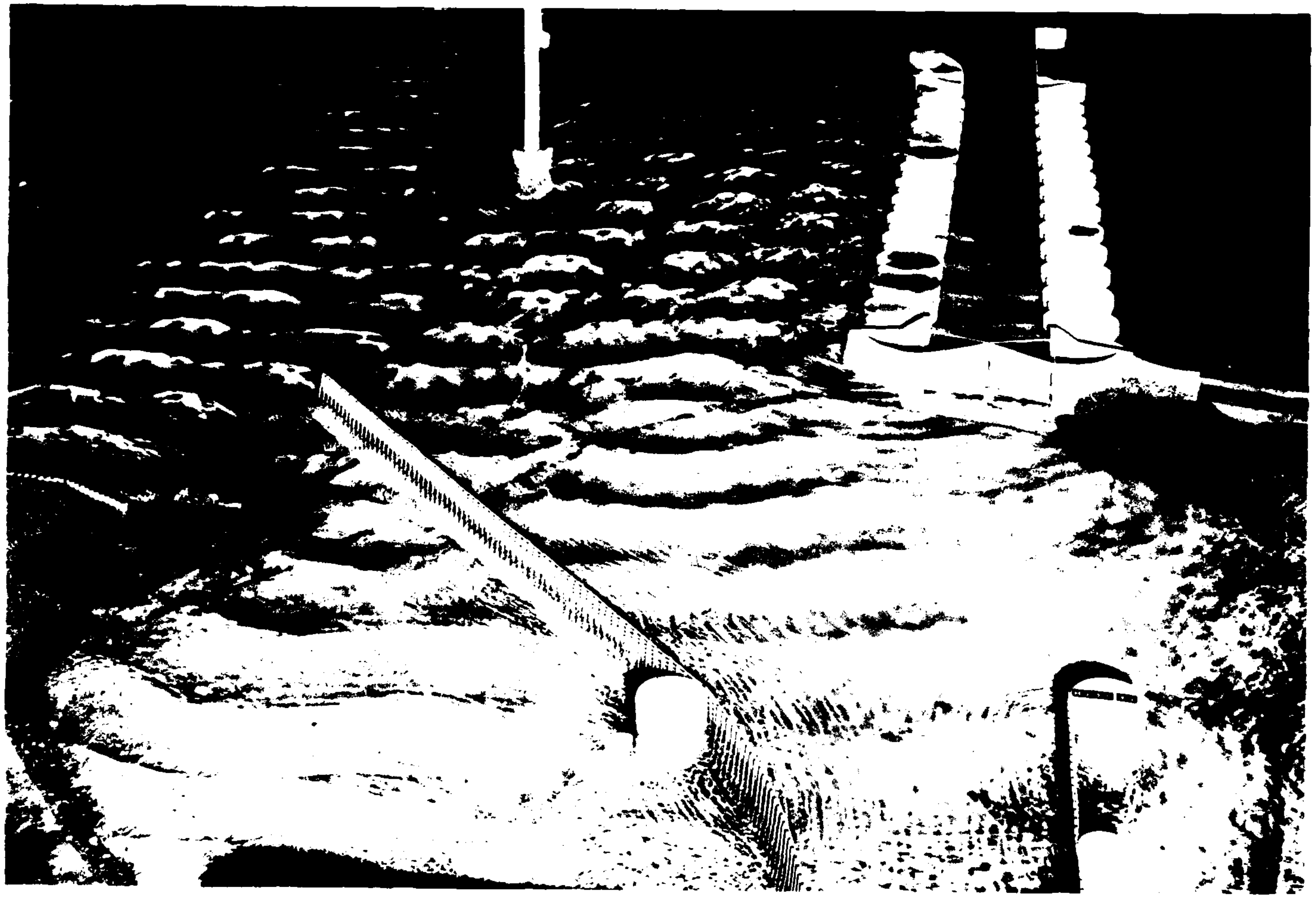


Photo 7. Typical wave patterns at temporary entrance for Plan IV-A; 4-sec, 4-ft waves from NW; swl = +1 ft msl

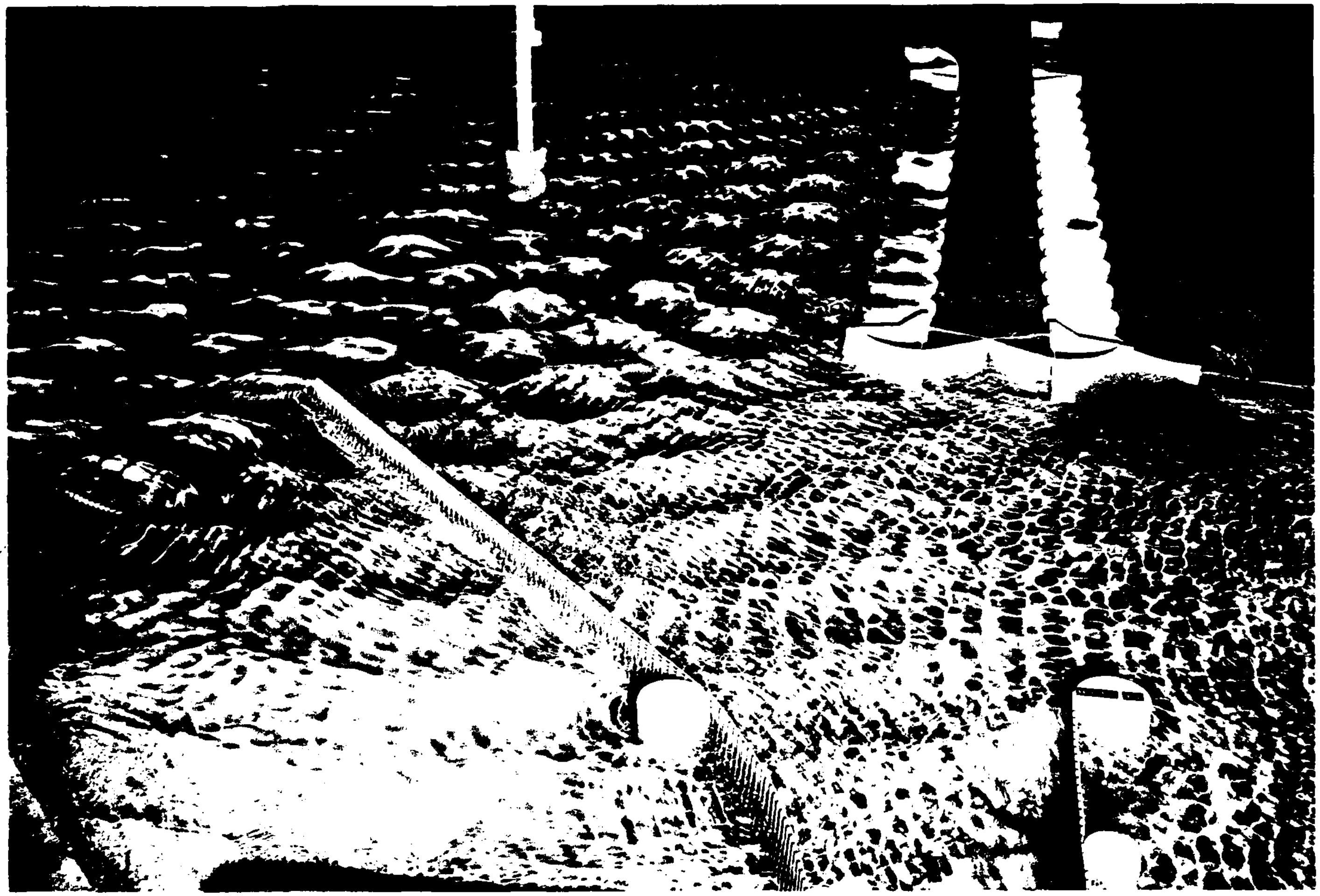


Photo 8. Typical wave patterns at temporary entrance for Plan IV-A; 4-sec, 4-ft waves from NW; swl = +4 ft msl

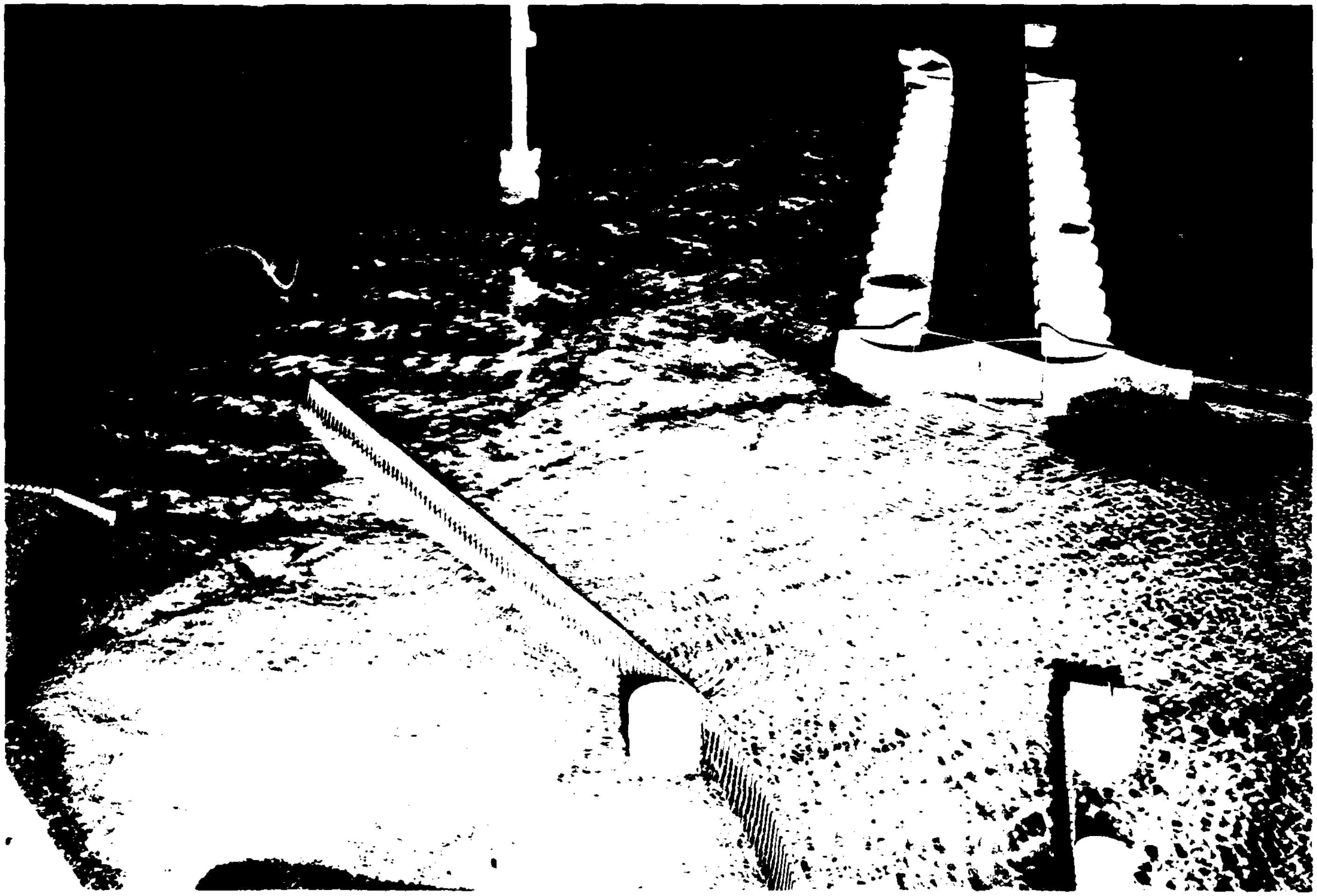


Photo 9. Typical wave patterns at temporary entrance for Plan IV-C; 4-sec, 4-ft waves from NW; swl = +1 ft msl

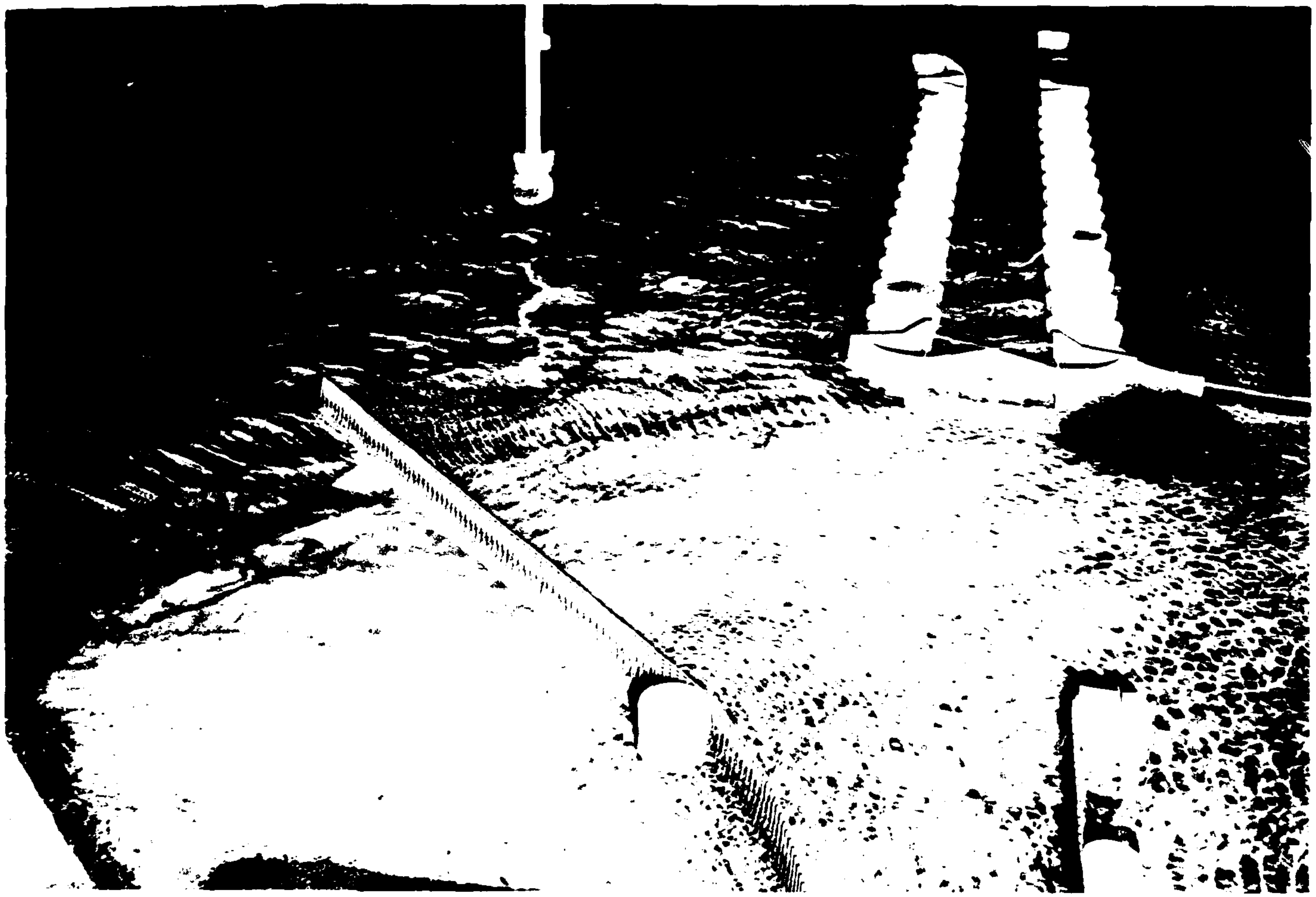


Photo 10. Typical wave patterns at temporary entrance for Plan IV-C; 4-sec, 4-ft waves from NW; swl = +4 ft msl

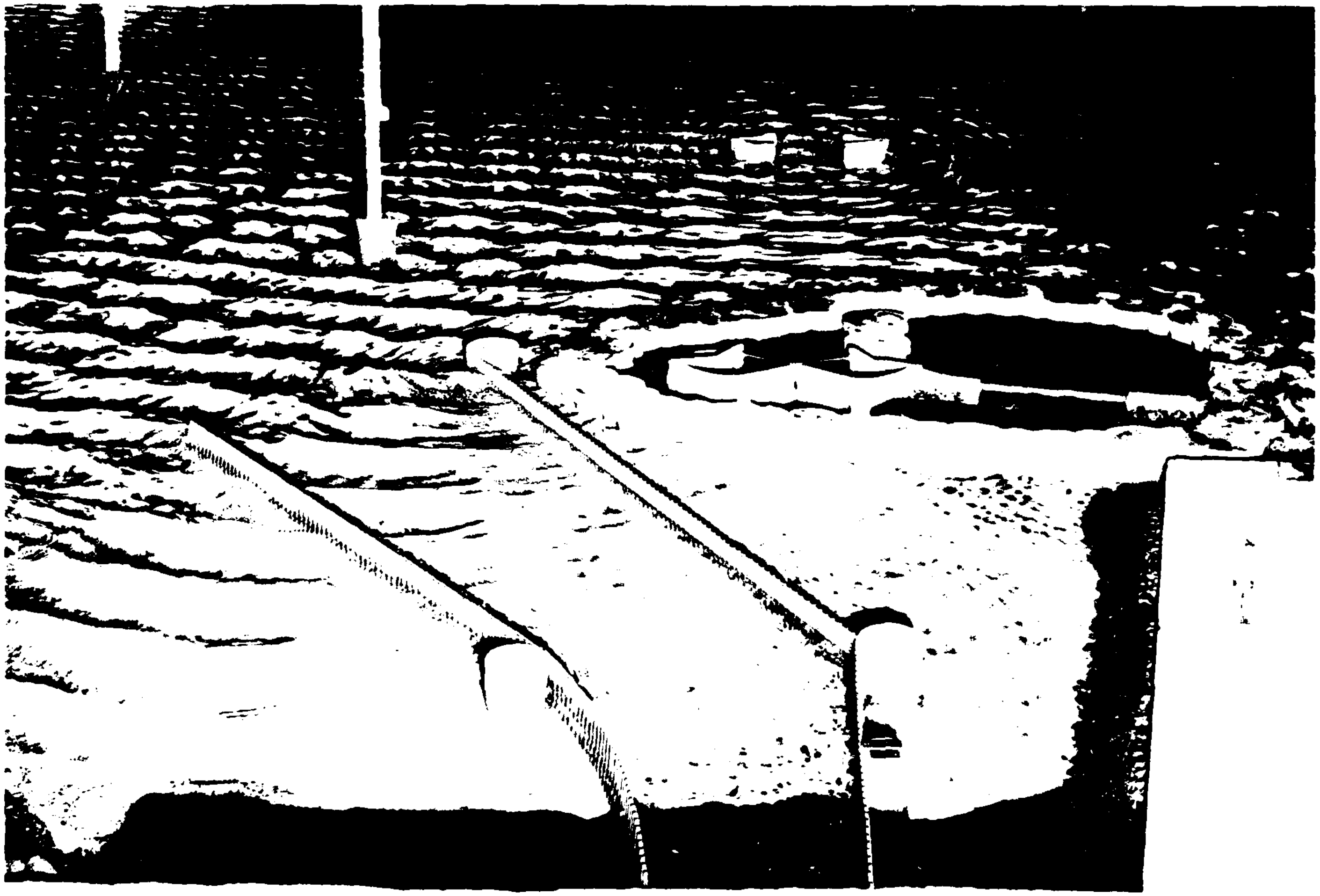


Photo 11. Typical wave patterns at temporary entrance for Plan III; 4-sec, 5-ft waves from N; swl = +1 ft msl

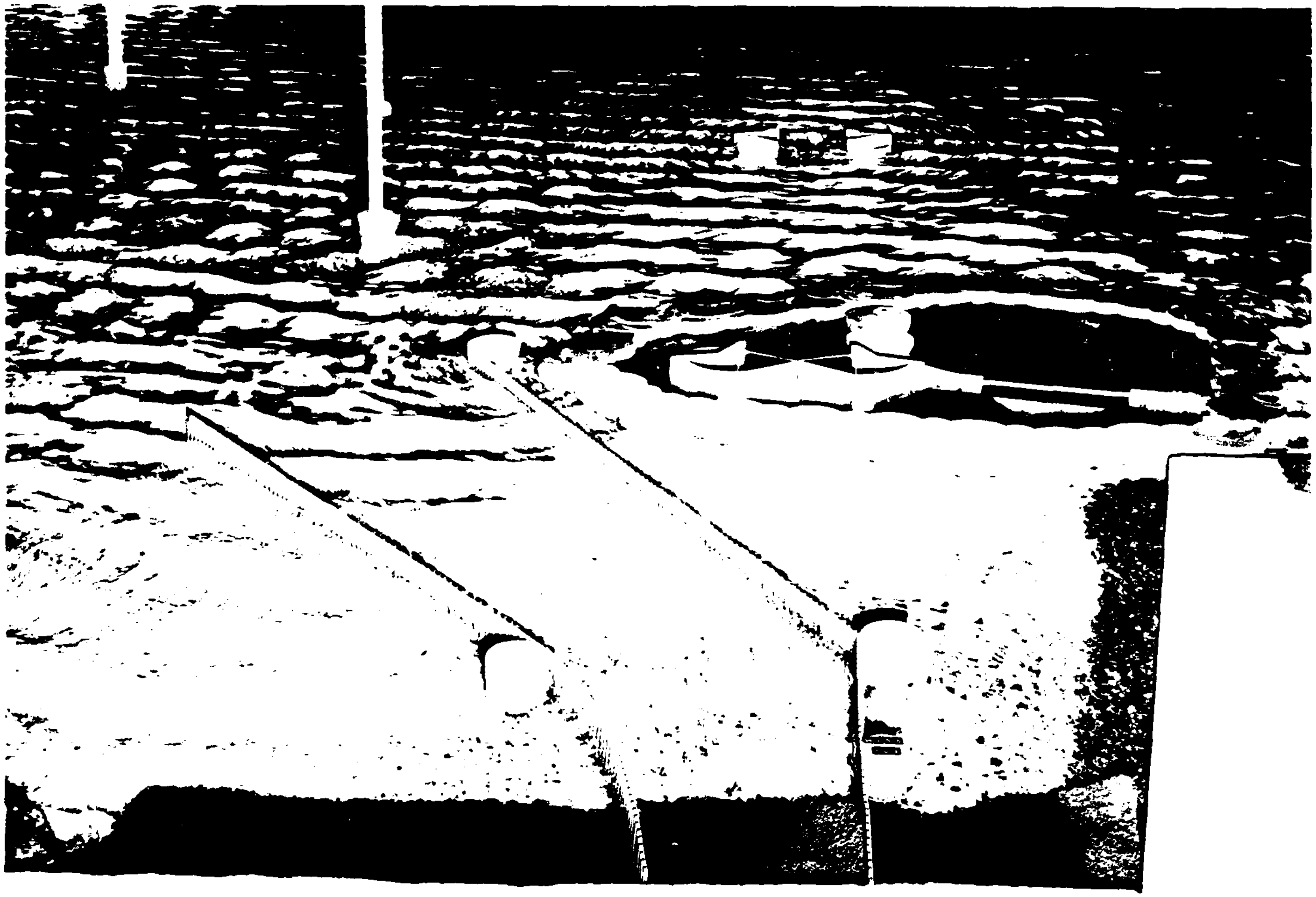


Photo 12. Typical wave patterns at temporary entrance for Plan III; 4-sec, 5-ft waves from N; swl = +4 ft msl

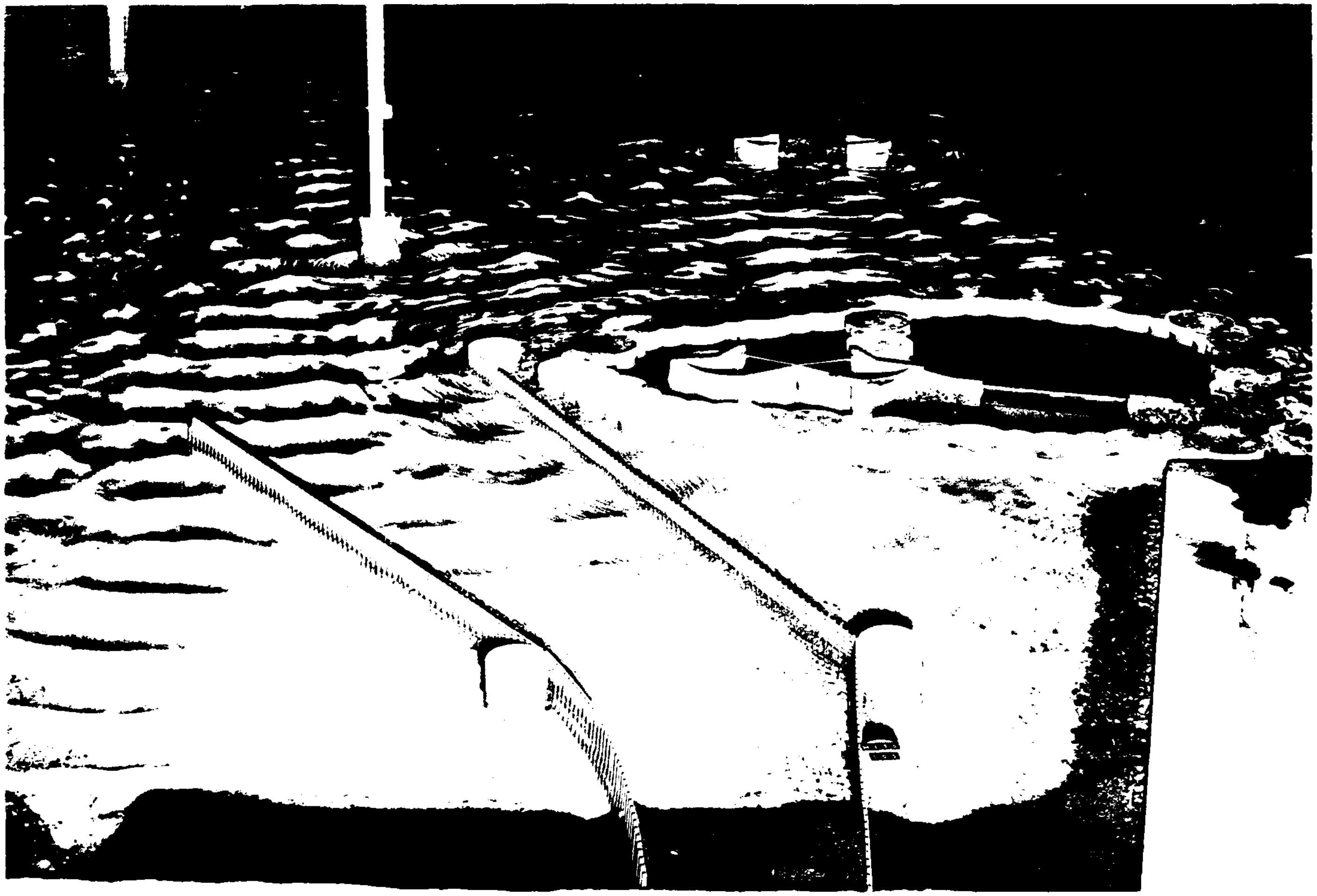


Photo 13. Typical wave patterns at temporary entrance for Plan III; 4-sec, 4-ft waves from NW; swl = +1 ft msl

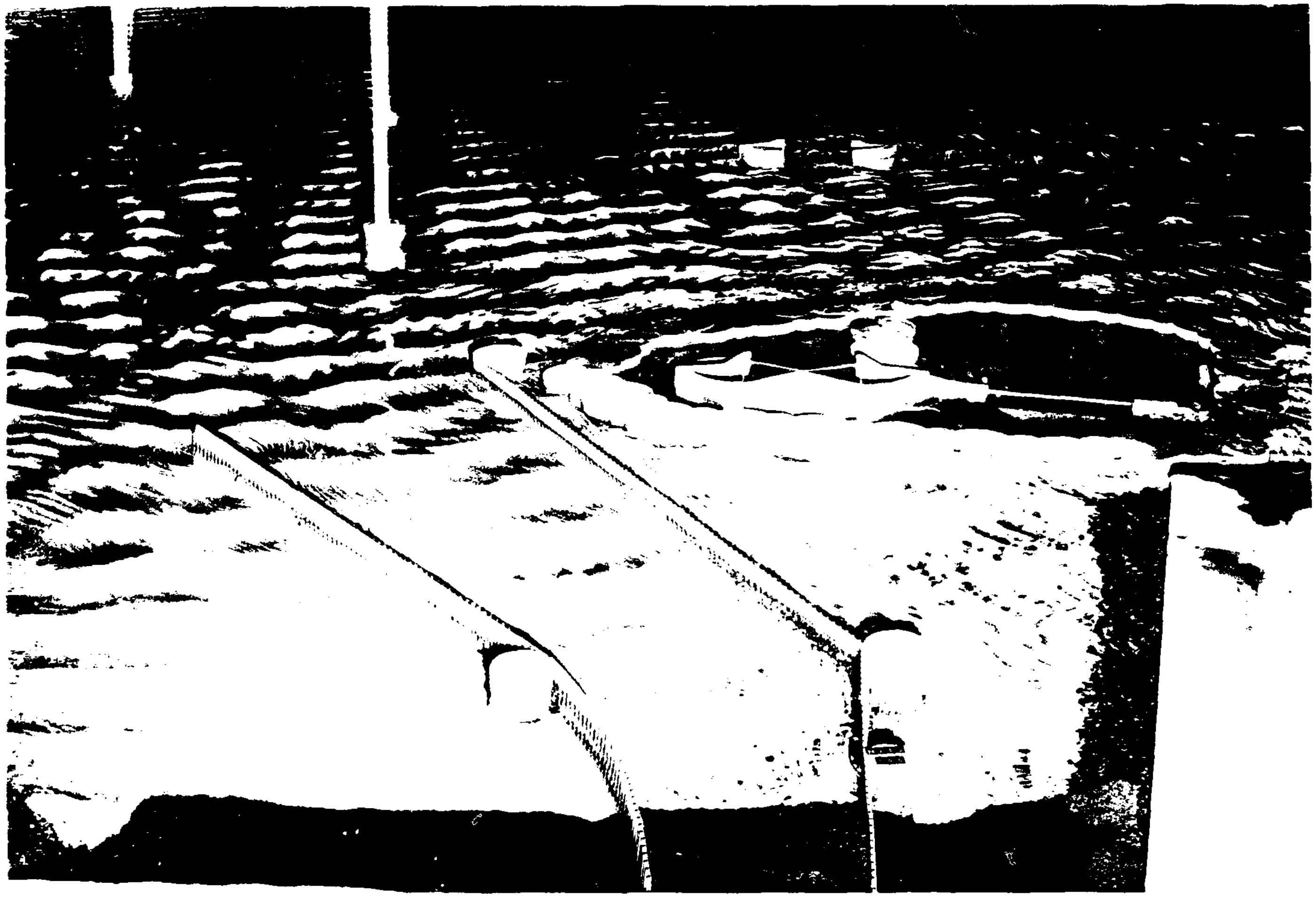


Photo 14. Typical wave patterns at temporary entrance for Plan III; 4-sec, 4-ft waves from NW; swl = +4 ft msl

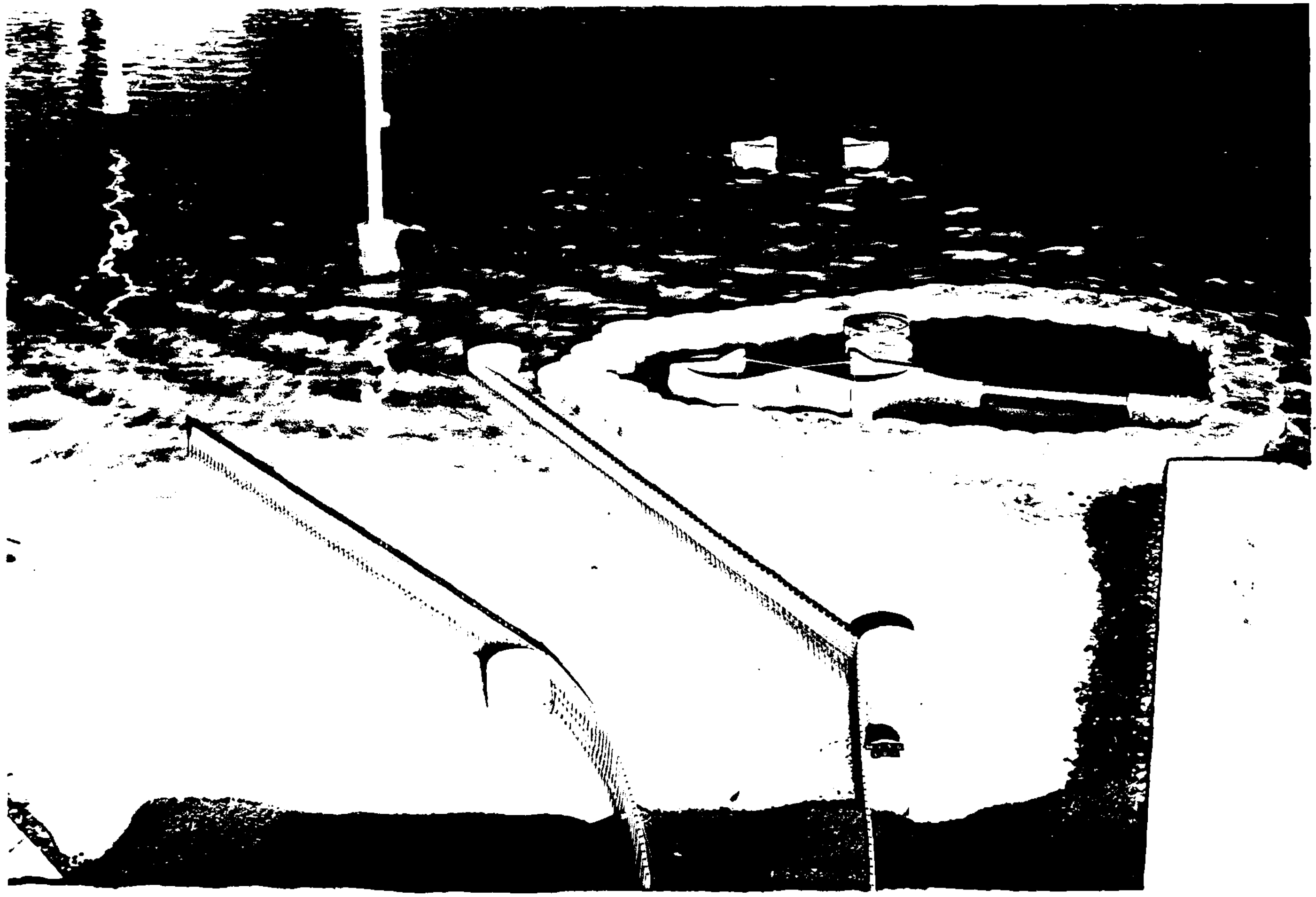


Photo 15. Typical wave patterns at temporary entrance for Plan III-A; 4-sec, 5-ft waves from N; swl = +1 ft msl

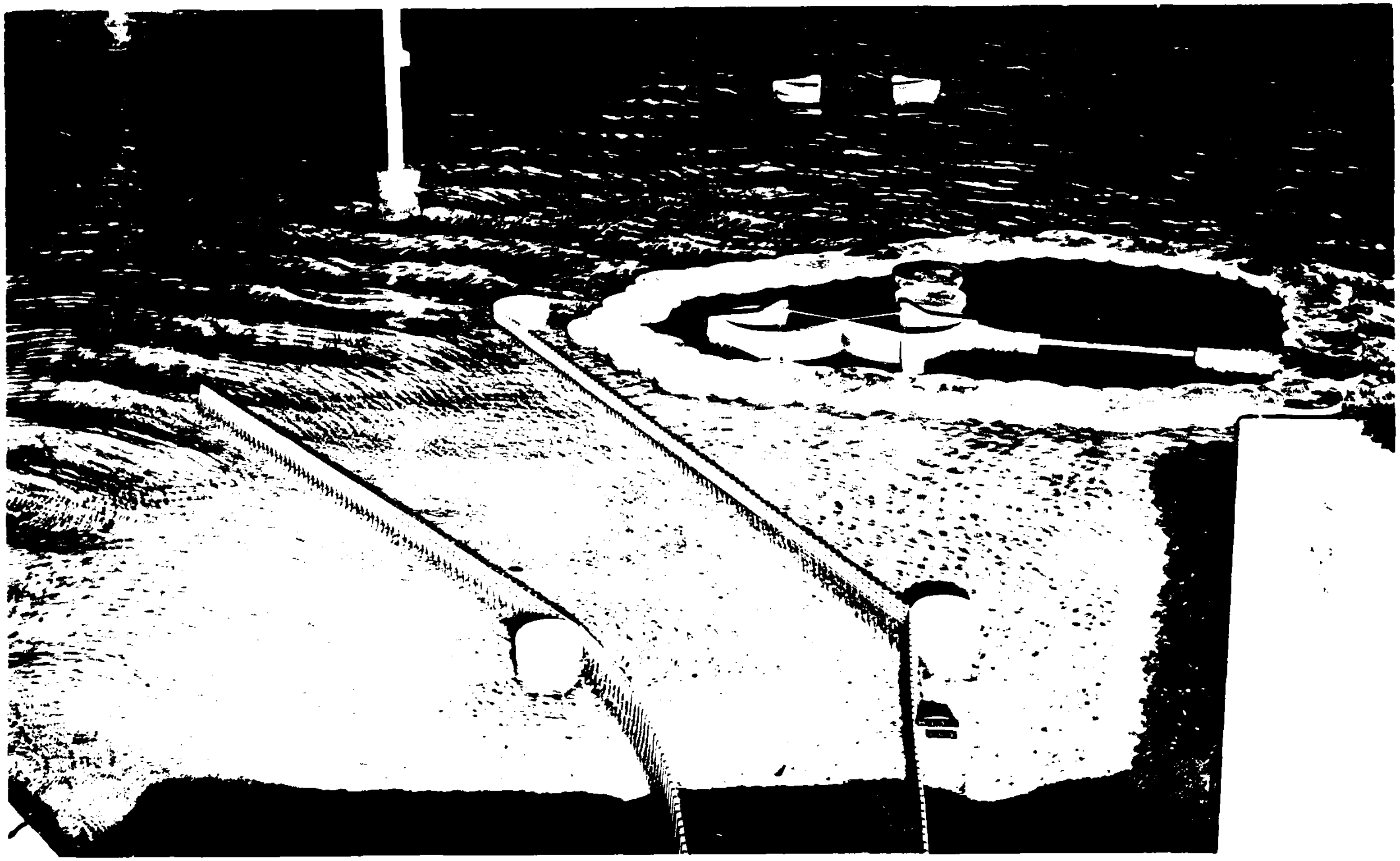


Photo 16. Typical wave patterns at temporary entrance for Plan III-A; 4-sec, 5-ft waves from N; swl = +4 ft msl

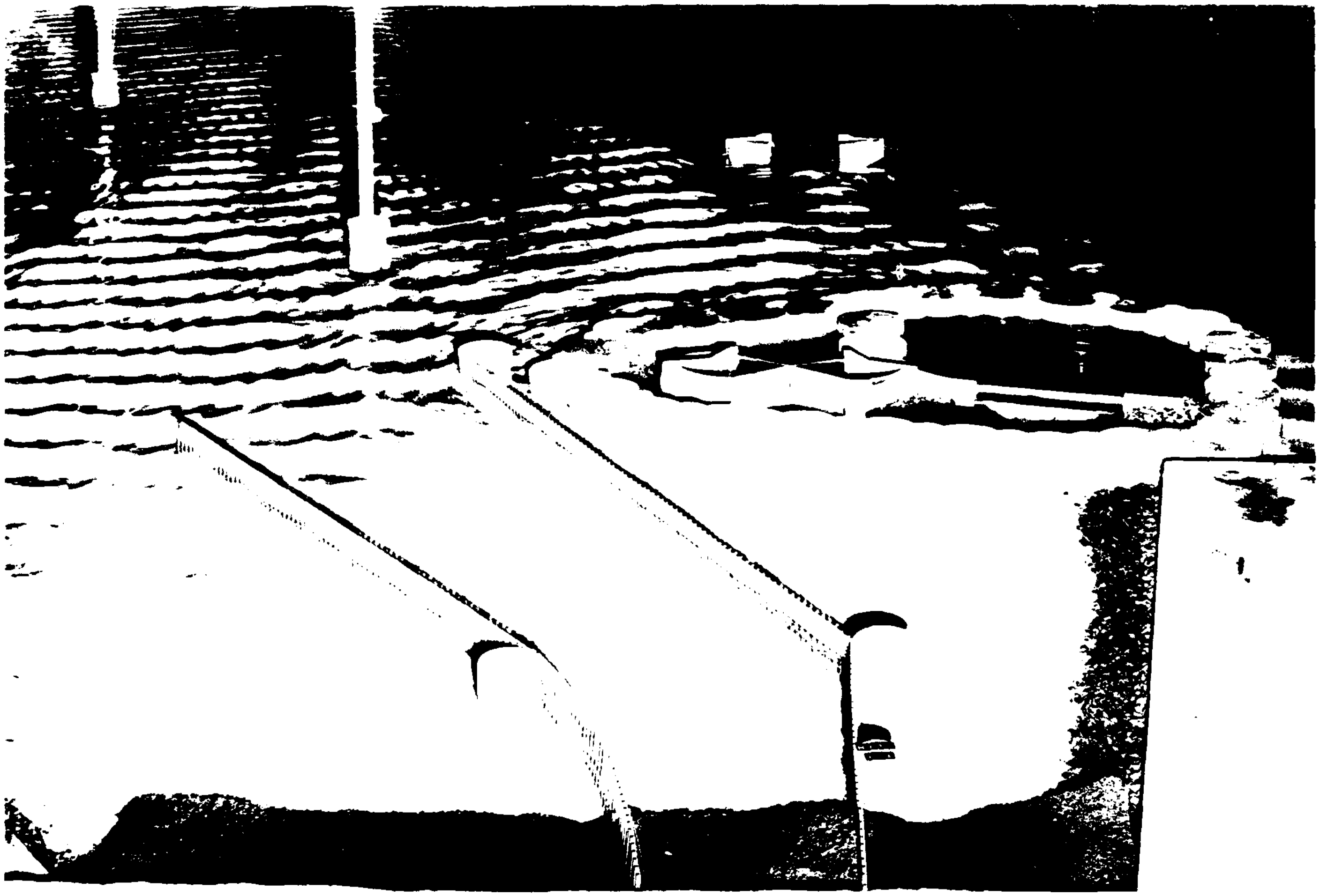


Photo 17. Typical wave patterns at temporary entrance for Plan III-A; 4-sec, 4-ft waves from NW; swl = +1 ft msl

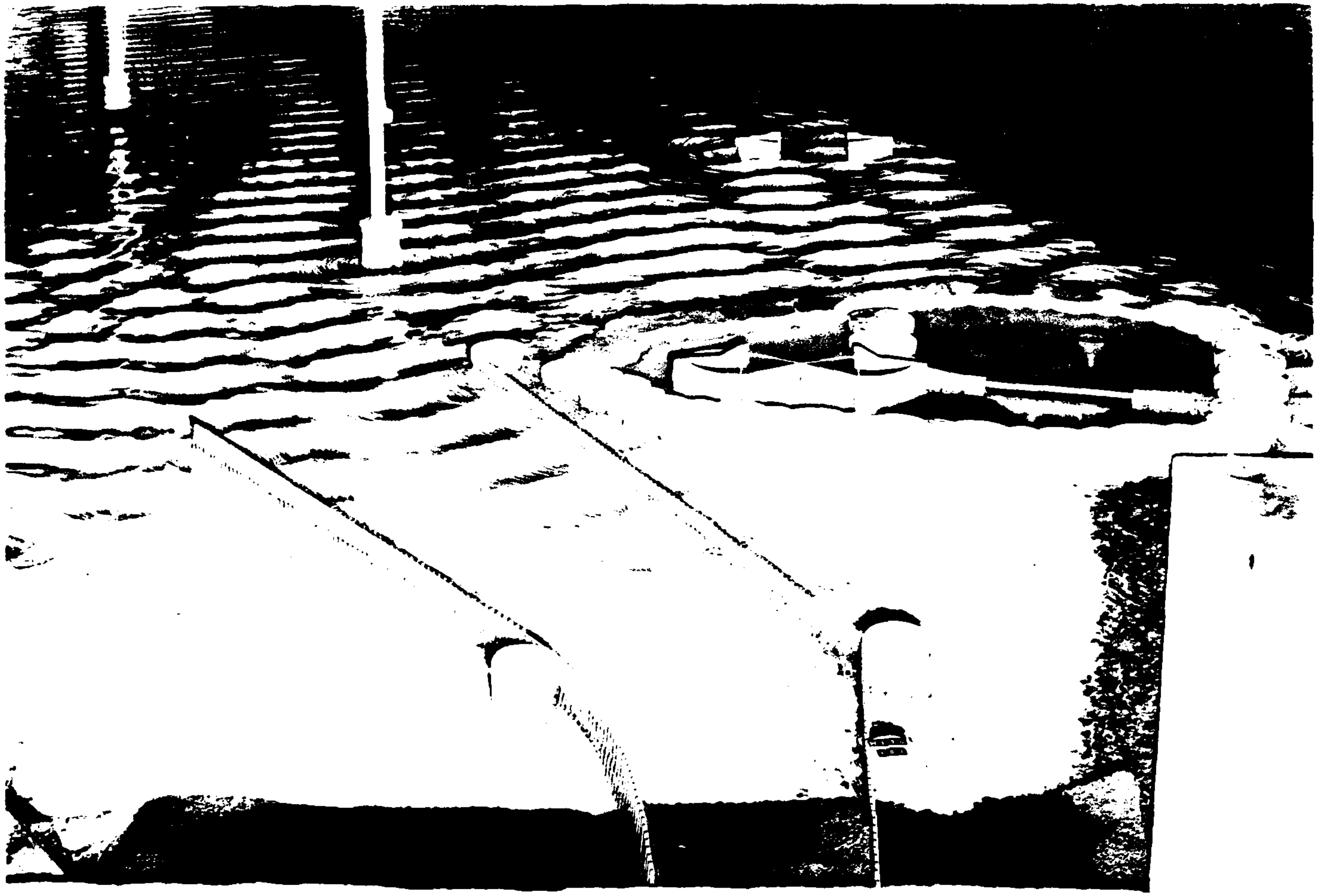


Photo 18. Typical wave patterns at temporary entrance for Plan III-A; 4-sec, 4-ft waves from NW; swl = +4 ft msl

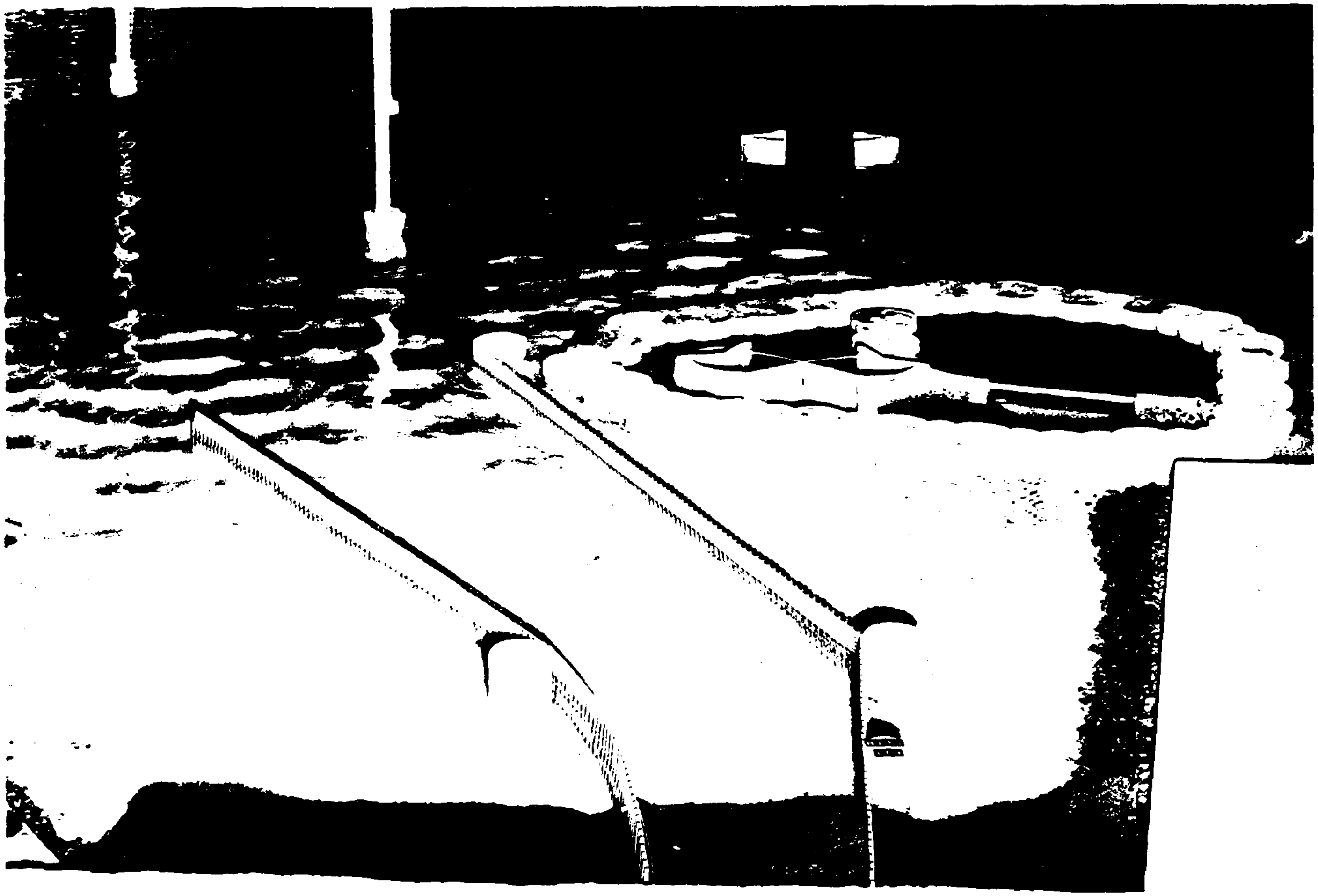


Photo 19. Typical wave patterns at temporary entrance for Plan III-B; 4-sec, 4-ft waves from NW; swl = +1 ft msl

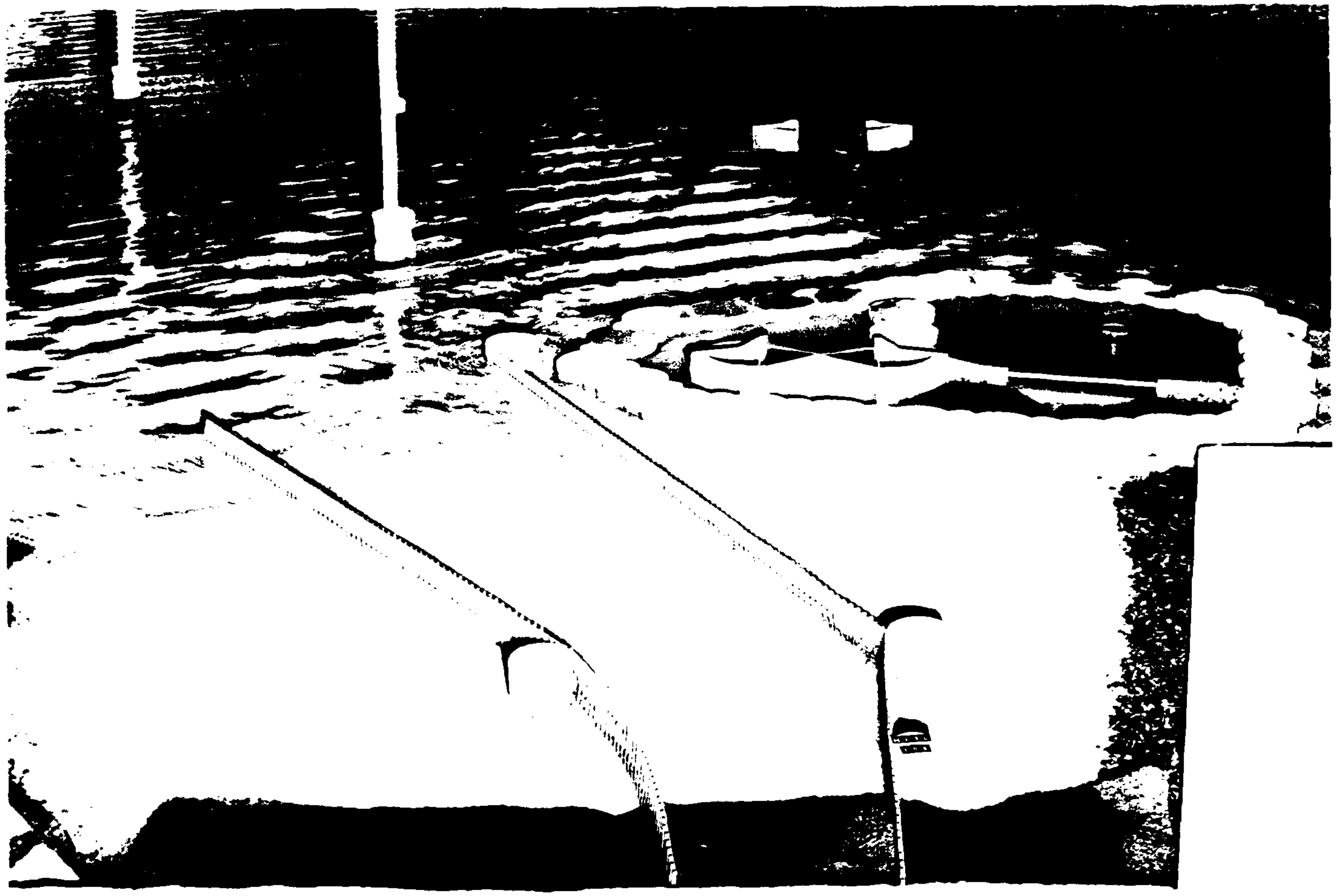


Photo 20. Typical wave patterns at temporary entrance for Plan III-B; 4-sec, 4-ft waves from NW; swl = +4 ft msl

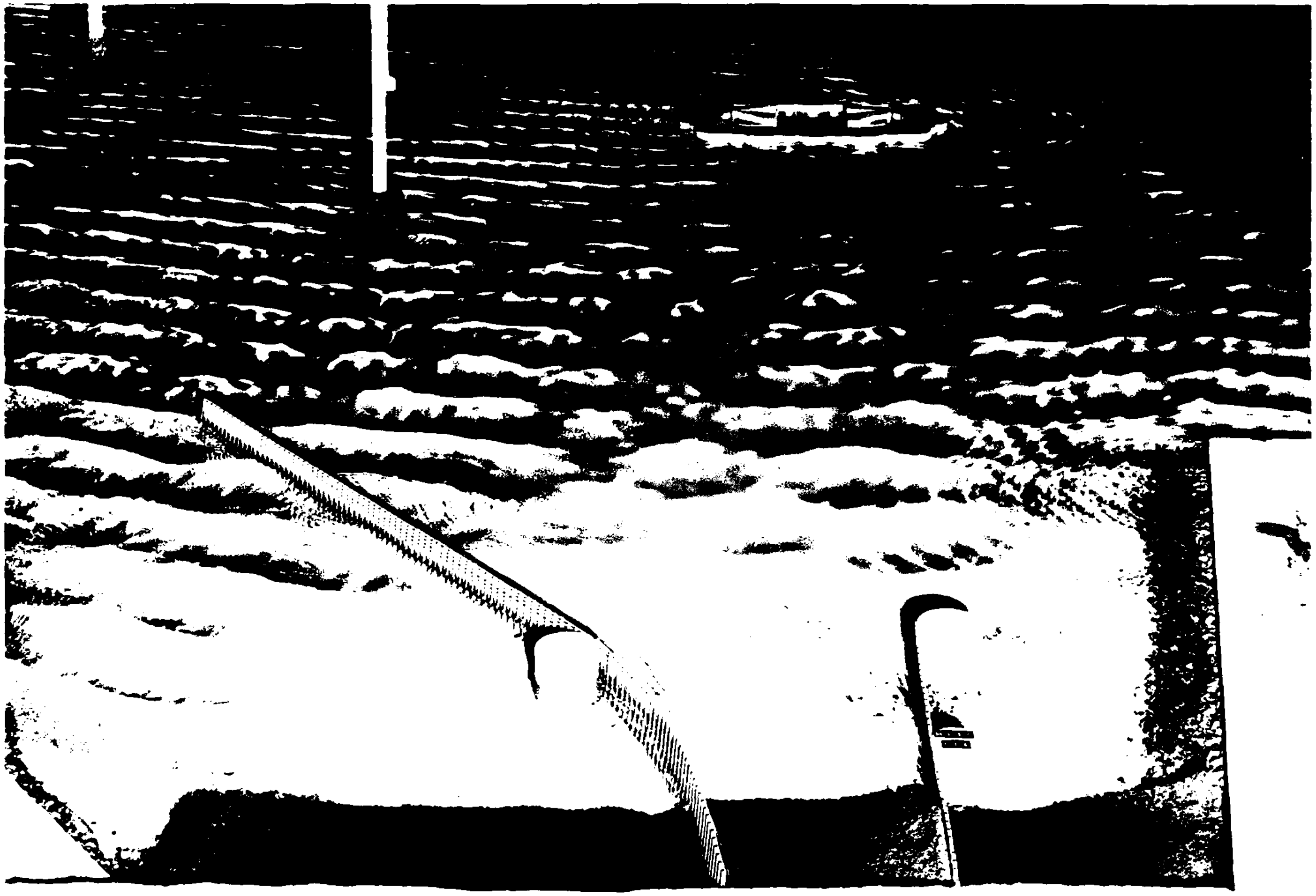


Photo 21. Typical wave patterns at temporary entrance for Plan II; 4-sec, 5-ft waves from N; swl = +1 ft msl

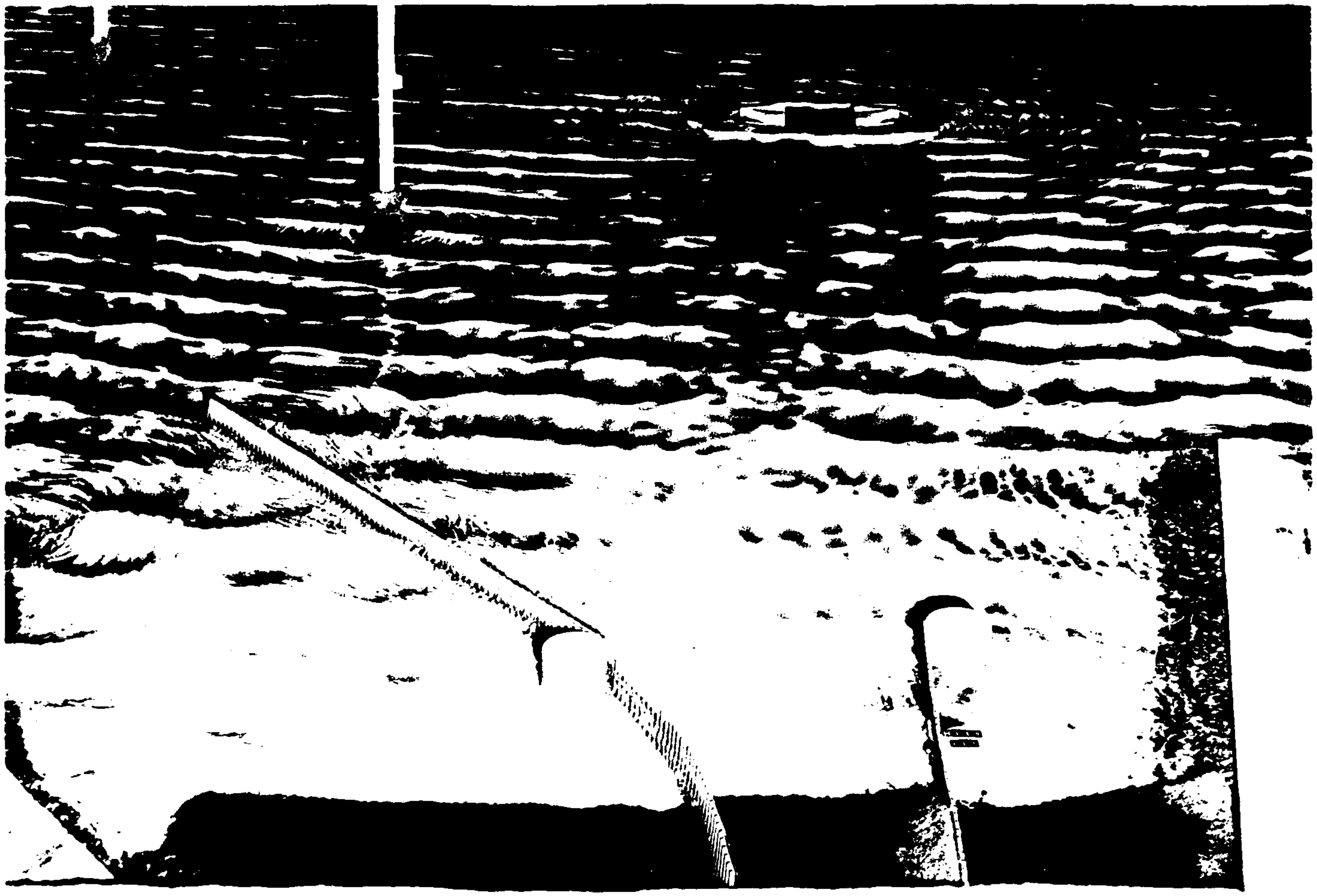


Photo 22. Typical wave patterns at temporary entrance for Plan II; 4-sec, 5-ft waves from N; swl = +4 ft msl

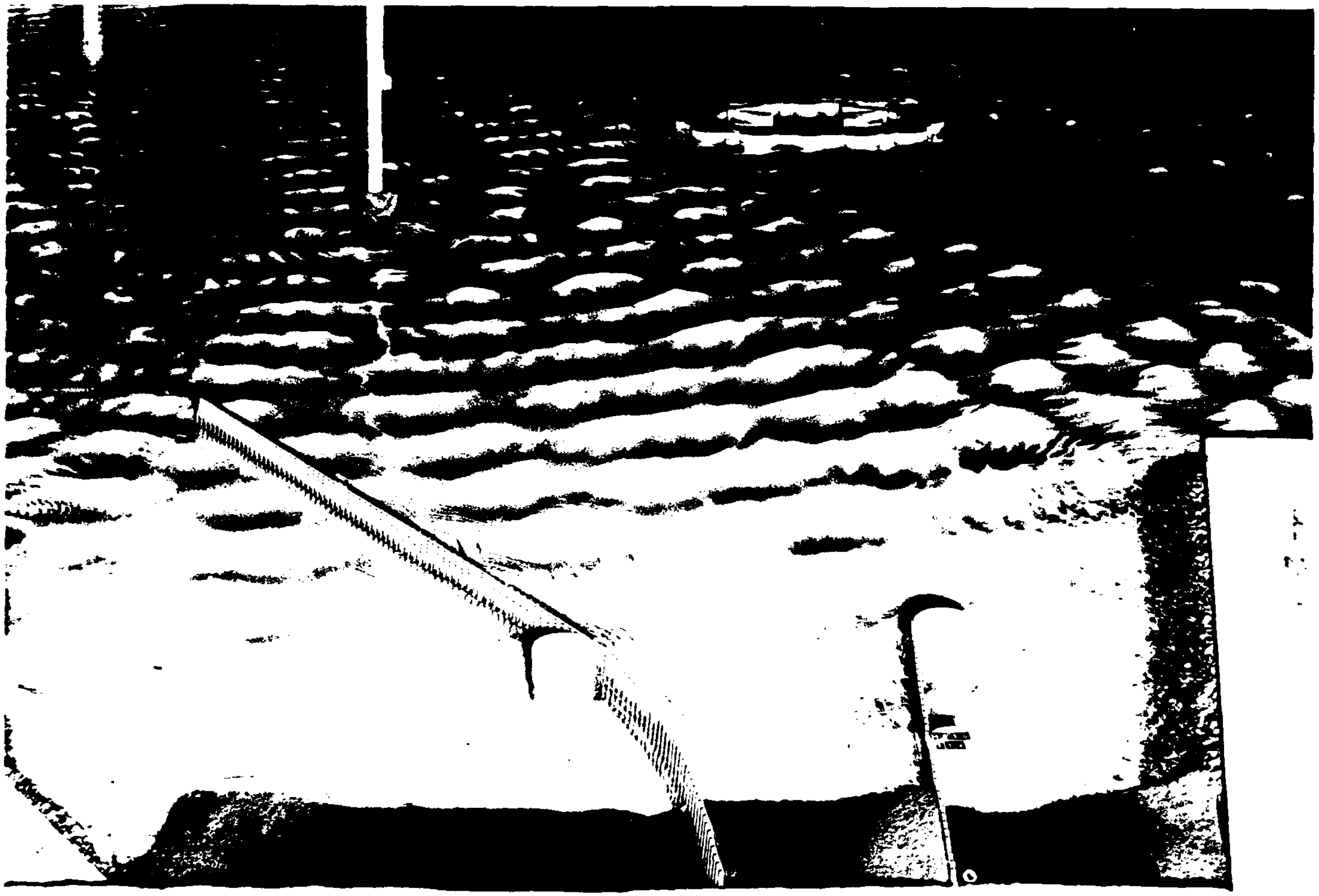


Photo 23. Typical wave patterns at temporary entrance for Plan II; 4-sec, 4-ft waves from NW; swl = +1 ft msl

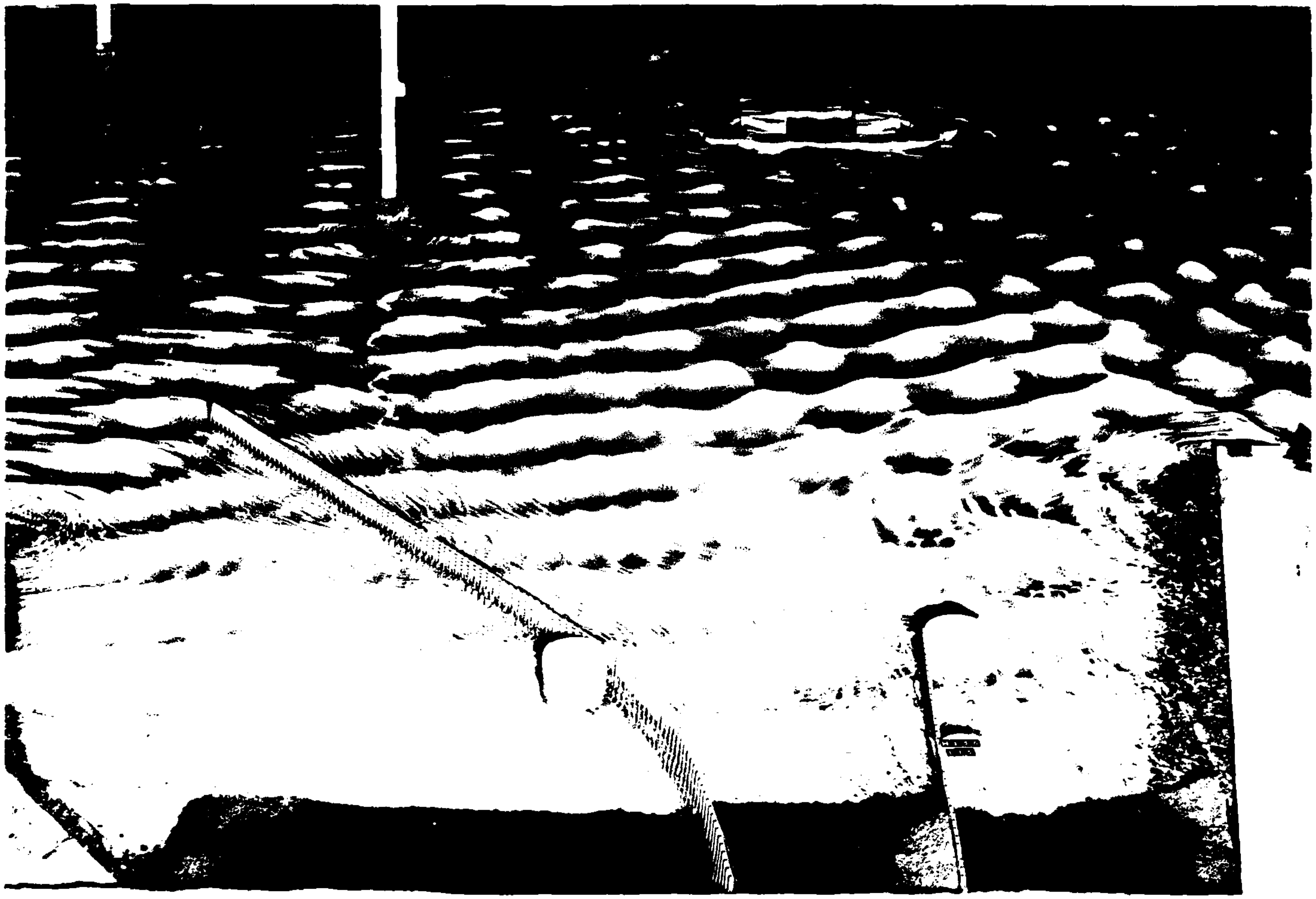


Photo 24. Typical wave patterns at temporary entrance for Plan II; 4-sec, 4-ft waves from NW; swl = +4 ft msl

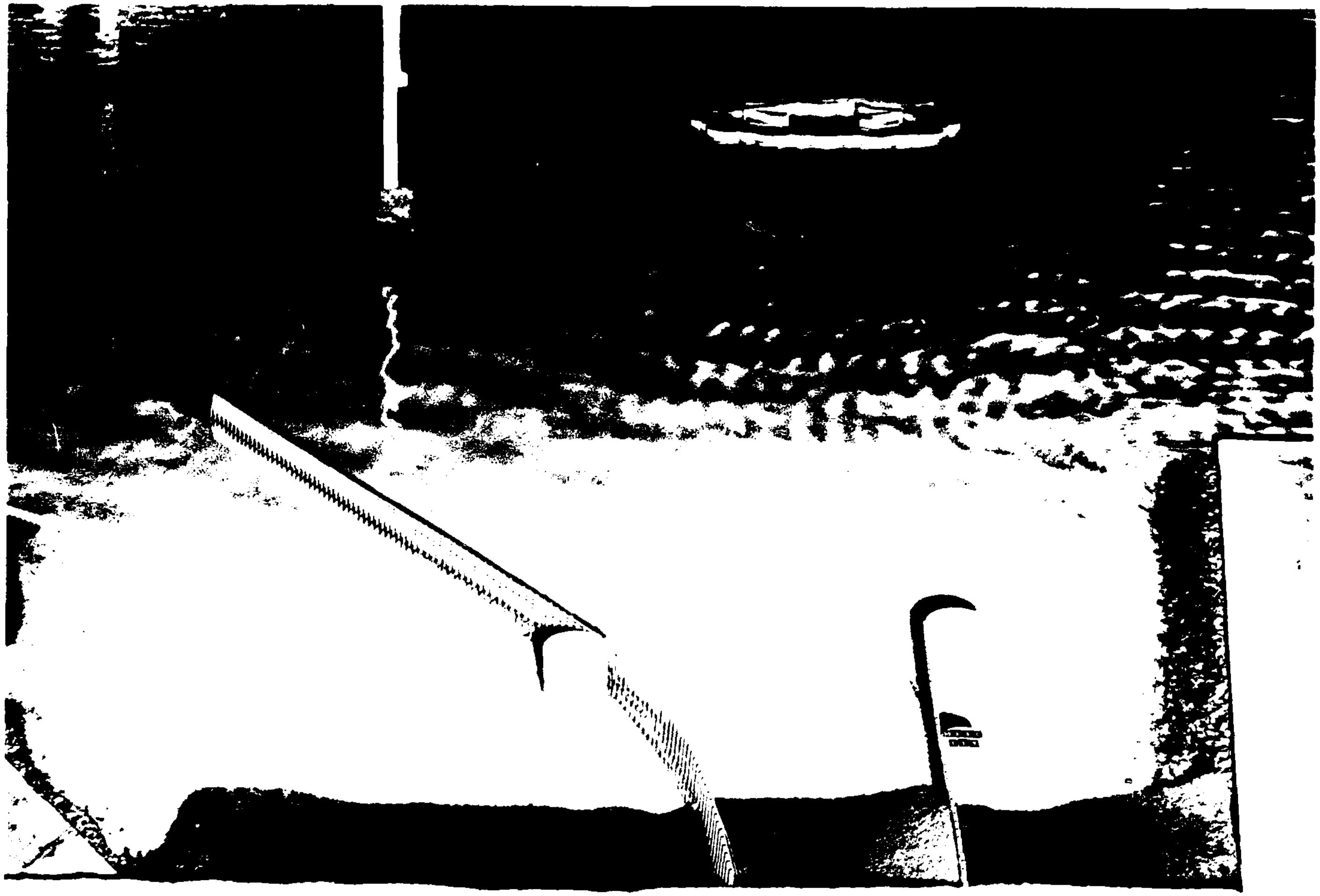


Photo 25. Typical wave patterns at temporary entrance for Plan II-A; 4-sec, 5-ft waves from N; swl = +1 ft msl

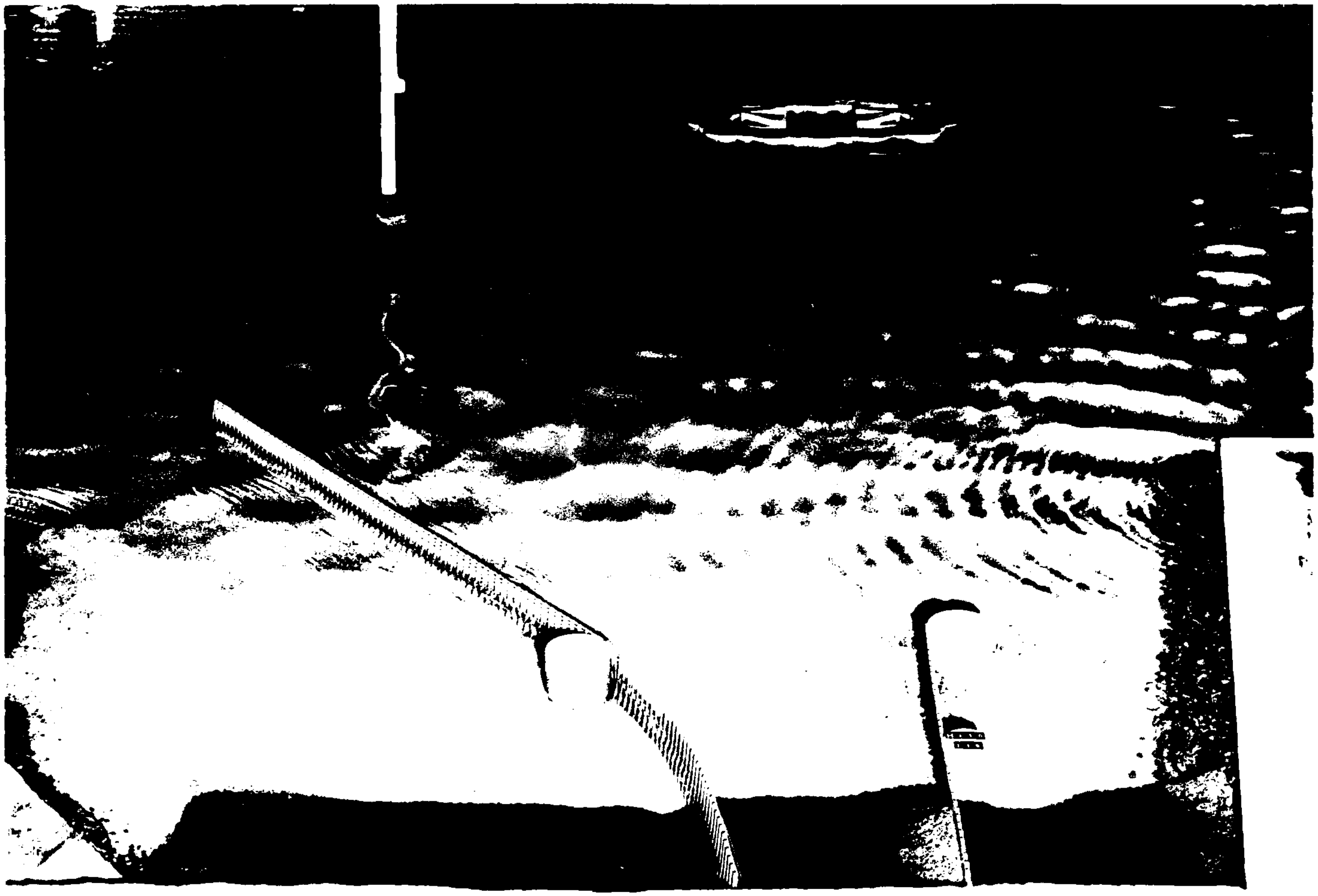


Photo 26. Typical wave patterns at temporary entrance for Plan II-A; 4-sec, 5-ft waves from N; swl = +4 ft msl

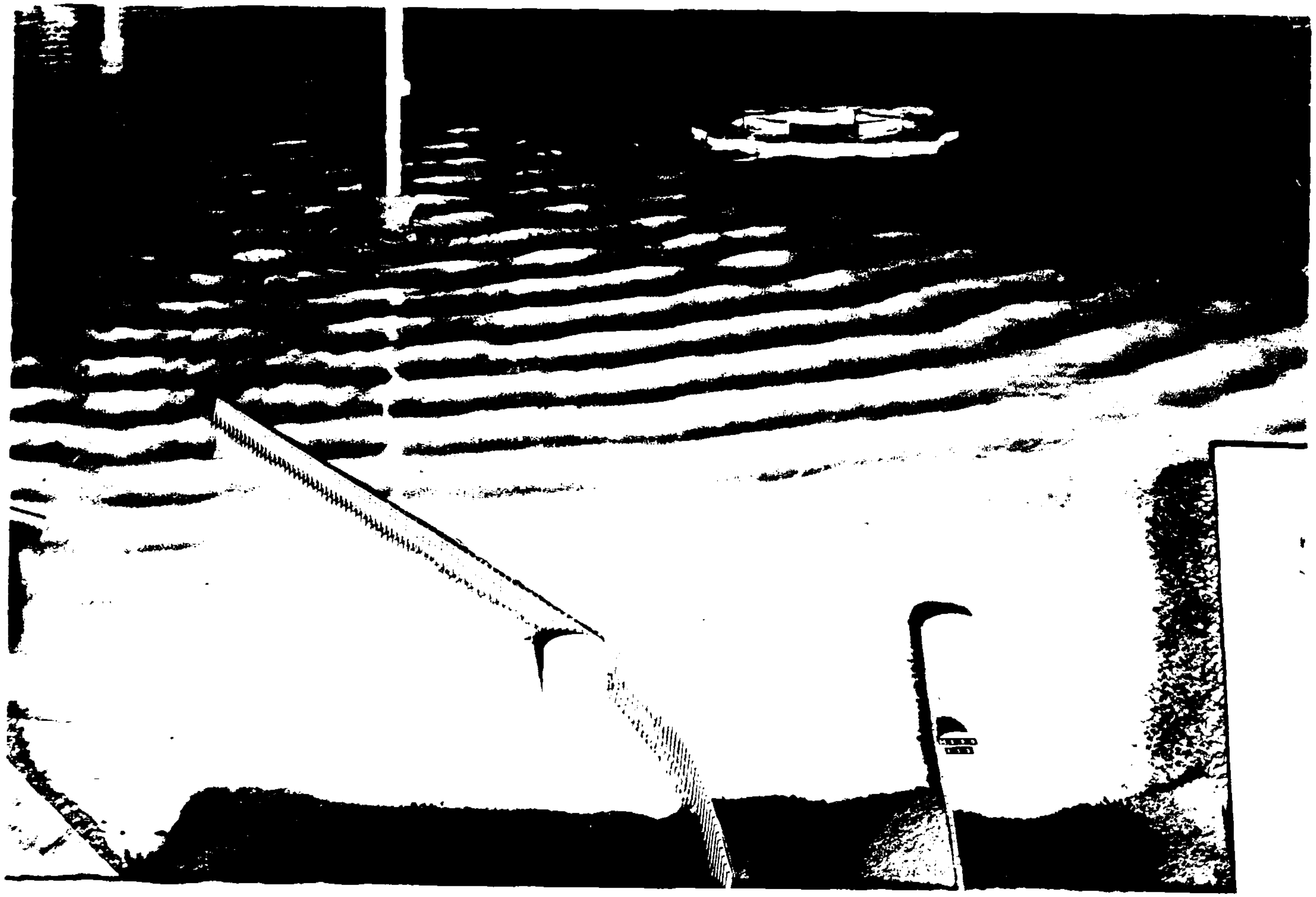


Photo 27. Typical wave patterns at temporary entrance for Plan II-A; 4-sec, 4-ft waves from NW; swl = +1 ft msl

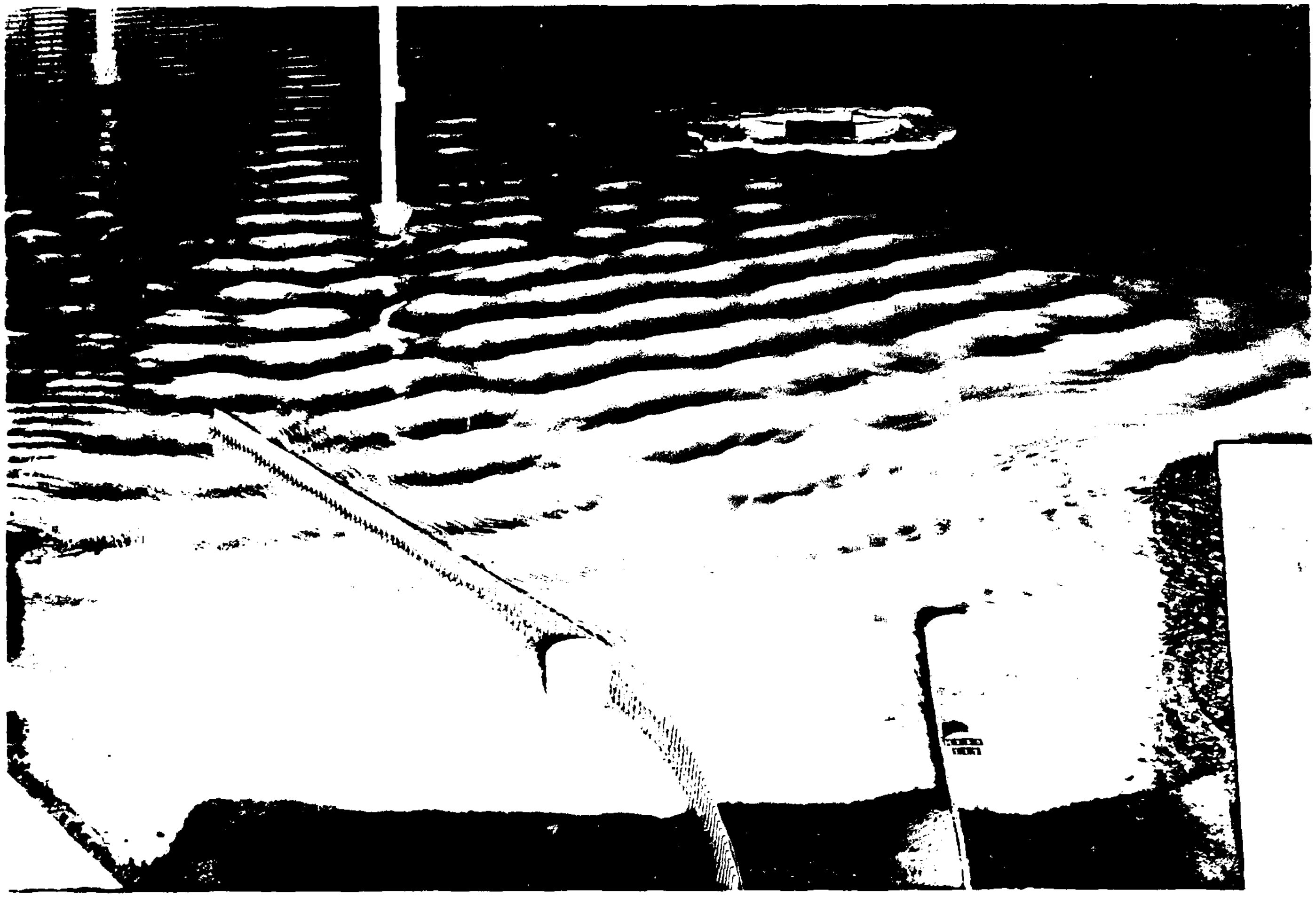


Photo 28. Typical wave patterns at temporary entrance for Plan II-A; 4-sec, 4-ft waves from NW; swl = +4 ft msl

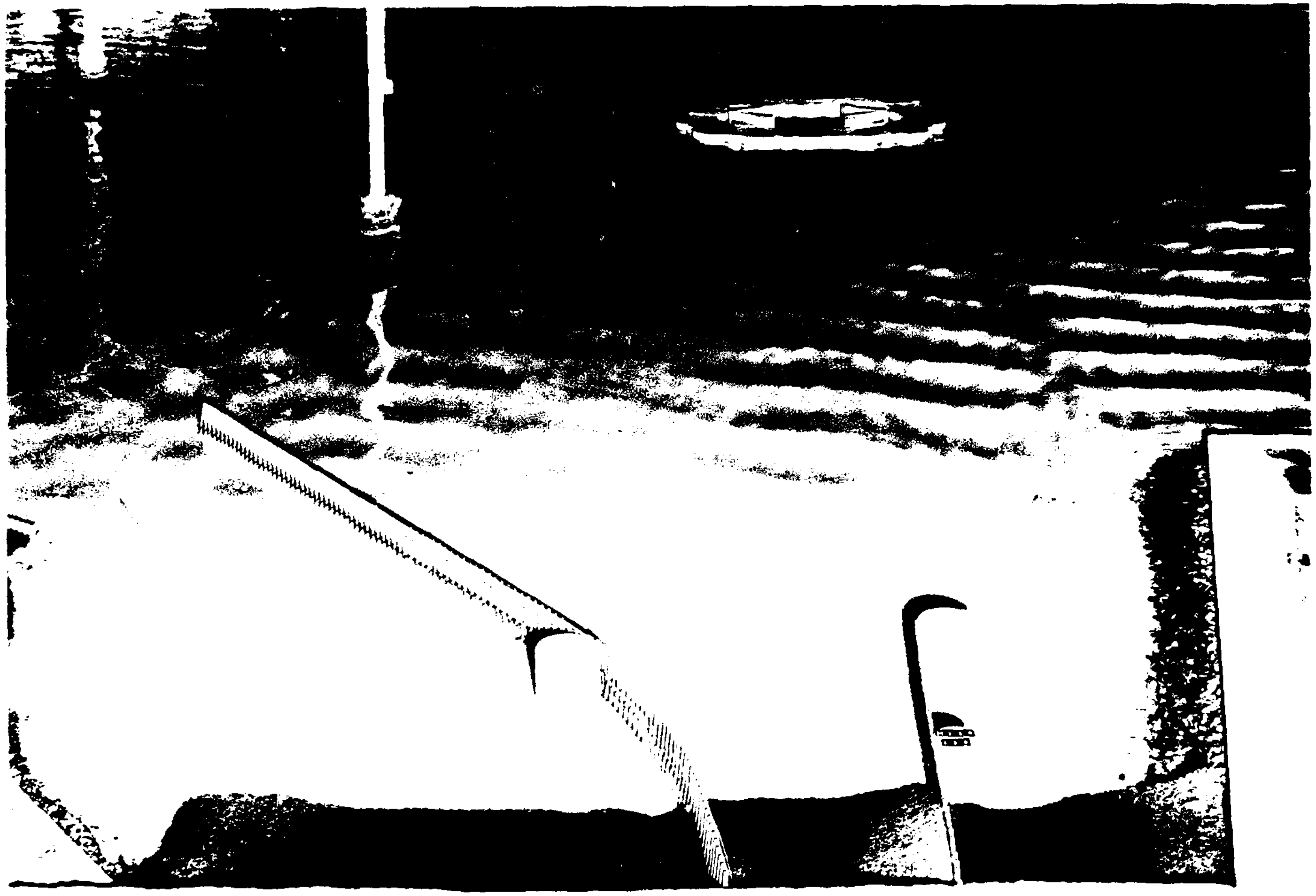


Photo 29. Typical wave patterns at temporary entrance for Plan II-C; 4-sec, 5-ft waves from N; swl = +1 ft msl

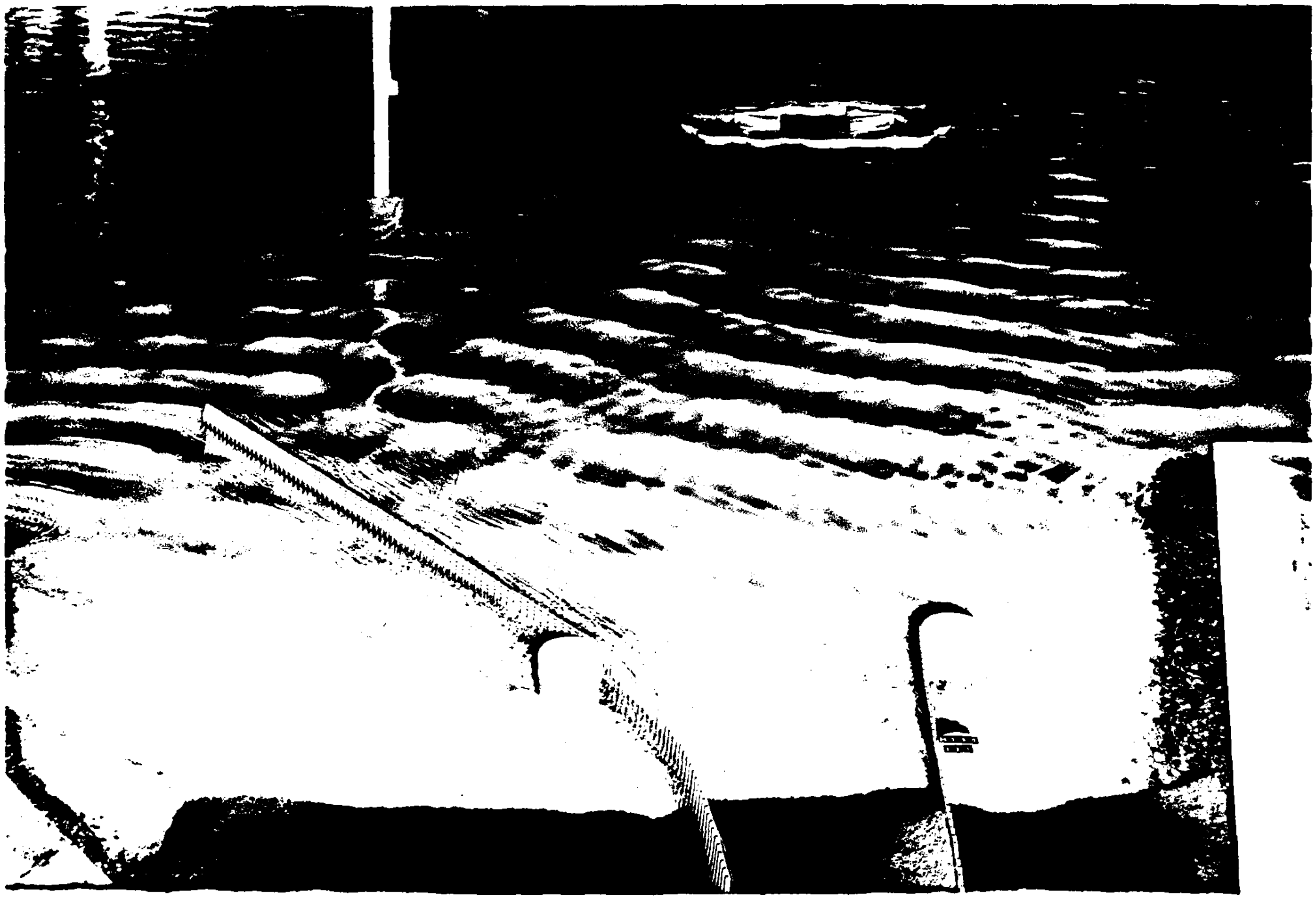


Photo 30. Typical wave patterns at temporary entrance for Plan II-C; 4-sec, 5-ft waves from N; swl = +4 ft msl

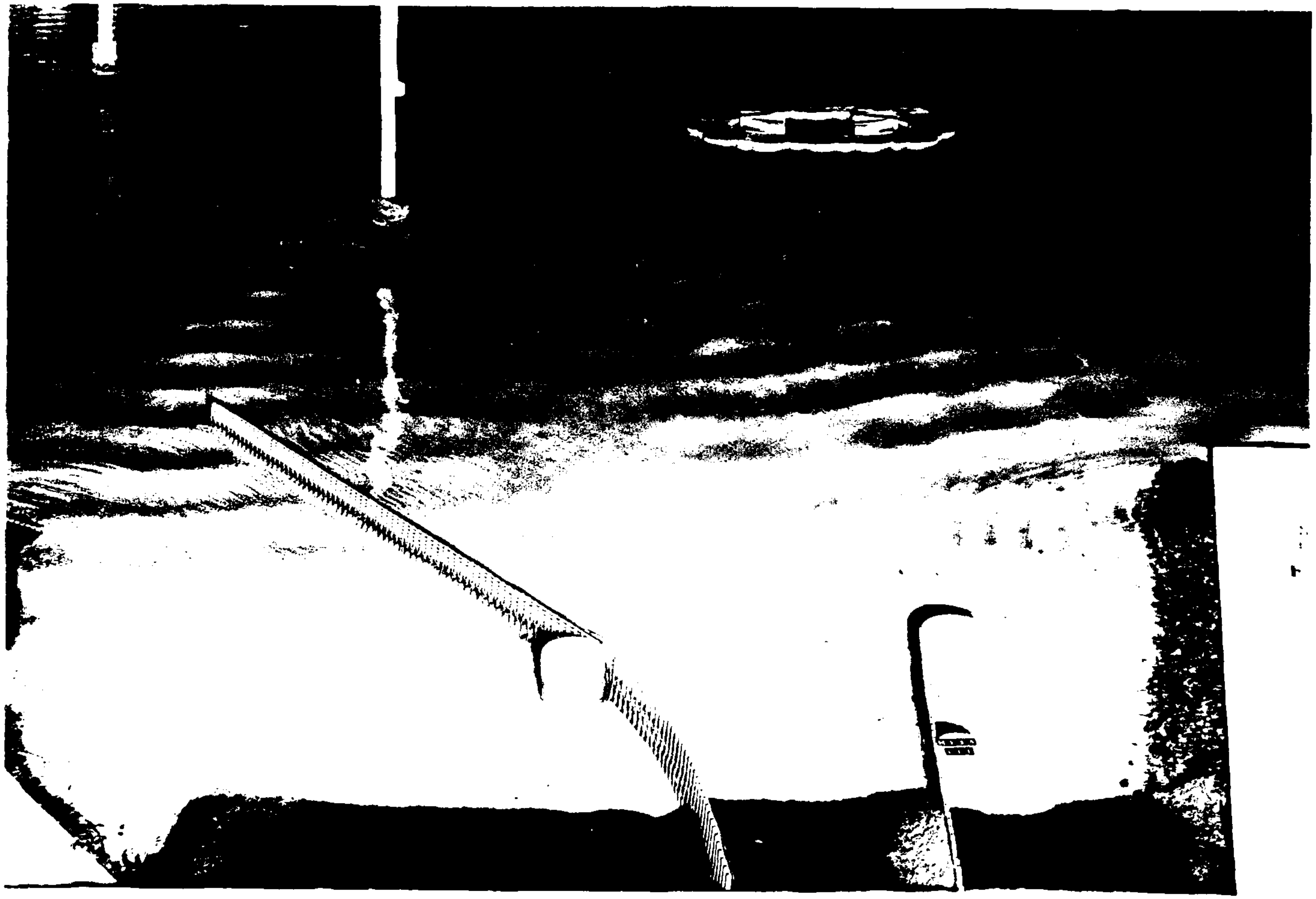


Photo 31. Typical wave patterns at temporary entrance for Plan II-D; 4-sec, 4-ft waves from NW; swl = +1 ft msl

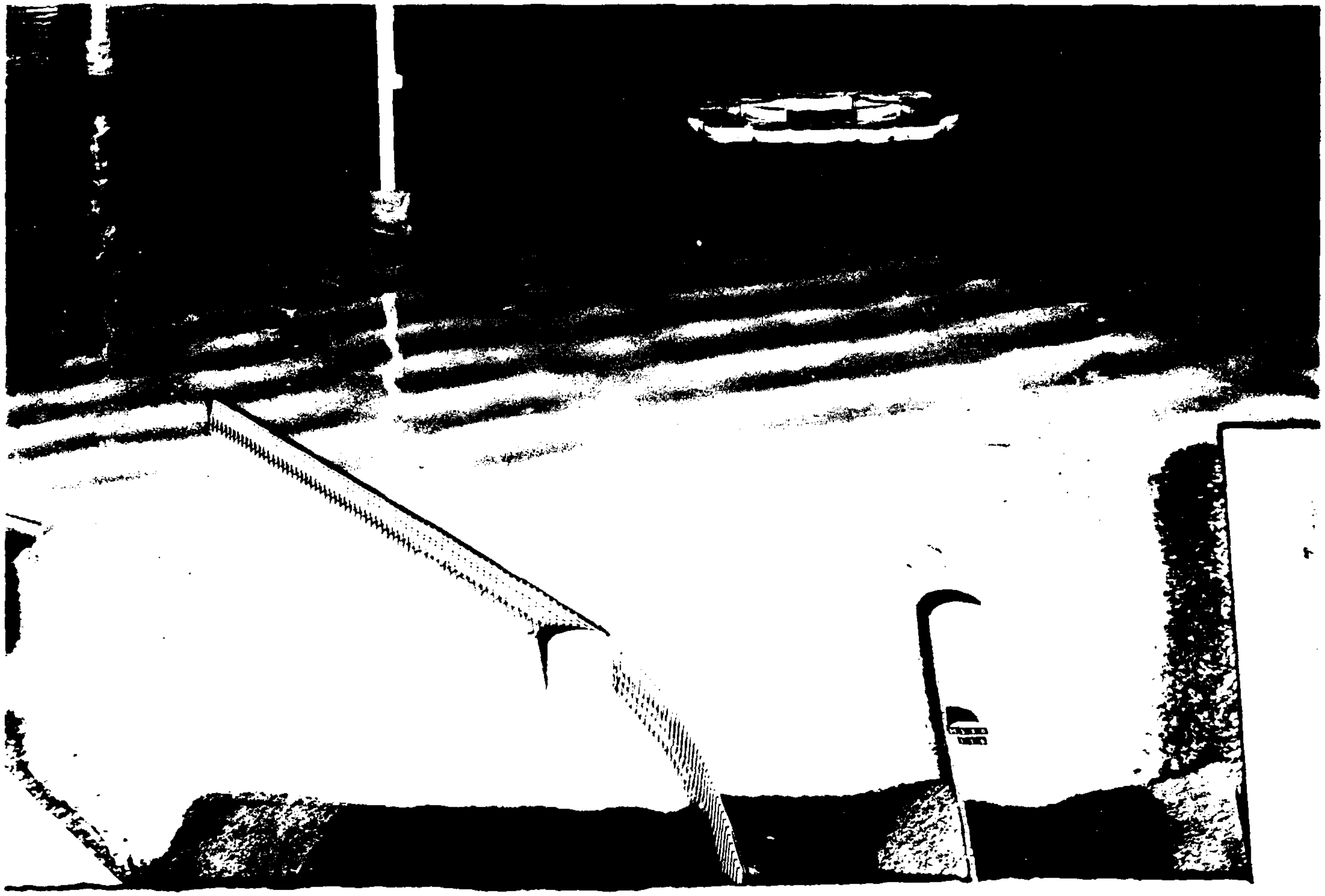
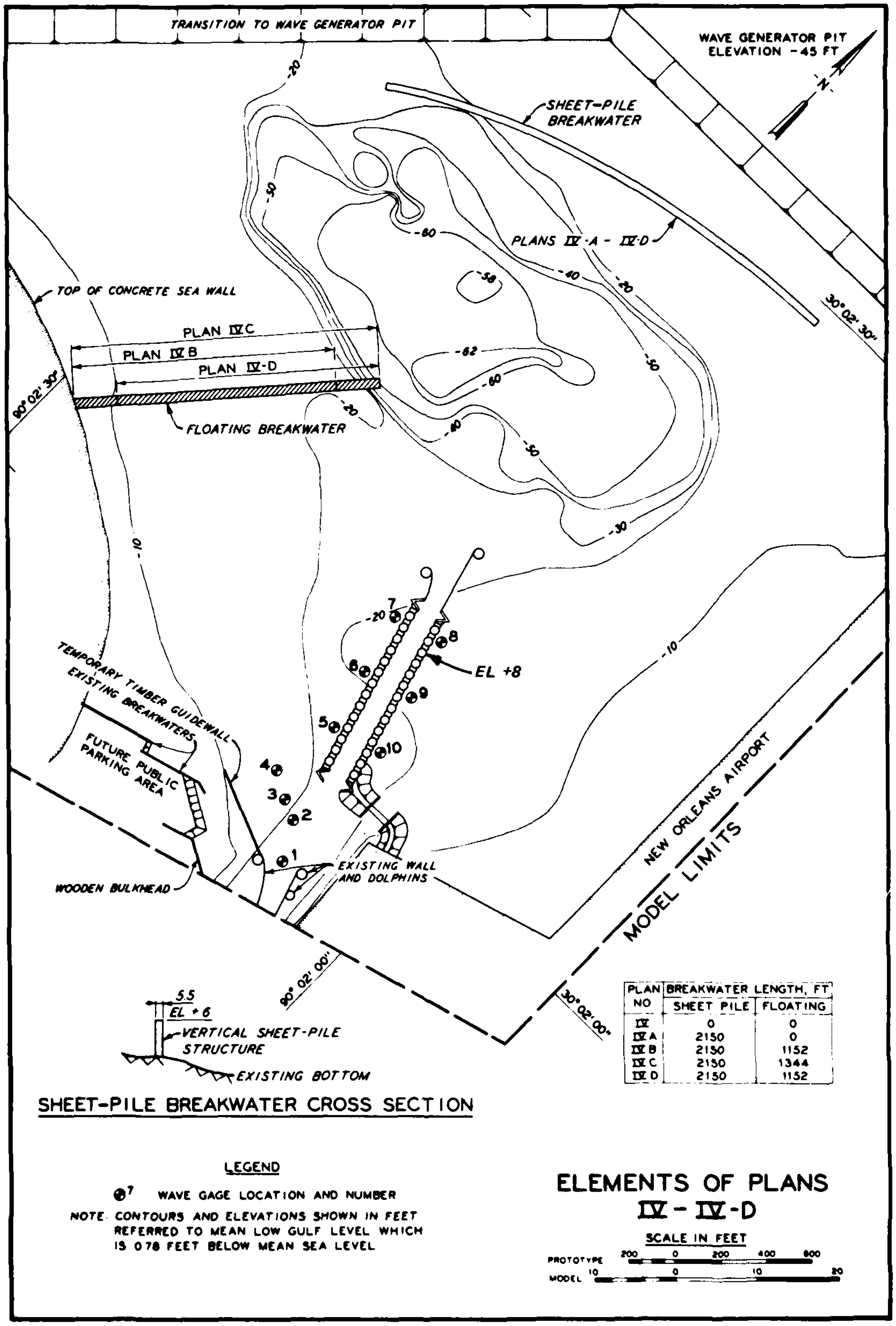


Photo 32. Typical wave patterns at temporary entrance for Plan II-D; 4-sec, 4-ft waves from NW; swl = +4 ft msl



PLAN NO	BREAKWATER LENGTH, FT	
	SHEET PILE	FLOATING
IV	0	0
IV A	2150	0
IV B	2150	1152
IV C	2150	1344
IV D	2150	1152

SHEET-PILE BREAKWATER CROSS SECTION

LEGEND

⊕[7] WAVE GAGE LOCATION AND NUMBER

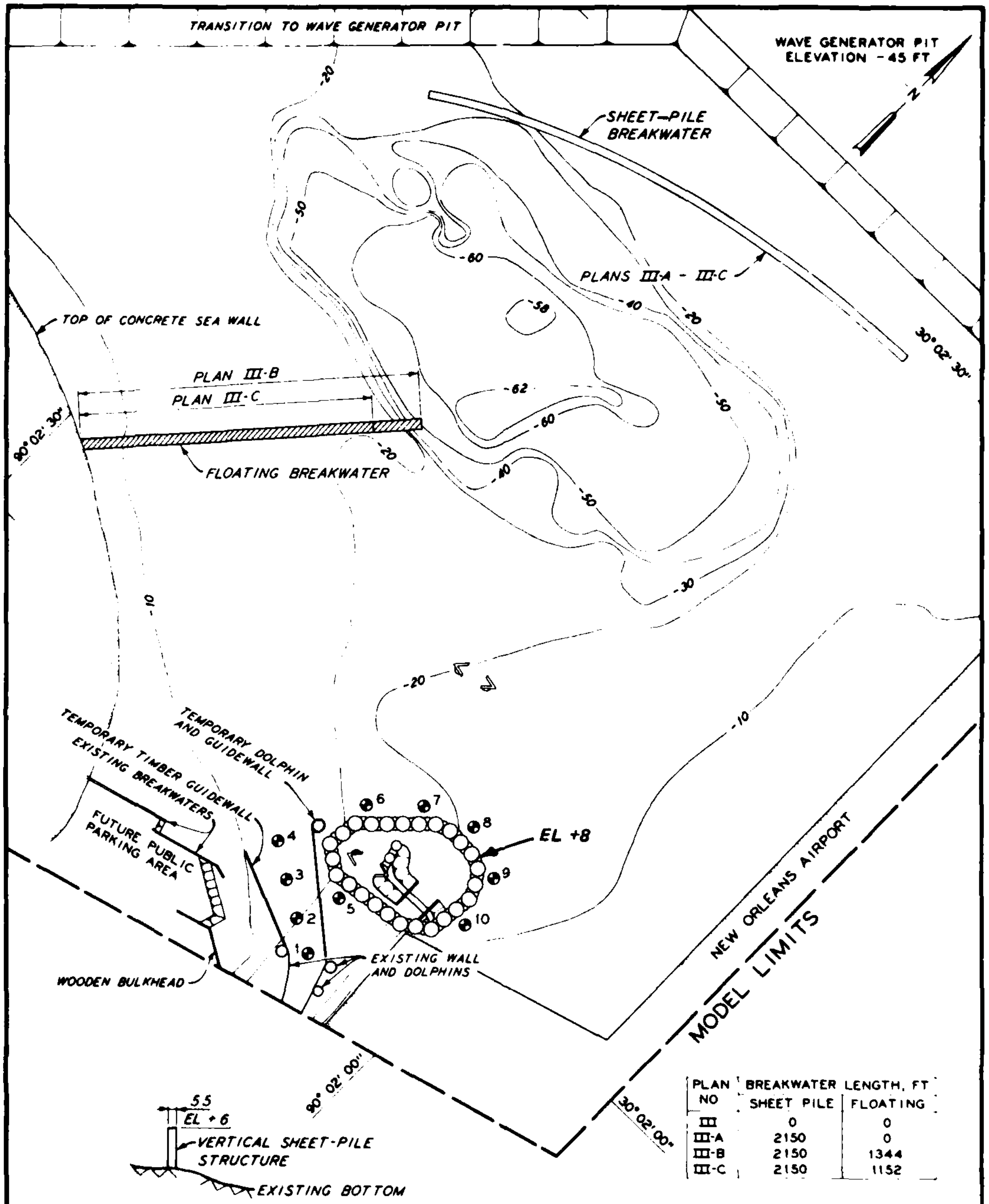
NOTE: CONTOURS AND ELEVATIONS SHOWN IN FEET REFERRED TO MEAN LOW GULF LEVEL WHICH IS 0.78 FEET BELOW MEAN SEA LEVEL

ELEMENTS OF PLANS IV - IV-D

SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 10 0 10 20



SHEET-PILE BREAKWATER CROSS SECTION

PLAN NO	BREAKWATER LENGTH, FT SHEET PILE	FLOATING
III	0	0
III-A	2150	0
III-B	2150	1344
III-C	2150	1152

LEGEND

⊕7 WAVE GAGE LOCATION AND NUMBER

NOTE CONTOURS AND ELEVATIONS SHOWN IN FEET REFERRED TO MEAN LOW GULF LEVEL WHICH IS 0.78 FEET BELOW MEAN SEA LEVEL

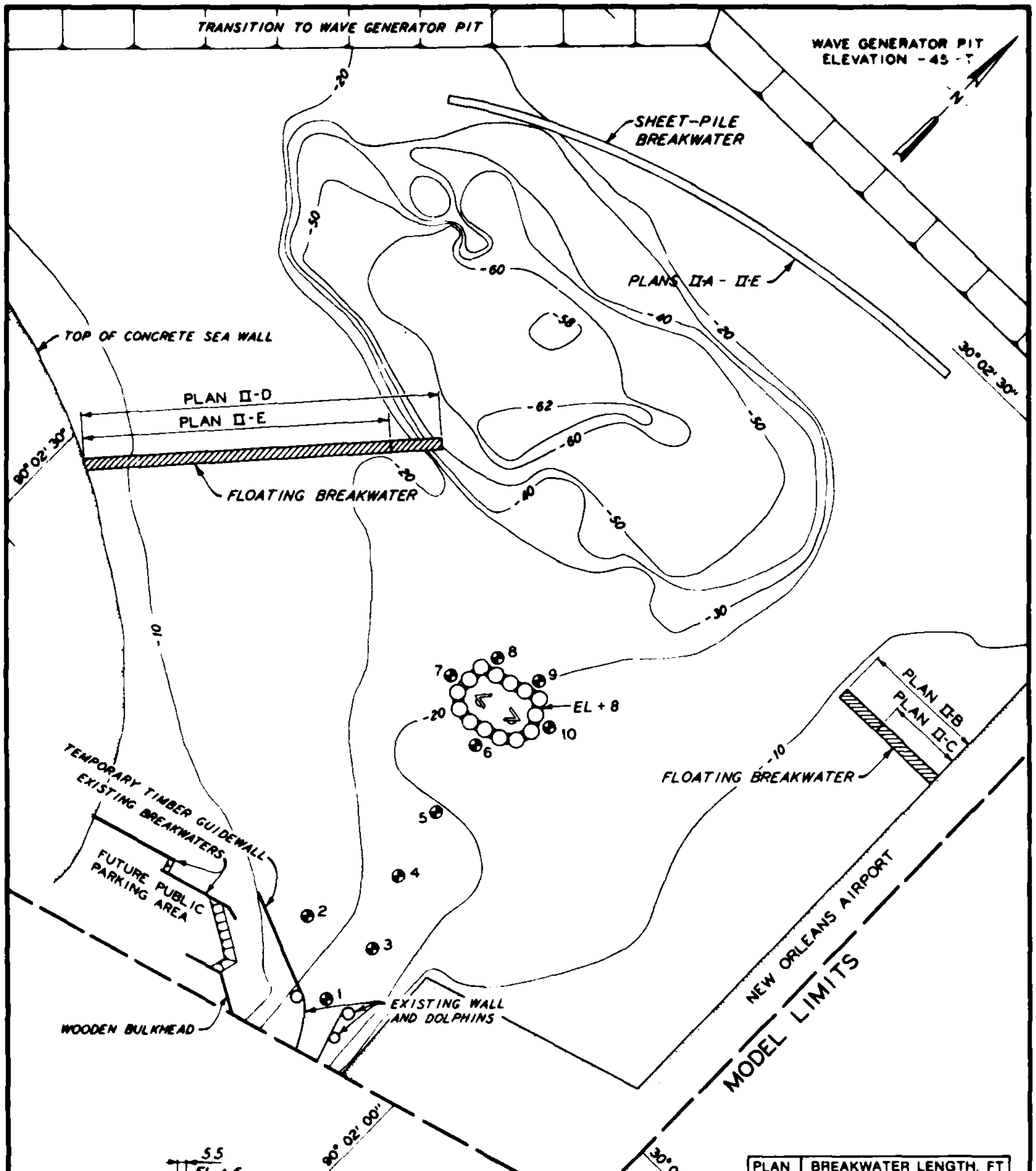
ELEMENTS OF PLANS III - III-C

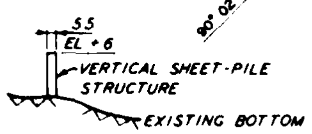
SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 10 0 10 20

PLATE 2





SHEET-PILE BREAKWATER CROSS SECTION

PLAN NO.	BREAKWATER LENGTH, FT SHEET PILE	FLOATING
II	0	0
IIA	2150	0
IIB	2150	480
IIC	2150	288
IID	2150	1344
IIE	2150	1152

LEGEND

⊕7 WAVE GAGE LOCATION AND NUMBER

NOTE: CONTOURS AND ELEVATIONS SHOWN IN FEET REFERRED TO MEAN LOW GULF LEVEL WHICH IS 0.78 FEET BELOW MEAN SEA LEVEL

ELEMENTS OF PLANS II - II-E

SCALE IN FEET

PROTOTYPE 200 0 200 400 600

MODEL 10 0 10 20

APPENDIX A: NOTATION

A	Area
b	Shallow-water orthogonal spacing
b_o	Deepwater orthogonal spacing
$(b_o/b)^{1/2}$	Refraction coefficient, K_r
H	Shallow-water wave height
H_o	Deepwater wave height
$H_{1/3}$	Significant wave height
K_r	Refraction coefficient
K_s	Shoaling coefficient
L	Length
T	Time
V	Velocity
$\forall$	Volume

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Bottin, Robert R
  Seabrook Lock Complex, Lake Pontchartrain, Louisiana; design for wave protection at a temporary entrance during various phases of lock construction; hydraulic model investigation / by Robert R. Bottin, Jr. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1980.
  27, [43] p., [2] leaves of plates : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; HL-80-8)
  Prepared for U. S. Army Engineer District, New Orleans, New Orleans, Louisiana.
  References: p. 27.

1. Breakwaters. 2. Hydraulic models. 3. Locks (Waterways). 4. Seabrook Lock Complex. 5. Water wave action on maritime structures. I. United States. Army. Corps of Engineers. New Orleans District. II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; HL-80-8.
TA7.W34 no.HL-80-8