MODEL STUDY OF PALMAS DEL MAR MARINA PUERTO RICO

The Effects Of Pier Head Baffles On Wave Heights

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MODEL STUDY OF PALMAS DEL MAR MARINA PUERTO RICO

The Effects Of Pier Head Baffles On Wave Heights

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Summary

A model study of a part of the Palmas del Mar Marina in Puerto Rico was undertaken by the NEA Hydraulic Laboratory in Reykjavik, Iceland. The study was a follow-up of a previous model study of the same marina done at the NEA Hydraulic Laboratory.

The present study was made to investigate some modifications to the previously tested marina structures. The main changes consisted of the addition of apron and baffles to pier heads for the purpose of dissipating the energy of incoming waves.

Three different sizes of baffles were tested. The results indicate that 2.5 m wide baffles placed at 5 m intervals can be effective in reducing incoming wave heights.

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1. Introduction

At the request of Dr. P. Bruun the NEA Hydraulic Laboratory in Reykjavík has conducted additional model studies of the marina planned at Palmas del Mar in Puerto Rico. This study was a follow-up of a previous study made at the NEA Laboratory a report on which was issued in September 1973. (Ref. 1).

The model tested in the present study consisted only of a portion of the previous model as shown in Fig. 1. The test section extended from the south side of the harbour approximately 200 meters to the north and from the harbour entrance about 300 meters into the harbour. The purpose of the tests was to evaluate the effects of the following modifications to the previous model:

A. Extension of the trestle pier into the harbour and a longer pier head. The pier head was the same type of structure as previously tested, but an apron was attached to the northern row of piles and a number of vertical baffles attached to the apron underneath the pier head.

B. 1) A short trestle pier was added extending into the harbour from the south shore opposite to the previous trestle pier. A short pier head, more or less parallel to the pier head on the other side was located at the end of the pier. This pier head was equipped with the same type of apron and baffles as the other pier head.

2) The short trestle pier was replaced by a rubble mound wall, but a pier head equipped with an apron and baffles as in B (1) was located at the end of the rubble mound wall.

The configuration used for the harbour entrance was that referred to as configuration A in the previous model study (see Fig. 1)

2. Model Scale and Hydraulic Similitude

The model scale used in the present study was the same as that used previously, i.e. 1:45. According to Froude's modeling law the following scale factors apply:

Geometrical scale			1:45
Velocity scale	$1:(45)^{1/2}$	=	1:6.71
Time scale	$1:(45)^{1/2}$	=	1:6.71
Area scale	$1:45^{2}$	=	1:2025
Volume scale	$1:45^{3}$	=	1:91125

3. Model Construction and Experimental Techniques.

The model layouts are shown in Figs 2-4. The model was constructed in the same manner as in the previous model study (Ref. 1). The apron and baffles on the pier heads were made from galvanized sheet iron.

Waves were produced by a pneumatic wave generator located just outside the harbour entrance. All waves measured in the tests are referred to the wave height just inside the harbour entrance. This wave height was measured at ten points over a length of 80 cm in the propagation direction. From these ten points the average wave height was calculated and used as a reference height.

4. Model Tests

All tests were conducted with waves approaching from E 20°S. As in the previous sutdy the wave characteristics investigated were the following:

Prototype			Model	
Height		Period	Height	Period
m	ft	sec	cm	sec
1.8	6.0	6	4.1	0.89
2.4	8.0	8	5.4	1.19
3.0	10.0	10	6.8	1.49

The tests were carried out at these periods as well as at periods slightly under and over those listed (± 5%).

Three sets of baffles were tested. The baffle width and spacing between baffles were as follows:

No.	Model		Prototype	
	Spacing s, cm	Width k, cm	Spacing s, cm	Width k, cm
1	10	2.5	450	112
2	20	5.0	900	225
3	11	5.5	495	248

In the first two sets the apron and baffles extended from the pier deck down about two thirds of the water depth, but in no. 3 the apron and baffles covered all the way from the pier deck down to the bottom.

Three different modifications to the previous model configuration were tested. The first two modifications were similar, with the north side trestle pier extended and a longer pier head. Another trestle pier of the same type was added from the south side extending into the harbour opposite to the other pier. A short pier head more or less parallel to the pier head on the other side was located at the end of this pier. The two pier heads thus formed a channel leading into the inner harbour. The only difference between the first two modifications was in the orientation of the north side pier head. In one position the direction of the pier head was E 29°S and in the other position the direction was E 15°S. These layouts are shown in Figures 2 and 3. All three types of baffles were tested with these two modifications. Baffle details are shown in Figure 5.

The third modification differed from the other two in that the trestle pier extending into the harbour from the south side was replaced by a rubble mound wall. The pier head at the end, on the other hand, was of the trestle type as before. The trestle piles adjacent to the east side of the syncrolift were removed leaving there a rubble mound wall, (see sheet no. 2, Ref. 1). This modification was tested only with baffle arrangement no. 3 (see above) For comparison purposes one test run was made for 8 sec. waves with aprons in place on both pier heads but no baffles. This arrangement is shown in Figure 4.

5. Discussion of Test Results

A summary of the average relative wave heights for each measuring area is presented in Table I. Some of the measuring areas in the present study correspond to measuring areas in the previous study (Ref. 1), and these are indicated with capital letters in parentheses in the table.

The test numbering system is constructed as follows. The first digit indicates whether the results were obtained in the previous model tests with the same harbour configuration (digit 0) or in the present tests (digit 1). The second digit indicates tests with the harbour configuration A of the previous model study (digit 0) or with one of the three modifications described in the last section. Thus the digit 1 indicates tests with trestle piers on north and south sides and the north pier head oriented in a direction E 29°S. The digit 2 stands for the same arrangement but with the pier head oriented in a direction E 15°S. The digit 3 is for the last modification where the south-side trestle pier was replaced by a rubble mound wall and the north pier head oriented E 15°S. The third digit indicates the baffle and apron arrangement with 0 standing for no baffles or apron, the digits 1, 2 and 3 indicating respectively the three different baffle types described in the last section, and 4 indicating tests with apron but no baffles. Finally the last digit indicates the wave period with 6, 8 and 0 standing for 6, 8 and 10 seconds respectively.

As expected comparison of results obtained in the previous model study and the corresponding results obtained in the present study (no. 000 and 100, see Table I) indicates some discrepancies. These discrepancies can be explained by the different outer boundaries of the two models. Perhaps the greatest deviation from previous results is found in measuring area 9 (S) where considerably higher waves are encountered in the present study. This phenomenon must be caused by wave reflection from the north wall of the present model.

The results in Table I show that some wave reduction is obtained with the baffles, especially with the largest ones. This is particularly true in measuring areas no. 7 and 8 where substantial reduction is found especially for the 8 sec wave. The relative wave height for this wave is seen to go from 0.32 for the previous model configuration (Test no. 1008) down to 0.18 at area no. 7 or a reduction of 44%. The fact that this reduction is the result of the baffles is clearly demonstrated by test no. 1348, where an apron was installed but no baffles. The relative wave height at area no. 7 is 0.40 compared to 0.18 with the baffles as discussed above.

Reduction of wave heights in one place by baffles brings on an increase at other places. Thus it is clear that the new configuration causes substantial increase in wave heights next to the baffles (stations 5, 11, 13 and 14, tests 1008 versus 1338).

It can be concluded therefore that the presence of baffles will reduce waves in the entrance channel to the inner harbour (stations 7 and 8).

References

1. Viggósson, G. and Erlendsson B.: Report on a Model Study of Palmas del Mar Marina. Prepared for the Palmas del Mar Company, San June, Puerto Rico. The National Energy Authority Hydraulic Laboratory, Reykjavík, Iceland, September 1973.

Table I. Results of model test runs

Wave direction for all test runs: E 20°S. Measuring areas are shown in Figs. 1 – 4.

Test nn.	Baffles		Apron	Pier head direction	Measuring area no.														
	Spacing s,cm	Width k,cm			1 (B)	2 (E)	3 (G)	4 (F)	5	6 (T)	7 (U)	8 (V)	9 (S)	10	11	12	13	14	15
0006	No baffles		No	–	1.00	0.57	0.21	0.28		0.09	0.21	0.25	0.14						
1006	No baffles		No	–	1.00	0.57	0.13	0.38	0.25	0.07	0.27	0.12	0.21	0.33	0.28	0.16	0.27	0.17	0.26
1116	450	112	Yes	E 29°S	1.00	0.56	0.10	0.39	0.21	0.11	0.29	0.14	0.19						
1126	900	225	Yes	E 29°S	1.00	0.57	0.12	0.44	0.23	0.12	0.28	0.14	0.20						
1336	495	248	Yes	E 15°S	1.00	0.60	0.12	0.44	0.27	0.15	0.26	0.10	0.12	0.24	0.16	0.04	0.24	0.20	0.05
0008	No baffles		No	–	1.00	0.46	0.20	0.36		0.12	0.25	0.09	0.09						
1008	No baffles		No	–	1.00	0.62	0.23	0.52	0.46	0.11	0.32	0.12	0.22	0.37	0.52	0.22	0.23	0.16	0.31
1118	450	112	Yes	E 29°S	1.00	0.61	0.22	0.51	0.45	0.14	0.33	0.10	0.23						
1218	450	112	Yes	E 15°S	1.00	0.59	0.21	0.52	0.42	0.12	0.31	0.11	0.22						
1128	900	225	Yes	E 29°S	1.00	0.63	0.20	0.52	0.47	0.12	0.31	0.09	0.19						
1138	495	248	Yes	E 29°S	1.00	0.60	0.22	0.53	0.42	0.09	0.20	0.09	0.18						
1238	495	248	Yes	E 15°S	1.00	0.60	0.13	0.55	0.44	0.12	0.17	0.07	0.17						
1338	495	248	Yes	E 15°S	1.00	0.57	0.18	0.53	0.57	0.20	0.18	0.07	0.11	0.51	0.54	0.07	0.45	0.36	0.18
1348	No baffles		Yes	E 15°S	1.00	0.65	0.23	0.56	0.60	0.12	0.40	0.20	0.15	0.51	0.71	0.05	0.23	0.32	0.18
0000	No baffles		No	–	1.00	0.91	0.26	0.60		0.28	0.39	0.18	0.05						
1000	No baffles		No	–	1.00	0.65	0.26	0.69	0.48	0.17	0.41	0.21	0.49	0.35	0.46	0.28	0.41	0.26	0.17
1110	450	112	Yes	E 29°S	1.00	0.60	0.23	0.64	0.47	0.12	0.33	0.16	0.36						
1330	495	248	Yes	E 15°S	1.00	0.65	0.22	0.66	0.59	0.09	0.37	0.19	0.22	0.47	0.58	0.09	0.41	0.20	0.10

The last digit in the test no. indicates wave period with 0 standing for 10 sec wave. The first digit of 0 indicates results obtained in previous model study and 1 indicates results of the present study. The second digit indicates model configuration, 0 is configuration A of previous study and 1,2,3 indicate the three different configurations of the present study. The third digit indicates baffle types with 0 standing for no baffles or aprons, 1,2,3 indicate the three different baffle sizes, and 4 indicates a test with aprons installed but no baffles.

Letters in parentheses refer to measuring areas in previous model study corresponding to measuring areas of the present study.

NEA HYDRAULIC LABORATORY	22/5'74 BE/AV
REYKJAVIK, ICELAND	Tnr. 26
PALMAS DEL MAR MARINA, PUERTO RICO	ORS-4
MODEL STUDY, SCALE 1:45	Fnr. 11784

0 50 100m

Scale 1:2000

Fig. 1

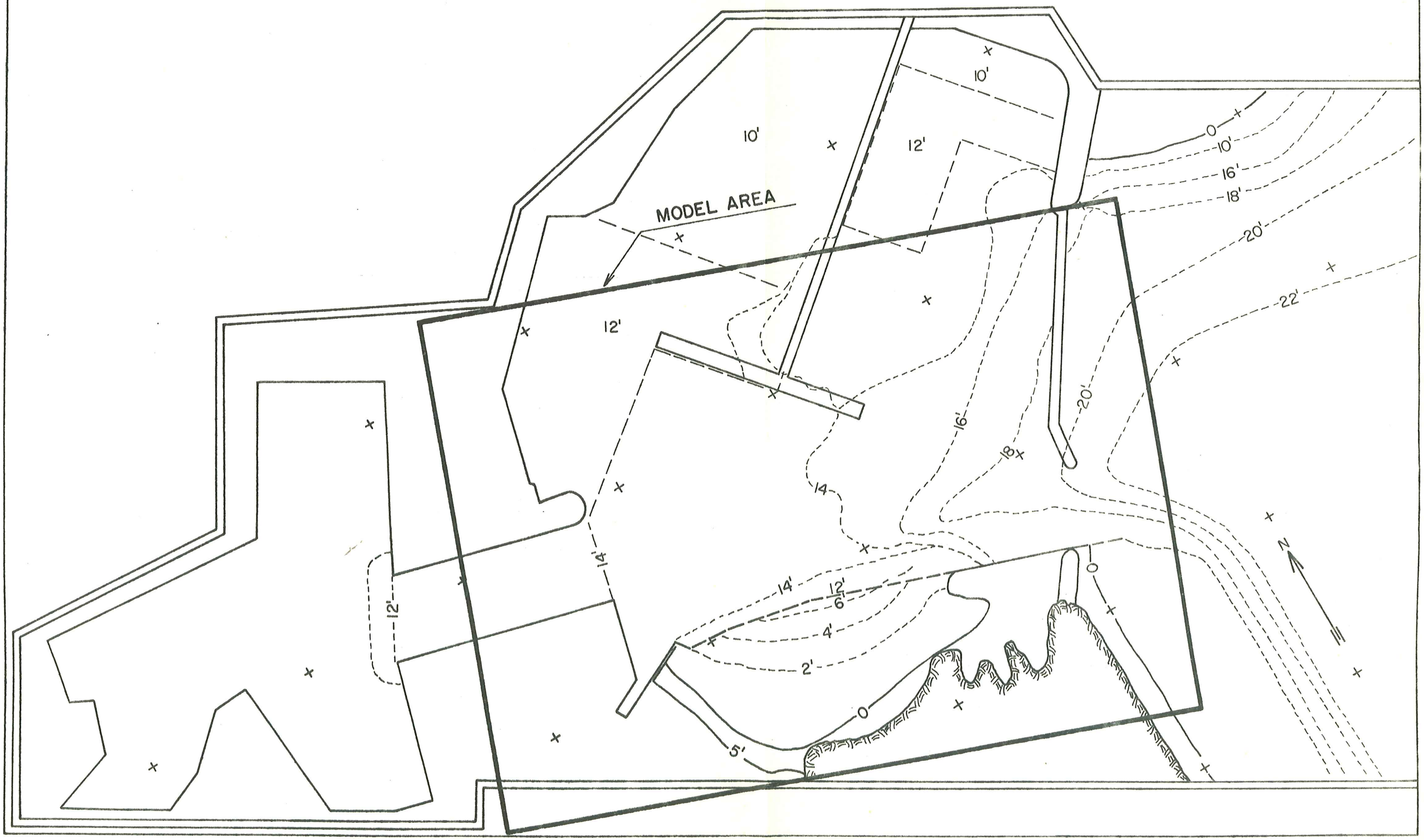
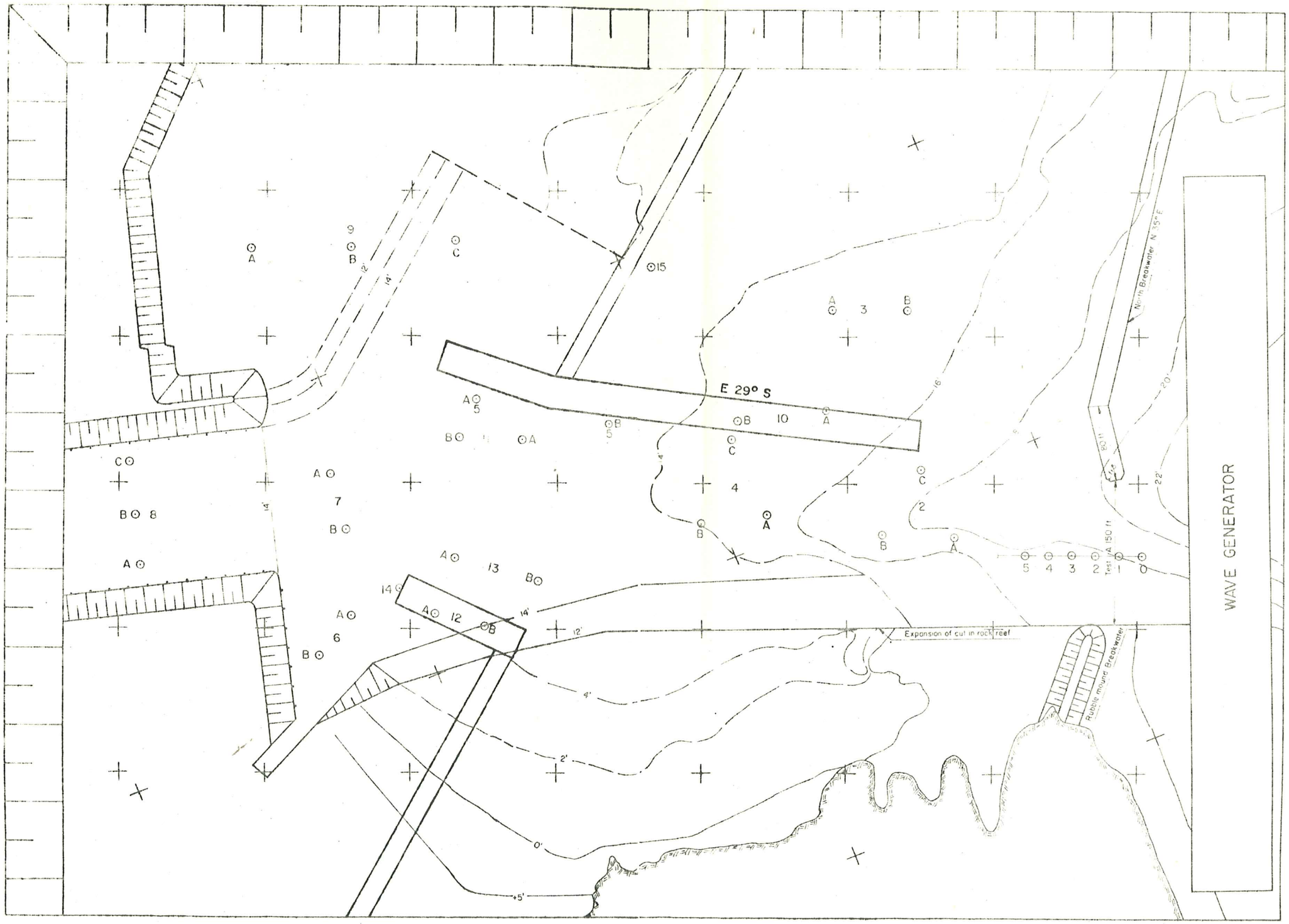


Fig. 2



0 10 20 30 40 50 60m
Scale 1: 1250

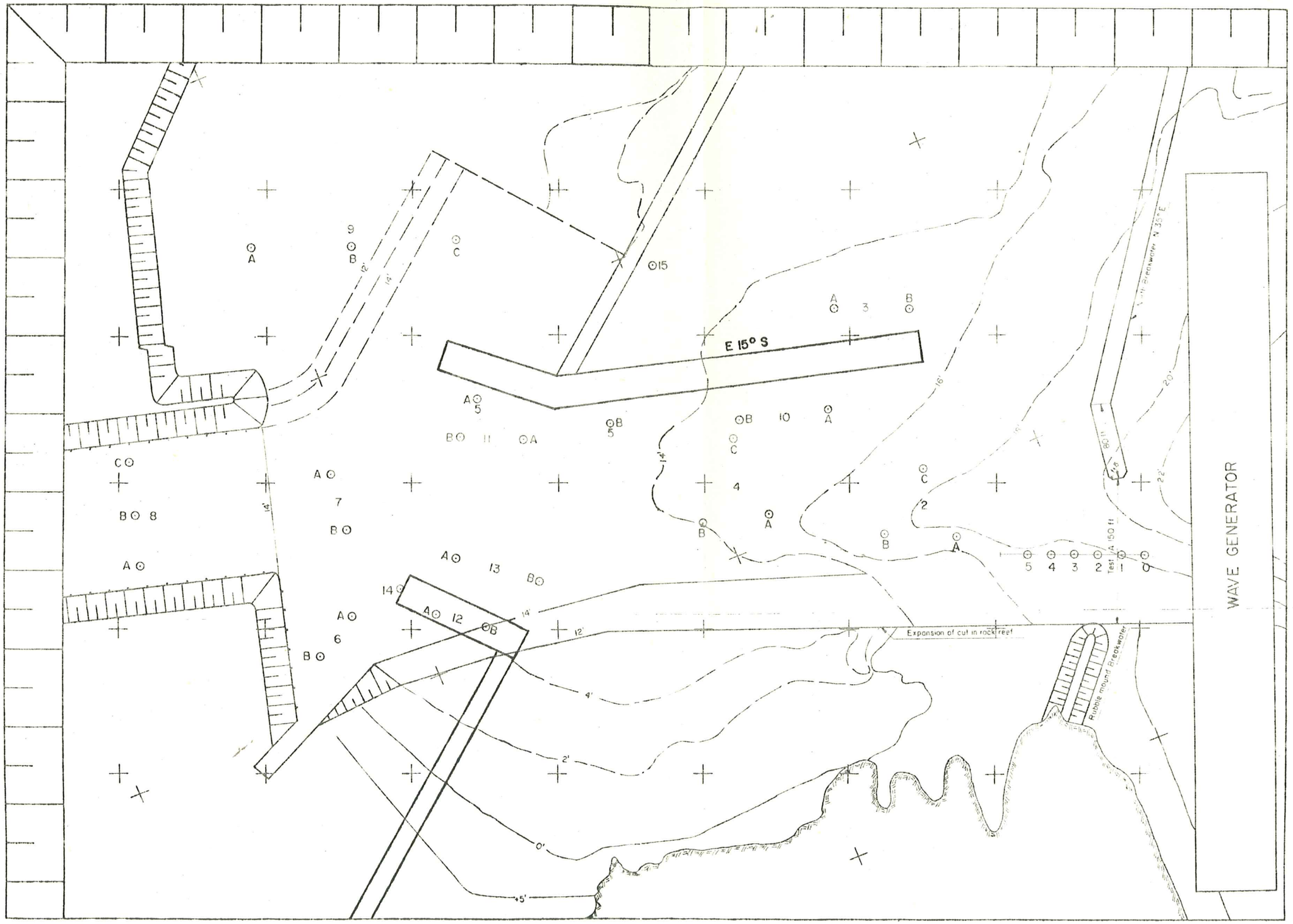
0 0,5 1,0 2,0m
Model scale 1:45
Sounding in feet

PALMAS DEL MAR MARINA
LAYOUT OF MODEL STUDY

NEA HYDRAULIC LABORATORY
REYKJAVIK ICELAND

CHKD by BE	Date April 1974	Fnr. 11749
Drawn by AV	ORS 4 / Tnr 26	

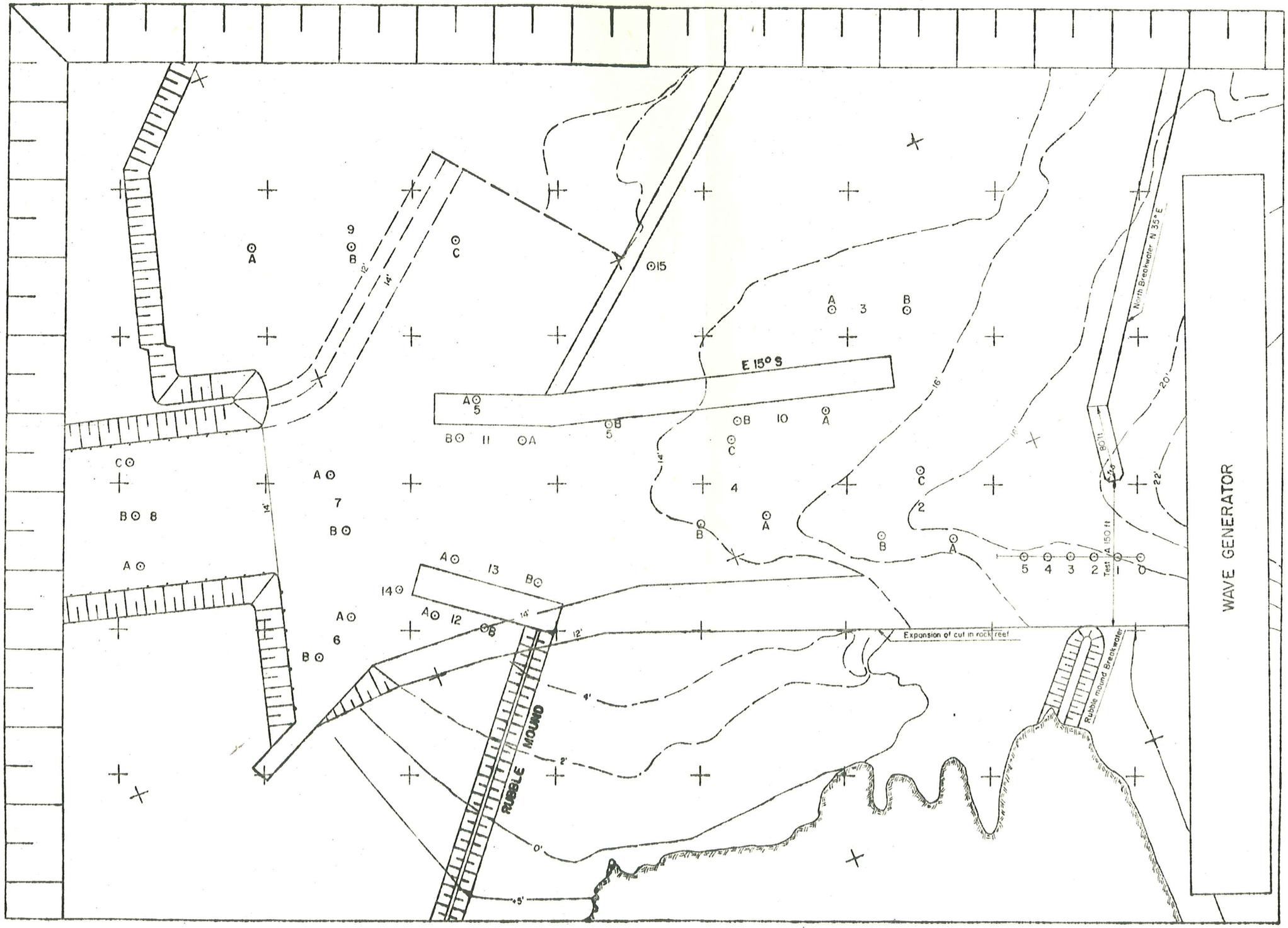
Fig. 3



PALMAS DEL MAR MARINA
LAYOUT OF MODEL STUDY
NEA HYDRAULIC LABORATORY
REYKJAVIK ICELAND

CHKD by BE	Date April 1974	Fnr. 11749
Drawn by AV	ORS 4 / Tnr. 26	

Fig. 4



0 10 20 30 40 50 60m
Scale 1:1250

0 0.5 1.0 2.0m
Model scale 1:45
Sounding in feet

PALMAS DEL MAR MARINA
LAYOUT OF MODEL STUDY

NEA HYDRAULIC LABORATORY
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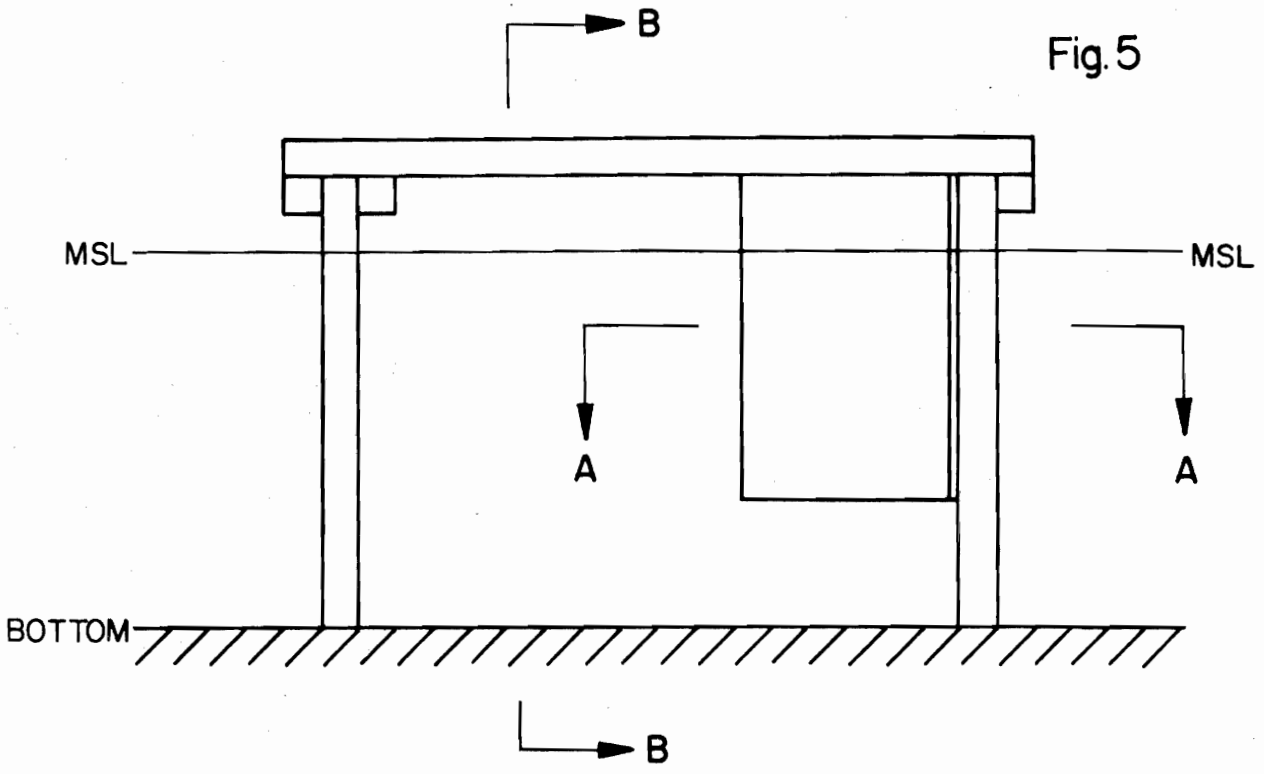
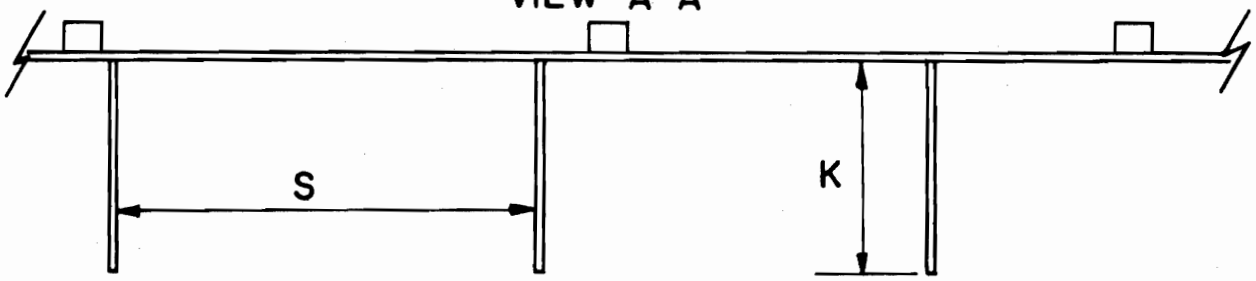
CHKD by BE	Date April 1974	Fnr. 11749
Drawn by AV	OR5 4 / Tnr. 26	

PALMAS DEL MAR MARINA, PUERTO RICO	MAY '74 BE/AV
MODEL STUDY	Tnr. 27
BAFFLES AND APRON ARRANGEMENTS FOR	ORS. 4
CONFIGURATION NO3, SCALE 1:2	Fnr. 11801

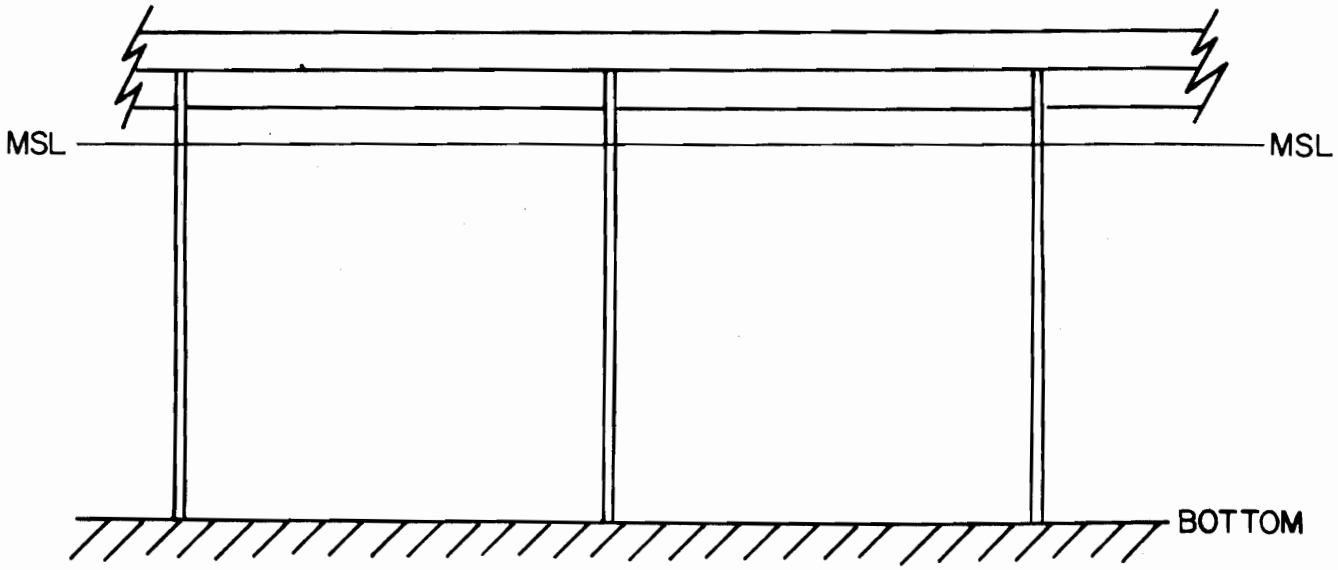
Fig. 5



VIEW A-A



VIEW B-B



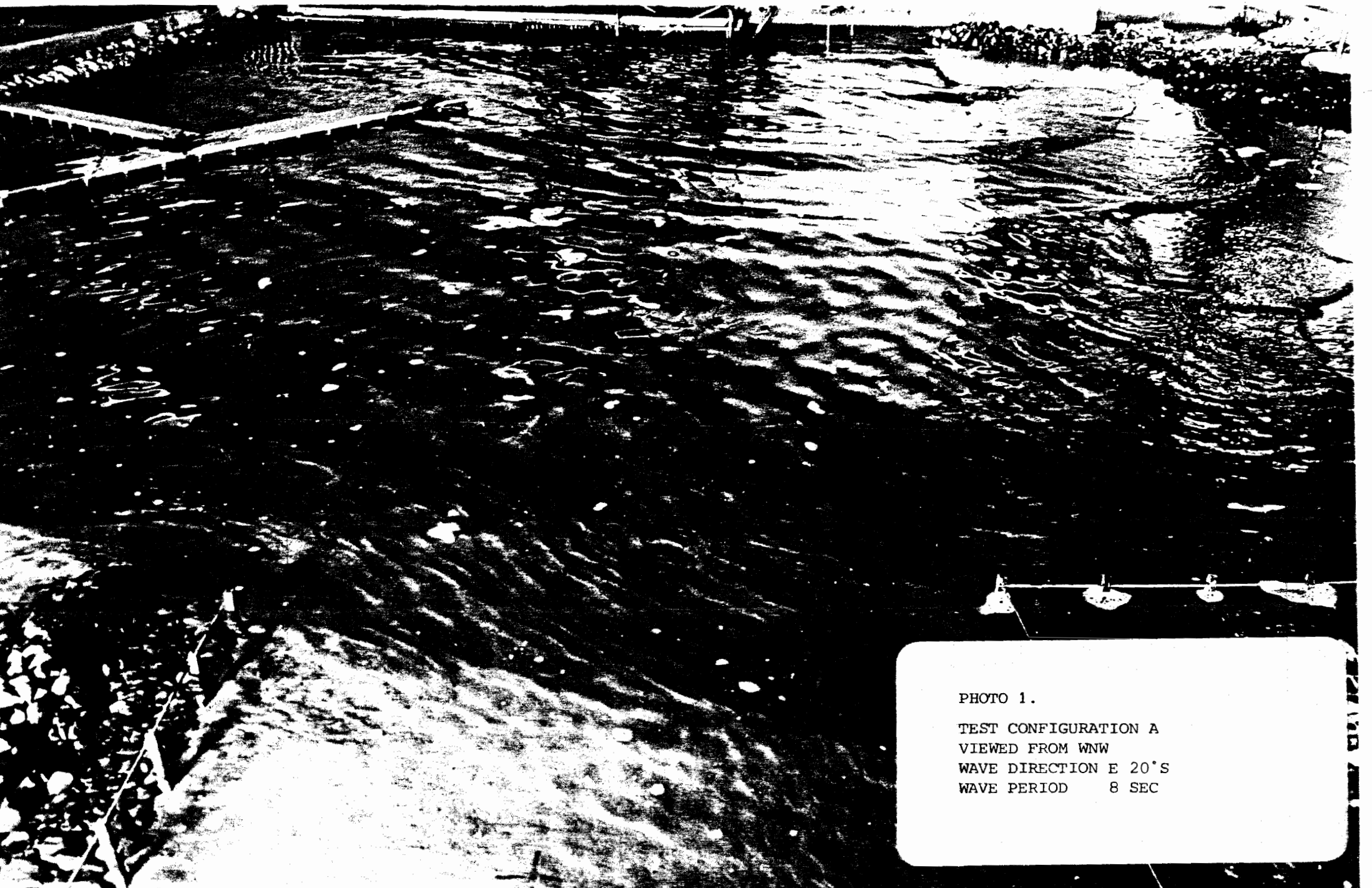


PHOTO 1.

TEST CONFIGURATION A
VIEWED FROM WNW
WAVE DIRECTION E 20°S
WAVE PERIOD 8 SEC

PHOTO 2.

TEST CONFIGURATION 3
VIEWED FROM WNW
WAVE DIRECTION E 20°S
WAVE PERIOD 85 SEC

PHOTO 3.

TEST CONFIGURATION A
VIEWED FROM SOUTH
WAVE DIRECTION E 20° S
WAVE PERIOD 8 SEC

PHOTO 4.

TEST CONFIGURATION 3
VIEWED FROM SOUTH
WAVE DIRECTION E 20°S
WAVE PERIOD 8 SEC