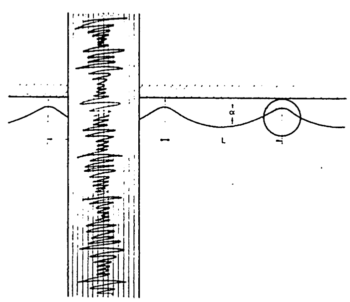
ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN
ANN ARBOR

MODEL STUDIES FOR HARBOR OF REFUGE FOR LIGHT DRAFT VESSELS AT BLACK RIVER HARBOR, GOGEBIC COUNTY, MICHIGAN, FOR THE MICHIGAN STATE WATERWAYS COMMISSION

by

E. F. Brater and L. D. Stair



Technical Report No. 7
Lake Hydraulics Laboratory
Department of Civil Engineering

June 1955

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Project 2289

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ABSTRACT

At the request of the Michigan State Waterways Commission a project was initiated for the purpose of determining the most effective breakwater arrangement for Black River Harbor, Gogebic County, Michigan. A scale model of the harbor area was constructed, including provision for simulating the discharge of the Black River. Storm wave characteristics were computed from wind records for three selected wind directions. Corresponding model waves were generated and projected on the harbor area. The degree of protection afforded by a series of breakwater arrangements was noted and two arrangements were selected for intensive study. Model wave heights and currents were measured and sedimentation characteristics were observed during a series of tests on the selected plans and their modifications. The studies resulted in the recommendation of three nearly equally effective breakwater arrangements for use at the Black River site.

INTRODUCTION

It is proposed to construct a harbor of refuge for light draft vessels at the mouth of the Black River where it empties into Lake Superior. The location is shown in Figure 1.

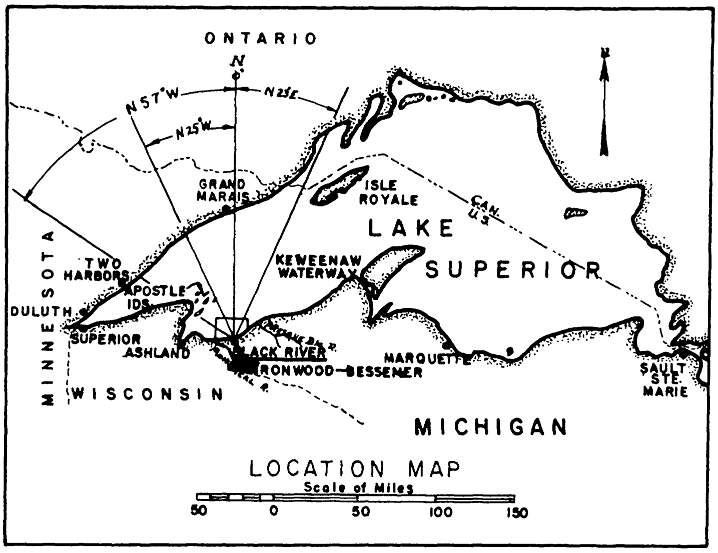

Figure 1. Location map.

The primary purpose of the model study is to design the breakwater system and to determine the relative effectiveness of various breakwater arrangements in protecting the harbor area from wave action. A secondary consideration is the determination of the tendency toward sedimentation exhibited by the breakwater systems. The results of the testing program in conjunction with economic considerations of the various plans, are to be used to provide the basis for the selection of the most suitable breakwater arrangement for the Black River Harbor.

The study was made as the result of a contract between the University of Michigan Engineering Research Institute and the Michigan State Waterways Commission dated August 1, 1954. The tests were conducted in the University of Michigan Lake Hydraulics Laboratory.[1]

[1] The University of Michigan Lake Hydraulics Laboratory is a facility of the Engineering Research Institute and the Department of Civil Engineering of the College of Engineering.

Mr. George W. Koronski, Vice Chairman of the Michigan State Waterways Commission visited the laboratory at various stages of the work. His cooperation and suggestions were most helpful in planning the testing program. Mr. Thomas L. Lott, Chairman, and Mr. Fred Lifton, Acting Director of the Waterways Commission, and Mr. Lattimer of the Commission staff, also visited the laboratory.

PROTOTYPE CONDITIONS

Existing facilities for the mooring of fishing and pleasure craft are located in the mouth of the Black River. Because of the narrow opening of the river and the distance between the mooring area and the lake opening there is partial protection from wave action. Additional protection from storms resulting from northwesterly winds is afforded by the Apostle Islands which reduce the fetch from this direction to approximately 25 miles. Entrance into the river is difficult once the storm from any direction has reached much intensity because of the shoal water opposite the river mouth.

Bottom soundings indicate the presence of rock from 4 to 20 feet below the lake floor, thus limiting the amount of dredging that may economically be performed and restricting the construction of the breakwaters to the rubble-mound type.

High bluffs extending east and west along Lake Superior show marked signs of erosion and are a source of detritus which accumulates in such quantities that it must be removed from time to time from the east bank of the river opening. The river drains from a wooded upland area through a deep rocky gorge. The erosion of the gorge does not appear to be of recent origin. Therefore, except during spring freshets the river flow is relatively low and free of sedimentary material.

TEST CONDITIONS

The basic wave data were prepared from records of wind velocity and duration occurring at the Keweenaw Waterway, approximately 85 miles to the east of the harbor location. Computations for deep water wave periods and amplitudes were based on the Sverdrup-Munk curves.[2,3]

[2]"Wind Waves and Swell, Principles in Forecasting," U.S. Hydrographic Office Publ. Misc. 11275, 1943.

[3]R. L. Weigel, "Bulletin of the Beach Erosion Board," Special Issue No. 1, 1948.

Wave refraction diagrams were constructed for three wind directions using the direct orthogonal method.[4] The directions selected included a quadrant from North 57° West to North 23° East at the extremes with a middle direction of North 25° West. The fetches corresponding to these wind directions were 25 miles for the North 57° West direction, 70 miles for the North 25° West direction, and 140 miles for the North 23° East direction. The directions are shown on the location map drawing and the refraction diagrams appear in Appendix C. Refraction of the waves for directions more easterly and westerly than the limiting directions chosen cause the waves to approach the harbor from substantially the same direction as those which were selected as representative of storm conditions. As a consequence the three directions mentioned above were used for test purposes.

A smaller wave size than that computed by the Sverdrup-Munk curves for the fetches given above was also used in testing the breakwater arrangements. The smaller wave size was selected to represent the condition that would commonly exist when small craft were entering the harbor prior to the storm reaching full intensity. This size wave also permitted comparison of harbor arrangements under conditions of no overtopping of the breakwaters by storm waves in order to measure better the diffraction effects of the waves entering the harbor mouth. A summary of the wave characteristics used in the testing program is given in Table I.

TABLE I

DEEP WATER WAVE CHARACTERISTICS

Wind Direction	Wave Period, seconds	Wave Length, feet	Wave Amplitude, feet
	Large Wave		
North 57° West	3.8	74	7.0
North 25° West	5.2	139	10.5
	5.2	139	9.0
North 23° East	5.4	149	11.0
	Small Wave		
All directions	3.4	59	4.5

Low water datum for Lake Superior is 601.6 feet above mean tide at New York. Throughout the tests the crests of the breakwaters were set 7 feet

[4] Johnson, O'Brien, and Isaacs, "Graphical Construction of Wave Refraction Diagrams," U.S. Hydrographic Office Publ. No. 605.

above low water datum and the lake stage was held at 602.6. Thus the crests of the breakwaters were 6 feet above the still water surface of the lake.

In the absence of data regarding the discharge of the Black River, a study was made of the adjacent river basins, the Montreal and the Presque Isle, to estimate the maximum, mean, and minimum daily discharges that might be expected to occur annually on the Black River. Records were available for the Montreal River at Saxon, Wisconsin, for the years 1938 to 1951 and for the Presque Isle River at Tula, Michigan, for the years 1944 to 1950. These rivers exhibited similar characteristics when the discharges were reduced to cu ft per second per square mile. It was therefore assumed that typical maximum, mean, and minimum discharges could be estimated by applying discharges per unit of area for these adjacent streams to the drainage area of the Black River. The values determined were 2600, 270, and 45 cfs, respectively. The tests for the determination of wave heights and surface currents were made with the model river discharge at its mean value. Tests that were made to determine sedimentation characteristics were conducted utilizing all three discharges in conjunction with a major storm wave.

MODEL REPRODUCTION OF PROTOTYPE CHARACTERISTICS

The model was constructed in a tank having the dimensions 90 by 54 feet. An undistorted linear scale of 1:75 was used. The regularity of the topography permitted the reproduction of the lake bottom in the model by bending 1/4-inch tempered masonite strips to conform to the contour locations. Contours were reproduced at 6-foot intervals of depth commencing with the low water datum plane. The soundings were supplied by the U.S. Army, Corps of Engineers. The size of the tank and the model scale selected permitted the reproduction of depths to the 42-foot contour. A plan view of the wave tank and template layout is shown in Figure 2.

The area between the contours was filled with well-compacted sand to within an inch of the ultimate bottom surface. The remaining inch was filled with cement mortar and shaped by screeding the cement between adjacent contours. A thin layer of cement topping was troweled to compensate for shrinkage of the cement during placement and permit a uniform surface finish to be obtained. Photographs of the model under construction are shown in Figures 3 and 4.

The accuracy of the model was checked during construction by means of an engineer's level. An additional and more delicate check was made by filling the tank to the lake stages corresponding to the contour intervals and noting the agreement between the contours and the corresponding shore lines.

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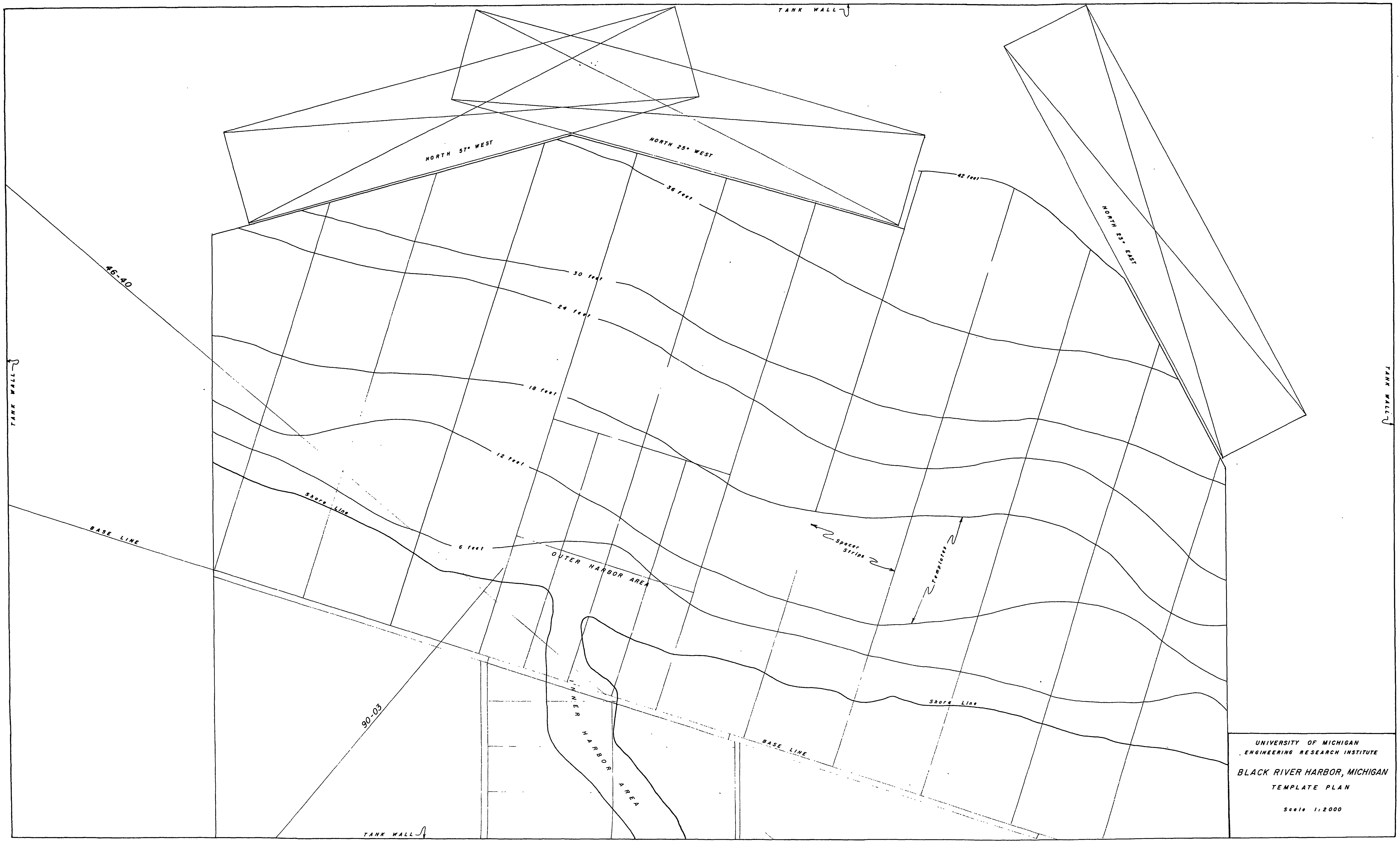


Figure 2. Plan view of model and templates.

Figure 3. Templates and sand in place.

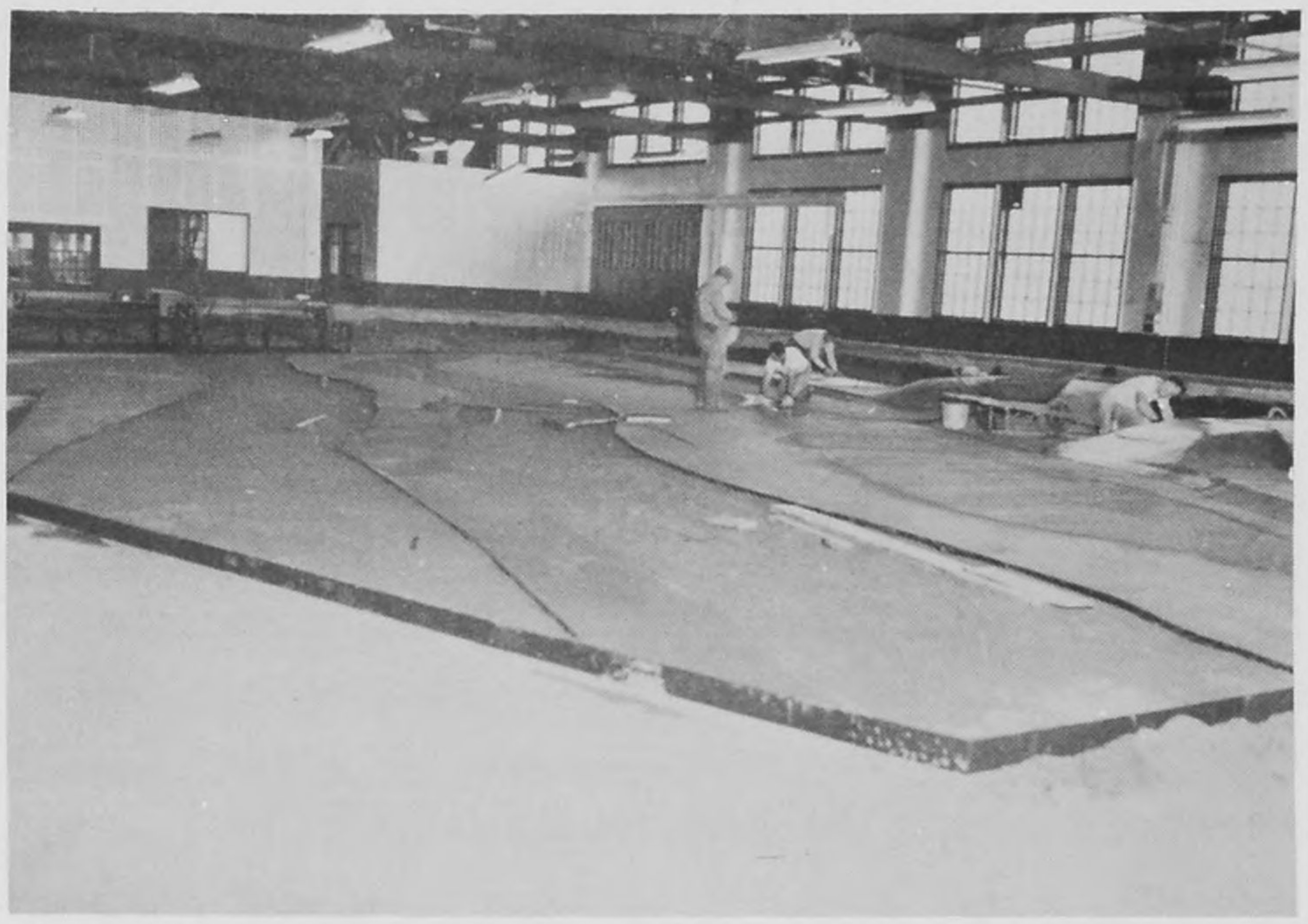


Figure 4. Troweling the cement bottom.

The waves were generated by means of a plunger-type wave machine, utilizing a plunger 30 feet in length. The wave machine is shown in Figure 5. The amplitude and period of the plunger were adjusted to produce waves with the desired characteristics. The wave machine, being portable, was shifted as required to simulate the various wave directions tested.

The river flow was reproduced by pumping water over a broad-crested weir into a section of river channel upstream of the harbor location. To prevent changing of the lake stage while the river was flowing, the water was simply circulated, using the tank as the source of water. The discharge of the pump was calibrated volumetrically to produce the river discharge desired.

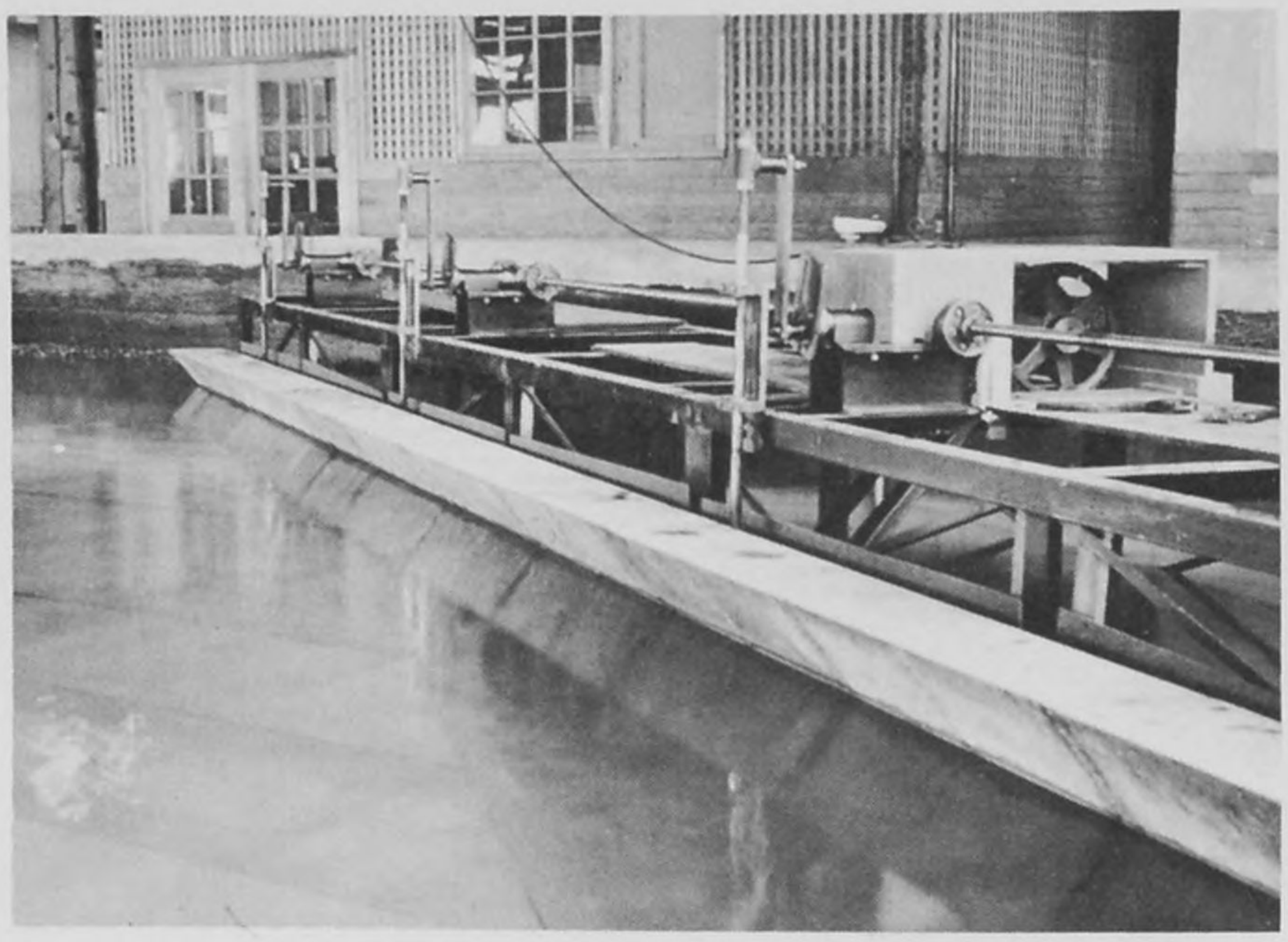


Figure 5. The wave generator.

The lake stage was checked by means of a hook gage mounted on the wall of the tank. Any lowering of the water surface elevation due to evaporation or leakage was made up prior to the running of the tests. Surface currents were measured by timing the movement of small wooden floats with reference to coordinate lines painted on the model.

Wave heights were measured by the use of electric resistance gages which vary an impressed voltage as contacts are shorted because of the rising and falling of the water surface. The changing voltage was then amplified in a cathode-follower-type amplifier and recorded on an oscillograph. The output of the amplifier was simultaneously passed through a full wave-rectifying filter circuit having a long-time constant and recorded on an oscillograph. The recording equipment is shown in Figure 6.

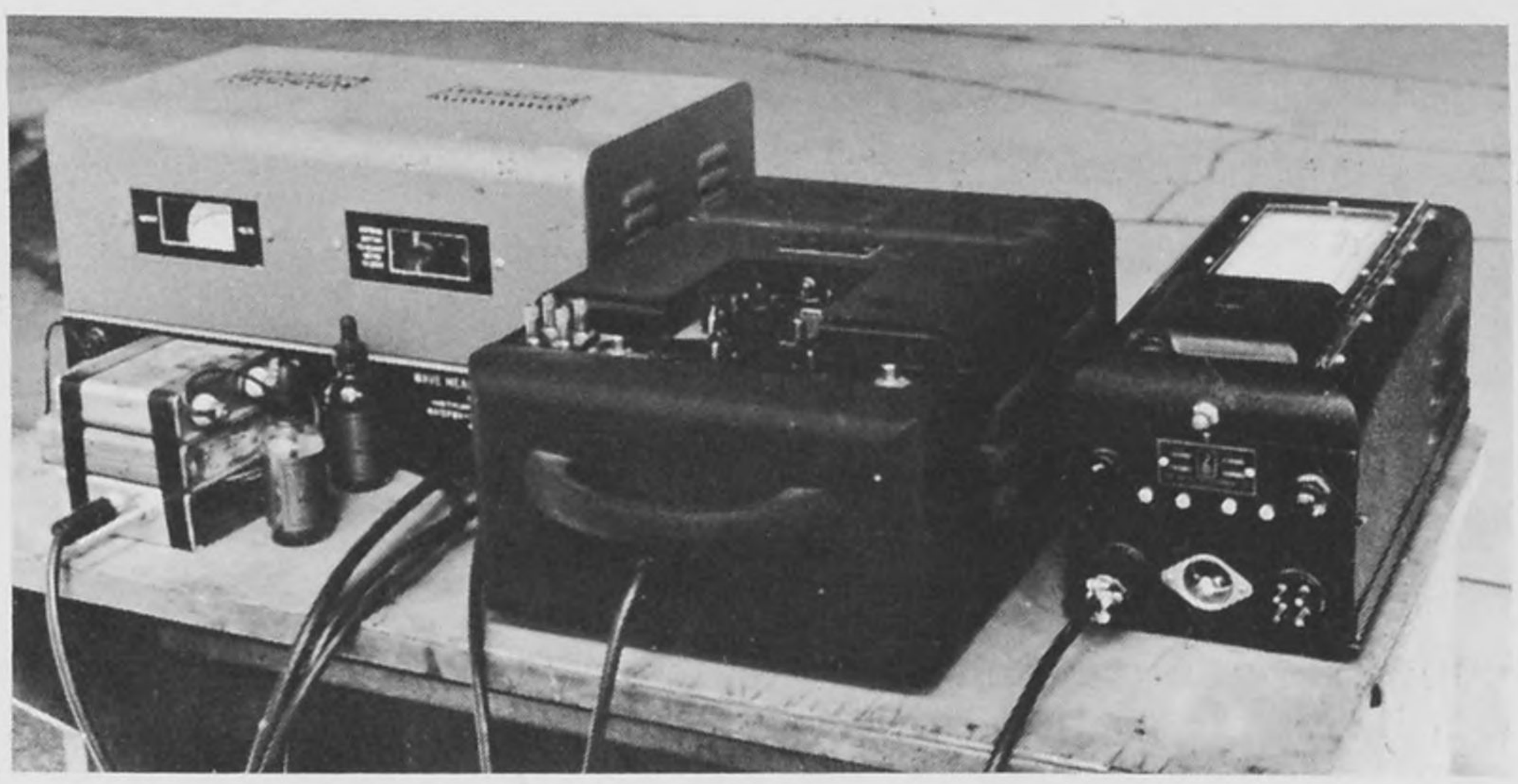


Figure 6. Wave recording equipment.

A significant wave height for each point was obtained by either calculating the average of the upper third of the waves passing the location or by adjusting the time constant of the filter circuit to give a corresponding average. The filter circuit average was checked by the alternate method for all doubtful values since certain refinements that are required have not as yet been incorporated into the system.

To study the possible areas of sedimentation and to plot the longshore currents set up by wave action in the vicinity of the various breakwater arrangements, an expanded mica material of small particle size was introduced into the model. The material was presoaked causing it to become slightly heavier than the water but still allowing it to be moved readily by the small currents generated in the model. The purpose of introducing this material was to obtain a picture of the relative strength and direction of the bottom currents in various locations for each of the wind directions tested. The areas of sedimentation as shown on the model drawings are regions of small bottom currents wherein sedimentation of the model occurred and wherein it is believed a corresponding tendency toward sedimentation will occur in the prototype.

THE TESTING PROGRAM

A series of preliminary observations were made by using portable, segmented breakwaters and arranging them in many feasible locations. For the more promising arrangements, the effect of minor variations in breakwater length and orientation was also determined. No quantitative measurements were made during these preliminary tests. The wave conditions in the mooring areas and harbor entrance were evaluated visually. By the process of refinement and elimination two designs, which were both effective and relatively economical, were chosen for intensive study. These plans were designated as Plans 1 and 2. Two modifications of Plan 2, Plans 2a and 2b, were also tested. These plans and modifications are shown in Figure 7.

Each of these plans had the harbor opening to the northwest with an overlapping easterly breakwater. The opening to the northwest was in the direction of the minimum fetch and the corresponding minimum wave amplitude. The overlapping easterly breakwater provided protection against the higher waves generated by the more easterly storms. The frequency of occurrence of major storms originating to the northwest is somewhat greater than for the northeast wind direction but it was felt that the greatly reduced fetch from this direction offset this disadvantage.

Plan 1 had the largest overlapping of the breakwaters to keep the size of the waves entering the harbor to a minimum. Turning room was provided

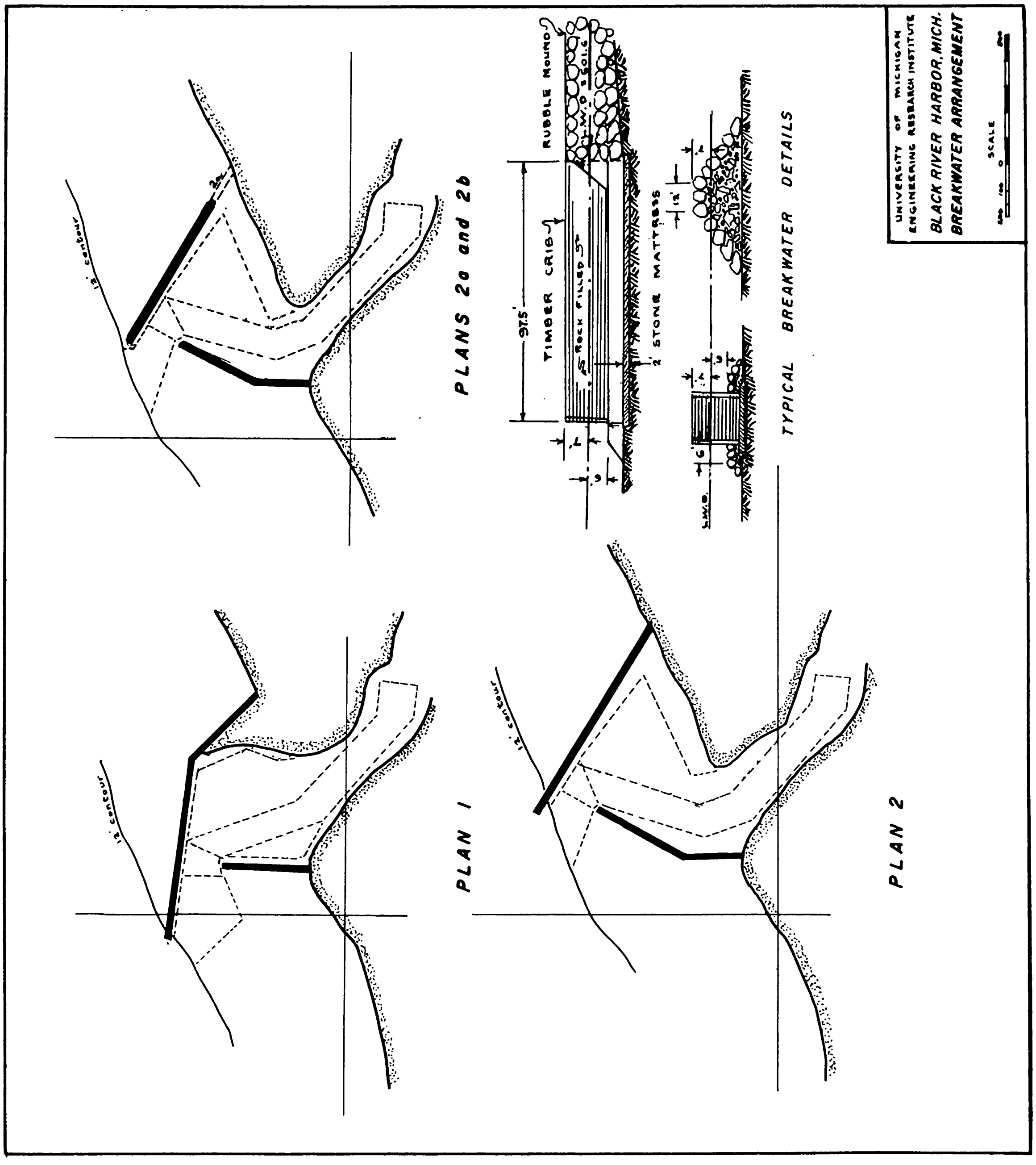


Figure 7. Breakwater arrangements.

beyond the harbor opening behind the shelter of the easterly breakwater to facilitate harbor entrance of approaching small craft.

Plan 2 was a modified arrowhead breakwater design arranged to give more freedom in the direction of approach to harbor entrance. This breakwater arrangement permitted larger waves to enter the harbor, but the breakwaters were positioned to give as smooth an entering wave as was possible. The harbor opening was shifted eastward to provide the maximum use of the diffraction "shadow zone" in protecting the harbor mooring area. Provision was made for a much larger beach to be used for the dissipation of wave energy that was allowed to enter the harbor.

Each of the plans was tested for the three major wind directions with both the large and the small wave to facilitate comparison of their performance. Additional observations were made of Plan 1 for storm waves approaching from a more westerly direction than North 57° West and of Plan 2 for intermediate directions to determine if these additional directions would give worse conditions than the standard wind directions. No such evidence was noted and as a consequence, data were taken only for the standard directions.

In testing Plan 2 for the wind direction North 25° West it was noticed that some breaking of the large wave was taking place beyond the harbor opening. An intermediate wave size was therefore observed for this direction to make certain that a somewhat smaller but nonbreaking wave would not give worse conditions inside the harbor than the standard wave size. The test showed that no significant change in wave height within the harbor occurred.

After the completion of testing Plan 2, two modifications of this plan were tested. These modifications were designated as Plans 2a and 2b. Plan 2a was similar to Plan 2 except that 50 feet were removed from the deep water end of the westerly breakwater and the easterly breakwater translated a similar distance westward. The projection of the easterly breakwater beyond the westerly breakwater tip was kept the same distance as for Plan 2. Plan 2b was identical to Plan 2a except that 150 feet of the shoreward end of the easterly breakwater were removed. The lengths and volumes of the breakwaters for the various plans are tabulated in Table II.

TABLE II

BREAKWATER DIMENSIONS

	Plan 1	Plan 2	Plan 2a	Plan 2b
Length of breakwater, ft	1,350	1,425	1,300	1,150
Volume of rubble mound, cu yd	23,000	23,000	20,000	19,000
Volume of dredging, cu yd	33,000	28,000	27,000	27,000

PRESENTATION OF RESULTS

All the data obtained from the tests are presented graphically in Appendix A. Photographs which were taken of each plan for the large wave condition for each wind direction are shown in Appendix B.

In Appendix A, the drawings of the various plans are grouped together according to the wind direction of the storm wave condition for which the tests were conducted. Test results indicating the heights of the waves in the vicinity of the harbor for the large and small waves are presented first, followed by the surface current drawings and sediment studies.

The wave-height drawings were prepared by measuring the height of the waves at selected locations and interpolating between adjacent locations to locate contours of equal wave height. The locations at which the wave heights were measured are shown on the drawings by means of arrows which also indicate the direction of wave propagation at the point in question. The spacing of the measuring stations varied and was smallest in regions of the largest change in wave height. To assist in evaluating the drawings those areas having a wave height of less than 1-1/2 feet have been cross-hatched. The amount of harbor area having a wave height less than 1.0 foot was determined for each plan and the values are tabulated in Table III.

TABLE III

HARBOR AREA (SQ FT) IN WHICH WAVE HEIGHT WAS LESS THAN 1.0 FOOT

	Plan 1	Plan 2	Plan 2a	Plan 2b
Wind North 57° West	219,000	204,500	196,000	196,000
Wind North 25° West	214,500	210,000	186,000	186,000
Wind North 23° East	247,000	164,000	164,000est	164,000est

The magnitude and direction of the surface current velocities in and around the harbor were shown on the drawings by the use of arrows. The lengths of the arrows were made proportional to the velocities according to the scale indicated on the drawings. The paths followed by the floats were shown as dashed lines. In some locations these paths showed variation with time and the paths may be seen to converge or cross.

The data for the longshore and bottom currents were taken initially by providing a thin layer of expanded mica over the model area and observing the movement of the material. Once the direction of transport was ascertained additional material was provided at the upstream end of the longshore current until the movement of the material in the model appeared to have reached a state of equilibrium. The longshore currents were shown by arrows to indicate their direction and assigned a line weight estimated to be proportional to their velocity. At the time the movement of the material appeared to be in equilibrium the area of deposition was noted, the confines being indicated on the drawings by a finely cross-hatched series of lines. No quantitative evaluation can be given to these hatched areas. They simply indicate the regions where there will be a tendency toward deposition in the prototype. The actual area of hatching depended to some extent on the manner in which movable material was introduced into the model. It should be noted that areas of deposition for one wind direction may be regions of scour for another wind direction. An evaluation of the test results for all three wind directions gives the best indication of the regions where deposition is most likely to occur.

ANALYSIS OF RESULTS

For all wind directions Plan 1 gave excellent protection from wave action for the mooring area located in the river and provided a quiet area in the outer harbor area beyond the river mouth. For no wind direction did the wave height in the outer harbor exceed 1-1/2 feet except just inside the harbor opening. The maximum wave obtained in the harbor opening was approximately 2.5 feet high and was caused by the North 57° West wind direction.

For one direction, North 23° East, the surface currents were quite strong across the entrance channel. For other wind directions the velocities were not excessive.

A minor tendency for sedimentation to occur in the harbor opening was noted during the times when northwest storms and low river discharges coincided. During higher river discharges for this and other storm directions this deposition was scoured into the lake. For all other conditions tested no material was noted entering the harbor. A general tendency for shoaling occurs for all wind directions on the shoreward side of the entrance channel.

Plan 2, and its modifications, gave excellent protection from wave action to the mooring area in the river for all wind directions. Although somewhat higher waves occurred in the outer harbor there is room for the expansion of facilities in a quiet zone beyond the river mouth. Waves up to 6 feet in amplitude were present in the harbor opening, the worst condition being for the North 23° East wind direction. However, waves from all wind directions lower than a breaking condition entered the opening in a smooth fashion, free of secondary wave patterns. For no direction were the surface currents induced by wave action excessive for Plan 2 or its modifications.

No material was noticed entering the harbor mouth to produce sedimentation for any combination of conditions tested for either Plan 2 or 2a. For Plan 2b sedimentation occurred in the 6-foot dredged area for all river discharges from each wind direction, entering the opening between the shoreward end of the easterly breakwater and the shoreline.

CONCLUSIONS

The model studies showed that Plans 1, 2, and 2a would provide very effective harbors. Plans 2, 2a, and 2b gave such similar results insofar as wave protection is concerned that any one of them could be used as a basis for comparison with Plan 1. Plan 2b showed undesirable sedimentation characteristics which would eliminate it from consideration. Plan 2a is more economical than Plan 2 because of the decreased breakwater length. The lengths and volumes of the breakwater as well as the volume of dredging required for each plan are shown in Table II. Shown in Table III are the harbor areas provided by each plan for the three wind directions in which the wave height was less than 1.0 foot. Some of the factors which might be used to evaluate the relative effectiveness of the plans are tabulated in Table IV. The more effective plan for each factor is given the value (1) and the less effective one is assigned the value (2).

Plan 1 was somewhat better for four of the factors, and Plans 2 and 2a had some advantages in the other five. If each of the factors is given the same weight, these plans must be considered equally effective for practical purposes. Any one of these plans would provide a good harbor for Black River. Selection of the plan to be constructed should be determined by the estimated cost of construction and by other criteria which may be of importance to the users of the harbor.

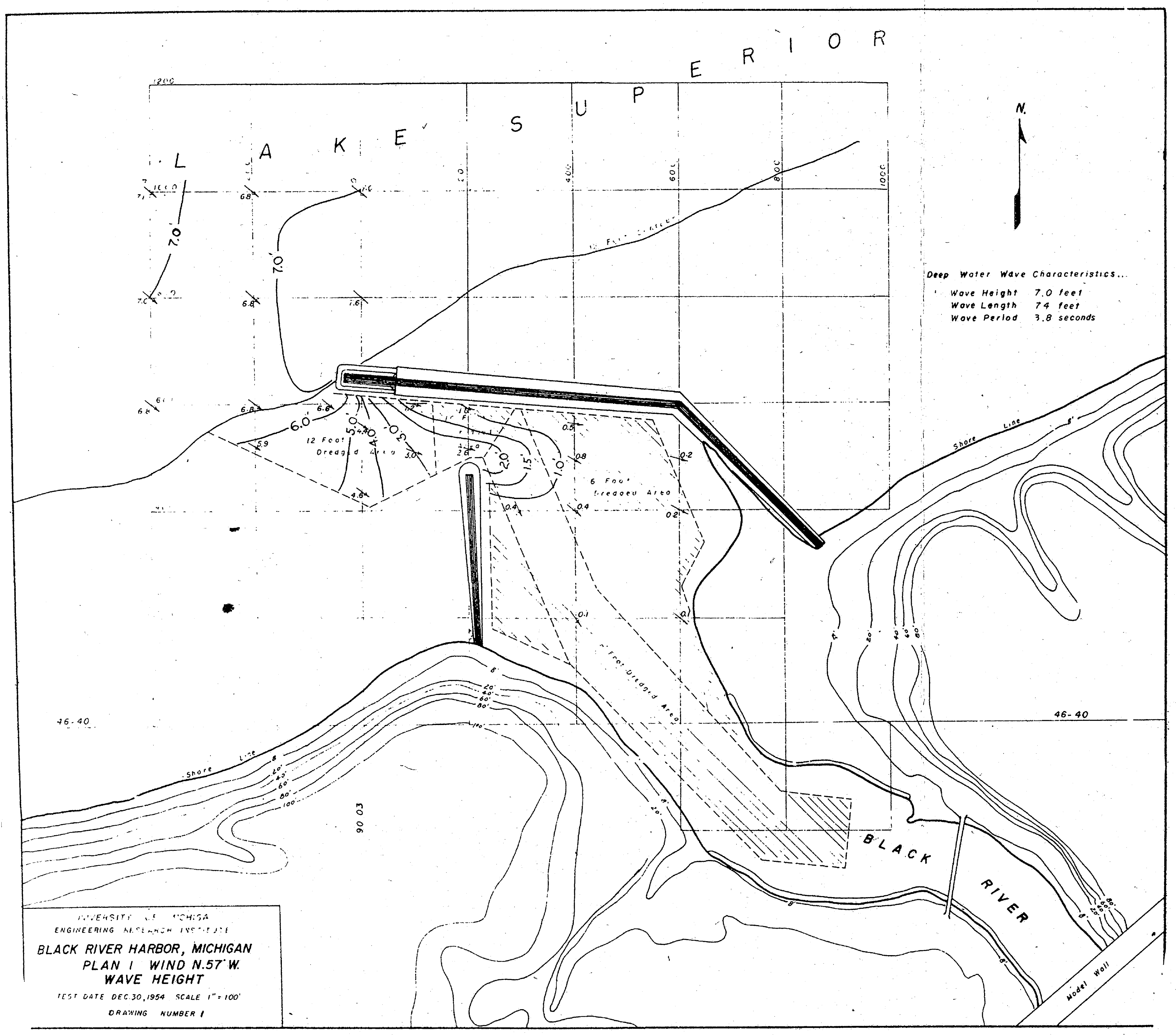
TABLE IV

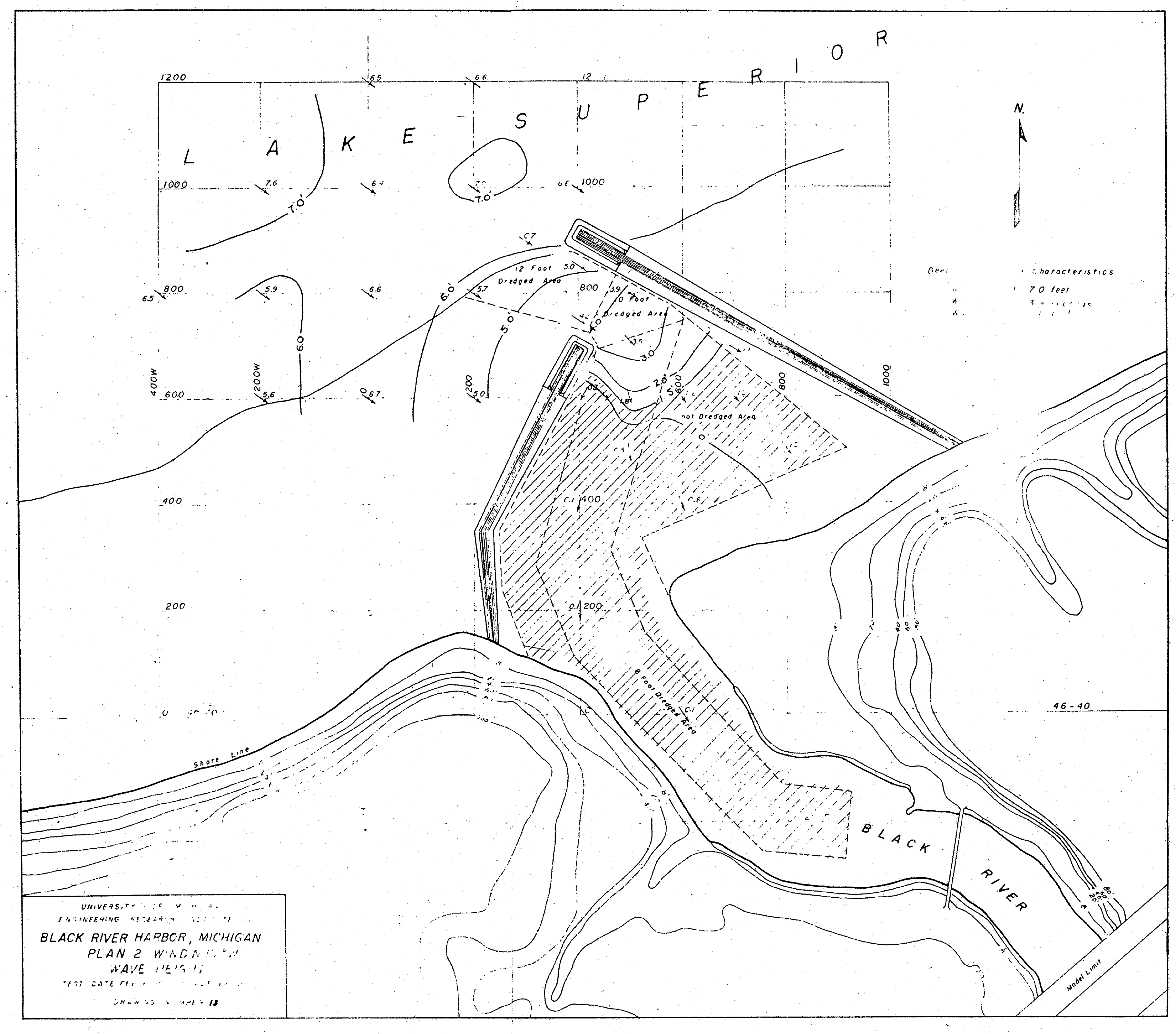
COMPARISON OF PLANS

Weighting Factors	Plan 1	Plan 2 or 2a
Wave height in the mooring area	1	2
Total size of mooring area	1	2
Wave height in outer harbor area	1	2
Wave height in the harbor opening	1	2
Ease of approach to harbor opening	2	1
Smoothness of wave entering harbor	2	1
Sedimentation in harbor area	2	1
Sedimentation seaward of breakwaters	2	1
Surface currents in entrance channel	2	1

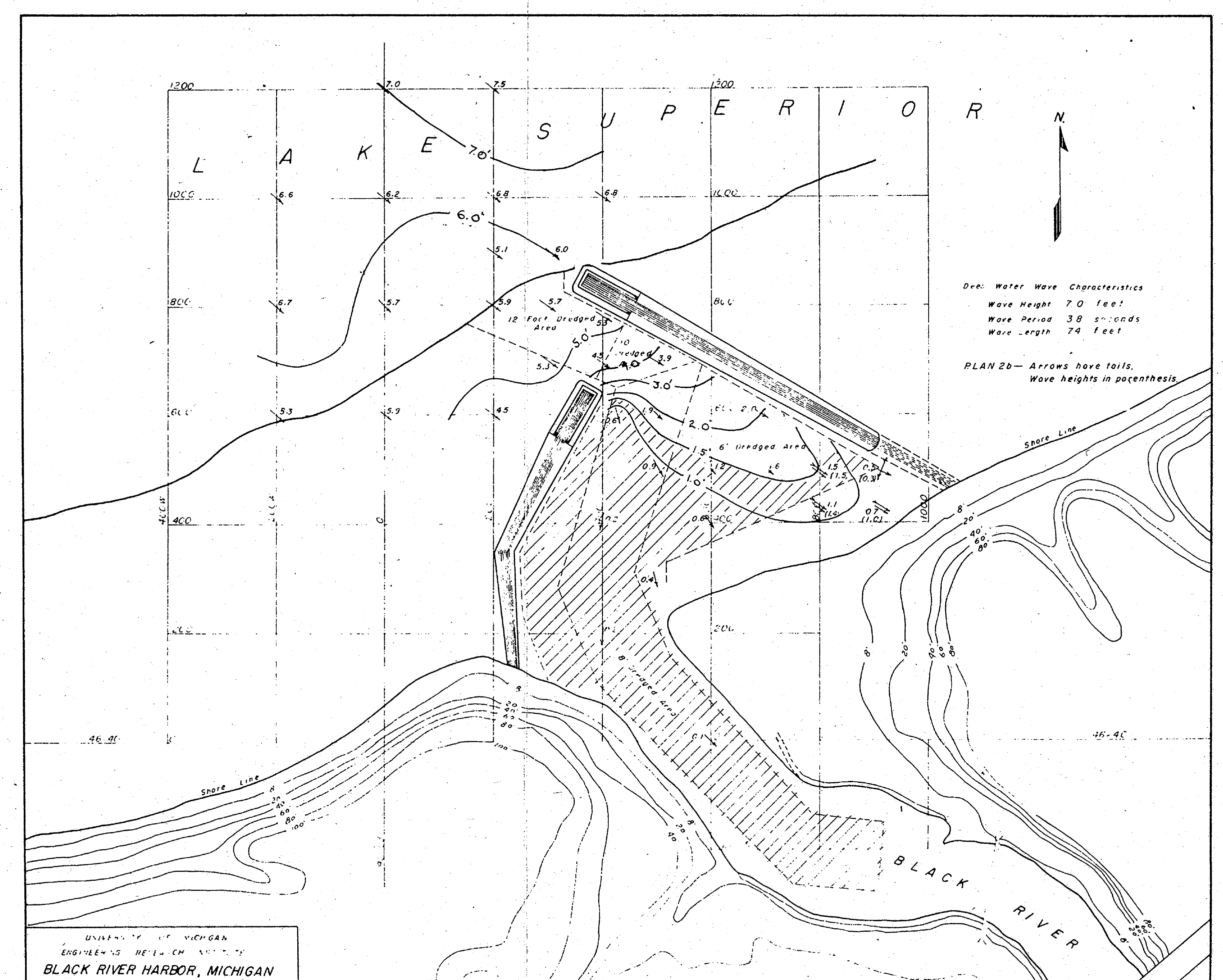
APPENDIX A

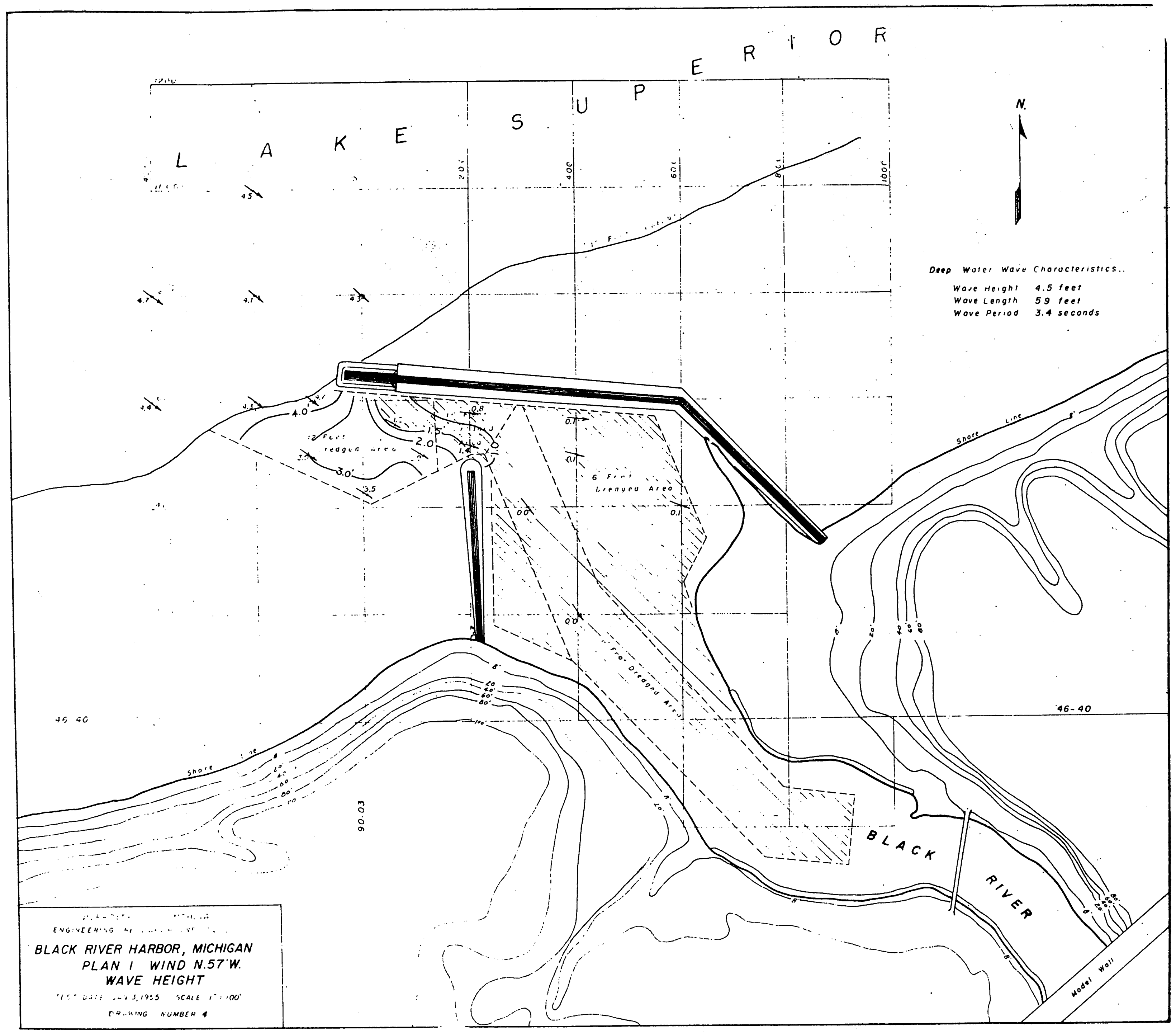
DRAWINGS SHOWING TEST DATA

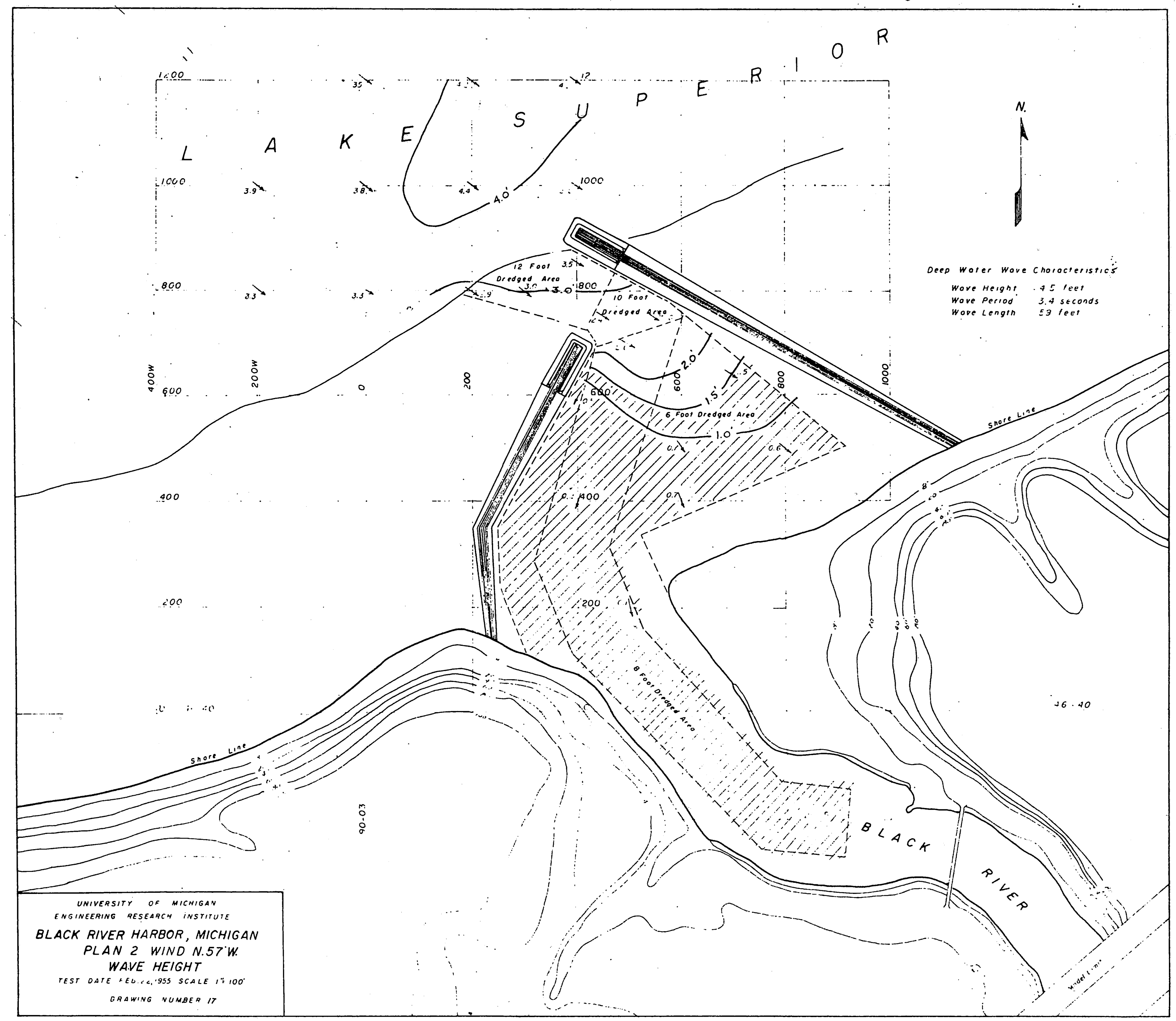




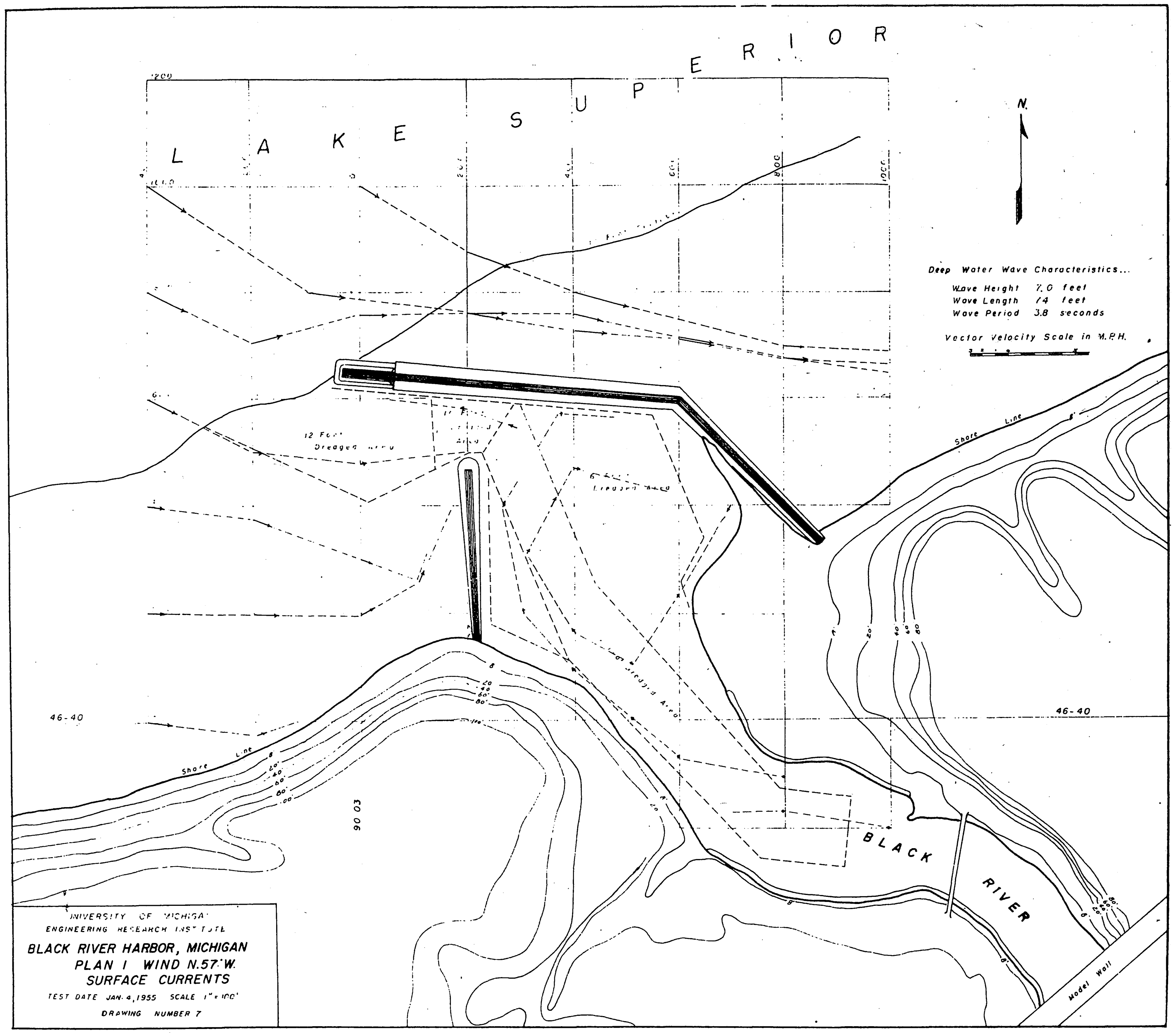
Wind North 57° West
Large Wave

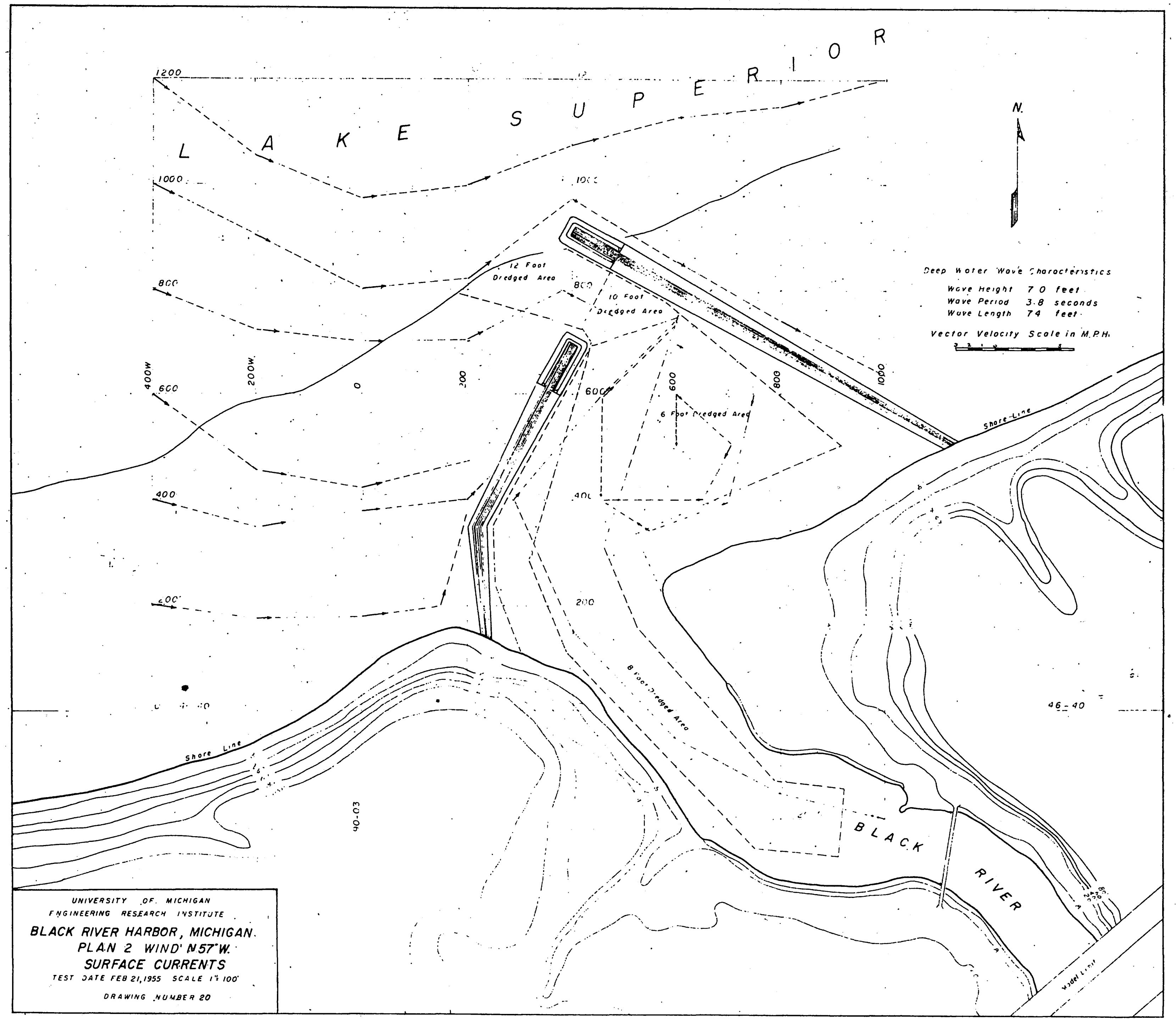




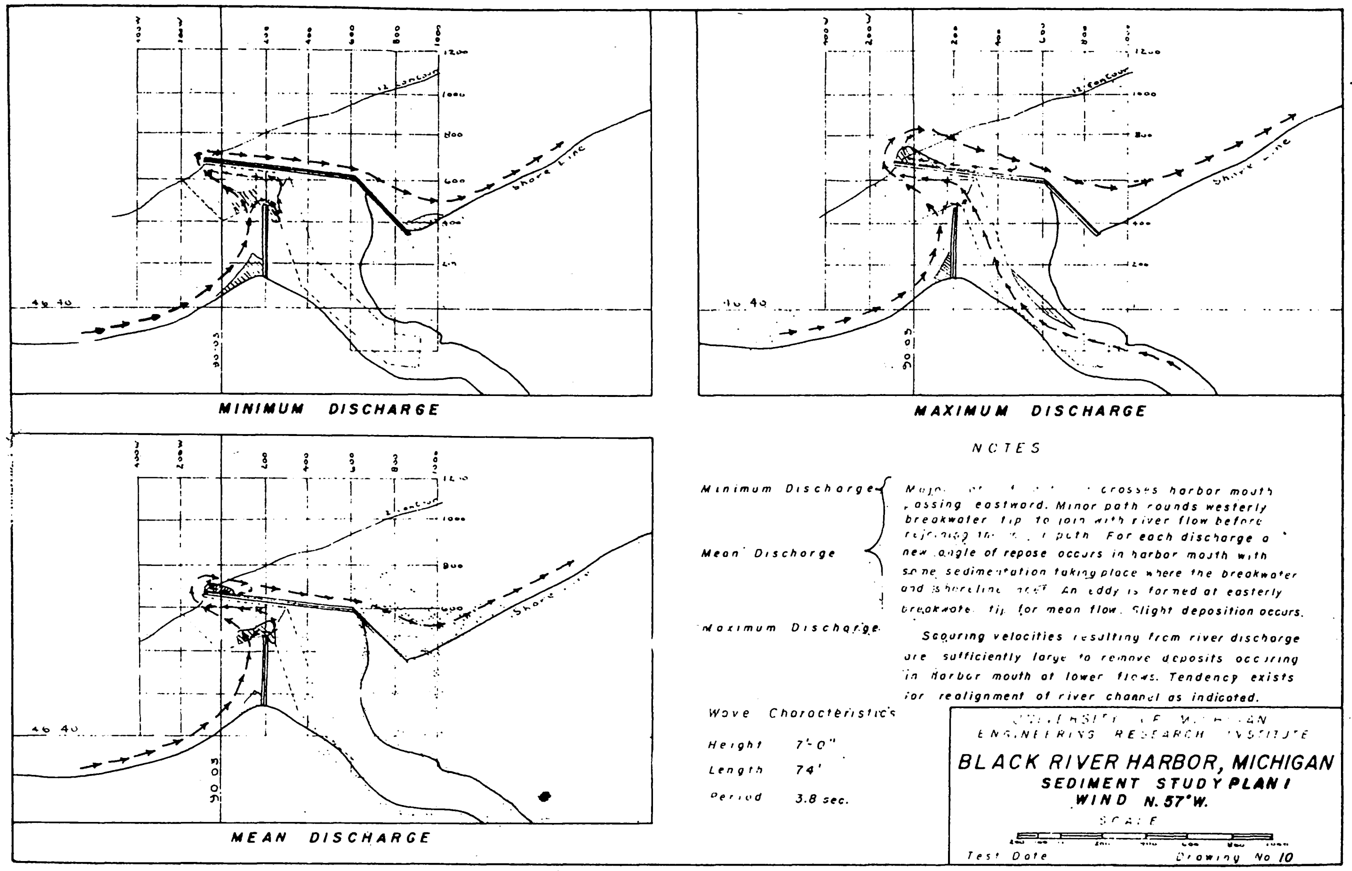


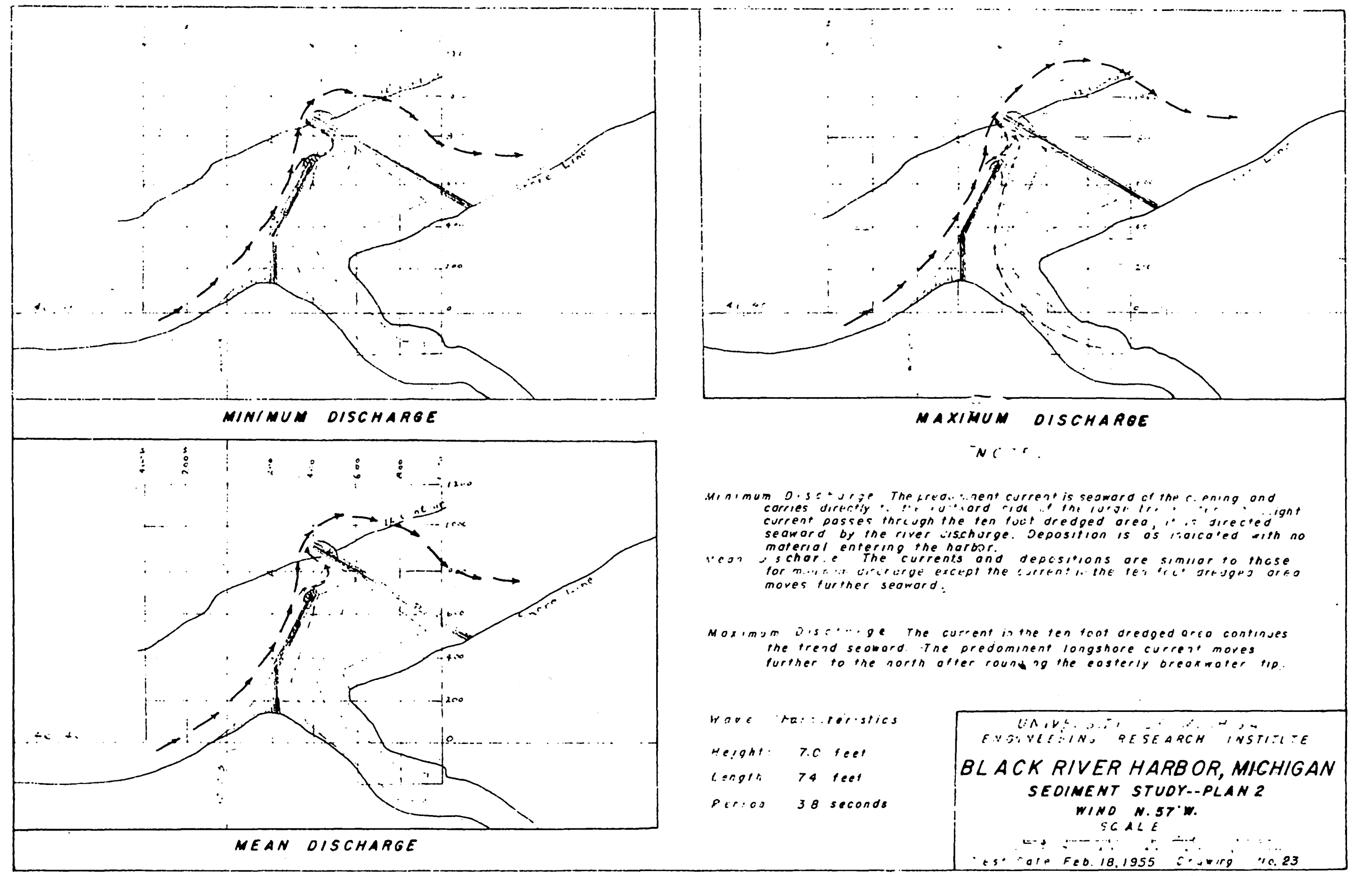
Wind North 57° West Small Wave

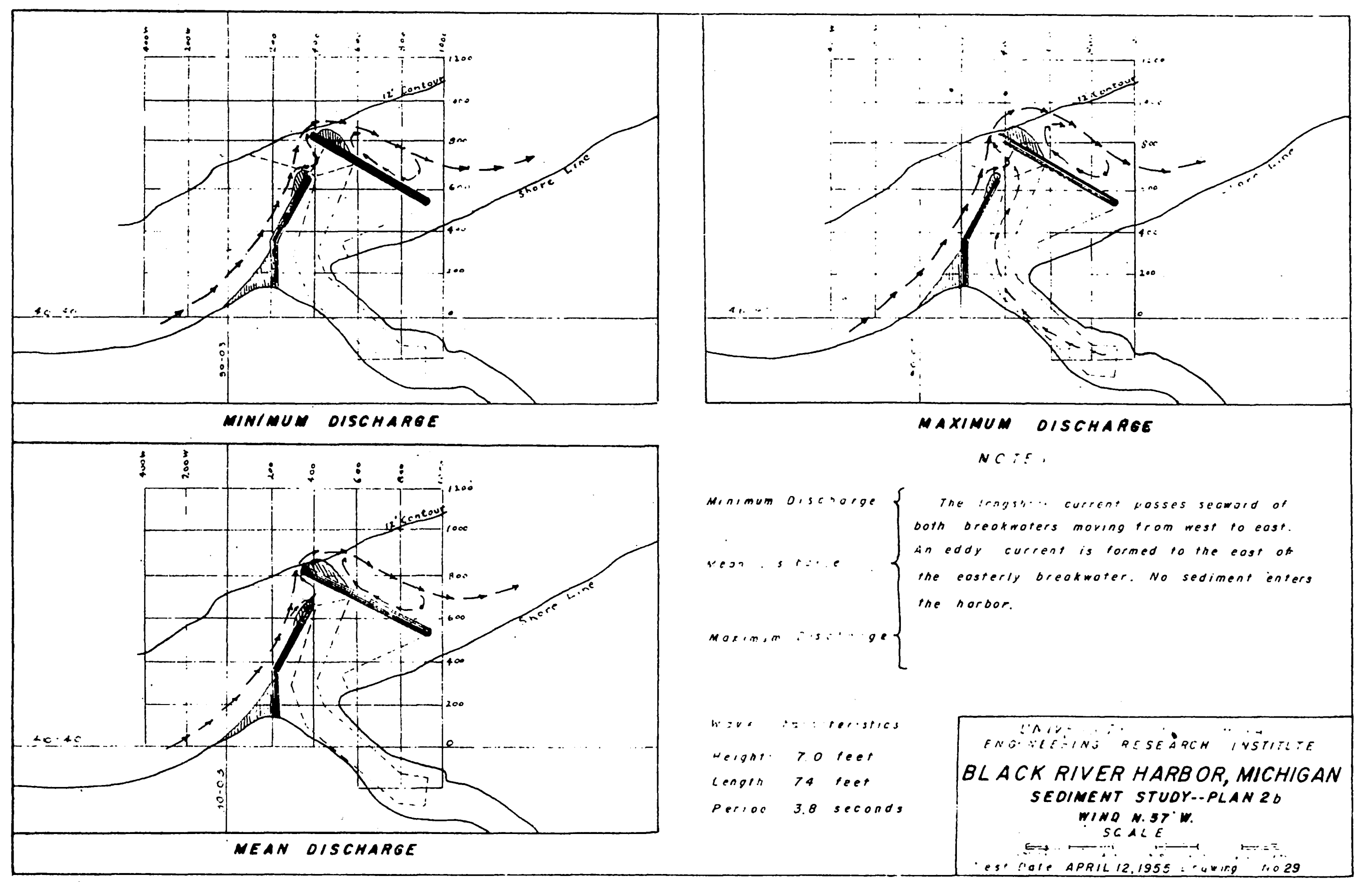




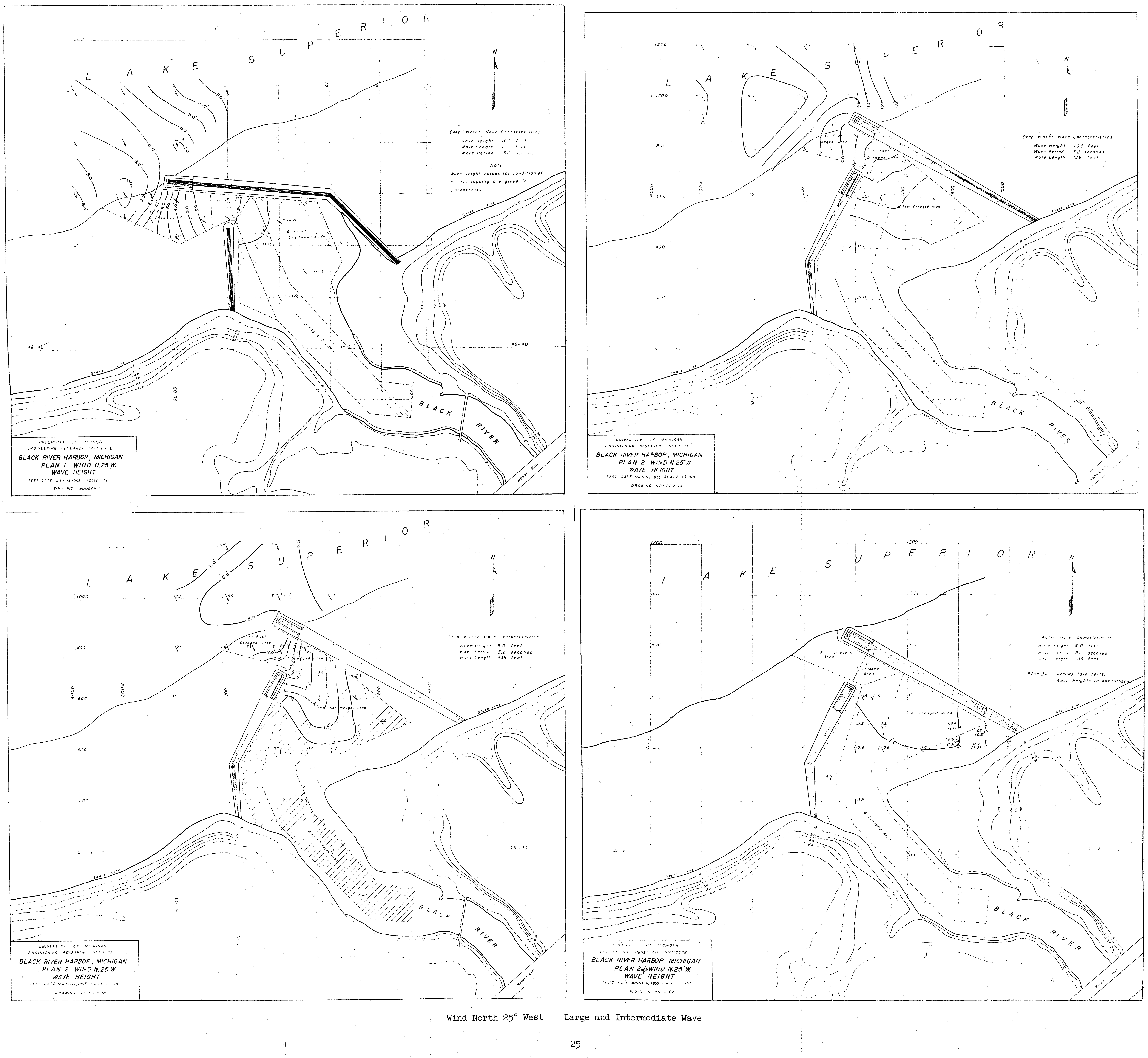
Wind North 57° West Surface Currents



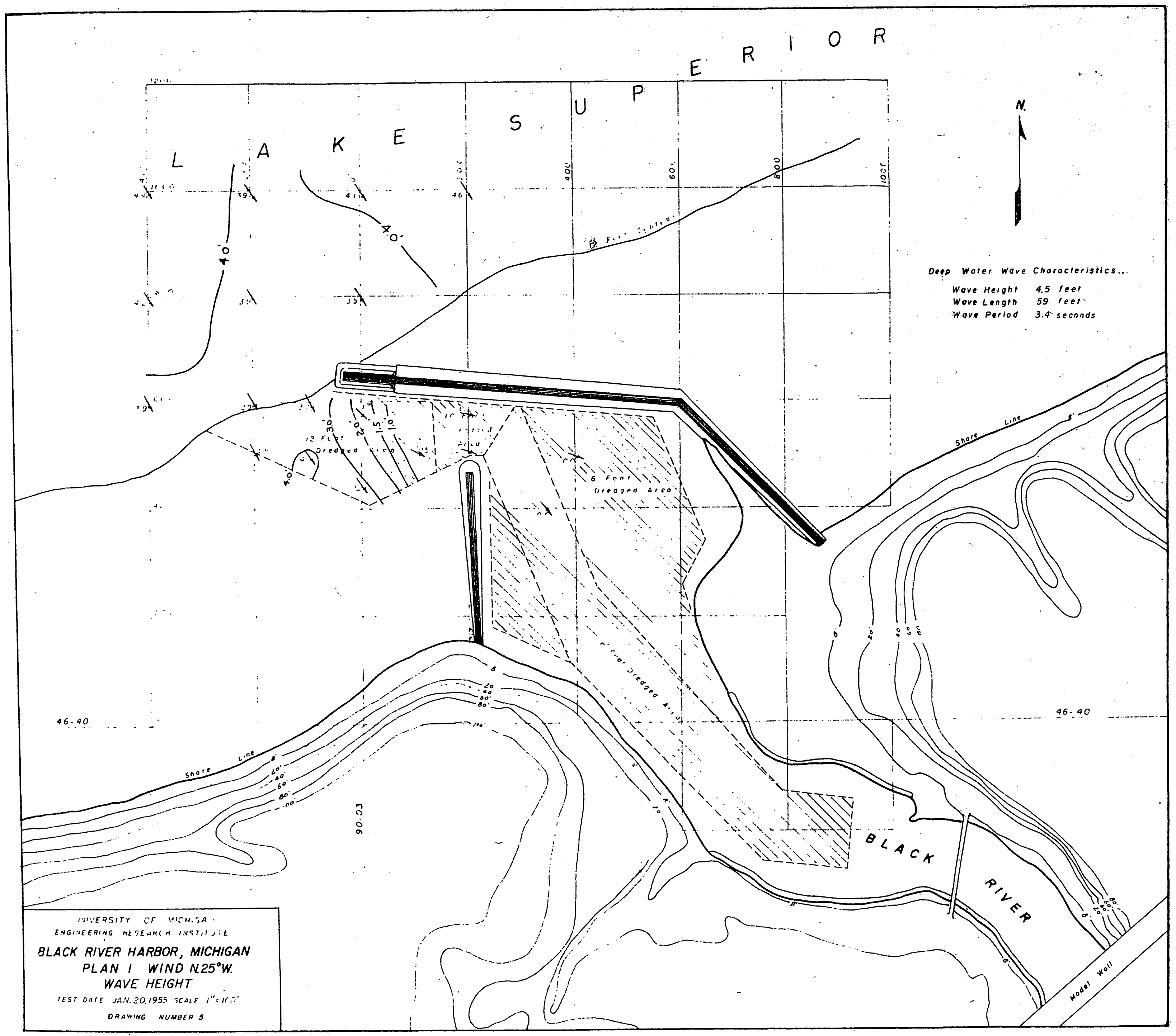


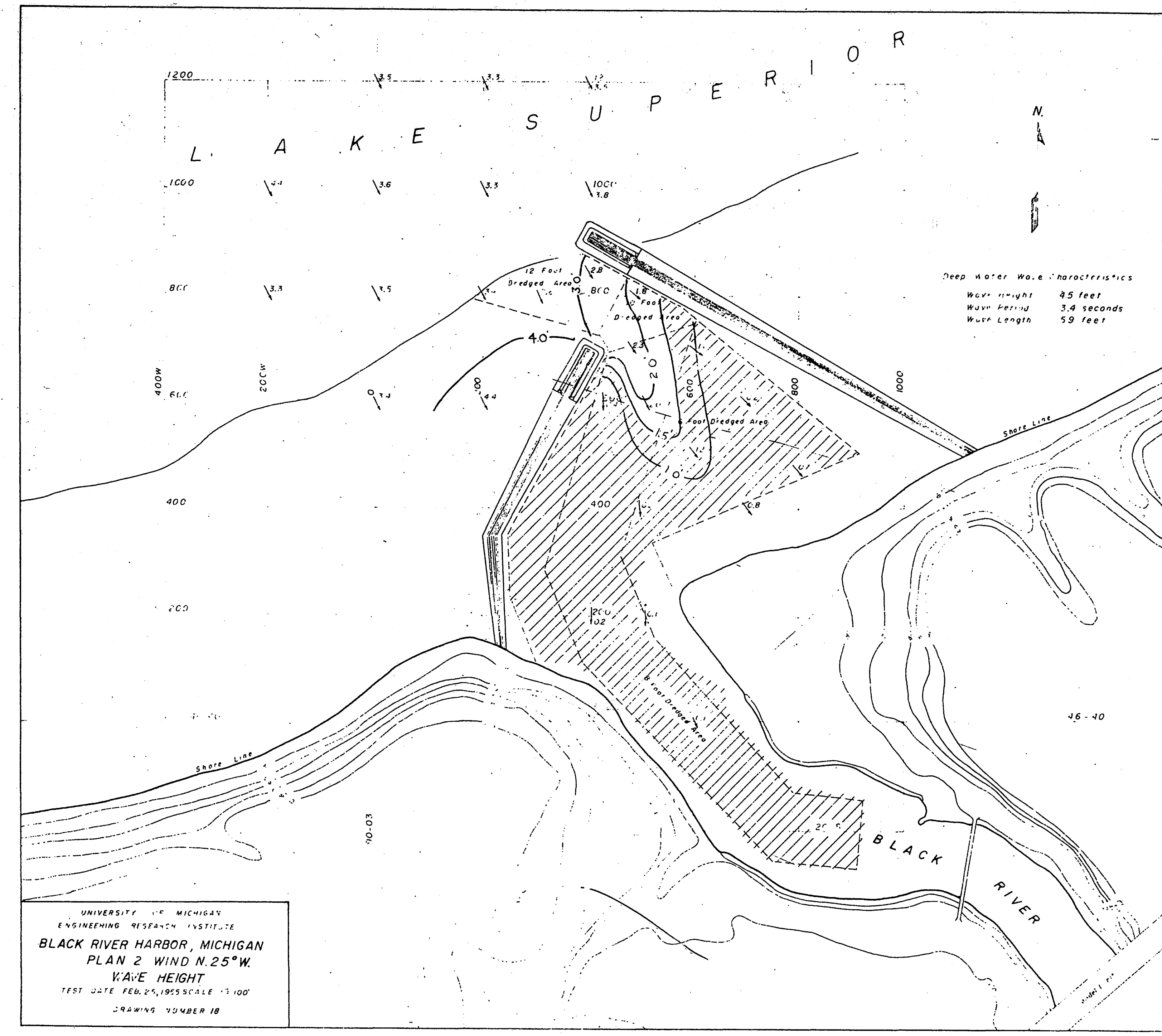


Wind North 57° West
Sediment Study

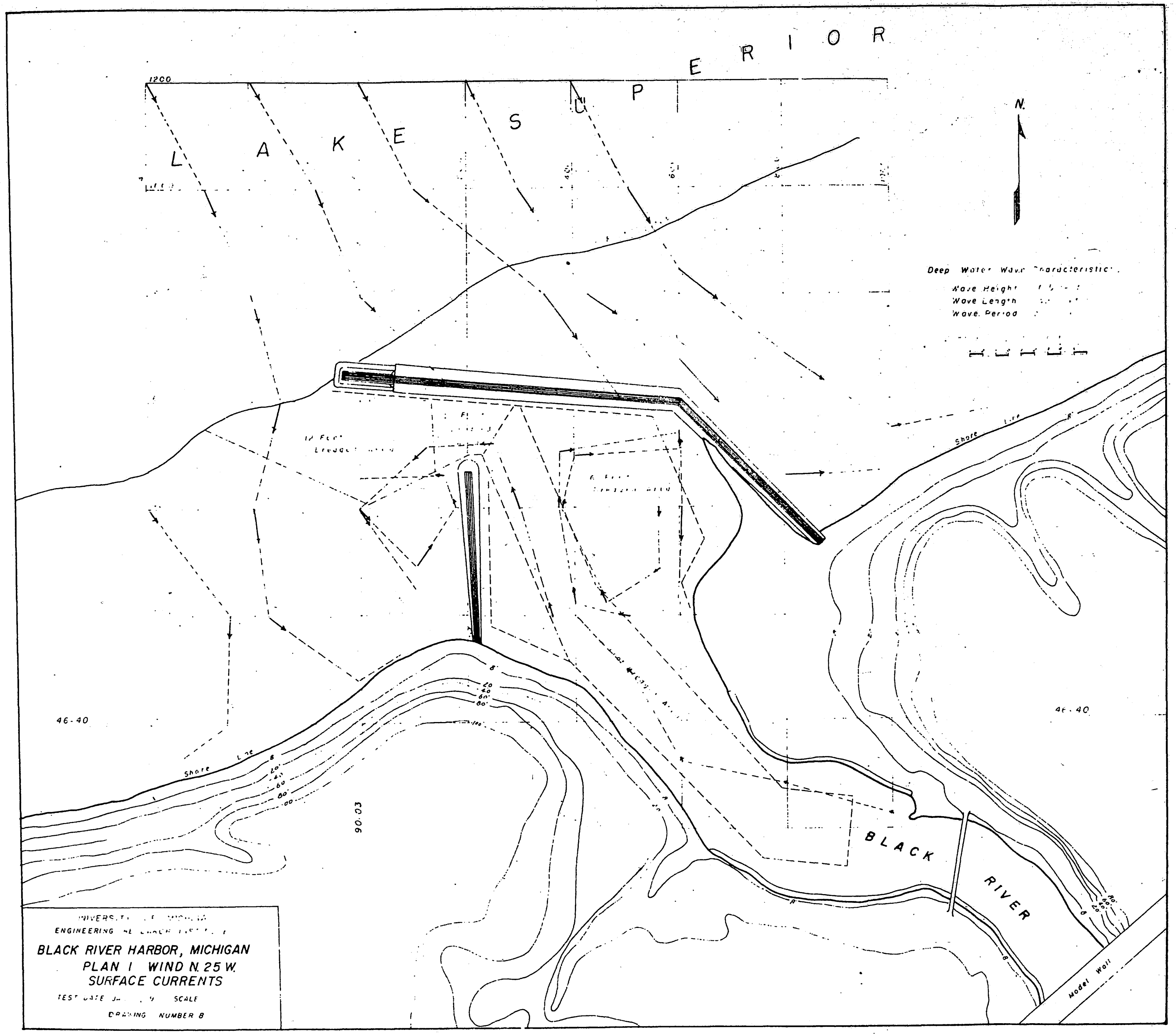


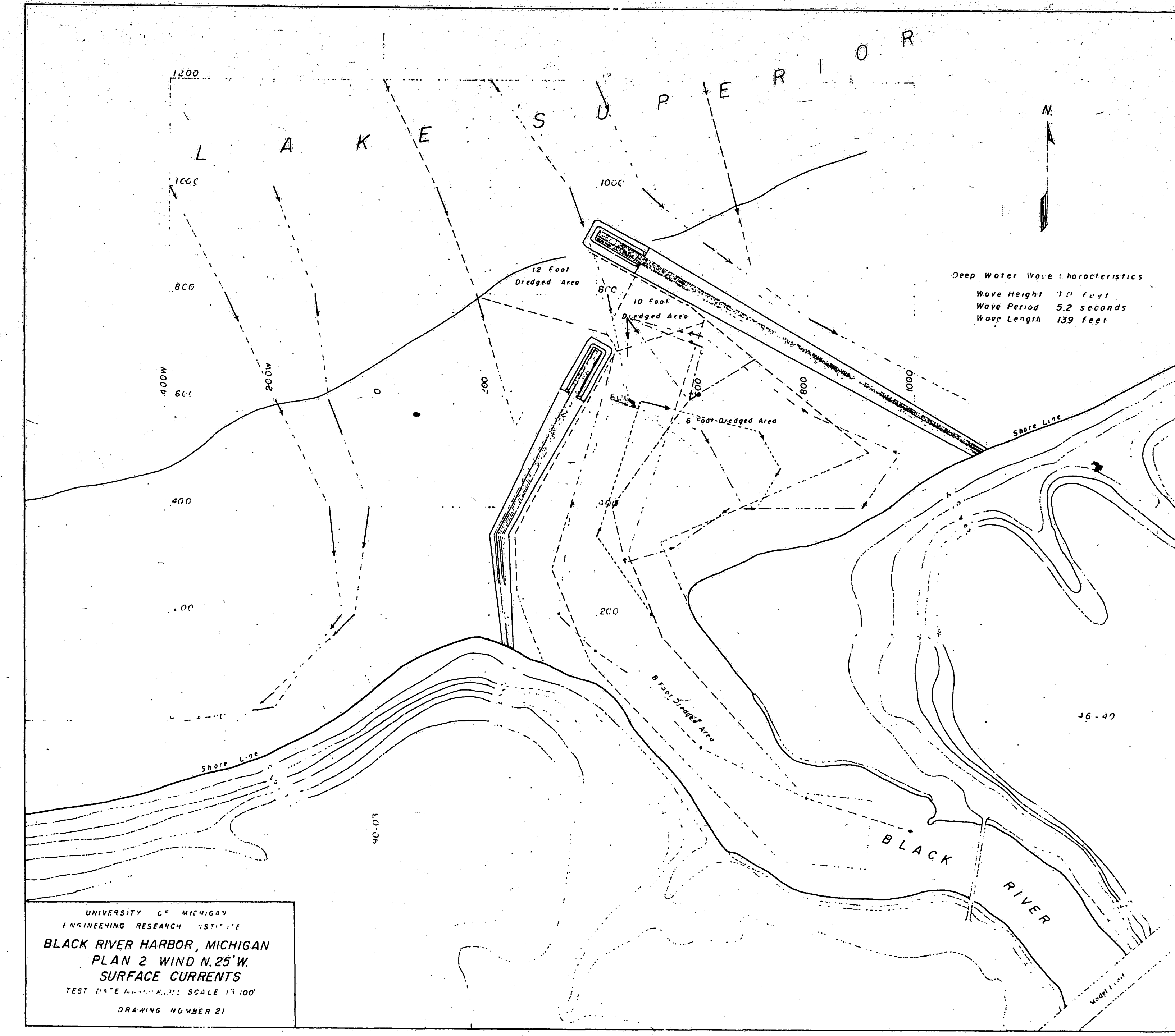
Wind North 25° West Large and Intermediate Wave



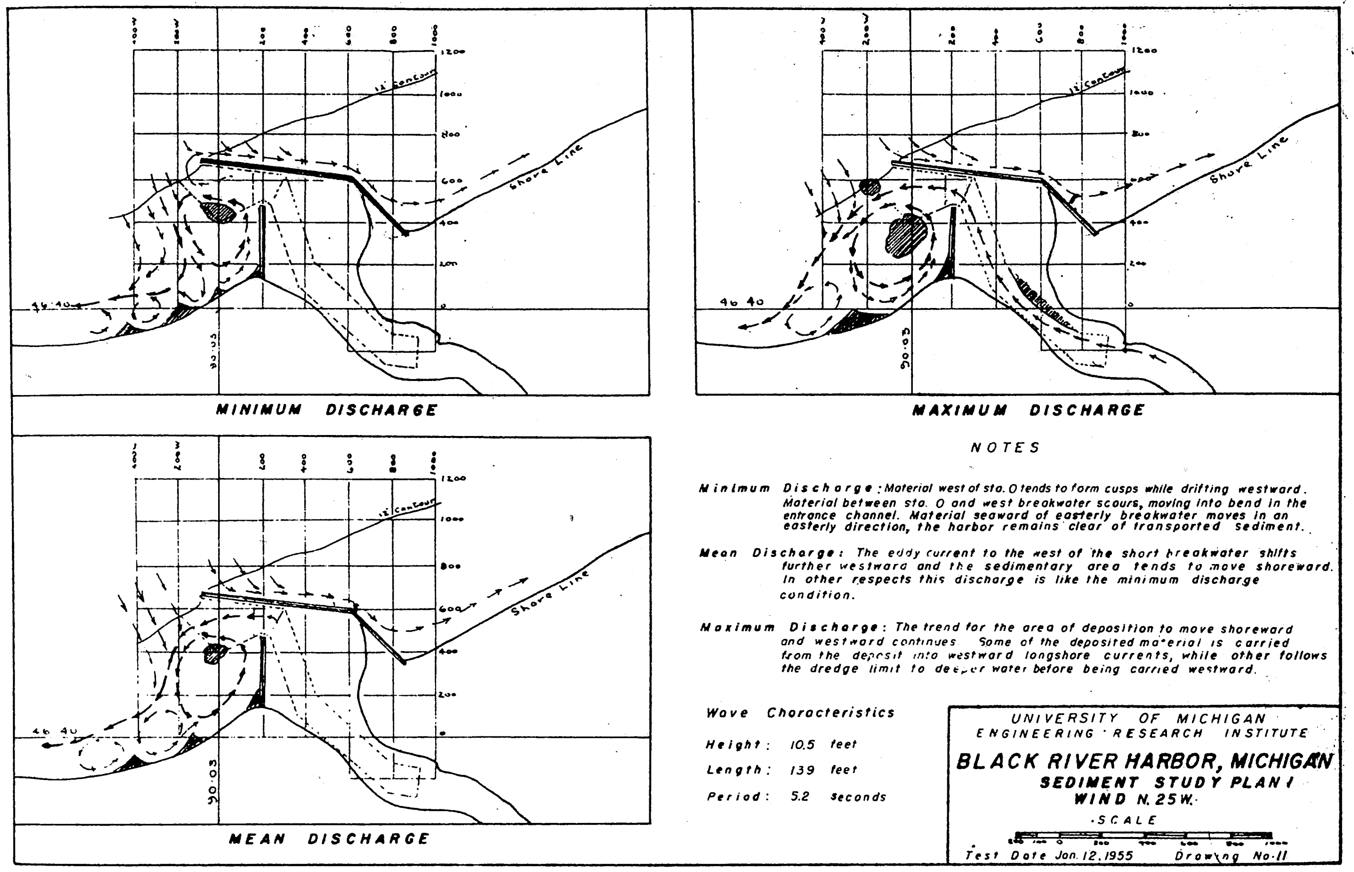


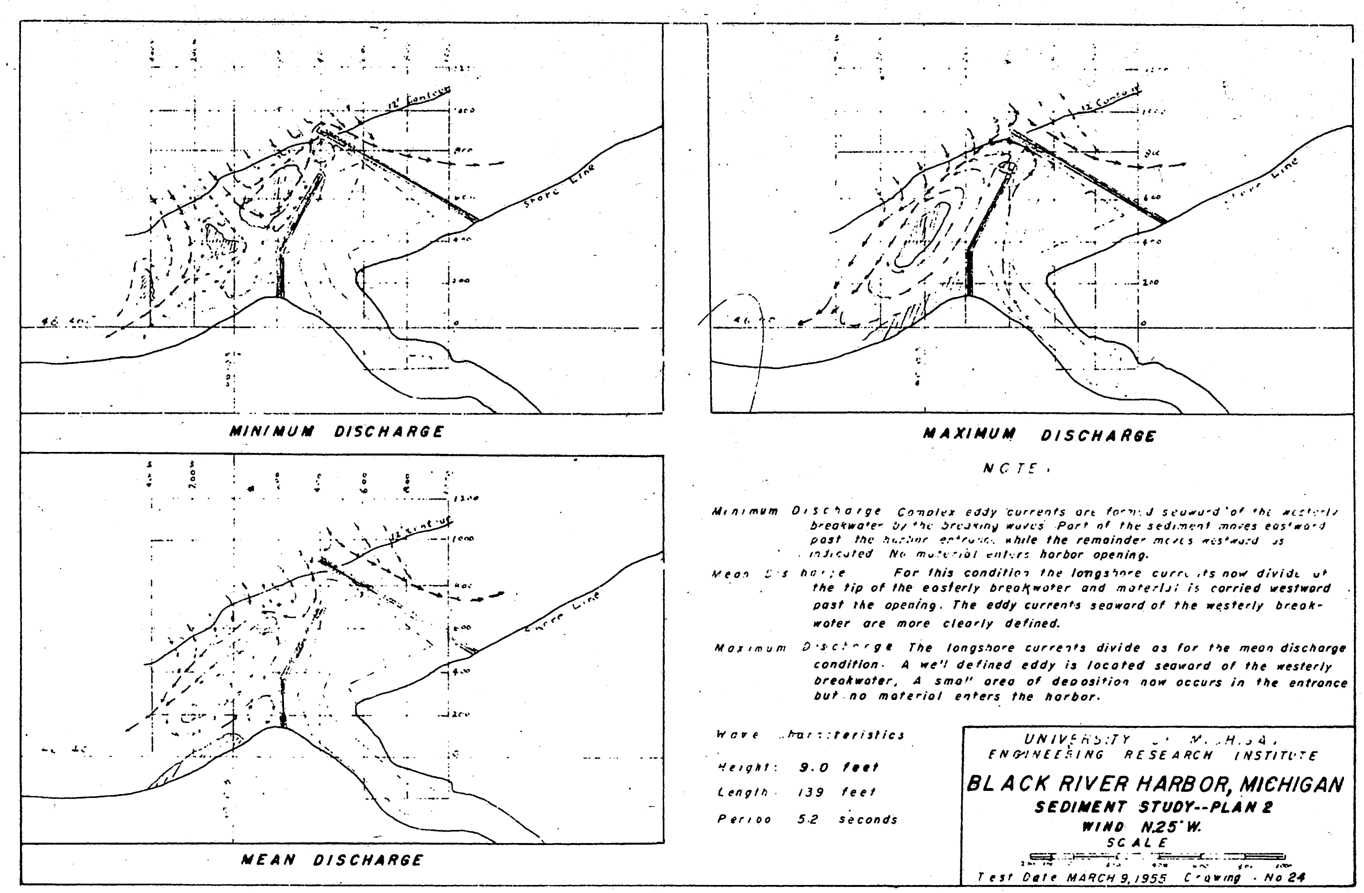
Wind North 25° West   Small Wave

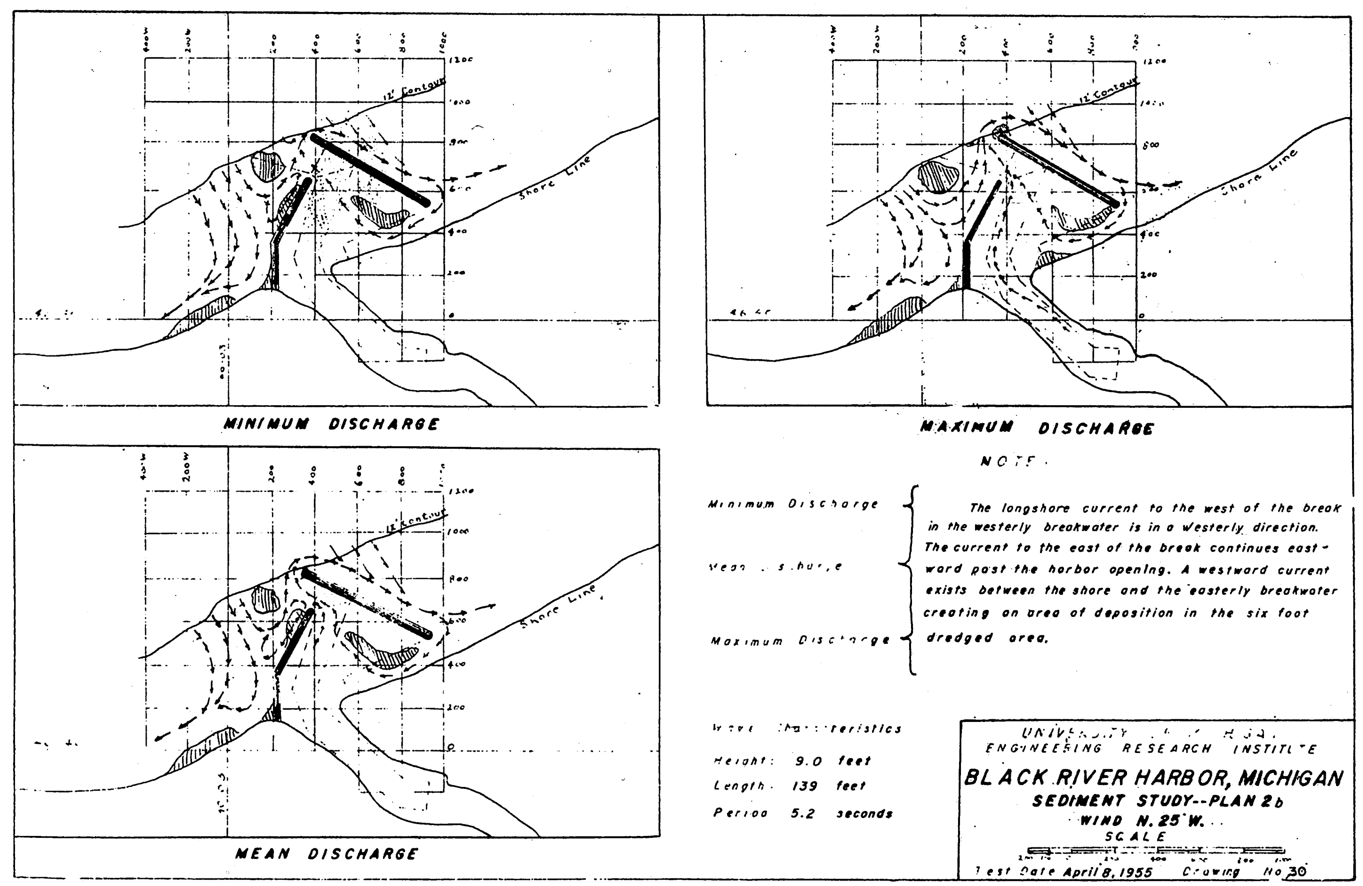




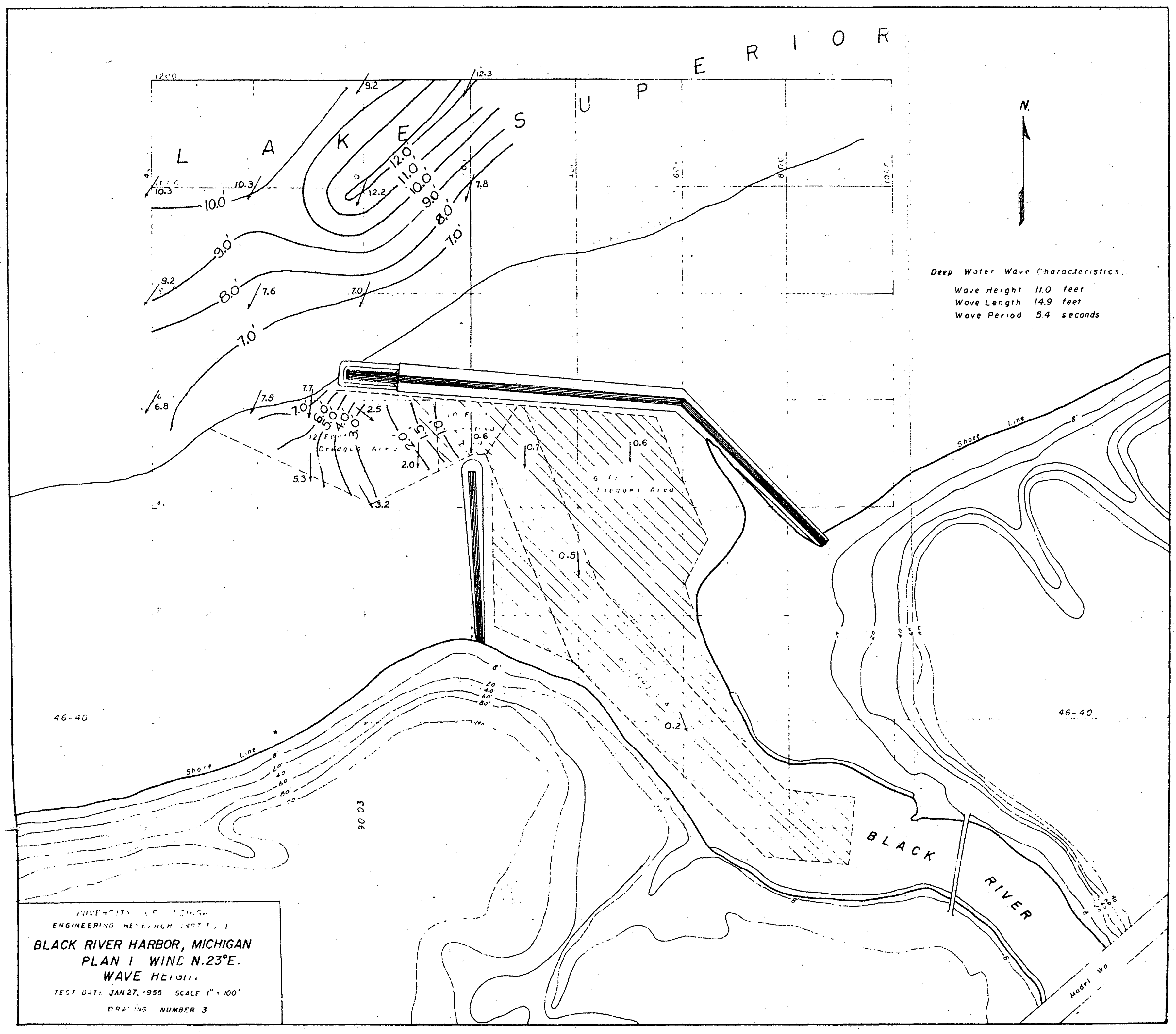
Wind North 25° West Surface Currents

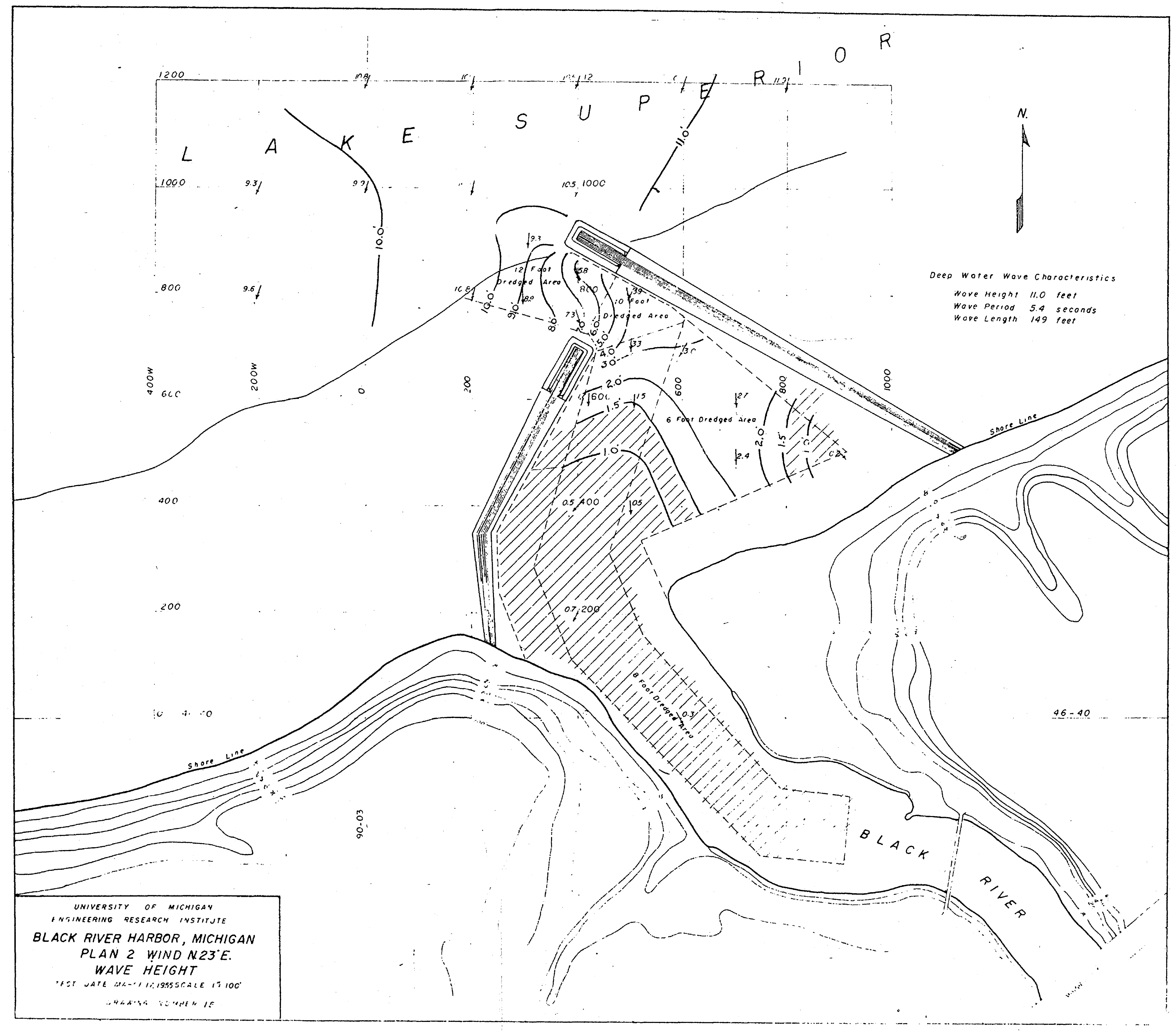


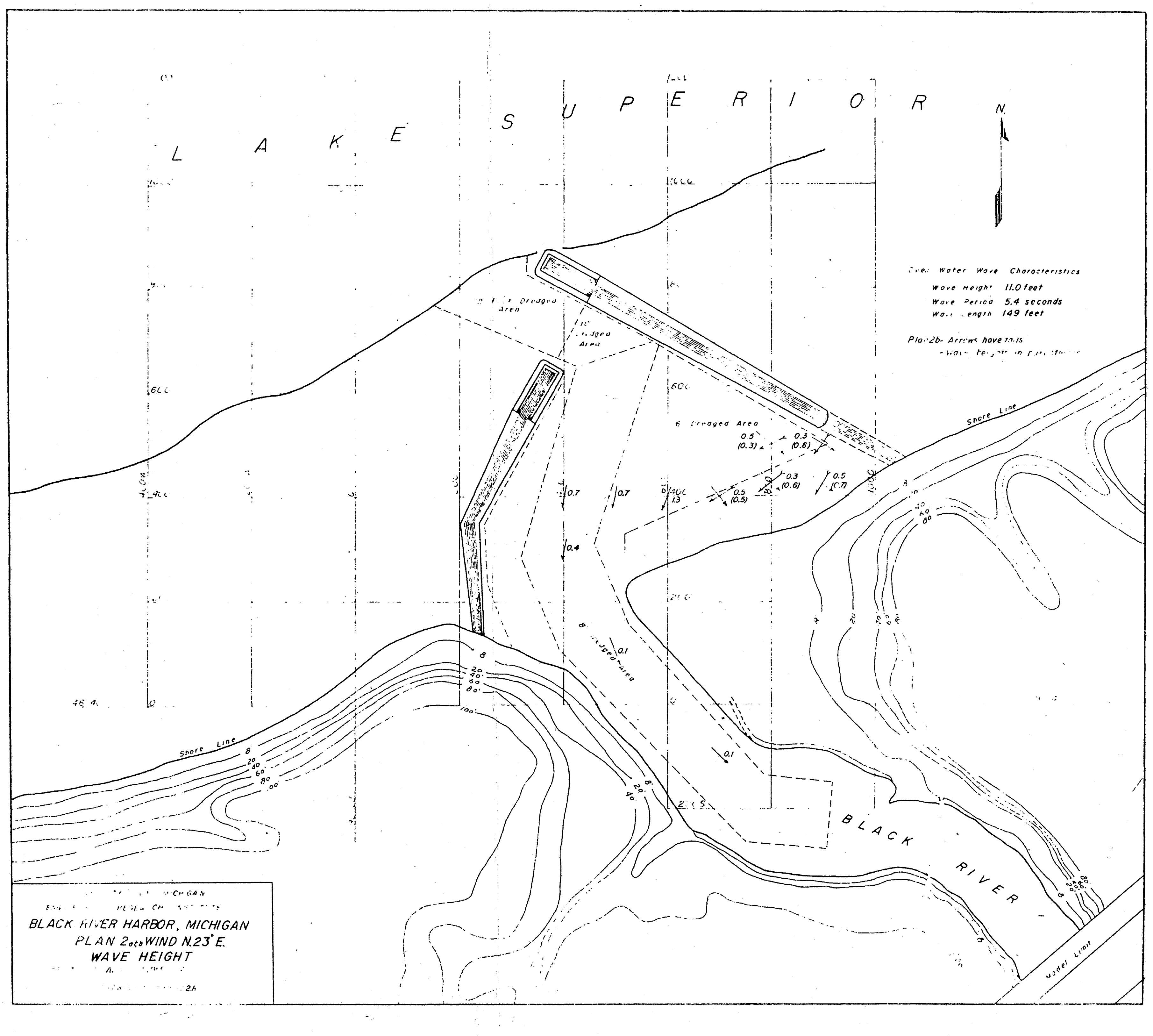




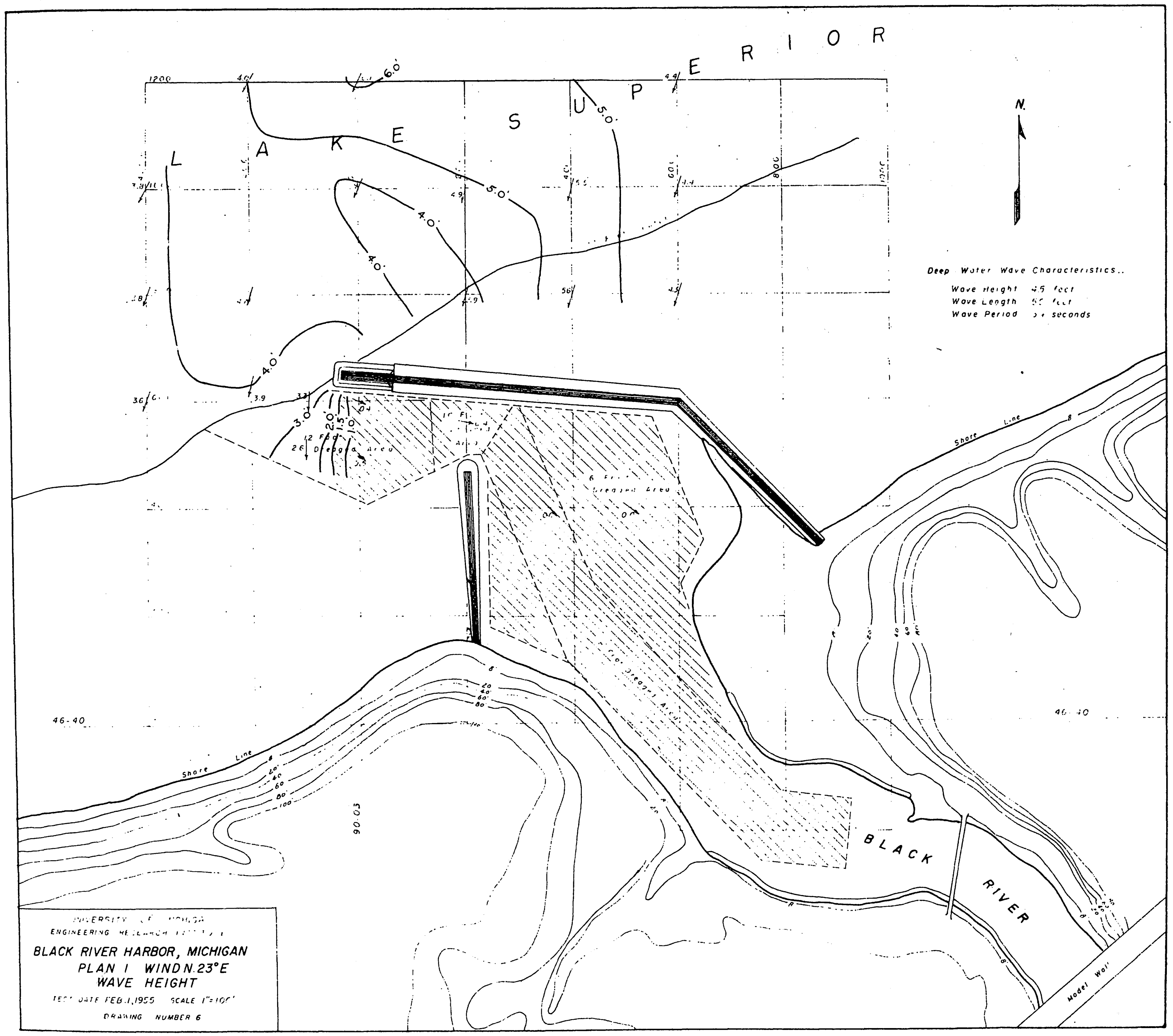
Wind North 25° West
Sediment Study

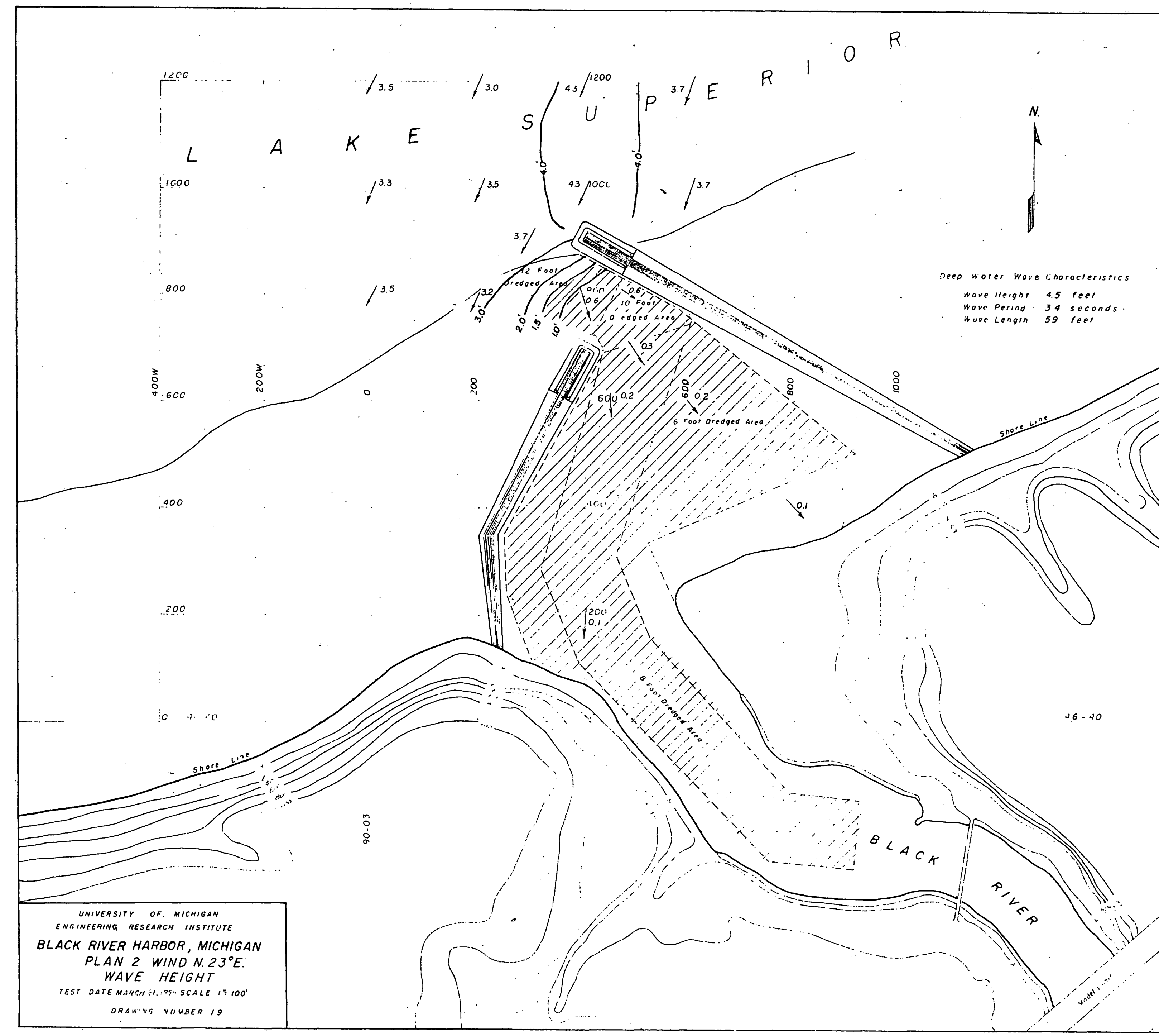




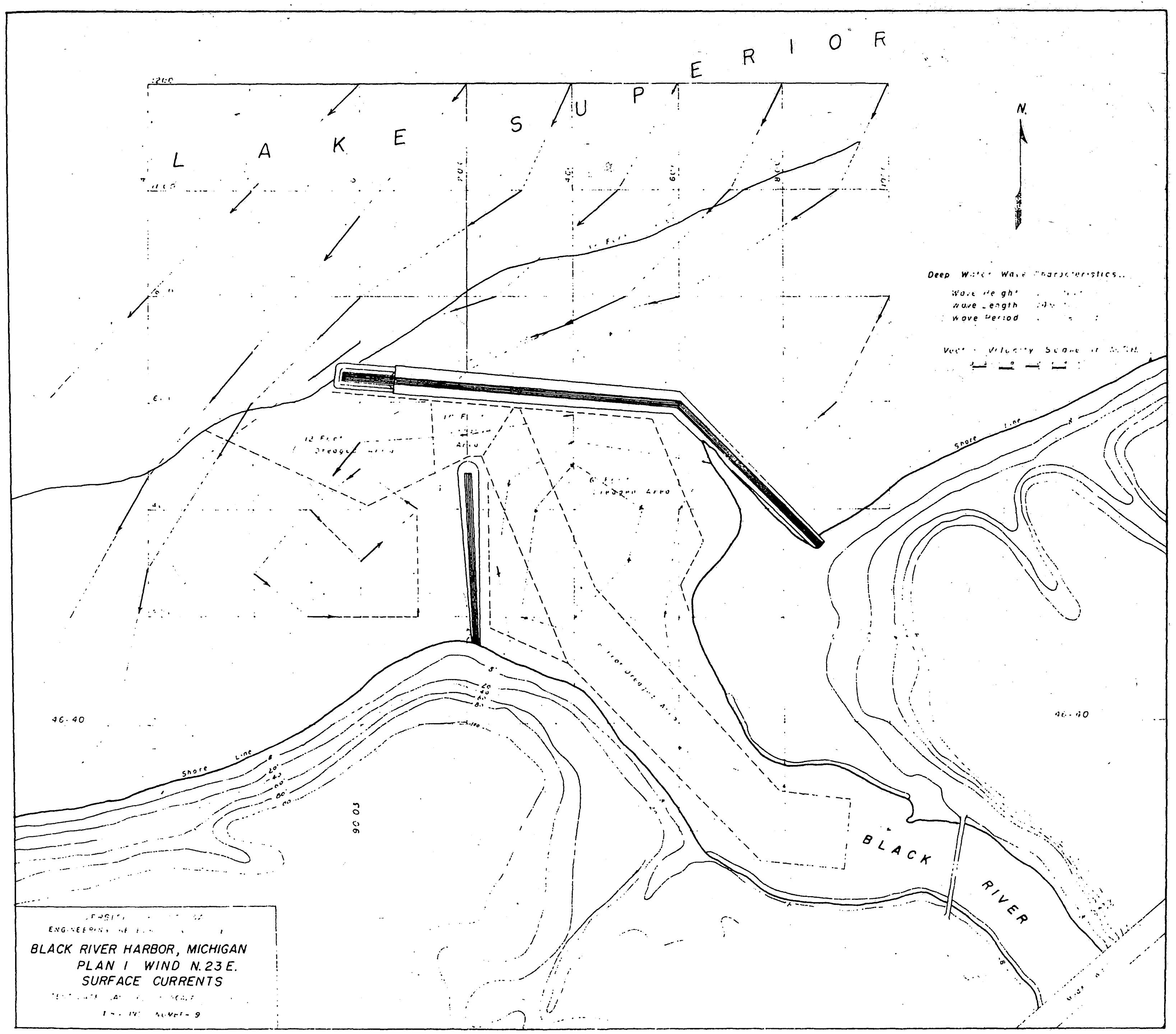


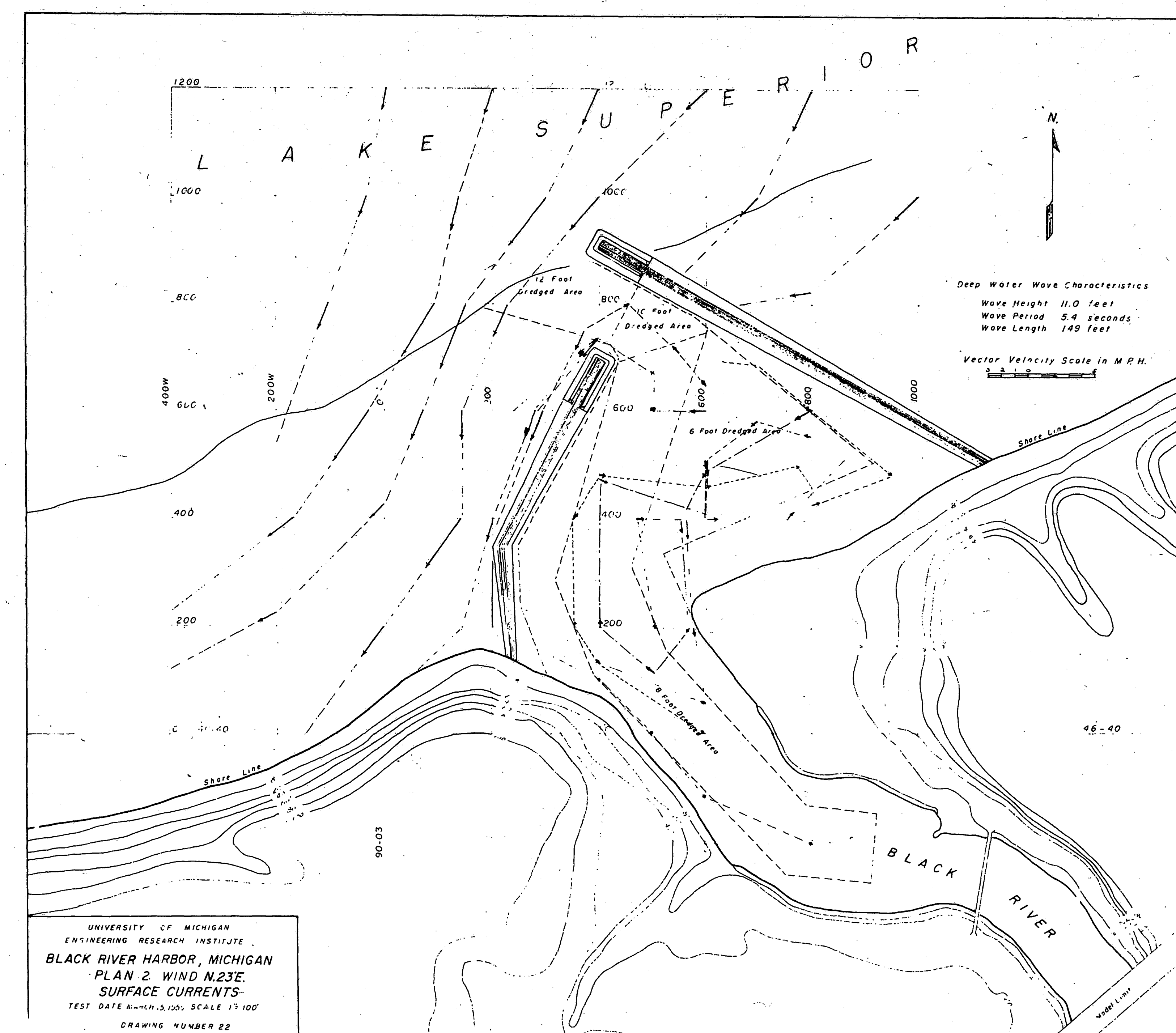
Wind North 23° East
Large Wave



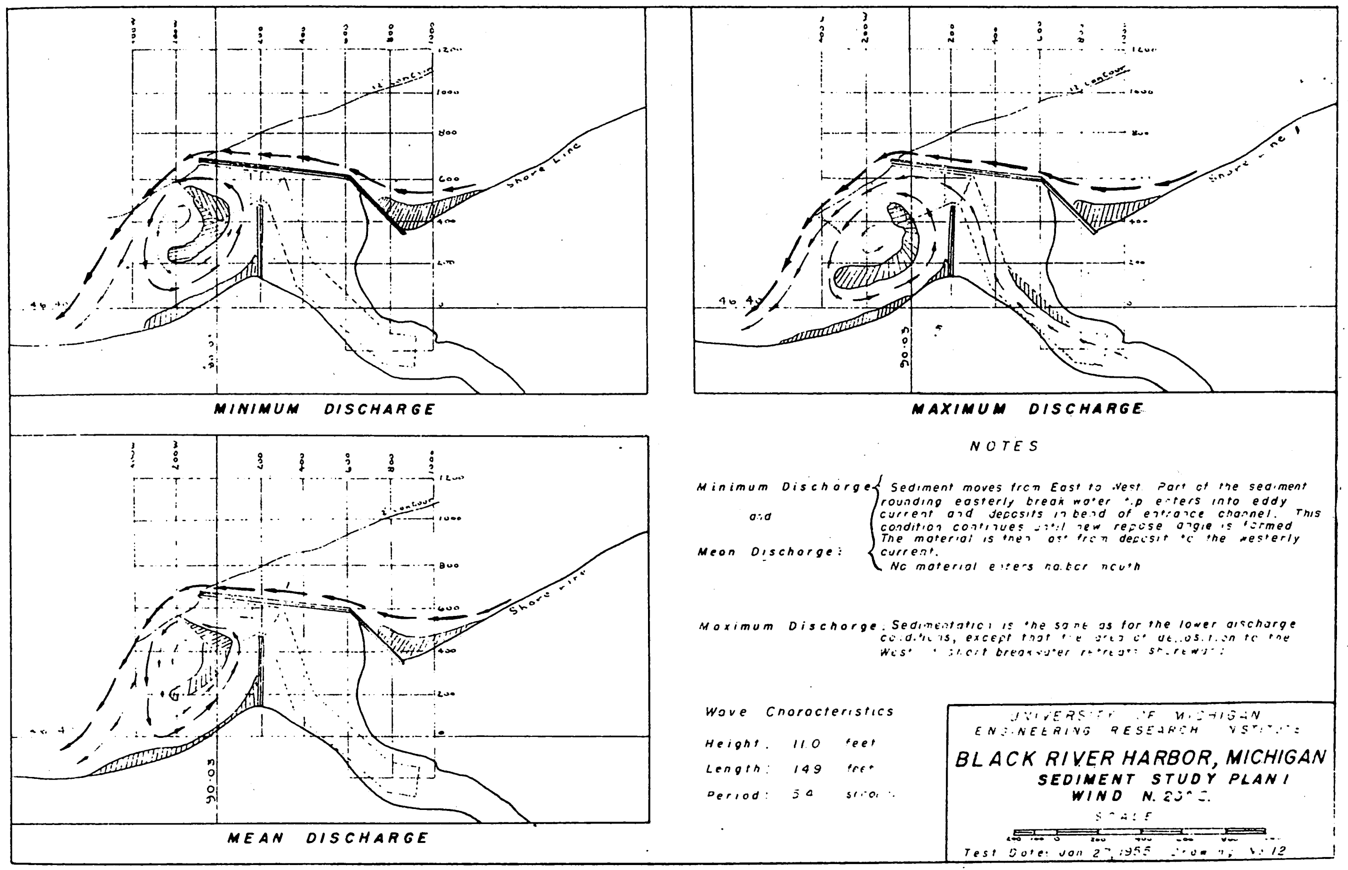


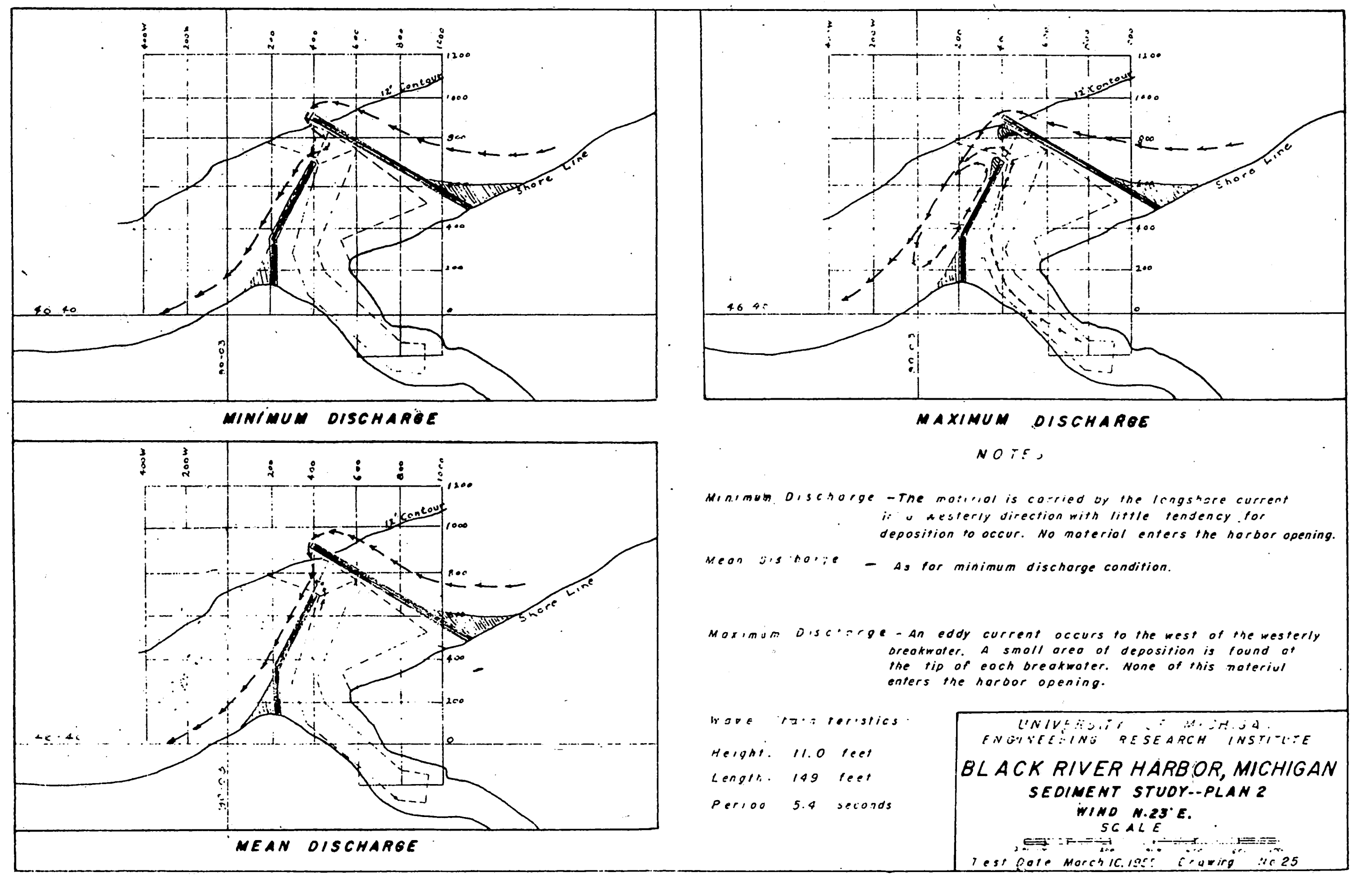
Wind North 23° East   Small Wave

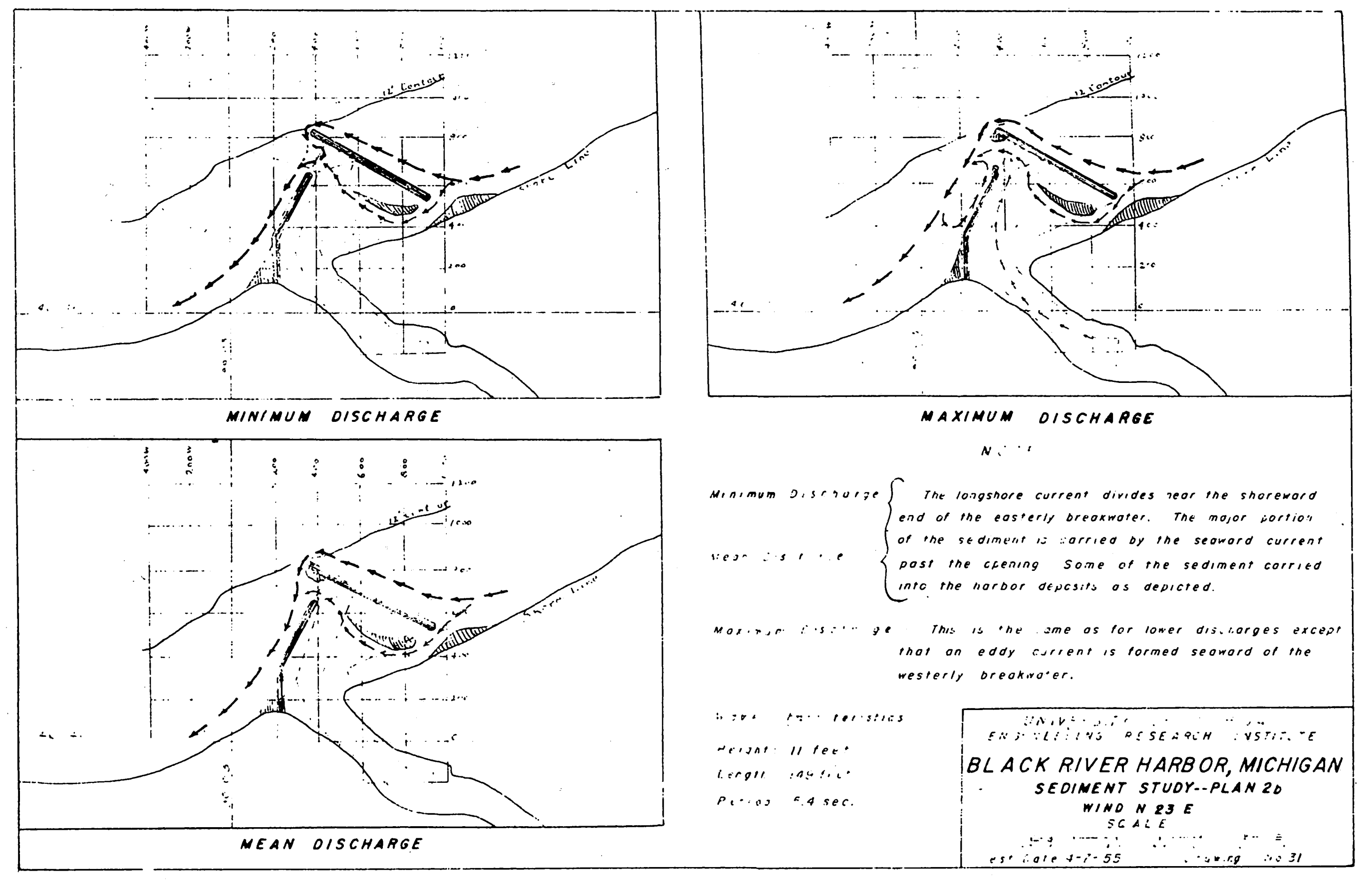




Wind North 23° East Surface Currents



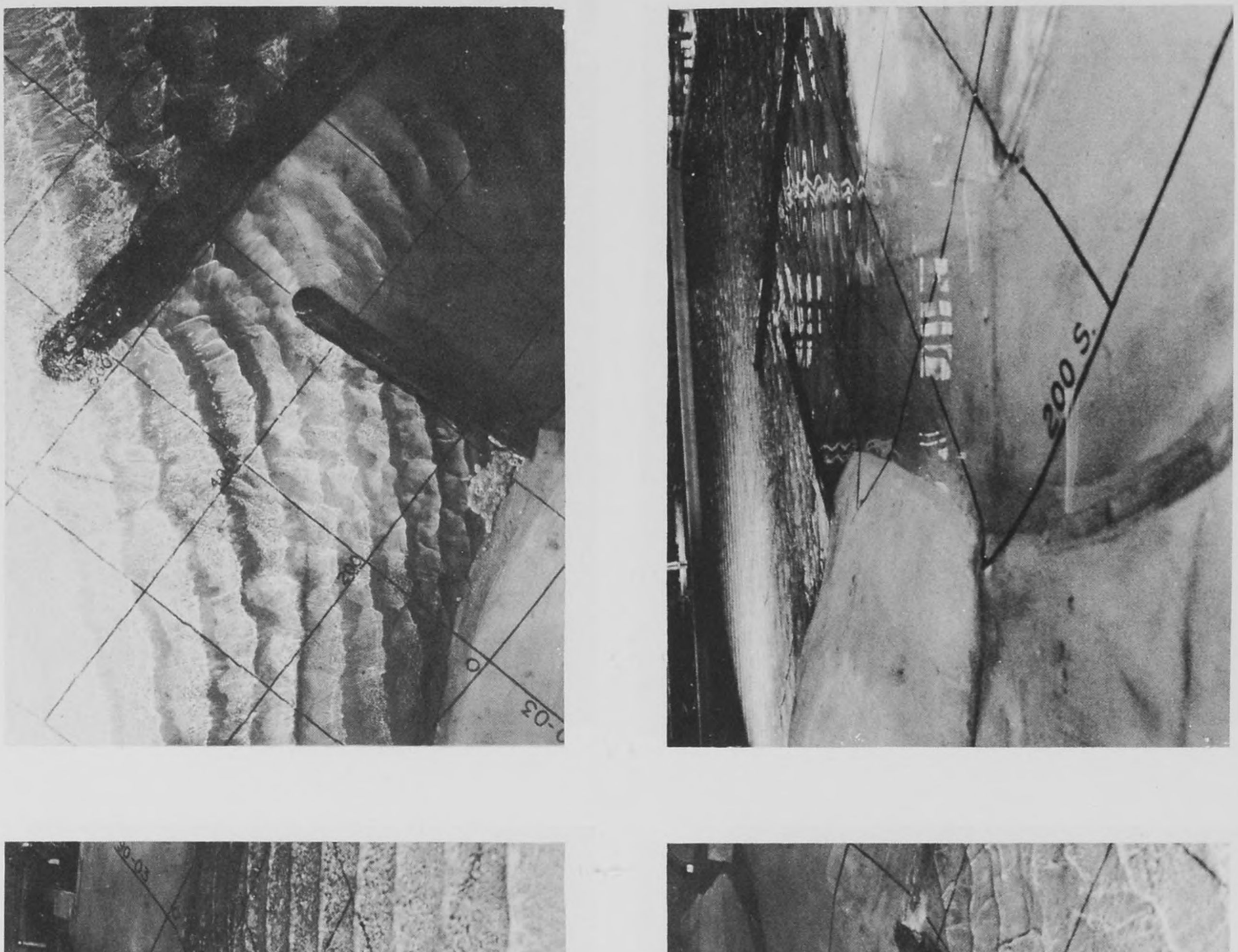




Wind North 23° East
Sediment Study

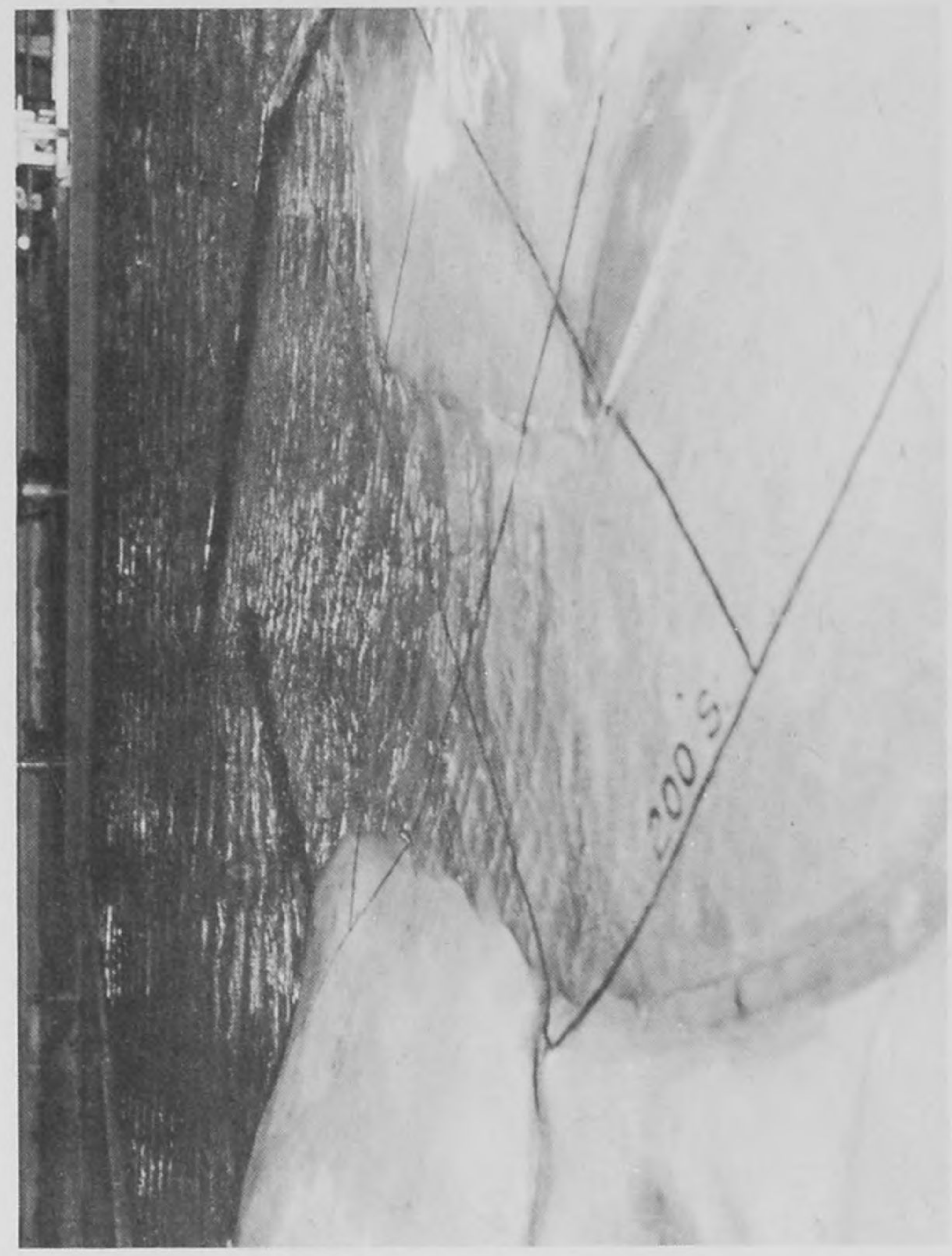
APPENDIX B

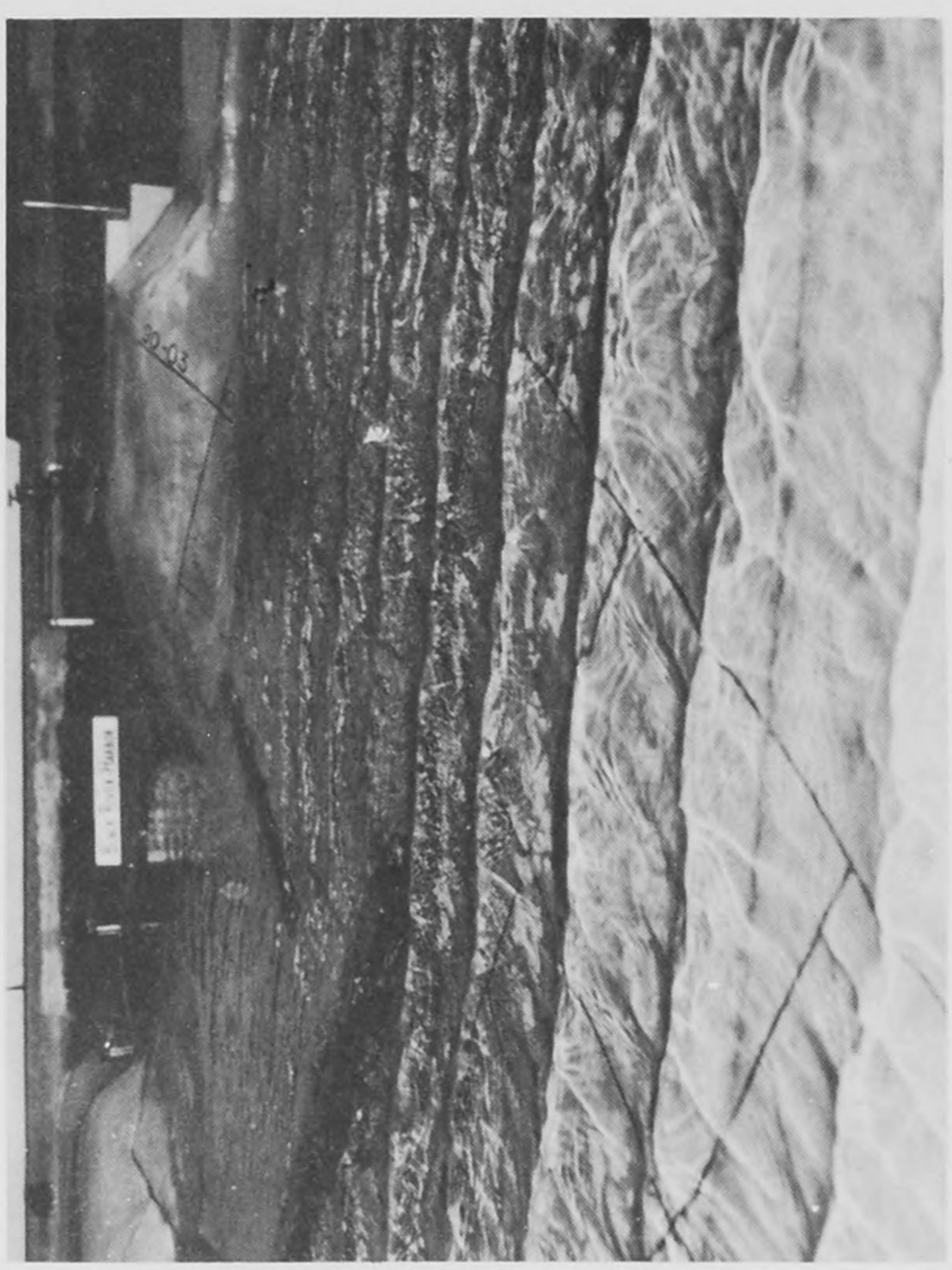
PHOTOGRAPHS SHOWING WAVE CONDITIONS DURING TESTS

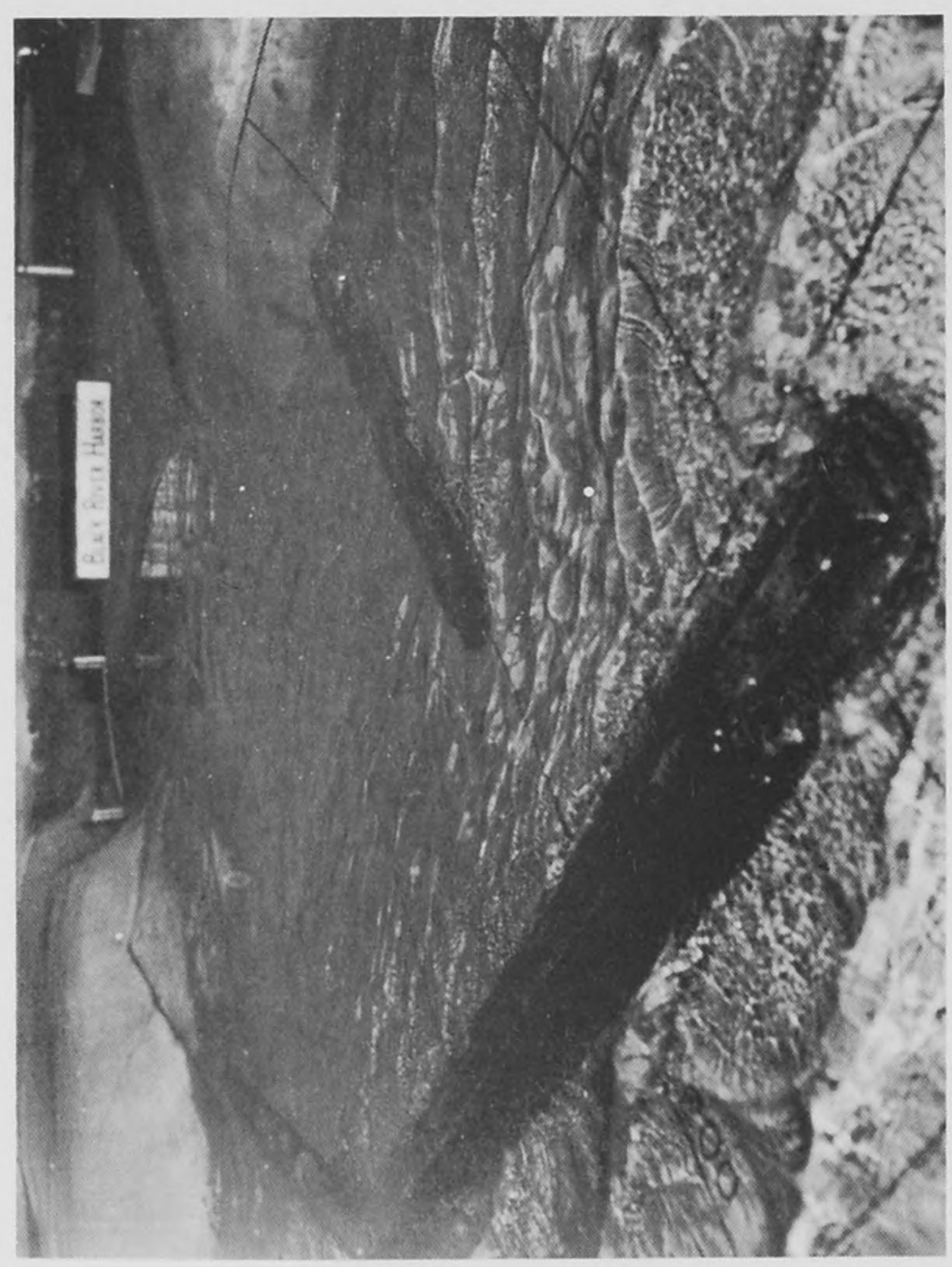


Plan 1 Wind North 57° West

Black River Harbor, Michigan
Plate 1

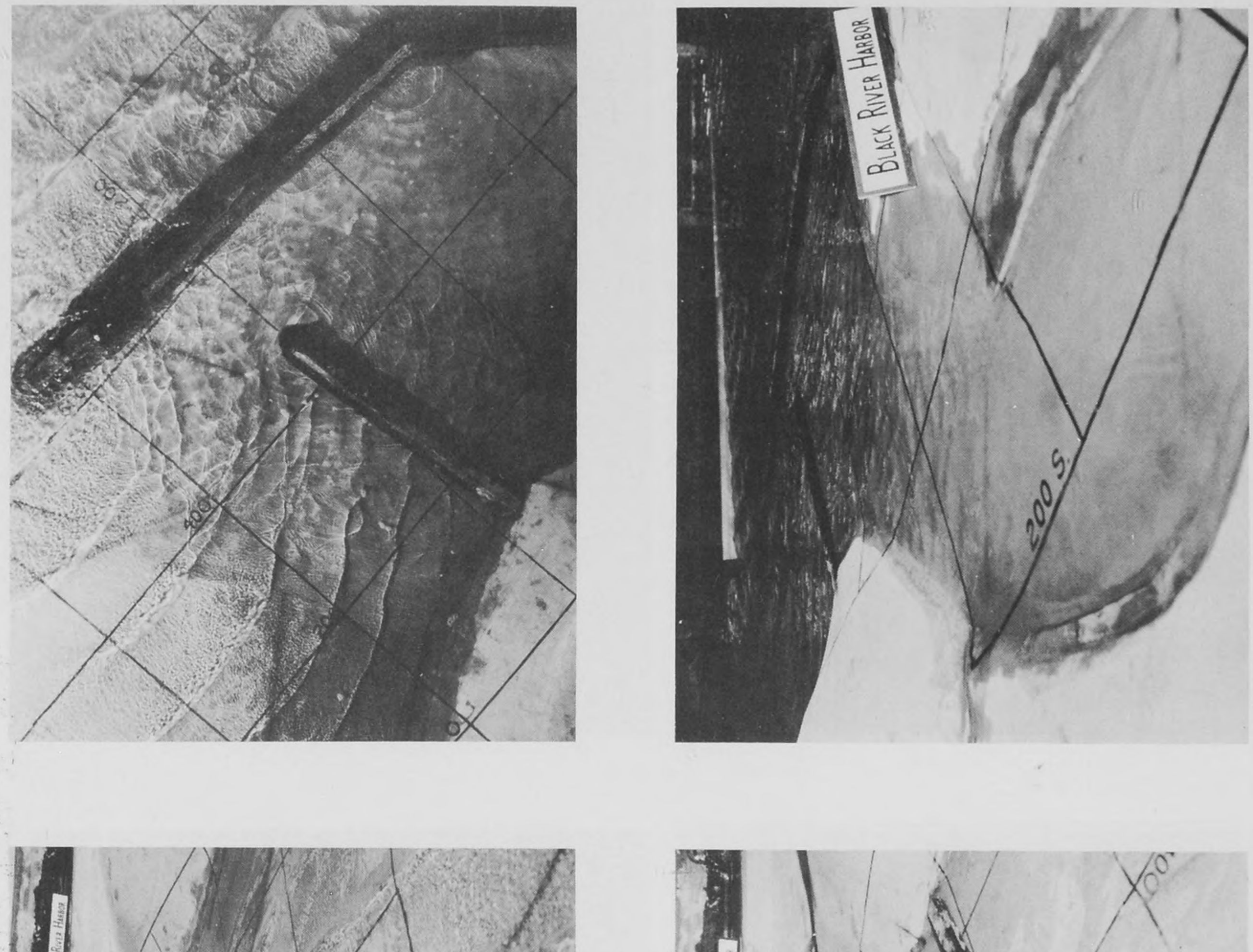






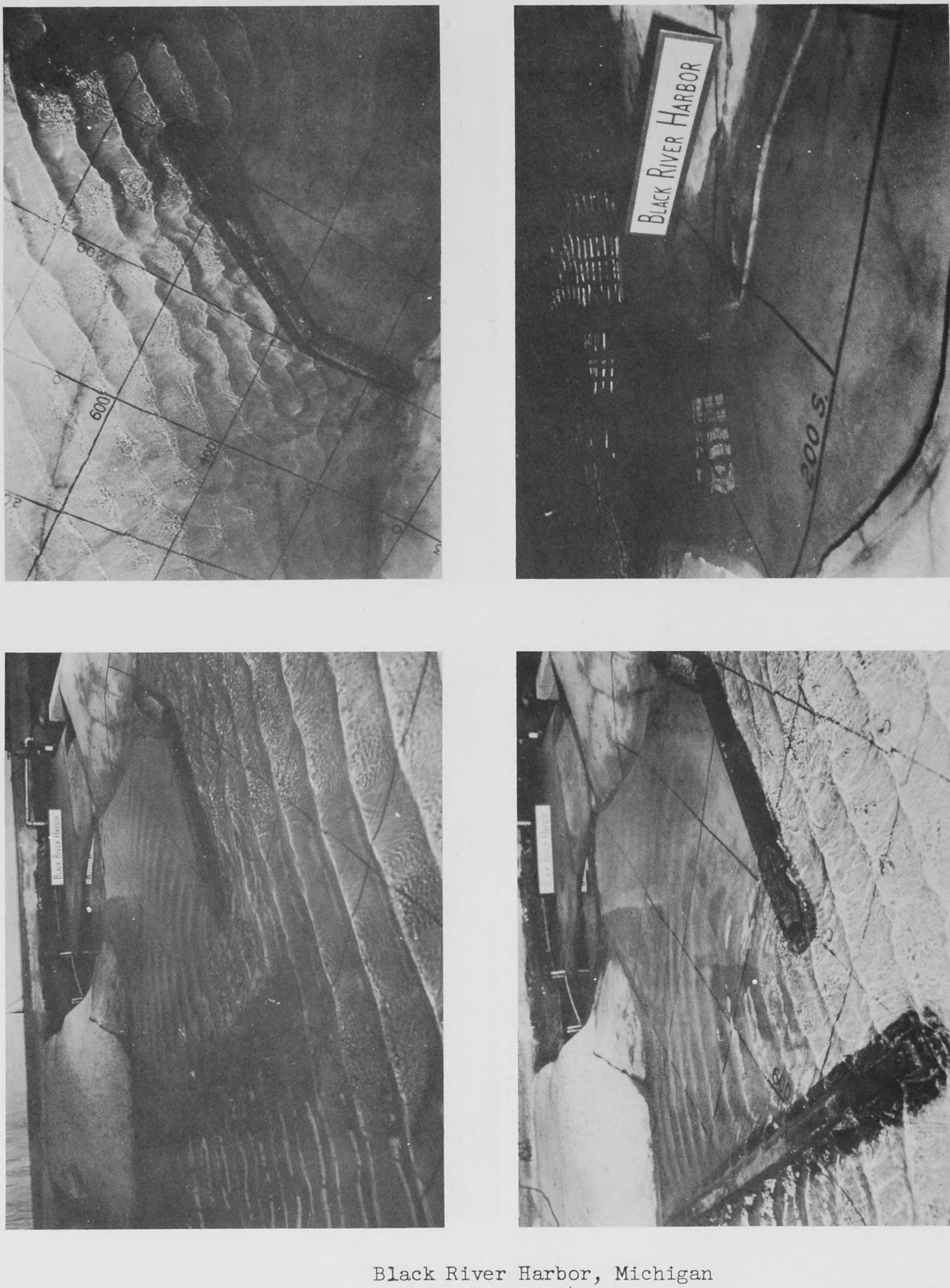
Plan 1 Wind North 25° West

Black River Harbor, Michigan
Plate 2



Plan 1 Wind North 23° East

Black River Harbor, Michigan
Plate 3

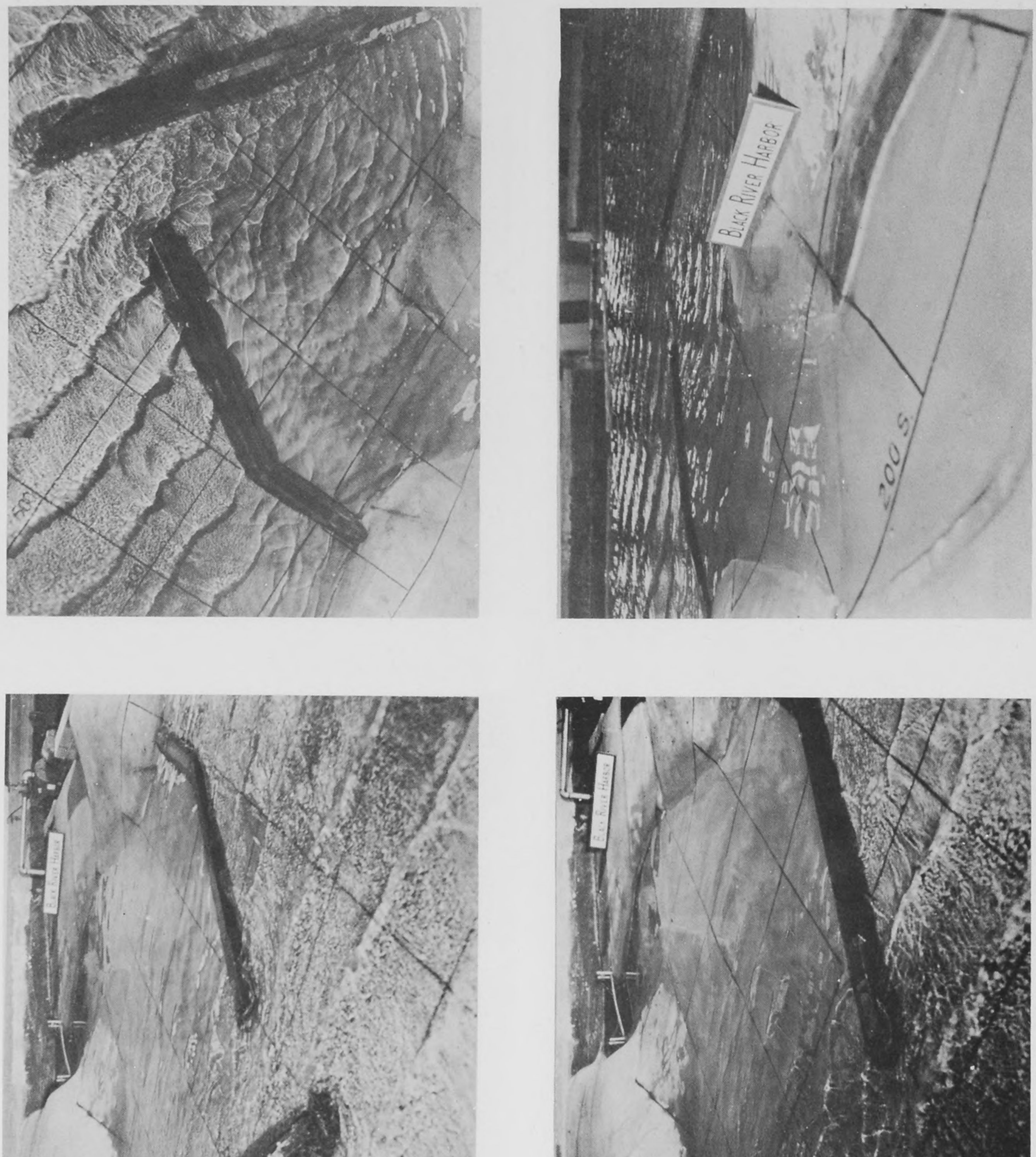


Plan 2 Wind North 57° West

Black River Harbor, Michigan
Plate 4

Plan 2 Wind North 25° West

Black River Harbor, Michigan
Plate 5

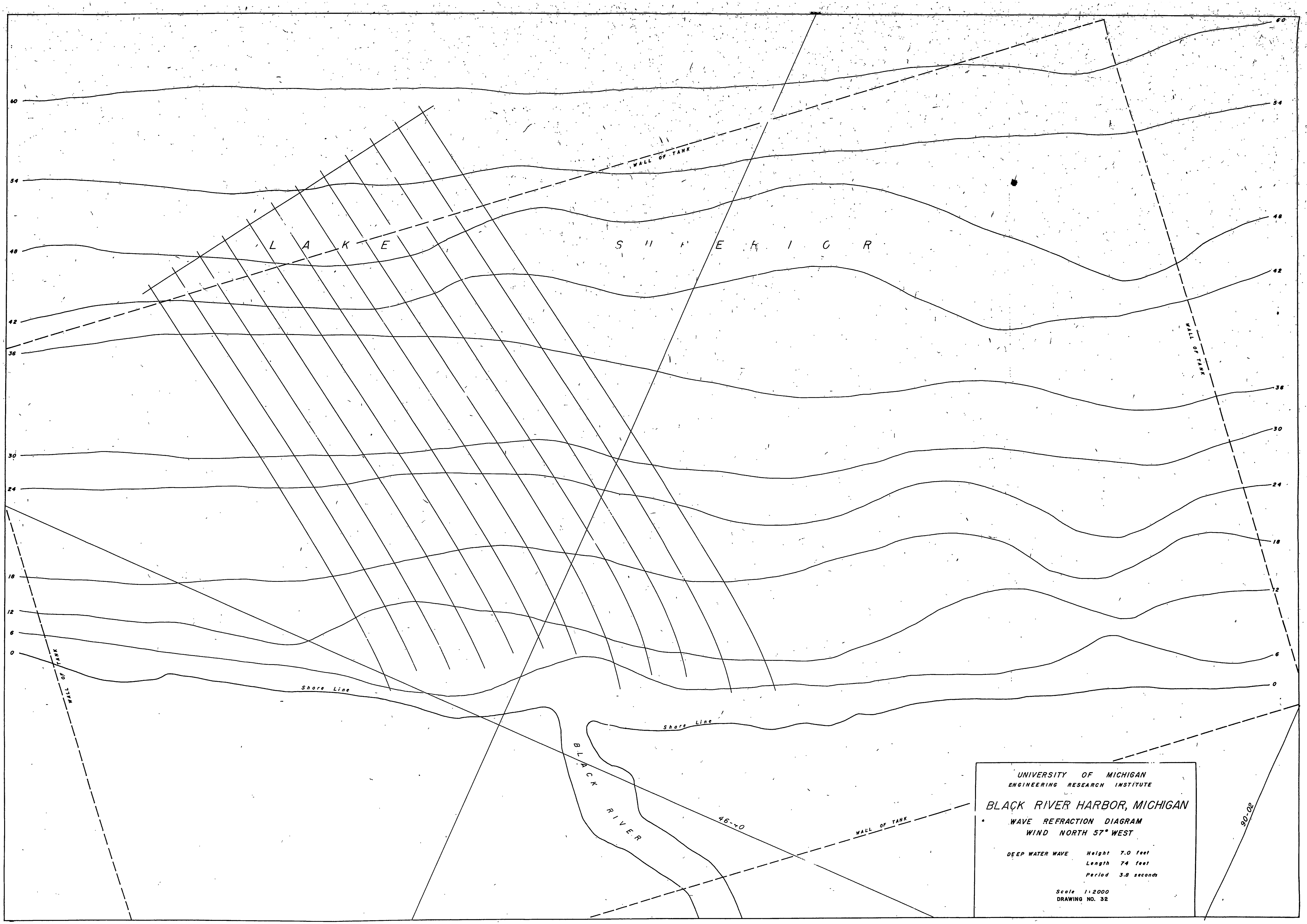


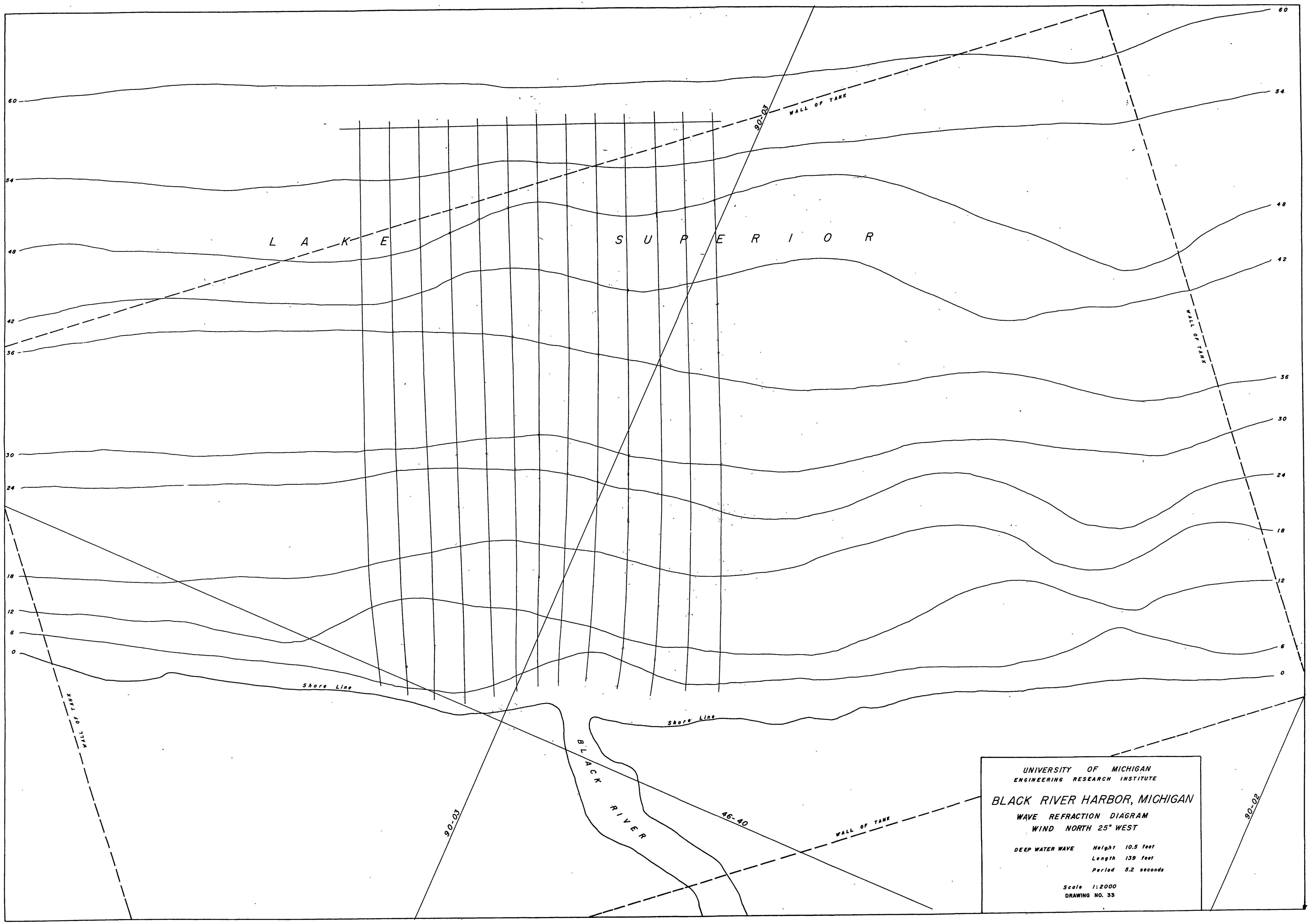
Plan 2 Wind North 23° East

Black River Harbor, Michigan
Plate 6

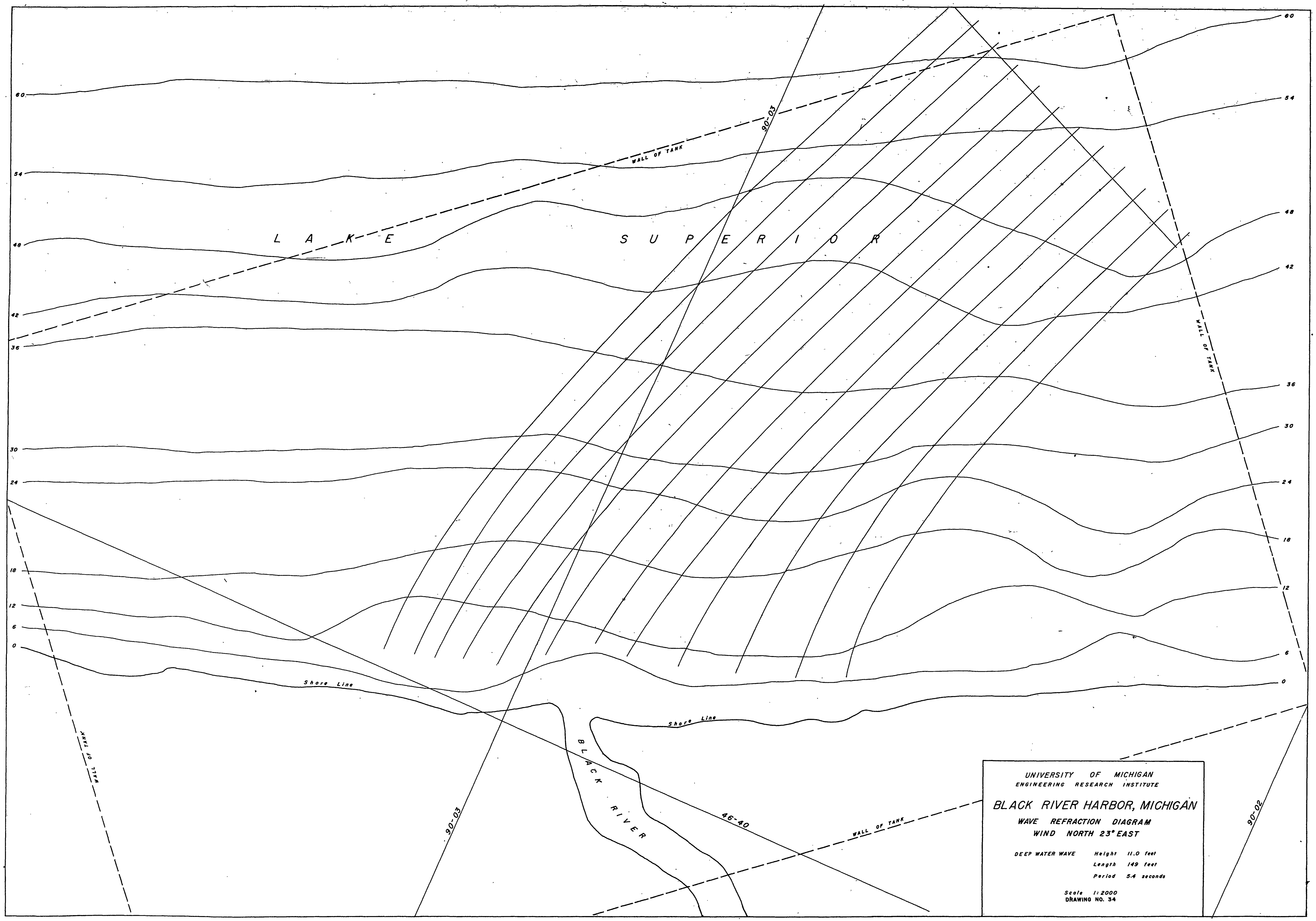
APPENDIX C

REFRACTION DIAGRAMS


UNIVERSITY OF MICHIGAN
ENGINEERING RESEARCH INSTITUTE
BLACK RIVER HARBOR, MICHIGAN
WAVE REFRACTION DIAGRAM
WIND NORTH 57° WEST
DEEP WATER WAVE Height 7.0 feet
Length 74 feet
Period 3.8 seconds
Scale 1:2000
DRAWING NO. 32
LAKE SUPERIOR
WALL OF TANK
Shore Line
BLACK RIVER
46-+0
90-02
60
54
48
42
36
30
24
18
12
6
0



60
54
48
42
36
30
24
18
12
6
0
L A K E S U P E R I O R
WALL OF TANK
90-03
Shore Line
BLACK RIVER
46-40
90-02
UNIVERSITY OF MICHIGAN
ENGINEERING RESEARCH INSTITUTE
BLACK RIVER HARBOR, MICHIGAN
WAVE REFRACTION DIAGRAM
WIND NORTH 25° WEST
DEEP WATER WAVE
Height 10.5 feet
Length 139 feet
Period 5.2 seconds
Scale 1:2000
DRAWING NO. 33



LAKE SUPERIOR
WALL OF TANK
90-03
90-02
46-40
Shore Line
BLACK RIVER
60
54
48
42
36
30
24
18
12
6
0
UNIVERSITY OF MICHIGAN
ENGINEERING RESEARCH INSTITUTE
BLACK RIVER HARBOR, MICHIGAN
WAVE REFRACTION DIAGRAM
WIND NORTH 23° EAST
DEEP WATER WAVE Height 11.0 feet
Length 149 feet
Period 5.4 seconds
Scale 1:2000
DRAWING NO. 34

AIIM SCANNER TEST CHART #2

Spectra

4 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

6 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

8 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

10 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

Times Roman

4 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

6 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

8 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

10 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

Century Schoolbook Bold

4 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

6 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

8 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

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News Gothic Bold Reversed

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Bodoni Italic

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6 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

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10 PT ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz;:",./?$0123456789

Greek and Math Symbols

4 PT ΑΒΓΔΕΞΘΗΙΚΛΜΝΟΠΦΡΣΤΥΩΧΨΖαβγδεξθηικλμνοπφρστυωχψζ≧∓",./≦±=≠°><⋫⋪⋗⋜≡

6 PT ΑΒΓΔΕΞΘΗΙΚΛΜΝΟΠΦΡΣΤΥΩΧΨΖαβγδεξθηικλμνοπφρστυωχψζ≧∓",./≦±=≠°><⋫⋪⋗⋜≡

8 PT ΑΒΓΔΕΞΘΗΙΚΛΜΝΟΠΦΡΣΤΥΩΧΨΖαβγδεξθηικλμνοπφρστυωχψζ≧∓",./≦±=≠°><⋫⋪⋗⋜≡

10 PT ΑΒΓΔΕΞΘΗΙΚΛΜΝΟΠΦΡΣΤΥΩΧΨΖαβγδεξθηικλμνοπφρστυωχψζ≧∓",./≦±=≠°><⋫⋪⋗⋜≡

White

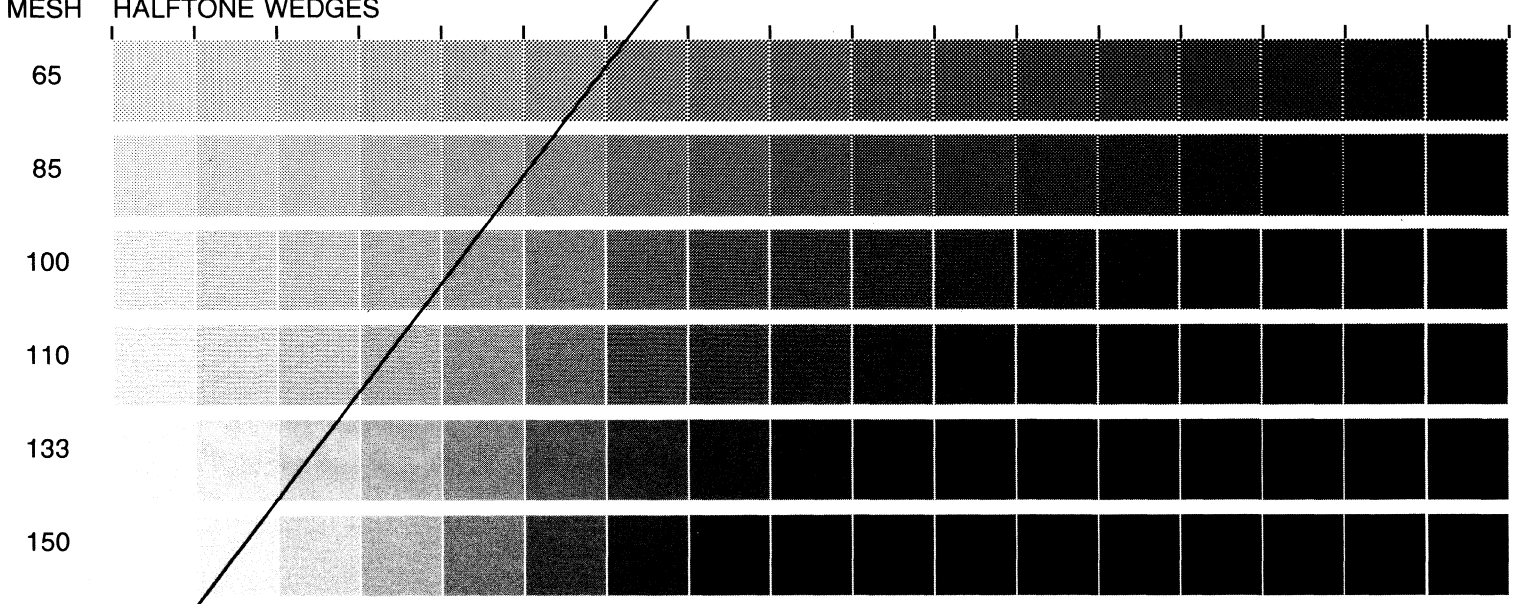
Black

Isolated Characters

e	m	1	2	3	a
4	5	6	7	o	•
8	9	0	h	I	B

A4 Page 6543210

MESH HALFTONE WEDGES



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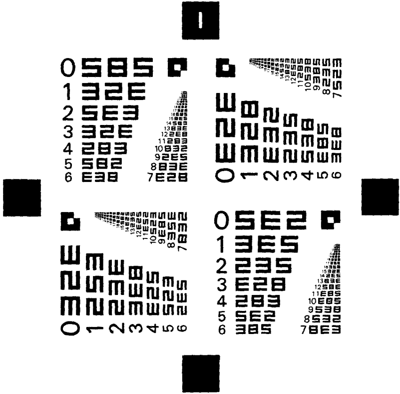
RIT ALPHANUMERIC RESOLUTION TEST OBJECT, RT-1-71



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