U. S. ARMY CORPS OF ENGINEERS

LAKE PONTCHARTRAIN, LOUISIANA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS

PART III - LAKESHORE

Prepared in the Office of the District Engineer
New Orleans District, Corps of Engineers
New Orleans, Louisiana

September 1968

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LMVED-TD (NOD 11 Sep 69) 3d Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 1 Dec 69

TO: District Engineer, New Orleans, ATTN: LMNED-PP

Referred to note approval.

FOR THE DIVISION ENGINEER:

George B. Davis
for A. J. DAVIS
Chief, Engineering Division

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LOUISIANA 70160

LMNED-PP

11 September 1969

SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

Division Engineer, Lower Mississippi Valley
ATTN: LMVED-TD

1. Reference is made to LMNED-PP letter dated 30 September 1968, subject as above, and to paragraph 2 of 2d and 4th Indorsements thereto.

2. Inclosed herewith are the additional wind tide and wave runup data for Orleans Parish.

FOR THE DISTRICT ENGINEER:

1 Incl (16 cys)
Data w/attachments

JEROME C. BAEHR
Chief, Engineering Division

Data Requested in Paragraph 2 of ENGCW-EZ 2d Ind dated 25 Feb 69 for Orleans Parish

1. Wind tides. The wind tide elevations shown in table 3, page 9, of the subject design memorandum for the Orleans Parish segment were intended to demonstrate the maximum expected tide for the SPH (Standard Project Hurricane). To establish the most critical wind direction, speed, and fetch length associated with the maximum wind tides in Orleans Parish, it was necessary to transpose and rotate the wind fields (isovel patterns) for Track A, SPH, furnished by the U. S. Weather Bureau(1)(2)(3)*.

Wind fields considered critical to the Citrus segment of the Orleans Parish lakefront, during peak storm period hours, are shown on plates 1, 2, and 3. These wind fields were used to compute a wind tide hydrograph for this segment as shown on plate 4. This hydrograph was assumed to apply generally along the entire Orleans Parish lakefront and was used with corresponding windspeeds and fetch depths to compute wave heights and runup along the south shore of Lake Pontchartrain within the limits of Orleans Parish.

2. Wave runup.

a. Wave runup for the Citrus and New Orleans East portions of the lakefront levees in Orleans Parish was computed in the same way as the runup determinations for the St. Charles and Jefferson Parish levees (reference is made to the pertinent section of inclosure 2, 4th Indorsement, dated 25 Jun 69 to LMNED-PP letter dated 30 Sept 68, and to paragraph 9 and plate 9 of subject DM).

b. The procedure used to compute wave runup along the seawall segment in Orleans Parish differs from that used for all other levee reaches along the south shore of the lake. A modification to the previous procedure was necessary because the land behind the existing seawall is generally lower in elevation than the seawall crest (8.0 feet ± mean sea level) and the levee is located approximately 250 feet behind the seawall (see plate 7 of subject DM). When the wind tide is of sufficient height to allow waves to overtop the seawall, water will pond behind the seawall and increase the stage at the levee. This ponding, in effect, permits wave setup to occur in addition to wind setup. Model study data developed by the Beach Erosion Board(4) using recorded observations at Narragansett Pier, Rhode Island, indicates a relationship between wave height, wave setup, and distance from berm crest to the back shore levee. The model study data was used to compute wave setup which was added to the maximum computed wind tide before wave runup was determined. This

*Numbers in parentheses indicate references in paragraph 3, Bibliography.

wave setup over the wind setup permits slightly larger waves to reach the levee than ordinarily would if the land behind the seawall were at the same elevation as the seawall crest. (See the discussion for St. Charles and Jefferson Parish concerning runup on levees with berms, inclosure 2, 4th Indorsement dated 25 Jun 69 to LMNED-PP letter dated 30 Sept 68.) These larger waves are possible within the ponding area because the water transported by the wave over the seawall crest toward the levee cannot completely return to the lake before the following wave crest traverses the seawall--the net effect being an increase in stage within the ponding area. An equilibrium point is reached when the potential energy of the raised water equals the kinetic energy of the wave climate. In addition, those waves which break on the seawall are regenerated between the seawall and the levee before reaching the levee. The height of the regenerated wave is limited by the magnitude of the parent wave (significant or otherwise), the horizontal distance between the seawall and the levee, and the average depth within the ponding area. The regenerated wave retains the parent wave period. Those waves which pass over the seawall crest unbroken continue toward the levee unchanged until they reach the levee toe. Only the significant wave in the wave spectrum expected within the ponding area was used to compute the wave runup and grade of the levee required, because smaller waves in the spectrum cause less runup than the significant wave when they break on the same slope.

c. Table 1 gives pertinent data used to determine wave characteristics along the three segments in Orleans Parish where wave runup is possible. Table 2 gives the design wave characteristics used in computing runup from the significant wave for each segment. Tables 3, 4, and 5 give the results of wave runup computations requested in the 2d Ind, ENGCW-EZ, dated 25 Feb 69.

TABLE 1
DATA USED TO DETERMINE WAVE CHARACTERISTICS
DESIGN HURRICANE

Parameters	Levee Location--Orleans Parish		
	Citrus-N.O. East	Seawall	Ponding Area
F - Length of fetch	5 mi.	5 mi.	250 ft. (±)
U - Windspeed, in m.p.h.	83	82	82
swl - Stillwater level, in feet m.s.l.	8.5	8.5	9.15
d - Average depth of fetch, in feet	21.4	21.6	2.43
d_t - Depth at toe of levee, in feet	11.5	-	3.85

TABLE 2
WAVE CHARACTERISTICS
DESIGN HURRICANE

Characteristics	Levee Location--Orleans Parish		
	Citrus-N.O. East	Seawall	Ponding Area
H_s - Significant wave height, in feet	7.5	7.5	0.62
T - Wave period, seconds	6.8	6.8	6.8
L_o - Deep water wave length, in feet	236.8	236.8	236.8
d/L - Relative depth	0.0904	0.0912	NA*
H_s/H_o' - Shoaling coefficient	0.9418	0.9409	NA
H_o' - Deep water wave height, in feet	7.97	7.97	NA
H_o'/T^2 - Wave steepness	0.172	0.172	0.013

*NA = not applicable

TABLE 3

DESIGN WIND TIDE, WAVE, AND WAVE RUNUP DATA*
TRACK A - CITRUS-N.O. EAST LAKEFRONT (Slope covered to elev. +6.5 with riprap)

Hour	Wind tide feet m.s.l.	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T sec.	H_o' feet	Hypothetical slope vert. to hor.	Runup el. feet m.s.l.	Design el. feet m.s.l.
+7	7.60	79	5	20.50	1.10	6.70	0.31	1 on 5	9.03	13.5
+9	8.50	83	5	21.40	2.00	6.80	0.77	1 on 5	11.35	13.5
+11	7.65	73	5	20.55	1.15	6.55	0.35	1 on 5	9.26	13.5

*For wave breaking at levee elevation +6.5 on 1 on 5 slope.

TABLE 4

DESIGN WIND TIDE, WAVE, AND WAVE RUNUP DATA*
TRACK A - CITRUS-N.O. EAST LAKEFRONT (Slope covered to elev. +6.5 with riprap)

Hour	Wind tide feet m.s.l.	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T sec.	H'_o feet	Hypothetical slope vert. to hor.	Runup el. feet m.s.l.	Design el. feet m.s.l.
+7	7.60	79	5	20.50	9.05	6.70	7.42	1 on 8.1	12.16	13.5
+9	8.50	83	5	21.40	9.60	6.80	7.97	1 on 7.9	13.44	13.5
+11	7.65	73	5	20.55	8.61	6.55	7.03	1 on 8.3	11.97	13.5

*For significant wave.

TABLE 5

DESIGN WIND TIDE, WAVE, AND WAVE RUNUP DATA
TRACK A - LEVEE ALONG ORLEANS PARISH SEAWALL SEGMENT

Hour	Wind tide & wave set up feet m.s.l.	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T sec.	H_s* feet	Levee slope vert. to hor.	Runup el. feet m.s.l.	Design el. feet m.s.l
+8	8.95	81	5	21.30	2.24	6.75	0.54	1 on 5	11.16	12.0
+9	9.15	83	5	21.60	2.43	6.80	0.62	1 on 5	11.66	12.0
+10	9.01	82	5	21.50	2.29	6.80	0.56	1 on 5	11.31	12.0

*Significant wave height within the ponding area.

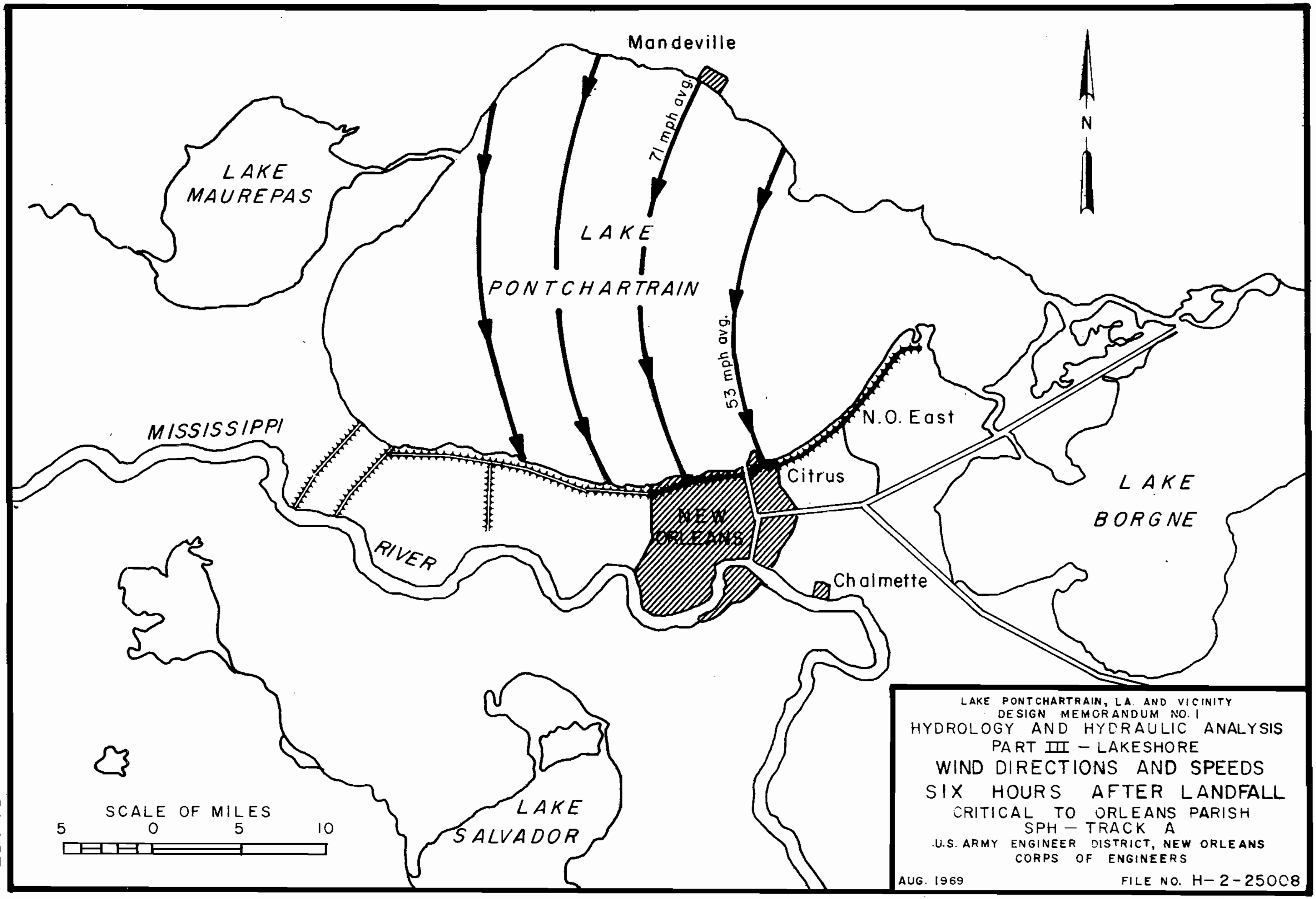
3. Bibliography.

(1) U. S. Weather Bureau, "Louisiana Hurricane of September 29, 1915, transposed to a Critical Track," Memorandum HUR 7-40, September 6, 1957.

(2) U. S. Weather Bureau, "Ratio Chart to Adjust Isovel Patterns in HUR 7-40 to Level of Updated SPH Patterns," Memorandum HUR 7-85A, February 17, 1966.

(3) U. S. Weather Bureau, National Hurricane Research Project Report No. 33, "Meteorological Considerations Pertinent to Standard Project Hurricane, Atlantic and Gulf Coasts of the United States," November 1959.

(4) U. S. Army Beach Erosion Board, "Model Study of Wave Set-Up Induced by Hurricane Waves at Narragansett Pier, Rhode Island," The Annual Bulletin, Vol. 12, July 1958, pp 9 to 20.



LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III – LAKESHORE

WIND DIRECTIONS AND SPEEDS
SIX HOURS AFTER LANDFALL
CRITICAL TO ORLEANS PARISH
SPH – TRACK A

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

AUG. 1969 FILE NO. H-2-25008

PLATE I

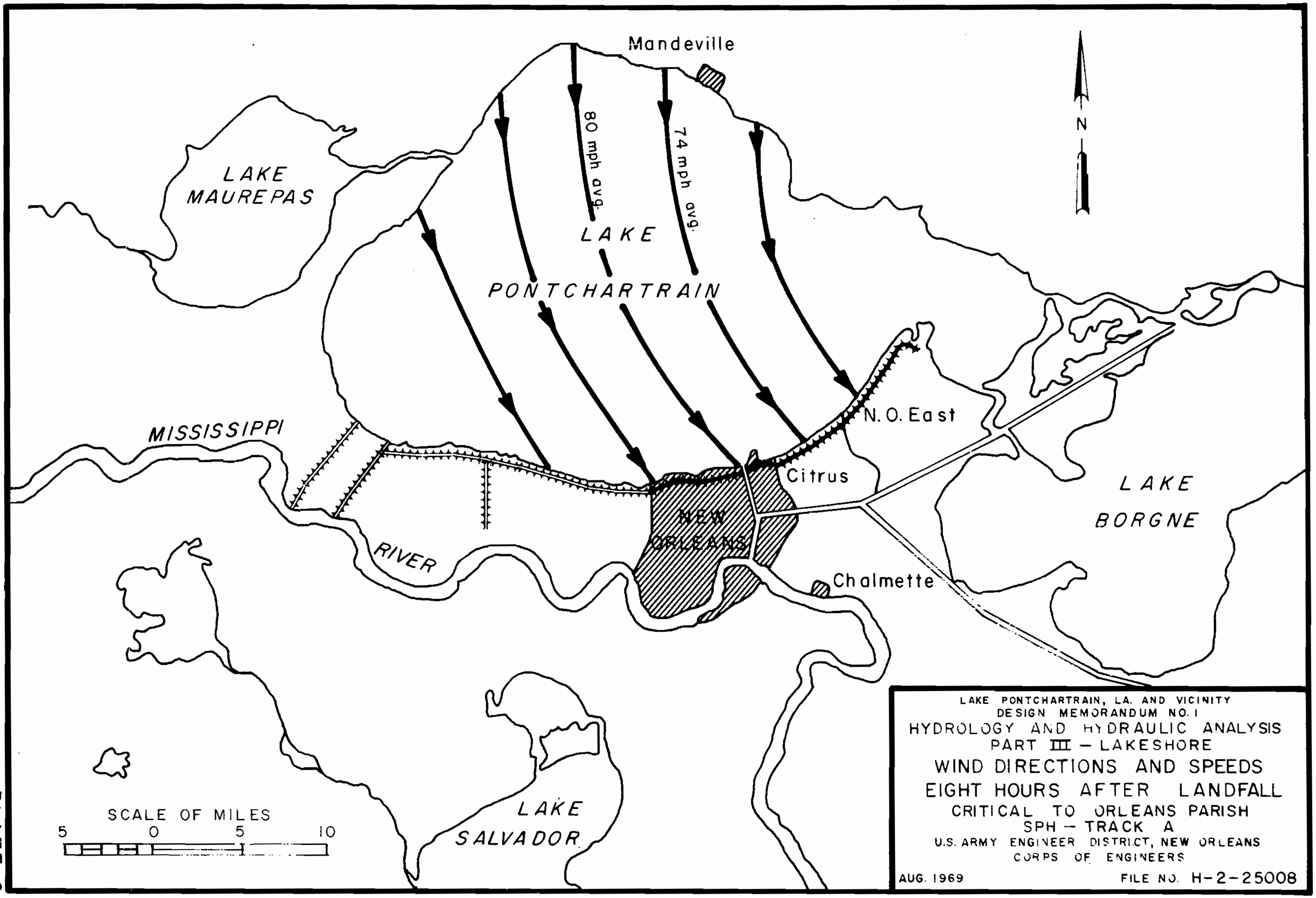


PLATE 2

PLATE 2

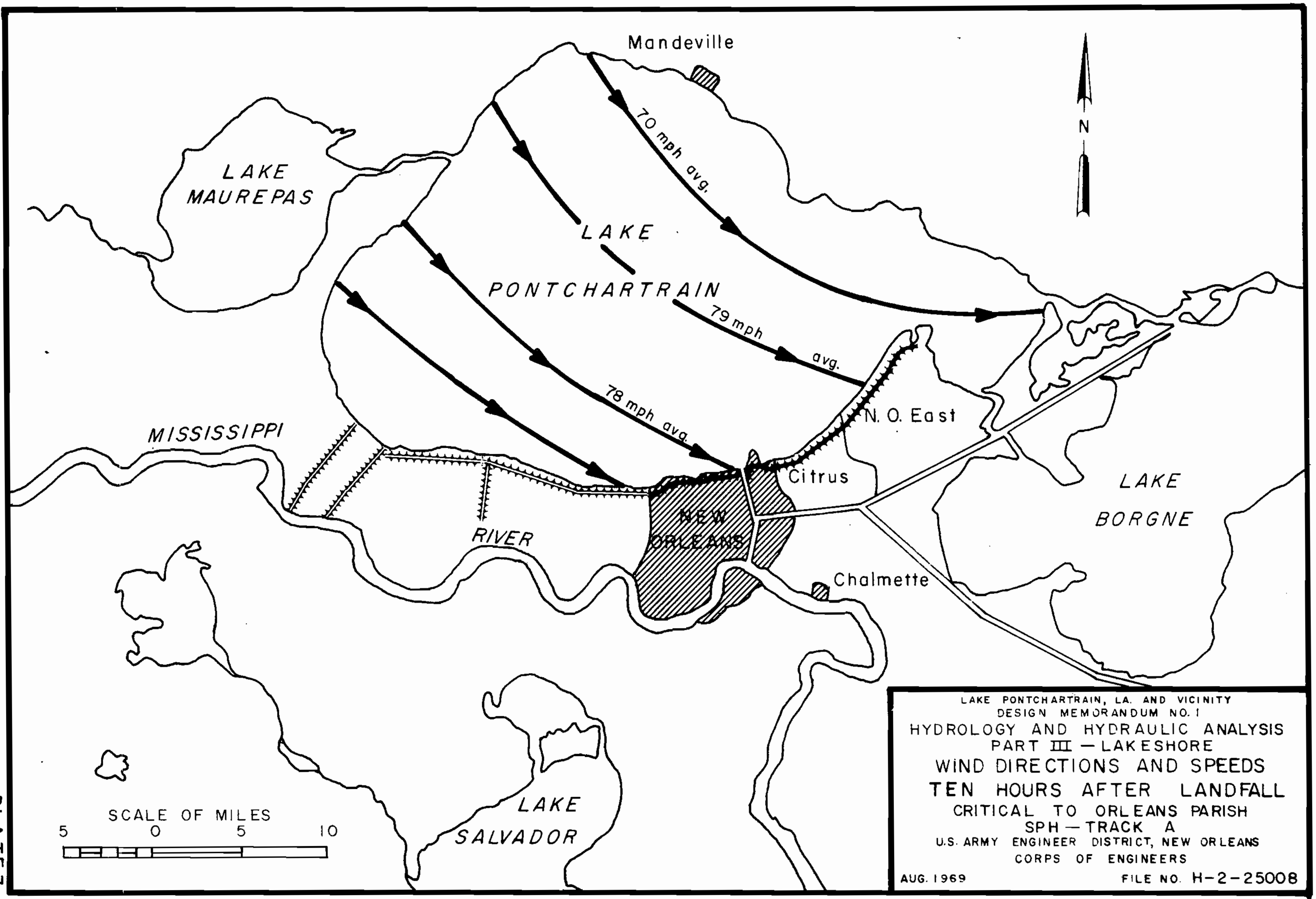
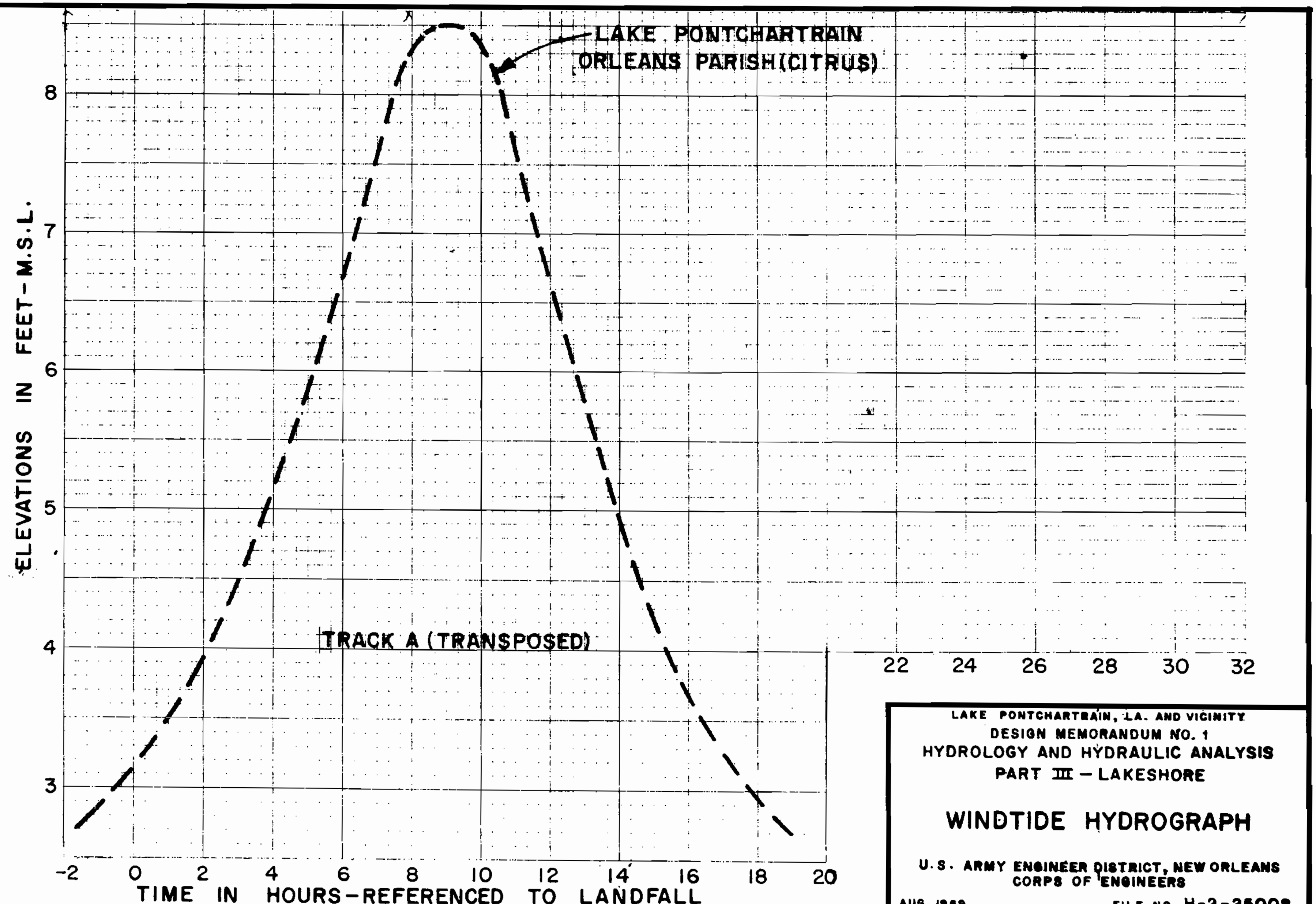


PLATE 3

PLATE 3



LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III – LAKESHORE

WINDTIDE HYDROGRAPH

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

AUG. 1969 FILE NO. H-2-25008

PLATE 4

LMVED-TD (NOD 11 Sep 69) 1st Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 30 Sep 69

TO: Chief of Engineers, ATTN: ENGCW-EZ

1. Forwarded pursuant to request contained in para 2 of 2d Ind and as stated in para 2 of LMVED-TD 5th Ind, 18 Jul 69, on correspondence referred to in para 1 of basic letter.

2. Additional data furnished by the District Engineer are considered satisfactory.

FOR THE DIVISION ENGINEER:

George B. Davis
GEORGE B. DAVIS
Acting Chief, Engineering Division

1 Incl
wd 2 cy

CF:
NOD-LMNED-PP

ENGCW-EZ (LMNED-PP,11 Sep 69) 2d Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Office of the Chief of Engineers, Washington, D. C. 20315 24 November 1969

TO: Division Engineer, Lower Mississippi Valley, ATTN: LMVED-TD

The additional wind tide and wave runup data for Orleans Parish are satisfactory.

FOR THE CHIEF OF ENGINEERS:

1 Incl
wd

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

LMVED-TD (NOD 30 Sep 69) 7th Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 9 Oct 69

TO: District Engineer, New Orleans, ATTN: LMNED-PP

Referred to note approval of this part.

FOR THE DIVISION ENGINEER:

A. J. DAVIS
Chief, Engineering Division

LMVED-TD (NOD 30 Sep 68) 1st Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 18 Oct 68

TO: Chief of Engineers, ATTN: ENGCW-V/ENGCW-E

1. Pursuant to para 17a, ER 1110-2-1150, the subject design memorandum is forwarded for your review and approval. Approval is recommended, subject to the following comments.

2. The location of "South Point" should be indicated on the plates.

3. Para 2, page 2. The second-to-last sentence in this paragraph indicates that the portion of the Orleans Parish lakefront levee which lies between the Jefferson-Orleans Parish line and the IHNC is not covered in this memorandum, while Table 3 lists the proposed elevation of protective structures in this reach. This difference should be reconciled.

4. Para 9c, page 9. The elevation to which the levee must be raised should be indicated.

5. Table 3, page 9. It is noted that the Jefferson Parish levee, which is contiguous to the St. Charles Parish levee, has a crown elevation 2.5 feet lower in elevation. Upon contact with NOD, it was learned that the reason for this difference is that the Standard Project Hurricane wind tide level for the St. Charles Parish levee occurs at its junction with the Bonnet Carre levee and slopes easterly to an elevation of 8.5 feet at the Jefferson Parish line. The present design plan for the St. Charles Parish levee is to put a break in grade at its midpoint with the western half having a crown elevation of 12.5 feet, and the eastern half having a crown elevation of 12.0 feet. Local interests are now in the process of raising the Jefferson Parish levees to elevation 14.0.

6. Para 10, page 9. The design of floodwalls should take into account possible damage to the foundation caused by erosion resulting from overtopping of the wall. Also, the maximum wave height should be assumed during design to insure that the wall is not overstressed.

7. Plate 8. a. The fact that the flagstone wall is an existing wall should be indicated.

LMVED-TD (NOD 30 Sep 68) 1st Ind 18 Oct 68
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

b. Since the flagstone may be structurally inadequate, the DM should indicate that this wall is not necessarily the protective structure and that only its general shape was used to determine wave runup.

FOR THE DIVISION ENGINEER:

George B. Davis

1 Incl
wd 2 cy

GEORGE B. DAVIS
Acting Chief, Engineering Division

CF:
NOD-LMNED-PP

ENGCW-EZ (LMNED-PP, 30 Sep 68) 2nd Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Office of the Chief of Engineers, Washington, D. C. 20315 25 Feb 1969

Division Engineer, Lower Mississippi Valley

1. Approved, subject to the comments of the Division Engineer and the following.

2. The results of the surge elevation determinations shown in Table 3 for the Jefferson Parish, where the surge is 2 feet lower in elevation than the adjacent St. Charles Parish, show a considerable variation for such a short distance and should be substantiated. In the event the wind direction and effective velocities contributed to the difference in surge height elevations, a slight shift in the hurricane track and windfield may result in equally as critical winds for Jefferson Parish as for St. Charles Parish. A clear explanation of procedures, with supporting data and criteria used in estimating wave characteristics and runup on embankment slopes, should be presented. The surge hydrographs computed for specific point locations should be submitted to supplement values shown for the reaches indicated in the subject design memorandum. In addition to the information furnished in Table 3, the wind speed MPH critical at the surge height peak, height of significant wave Hs/ft., average water depth feet used for the particular location and wave period T/sec should be furnished, similar to Tables A-14 and A-15 in House Document No. 231, 89 Congress, First Session, July 1965.

FOR THE CHIEF OF ENGINEERS:

1 Incl
wd

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

LMVED-TD (NOD 30 Sep 68) 3d Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 6 Mar 69

TO: District Engineer, New Orleans, ATTN: LMNED-PP

Referred to note approval, subject to the comments in the previous indorsements.

FOR THE ACTING DIVISION ENGINEER:

George B. Davis
for A. J. DAVIS
Chief, Engineering Division

LMNED-PP (NOD 30 Sept 68) 4th Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, New Orleans District, Corps of Engineers, PO Box 60267, New Orleans, La. 70160 25 Jun 69

TO: Division Engineer, Lower Mississippi Valley, ATTN: LMVED-TD

1. The following statements are submitted as resolutions of comments made in 1st Ind dated 18 Oct 68:

a. Ref. par. 2. This comment is concurred in.

b. Ref. par. 3. That portion of the Orleans Parish lakefront levee which lies between the Jefferson-Orleans parish line and the IHNC should have been included in the second-to-last sentence of paragraph 2 page 2, subject DM.

c. Ref. par. 4. The first portion of the sentence of paragraph 9c, page 9, subject DM, should read as follows: "In view of the proximate location of the existing levee to the New Orleans lakefront seawall in the vicinity of the U. S. Coast Guard Station, as shown on plate 7, wave runup is such that the levee must be raised to elevation 17.5 feet mean sea level, an increase of 5.5 feet on a 1 on 8 slope which would require 88 feet of additional right-of-way. The landside toe would fall well into a parking area and eliminate its utility," hence....

d. Ref. par. 5. This comment is concurred in.

e. Ref. par. 6. Riprap will be provided where needed in the design of floodwalls to insure protection against erosion damage to the foundation area resulting from overtopping of the wall. Also, the maximum wave height will be assumed in the design to insure that the floodwalls are not overstressed.

f. Ref. par. 7a. This comment is concurred in.

g. Ref. par. 7b. The flagstone wall shown on plate 8 illustrates the general shape which was used to determine wave runup. Structural strength will be achieved with an inner core of properly reinforced concrete which will be faced with flagstone for beautification.

LMNED-PP (NOD 30 Sept 68) 4th Ind 25 Jun 69
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

2. The general design memorandum for the St. Charles Parish lakefront levee is presently scheduled to be completed in August 1969. Therefore, the data requested in paragraph 2 of 2d Ind dated 25 Feb 69 for Jefferson Parish and St. Charles Parish are inclosed herewith (incl 2) for review and approval prior to completion of the general design memorandum. The data for all other areas covered in the subject DM will be forwarded as soon as possible.

FOR THE DISTRICT ENGINEER:

Added 1 incl (16 cys)
2. Data w/attachments

JEROME C. BAEHR
Chief, Engineering Division

Data Requested in Paragraph 2 of ENGCW-EZ 2d Ind dated 25 Feb 69 for Jefferson and St. Charles Parishes

1. Windtides.

a. The windtide determinations shown in table 3, page 9, of the subject Design Memorandum for Jefferson and St. Charles Parishes were intended to demonstrate the maximum expected tide along each parish. These maximum windtides occur at approximately the western extremity of each parish levee, a distance of 5.7 miles apart. See plate 1 (attachment 1). Windtide hydrographs computed for the two locations are shown on plate 2 (attachment 2) for track C; however, Standard Project Hurricanes can traverse the project area from several directions and cause similar hydrographs to occur at these two locations. The actual location of the hurricane center and the windfield is of greater significance when determining the maximum expected windtide or surge for a particular location. A hurricane, Track C, met these requirements and was used as an aid to generate the hydrographs for the purpose of this discussion. Plate 2 shows that the peak windtide in Jefferson Parish occurs approximately 1 hour prior to the maximum at the St. Charles Parish location. If a hurricane approached from another direction, for instance Track A, the reverse could occur because the highest onshore winds would travel from west to east.

b. For Track C both stages are practically the same 1 hour after landfall. The same critical wind direction and practically the same average windspeeds were used to compute these stages (82 miles per hour for Jefferson Parish and 77 miles per hour for St. Charles Parish). The wind direction and windspeeds for the critical hour (1 hour after landfall) in Jefferson Parish are shown on plate 1. The height of a windtide is equally as dependent upon the maximum effective fetch length and depth as it is upon the wind direction and velocity. For this particular hour, the fetch lengths are 30.1 miles long for Jefferson Parish and 30.9 miles long for St. Charles Parish and the average undisturbed fetch depths along the segmental strips are 15.3 feet for Jefferson Parish and 14.4 feet for St. Charles Parish. It can be shown from a study of the windtide equations (see par 8d, page 7 of subject design memorandum) that for a given windspeed (U) and incremental fetch length (ΔX), a larger setup increment (ΔS_i) will be computed for a shallower fetch (dT) over the increment. The differences in windspeed and differences in fetch length and depth are offsetting at 1 hour after landfall.

c. The wind direction and windspeeds for the critical hour (2 hours after landfall) in St. Charles Parish are shown on plate 3 (attachment 3). It should be noted on plate 3 that the segmental strips and the wind directions are parallel to each other and both extend in an east-west direction along the south shore of Lake Pontchartrain for hurricane Track C. The effective fetch length for the Jefferson Parish segmental strip is 24.4 miles and for the St. Charles Parish segmental strip it is 33.5 miles--a difference of 9.1 miles. The average undisturbed depth of fetch for Jefferson Parish is 15.2 feet and for St. Charles Parish it is 14.8 feet, a difference less than that for the previous hour. The greater fetch length and slightly shallower average undisturbed depth along the St. Charles Parish segmental strip causes the 2-foot difference in computed windtides since the average windspeeds (87 miles per hour for Jefferson Parish and 85 miles per hour for St. Charles Parish) and wind directions are virtually the same for each location. In effect this means that the windtide is increasing from east to west along the south shore of Lake Pontchartrain. Similar explanations apply to other differences which are evident on plate 2 for several hours after the peak. See wind direction and windspeeds at 4 hours after landfall, plate 4 (attachment 4).

d. Studies in Lake Pontchartrain of experienced hurricanes considered critical to the western half of Lake Pontchartrain (hurricanes of September 1915 and September 1965, "Betsy") have indicated rates of windtide increase along shore of 5.9 feet (12.0 feet - 6.1 feet) in 12.5 miles, 4 feet (13.0 feet - 9.0 feet) in 7.5 miles(1)*, and 1.9 feet (12.1 feet - 10.2 feet) in 6.1 miles.(2) These rates converted to 2 feet in X miles would be: 2.0 feet in 4.2 miles, 2.0 feet in 3.8 miles, and 2.0 feet in 6.4 miles. For the case under discussion, a rise of 2 feet occurs in 5.7 miles; this rate is in close agreement with the experienced rates just cited. Plate 5 (attachment 5) shows the windtide profile at 2 hours after landfall for the two locations plotted with reference to a common nodal line where neither setup nor setdown occurs. The nodal line is located at the average lake stage to which the lake surface would resolve to if all wind effects were to cease. These profiles demonstrate the rate of increase or decrease in windtide per mile along the segmental strips on either side of the nodal line. It should be noted on plate 5 that a 2-foot drop occurs along the St. Charles Parish profile from the windward shore to a point 4.0 miles offshore and that a slightly steeper rate (2.2 feet) occurs along the Jefferson Parish profile for the same 4.0-mile interval offshore. This steeper rate of windtide setup for the Jefferson Parish profile on the setup side of the nodal line is attributable to a shallower average fetch depth (18.8 feet in Jefferson Parish as compared

*Numbers in parentheses indicate references in paragraph 3, Bibliography.

to 19.9 feet in St. Charles Parish), and to a much lesser degree, the higher windspeed of 87 m.p.h. in Jefferson Parish as compared to 85 m.p.h. in St. Charles Parish. These average fetch depths include the average windtide plus the undisturbed lake depths.

e. Based upon the discussion in paragraphs b, c, and d above, it is reasonable to assume that the windtide will slope smoothly upward from the Jefferson Parish-St. Charles Parish boundary westward to the western extremity of the St. Charles Parish levee. Plate 6 (attachment 6) shows the windtide surface contours at 2 hours after landfall when the 2-foot differential occurs. A study of these contours and the windtide elevations at the westward end of the two northernmost segmental strips reveals that the windtide increases from east to west along the north shore of Lake Pontchartrain also. When the final levee cross sections are determined, the required elevation of St. Charles Parish levee will be somewhat lower at its eastern extremity because of the lower windtide at that location.

2. Wave runup.

a. Wave runup on a protective structure depends on the characteristics of the structure (i.e., shape and roughness), the depth of water at the structure, and the wave characteristics. The vertical height to which water from a breaking wave will run up on a given protective structure determines the top elevation to which the structure must be built to prevent wave overtopping and resultant flooding of the area to be protected. Wave runup is considered to be the ultimate height to which water in a wave ascends on the proposed slope of a protective structure. This condition usually occurs when the windtide is at the maximum elevation.

b. The parameters which determine wave characteristics are the fetch length, the windspeed, duration of wind, and the average depth of water over the fetch. In determining the design wave characteristics, it was assumed that steady state conditions prevail; that is, the windspeed is constant in one direction over the fetch and blows long enough to create a fully developed sea. The windspeed (U) is an average velocity over the fetch (F) and is obtained from the isovel patterns for synthetic hurricanes critical to the levee locations. The depth of fetch (d) is the average windtide height plus the average normal depth.

c. In order to compute wave runup on a protective structure, the significant wave height (H_s) and wave period (T) in the vicinity of the structure must be known. They were determined according to Bretschneider[3] and as described in paragraph 1.25 of the U. S. Army Coastal Engineering Research Center, Technical Report No. 4, "Shore Protection, Planning and Design," Third Edition, 1966, pp 51 through 62. The windspeed and depth used in determining H_s and T are average values over a 5-mile fetch. Data used to determine design hurricane wave characteristics in the vicinity of the protective structures are shown in table 1.

TABLE 1
DATA USED TO DETERMINE WAVE CHARACTERISTICS
DESIGN HURRICANE

Parameters	Levee Locations, Parishes Jefferson	St. Charles
F - Length of fetch, in miles	5	5
U - Windspeed, in m.p.h.	85	87
swl - Stillwater level, in feet m.s.l.	8.7	10.4
d - Average depth of fetch, in feet	20.5	20.3
d_t - Depth at toe of levee, in feet	7.7	9.4

d. Wave runup was calculated by use of model study data developed by Saville (4)(5)(6)(7) which relate relative runup (R/H_o'), wave steepness (H_o'/T^2), and relative depth (d/H_o'). The significant wave height (H_s) and wave period (T) can be determined from the data in table 1. The equivalent deep water wave height (H_o') can be determined from table D-1 of Technical Report No. 4 which relates (d/L_o) to (H/H_o'). The deep water wave length (L_o) is determined from the equation:

$$L_o = 5.12T^2$$

When determining runup from the significant wave, H in the term (H/H_o') is equal to H_s. Wave characteristics used in computing runup from the significant wave are shown in table 2.

TABLE 2
WAVE CHARACTERISTICS
DESIGN HURRICANE

Characteristic	Levee Locations, Parishes Jefferson	St. Charles
H_s - Significant wave height, in feet	7.52	7.47
T - Wave period, seconds	6.75	6.80
L_o - Deep water wave length, in feet	233.3	236.8
d/L_o - Relative depth	0.0880	0.0858
H_s/H_o' - Shoaling coefficient	0.9445	0.9472
H_o' - Deep water wave height, in feet	7.96	7.92
H_o'/T^2 - Wave steepness	0.175	0.171

e. With the terms d/H_o' and H_o'/T^2 known, runup on a protective structure can be computed if the slope of the structure is known. The levee configurations used in these computations had stabilizing berms on the water side (see plate 7, attachment 7). These berms broke the continuity of the levee slope and Saville's method(7) for determining wave runup on composite slopes was used (see plate 8, attachment 8). In using this method, the actual composite slope is replaced by a hypothetical single constant slope. This hypothetical slope is computed by estimating the value of wave runup and then determining the slope of a line from the point where the wave breaks to the estimated point of runup. The breaking depth is determined from the equation:

$$d_b = \frac{0.667\ H_o'}{(H_o'/T^2)^{1/3}}$$

Using the slope of this line, which is the hypothetical slope, a value of runup is determined. If the value of runup determined is different from the estimated runup, the process is then repeated using the new value of runup to obtain a new hypothetical slope which, in turn, determines a new value of runup. This process is repeated until the estimated value of runup agrees with the computed value of runup. After the runup is determined for a smooth impermeable structure of the same slope, the computed runup is reduced according to a ratio of the length of riprap covered slope to the total length of slope and a ratio of the runup on a 1 on 1 1/2 slope covered with a single layer of riprap to the runup on a 1 on 1 1/2 smooth impermeable slope. The method of computing the reduction of runup on riprap covered slopes is presented on page 194 of Technical Report No. 4 previously mentioned in paragraph c above.

f. Protective structures exposed to wave runup will be constructed to an elevation that is sufficient to prevent all overflow from the significant wave and waves smaller than the significant wave accompanying the design hurricane. Waves larger than the significant wave will break farther offshore and will not endanger the security of the structures. During the time of maximum windtide the berms on the water side of the levees become submerged and waves of lesser height than the significant wave, but of the same period, break at the levee toe or farther up the levee slope. Sometimes runup from these smaller waves reaches an elevation higher than that from the significant wave; therefore, runup resulting from these smaller waves must also be computed. The equivalent deep water wave height for these smaller waves was computed from a new breaking depth (d_b) over each berm by the equation:

$$H_o' = \frac{1.84}{T}\ (d_b)^{3/2}$$

Runup was computed for the significant wave and for smaller waves breaking on each berm and the required levee height was determined by adding the highest computed runup value to the maximum stillwater elevation. Design runup values and proposed elevations of protective structures are shown in tables 3 through 8 (attachments 9 through 14). The runup elevations shown in table 3 are based on preliminary levee cross sections and since runup depends on the section configuration, runup elevations will be recomputed and necessary adjustments made if the final section for St. Charles Parish is materially different from the preliminary section used in this analysis. It should be noted that the Jefferson Parish levee is an existing levee which was recently raised from elevation +10.0 feet to +14.0 feet mean sea level as an interim protection measure by local interests to afford a greater degree of protection until the barrier complex at the Chef Menteur and Rigolets Passes is completed.

3. Bibliography.

(1) U. S. Army Engineer District, New Orleans, "Hurricane Study, History of Hurricane Occurrences Along Coastal Louisiana," Report, December 29, 1961, plate 11.

(2) U. S. Army Engineer District, New Orleans, "Hurricane Betsy, September 8-11, 1965," Report, November 1965, plate 5.

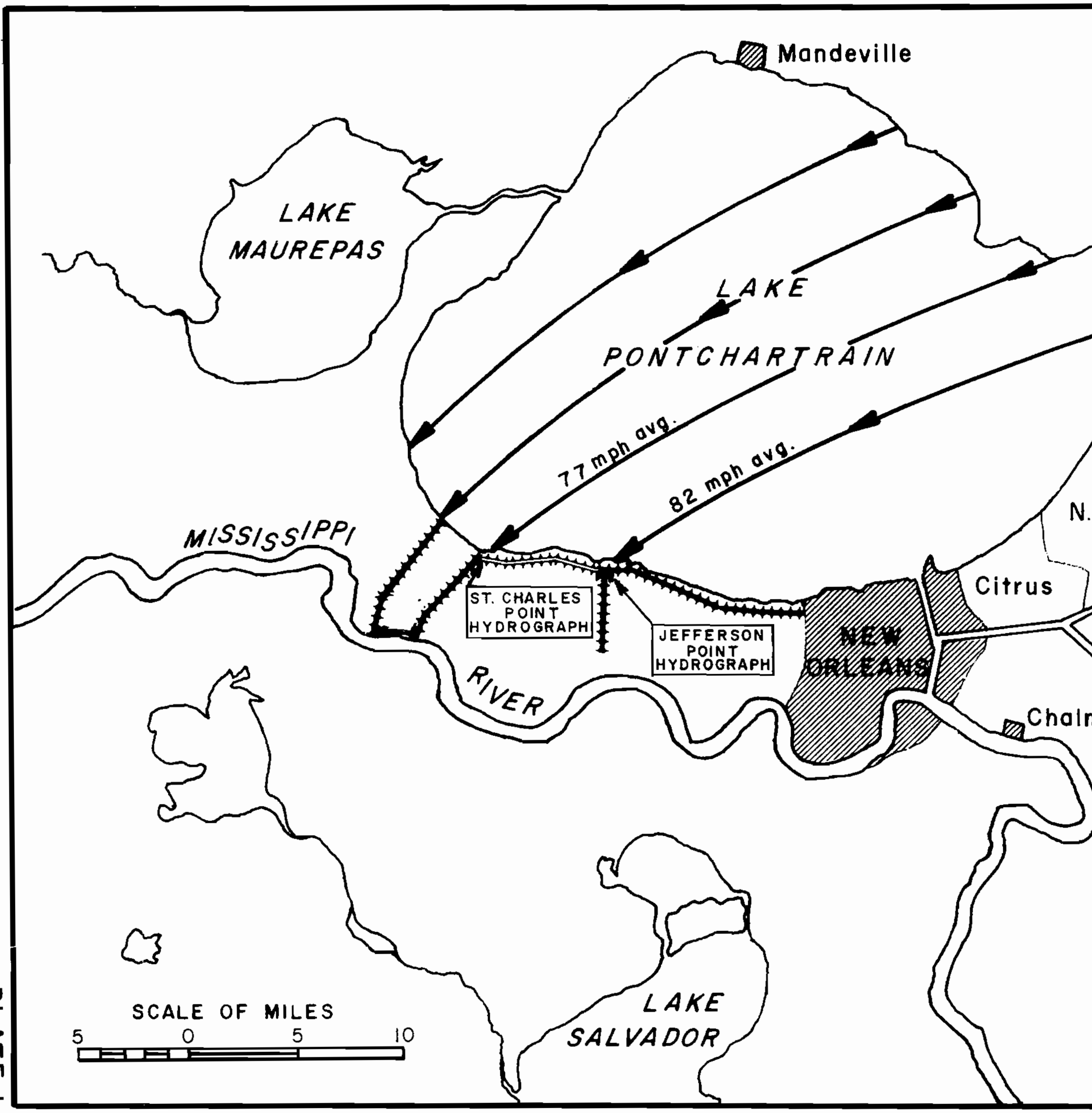
(3) Bretschneider, C. L., "Prediction of Wind Waves and Set-Up in Shallow Water, with Special Application to Lake Okeechobee, Florida," Unpublished Paper, Texas A&M College, August 1954.

(4) Saville, Thorndike, Jr., "Laboratory Data on Wave Run-up and Overtopping on Shore Structures," Beach Erosion Board, Technical Memorandum No. 64, October 1955.

(5) Saville, Thorndike, Jr., "Wave Run-Up on Shore Structures," Journal of the Waterways Division of the American Society of Civil Engineers, Vol. 82, No. WW 2, April 1956.

(6) Saville, Thorndike, Jr., Inclosure to letter from Beach Erosion Board to U. S. Army Engineer District, New Orleans, 1 July 1958.

(7) Saville, Thorndike, Jr., "Wave Run-Up on Composite Slopes," Proc of the 6th Conference on Coastal Engineering, Council on Wave Research, University of California 1958.



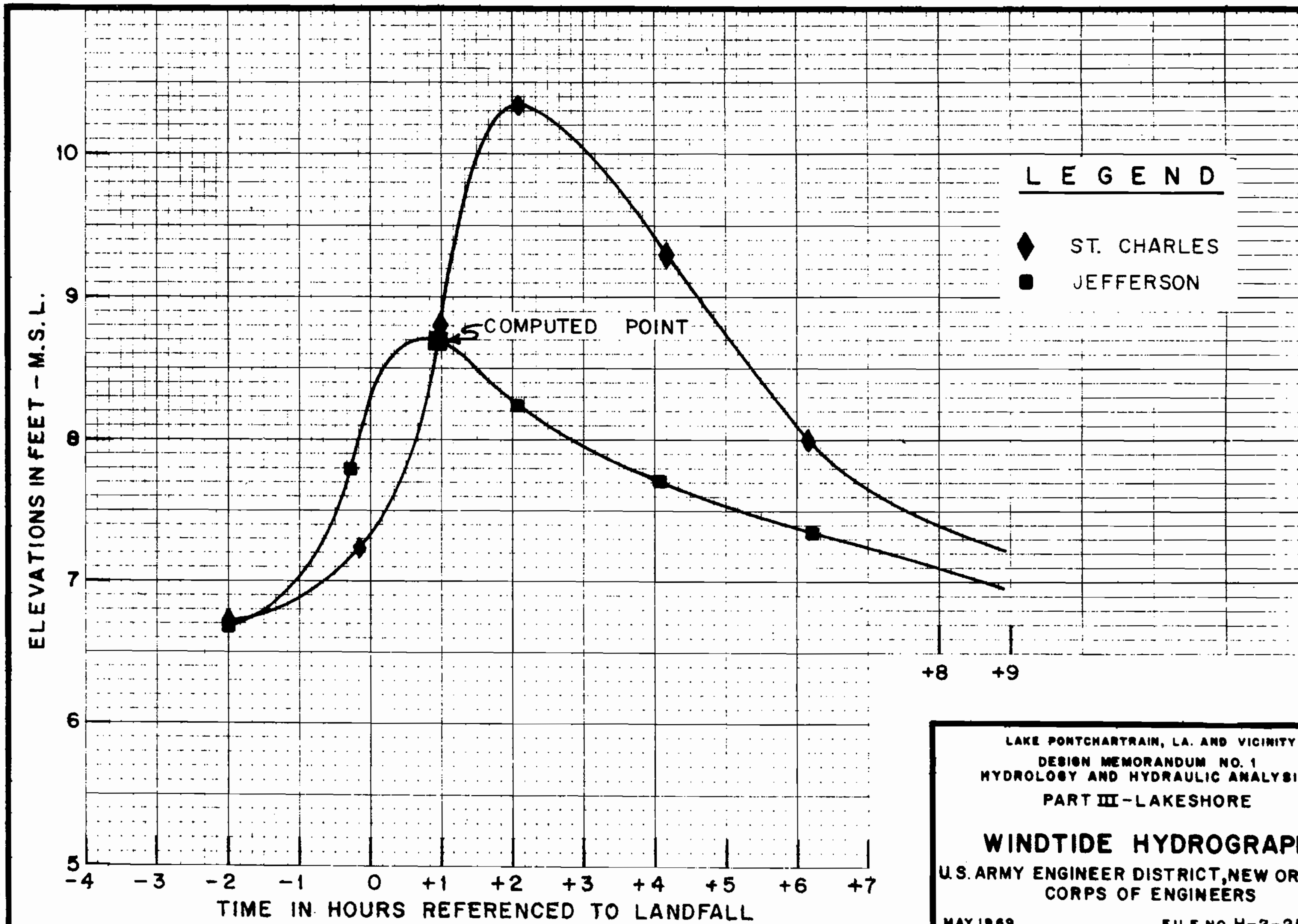
LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE

WIND DIRECTIONS AND SPEEDS ONE HOUR AFTER LANDFALL CRITICAL TO JEFFERSON

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

MAY 1969 FILE NO. H-2-25008

PLATE I



LAKE PONTCHARTRAIN, LA. AND VICINITY

DESIGN MEMORANDUM NO. 1

HYDROLOGY AND HYDRAULIC ANALYSIS

PART III – LAKESHORE

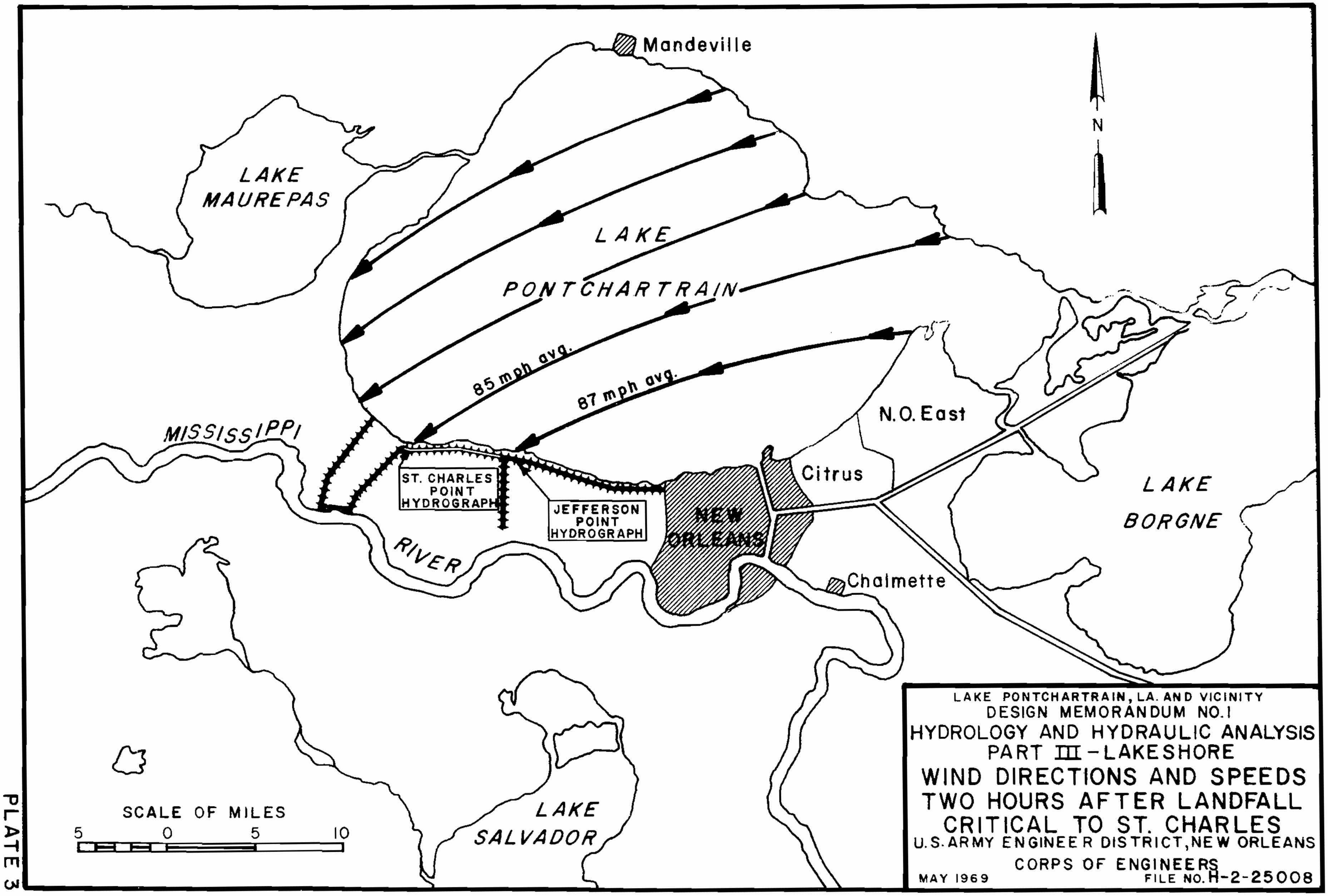
WINDTIDE HYDROGRAPHS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS

MAY 1969 FILE NO. H-2-25008

PLATE 2



LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE

WIND DIRECTIONS AND SPEEDS
TWO HOURS AFTER LANDFALL
CRITICAL TO ST. CHARLES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
MAY 1969 FILE NO. H-2-25008

PLATE 3

PLATE 3

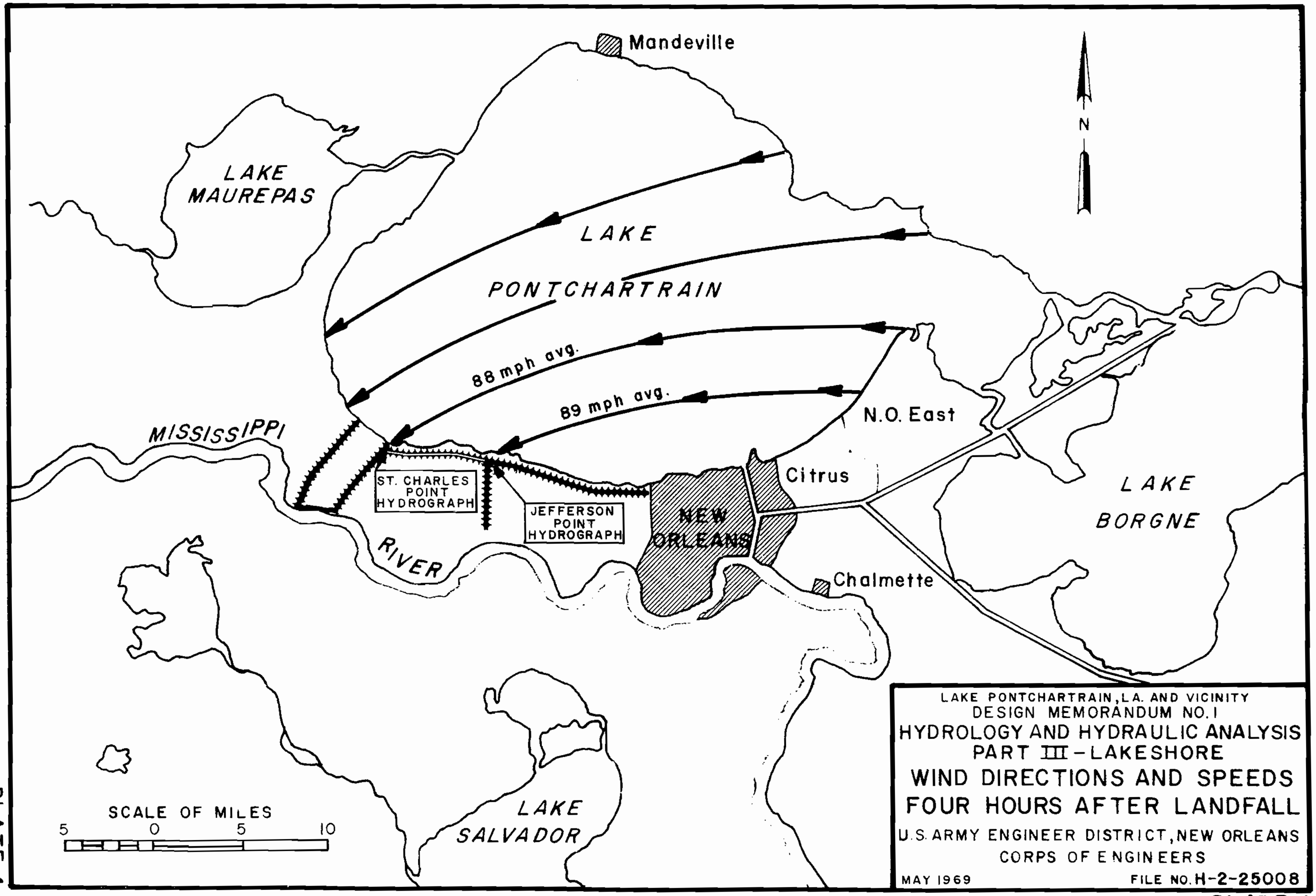
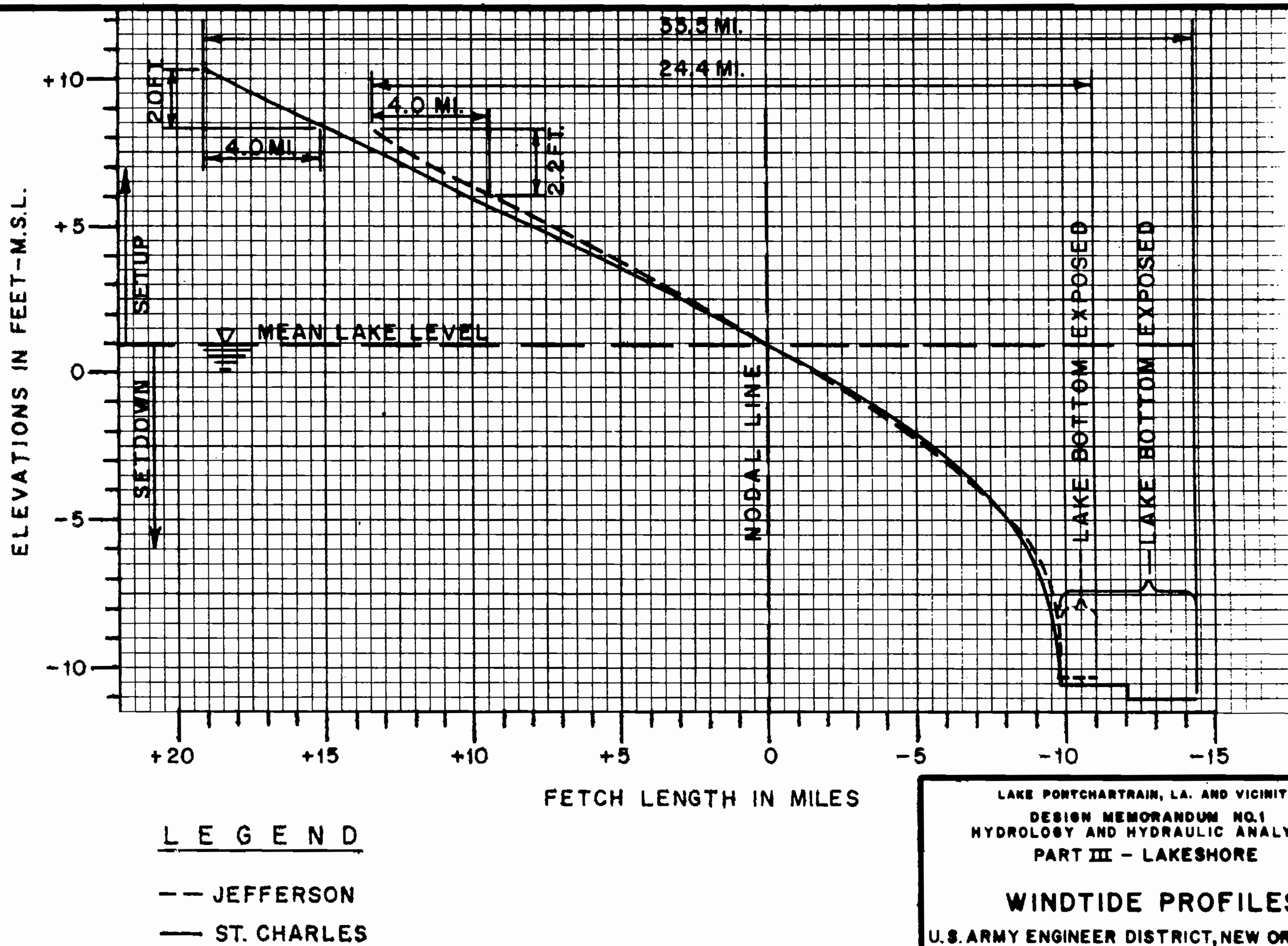

Mandeville
N
LAKE MAUREPAS
LAKE PONTCHARTRAIN
88 mph avg.
89 mph avg.
MISSISSIPPI RIVER
ST. CHARLES POINT HYDROGRAPH
JEFFERSON POINT HYDROGRAPH
N.O. East
Citrus
NEW ORLEANS
Chalmette
LAKE BORGNE
LAKE SALVADOR
SCALE OF MILES
5 0 5 10
LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE
WIND DIRECTIONS AND SPEEDS
FOUR HOURS AFTER LANDFALL
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
MAY 1969
FILE NO. H-2-25008

PLATE 4

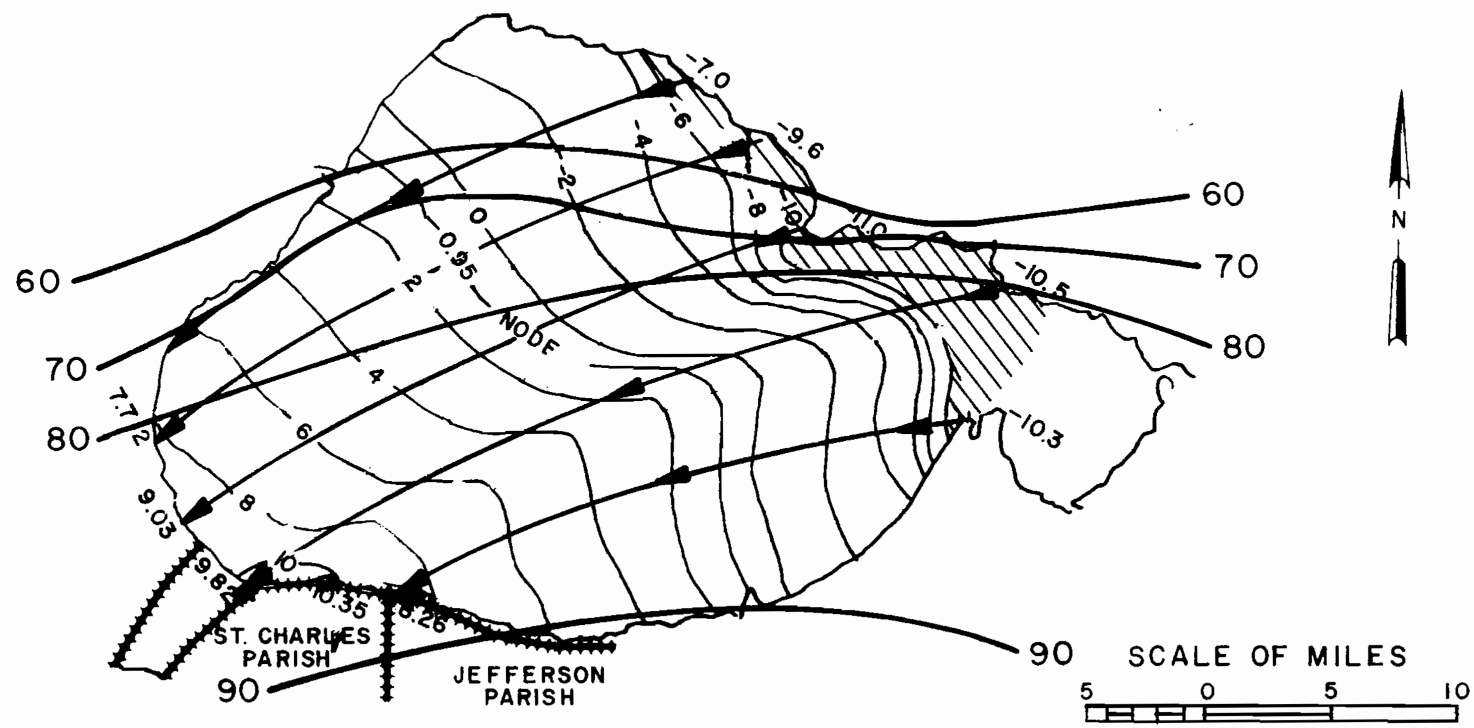


LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE

WINDTIDE PROFILES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

MAY 1969 FILE NO. H-2-25008



NOTE:
SPH - Track C
Two hours after landfall

LEGEND:
Wind speed MPH
Wind direction
Exposed bottom
Water surface contour, MSL
Parish levees

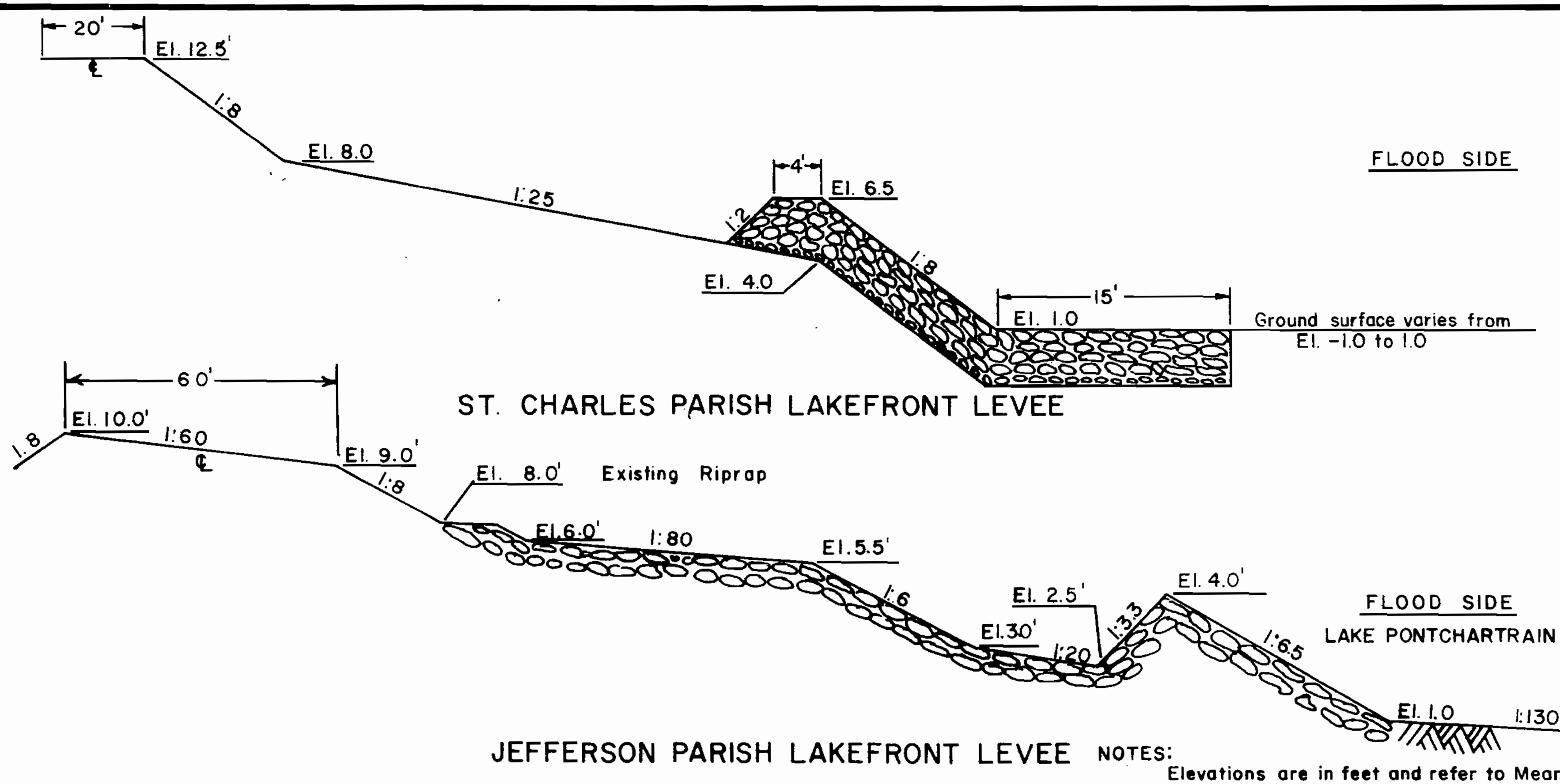
LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE

LAKE SURFACE CONTOURS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

MAY 1969 FILE NO. H-2-25008

PLATE 6



NOTES:
Elevations are in feet and refer to Mean Sea Level.
Sections not drawn to scale.

LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS

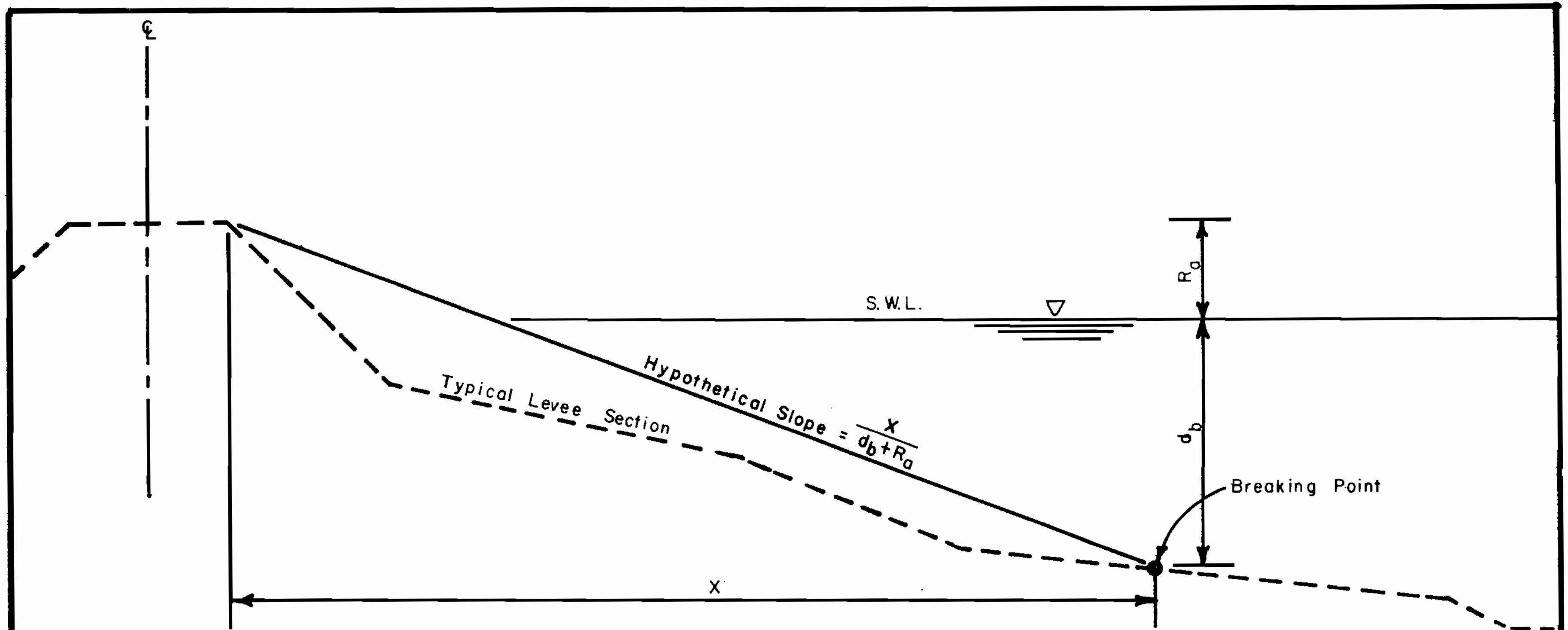
PART III – LAKESHORE

TYPICAL CROSS SECTIONS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

MAY 1969 FILE NO. H-2-25008

PLATE 7



LEGEND

R_a = assumed runup

d_b = breaking depth of wave

X = horizontal distance from breaking point to elevation of runup

S.W.L.= stillwater level

LAKE PONTCHARTRAIN, LA. AND VICINITY

DESIGN MEMORANDUM NO 1

HYDROLOGY AND HYDRAULIC ANALYSIS

PART III—LAKESHORE

DETERMINATION OF HYPOTHETICAL SLOPE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS

MAY 1969 FILE NO. H-2-25008

PLATE 8

TABLE 3

DESIGN WINDTIDE, WAVE, AND WAVE RUNUP DATA*
TRACK C - Jefferson Parish (Slope Covered to Elev. +8.0 with Riprap)

Hour	Windtide feet m.s.l.	Wind m.p.h.	Fetch miles	Av. depth feet	H_s feet	T Sec.	d_b feet	Hypothetical Slope Vert. to hor.	Runup El. feet m.s.l.	Design El. feet m.s.l.	Existing El. feet m.s.l.
-2	6.69	75	5	17.76	6.14	6.20	7.95	1 on 49.8	7.36	10.0	14.0
0	8.28	81	5	19.45	7.00	6.55	8.91	1 on 35.4	9.30	10.0	14.0
+1	8.67	86	5	20.53	7.52	6.75	9.52	1 on 37.6	9.67	10.0	14.0
+2	8.26	88	5	19.07	7.25	6.60	9.16	1 on 36.3	9.25	10.0	14.0
+4	7.73	89	5	17.85	6.84	6.45	8.66	1 on 41.9	8.64	10.0	14.0

*For significant wave

TABLE 4

DESIGN WINDTIDE, WAVE, AND WAVE RUNUP DATA*
TRACK C - Jefferson Parish (Slope Covered to Elev. +8.0 with Riprap)

Hour	Windtide feet m.s.l.	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T Sec.	H'_o feet	Hypothetical Slope Vert. to hor.	Runup El. feet m.s.l.	Design El. feet m.s.l.	Existing El. feet m.s.l.
-2	6.69	75	5	17.76	5.69	6.20	4.03	1 on 14.7	7.81	10.0	14.0
0	8.28	81	5	19.45	7.28	6.55	5.52	1 on 19.7	9.58	10.0	14.0
+1	8.67	86	5	20.53	7.67	6.75	5.79	1 on 20.9	10.00	10.0	14.0
+2	8.26	88	5	19.07	7.26	6.60	5.52	1 on 19.3	9.55	10.0	14.0
+4	7.73	89	5	17.85	6.73	6.45	4.98	1 on 17.1	8.67	10.0	14.0

*For wave breaking at levee toe (el. +1.0 ft)

TABLE 5

DESIGN WINDTIDE, WAVE, AND WAVE RUNUP DATA*
TRACK C - Jefferson Parish (Slope Covered to Elev. +8.0 with Riprap)

Hour	Windtide feet m.s.l.	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T Sec.	H'_o feet	Hypothetical Slope vert. to hor.	Runup El. feet m.s.l.	Design El. feet m.s.l.	Existing El. feet m.s.l.
-2	6.69	75	5	17.76	0.69	6.20	0.17	-	-	-	14.0
0	8.28	81	5	19.45	2.28	6.55	0.97	1 on 13.6	9.19	10.0	14.0
+1	8.67	86	5	20.53	2.67	6.75	1.19	1 on 16.2	9.51	10.0	14.0
+2	8.26	88	5	19.07	2.26	6.60	0.94	1 on 12.9	9.11	10.0	14.0
+4	7.73	89	5	17.85	1.73	6.45	0.65	1 on 9.4	8.75	10.0	14.0

*For wave breaking at el. +6.0

TABLE 6

DESIGN WINDTIDE, WAVE, AND WAVE RUNUP DATA*
TRACK C - St. Charles Parish (Slope Covered to Elev. +6.5 with Riprap)

Hour	Windtide feet	Wind m.p.h.	Fetch miles	Av. depth feet	Hs feet	T Sec.	d_b feet	Hypothetical Slope Vert. to hor.	Runup El. feet m.s.l.	Design El. feet m.s.l.
-2	6.71	76	5	17.10	6.1	6.10	7.79	1 on 54.5	7.33	12.50
0	7.35	79	5	17.11	6.3	6.20	8.01	1 on 48.0	8.06	12.50
+2	10.35	87	5	20.31	7.5	6.80	9.57	1 on 23.2	12.01	12.50
+4	9.41	88	5	19.44	7.3	6.70	9.30	1 on 32.1	10.62	12.50
+6	8.10	82	5	18.36	6.6	6.40	8.45	1 on 41.3	8.96	12.50

*Significant wave breaking offshore

TABLE 7

DESIGN WINDTIDE, WAVE, AND WAVE RUNUP DATA*
TRACK C - St. Charles Parish (Slope Covered to Elev. +6.5 with Riprap)

Hour	Windtide feet	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T Sec.	H'_o feet	Hypothetical Slope Vert. to hor.	Runup El. feet m.s.l.	Design El. feet m.s.l.
-2	6.71	76	5	17.10	5.71	6.10	4.10	1 on 20.9	7.80	12.50
0	7.35	79	5	17.11	6.35	6.20	4.75	1 on 19.4	8.66	12.50
+2	10.35	87	5	20.31	9.35	6.80	7.74	1 on 15.4	12.74	12.50
+4	9.41	88	5	19.44	8.41	6.70	6.70	1 on 16.4	11.41	12.50
+6	8.10	82	5	18.36	7.10	6.40	5.44	1 on 18.0	9.70	12.50

*Wave breaking at levee toe (el. +1.0 ft.)

TABLE 8

DESIGN WINDTIDE, WAVE, AND WAVE RUNUP DATA*
TRACK C - St. Charles Parish (Slope Covered to Elev. +6.5 with Riprap)

Hour	Windtide feet	Wind m.p.h.	Fetch miles	Av. depth feet	d_b feet	T Sec.	H'_o feet	Hypothetical Slope Vert. to hor.	Runup El. feet m.s.l.	Design El. feet m.s.l.
-2	6.71	76	5	17.10	0.21	6.10	-	-	-	12.50
0	7.35	79	5	17.11	0.85	6.20	0.23	-	-	12.50
+2	10.35	87	5	20.31	3.85	6.80	2.04	1 on 27.1	11.06	12.50
+4	9.41	88	5	19.44	2.91	6.70	1.36	1 on 34.2	9.83	12.50
+6	8.10	82	5	18.36	1.60	6.40	0.58	1 on 58.9	-	12.50

*Wave breaking at el. +6.5 ft.

LMVED-TD (NOD 30 Sep 68) 5th Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 18 Jul 69

TO: Chief of Engineers, ATTN: ENGCW-EZ

1. The actions indicated in the 4th Ind to satisfy comments in previous indorsements are considered satisfactory and approval is recommended.

2. Reference para 2, 4th Ind. The procedure the district has taken to submit those data requested by para 2, 2d Ind, is considered satisfactory. Data for the remaining locations will be furnished when available.

FOR THE DIVISION ENGINEER:

1 Incl
wd 2 cy

A. J. DAVIS
Chief, Engineering Division

CF:
NOD-LMNED-PP

ENGCW-EZ (LMNED-PP, 30 Sept 68) 6th Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

DA, Office of the Chief of Engineers, Washington, D. C. 20315, 1 October 1969

TO: Division Engineer, Lower Mississippi Valley

Reference 4th indorsement.

a. Paragraph 1. The information furnished and actions proposed by the District Engineer are satisfactory.

b. Paragraph 2. The data provided in Inclosure 2 on (a) windtides and (b) wave runup for the Jefferson and St. Charles Parishes are satisfactory.

FOR THE CHIEF OF ENGINEERS:

Homer B. Willis
WENDELL E. JOHNSON
for Chief, Engineering Division
Civil Works

1 Incl
wd

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P. O. BOX 60267
NEW ORLEANS, LOUISIANA 70160

LMNED-PP

30 September 1968

SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part III - Lakeshore

Division Engineer, Lower Mississippi Valley
ATTN: LMVED-TD

1. Forwarded herewith for review and approval, in accordance with the provisions of ER 1110-2-1150, dated 1 July 1966, is the subject design memorandum.

2. Approval of this memorandum is recommended.

1 Incl (16 cys)
DM No. 1

Herbert R. Haar, Jr.
HERBERT R. HAAR, JR.
Colonel, CE
District Engineer

LAKE PONTCHARTRAIN, LOUISIANA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS

PART III - LAKESHORE

STATUS OF DESIGN MEMORANDA

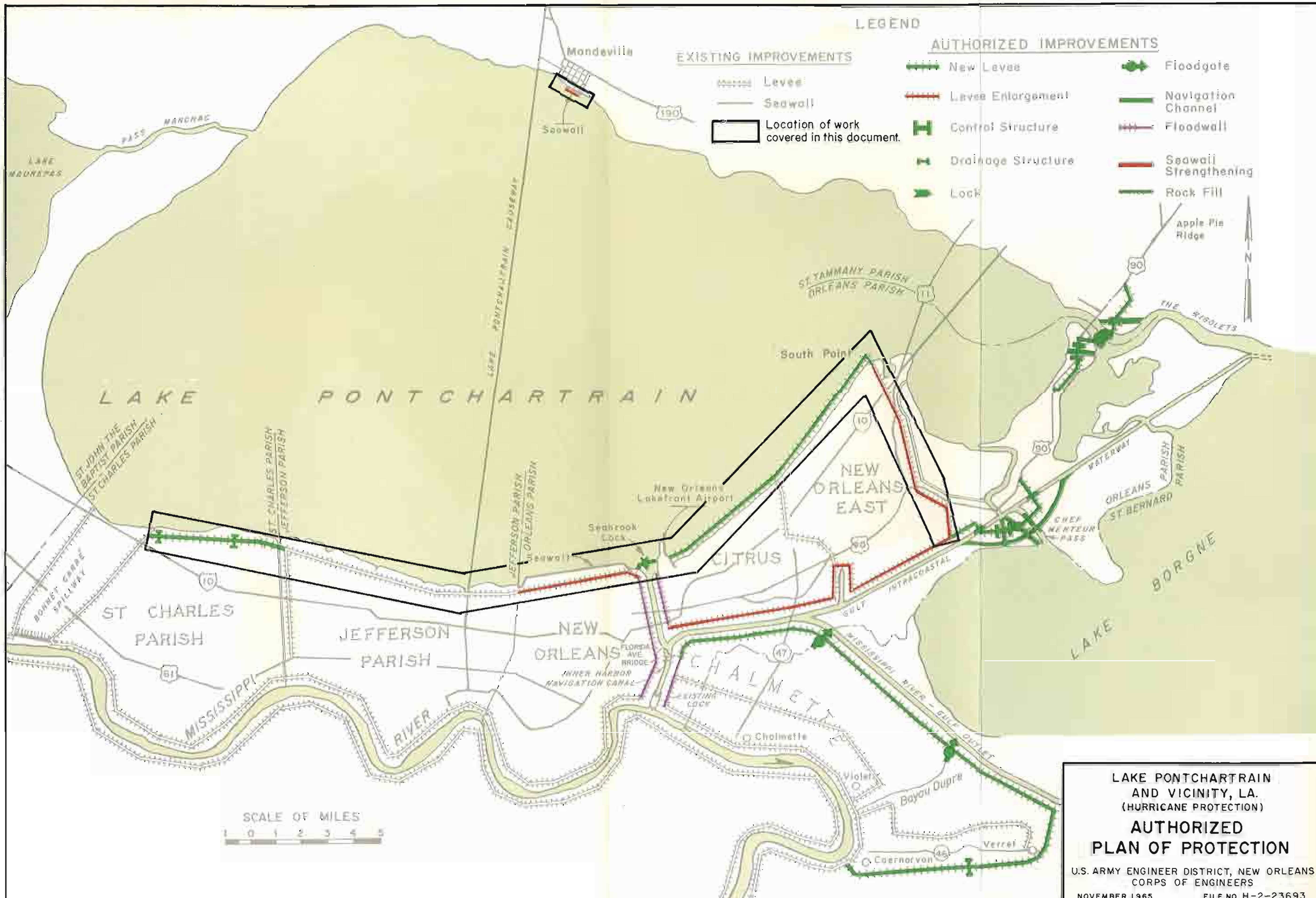
Design Memo No.		
1	Hydrology and Hydraulic Analysis	
	Part I - Chalmette	Approved 27 Oct 66
	Part II - Barrier	Approved 18 Oct 67
	Part III - Lakeshore	Submitted 30 Sept 68
	Part IV - Chalmette Extension	Approved 1 Dec 67
2	Lake Pontchartrain Barrier Plan, GDM, Advance Supplement, Inner Harbor Navigation Canal Levees	Approved 31 May 67
2	Lake Pontchartrain Barrier Plan, GDM, Citrus Back Levee	Approved 29 Dec 67
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 1, Lake Pontchartrain Barrier, Rigolets Control Structure, Closure Dam, and Adjoining Levees	Scheduled Oct 68
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 2, Lake Pontchartrain Barrier, Rigolets Lock and Adjoining Levees	Scheduled Oct 68
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 3, Lake Pontchartrain Barrier, Chef Menteur Complex	Scheduled Oct 68
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 4, New Orleans East Back Levees	Scheduled Aug 69
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 5, Orleans Parish Lakefront Levees	Scheduled Apr 70
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 6, St. Charles Parish Lakefront Levees	Scheduled Dec 68

STATUS OF DESIGN MEMORANDA (cont'd)

Design Memo No.	Title	Status
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 7, St. Tammany Parish, Mandeville Seawall	Scheduled Feb 71
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 8, IHNC Remaining Levees	Approved 6 Jun 68
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 9, New Orleans East Levee from South Point to GIW	Scheduled Mar 69
3	Chalmette Area Plan, GDM	Approved 31 Jan 67
3	Chalmette Area Plan GDM, Supplement No. 1, Chalmette Extension	Scheduled Sep 68
4	Lake Pontchartrain Barrier Plan and Chalmette Area Plan, GDM, Florida Avenue Complex, IHNC	Not scheduled
5	Chalmette Area Plan, DDM, Bayous Bienvenue and Dupre	Submitted 25 Jun 68
6	Lake Pontchartrain Barrier Plan, DDM, Rigolets Control Structure and Closure	Scheduled Sep 69
7	Lake Pontchartrain Barrier Plan, DDM, Chef Menteur Control Structure and Closure	Scheduled Sep 69
8	Lake Pontchartrain Barrier Plan, DDM, Rigolets Lock	Scheduled Nov 69
9	Lake Pontchartrain Barrier Plan, DDM, Chef Menteur Navigation Structure	Scheduled Sep 69
10	Lake Pontchartrain Barrier Plan, DDM, St. Charles Parish Drainage Structure	Scheduled Jan 70
11	Beautification	Not scheduled

STATUS OF DESIGN MEMORANDA (cont'd)

Design Memo No.	Title	Status
12	Source of Construction Materials	Approved 30 Aug 66
1	Lake Pontchartrain, La., and Vicinity, and Mississippi River-Gulf Outlet, La., GDM, Seabrook Lock	Scheduled Oct 68
2	Lake Pontchartrain, La. and Vicinity, and Mississippi River-Gulf Outlet, La., DDM, Seabrook Lock	Scheduled Apr 69



LAKE PONTCHARTRAIN AND VICINITY, LA.
(HURRICANE PROTECTION)

AUTHORIZED PLAN OF PROTECTION

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

NOVEMBER 1965 FILE NO. H-2-23693

REV. APRIL 1968

LAKE PONTCHARTRAIN, LOUISIANA AND VICINITY
DESIGN MEMORANDUN NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS

PART III - LAKESHORE

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2	Purpose and scope	1
3	Description	2
4	Problem	3
5	Plan of protection	3
	SECTION II - CLIMATOLOGY AND HYDROLOGY	
6	Climatology	4
7	Hydrology	4
	SECTION III - TIDAL HYDRAULIC DESIGN	
8	Storm wind tides and computing procedures	4
9	Wave runup	8
10	Residual flooding	9
11	Frequency estimates	10
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2	Authorized plan of protection
3	Hurricane tracks
4	Standard project hurricane, Track A isovel pattern critical to south shore
5	Standard project hurricane, Track C isovel pattern critical to south shore
6	Standard project hurricane, Track F isovel pattern critical to south shore
7	Typical cross sections
8	Typical cross sections
9	Typical cross sections

GLOSSARY

ASTRONOMICAL TIDE - See PREDICTED NORMAL TIDE.

ATMOSPHERIC PRESSURE ANOMALY - The difference between atmospheric pressure at any point within the hurricane and normal pressure at the periphery of the hurricane.

BUILDUP - The increase, in feet, over that from other causes, of water surface elevation in a body of water resulting from:

a. Convergence in depth or width
b. Construction of a barrier
c. Ponding

CENTRAL PRESSURE INDEX - A parameter of hurricane intensity which reflects the minimum atmospheric pressure attained within the eye of a particular hurricane.

FETCH - The continuous area of water over which the wind blows in essentially a constant direction. Often used synonymously with FETCH LENGTH

FETCH LENGTH - The horizontal distance over which the wind from a fixed direction may have unobstructed contact with the water surface.

HURRICANE - A cyclonic storm, usually of tropical origin, containing winds of 75 miles per hour or more.

a. DESIGN HURRICANE - That hurricane selected by the reporting office as a basis for design of the proposed plan of improvement.

b. STANDARD PROJECT HURRICANE - A hypothetical hurricane intended to represent the most severe combination of hurricane parameters that is reasonably characteristic of the region involved, excluding extremely rare combinations.

c. PROBABLE MAXIMUM HURRICANE - A hypothetical hurricane that might result from the most severe combination of hurricane parameters that is considered reasonably possible in the region involved. This hurricane is substantially more severe than the standard project hurricane and is seldom used as the controlling consideration in design.

d. MODERATE HURRICANE - A hurricane that may be expected from a combination of hurricane parameters that is frequently experienced in the region.

e. TRANSPOSED HURRICANE - A storm transferred from actually observed location to another location for the purpose of study, with appropriate changes in storm characteristics.

HURRICANE TRACK - The line connecting successive locations of central pressure of the hurricane.

HURRICANE SPEED - The rate of forward movement of the hurricane eye in knots or miles per hour.

HURRICANE SURGE - The mass of water causing an increase in elevation of the water surface above normal tide at the time of a hurricane.

HURRICANE SURGE HEIGHT - The elevation of the stillwater level at a given point resulting from normal tide and hurricane surge action. It may be the result of one or more of the following components:

a. Predicted normal tide
b. Pressure setup
c. Setup due to winds over the continental shelf
d. Buildup

In inland lakes, hurricane surge height is the average lake level and does not include local wind setup.

HURRICANE TIDE - The elevation of the stillwater level at a given point during a hurricane. In inland lakes, it is the sum of hurricane surge height and additional local wind setup.

ISOVEL - Line connecting points of simultaneous equal wind velocities and in this report represents a 5-minute average, 30 feet above the boundary surface.

KNOT - A velocity equal to one nautical mile (6,080 feet) per hour, or about 1.15 statute miles per hour.

LANDFALL - The arrival of a hurricane center at the coastline.

LEEWARD - The direction toward which the wind is blowing; the direction toward which waves are travelling.

OVERTOPPING - The amount of water passing over the top of a structure as a result of wave runup or surge action.

PREDICTED NORMAL TIDE - The periodic rising and falling of the water that results from gravitational attraction of the moon and sun acting upon the rotating earth.

PRESSURE SETUP - A rise in the surface of a large body of water caused by a measurable reduction in local atmospheric pressure at sea level.

RANGE - An imaginary line representing the centerline of a narrow fetch over which the hurricane surge height is computed.

RUNUP - The vertical elevation above stillwater level to which water rises on the face of a structure as a result of wave action.

SETDOWN - The decrease in water surface elevation behind a water-retaining barrier or at a windward shore due to wind action.

SETUP - The vertical rise in the stillwater level, above that which would occur without wind action, caused by wind stresses on the surface of the water.

SIGNIFICANT WAVE - A statistical term denoting waves having the average height and period of the highest one-third waves of a given wave train.

STILLWATER LEVEL - The elevation of the water surface if all wave action were to cease.

STORM SURGE - Same as HURRICANE SURGE, except that it may be caused by storms not of hurricane characteristics as well as by hurricanes.

WAVE HEIGHT - The vertical distance between the crest and the preceding trough. (Referenced to significant waves in this report.)

WAVE ORTHOGONAL - An imaginary line, drawn normal to each individual line of a system representing, in plan presentation, the locations of the crests of each individual wave of a given wave train.

GLOSSARY (cont'd)

WAVE SETUP - The superelevation of the water surface above the hurricane surge height due to wave action alone.

WAVE TRAIN - A series of waves from the same direction.

WINDWARD - The direction from which the wind is blowing.

WIND SETUP - Same as SETUP.

WIND TIDE LEVEL - Same as stillwater level.

LAKE PONTCHARTRAIN, LOUISIANA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS

PART III - LAKESHORE

SECTION I - GENERAL

1. PROJECT AUTHORIZATION

The project was authorized under Public Law 298, 89th Congress, 1st Session, approved 27 October 1965. General information and basic data on the entire project are available in House Document No. 231, 89th Congress, 1st Session. A number of significant changes in the plans presented in the House Document have been developed during detailed planning and incorporated into the project as departures from the project document plan within the discretionary authority of the Chief of Engineers. These changes include the following:

a. The controlling elevation of the Seabrook Lock was changed from 13.2 feet m.s.l. to 7.2 feet m.s.l.[1] (Ref. LMNED-PP letter dated 19 October 1966 subject, "Lake Pontchartrain, La. and Vicinity - Report on Controlling Elevation of Seabrook Lock" and indorsements thereto.)

b. The Chalmette Area Plan was expanded to include a larger protected area. (Ref. LMNED-PR letter dated 29 November 1966 subject, "Lake Pontchartrain, La. and Vicinity - Modification of the Chalmette Area Plan to Include Larger Area" and indorsements thereto.)

c. The Lake Pontchartrain Barrier was relocated between New Orleans East and the east bank of Chef Menteur Pass. (Ref. LMNED-PP letter dated 13 March 1967 subject, "Lake Pontchartrain, La. and Vicinity - Evaluation of Alternate Plans Involving Modifications in the Alignment of the Lake Pontchartrain Barrier" and indorsements thereto.)

2. PURPOSE AND SCOPE

Initially, it was planned to present the Hydrology and Hydraulic Analysis Design Memorandum for the Lake Pontchartrain, Louisiana and Vicinity project in a series of three separate reports subtitled

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[1]Mean sea level, the datum to which all elevations in this memorandum are referenced, unless otherwise indicated.

Part I - Chalmette, Part II - Barrier, and Part III - Lakeshore. As previously mentioned, subsequent to completion of Part I, the project was modified, under the discretionary authority of the Chief of Engineers, to enlarge the protected area of the Chalmette Area Plan; accordingly, Part IV - Chalmette Extension was prepared to cover the hydraulics of this enlargement. In Part I - Chalmette, the climatology and hydrology for the entire project area and the development of design elevations for the Chalmette, IHNC (Inner Harbor Navigation Canal), Citrus Back, and New Orleans East back flood protection works were presented. Part II - Barrier includes the description and analyses of essential data, assumptions, and criteria used for, and the results of studies which provide the bases for determining design surge heights, runup, overtopping, and frequencies for the Lake Pontchartrain Barrier. Also included are the average levels of Lake Pontchartrain for the design hurricane on different tracks. These levels reflect the influence of barrier overtopping, direct rainfall, and tributary inflow, and will be used in the hydraulic design of the lakeshore protection to be covered in this document, Part III - Lakeshore. Specifically, the proposed elevation of flood protective works along the St. Charles and Jefferson Parishes lakeshores, and the Orleans Parish lakeshore from New Orleans Lakefront Airport to South Point thence south to the GIWW (Gulf Intracoastal Waterway) will be determined in this memorandum. Since the existing seawall on the north shore at Mandeville does not require establishment of an elevation but only strengthening of the seawall, hydraulic data pertinent to this area will not be presented herein.

3. DESCRIPTION

a. The project area, as shown on plate 1, is located in southeastern Louisiana in the vicinity of New Orleans. The dominant topographic feature is Lake Pontchartrain, a shallow tidal basin approximately 640 square miles in area and averaging 12 feet in depth. Lake Pontchartrain is connected to the Gulf of Mexico through Chef Menteur Pass and the Rigolets, Lake Borgne, and Mississippi and Chandeleur Sounds, and also is connected with lesser Lake Maurepas to the west. Chef Menteur Pass and the Rigolets have developed naturally deep and wide channels having adequate capacity for normal tidal flows and discharges of tributary flow.

b. The area along the south shore of Lake Pontchartrain is essentially uniform in topography. The land slopes gently downward from an average elevation of 12 feet along the natural banks of the Mississippi River to approximately sea level near the lakeshores. All of this area is protected from the river overflow by the main line Mississippi River levee system and most of the area is afforded partial protection from tidal overflow. Runoff within the protected areas is pumped into the lake and the pumping operations have lowered the ground water surface causing subsidence of natural ground elevations to as much as -7 feet by drying the highly organic soils above the water table.

4. PROBLEM

a. The area surrounding Lake Pontchartrain is susceptible to flooding from wind-driven hurricane tides from the lake. This condition is aggravated by increases in lake level resulting from the influx of tidal surges from Lake Borgne and the Gulf of Mexico that accompany hurricanes from the southeast, south, and southwest. The occurrence of the SPH (Standard Project Hurricane) critical to the south shore of Lake Pontchartrain would result in an 11-foot surge in Lake Borgne. This surge would enter Lake Pontchartrain through the Rigolets and Chef Menteur passes, and the IHNC, raising the average lake elevation by as much as 6 feet.

b. As the hurricane winds blow over the surge-elevated lake, wind tides and waves would be generated against the south shore causing overtopping of all existing protective works and massive ponding in the developed areas. Much of the development in the New Orlenas area is below mean sea level, some land being as low as 7 feet below and a considerable portion more than 2 feet below. Because of these low elevations, flooding as deep as 16 feet would result from overtopping during the SPH.

c. On several occasions, the marsh area between Lake Borgne and Lake Pontchartrain has been flooded up to an elevation of 11 feet. Prior to 1966, these stages, especially during hurricane "Betsy," have caused overtopping of the then existing Chalmette back levee, the IHNC levees, and the Citrus and New Orleans East back levees.

5. PLAN OF PROTECTION

The authorized plan of protection is described in the following subparagraphs and shown on plate 2.

a. A barrier will be constructed along the east shore of Lake Pontchartrain extending from the New Orleans levee system to high ground in St. Tammany Parish to control hurricane-generated stages in the lake. Included as parts of the barrier will be navigation and control structures in Chef Menteur Pass and the Rigolets. Existing protective works along the south shore of the lake will be raised, strengthened, and extended. A lock will be constructed at the lakeward end of the IHNC to alleviate high velocities in the canal, control salt water intrusion into Lake Pontchartrain, and control the entry of hurricane tides into the lake. Protective systems facing Lake Borgne, including the levees along the IHNC, the GIWW, and the MR-GO (Mississippi River-Gulf Outlet) will be raised and strengthened to provide adequate protection. The existing seawall on the north shore at Mandeville will be strengthened.

b. A new levee along the south bank of the MR-GO to Bayou Dupre, thence returning to the Mississippi River levee at Violet, La. was authorized for the Chalmette area. As previously explained, a departure from the authorized plan to extend the levee along the MR-GO to a point north of Verret, thence to Verret and returning south of Louisiana Highway 46 to the Mississippi River to Caernarvon, La. has been adopted.

SECTION II - CLIMATOLOGY AND HYDROLOGY

6. CLIMATOLOGY

The project area is located in a subtropical latitude having mild winters and hot, humid summers. Prevailing southerly winds produce conditions favorable to convective thundershowers in the summer season, and in the colder season, frontal passages produce squalls and sudden temperature changes. Refer to Part I - Chalmette of this memorandum for a more detailed discussion of temperature, rainfall, and wind in the project area.

7. HYDROLOGY

The water level in Lake Pontchartrain is subject to variations from direct rainfall, tributary inflow, wind-driven water movements, and flow through Chef Menteur Pass, the Rigolets, and the IHNC caused by tidal variations originating in the Gulf of Mexico. Infrequently, the lake level is influenced by diversion of Mississippi River floodflow through Bonnet Carre' Spillway. Combinations of these factors determine the salinity regimen in the lake. A detailed discussion of project area hydrology is given in Part I - Chalmette.

SECTION III - TIDAL HYDRAULIC DESIGN

8. STORM WIND TIDES AND COMPUTING PROCEDURES

a. General. In determining critical conditions for the various subareas of the Lake Pontchartrain, Louisiana and Vicinity project, different hurricane tracks are used. Tracks A, C, and F are used in the hydraulic design of the various features of the protective system in the respective subareas. These tracks along with tracks of the more significant historical hurricanes are shown on plate 3. A method of computing wind tides in lakes was used to determine maximum and minimum stillwater levels along the protected shore. The average lake levels during storms proceeding on the three tracks were presented in Part II - Barrier and will only be summarized herein. These lake levels are the starting elevations used in the storm wind-tide computations. A description of these computations is presented in paragraph 8d.

b. Lake levels. The average high tide in Lake Pontchartrain during the hurricane season is 0.7 foot and is the selected lake level at which the control structures are closed when a hurricane enters the Gulf of Mexico or is discovered offshore. The average high tide of 1.4 feet as indicated in Part II - Barrier has been revised based on the results from releveling by the U. S. Coast and Geodetic Survey which disclosed that the zero gage reading for determining average lake levels was about 0.7 foot lower than originally considered. The increase in average lake level can be computed at any hour by use of storage tables and estimates of cumulative quantities of direct rainfall, tributary inflow, and barrier overflow from Lake Borgne. Table 1 gives the average level at the critical hour for each track.

TABLE 1
CRITICAL AVERAGE LAKE ELEVATIONS
DESIGN HURRICANE

Track	Starting lake stage	Contributions: Rainfall	Runoff	Overflow	Final lake stage
	feet	feet	feet	feet	feet
A	0.7	0.6	0.1	0.2	1.6
C	0.7	0.7	0.1	0.7	2.2
F	0.7	0.7	0.1	0.6	2.1

c. Synthetic storms. Parameters for certain synthetic storms and methods for derivation of others were furnished by the U. S. Weather Bureau. The SPH is used as the design hurricane for all locations in the project area, the track and forward speed being changed as appropriate. Tracks A, C, and F give three synthetic storms (1)(2)(3)[2] and they were derived as discussed in paragraph 8c of Part I - Chalmette. Table 2 shows the characteristics of the design hurricane for the three tracks. Plates 4, 5, and 6 show isovel patterns for the design hurricane on tracks A, C, and F, respectively, at the hour of maximum wind tide level at the south shore. The original SPH isovel patterns were revised based on recent studies by the U. S. Weather Bureau(4)(5)(6).

TABLE 2
DESIGN HURRICANE CHARACTERISTICS

Track[1]	C.P.I.	Radius of maximum winds	Forward speed	Max.[2] wind	Direction of approach
	inches	nautical miles	knots	m.p.h.	
A	27.6	30	6	100	South
C	27.6	30	5	100	SSE
F	27.6	30	11	100	East

[1]Tracks are shown on plate 3.
[2]Referenced to 30 feet above the boundary surface.

d. Wind tides. Maximum wind-tide levels along the south shore were computed by use of a general wind-tide level formula based on the steady state concept of water superelevation (7)(8)(9). The storms under consideration are accompanied by strong winds which blow over Lake Pontchartrain and drive large quantities of water toward the leeward shore. It was necessary for design of the lakeshore flood protection works to determine the height of the wind-tide level along various reaches of the authorized protection. This was accomplished by dividing the lake into four or five parallel segmental strips and by computing setup and setdown along the imaginary strips from the windward shoreline to the leeward shoreline where the protection is located. The average windspeeds and depths in each strip were determined from isovel patterns and hydrographic charts for each wind-tide level computation. The wind-tide levels were computed by a trial and error method of step integration beginning at the nodal point of the strip and proceeding toward either shore. Each strip was divided into several sections of approximately equal length. The total summation of setup at the end of each section was added to the average

[2]Numbers in parentheses indicate references in Section IV - Bibliography.

depth of the next section and this summation gave a new depth to be used in the next setup computation. The equations for computing the wind setup are given as follows:

$$\Delta S_i = d_T \left[\sqrt{\frac{2kU^2 \Delta x}{g(d_T)^2} + 1} - 1 \right]$$

$$d_T = d_i + \sum_{i=1}^{i=M-1} \Delta S_i$$

$$S = \sum_{i=1}^{i=M} \Delta S_i$$

where ΔS_i is the incremental rise (or fall) in water elevation over the corresponding increment ΔX;

d_i = mean depth of section, exclusive of any setup;

d_T = total mean depth including the rise from all preceding sections; but not including ΔS_i for the section under consideration;

S = the total setup or setdown at shore;

M = number of sections;

U = windspeed in feet/second;

k = constant taken as $3.3X10^{-6}$;

g = acceleration due to gravity.

When computations are performed along the axis of the strip in the direction of the wind, beginning at the assumed nodal point, ΔS_i will be positive. In the opposite direction from the nodal point, ΔS_i will be negative. A check on the computations was made by computing the volume balance of water using the following equation:

$$\sum_{i=1}^{i=M} B_i S_i \Delta X = 0$$

where B_i is the mean width of the section corresponding to S_i, the average value over the increment ΔS_i. Successive nodal locations were assumed along each strip and trial computations made until set up and set down volumes were within 5 percent of each other. The final balanced setup or setdown elevation was then used as the design stillwater level for a particular location. Table 3 shows the maximum wind-tide levels computed at different locations along the lakeshore.

9. WAVE RUNUP

a. Wave runup on a protective structure depends on the characteristics of the structure (i.e., shape and surface roughness), the depth of water at the structure, and the wave characteristics. The vertical height to which water from a breaking wave will run up on a given protective structure determines the top elevation to which the structure must be built to prevent wave overtopping and resultant flooding of the area to be protected. Wave runup is considered to be the ultimate height to which water in a wave ascends on the proposed slope of a protective structure. This condition usually occurs when the wind-tide level is at the maximum elevation. The method of computing wave runup was presented in Part IV -Chalmette Extension; therefore, only results of runup computations for the lakeshore structures will be presented herein.

b. The elevation of protective structures not exposed to wave runup will be constructed to approximately 1 foot above the maximum computed wind-tide level for the design hurricane. Protective structures exposed to wave runup will be constructed to an elevation that is sufficient to prevent all overflow from the significant wave and waves smaller than the significant wave accompanying the design hurricane. Waves larger than the significant wave will be allowed to overtop the protective structures; however, such overtopping will not endanger the security of the structures or cause excessive interior flooding. During the time of maximum wind-tide levels, the berms on the lakeside of the levees become submerged and waves of lesser height than the significant wave, but of the same period, break farther up the levee slope. Sometimes runup from these smaller waves reach an elevation higher than that from the significant wave; therefore, runup resulting from these smaller waves must also be computed. Runup was computed for the significant wave and for smaller waves breaking on each berm and the required levee height was determined by adding the highest computed runup value to the maximum stillwater elevation. Design runup values and proposed elevations of the protective structures are shown in table 3. The runup elevations shown in table 3 are based on the preliminary levee cross sections shown on plates 7, 8, and 9. Since runup depends on the section configuration, runup elevations will be recomputed and necessary adjustments made if the final sections are materially different from the preliminary sections used in this analysis.

c. In view of the proximate location of the existing levee to the New Orleans lakefront seawall in the vicinity of the U. S. Coast Guard Station, as shown on plate 7, wave runup is such that the levee must be raised several feet to afford protection from the design hurricane; hence, enlargement of the existing levee is impracticable. Accordingly, construction of a floodwall to elevation 13.5, lakeward of the existing levee, to reduce wave runup on the levee is the most practical method of providing protection. This rationale also applies with respect to construction of a floodwall in the vicinity of the American Standard Company.

d. Further, it was determined, based on the relatively wide crown of the existing Jefferson Parish lakefront levee, that sloping the levee crown without an increase in elevation, as shown on plate 9, will prevent overtopping from the significant wave.

TABLE 3
WAVE RUNUP AND PROPOSED ELEVATIONS OF PROTECTIVE STRUCTURES
DESIGN HURRICANE

Location	Wind-tide level	Wave runup	Free-board	Proposed elevation of protective structures	Critical track
	ft.m.s.l.	ft.	ft.	ft. m.s.l.	
St. Charles Parish	10.5	2	-	12.5	F
Jefferson Parish	8.5	1.5	-	10.0	C
Orleans Parish					
Seawall segment	8.5	3.5	-	12.0	A
Citrus to South Point	8.5	5	-	13.5	A
South Point to Hwy 90	8.5-11.5	-	1	12.5	F
Hwy 90 to GIWW	11.5-12.8	-	1	12.5-14.0	F
Outfall canals	8.5	-	1	9.5	A

10. RESIDUAL FLOODING

Protective structures were designed to prevent wave overtopping from the significant or any lower wave that would be experienced during an occurrence of the design hurricane. However, 14 percent of the waves in a spectrum are higher than the significant wave and the maximum wave height to be expected is about 1.87 times the significant wave height. Thus, the protected structures herein will be overtopped by those waves of the spectrum which exceeds the significant wave. Studies indicate that no material flooding will result if design grades allowed overtopping by waves higher than the significant wave.

11. FREQUENCY ESTIMATES

The procedure developed for making frequency estimates is described in paragraph 9a of Part I - Chalmette. The design hurricane has a frequency of about once in 300 years on Lake Pontchartrain.

12. DESIGN HURRICANE

As previously stated in Part I - Chalmette, the SPH was selected as the design hurricane due to the urban nature of the project area.

SECTION IV - BIBLIOGRAPHY

(1) U. S. Weather Bureau, "Louisiana Hurricane of September 29, 1915, Transposed to a Critical Track," Memorandum HUR 7-40, September 6, 1957.

(2) U. S. Weather Bureau, "SPH Wind Field for Track C with a Rotated SPH Pattern," Memorandum HUR 7-62A, September 28, 1959.

(3) U. S. Weather Bureau, "SPH Wind Fields for Track F with Forward Speed 5 Knots Critical for Area I," Memorandum HUR 7-63, September 21, 1959.

(4) U. S. Weather Bureau, "Standard Project Hurricane Wind Field Patterns (revised) to Replace Existing Patterns in NHRP Report No. 33, for Zones B and C," Memorandum HUR 7-84, August 17, 1965.

(5) U. S. Weather Bureau, "Adjustments to SPH isovel patterns in Memoranda HUR 7-62, 7-62A, 7-63, 7-64, and 7-65," Memorandum HUR 7-85, November 3, 1965.

(6) U. S. Weather Bureau, "Ratio Chart to Adjust Isovel Patterns in HUR 7-40 to Level of Updated SPH Patterns," Memorandum HUR 7-85A, February 17, 1966.

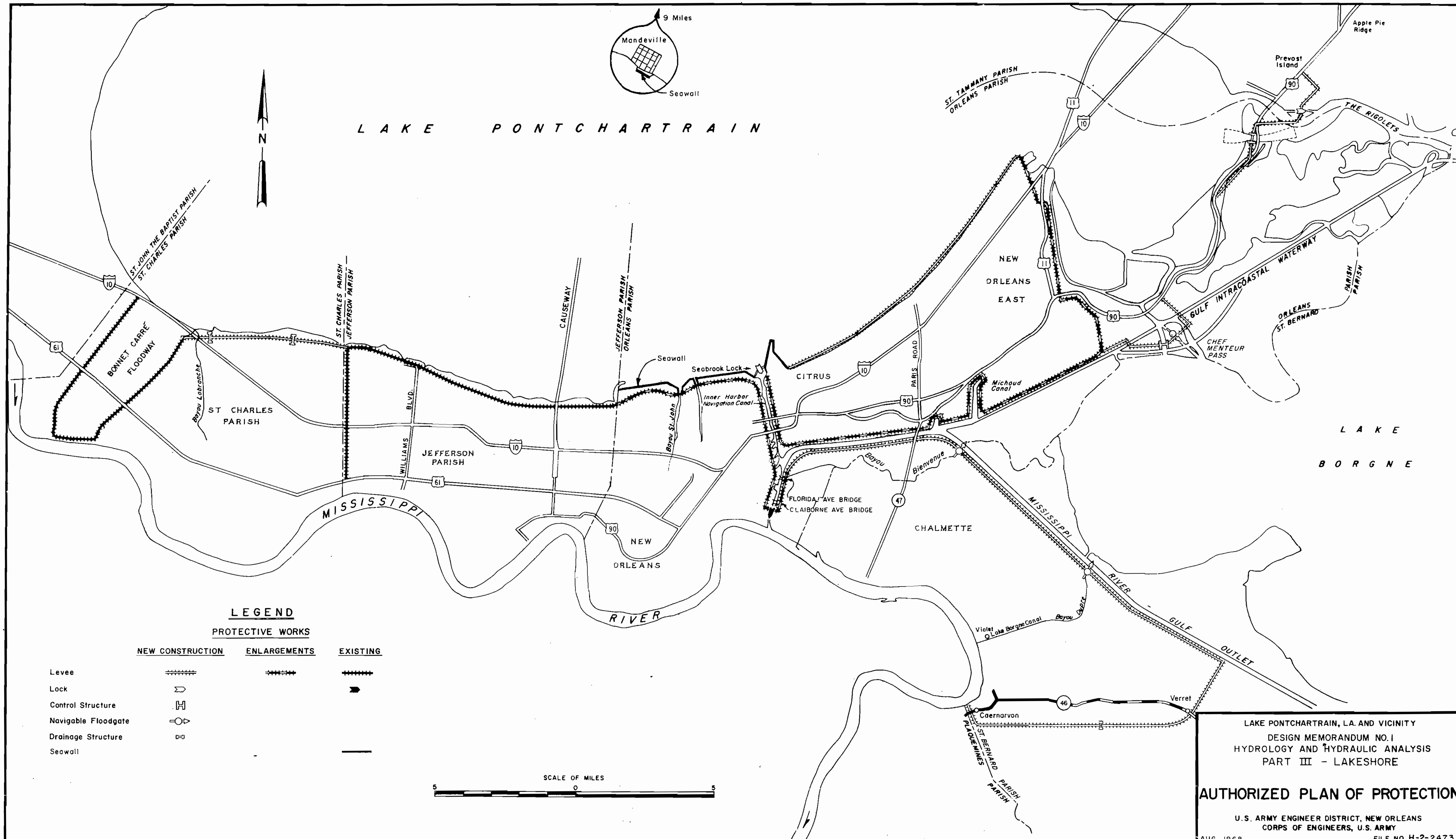
(7) Beach Erosion Board Coastal Engineering Research Center, "Shore Protection Planning and Design," Technical Report No. 4, June 1966.

(8) Saville, Thorndike, Jr., "Wind Set-Up and Waves in Shallow Water." Beach Erosion Board, Technical Memorandum No. 27, June 1952.

(9) U. S. Army Engineer District, Jacksonville, "Design Memorandum. Wind Tides Prcduced by Hurricanes," Partial Definite Project Report, Central and Southern Florida Project, for Flood Control and Other Purposes, Part IV, Supplement 2, Section 3, July 26, 1956.

PROJECT AREA
LOUISIANA
MISSISSIPPI
LIVINGSTON PARISH
ASCENSION PARISH
TANGIPAHOA PARISH
ST TAMMANY PARISH
ST JOHN THE BAPTIST PARISH
ST JAMES PARISH
ST CHARLES PARISH
JEFFERSON PARISH
ORLEANS PARISH
ST BERNARD PARISH
LAKE MAUREPAS
LAKE PONTCHARTRAIN
LAKE BORGNE
LAKE ST. CATHERINE
MISSISSIPPI SOUND
MISSISSIPPI RIVER
MISSISSIPPI RIVER GULF OUTLET
NEW ORLEANS EXPRESSWAY BRIDGE
BONNET CARRE' SPILLWAY
INNER HARBOR NAVIGATION CANAL
LITTLE WOODS CANAL
DWYER CANAL
FLORIDA AVE CANAL
NEW RIVER CANAL
GULF INTRACOASTAL WATERWAY
CHEF MENTEUR PASS
PASS MANCHAC
RIGOLETS
PEARL RIVER
Amite River
Tickfaw
Tangipahoa River
Tchefuncte R.
Blind River
Bayou Lacombe
Bayou Liberty
B. Bonfouca
Bayou Sauvage
NEW ORLEANS
Madisonville
Mandeville
Slidell
North Shore
South Shore
Manchac
Frenier Beach
La Place
Sorrento
Kenner
Metairie
West End
Pontchartrain Beach
New Orleans Airport
Little Woods
Citrus
Michoud
Lee Station
Algiers
Gretna
Chalmette
Violet
Long Point
GRAND ISLAND
New Orleans International Airport (Moisant Field)
ILLINOIS CENTRAL
SOUTHERN PACIFIC
SOUTHERN R.R.
N
SCALE OF MILES
5 0 5
LEGEND
Existing levee
Existing seawall
Railroad embankment
Spoil
MISSISSIPPI
ALABAMA
LOUISIANA
PEARL R.
Mobile
Biloxi
Gulfport
Bay St Louis
Long Point
LAKE PONTCHARTRAIN
NEW ORLEANS
RIVER
GIWW
BRETON SOUND
GULF OF MEXICO
VICINITY MAP
SCALE OF MILES
0 50 100
LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE
GENERAL MAP
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
AUG. 1968
FILE NO. H-2-24731

PLATE I



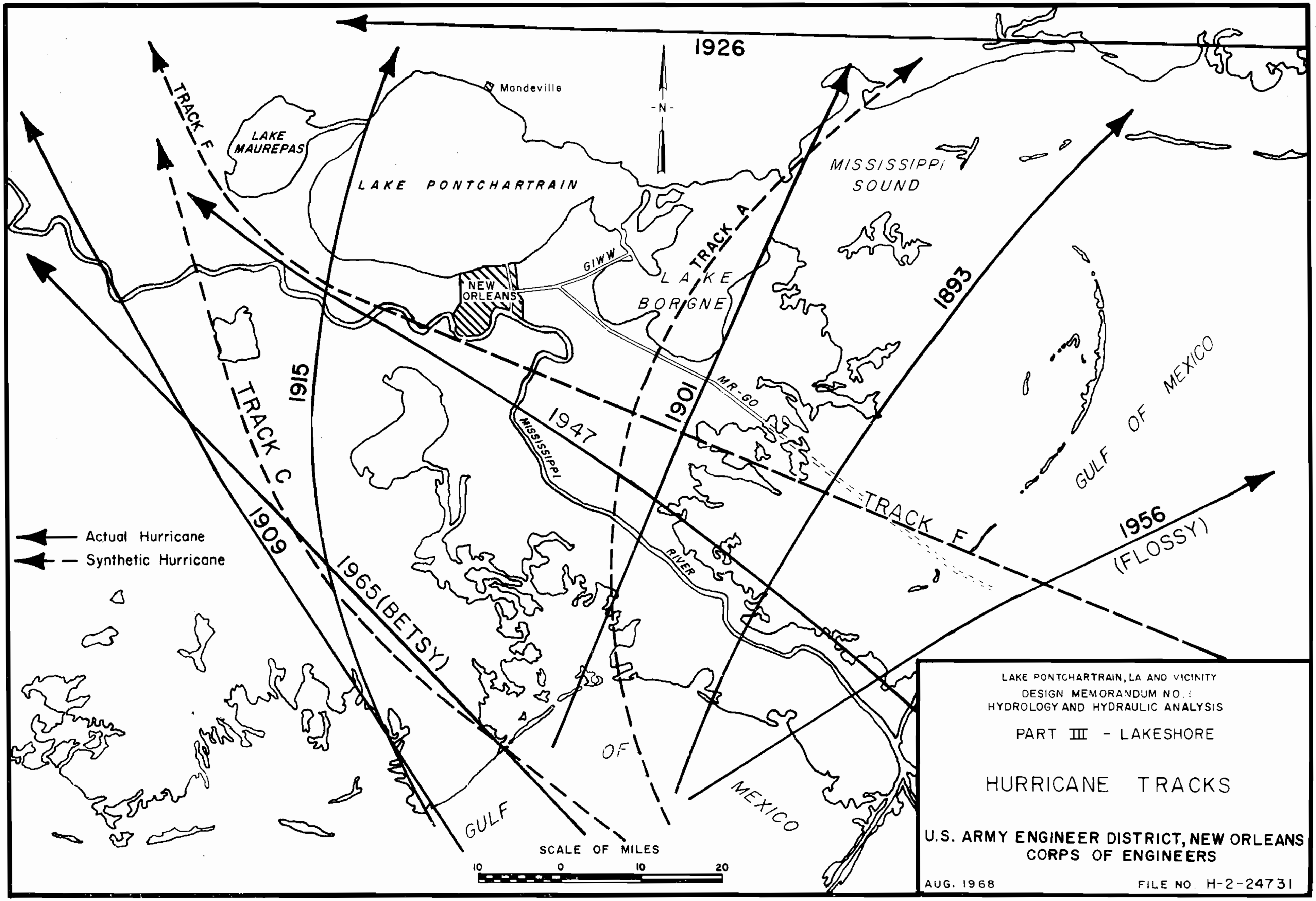
LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART III - LAKESHORE

AUTHORIZED PLAN OF PROTECTION

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS, U.S. ARMY

AUG. 1968 FILE NO. H-2-24731

PLATE 2



LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS

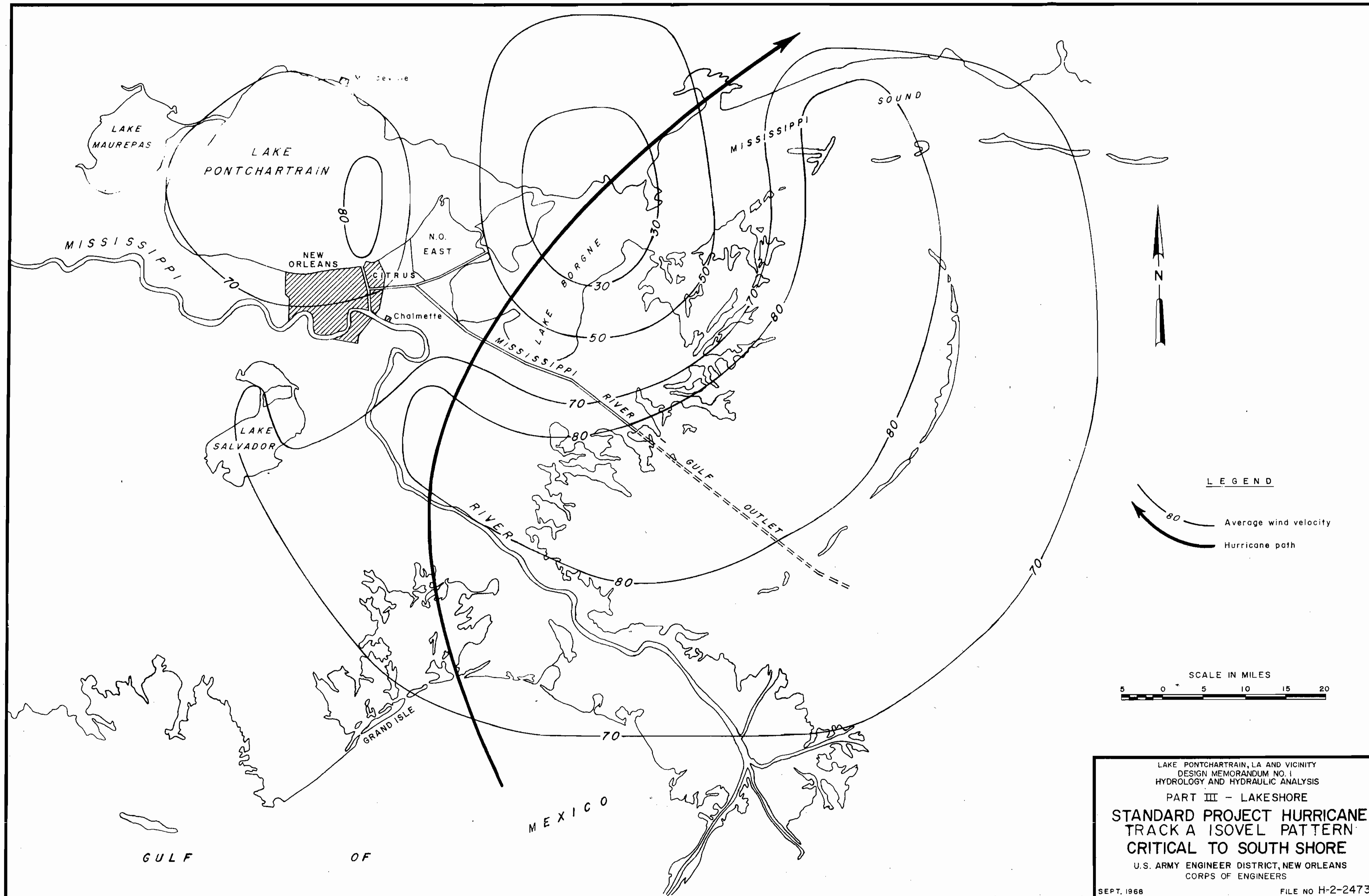
PART III - LAKESHORE

HURRICANE TRACKS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

AUG. 1968 FILE NO. H-2-24731

PLATE 3



LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS

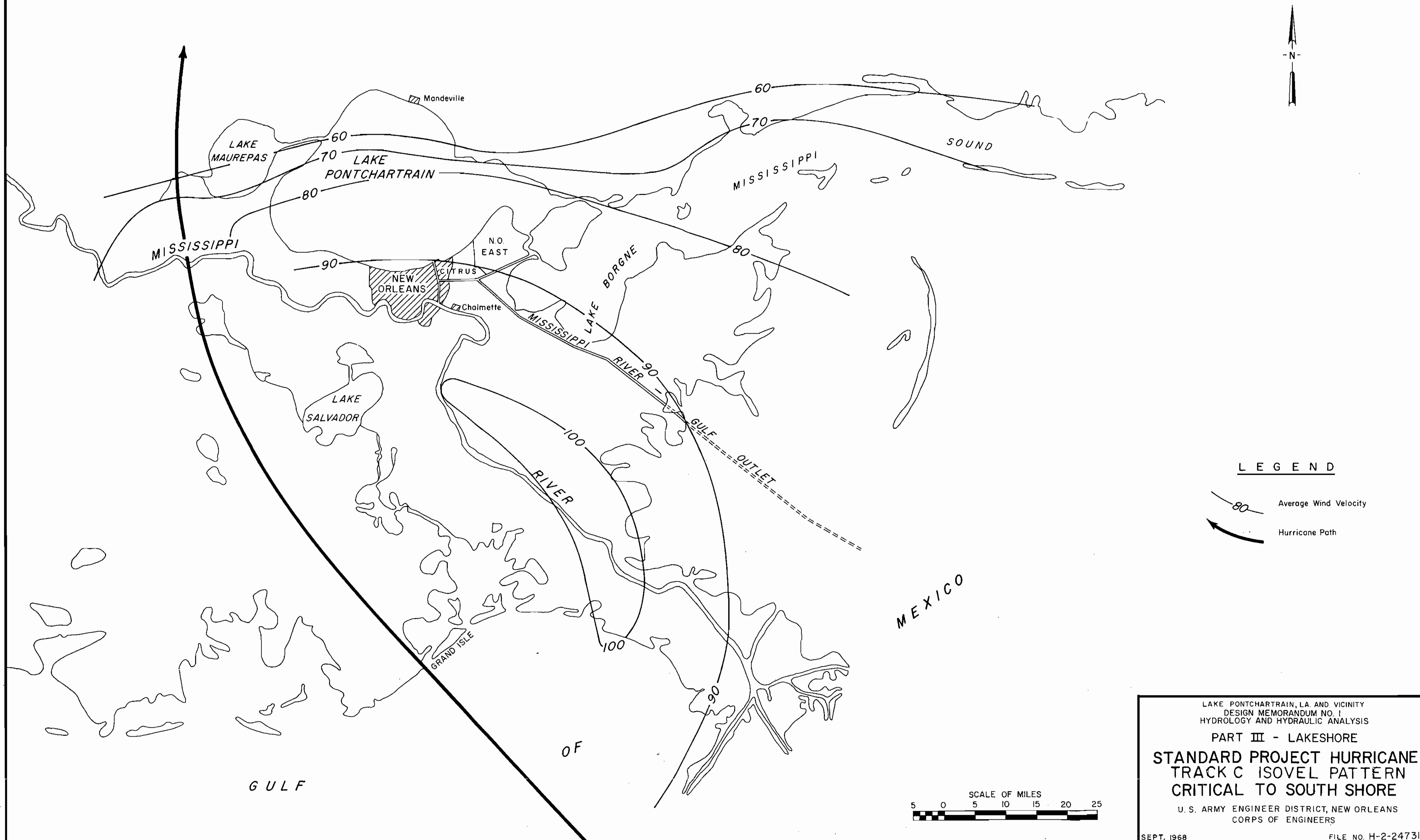
PART III - LAKESHORE

STANDARD PROJECT HURRICANE
TRACK A ISOVEL PATTERN
CRITICAL TO SOUTH SHORE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

SEPT. 1966 FILE NO H-2-24731

PLATE 4



LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS

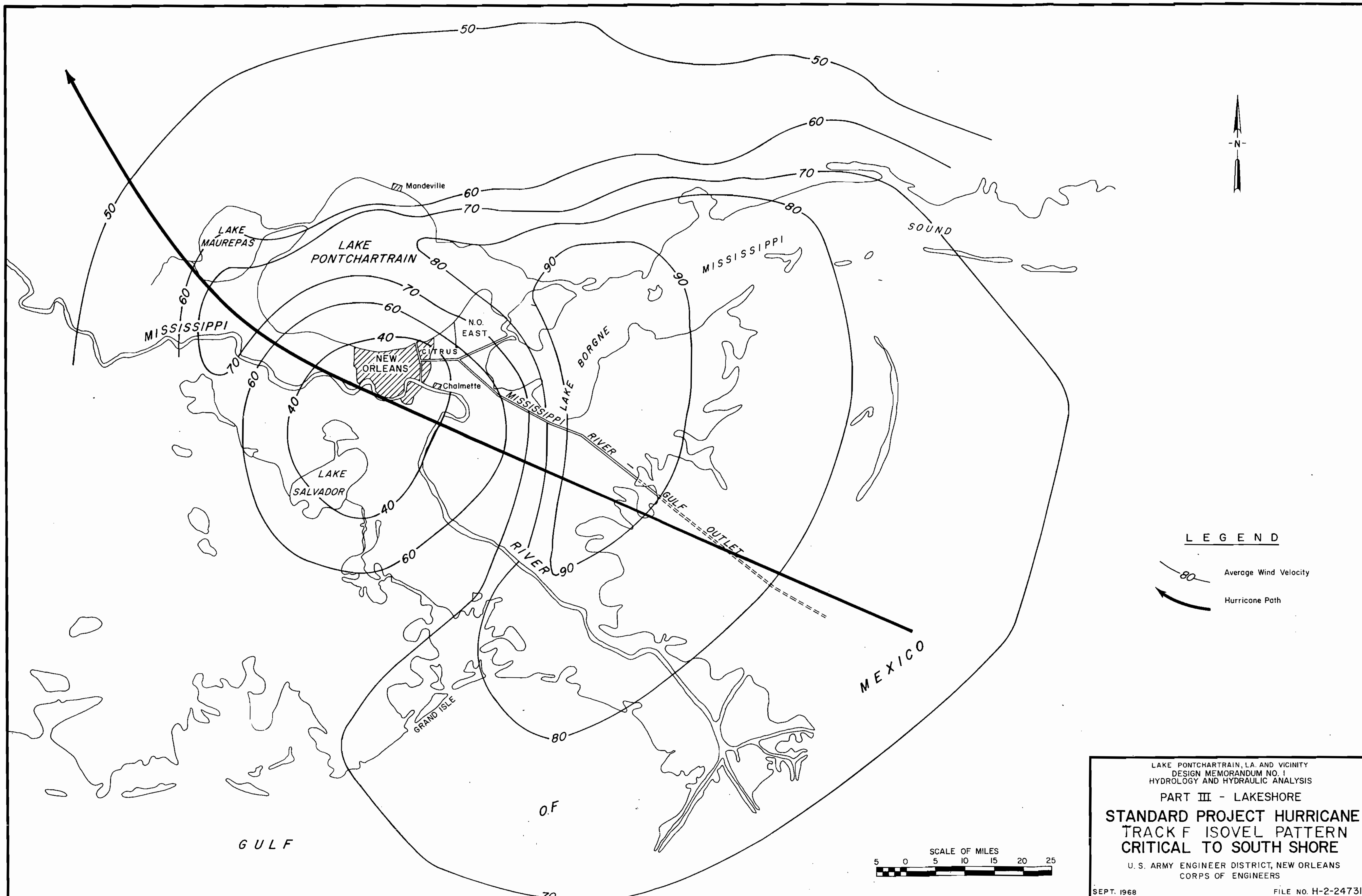
PART III - LAKESHORE

STANDARD PROJECT HURRICANE TRACK C ISOVEL PATTERN CRITICAL TO SOUTH SHORE

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

SEPT. 1968 FILE NO. H-2-24731

PLATE 5



LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS

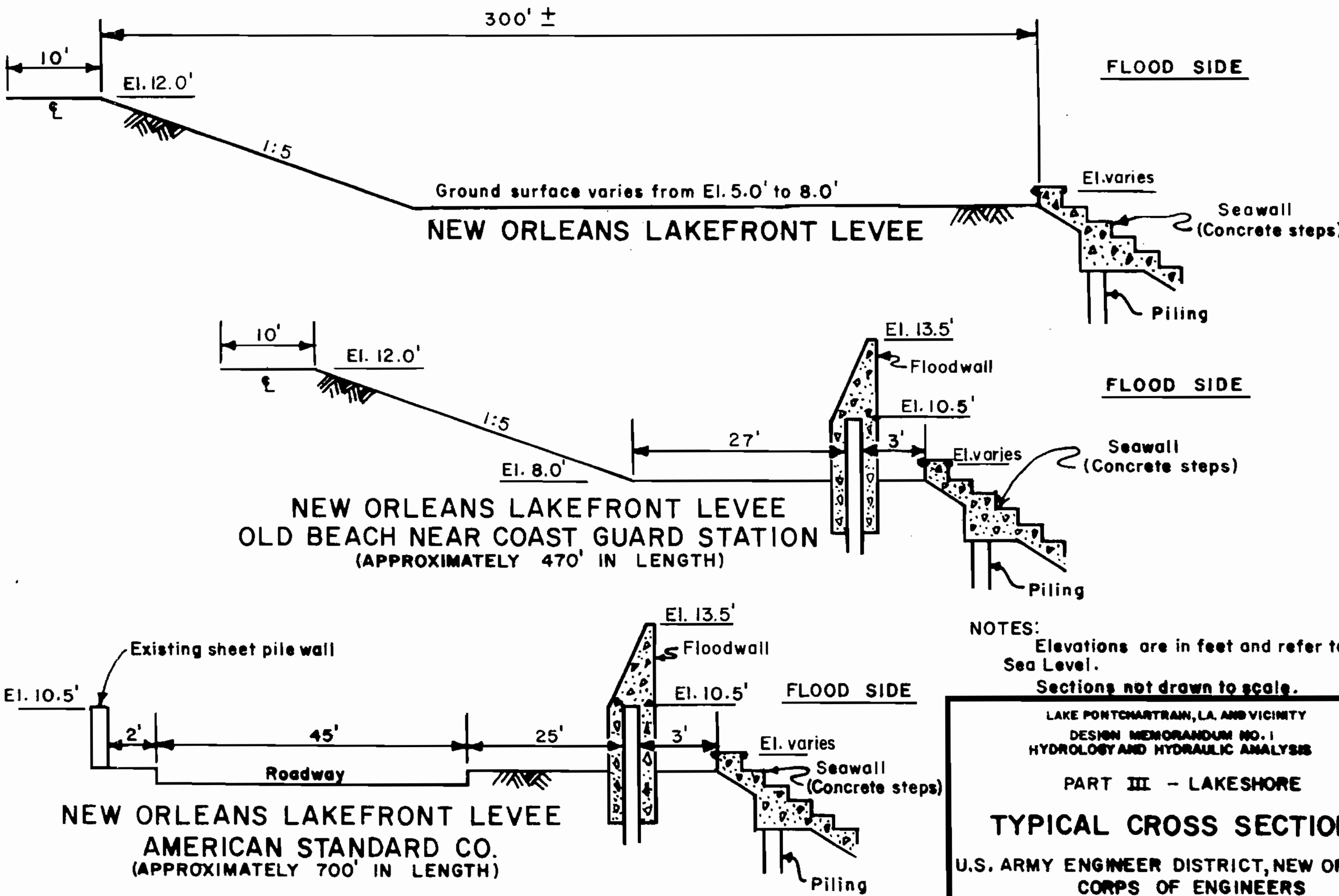
PART III - LAKESHORE

STANDARD PROJECT HURRICANE
TRACK F ISOVEL PATTERN
CRITICAL TO SOUTH SHORE

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

SEPT. 1968 FILE NO. H-2-24731

PLATE 6



NOTES:
Elevations are in feet and refer to Mean Sea Level.
Sections not drawn to scale.

LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS

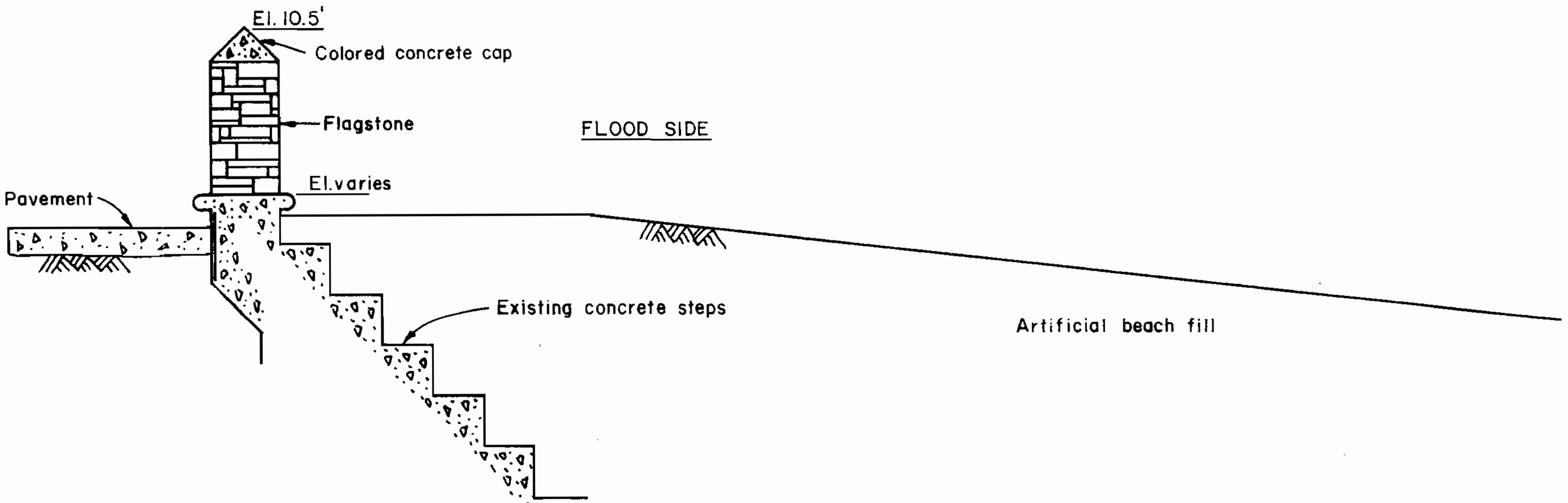
PART III - LAKESHORE

TYPICAL CROSS SECTIONS

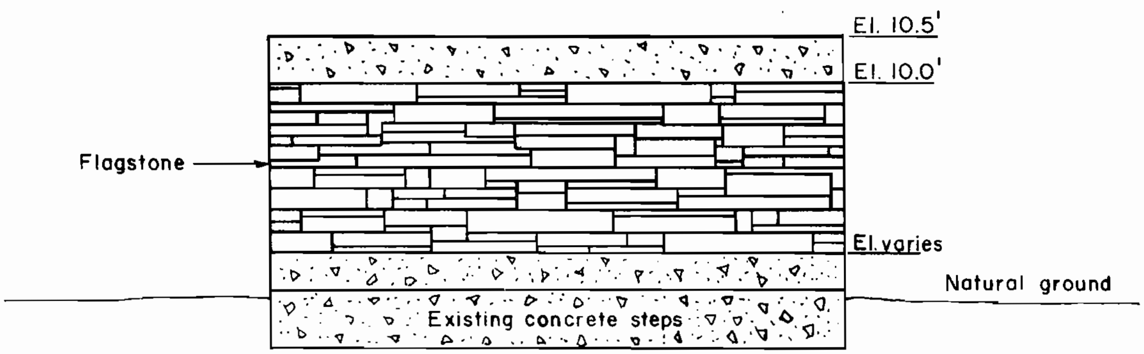
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

SEPT. 1968 FILE NO. H-2-24731

PLATE 7



NEW ORLEANS LAKEFRONT
PONTCHARTRAIN BEACH AMUSEMENT PARK



FLOOD SIDE ELEVATION

NOTES:

Elevations are in feet and refer to Mean Sea Level.

Sections not drawn to scale.

LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS

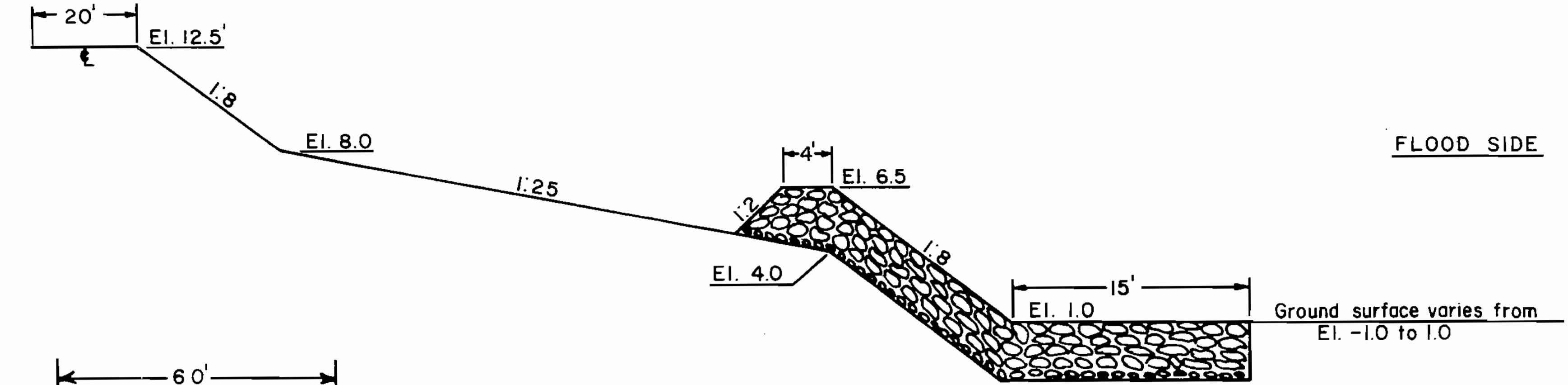
PART III — LAKESHORE

TYPICAL CROSS SECTIONS

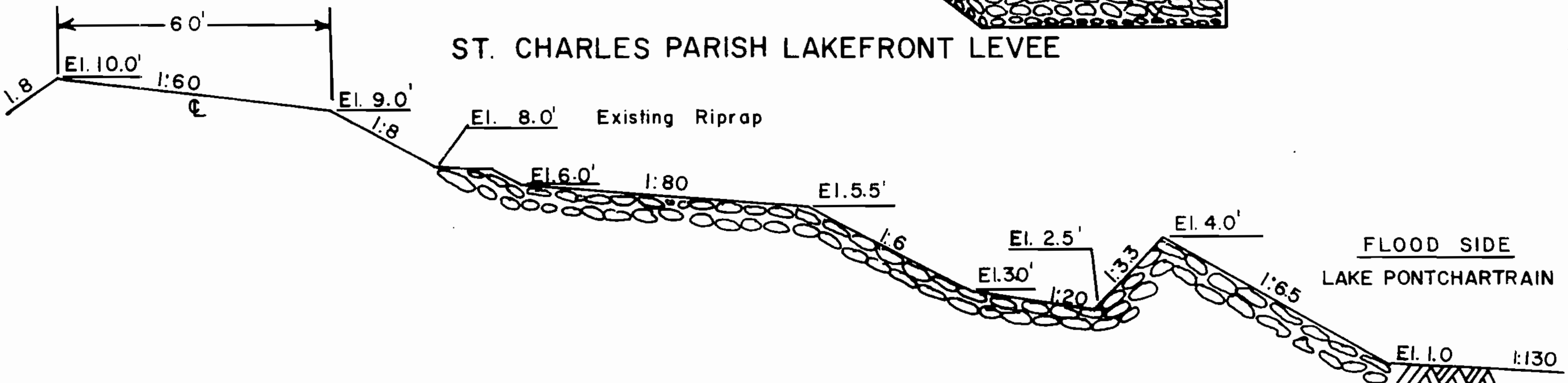
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

SEPT. 1968 FILE NO. H-2-24731

PLATE 8

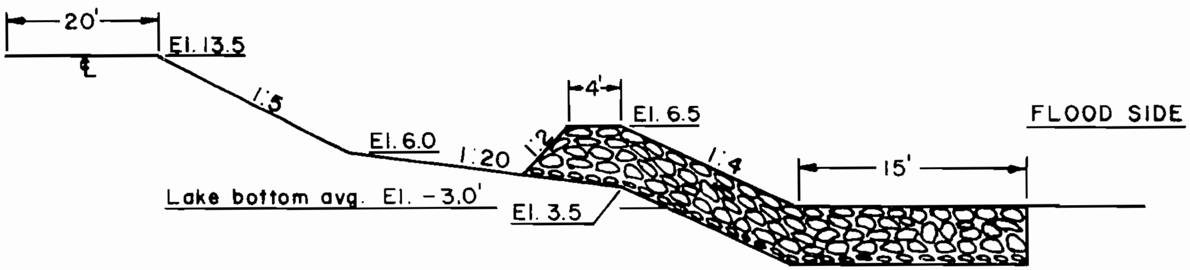


ST. CHARLES PARISH LAKEFRONT LEVEE



JEFFERSON PARISH LAKEFRONT LEVEE

NOTES:
Elevations are in feet and refer to Mean Sea Level.
Sections not drawn to scale.



CITRUS & NEW ORLEANS EAST LAKEFRONT LEVEES

LAKE PONTCHARTRAIN, LA. AND VICINITY
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PART III — LAKESHORE

TYPICAL CROSS SECTIONS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

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PLATE 9