U. S. ARMY CORPS OF ENGINEERS

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

PART IV - CHALMETTE EXTENSION

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

October 1967

LMVED-TD (NOD 12 Oct 67) 3d Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part IV - Chalmette Extension

DA, Lower Miss. Valley Div, CE, Vicksburg, Miss. 39180 6 Dec 67

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

Referred to note approval.

FOR THE DIVISION ENGINEER:

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

LMVED-TD (NOD 12 Oct 67) 1st Ind
SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part IV - Chalmette Extension

DA, Lower Miss. Valley Div, CE, Vicksburg, Miss. 39180 1 Nov 67

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

Subject design memorandum is forwarded for review and approval pursuant to paragraph 17, ER 1110-2-1150. Approval is recommended.

FOR THE DIVISION ENGINEER:

wd 2 cy incl 1

GEORGE B. DAVIS
Acting Chief, Engineering Division

Copy furnished:
NOD, ATTN: LMNED-PP

ENGCW-EZ (LMNED-PP 12 Oct 67) 2d Ind

DA, CofEngrs, Washington, D. C., 20315, 1 December 1967

TO: Division Engineer, Lower Mississippi Valley Division

Approved.

FOR THE CHIEF OF ENGINEERS:

incl w/d

WENDELL E. JOHNSON
Chief, Engineering Division
Civil Works

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

IN REPLY REFER TO
LMNED-PP

12 October 1967

SUBJECT: Lake Pontchartrain, Louisiana and Vicinity, Design Memorandum No. 1, Hydrology and Hydraulic Analysis, Part IV - Chalmette Extension

TO: 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, is the subject design memorandum.

2. Approval of this memorandum is recommended.

1 Incl (9 cys)
DM No. 1

Thomas J. Bowen
THOMAS J. BOWEN
Colonel, CE
District Engineer

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

PART IV - CHALMETTE EXTENSION

STATUS OF DESIGN MEMORANDA

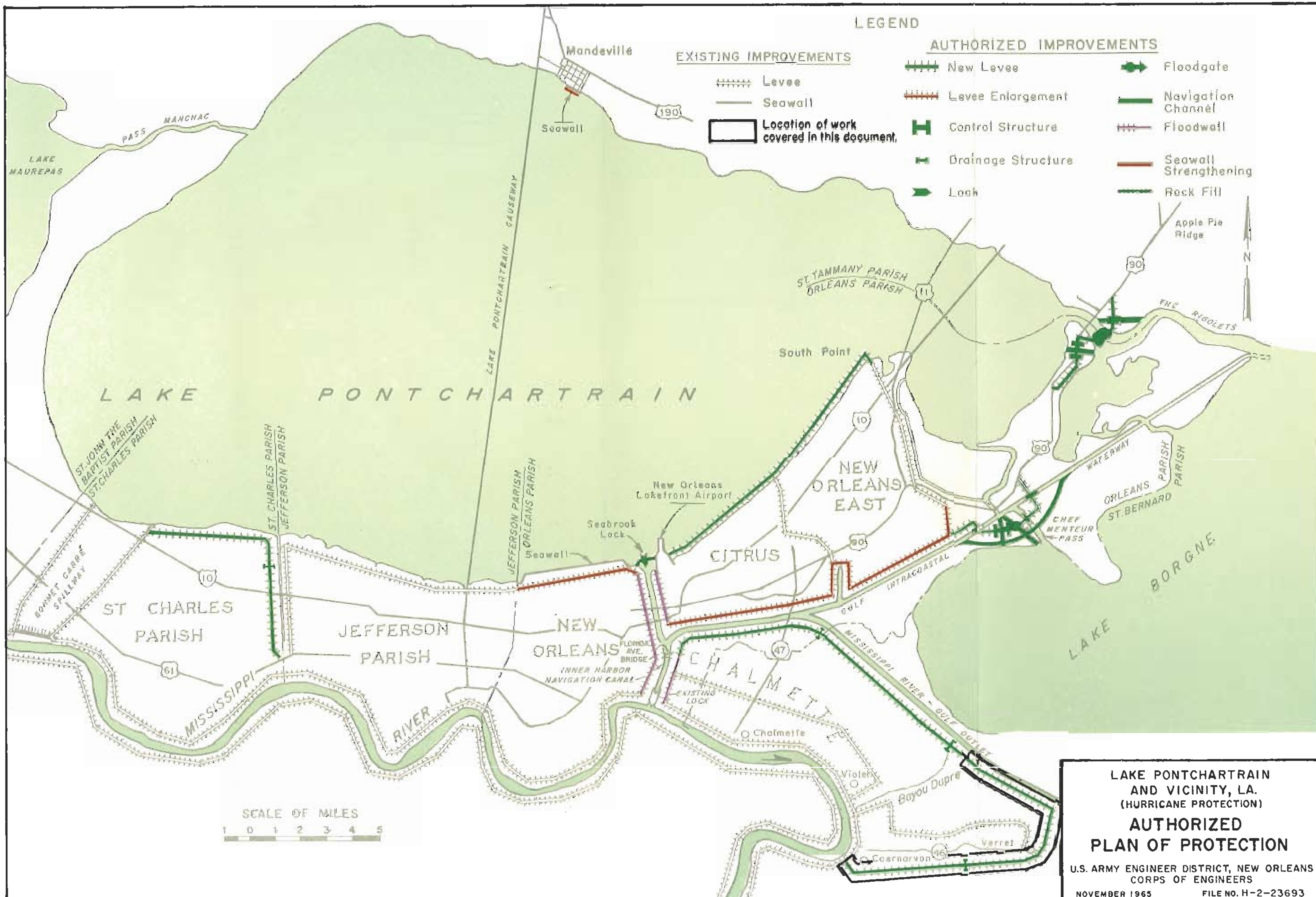
Design memo No.	Title	Status
1	Hydrology and Hydraulic Analysis	
	Part I - Chalmette	Approved 27 Oct 66
	Part II - Barrier	Submitted Aug 67
	Part III - Lakeshore	Scheduled Jul 68
	Part IV - Chalmette Extension	Submitted Oct 67
2	Lake Pontchartrain Barrier Plan, GDM, Advance Supplement, Inner Harbor Navigation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

STATUS OF DESIGN MEMORANDA (cont'd)

Design memo No.	Title	Status
2	Lake Pontchartrain Barrier Plan, GDM, Supplement No. 6, St. Charles Parish Lakefront Levees	Scheduled Dec 68
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	Scheduled Jan 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 Feb 68
4	Lake Pontchartrain Barrier Plan & Chalmette Area Plan, GDM Florida Avenue Complex, IHNC	Not scheduled
5	Chalmette Area Plan, DDM, Bayous Bienvenue and Dupre	Scheduled Dec 67
6	Lake Pontchartrain Barrier Plan, DDM, Rigolets Control Structure and Closure	Scheduled Feb 69
7	Lake Pontchartrain Barrier Plan, DDM, Chef Menteur Control Structure and Closure	Scheduled Feb 69
8	Lake Pontchartrain Barrier Plan, DDM, Rigolets Lock	Scheduled Feb 69
9	Lake Pontchartrain Barrier Plan, DDM, Chef Menteur Navigation Structure	Scheduled Jan 69

STATUS OF DESIGN MEMORANDA (cont'd)

Design memo No.	Title	Status
10	Lake Pontchartrain Barrier Plan, DDM, Gantry Crane - Chef Menteur Control Structure	Scheduled Jan 70
11	Lake Pontchartrain Barrier Plan, DDM, St. Charles Parish Drainage Structure	Scheduled Jan 70
12	Source of Construction Materials	Approved 30 Aug 66
13	Lake Pontchartrain Barrier Plan, DDM, Gantry Crane - Rigolets Control Structure	Scheduled Jul 70
14	Beautification	Not scheduled
1	Lake Pontchartrain, La. and Vicinity,and Mississippi River-Gulf Outlet, La., GDM, Seabrook Lock	Scheduled Mar 68
2	Lake Pontchartrain, La. and Vicinity, and Mississippi River-Gulf Outlet, La., DDM, Seabrook Lock	Scheduled Aug 68


LEGEND
EXISTING IMPROVEMENTS
Levee
Seawall
Location of work covered in this document.
AUTHORIZED IMPROVEMENTS
New Levee
Levee Enlargement
Control Structure
Drainage Structure
Lock
Floodgate
Navigation Channel
Floodwall
Seawall Strengthening
Rock Fill
LAKE PONTCHARTRAIN
LAKE MAUREPAS
PASS MANCHAC
Mandeville
Seawall
LAKE PONTCHARTRAIN CAUSEWAY
ST. TAMMANY PARISH
ORLEANS PARISH
South Point
Apple Pie Ridge
THE RIGOLETS
N
ST. JOHN THE BAPTIST PARISH
ST. CHARLES PARISH
ST. CHARLES PARISH
JEFFERSON PARISH
JEFFERSON PARISH
ORLEANS PARISH
BONNET CARRE SPILLWAY
ST CHARLES PARISH
JEFFERSON PARISH
NEW ORLEANS
New Orleans Lakefront Airport
Seabrook Lock
Seawall
CITRUS
NEW ORLEANS EAST
CHEF MENTEUR PASS
ORLEANS PARISH
ST. BERNARD PARISH
GULF INTRACOASTAL WATERWAY
LAKE BORGNE
FLORIDA AVE. BRIDGE
INNER HARBOR NAVIGATION CANAL
EXISTING LOCK
CHALMETTE
Chalmette
MISSISSIPPI RIVER
MISSISSIPPI RIVER - GULF OUTLET
Violet
Bayou Dupre
Verret
Caernarvon
SCALE OF MILES
1 0 1 2 3 4 5
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. MAY 1967

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

PART IV - CHALMETTE EXTENSION

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLES

PLATES

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 synonomously 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 ground level.

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.

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.

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.

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 IV - CHALMETTE EXTENSION

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.* (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 Part I - Chalmette, Part II - Barrier, and Part III - Lakeshore. As previously mentioned,

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

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 added 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, Inner Harbor Navigation Canal, Citrus Back, and New Orleans East back protection works were presented. In Part II - Barrier, the description and analyses of essential data, assumptions, criteria used, and the results of studies which provide the bases for determining design surge heights, runup, overtopping, and frequencies for the Lake Pontchartrain Barrier were covered. Preparation of Part III - Lakeshore is presently underway and will cover the development of design elevations for the areas along the shores of Lake Pontchartrain. This document, Part IV - Chalmette Extension, presents the development of design elevations for the levees utilized for the Chalmette extension.

3. Description. The Lake Pontchartrain, La. and Vicinity, project area is shown on plate 1. The project plan consists of two independent units--the Lake Pontchartrain Barrier Plan and the Chalmette Area Plan. Only the Chalmette area is pertinent to this report. The Chalmette area slopes from the alluvial ridge along the Mississippi River to the Lake Borgne Basin. The land adjacent to the Mississippi River ranges in elevation from 4 to 10 feet and slopes away from the river at about 1 foot per 1,000 feet to an elevation of approximately 1.0. The remainder of the Chalmette area averages 1.0, except that in the area where the spoil from excavating the MR-GO was placed, the elevation varies from 4.0 to 10.0. The area north of Poydras between the Mississippi River levee and the back levee which parallels the river approximately 2 miles from the river and the area from Poydras to Verret between Highway 46 and the back levee which parallels the highway approximately 1 mile north of the highway are presently protected from tidal inundation. The remainder of the Chalmette area is subject to tidal overflow.

4. Problems. On several occasions, the marsh area between Lake Borgne and Lake Pontchartrain has been flooded up to elevations of 11 feet. As the hurricane winds blow over the surge-elevated Lake Borgne and surrounding areas, wind tides and waves would be generated causing overtopping of the existing protective works and massive ponding in the developed areas.

5. Plan of protection. The authorized plan of protection is shown on plate 2. The Chalmette Area Plan, as modified by LMNED-PR letter dated 29 November 1966, consists of floodwall

along the east bank of the IHNC extending from the IHNC lock to Florida Avenue, thence levee along the IHNC to the MR-GO, thence along the south bank of the MR-GO to approximately 6.5 miles southeast of Bayou Dupre, thence southwest to Verret, La., thence west south of Highway 46 and tieing into the Mississippi River levee at Caernarvon, La., with navigable floodgates in Bayous Bienvenue and Dupre and a drainage structure in the vicinity of the Whitehall Canal. Subsequent to hurricane "Betsy" to increase the degree of protection in the interim, local interests drove sheet piling along the IHNC east levee between the IHNC lock and Florida Avenue to a construction grade of 11 feet, raised the Chalmette back levee to a construction grade of 13.0 feet, drove sheet piling along the Chalmette back levee to a construction grade of 16.0 feet, and constructed a levee between Caernarvon and Verret south of Highway 96 to a grade of 10.0 feet.

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 Design Memorandum No. 1, Part I - Chalmette, approved 27 October 1966, for a more detailed discussion of temperature, rainfall, and wind in the project area.

7. Hydrology. The Chalmette area is subject to direct rainfall, discharge from interior drainage of a portion of New Orleans west of the IHNC, and flow through connecting canals and Bayous Bienvenue and Dupre caused by tidal variations originating in the Gulf of Mexico. A detailed discussion of project area hydrology is given in Design Memorandum No. 1, Part I - Chalmette.

SECTION III - TIDAL HYDRAULIC DESIGN

8. Storm surges.

a. General. The method of computing surges was fully described in Part I - Chalmette and will only be summarized herein. In determining critical conditions for the various subareas, different tracks are used. Tracks C and F are used for the Chalmette extension, track C being critical to the levee south of Highway 46 and track F being critical to the levee along the MR-GO. The two tracks along with tracks of more significant historical hurricanes are shown on plate 3.

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

TABLE 1
DESIGN HURRICANE CHARACTERISTICS

Track*	C.P.I.	Radius of maximum winds	Forward speed	Max.** wind	Direction of approach
	inches	nautical miles	knots	m.p.h.	
C	27.6	30	5	100	SSE
F	27.6	30	11	100	East

* Tracks are shown on plate 3.
**Referenced to 30 feet above the surface.

c. Surges.

(1) Maximum surge heights required for determination of levee heights were computed by use of a general wind tide formula based on the steady state concept of water super-elevation(6)(7)(8) as described in paragraph 8.d. of Part I - Chalmette.

(2) Marshlands that fringe the study area are inundated for considerable distances inland by hurricane surges that approach the shores. The limit of overland surge penetration is dependent upon the height of the surge and the duration of high stages at the coast. The surge height at the coastline depends primarily on the direction and intensity of winds and the forward speed of the hurricane. Bays are prevalent in the project area

*Numbers in parentheses indicate references in Section IV - Bibliography.

and influence surge heights at inland locations. The routing of these surges overland by conventional methods was complicated by the undefinable effect of high windspeeds on flow, such that the procedures yielded questionable results when applied to different experienced hurricanes in a given location. Attempts to correlate hurricane forward speeds, surge hydrographs at the coastline, and surge heights at inland locations also yielded inconsistent and therefore unusable relationships. A study of available observed high water marks at the coastline and inland, indicates a consistent simple relation between the maximum surge height and the distance inland from the coast, as shown on plate 6. This relationship exists independently of the forward speed of the hurricane, windspeed, or direction. The data indicate that the weighted mean decrease in surge heights inland is at the rate of 1.0 foot per 2.75 miles. This relationship remains true even in the western portion of Louisiana where relatively high chenieres, or wooded ridges, parallel the coast. Efforts to establish time lags between crest surge heights at the coast and at inland locations were unsuccessful because of inadequate basic data.

(3) For the purpose of surge routing procedures, the coastline is defined as the locus of points where the maximum surge heights would be observed along fetches normal to the general coast. This synthetic coastline has been designated the surge reference line (SRL) and is shown on plate 7. In order to determine maximum surge heights at inland locations, it was necessary to compute maximum surge heights at the SRL, and then reduce these computed elevations at the rate of 1.0 foot per 2.75 miles to the levee location. The procedure has given satisfactory results in the project area and has verified the observed data in other study areas.

(4) Surge heights were computed for three locations--MR-GO at Bayou Dupre, Verret, and Toca. Surge heights at these three locations represent the range of surge heights expected for the entire Chalmette extension levee. Verret and Toca are several miles inland from the SRL (see plate 7); therefore, it was necessary to reduce the synthetic surge computed for the SRL to obtain the surge height at the inland locations. The design surge heights are shown in table 2.

TABLE 2
SURGE HEIGHTS
DESIGN HURRICANE

Range	Track	Surge adjustment factor	Time* to maximum surge	Maximum surge height: Surge reference line	Maximum surge height: Levee location
			hours	feet	feet
MR-GO	F	0.30	-1	12.5	12.5
Verret	C	0.48	+2	15.1	12.2
Toca	C	0.52	+2	15.8	11.8

*Referenced to landfall

9. 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 surge 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 surge height minus the average elevation of prominent topographic features over the fetch. At locations inland from the SRL, the average elevation of the top of marsh grass[9] was taken as the prominent feature. This resulted in decreasing the effective depth of fetch.

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(10) and as described in paragraph 1.25 of reference (6). 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 3.

TABLE 3
DATA USED TO DETERMINE WAVE CHARACTERISTICS
DESIGN HURRICANE

Parameters	Levee location		
	MR-GO	Verret	Toca
F - Length of fetch, in miles	5	5	5
U - Windspeed in m.p.h.	91	85	90
swl - Stillwater level, in feet	12.5	12.2	11.8
d - Average depth of fetch, in feet	16.3	10.1	9.7
d_t - Depth at toe of levee, in feet	7.5	8.2	7.8

d. Wave runup was calculated by use of model study data developed by Saville(11)(12)(13)(14) which relate relative runup (R/H_o'), wave steepness (H_o'), and relative depth (d/H_o'). The significant wave height (H_s) and wave period (T) can be determined from the data in table 3. The equivalent deep water wave height (H_o') can be determined from table D-1 of reference (6) which related d/L_o to H/H_o'. The deep water wave length (L_o) is determined from the equation:

$$L_o = 5.12\ T^2$$

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 4.

TABLE 4
WAVE CHARACTERISTICS
DESIGN HURRICANE

Characteristic	Levee location		
	MR-GO	Verret	Toca
H_s - Significant wave height, in feet	6.6	4.4	4.5
T - Wave period, seconds	6.2	5.1	5.1
L_o - Deep water wave length, in feet	197	133	133
d/L_o - Relative depth	0.08249	0.07584	0.07284
H_s/H_o' - Shoaling coefficient	0.9513	0.9610	0.9661
H_o' - Deep water wave height, in feet	6.9	4.6	4.7
H_o'/T^2 - Wave steepness	0.781	0.176	0.179

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 8). These berms broke the continuity of the levee slope and Saville's[14] method of determining wave runup on composite slopes was used (see plate 9). In using this method, the actual composite slope is replaced by a hypothetical single constant slope. This hypothetical slope is computed by estimating a 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.

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 be allowed to overtop the protective structures but such overtopping will not endanger the security of the structures or cause excessive interior flooding. During the time of maximum surge height 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 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. The equivalent deep water wave height for the smaller waves breaking on the berms was computed 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 table 5. The runup elevations shown in table 5 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 is materially different from the preliminary section.

TABLE 5
WAVE RUNUP AND PROPOSED ELEVATIONS OF PROTECTIVE STRUCTURES
STANDARD PROJECT HURRICANE

Location	Average depth	H_s	T	Surge height	Wave runup	Levee grade
	ft.	ft.	sec.	ft.m.s.l.	ft.	ft.m.s.l.
Bayou Dupre to Verret	16.3	6.6	6.2	12.5	4.6	17.5
Verret to Toca	10.1	4.4	5.1	12.2	4.8	17.5 to 16.5
Toca to Caernarvon	9.7	4.5	5.1	11.8	4.4	16.5

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 protective structures herein will be overtopped by those waves of the spectrum which exceed the significant wave. Studies indicate that no significant flooding will result from such overtopping.

11. Frequency estimates. The procedure developed for making frequency estimates is described in paragraph 9.a. of Part I - Chalmette. The design hurricane for the Chalmette extension has a frequency of about once in 200 years.

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

13. Hydraulic design interior drainage. The hydraulic design for the interior drainage of the Chalmette extension area will be covered in Design Memorandum No. 3, General Design, Chalmette Area Plan, Supplement No. 1, Chalmette Extension.

SECTION IV - BIBLIOGRAPHY

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

(2) 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.

(3) 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.

(4) 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, 1956.

(5) 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.

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

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

(8) U. S. Army Engineer District, Jacksonville, "Design Memorandum, Wind Tides Produced 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.

(9) University of California, "Effect of Bottom Roughness on Wind Tide in Shallow Water," Beach Erosion Board, Technical Memorandum No. 95, May 1957.

(10) 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.

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

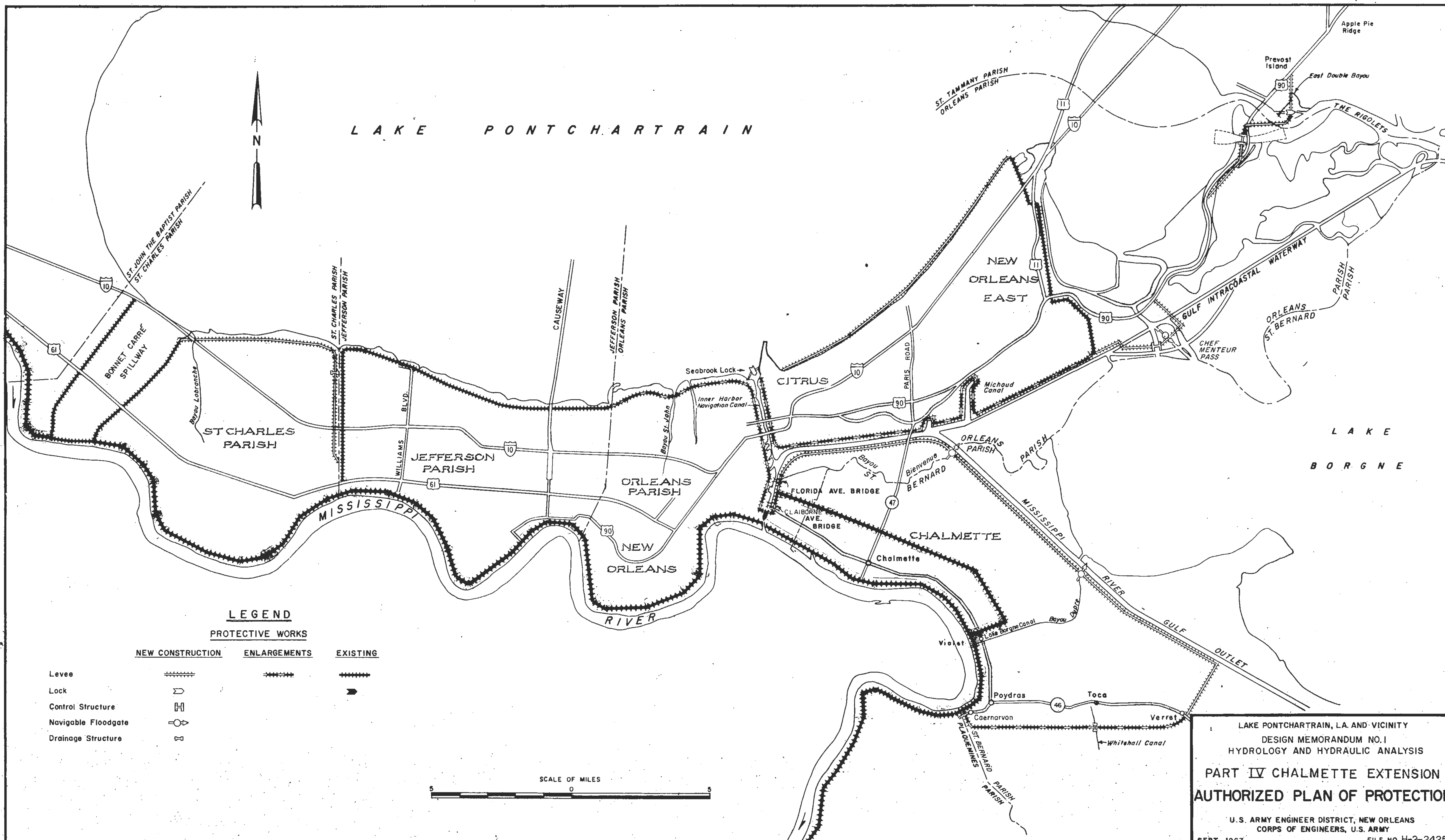
(12) Saville, Thorndike, Jr., "Wave Run-Up on Shore Structures," Journal of the Waterways Division of the American Society of Civil Engineers, Vol. 82, No. WW 2, April 1956.

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

(14) 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.

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
PLAQUEMINES PARISH
LAKE MAUREPAS
LAKE PONTCHARTRAIN
LAKE BORGNE
LAKE ST. CATHERINE
MISSISSIPPI SOUND
GRAND ISLAND
PASS MANCHAC
BONNET CARRE' SPILLWAY
INNER HARBOR NAVIGATION CANAL
LITTLE WOODS CANAL
DWYER CANAL
FLORIDA AVE. CANAL
GULF INTRACOASTAL WATERWAY
CHEF
MENTEUR PASS
RIGOLETS
MISSISSIPPI RIVER GULF OUTLET
MISSISSIPPI RIVER
GREATER NEW ORLEANS EXPRESSWAY BRIDGE
NEW RIVER CANAL
NEW ORLEANS
Manchac
Madisonville
Mandeville
Slidell
North Shore
South Shore
Sorrento
Frenier Beach
La Place
Kenner
Metairie
West End
Pontchartrain Beach
New Orleans Airport
Citrus
Little Woods
Michoud
Lee Station
Chalmette
Algiers
Gretna
Violet
Poydras
Toca
Verret
Long Point
New Orleans International Airport (Moisant Field)
ILLINOIS CENTRAL
SOUTHERN PACIFIC
LEGEND
Existing levee
Existing seawall
Railroad embankment
Levee, new or enlargement
SCALE OF MILES
5 0 5
N
VICINITY MAP
MISSISSIPPI
ALABAMA
LOUISIANA
Mobile
Gulfport
Biloxi
Bay St. Louis
Long Point
NEW ORLEANS
BRETON SOUND
GULF OF MEXICO
SCALE OF MILES
0 50 100
LAKE PONTCHARTRAIN, LA. AND VICINITY
DESIGN MEMORANDUM NO. I
HYDROLOGY AND HYDRAULIC ANALYSIS
PART IV – CHALMETTE EXTENSION
GENERAL MAP
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
SEPT. 1967
FILE NO. H-2-24253

PLATE I



LAKE PONTCHARTRAIN, LA. AND VICINITY

DESIGN MEMORANDUM NO. I

HYDROLOGY AND HYDRAULIC ANALYSIS

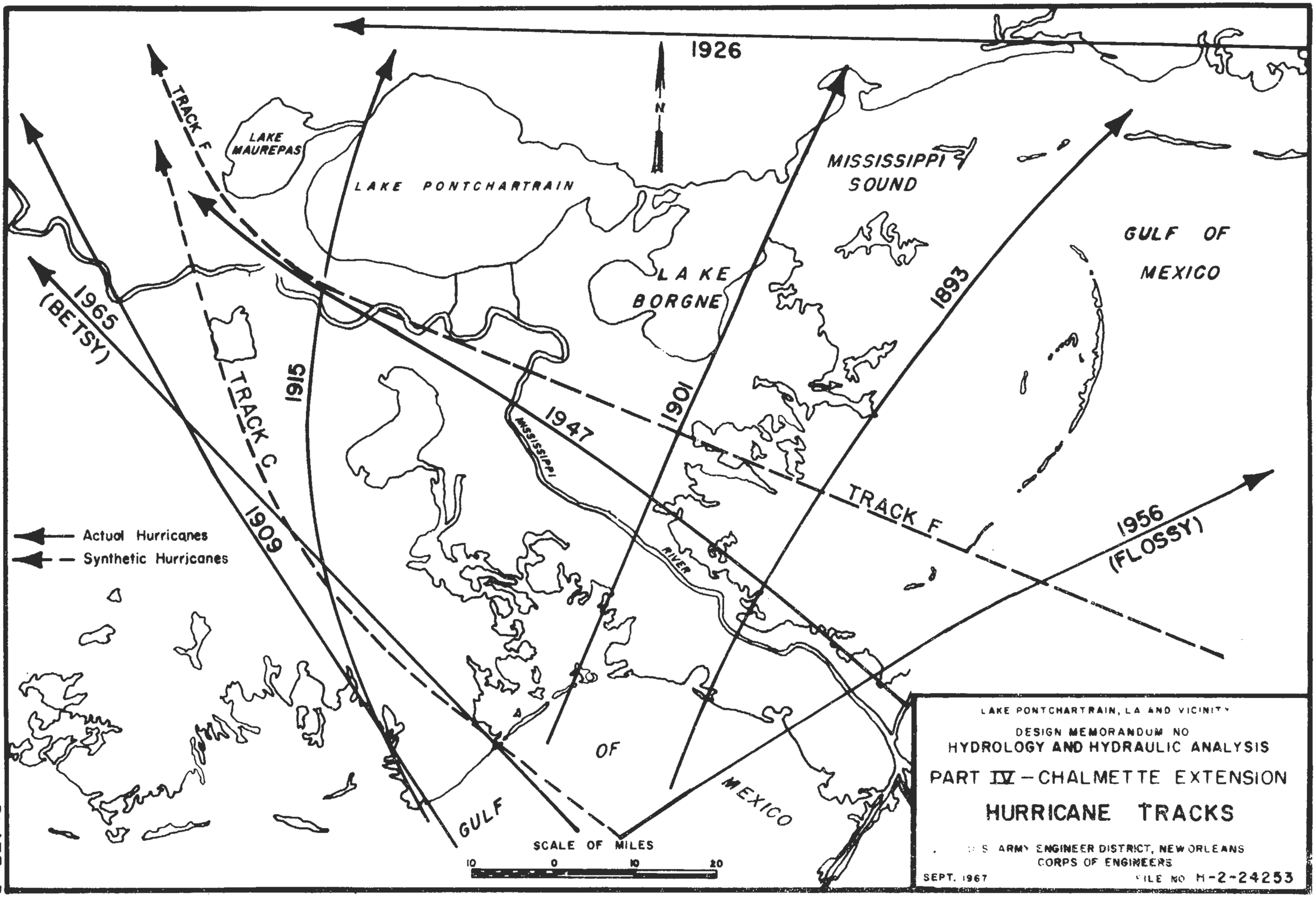
PART IV CHALMETTE EXTENSION

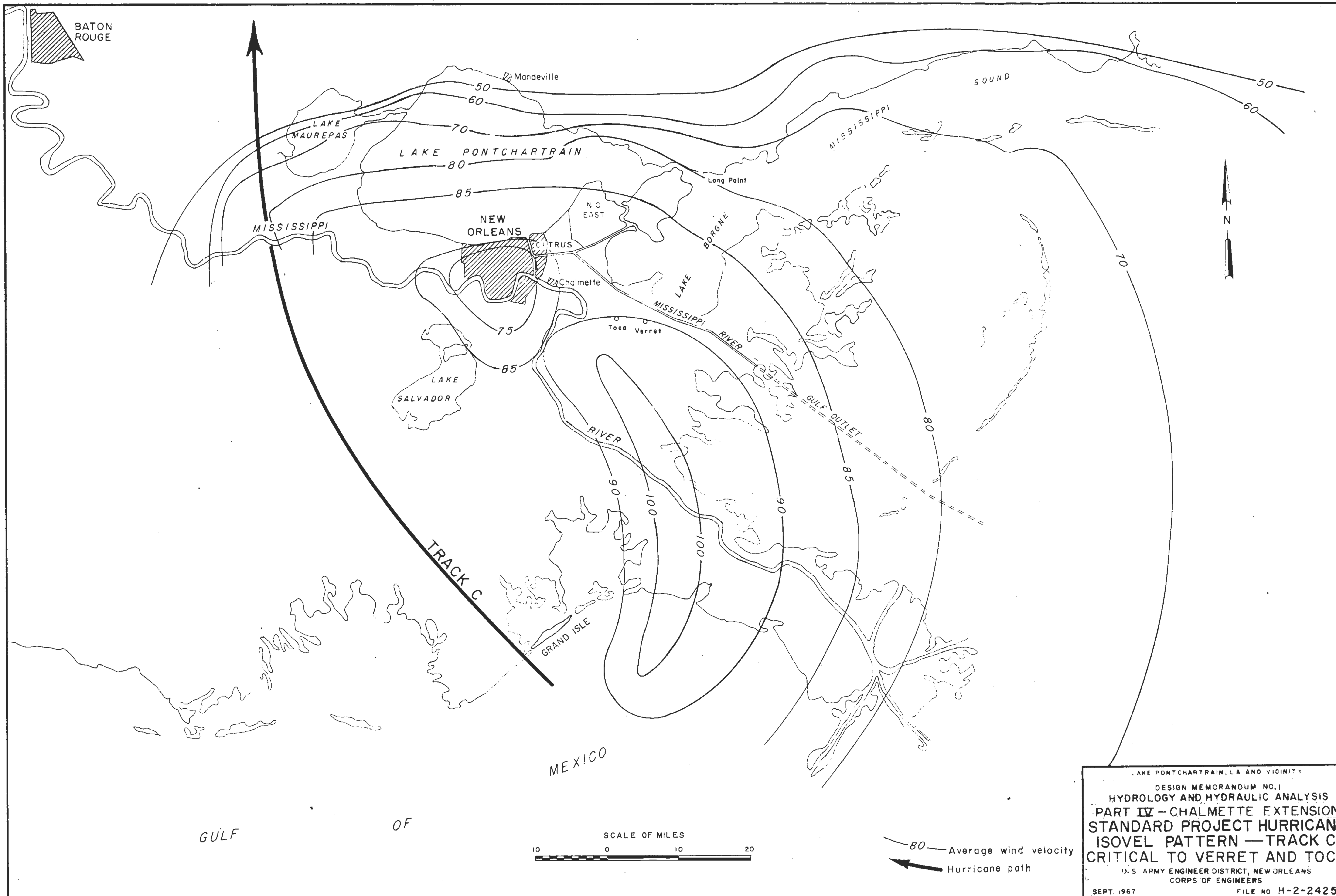
AUTHORIZED PLAN OF PROTECTION

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS, U.S. ARMY

SEPT. 1967 FILE NO. H-2-24253


1926
N
LAKE MAUREPAS
LAKE PONTCHARTRAIN
MISSISSIPPI SOUND
GULF OF MEXICO
LAKE BORGNE
TRACK F
TRACK C
1965 (BETSY)
1915
1909
1947
1901
1893
1956 (FLOSSY)
MISSISSIPPI RIVER
GULF OF MEXICO
Actual Hurricanes
Synthetic Hurricanes
SCALE OF MILES
10 0 10 20
LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO
HYDROLOGY AND HYDRAULIC ANALYSIS
PART IV - CHALMETTE EXTENSION
HURRICANE TRACKS
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
SEPT. 1967
FILE NO H-2-24253

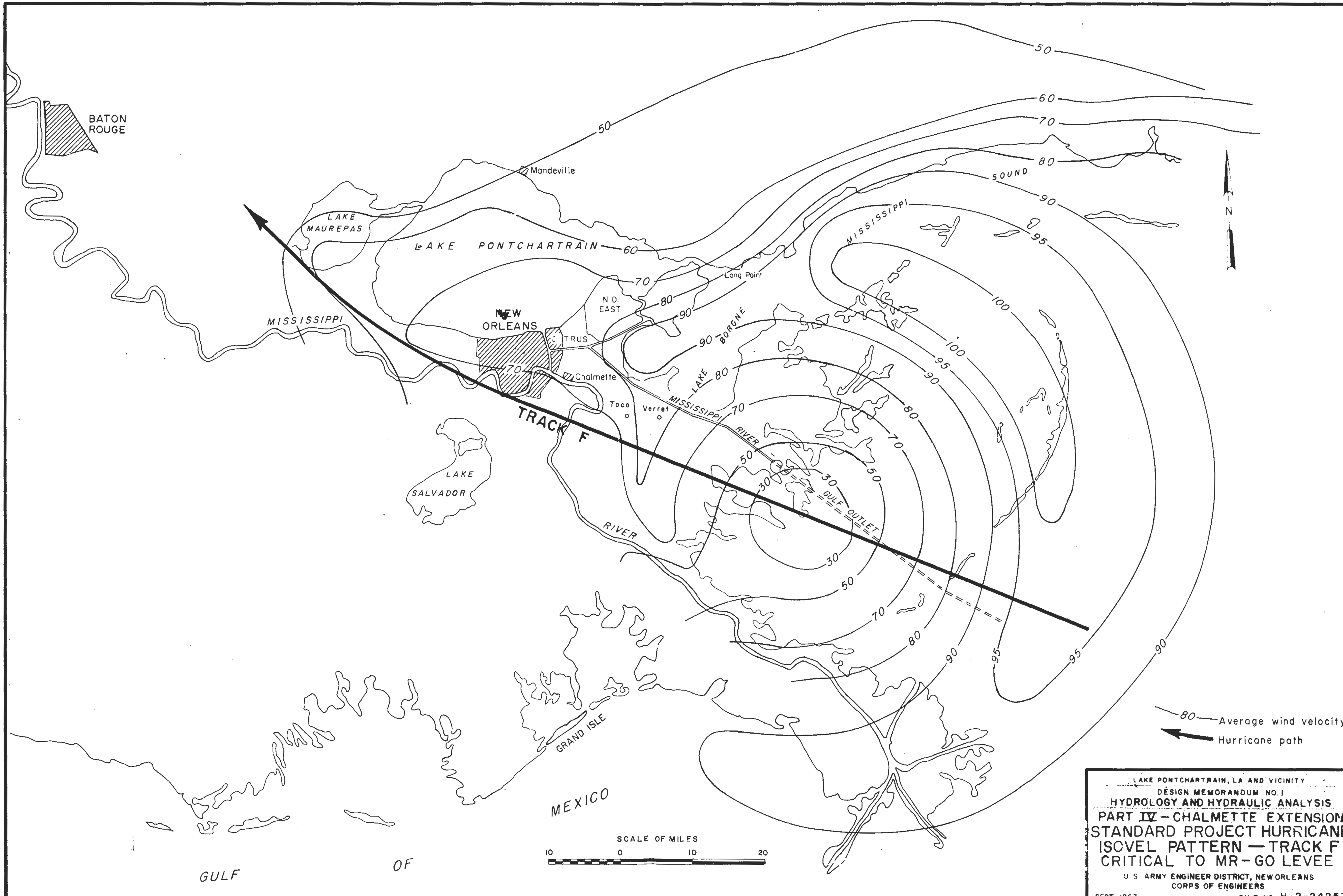


LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART IV – CHALMETTE EXTENSION

STANDARD PROJECT HURRICANE
ISOVEL PATTERN — TRACK C
CRITICAL TO VERRET AND TOCA

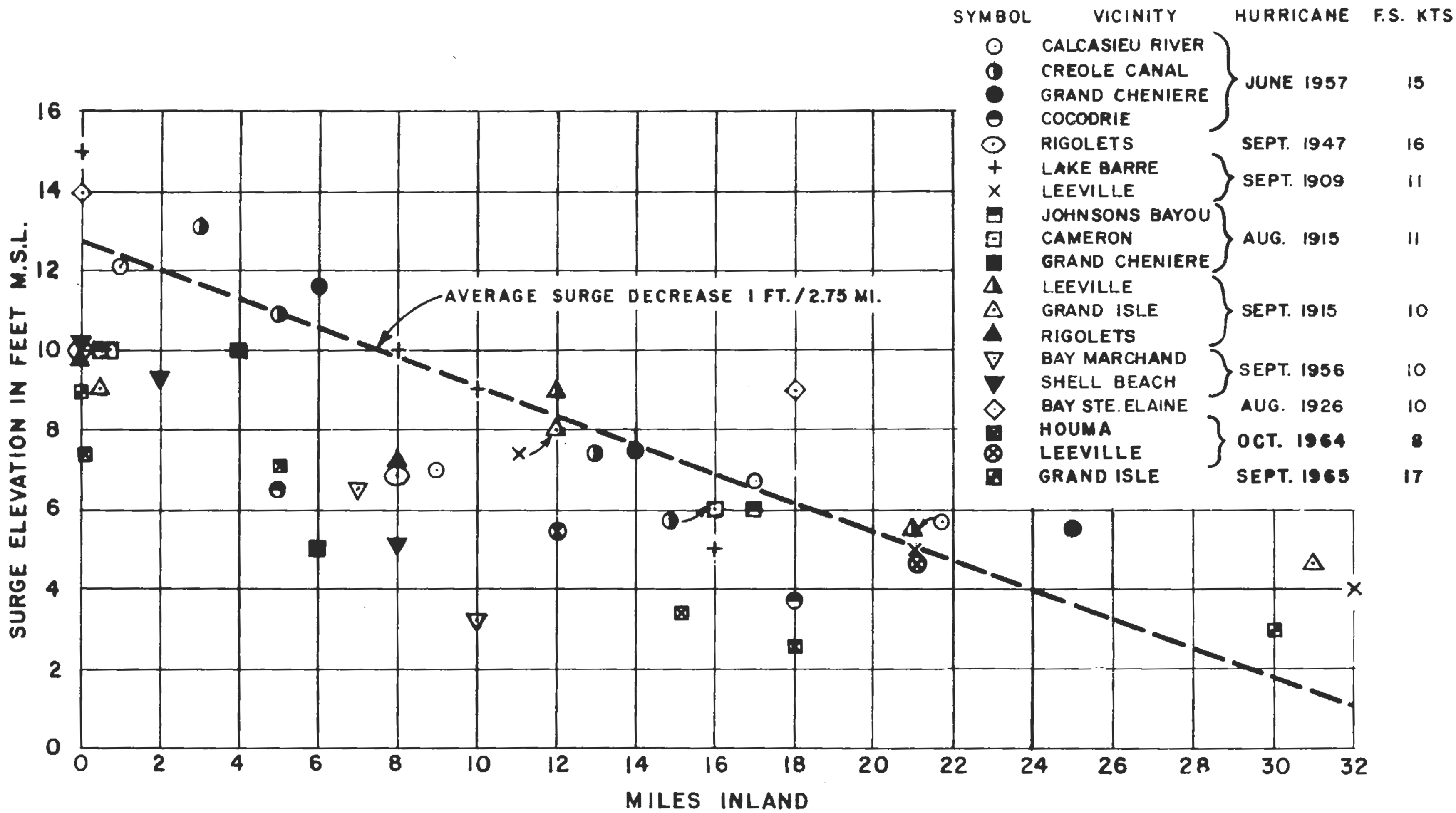
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

SEPT. 1967 FILE NO. H-2-24253



LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART IV - CHALMETTE EXTENSION
STANDARD PROJECT HURRICANE
ISOVEL PATTERN — TRACK F
CRITICAL TO MR-GO LEVEE
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
SEPT. 1967 FILE NO. H-2-24253

PLATE 5



LAKE PONTCHARTRAIN, LA AND VICINITY

DESIGN MEMORANDUM NO

HYDROLOGY AND HYDRAULIC ANALYSIS

PART IV – CHALMETTE EXTENSION

OVERLAND SURGE ELEVATIONS

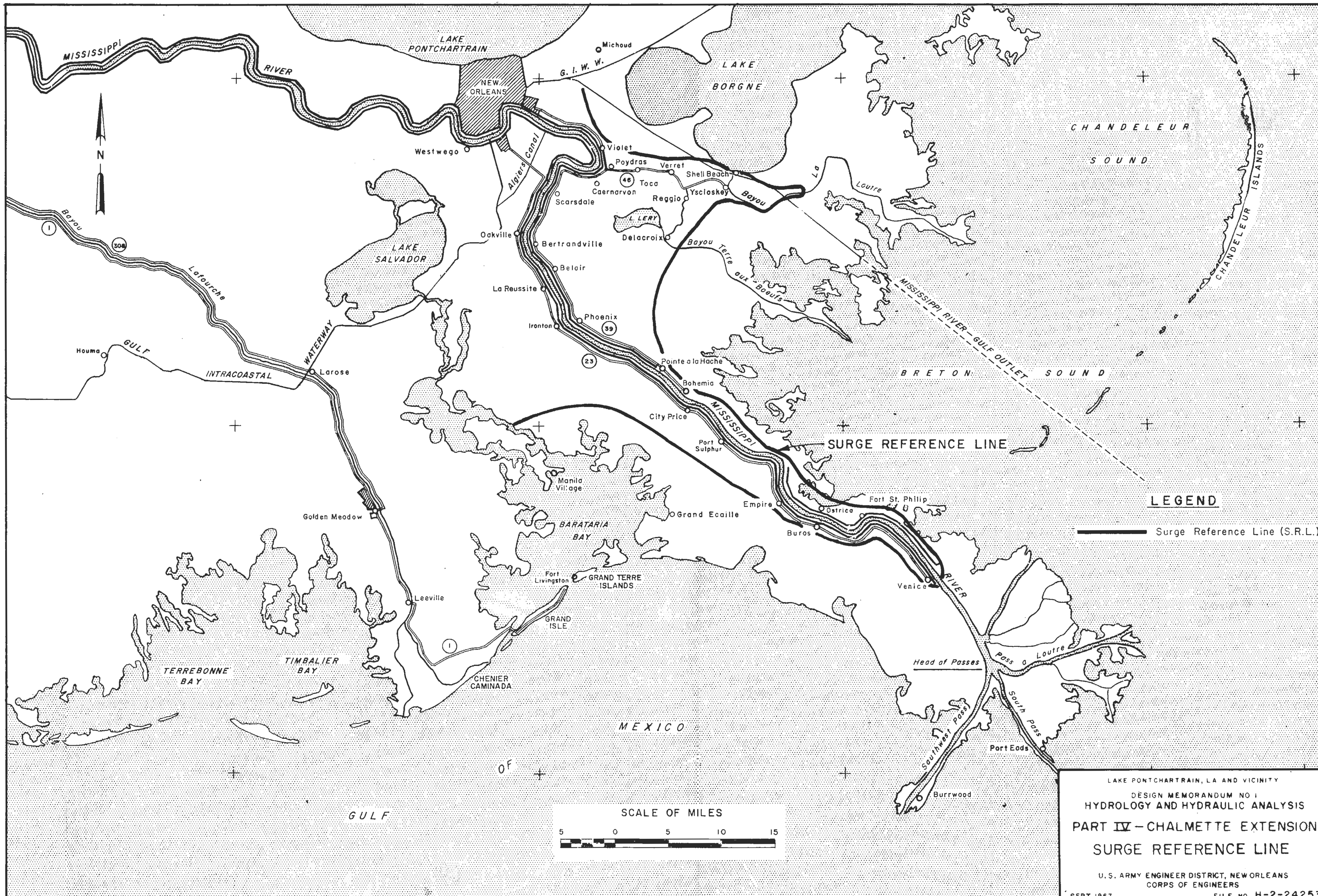
COASTAL LOUISIANA

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS

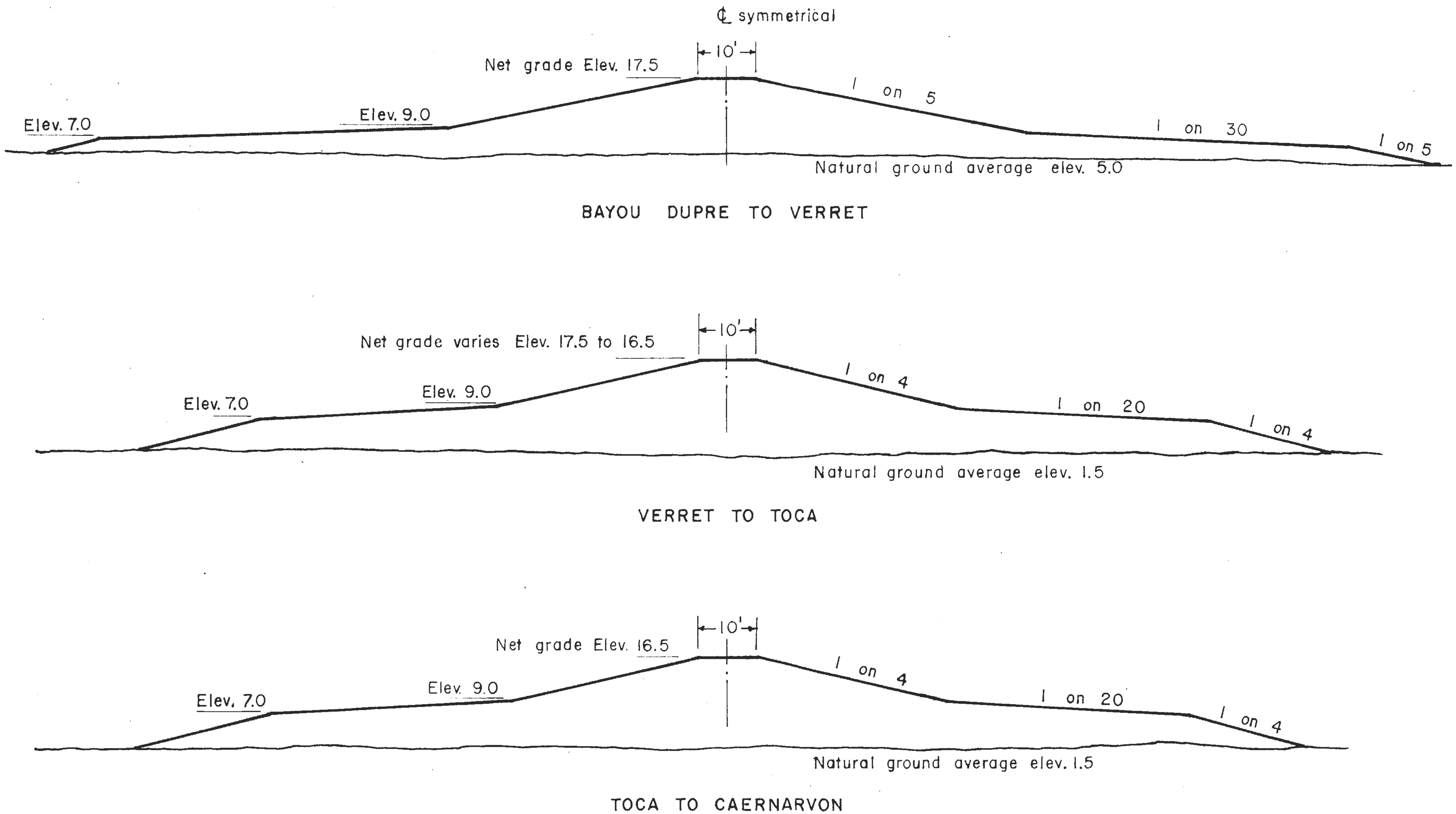
SEPT. 1967 FILE NO. H-2-24253

PLATE 6



LAKE PONTCHARTRAIN, LA AND VICINITY
DESIGN MEMORANDUM NO. 1
HYDROLOGY AND HYDRAULIC ANALYSIS
PART IV – CHALMETTE EXTENSION
SURGE REFERENCE LINE
U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
SEPT. 1967 FILE NO. H-2-24253

PLATE 7



NOTE: Elevations are in feet and refer to mean sea level.

LAKE PONTCHARTRAIN, LA. AND VICINITY

DESIGN MEMORANDUM NO. I

HYDROLOGY AND HYDRAULIC ANALYSIS

PART IV – CHALMETTE EXTENSION

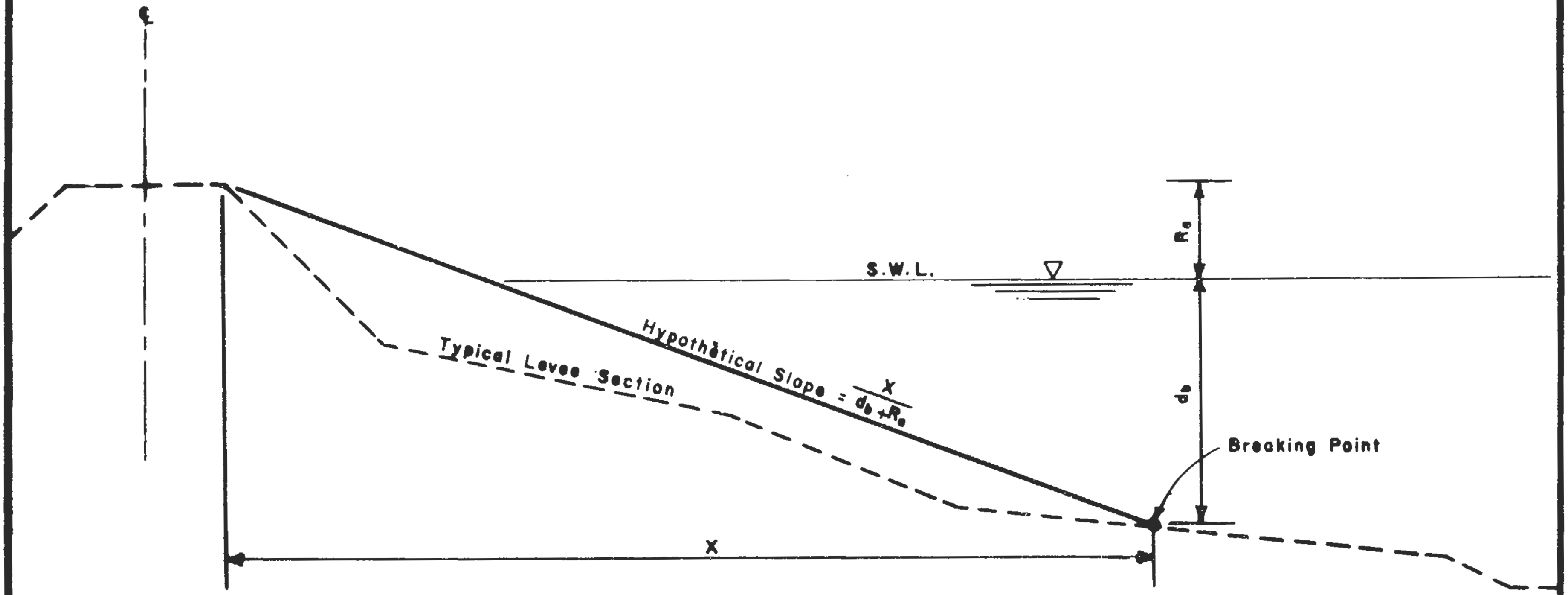
TYPICAL LEVEE SECTIONS

U. S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS

SEPT. 1967 FILE NO. H-2-24253

PLATE 8



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

HYDROLOGY AND HYDRAULIC ANALYSIS

PART IV – CHALMETTE EXTENSION

DETERMINATION OF HYPOTHETICAL SLOPE

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

SEPT. 1967 FILE NO. H-2-24253

PLATE 9