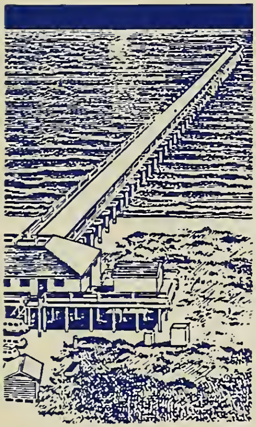
US Army Corps of Engineers



TECHNICAL REPORT CERC-87-11

HURRICANE DANNY STORM SURGE DATA

Report 4

by

Andrew W. Garcia, William S. Hegge

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

August 1987

Report 4 of a Series

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Under Hurricane Surge Prototype Data Collection
Work Unit 321-31662

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A summary of storm surge high-water mark, hydrograph, and wave data acquired during and subsequent to Hurricane Danny is presented. Of particular interest are the wave data taken from an offshore oil platform located only 10 miles from the track of the hurricane. The data were obtained and assembled as part of a long-term research effort by the US Army Corps of Engineers to establish a quantitative data set with the objective of providing, in a series of documents, the data necessary for simulation and verification of numerical surge models. The data contained herein were obtained primarily by the US Army Engineer Waterways Experiment Station and the US Army Engineer District, Galveston, with supplemental data from contributing agencies and institutions. Additional information is included in the form of photographs and descriptive narrative to aid investigators in assessing the degree of importance of an individual measurement for the purpose of model verification.

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Hurricane Surge Prototype Data Collection Work Unit 321-31662

PREFACE

The information and data presented herein were assembled and analyzed from 1985 to 1986 by authorization from the Office, Chief of Engineers (OCE), Coastal Engineering Area of Civil Works Research and Development, as a mission requirement of the Hurricane Surge Prototype Data Collection Work Unit 321-31662. Messrs. John H. Lockhart, Jr., and John Housley are the OCE Technical Monitors for the Coastal Engineering Research Area.

The work unit is a multiyear project of the US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC), under general supervision of Dr. James R. Houston, Chief, CERC; Mr. Thomas W. Richardson, Chief, Engineering Development Division; and Dr. Dennis R. Smith, former Chief, Prototype Measurement and Analysis Branch (CD-P). Dr. Charles L. Vincent is CERC Program Manager. Mr. Andrew W. Garcia, CD-P, is the Principal Investigator of the Hurricane Surge Prototype Data Collection work unit, and Mr. William S. Hegge, CD-P, is the engineer in charge of data collection activities. This report was prepared by Messrs. Garcia and Hegge and edited by Ms. Jamie W. Leach, Information Products Division, Information Technology Laboratory, WES.

This report is fourth in a series. Reports 1-3 provided similar data on Hurricanes Chris, Alicia, and Elena, respectively.

Commander and Director of WES during report publication was COL Dwayne G. Lee, CE. Technical Director was Dr. Robert W. Whalin.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
knots (international)	0.5144444	metres per second
miles (US statute)	1.609347	kilometres
millibars	100.0000	pascals

HURRICANE DANNY STORM SURGE AND WAVE DATA

PART I: INTRODUCTION

1. This report is the fourth in a series* providing a data base directed toward verification of numerical storm surge models. As such, the emphasis is on quantitative measurements of the hydrodynamic and meteorologic parameters of Hurricane Danny rather than on documentation of structural damage or changes in coastal morphology. The wave data contained in Part IV were obtained by a US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC), wave gage located on Shell Oil Company Platform Vermilion 22 located at latitude 29°28.2' N, longitude 92°33.0' W. The eye of Danny passed very near Vermilion 22, resulting in a rare opportunity to acquire locally generated hurricane wave data. These data are included to permit assessment and verification of hurricane-generated wave models.

2. Contained herein are coastal and inland hydrographs and basic meteorological data associated with Hurricane Danny. These data have been compiled from a variety of sources; consequently, they cannot be guaranteed to be absolutely accurate. Nevertheless, every reasonable effort has been made to ensure the data are as consistent and complete as possible.

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* Thomas H. Flor. 1983 (Jul). "Poststorm Reconnaissance of Tropical Storm Chris," Miscellaneous Paper HL-83-5, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Andrew W. Garcia and Thomas H. Flor. 1984 (Nov). "Hurricane Alicia Storm Surge and Wave Data," Technical Report CERC-84-6, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Andrew W. Garcia and William S. Hegge. 1987. "Hurricane Elena Storm Surge Data," Technical Report CERC-87-10, Report 3, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

PART II: METEOROLOGICAL DISCUSSION

3. Hurricane Danny was identified as a poorly defined tropical depression on 12 August 1985 while located just south of the western tip of Cuba.* The minimum central pressure at the time was a relatively high 1010 mb.** During the next 24 hr, the central pressure increased slightly to 1011 mb., and the system showed little change in organization or strength. By the morning of 14 August, the depression had passed through the Yucatan Straits into the Gulf of Mexico. The central pressure began dropping, and the winds rapidly increased to tropical storm speed of 35 knots. During the following 24 hr, the storm intensified very rapidly, reaching hurricane intensity early on the morning of 15 August 1985. Danny was then located about 225 miles south of New Orleans, La., moving toward Port Arthur, Tex. During the day, the hurricane assumed a more northerly course and made landfall late during the evening of 15 August 1985, just east of Grand Chenier, La.

4. Danny was classified as a minimal hurricane, a Category 1 on the Saffir-Simpson scale, which ranges from a minimum of 1 to a maximum of 5. The hurricane attained its greatest intensity at the time of landfall with maximum sustained winds of about 90 mph and a minimum central pressure of 987 mb. Danny weakened rapidly after moving inland across Louisiana and within 20 hr had weakened to a tropical depression. An unusual feature of Danny's movement through the Gulf of Mexico was the remarkably constant speed of translation during the 2 days prior to landfall. From 1200 Greenwich mean time (Gmt) 13 August to 1200 Gmt 15 August, 12-hr averages of Danny's forward speed ranged from 13.2 mph to 14.2 mph. The distances traversed during four 12-hr intervals beginning at 1200 Gmt 13 August were 170, 159, 158, and 160 statute miles. Average speeds for these distances were 14.2, 13.2, 13.2, and 13.3 mph, respectively. Figure 1 shows the approximate track of Danny. Table 1 contains the preliminary best-track information.

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* The meteorological discussion and information contained in Table 1 are taken from the preliminary report on Hurricane Danny provided by the National Hurricane Center.

** A table of factors for converting non-SI units of measurement to metric (SI) is presented on page 3.

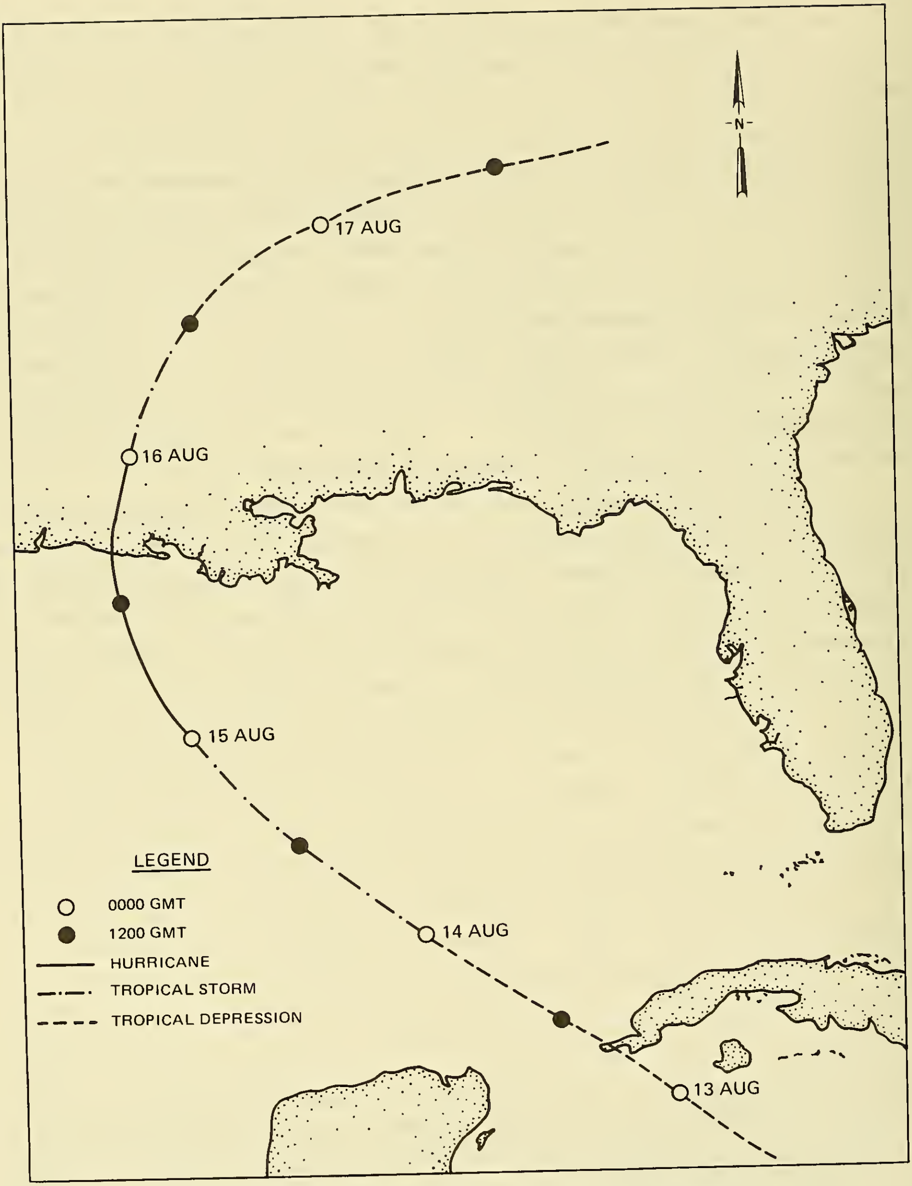


Figure 1. Approximate track of Hurricane Danny.

Table 1

Preliminary Best Track - Hurricane Danny

12-20 August 1985

Date	Time Gmt	Position, deg Latitude	Longitude	Pressure mb	Wind knots	Stage
8/12	0000	18.5	80.7	1010	25	Tropical depression
8/12	0600	19.2	81.4	1010	25	↓
8/12	1200	19.9	82.1	1010	25	
8/12	1800	20.5	82.9	1011	25	
8/13	0000	21.1	83.7	1011	25	
8/13	0600	21.7	84.6	1011	25	
8/13	1200	22.3	85.6	1011	30	
8/13	1800	23.0	86.7	1011	30	
8/14	0000	23.7	87.8	1010	35	Tropical storm
8/14	0600	24.4	88.8	1007	45	Tropical storm
8/14	1200	25.1	89.8	1004	50	Tropical storm
8/14	1800	25.9	90.7	1001	60	Tropical storm
8/15	0000	26.8	91.5	997	70	Hurricane
8/15	0600	27.8	92.2	995	75	Hurricane
8/15	1200	28.9	92.6	988	80	Hurricane
8/15	1800	30.0	92.7	988	70	Hurricane
8/16	0000	31.0	92.4	992	50	Tropical storm
8/16	0600	32.0	92.0	997	40	Tropical storm
8/16	1200	32.9	91.4	1000	30	Tropical depression
8/16	1800	33.7	90.4	1002	30	↓
8/17	0000	34.3	89.2	1004	30	
8/17	0600	34.7	87.8	1006	30	
8/17	1200	35.0	86.3	1008	30	
8/17	1800	35.3	94.8	1010	30	
8/18	0000	35.6	83.4	1011	25	
8/18	0600	35.8	82.0	1011	25	
8/18	1200	36.0	80.6	1012	25	
8/18	1800	36.3	79.2	1012	25	
8/19	0000	36.7	77.9	1012	25	Extratropical
8/19	0600	37.1	76.6	1012	25	↓
8/19	1200	37.5	75.3	1012	25	
8/19	1800	38.0	74.0	1013	25	
8/20	0000	38.5	72.7	1013	20	
8/20	0600	39.1	71.5	1014	20	
8/20	1200	39.7	70.4	1014	20	
8/20	1800	40.4	69.4	1014	20	
			Minimum Pressure			
8/15	1620	29.6	92.7	987	80	Hurricane
			Landfall			
8/15	1630	29.6	92.7	987	80	Hurricane

PART III: HYDROGRAPHIC DATA

5. The impact of the storm surge generated by Danny was minimal due to the relatively low intensity of the hurricane and landfall being in a remote and sparsely populated area of the Louisiana coastline. Moreover, much of the reach of coastline affected by Danny is shallow swampland which tended to dissipate the surge before it reached populated areas. Figures 2-4 show the locations of hydrographs covering the reach of coastline from Cameron, La., to the Rigolets near Slidell, La. Table 2 is the index to the tide gage locations. The hydrographs are contained in Plates 1-20. Table 3 is a listing of the maximum water elevations recorded at each hydrograph location.

6. Significant increases in water levels associated with the storm were confined to approximately 60 miles of coastline extending westward from Atchafalaya Bay to Pecan Island, La. These increases are evident in Plates 3-10, all of which were obtained within the previous reach of coastline. The highest water level recorded was 7.7 ft, relative to NGVD, which occurred at Lukes Landing just north of Point Chevreuil, La. (Plate 7). Other high-water levels were recorded at Vermilion Lock, east (7.1 ft, Plate 5), Freshwater Bayou Lock (6.7 ft, Plate 3), and Atchafalaya Bay, Eugene Island (6.7 ft, Plate 9).

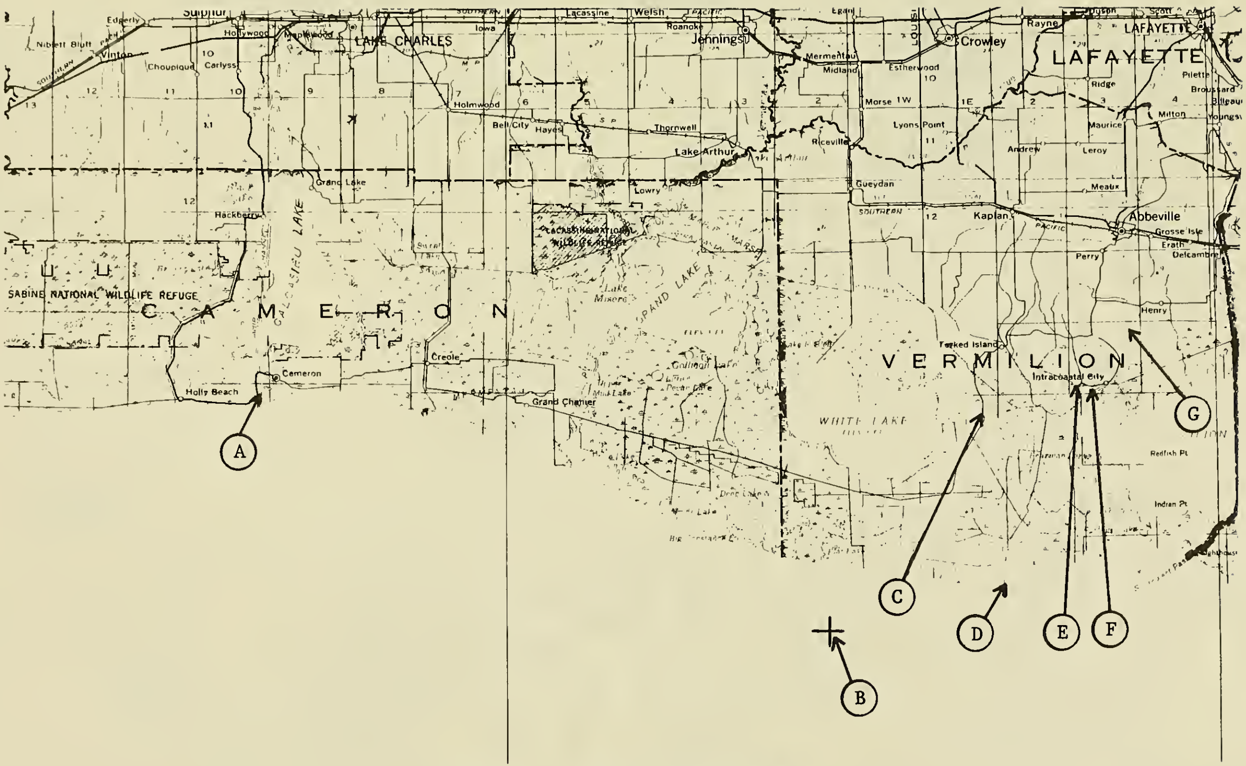


Figure 2. Gaging locations A-G

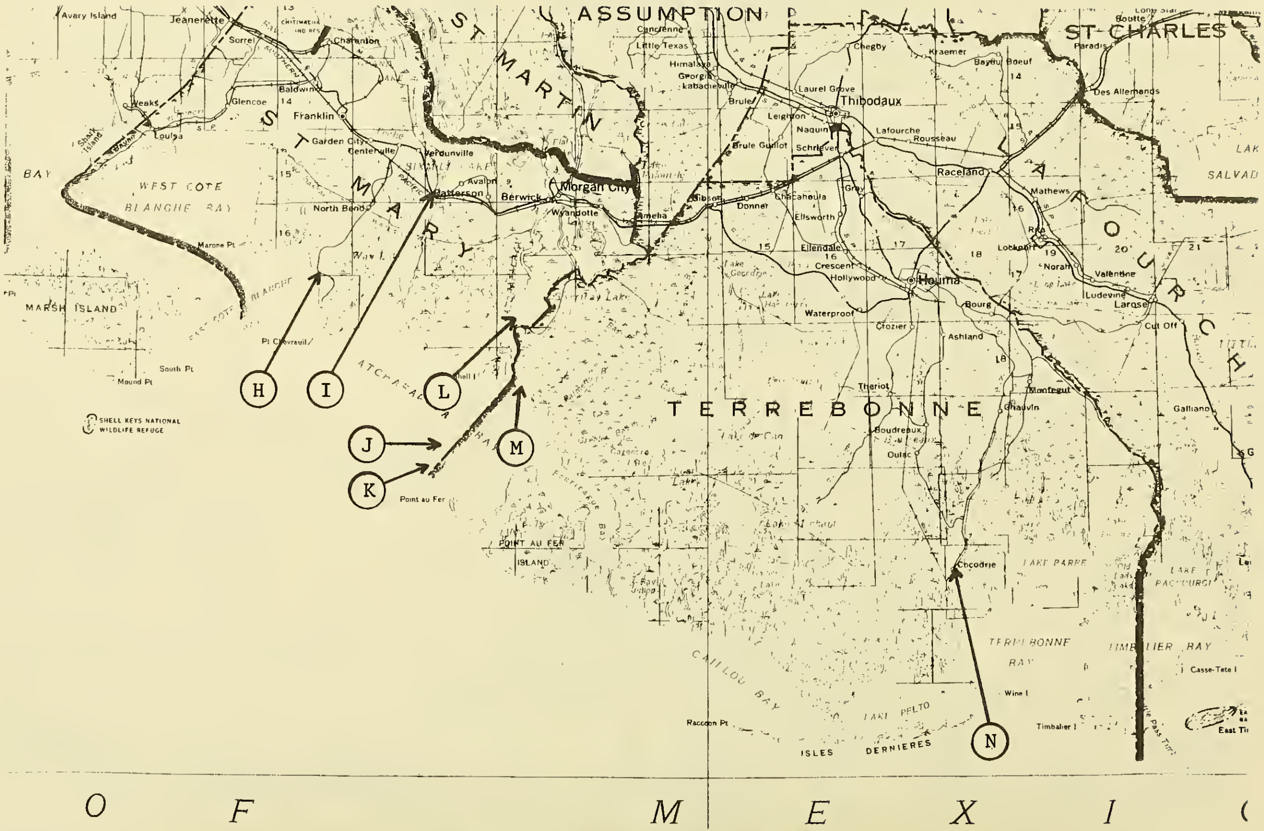


Figure 3. Gaging locations H–N

Figure 4. Gaging locations O-U

Table 2

Index to Tide Gage Locations

Figure No.	Location	Gage Title
2	A	Calcasieu Pass, La.
2	B	Vermilion 22 platform, La.
2	C	Schooner Bayou control structure, La.
2	D	Freshwater Bayou Lock (South), La.
2	E	Vermilion Lock (West), La.
2	F	Vermilion Lock (East), La.
2	G	Vermilion River, at Bancker, La.
3	H	Lukes Landing, La.
3	I	Calumet, La.
3	J	Atchafalaya Bay, Eugene Island, La.
3	K	Eugene Island, N-62, La.
3	L	Sweet Bay Lake, La.
3	M	Round Bayou at Deer Island, La.
3	N	Bayou Petit Caillou at Cocodrie, La.
4	O	Bayou Lafourche at Leeville, La.
4	P	Grand Isle, La.
4	Q	Venice, La.
4	R	Southwest Pass, La.
4	S	Head of Passes, La.
4	T	Port Eads, La.
4	U	Lake Borgne at Rigolets, La.

Table 3

Times and Heights of Maximum Elevations

Location	Max. Water Elev., ft	Time, CDT/Date	Datum	Source
Calcasieu Pass, La.	2.8	0630/15/08/85	NGVD	CE
Grand Chenier, La.	3.1	Unknown	NGVD	CE
Schooner Bayou Control Structure, La.	5.8	1600/15/08/85	NGVD	CE
Freshwater Bayou Lock (South), La.*	6.7	1230/15/08/85	NGVD	CE
Vermilion Lock (West), La.	2.6	1800/15/08/85	NGVD	CE
Vermilion Lock (East), La.	7.1	1400/15/08/85	NGVD	CE
Vermilion River at Bancker, La.	5.8	1700/15/08/85	NGVD	CE
Lukes Landing, La.*	7.7	1000/15/08/85	NGVD	CE
Calumet, La.	6.1	1200/15/08/85	NGVD	CE
Atchafalaya Bay, Eugene Island	6.7	1000/15/08/85	NGVD	CE
Eugene Island, N-62	5.8	1100/15/08/85	NGVD	CE
Sweet Bay Lake, La.	5.8	1230/15/08/85	NGVD	CE
Round Bayou at Deer Island, La.	6.2	1230/15/08/85	NGVD	CE
Bayou Petit Caillou at Cocodrie, La.	5.3	1000/15/08/85	NGVD	CE
Bayou Lafourche at Leeville, La.	3.8	1300/15/08/85	NGVD	CE
Grand Isle, La.	3.8	0830/15/08/85	NGVD	NOS
Venice, La.	3.9	1000/15/08/85	NGVD	CE
Southwest Pass, La.	4.0	0830/15/08/85	NGVD	CE
Head of Passes, La.	2.8	0900/15/08/85	NGVE	CE
Port Eads, La.	3.0	0900/15/08/85	NGVD	CE
Lake Borgne at Rigolets, La.	4.1	1130/15/08/85	NGVD	CE

Note: CDT = Central Daylight Time.
NGVD = National Geodetic Vertical Datum.
CE = Corps of Engineers.
NOS = National Ocean Service.
* Incomplete record.

PART IV: WAVE DATA

7. Wave and tide gages on the Shell Oil Company platform, Vermilion 22, were being operated by CERC during Danny's passage through the Gulf of Mexico. The location of Vermilion 22 latitude is 29°28.2' N, longitude 92°33.0' W, and the water depth is about 9 m. At the point of closest approach, the eye of Danny was within 10 miles of Vermilion 22. Figure 5 is the hydrograph of observed and predicted tides at the location of Vermilion 22. Figure 6 is a plot of observed minus predicted water levels.

8. Wave measurements were made using a self-contained, internal-recording pressure gage. The wave data were spectrally processed via a Fast Fourier Transform algorithm and corrected for depth attenuation effects according to linear wave theory. Figure 7 is a plot of the significant wave height for 13-17 August 1986, corresponding to the approximate time of passage of Danny. The greatest significant wave height occurring during Danny's passage was 9.71 ft with a period at the spectral peak of 9.5 sec. Appendix A contains plots of the wave spectra observed at 1030 on 14 August 1985 to 1030 on 16 August 1985. The spectra contained in Figures A2-A13 are characteristic of the evolution of a storm-generated sea state.

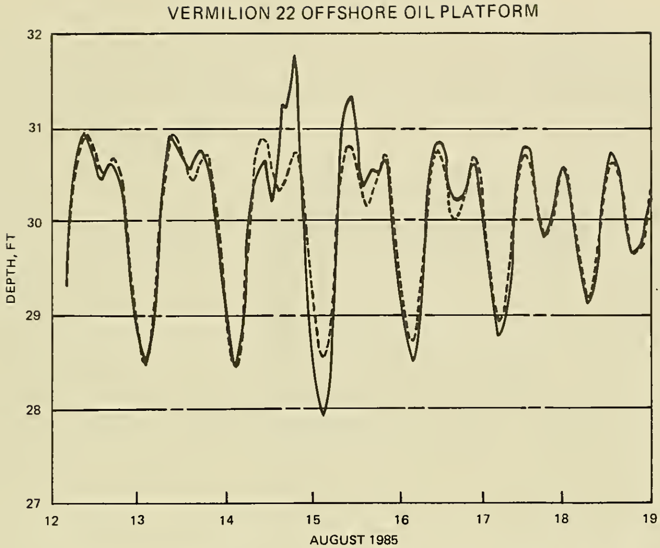


Figure 5. Hydrograph, observed and predicted tides, Shell Oil platform, Vermilion 22, La.

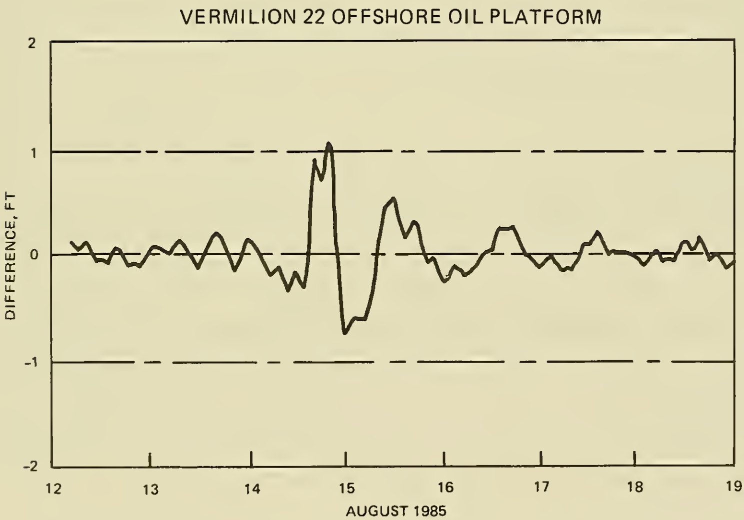


Figure 6. Difference between observed and predicted tides, Shell Oil platform, Vermilion 22, La.

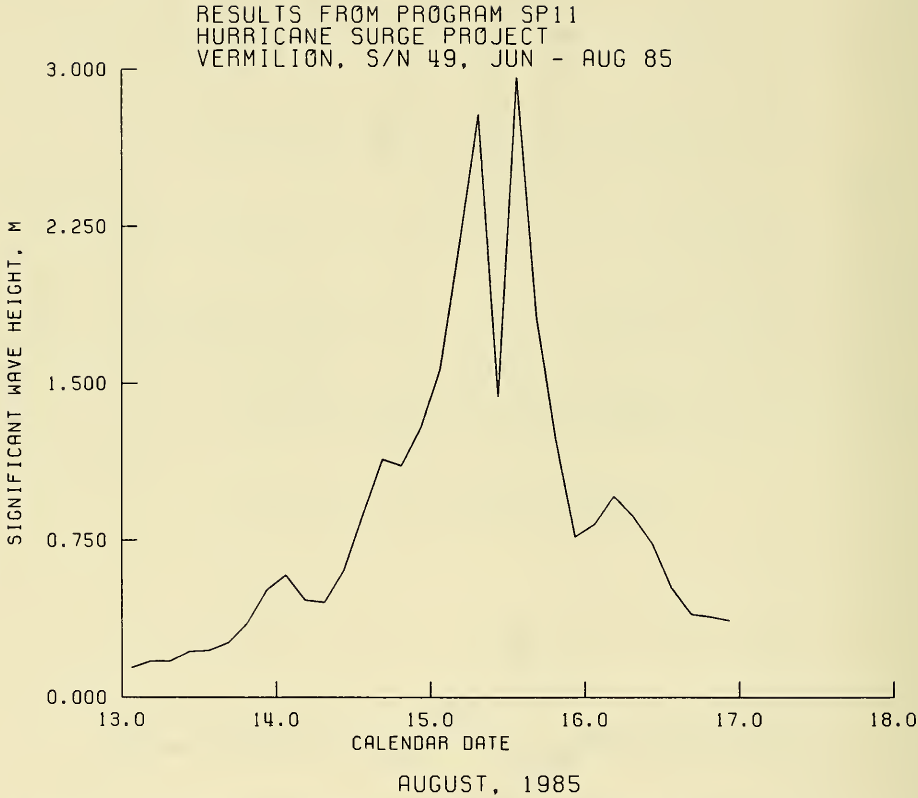


Figure 7. Significant wave height, Shell Oil platform, Vermilion 22, La.

9. The poststorm survey of high-water marks and damage caused by Danny was conducted during 10-17 August 1985. The photos contained herein include both ground-level and aerial views.

10. Wind damage was the most evident sign of the hurricane's passage in the western part of Louisiana. Photo 1 shows metal sheeting stripped from the sides and roof of the Crain Brothers building at Grand Chenier, La. Just east of Grand Chenier, near Pecan Island, La., utility poles lay on the ground alongside the road (Photo 2). Just north of Pecan Island on Highway 82E, the roof was torn from a mobile home and deposited alongside it (Photo 3).

11. Farther east in Louisiana, there was evidence of surge damage in addition to wind damage. At Intracoastal City, La., a line of debris on a fence indicated the high-water mark was approximately 3 ft above ground level (Photo 4). At the site of the air logistics base just north of town, 1 ft of water was still standing at the time of the survey (Photo 5). There was widespread wind damage in this area, as shown by the collapsed farm equipment shed that was located nearby (Photo 6). Combined wind and surge damage was also evident east of Intracoastal City. In Cypremort Point, La., the metal siding of a boathouse was wind damaged (Photo 7), and a nearby trailer sustained surge damage (Photo 8). The surge was estimated to be about 2 ft above ground level which was enough to tear the metal siding and displace the air conditioning unit on the trailer.

12. The aerial survey of Grand Isle, La., revealed a large amount of flooding, but it is uncertain if the flooding was caused by coastal surge or local rainfall. The most definite evidence of surge was seen on the beaches on the southern side of Grand Isle where debris lines and beach scarps were clearly visible (Photo 9). A closeup of the beach scarp (Photo 10) shows the height of the cut into the beach slope to be 3 to 5 ft above normal tide level.

PART VI: CONCLUSION

13. Hurricane Danny was the second Atlantic and the first landfalling hurricane of the 1985 season. Classed as Category 1 on the Saffir-Simpson scale, it reached maximum intensity just prior to landfall with an estimated maximum windspeed of about 90 mph and observed windspeeds of 70 mph or more in all quadrants. The surge generated by Danny was confined primarily to Vermilion and Atchafalaya Bays. Eastward of Atchafalaya Bay, surge levels exceeded the predicted tide by about a foot or less. However, within Vermilion and Atchafalaya Bays, surge levels as much as 5 ft above the expected astronomical tide were recorded. Surge levels diminished rapidly with distance inland, and the poststorm survey indicated only communities located on the periphery of Vermilion and Atchafalaya Bays to be significantly affected.

14. Wave data acquired at the Vermilion 22 platform during Danny should prove particularly useful for verification of numerical wave models. The close passage of Danny to Vermilion 22 resulted in rapidly varying wave conditions, a particularly severe test of the growth, propagation, and decay algorithms used in wave models.

Photo 1. Damaged metal sheeting on Crain Brothers building, Grand Chenier, La.

Photo 2. Downed utility poles near Pecan Island, La.

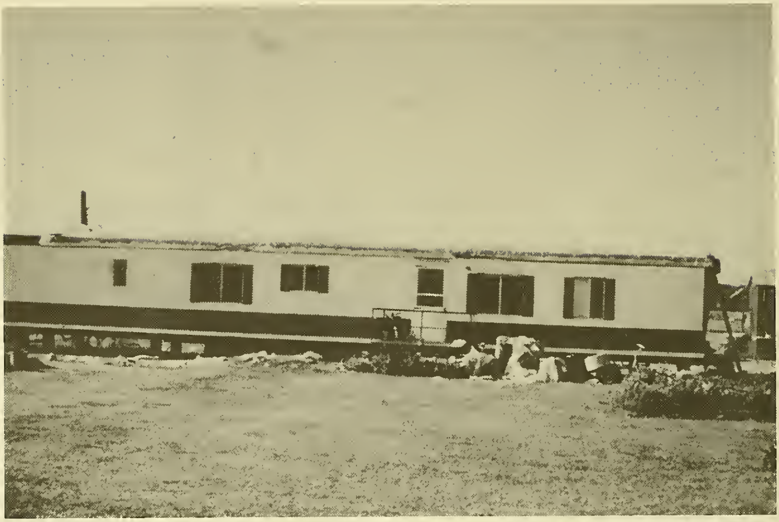


Photo 3. Mobile home roof damage near Pecan Island, La.

Photo 4. Debris line on fence, Intracoastal City, La.

Photo 5. Residual flooding of the air logistics base near Intracoastal City, La.

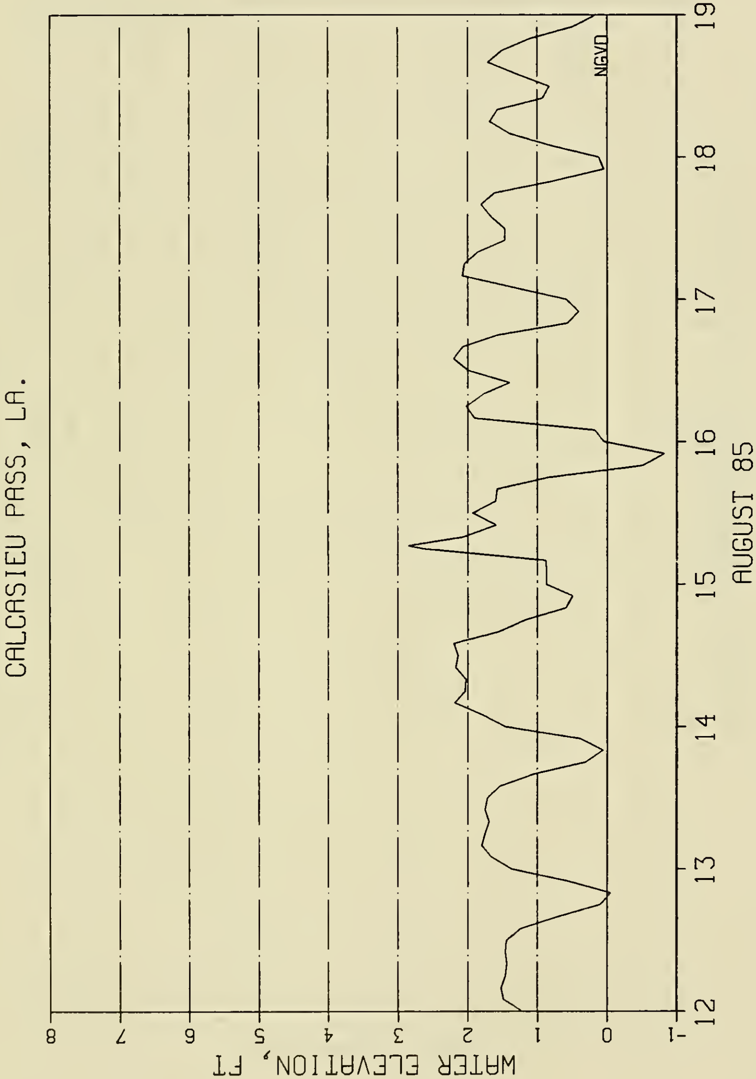
Photo 6. Collapsed farm equipment shed near Intracoastal City, La.

Photo 7. Damaged metal sheeting on a boathouse, Cypremont Point, La.

Photo 8. Surge damage to mobile home, Cypremont Point, La.

Photo 9. Debris line and beach scarp, southern shore of Grand Isle, La.

Photo 10. Beach scarp, southern shore of Grand Isle, La.


CALCASIEU PASS, LA.
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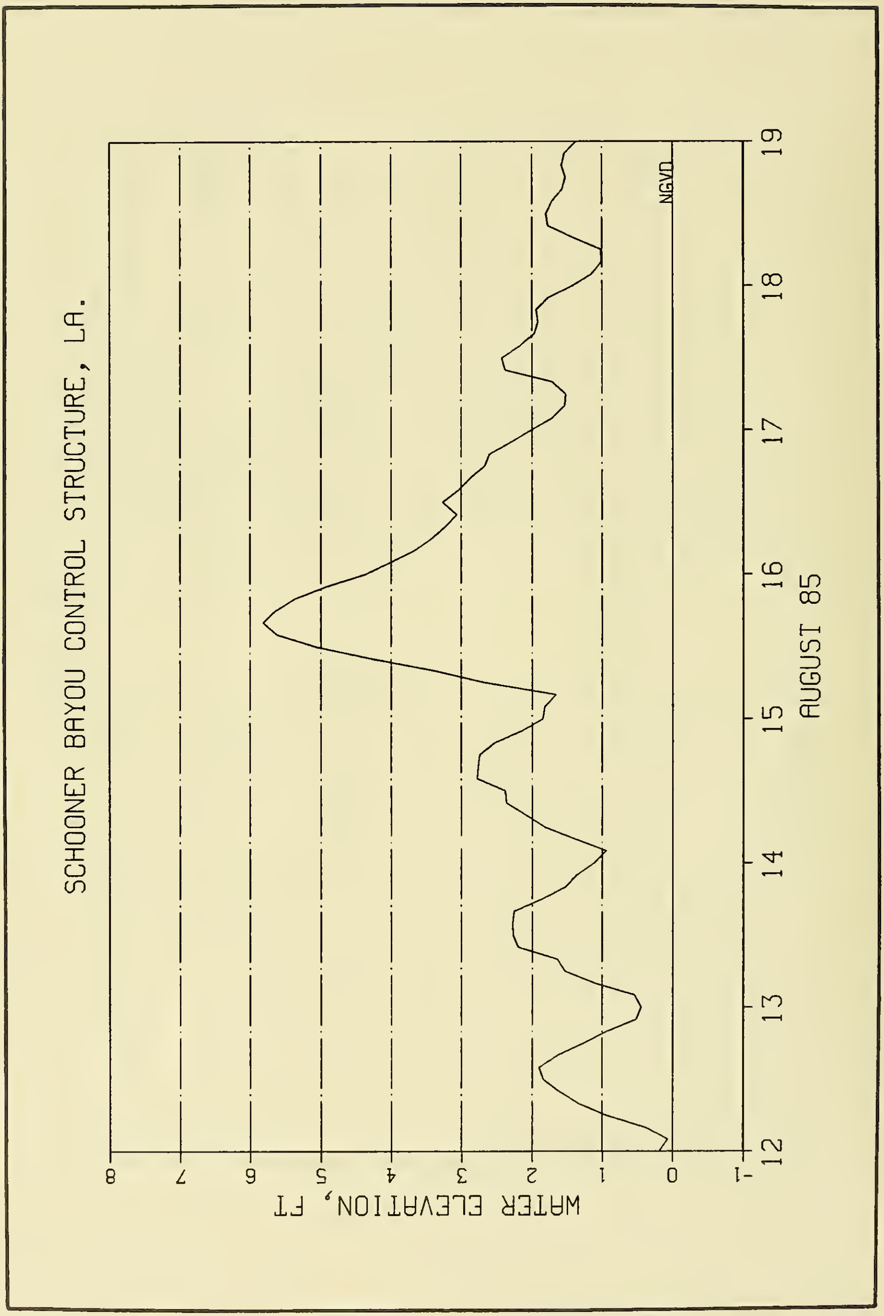

SCHOONER BAYOU CONTROL STRUCTURE, LA.
WATER ELEVATION, FT
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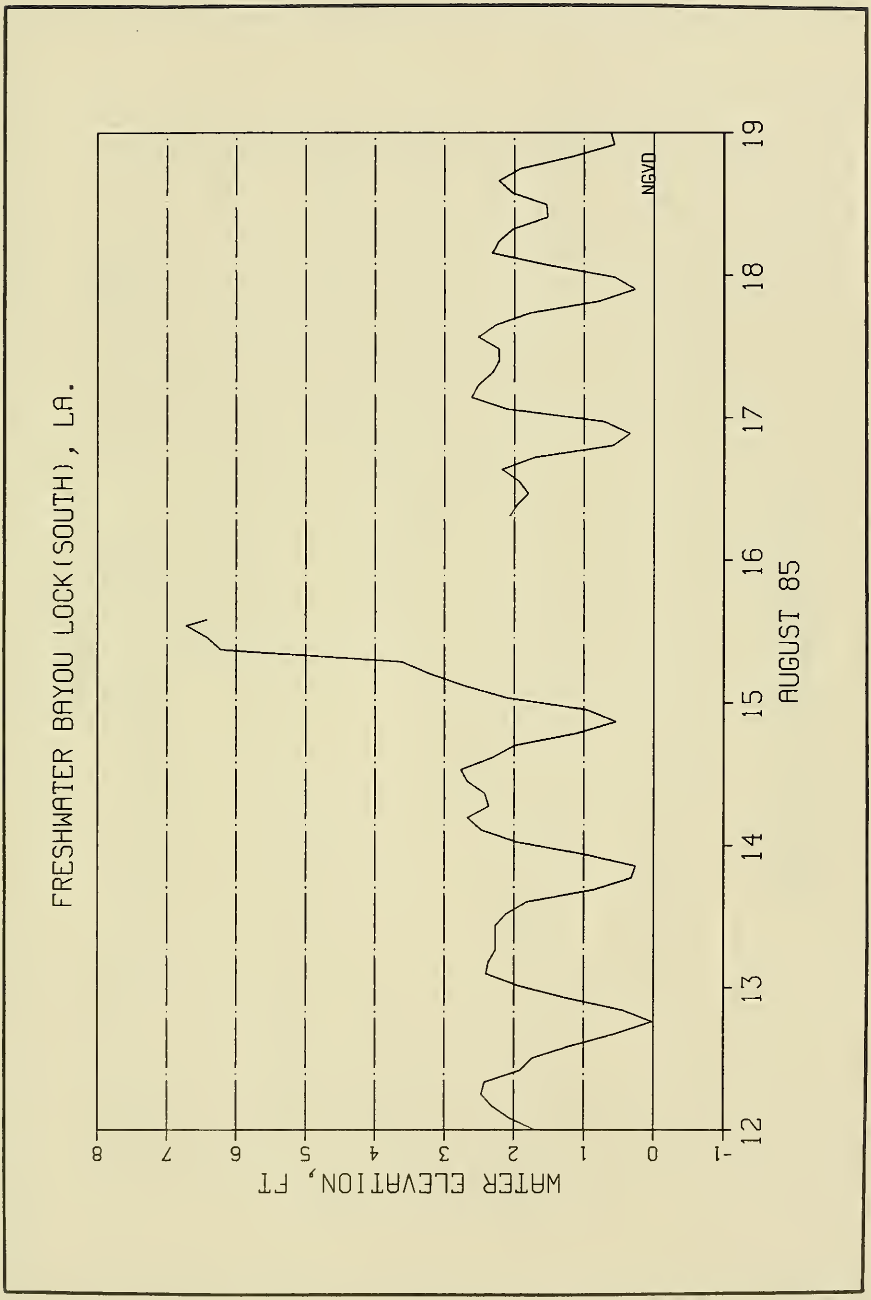
AUGUST 85

PLATE 2



FRESHWATER BAYOU LOCK(SOUTH), LA.
WATER ELEVATION, FT
AUGUST 85
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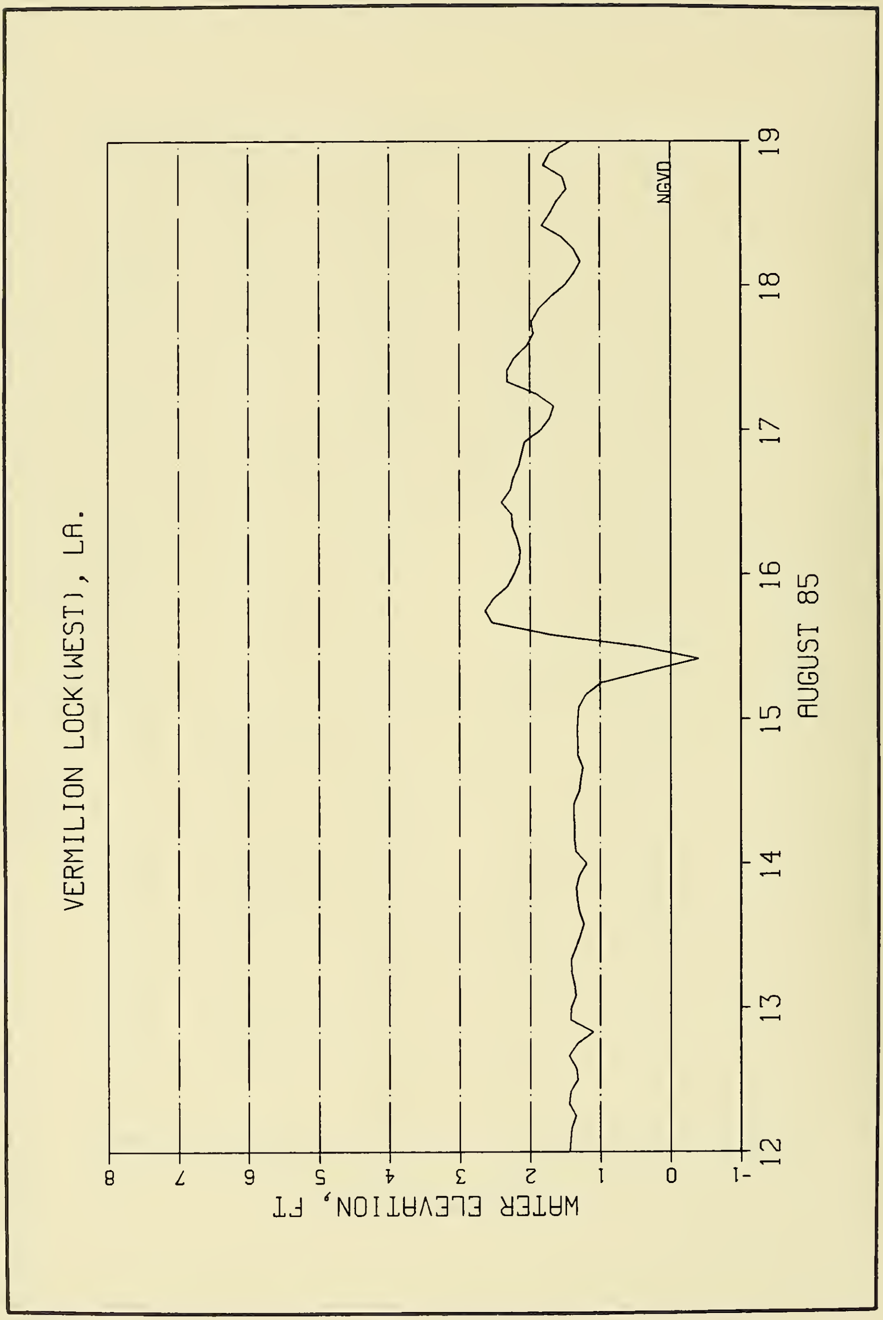
PLATE 3



VERMILION LOCK(WEST), LA.
WATER ELEVATION, FT
-1 0 1 2 3 4 5 6 7 8
NGVD
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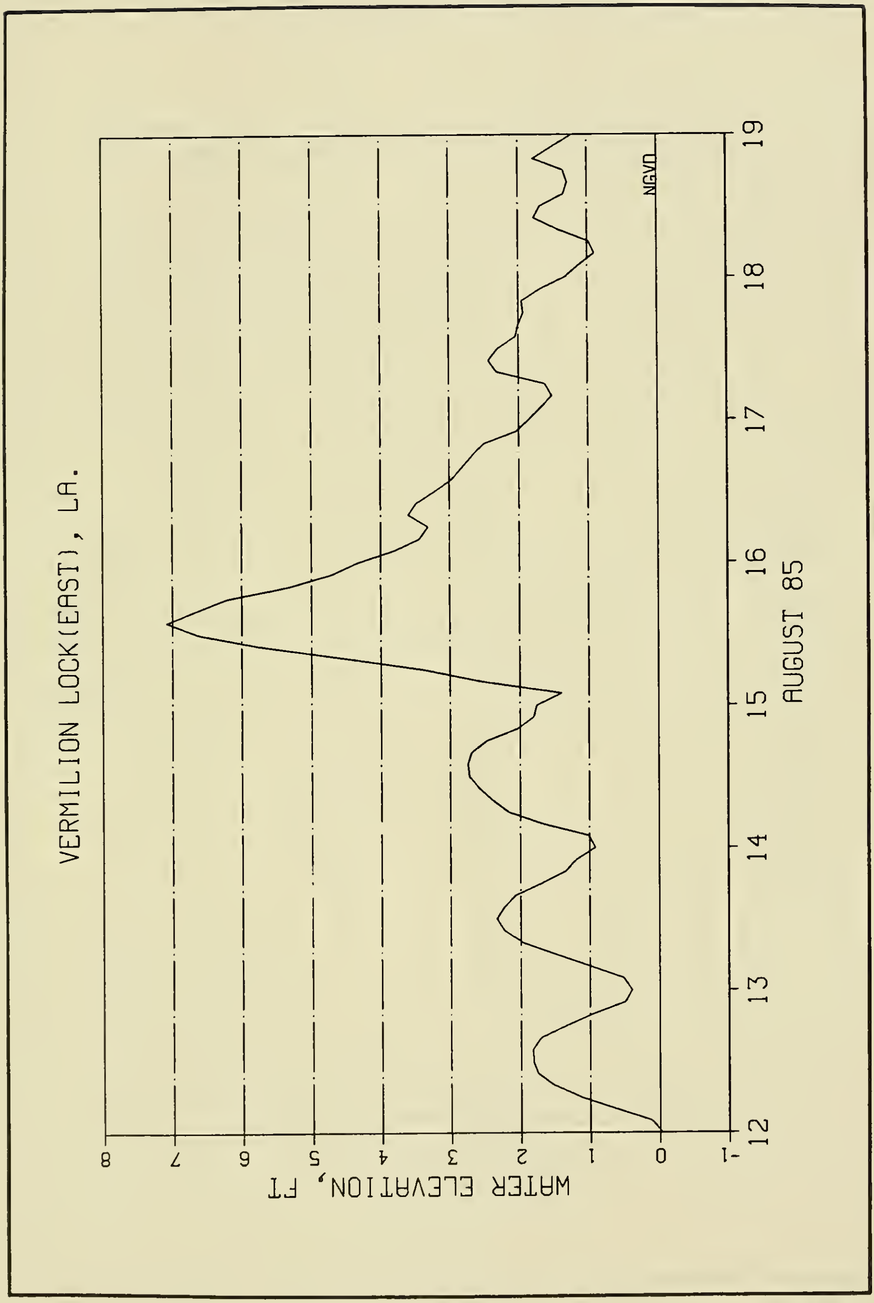
AUGUST 85

PLATE 4


VERMILION LOCK(EAST), LA.
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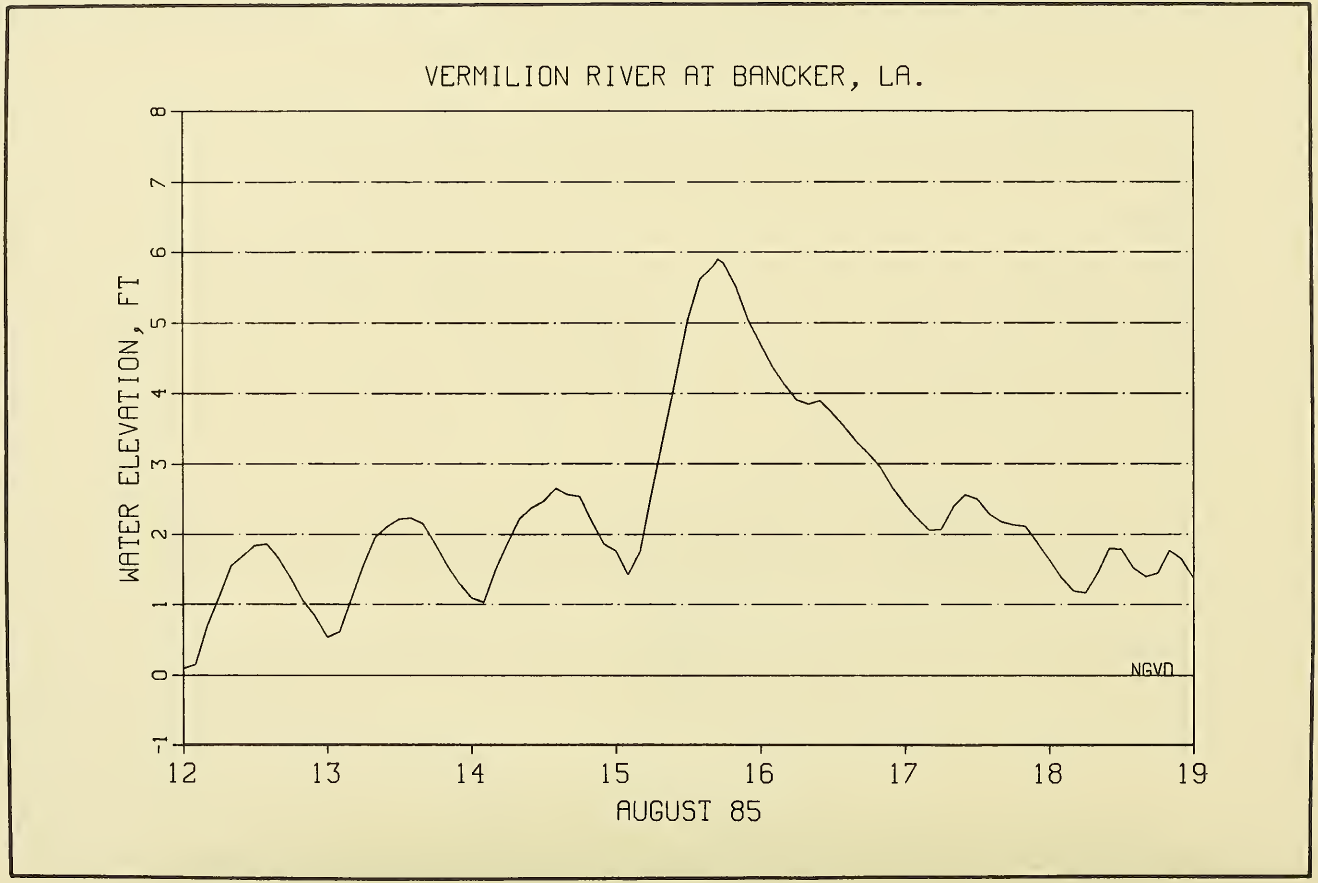

VERMILION RIVER AT BANCKER, LA.
WATER ELEVATION, FT
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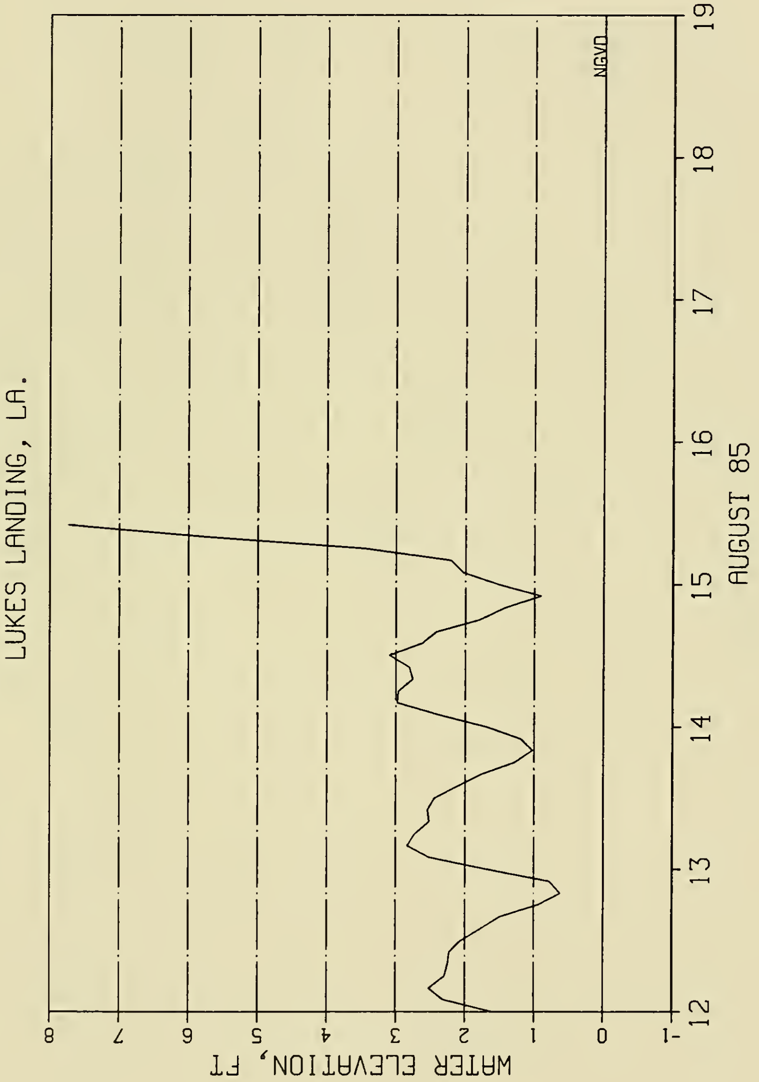
AUGUST 85

PLATE 6


LUKES LANDING, LA.
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CALUMET, LA.
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18
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PLATE 8

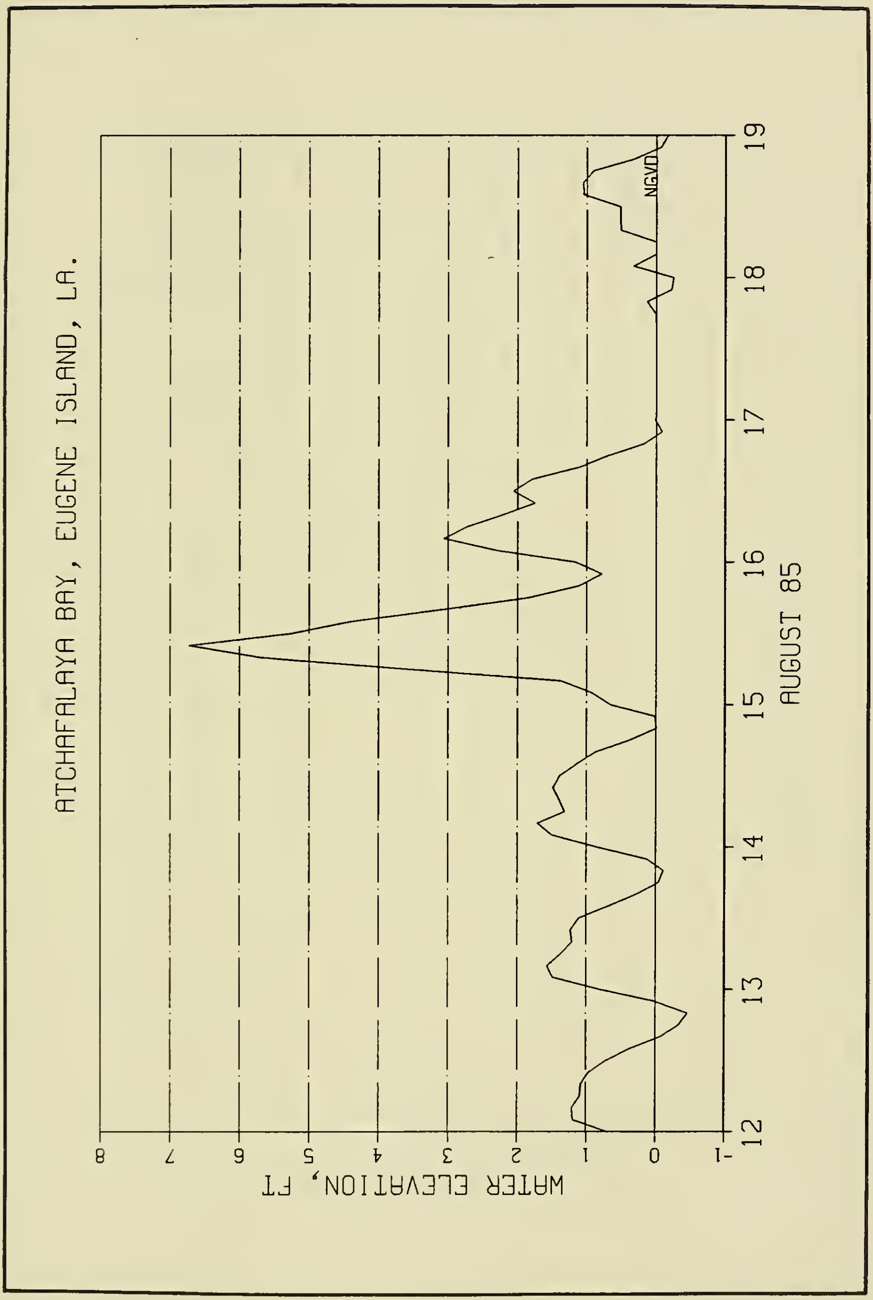

ATCHAFALAYA BAY, EUGENE ISLAND, LA.
WATER ELEVATION, FT
AUGUST 85
NGVD
-1
0
1
2
3
4
5
6
7
8
12
13
14
15
16
17
18
19

PLATE 9

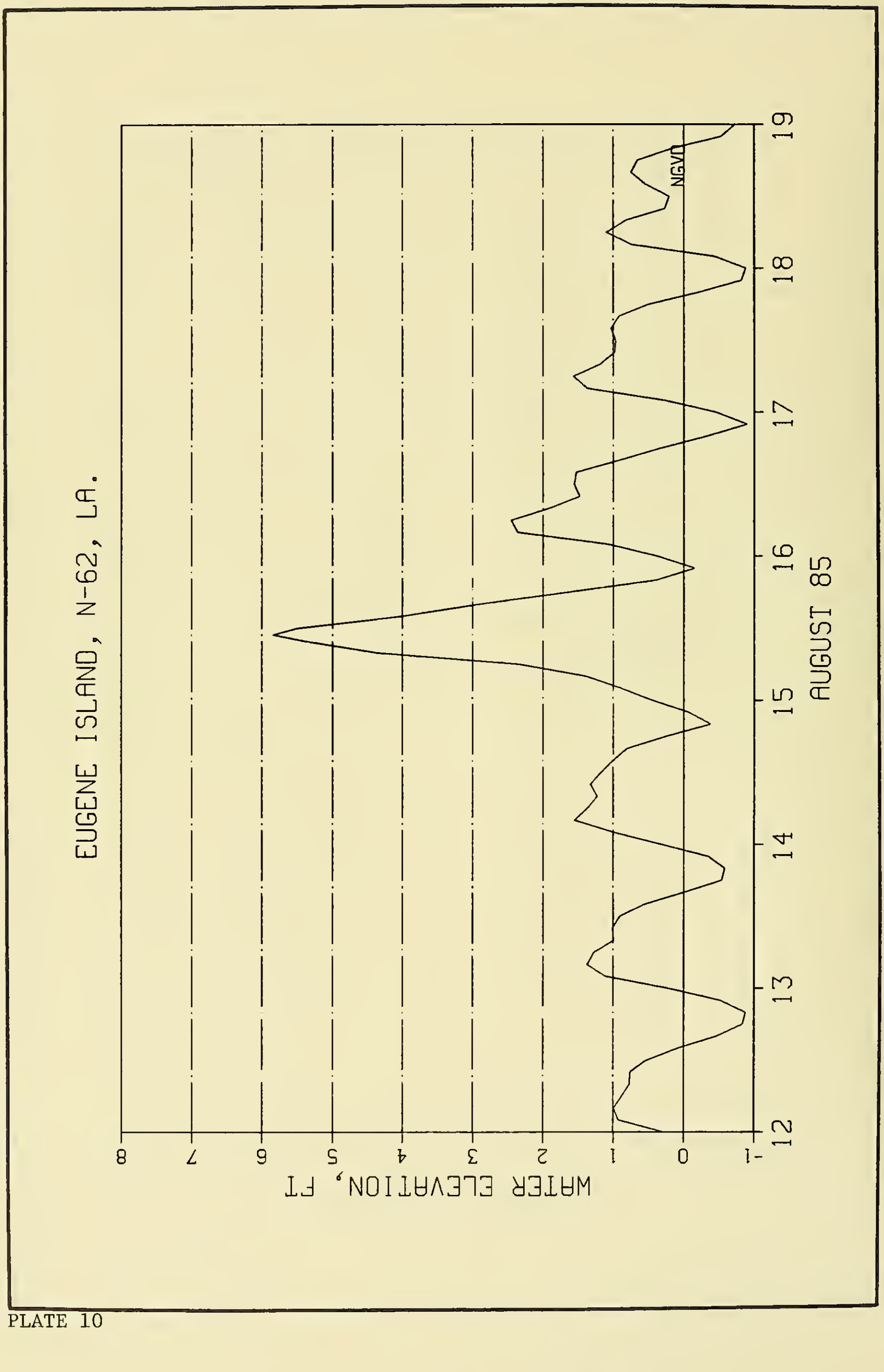

EUGENE ISLAND, N-62, LA.
WATER ELEVATION, FT
AUGUST 85
NGVD
-1
0
1
2
3
4
5
6
7
8
12
13
14
15
16
17
18
19

PLATE 10

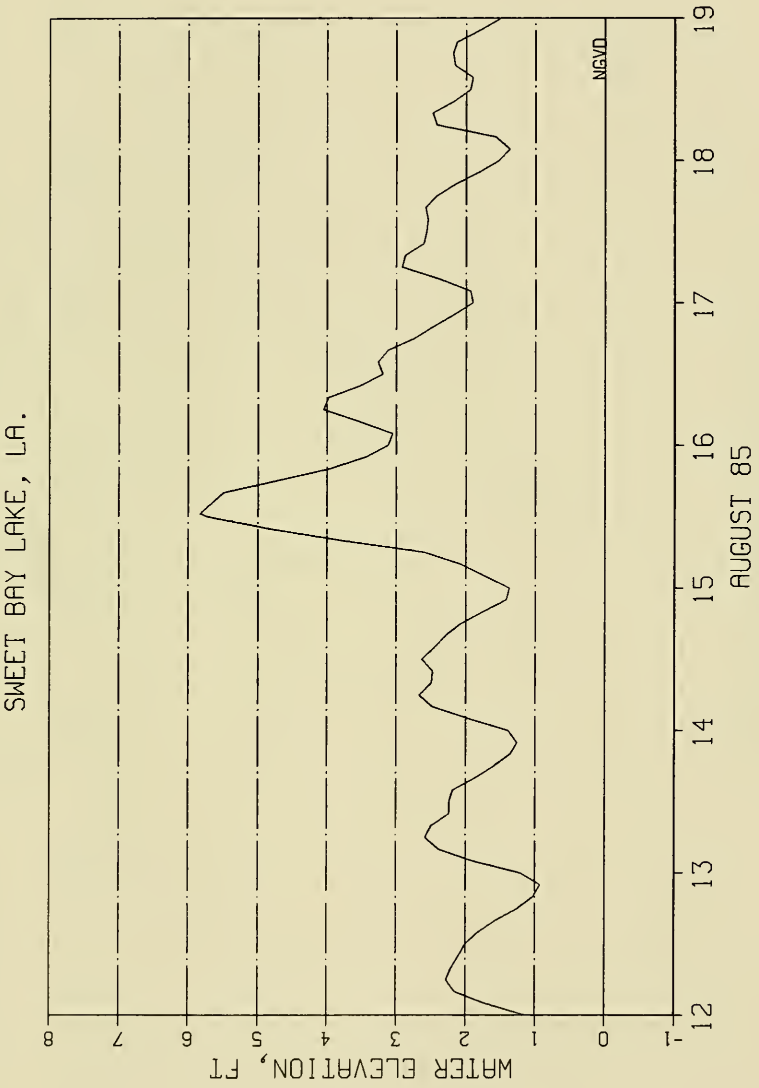

SWEET BAY LAKE, LA.
WATER ELEVATION, FT
AUGUST 85
NGVD
-1
0
1
2
3
4
5
6
7
8
12
13
14
15
16
17
18
19

PLATE 11

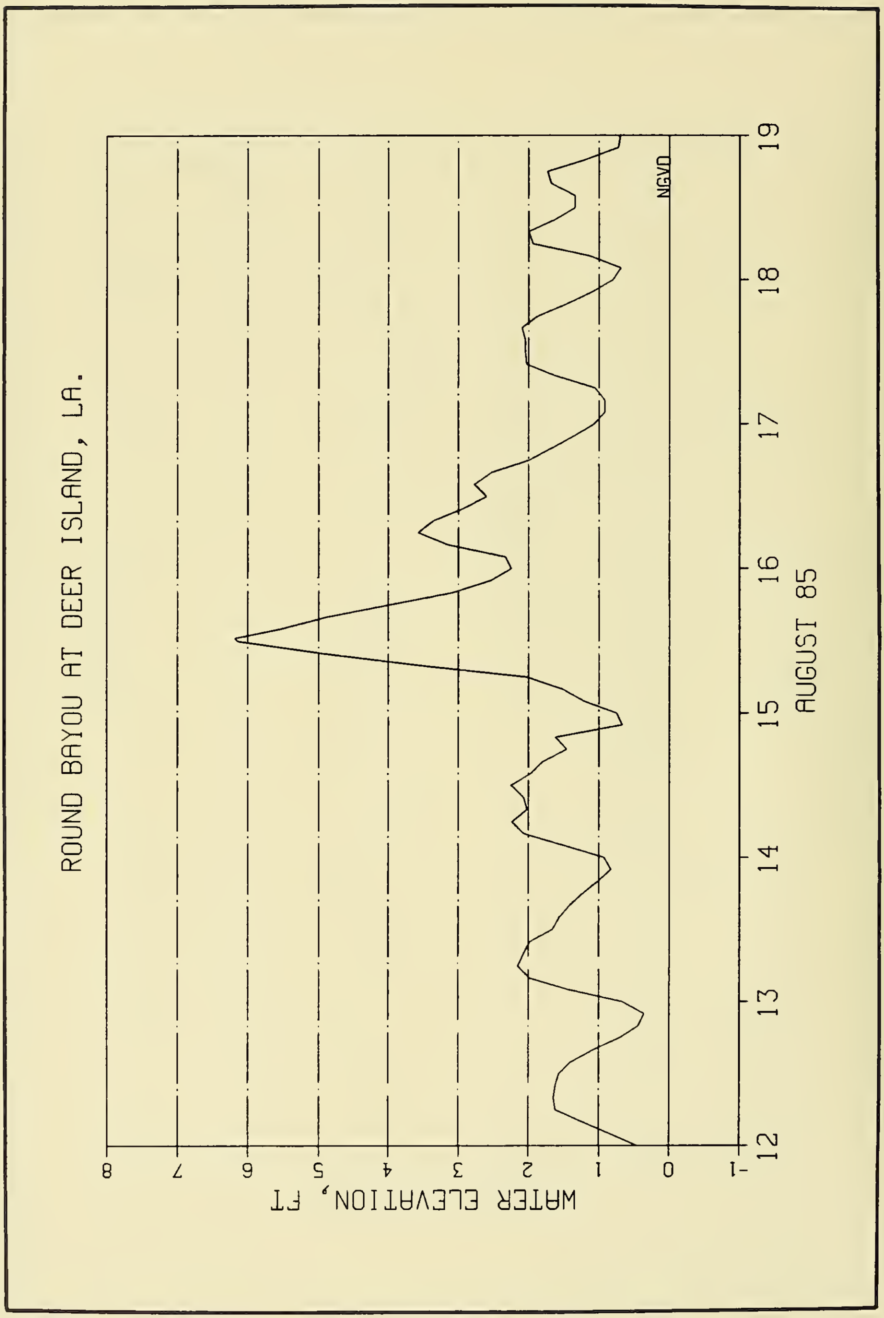
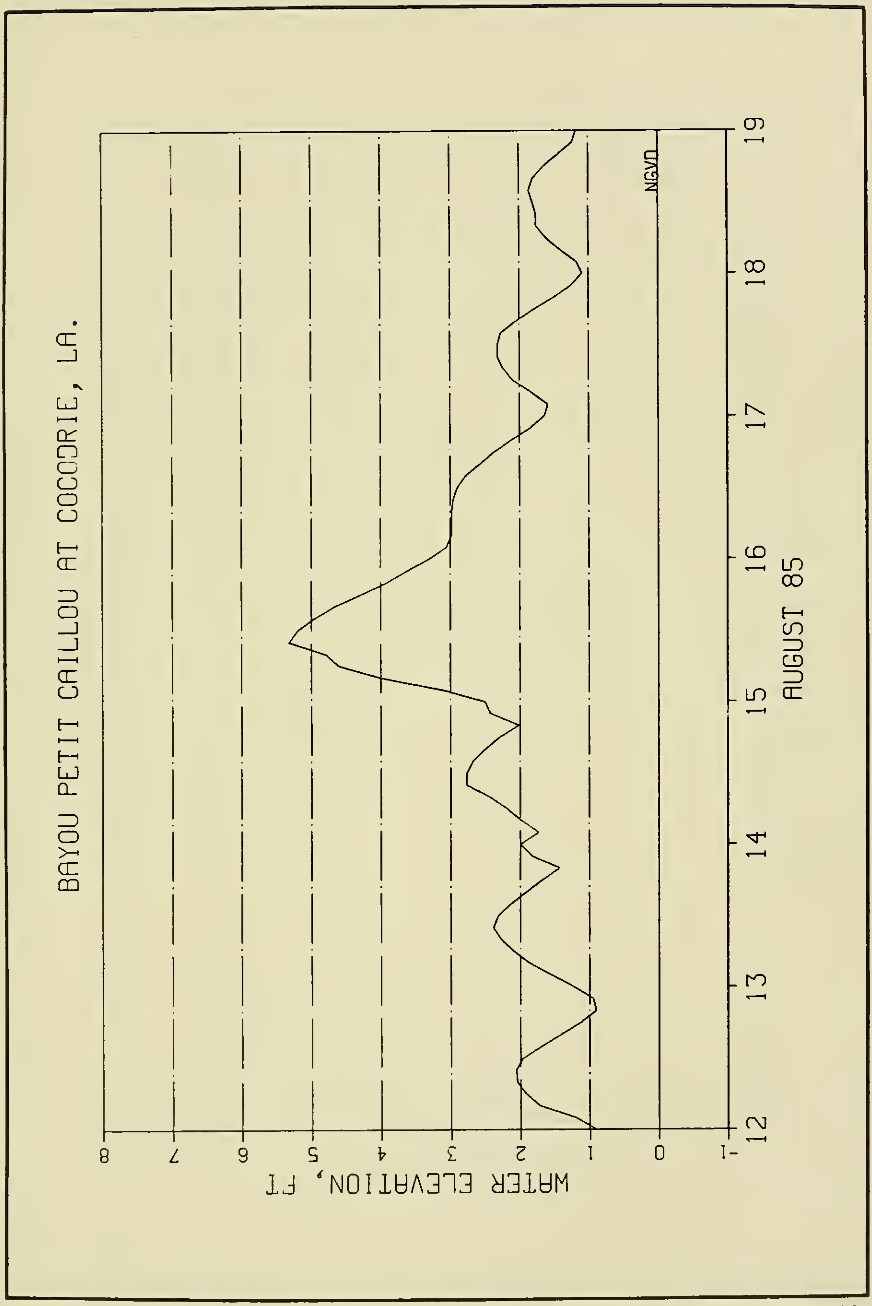

ROUND BAYOU AT DEER ISLAND, LA.
WATER ELEVATION, FT
AUGUST 85
NGVD
-1
0
1
2
3
4
5
6
7
8
12
13
14
15
16
17
18
19

PLATE 12



BAYOU PETIT CAILLOU AT COCODRIE, LA.
WATER ELEVATION, FT
8
7
6
5
4
3
2
1
0
-1
NGVD
12
13
14
15
16
17
18
19
AUGUST 85

PLATE 13

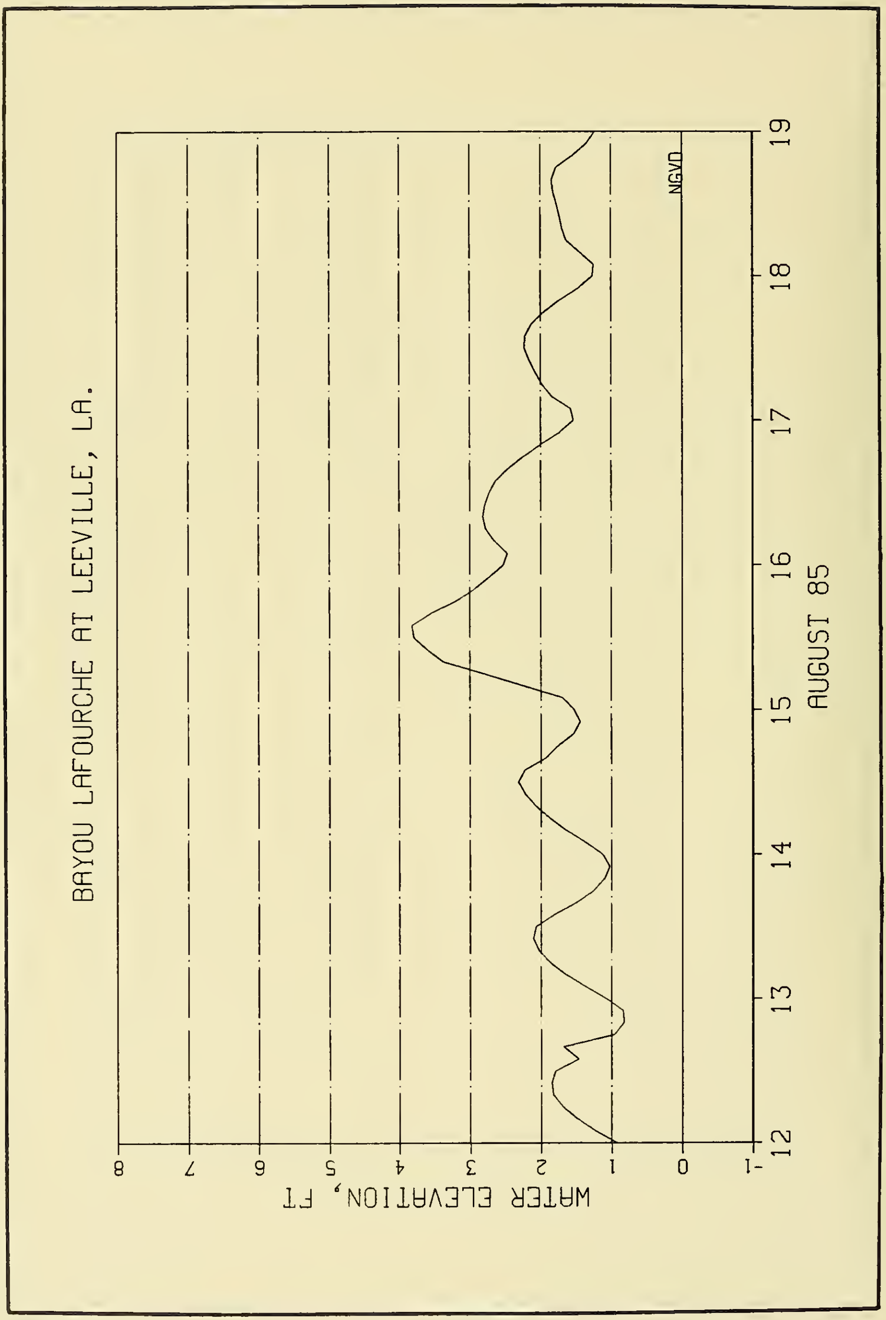

BAYOU LAFOURCHE AT LEEVILLE, LA.
WATER ELEVATION, FT
8
7
6
5
4
3
2
1
0
-1
NGVD
12
13
14
15
16
17
18
19
AUGUST 85

PLATE 14

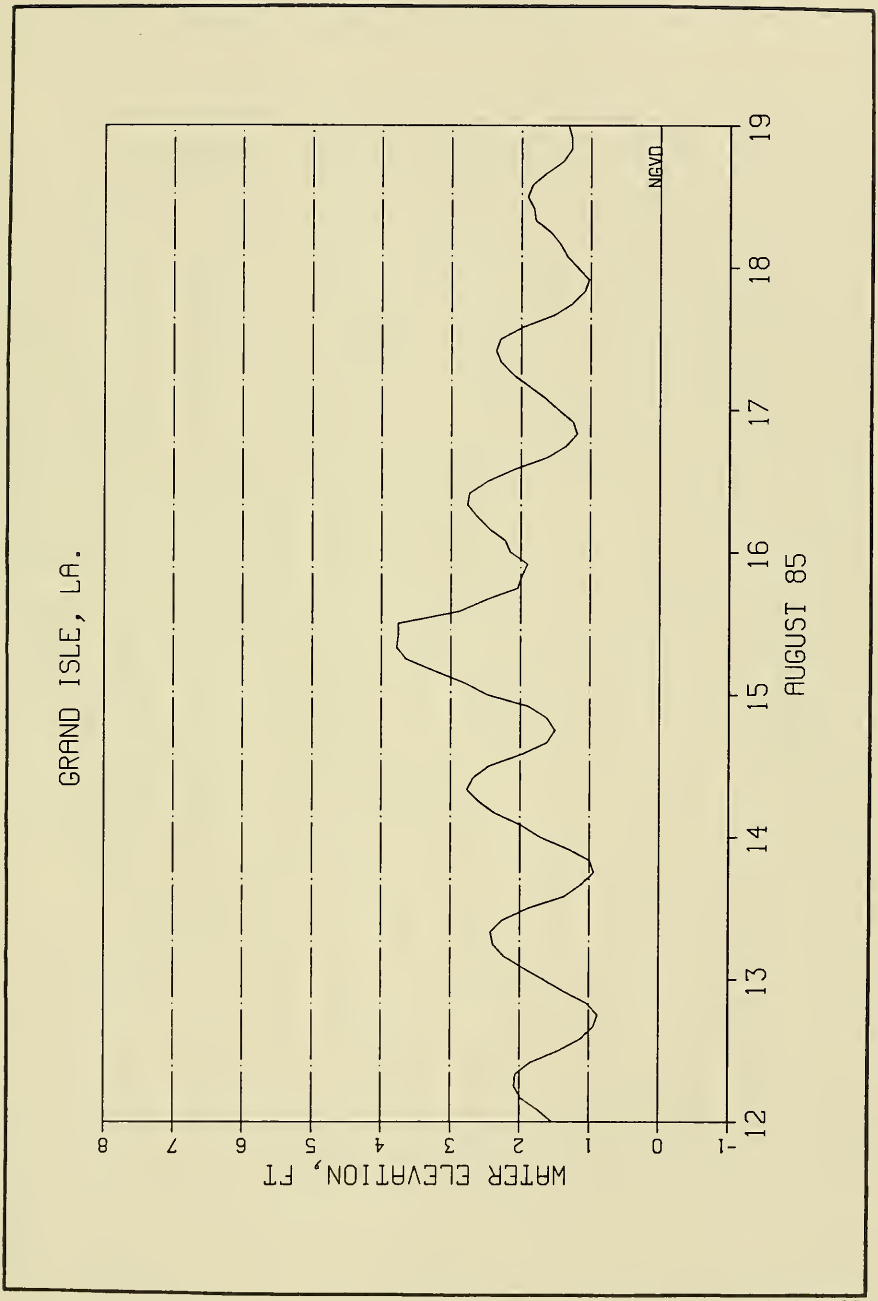
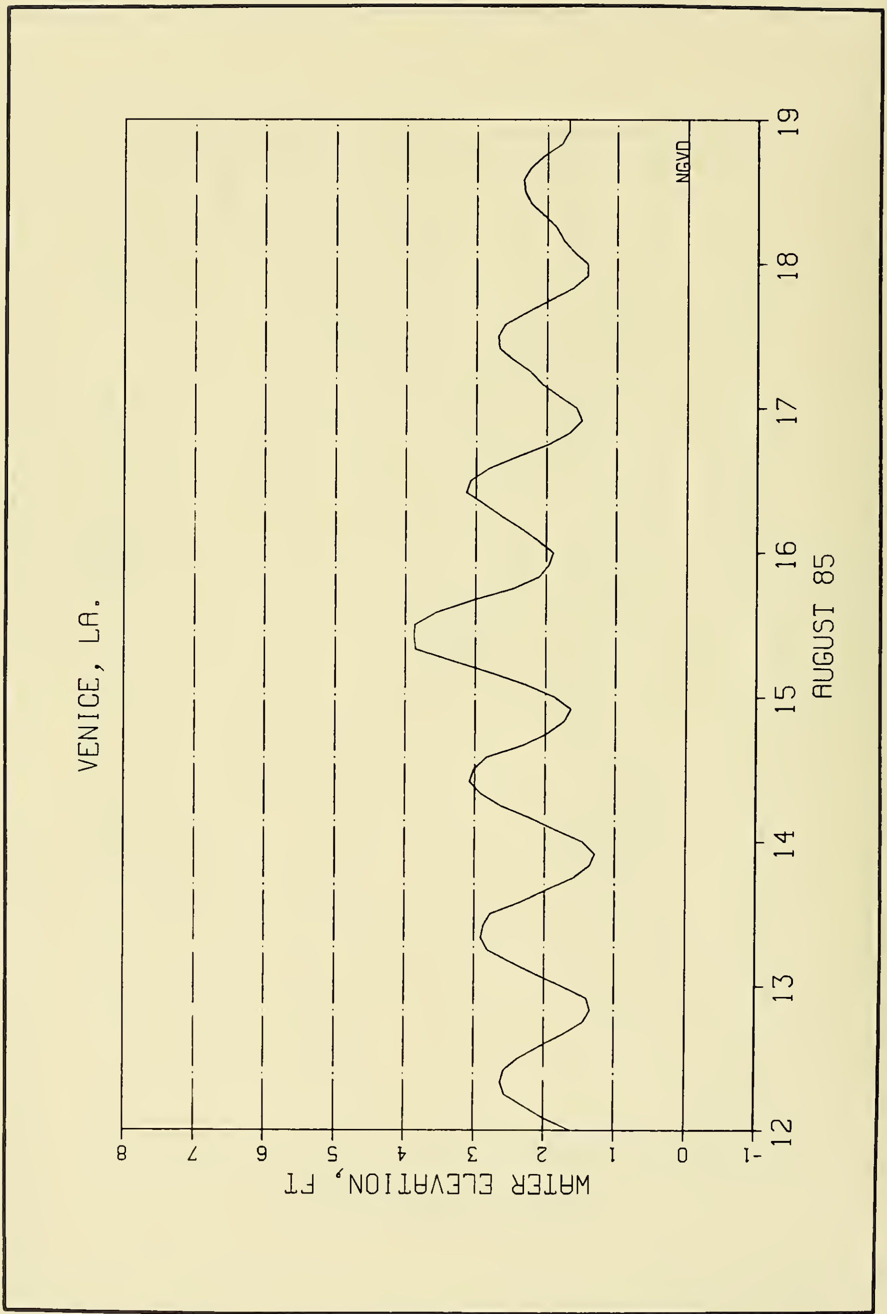

GRAND ISLE, LA.
WATER ELEVATION, FT
AUGUST 85
NGVD
-1
0
1
2
3
4
5
6
7
8
12
13
14
15
16
17
18
19

PLATE 15



VENICE, LA.
WATER ELEVATION, FT
-1
0
1
2
3
4
5
6
7
8
NGVD
12
13
14
15
16
17
18
19
AUGUST 85

PLATE 16

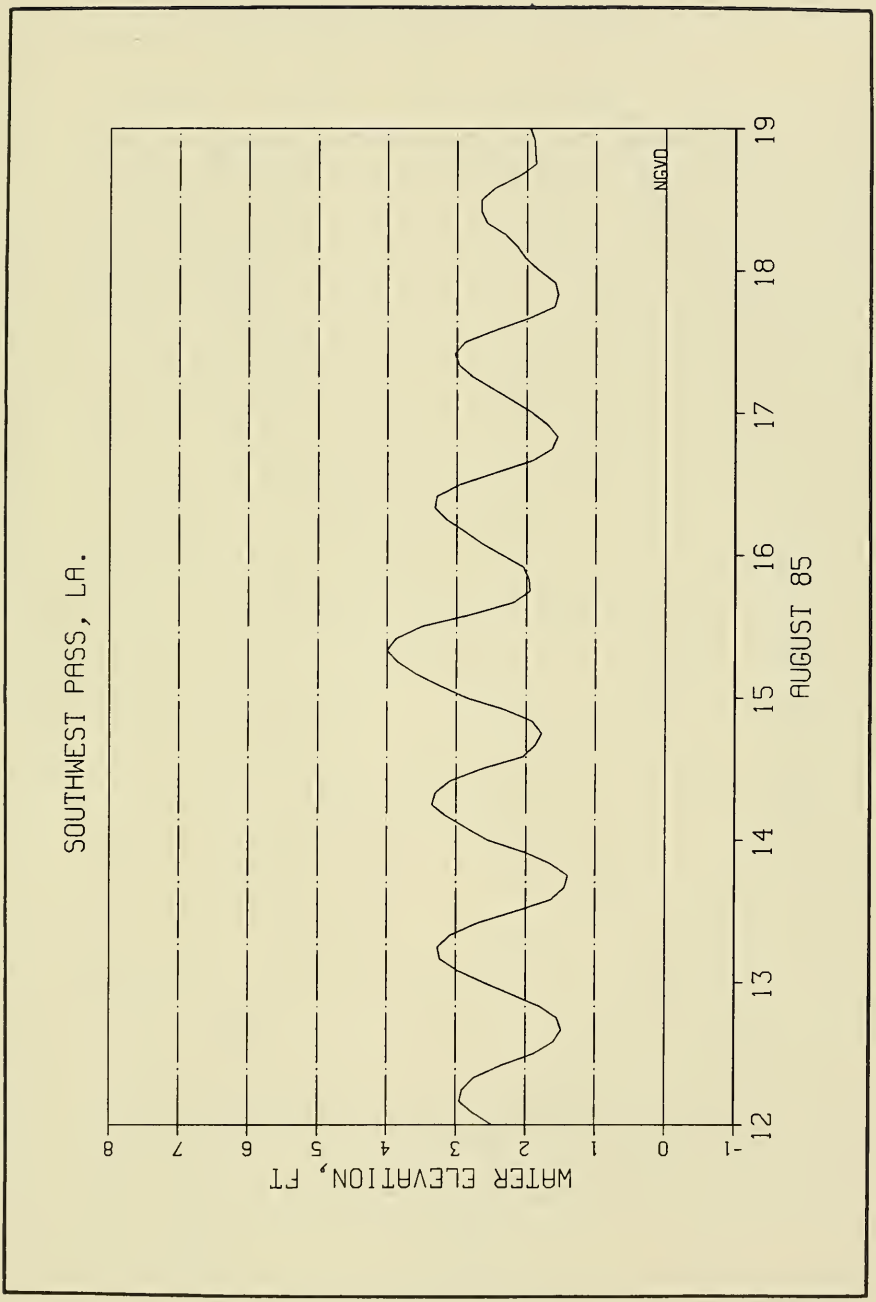
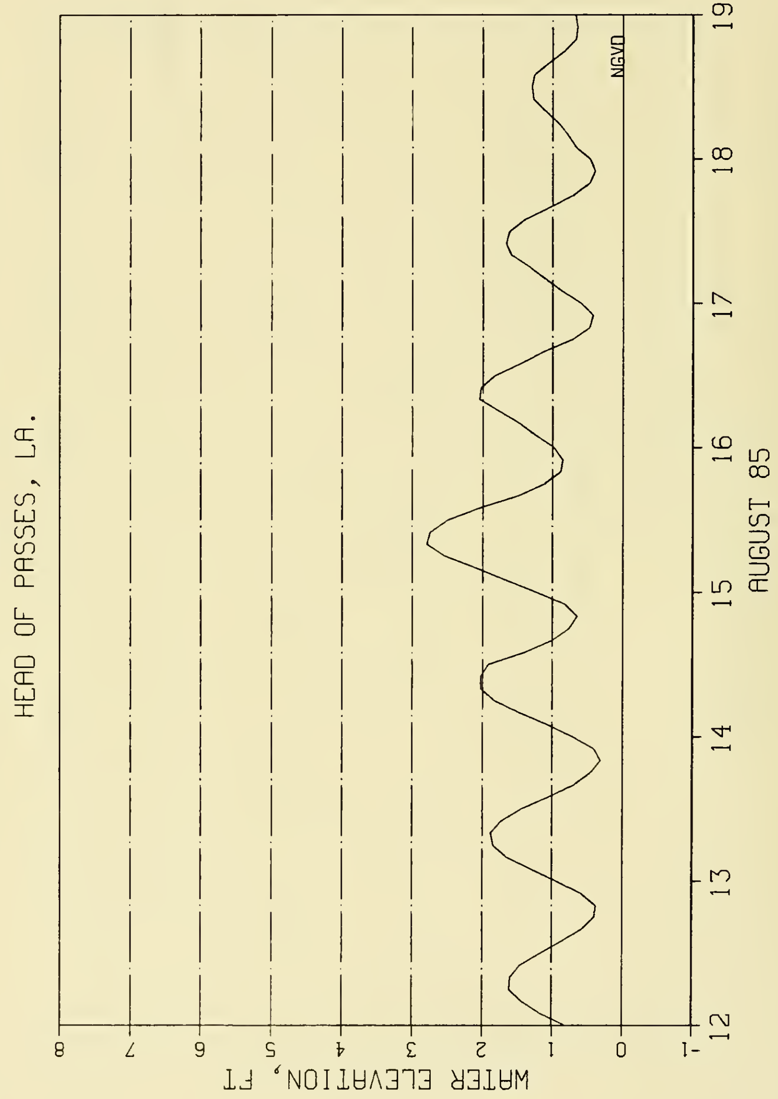
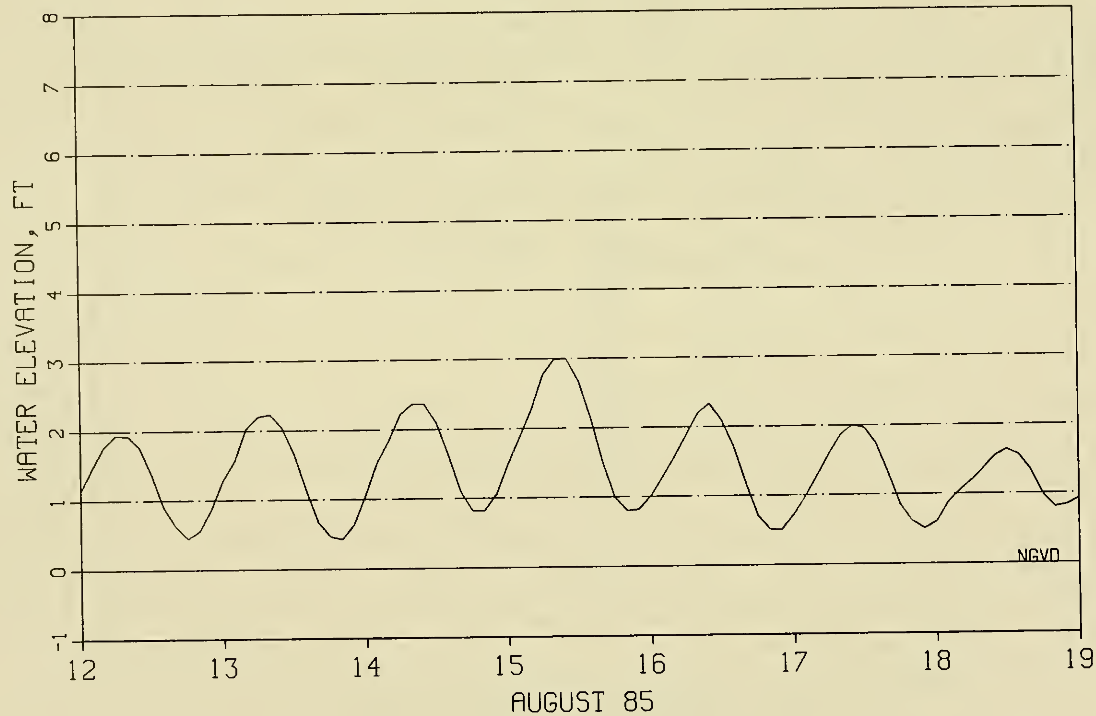

SOUTHWEST PASS, LA.
WATER ELEVATION, FT
-1
0
1
2
3
4
5
6
7
8
NGVD
12
13
14
15
16
17
18
19
AUGUST 85

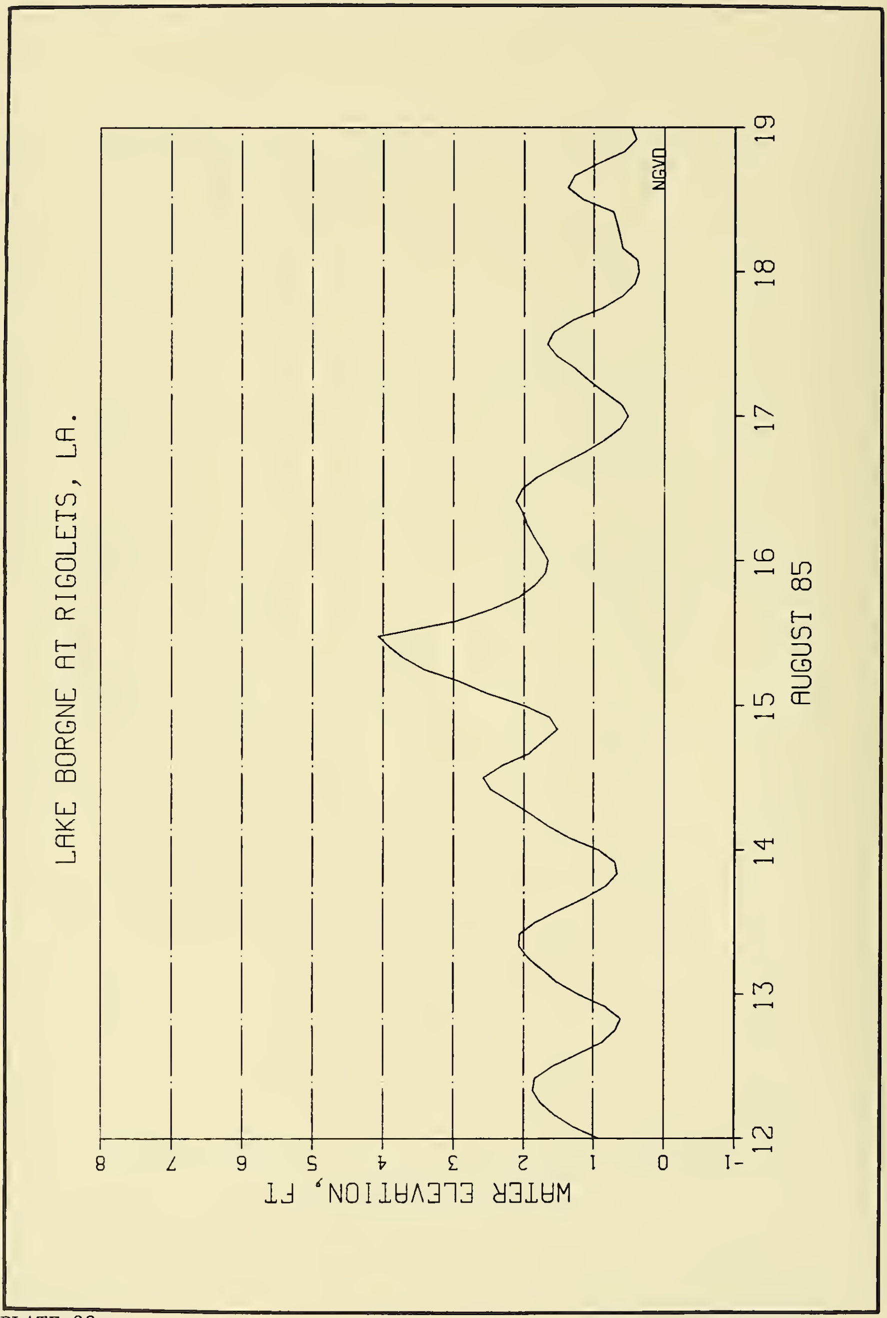
PLATE 17


HEAD OF PASSES, LA.
WATER ELEVATION, FT
-1
0
1
2
3
4
5
6
7
8
NGVD
12
13
14
15
16
17
18
19
AUGUST 85

PORT EADS, LA.



WATER ELEVATION, FT
8
7
6
5
4
3
2
1
0
-1
NGVD
12
13
14
15
16
17
18
19
AUGUST 85



LAKE BORGNE AT RIGOLETS, LA.
WATER ELEVATION, FT
-1
0
1
2
3
4
5
6
7
8
NGVD
12
13
14
15
16
17
18
19
AUGUST 85

PLATE 20

APPENDIX A: WAVE SPECTRA

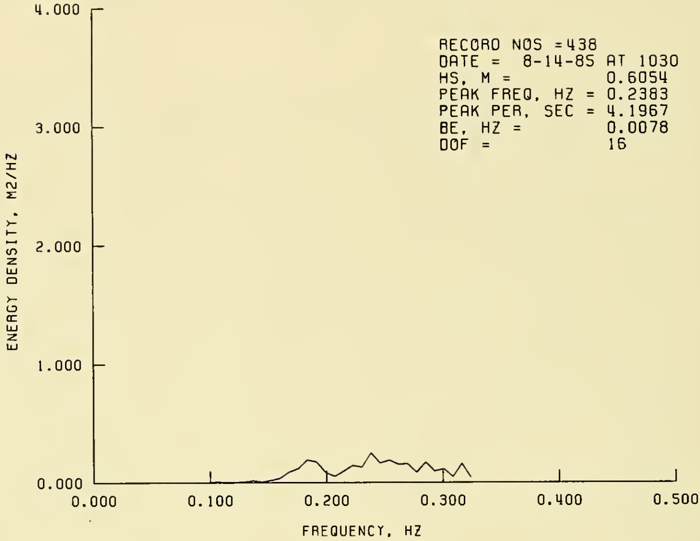


Figure A1. Wave spectrum, Shell Oil platform, Vermilion 22, at 1030, 14 August 1985

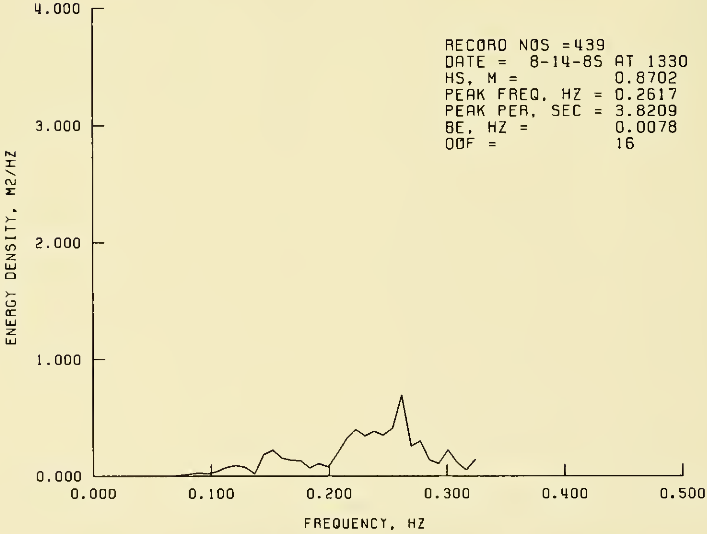


Figure A2. Wave spectrum, Shell Oil platform, Vermilion 22, at 1330, 14 August 1985

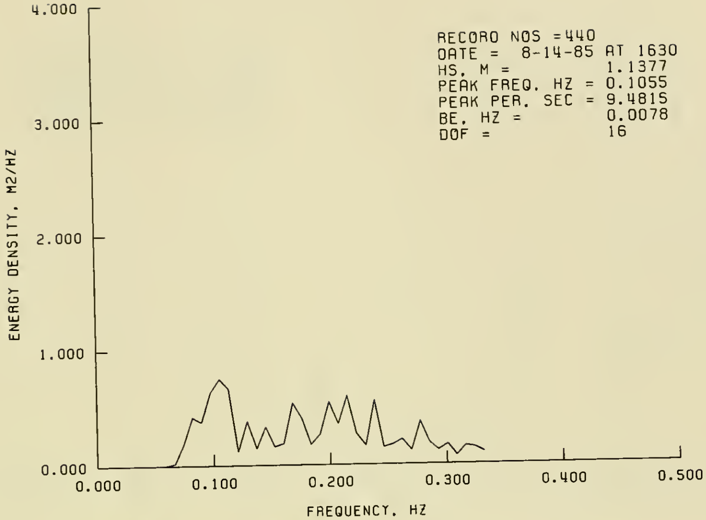


Figure A3. Wave spectrum, Shell Oil platform, Vermilion 22, at 1630, 14 August 1985

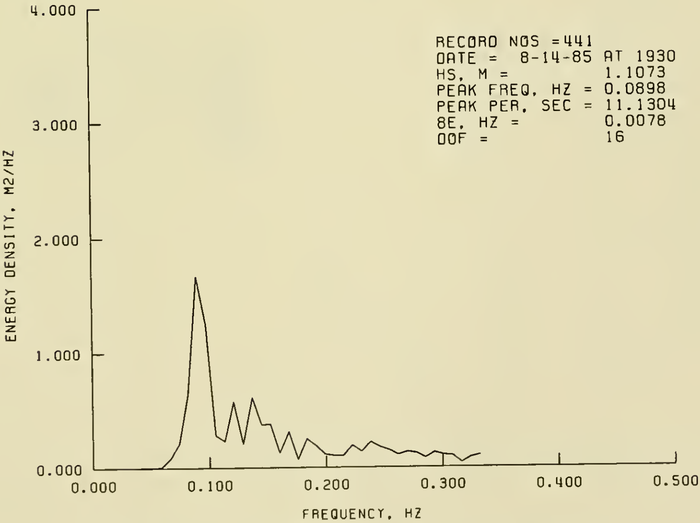


Figure A4. Wave spectrum, Shell Oil platform, Vermilion 22, at 1930, 14 August 1985

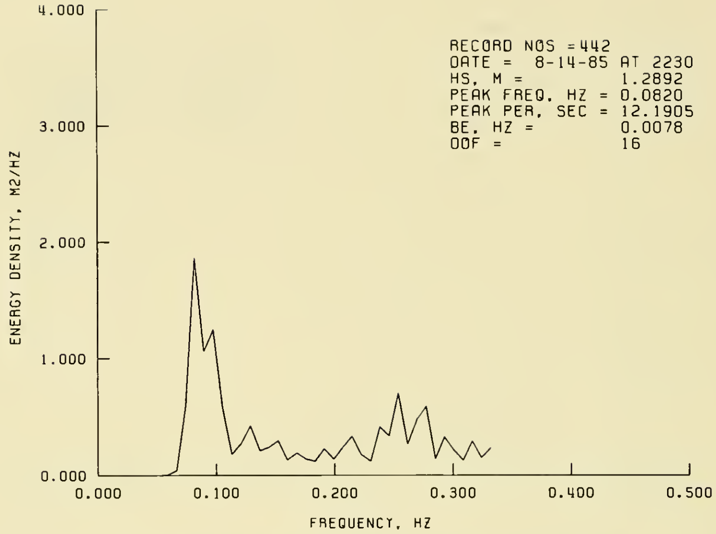


Figure A5. Wave spectrum, Shell Oil platform, Vermilion 22, at 2230, 14 August 1985

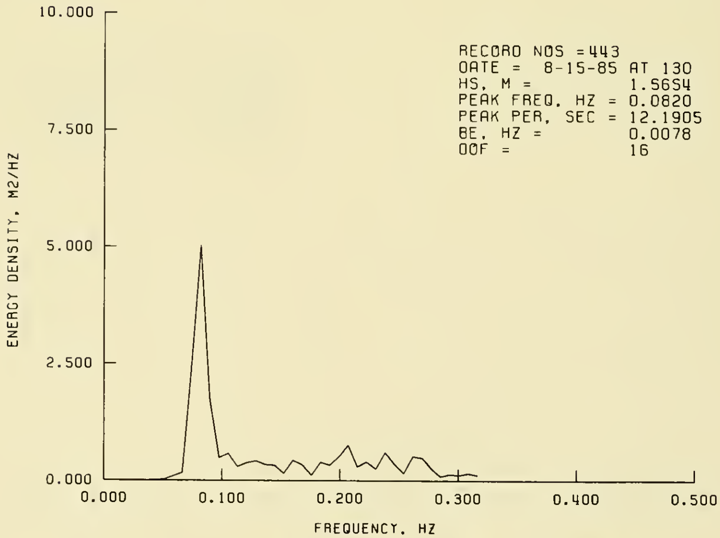


Figure A6. Wave spectrum, Shell Oil platform, Vermilion 22, at 0130, 15 August 1985

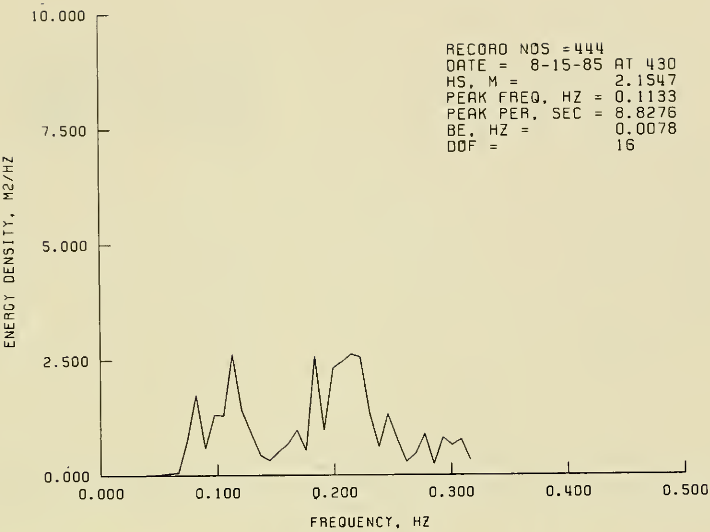


Figure A7. Wave spectrum, Shell Oil platform, Vermilion 22, at 0430, 15 August 1985

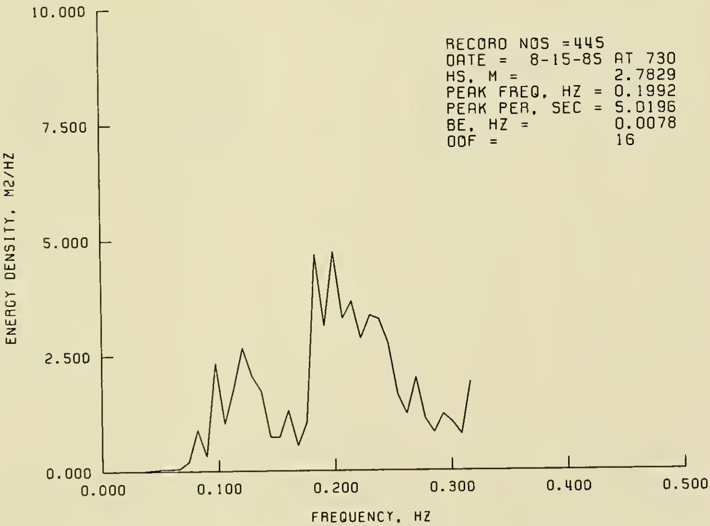


Figure A8. Wave spectrum, Shell Oil platform, Vermilion 22, at 0730, 15 August 1985

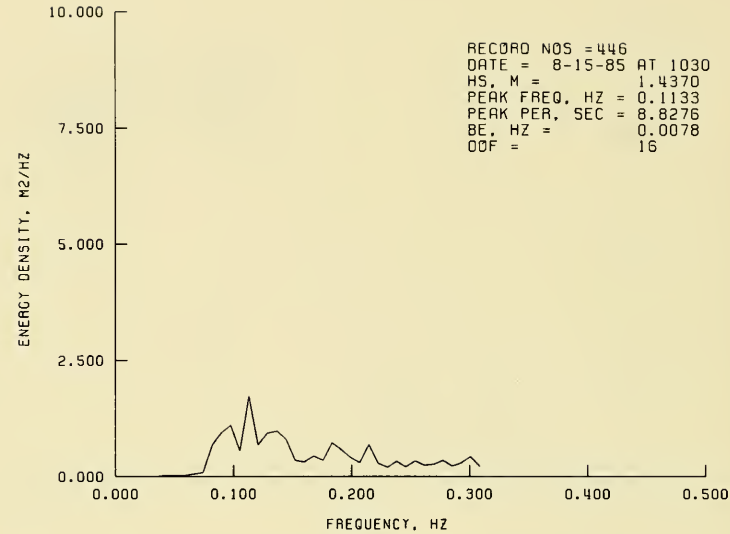


Figure A9. Wave spectrum, Shell Oil platform, Vermilion 22, at 1030, 15 August 1985

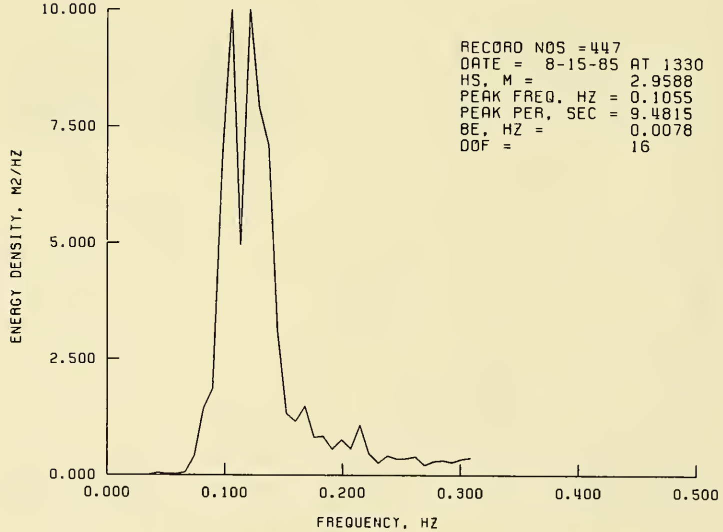


Figure A10. Wave spectrum, Shell Oil platform, Vermilion 22, at 1330, 15 August 1985

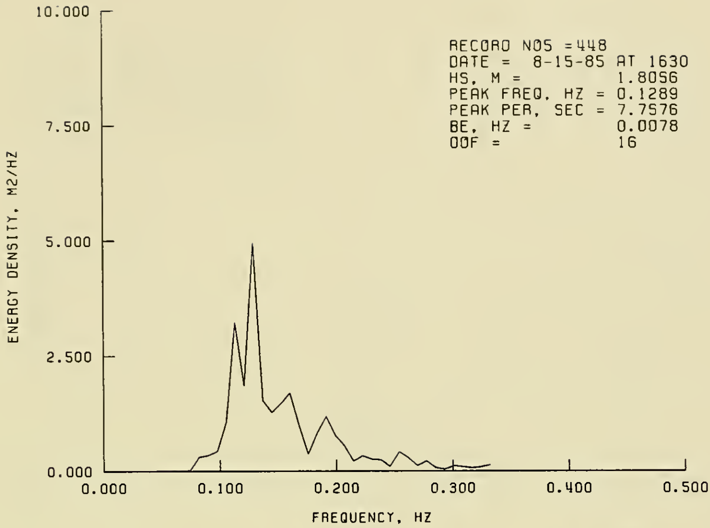


Figure A11. Wave spectrum, Shell Oil platform, Vermilion 22, at 1630, 15 August 1985

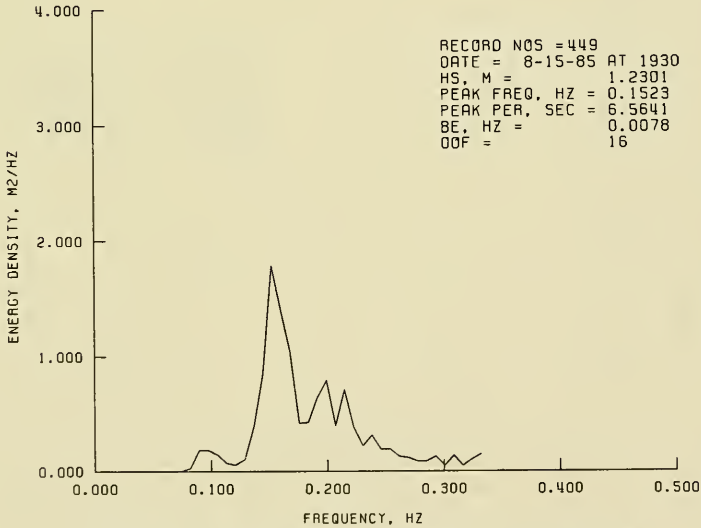


Figure A12. Wave spectrum, Shell Oil platform, Vermilion, 22 at 1930, 15 August 1985

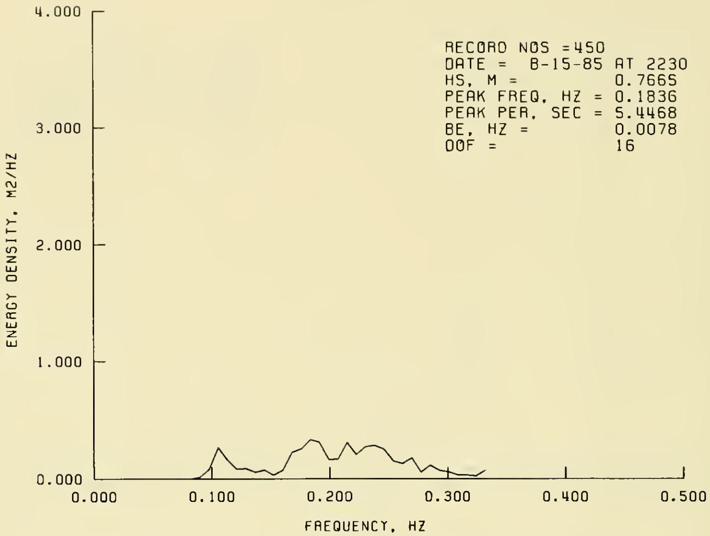


Figure A13. Wave spectrum, Shell Oil platform, Vermilion 22, at 2230, 15 August 1985

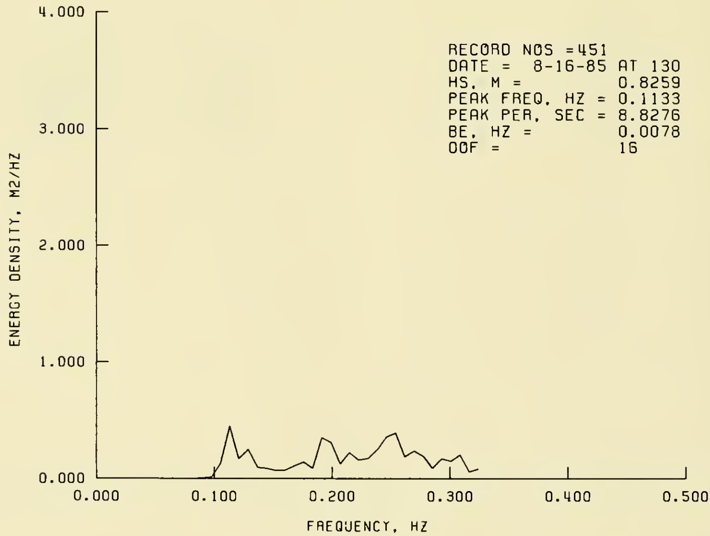


Figure A14. Wave spectrum, Shell Oil platform, Vermilion 22, at 0130, 16 August 1985

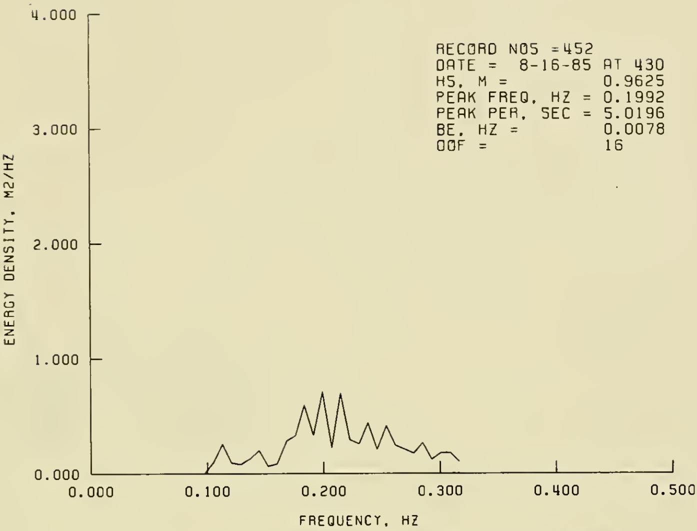


Figure A15. Wave spectrum, Shell Oil platform, Vermilion 22, at 0430, 16 August 1985

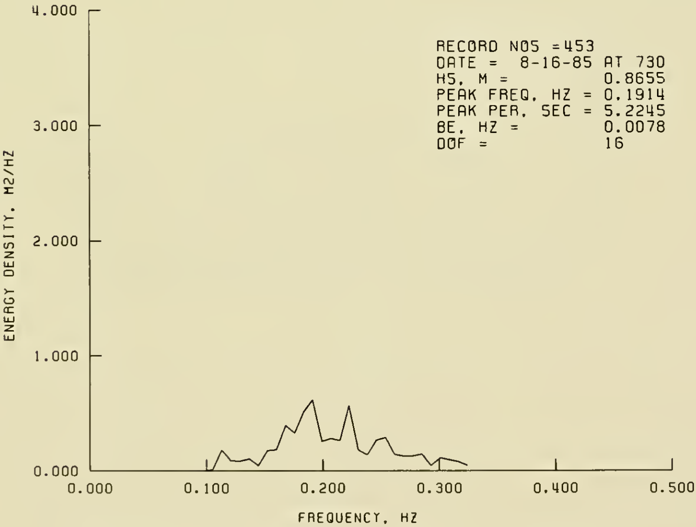


Figure A16. Wave spectrum, Shell Oil platform, Vermilion 22, at 0730, 16 August 1985

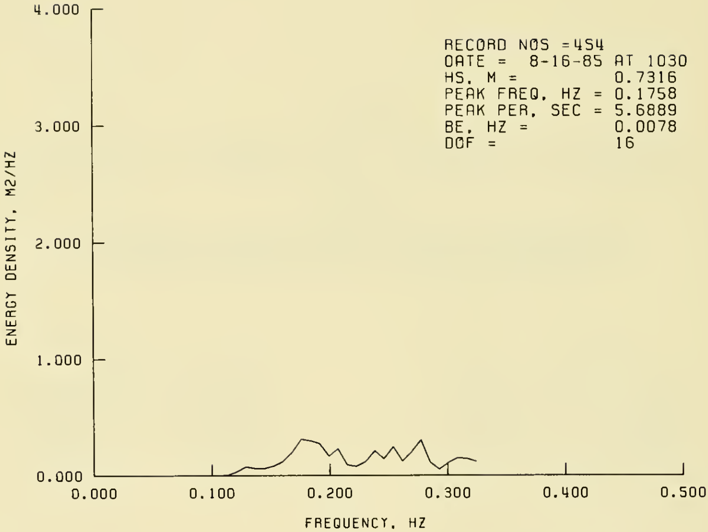


Figure A17. Wave spectrum, Shell Oil platform, Vermilion 22, at 1030, 16 August 1985