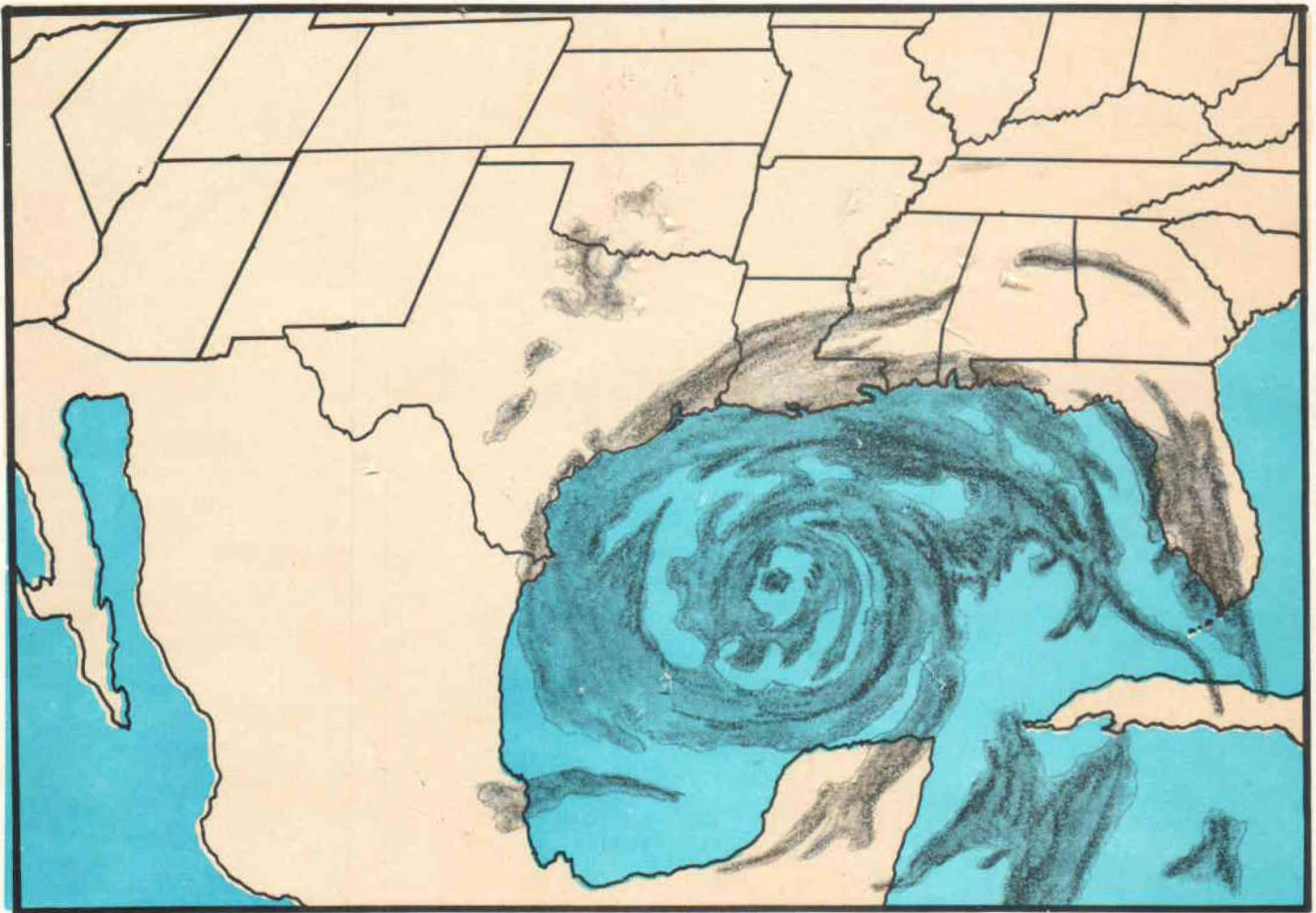


HURRICANE ALLEN

3-10 AUGUST 1980



**U.S. ARMY ENGINEER DISTRICT, GALVESTON
CORPS OF ENGINEERS GALVESTON, TEXAS**



REPORT
ON
HURRICANE ALLEN
3-10 AUGUST 1980

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
GALVESTON, TEXAS

JULY 1981

For sale by:

District Engineer
U. S. Army Engineer District, Galveston
P. O. Box 1229, Galveston, Texas 77553

Price: \$3.00

FOREWORD

ALLEN began as a low-pressure system over west Africa and became the season's first hurricane on Sunday, 3 August 1980. Before making landfall near Brownsville one week later, the storm had churned its way from the Caribbean to Texas' doorstep as a category 5 hurricane, the most severe classification. Fortunately, for the anxious residents of the lower coast, the storm suddenly weakened just hours before it moved inland. However, it was still strong enough to cause almost \$300 million in damage and alter the landscape for years. Hundreds of families in coastal communities and inland towns lost their homes to the wind and surge, or suffered severe flood damage from the torrential rain accompanying the storm. Nine counties in south Texas were declared major disaster areas by President Carter.

HURRICANE ALLEN

AUGUST 1980

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<u>Attachment</u>	<u>Description</u>
1	FLOOD PLAIN MAPS
2	TIDE GAGE DATA FROM VARIOUS STATIONS ALONG THE TEXAS COAST

HURRICANE ALLEN
August 1980
AUTHORITY AND SCOPE

AUTHORITY AND PURPOSE

This report has been prepared pursuant to ER 500-1-1, paragraph 4-4g(2), dated 9 January 1978. The purposes of this report are to record the pertinent meteorologic and hydrologic phenomena of the storm and to present an estimate of damage to physical property. The data presented and the conclusions drawn are consistent with the time, manpower, and funds available to collect field data.

SCOPE

This report is a summary of the meteorologic and hydrologic features of Hurricane ALLEN and the damages caused by the storm. The origin and history of the storm, emergency operations, post-storm data collection, and the evaluation of damages are covered in the report. A more complete compilation of information, including high-water mark data, damage survey data, and photographs, is on file in the Galveston District Office.

EVACUATION

Anxiety, and in some cases fear and panic, developed among residents of the entire Texas coast as they listened to national and local weather forecasters label ALLEN as one of the most intense hurricanes ever to develop in the Atlantic and saw on their television screens that it was headed their way. Vivid recollections and reminders of the destruction brought about by Hurricanes CARLA (1961), BEULAH (1967), and CELIA (1970) prompted many to begin taking the necessary precautions to protect their personal property and plan for the anticipated evacuation. The National Weather Service first advised evacuation of low-lying areas along the Texas coast early on the afternoon of 8 August. By late afternoon, the mass exodus of an estimated 950,000 persons, fleeing from the coastal reaches of Texas to higher ground in the interior, had begun.

During the peak of evacuations, 422 shelters were opened to provide shelter and care to 400,000 Texas coast evacuees seeking safety during Hurricane ALLEN. Other evacuees sought commercial lodging or refuge with friends or relatives who lived farther inland.

There were only two deaths directly attributed to ALLEN in the United States, and these were drownings in the Corpus Christi area. However, hurricane warnings were issued in time to

THE STORM

ORIGIN AND HISTORY OF THE STORM

ALLEN began as a large cloud mass off of the northwest African coast on 30 July 1980. The cloud mass slowly drifted westward in the Atlantic Ocean, and on 1 August developed a closed circulation pattern and was, therefore, referred to as a tropical depression. The depression formed about 1,300 miles east of the Windward Islands, and the storm was tracked by the National Weather Service satellite as it moved across the Atlantic toward the Caribbean Sea. Rapidly developing, the depression was upgraded to a tropical storm during the early morning hours of 3 August, and by evening it had intensified to hurricane strength. By the time the first aircraft reconnaissance flight was made into the system during the afternoon of 3 August, ALLEN had developed winds of 100 miles per hour (m.p.h.) and a minimum pressure of 28.56 inches of mercury. The pressure dropped to 28.08 inches of mercury by that evening as the eye of the storm passed just north of Barbados and south of St. Lucia.

The storm continued westward into the Caribbean at a forward speed of about 20 m.p.h. On the evening of 4 August the pressure within the system fell to 26.90 inches of mercury, making ALLEN the most intense and dangerous hurricane ever recorded in the eastern Caribbean. However, as the hurricane passed between Haiti and Jamaica on 5 August, its circulation interacted with the mountainous terrain and weakened.

main force spare the heavily populated Brownsville and South Padre Island areas. During the early morning hours of 10 August, the storm then turned westward and moved inland about 30 miles north of Brownsville across the sparsely populated area that was once a part of the King Ranch. After slowly departing Texas in a west-northwesterly direction, ALLEN's circulation encountered the mountains of northern Mexico and rapidly dissipated. The path of the storm is shown on Figure 1.

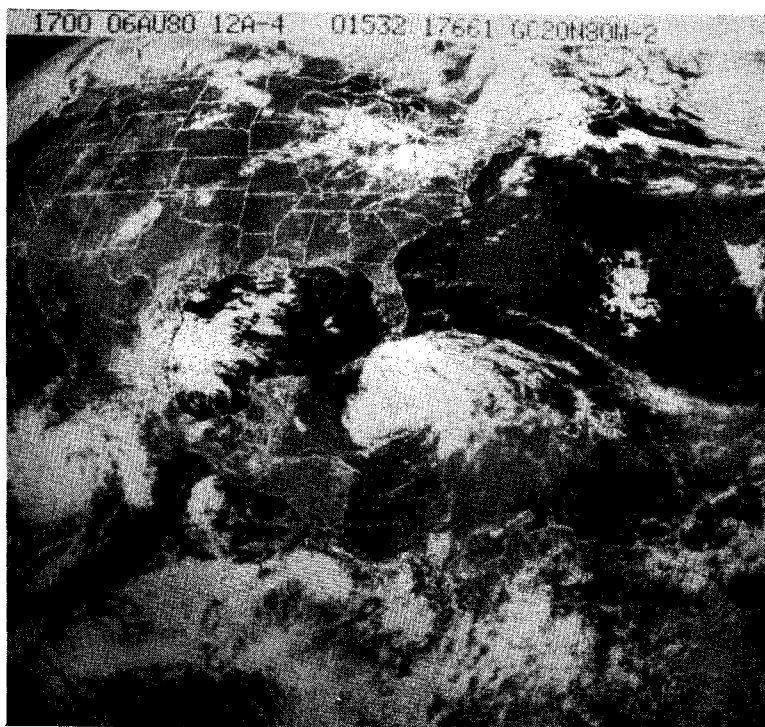
ALLEN brought much grief to people along its path across the Caribbean to the Gulf of Mexico. The following is a brief summary of the known damages incurred to the Caribbean islands and adjacent landmasses along with satellite photos taken by the National Weather Service during ALLEN's 1,200-mile rampage through the Caribbean. The damage data were obtained from a report on Hurricane ALLEN prepared by the National Oceanic and Atmospheric Administration in Asheville, North Carolina, and from newspaper and magazine articles.

Windward and Leeward Islands. Hurricane ALLEN caused considerable damage on the islands of Barbados and St. Lucia. Winds in excess of 100 m.p.h. and flash flooding were reported on St. Lucia. About 500 homes were damaged or destroyed on Barbados. Eighteen people were killed on St. Lucia, and one other death was reported on the island of Guadeloupe.



Satellite photo taken on 3 August as ALLEN passed near the Windward and Leeward Islands

Cuba and the Cayman Islands. Cuba received only a glancing blow as ALLEN passed by, and, although three people died, there were no reports of significant damage. Cayman Brac, one of the Cayman Islands, was raked by winds in excess of 115 m.p.h. and sustained considerable property damage; however, there were no casualties reported.



Satellite photo taken on 6 August as ALLEN passed near Cuba and the Cayman Islands

BAROMETRIC PRESSURES AND WIND VELOCITIES

As ALLEN moved inland at about 1 a.m. on 10 August, lowest land pressures of 28.62 and 29.26 inches of mercury were recorded at Brownsville and Corpus Christi, respectively. The highest winds reported at land stations were gusts of 138 m.p.h. at Port Mansfield, 109 m.p.h. at Aransas Pass, and 92 m.p.h. at the Corpus Christi Airport. Highest sustained winds of 138 m.p.h. were recorded at an oil rig 50 miles east of Brownsville. The peak gust at the Brownsville Airport was 78 m.p.h.

STORM SURGE AND WAVES

ALLEN caused surges along the open coast ranging from 8.8 feet near Brownsville, to 8.9 feet at Port Aransas, to 5 feet at Freeport, and 4 feet near Galveston. Inland surges ranged from about 8 to 9.5 feet along the lower coast and approximately 8 feet in upper Corpus Christi Bay. The surge caused severe erosion of beaches and their dune systems along the shoreline of the Texas coast as far north as the Sabine River. The sand dunes which once served to protect against the full impact of the storm waves and surge were cut away as if by a knife, leaving bluffs of bare sand facing the sea. On South Padre Island, there were 68 places where the island was cut, connecting the bay behind the island and the Gulf. Extensive damage occurred where there had been human tampering with the dune system.



Washover Channels - South Padre Island



Washover Channels - South Padre Island

The surges and waves accompanying Hurricane ALLEN had only a moderate impact on the Corpus Christi Beach Project, completed in February 1978. The project, jointly constructed by the City of Corpus Christi and the Federal government, consists of a 1.4-mile stretch of restored beach which was a popular recreation area in the early part of the century and as late as the 1940's. ALLEN produced a surge of approximately 8 feet in this area with additional wave height. The beach was inundated for several hours to a maximum of approximately 4.5 feet. About 7,600 cubic yards of sand were lost; however, the beach held up exceptionally well under the circumstances. The beach's utility has not decreased although some surface area has been lost.

Nearshore wave heights were not recorded; however, based on damages to structures near the coastline, wave heights of six feet or greater were common. Tremendous wave heights were recorded at some distance from the center of the storm. For example, a 49.5-foot wave was recorded offshore of Cameron, Louisiana, a distance of about 190 miles from the storm center.

RAINFALL

As Hurricane ALLEN approached the coast and moved inland, torrential rains fell on south Texas and northeast Mexico. Storm rainfall totals ranged from 5 to 10 inches over much of the area; however, totals exceeded 15 inches in some areas.

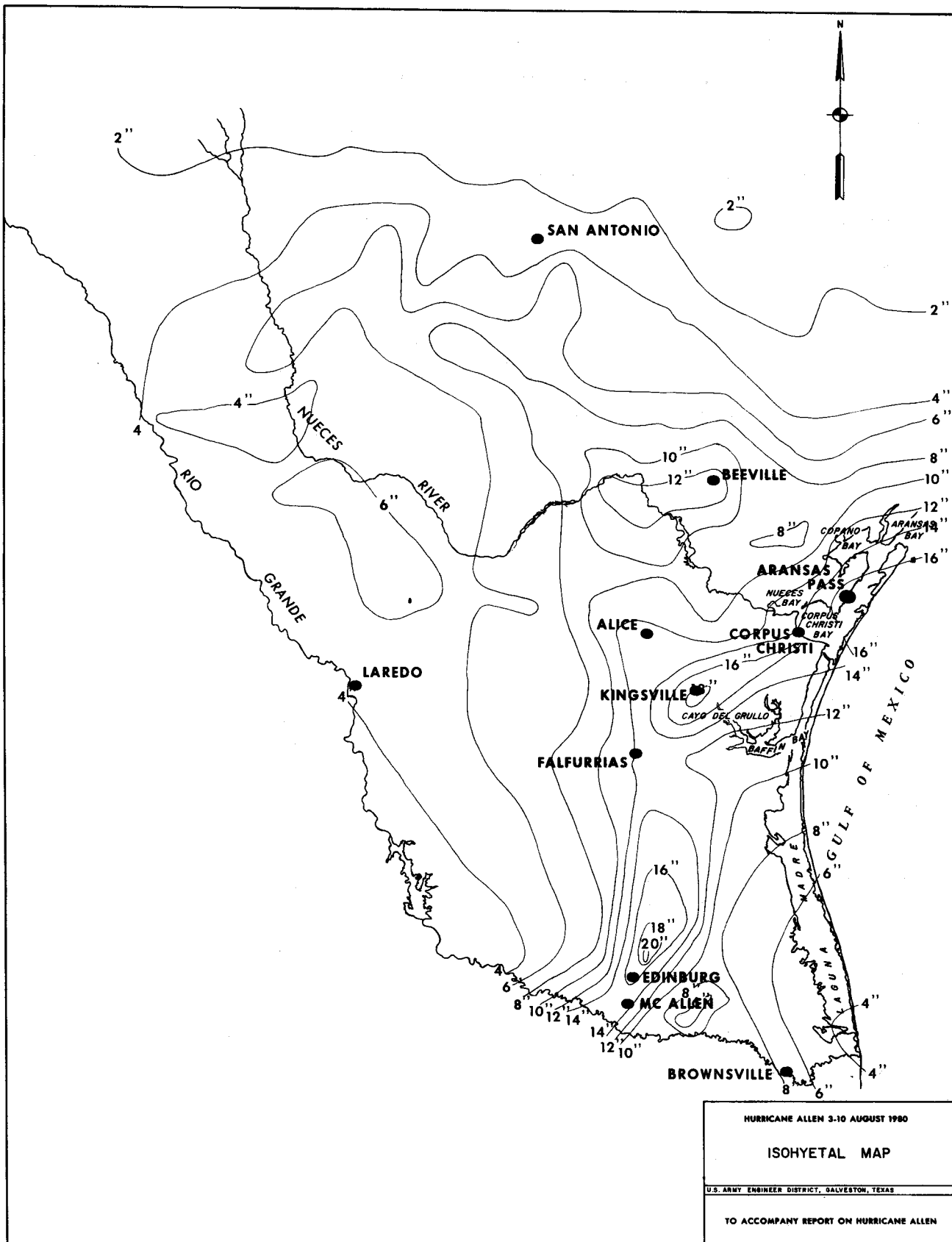


FIGURE 2

HURRICANE ALLEN
August 1980
AUTHORITY AND SCOPE

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EMERGENCY OPERATIONS

The progress of ALLEN was monitored by the Construction-Operations Division of the Galveston District Office as the storm moved through the Caribbean Sea toward the Gulf of Mexico. Based on projections of the storm's path by the National Weather Service, 24-hour Hurricane Base Operations were activated at the Galveston District Office on 8 August at 8 a.m. to closely monitor the storm's progress as it approached the Texas coast. However, shortly before noon the coastal area from Brownsville to High Island was placed under hurricane warnings, and Hurricane Headquarters were established at the Houston Resident Office in League City to monitor the storm on a continuous basis. Continuous monitoring permits appropriate emergency action to be initiated as conditions warrant.

After ALLEN made landfall, Hurricane Headquarters were suspended at the Houston Resident Office around noon on 10 August and reorganized at the District Office in Galveston shortly thereafter. The Galveston District team was established to respond to telephone inquiries; provide status reports to higher authority; and to plan, organize, and staff a hurricane emergency office in the affected area to coordinate disaster recovery operations.

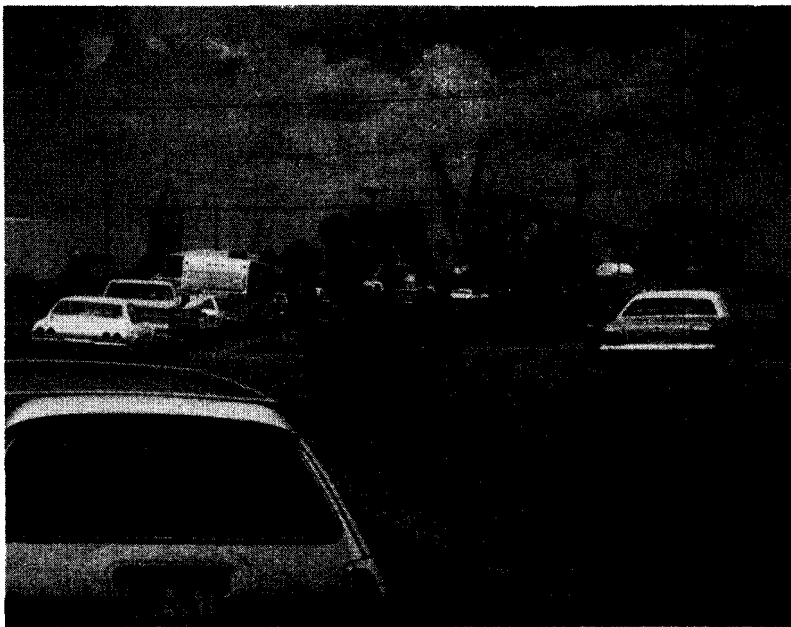
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During the peak of evacuations, 422 shelters were opened to provide shelter and care to 400,000 Texas coast evacuees seeking safety during Hurricane ALLEN. Other evacuees sought commercial lodging or refuge with friends or relatives who lived farther inland.

There were only two deaths directly attributed to ALLEN in the United States, and these were drownings in the Corpus Christi area. However, hurricane warnings were issued in time to

permit evacuation before escape routes became impassable, and the deaths apparently resulted from failure to heed the warnings promptly. The reported indirect deaths were: 13 in an oil company evacuation helicopter which crashed while taking workmen from the Louisiana offshore oil rigs; 4 in an offshore oil rig collapse off the Louisiana coast; 3 fishermen swept off the jetties by large swells in the Galveston area; and 2 victims of heart attacks. There were also several deaths in automobile accidents during the period of evacuation. This low incidence of fatalities is creditable to the willing cooperation of the general public, local police, Civil Defense officials, and other disaster relief agencies in the successful evacuation that was accomplished without benefit of a state-wide evacuation plan.



Evacuation - Port Aransas

THE STORM

ORIGIN AND HISTORY OF THE STORM

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The storm continued westward into the Caribbean at a forward speed of about 20 m.p.h. On the evening of 4 August the pressure within the system fell to 26.90 inches of mercury, making ALLEN the most intense and dangerous hurricane ever recorded in the eastern Caribbean. However, as the hurricane passed between Haiti and Jamaica on 5 August, its circulation interacted with the mountainous terrain and weakened.

ALLEN passed just north of Jamaica and the Cayman Islands on 6 August. The central pressure began to fall rapidly again as the circulation moved over the warm waters of the northwestern Caribbean. On the afternoon of 7 August, when the storm was located in the Yucatan Channel, a record breaking minimum pressure of 26.55 inches of mercury was observed by a reconnaissance aircraft. This is the lowest pressure ever observed in the western Caribbean and the second lowest ever recorded in the Atlantic, Caribbean, and Gulf of Mexico. (An unnamed storm that devastated the Florida Keys on Labor Day, 1935, had a barometer reading of 26.35 inches of mercury). ALLEN began losing strength for a second time as the center passed near the northern coast of the Yucatan Peninsula on the morning of 8 August.

As ALLEN began to drift west-northwesterly across the warm waters of the Gulf of Mexico on 8 August, the ominous square flags with black centers and red borders went up along the Texas coast signifying that a hurricane warning was in effect. The huge cloud mass covered the entire Gulf, nearly touching the shore on all sides.

ALLEN stalled for a few hours off the Texas coast around midnight on 9 August, and a second eye developed around the central eye. Once more, the hurricane changed its path, weakened, and moved just enough to the northwest to have its

main force spare the heavily populated Brownsville and South Padre Island areas. During the early morning hours of 10 August, the storm then turned westward and moved inland about 30 miles north of Brownsville across the sparsely populated area that was once a part of the King Ranch. After slowly departing Texas in a west-northwesterly direction, ALLEN's circulation encountered the mountains of northern Mexico and rapidly dissipated. The path of the storm is shown on Figure 1.

ALLEN brought much grief to people along its path across the Caribbean to the Gulf of Mexico. The following is a brief summary of the known damages incurred to the Caribbean islands and adjacent landmasses along with satellite photos taken by the National Weather Service during ALLEN's 1,200-mile rampage through the Caribbean. The damage data were obtained from a report on Hurricane ALLEN prepared by the National Oceanic and Atmospheric Administration in Asheville, North Carolina, and from newspaper and magazine articles.

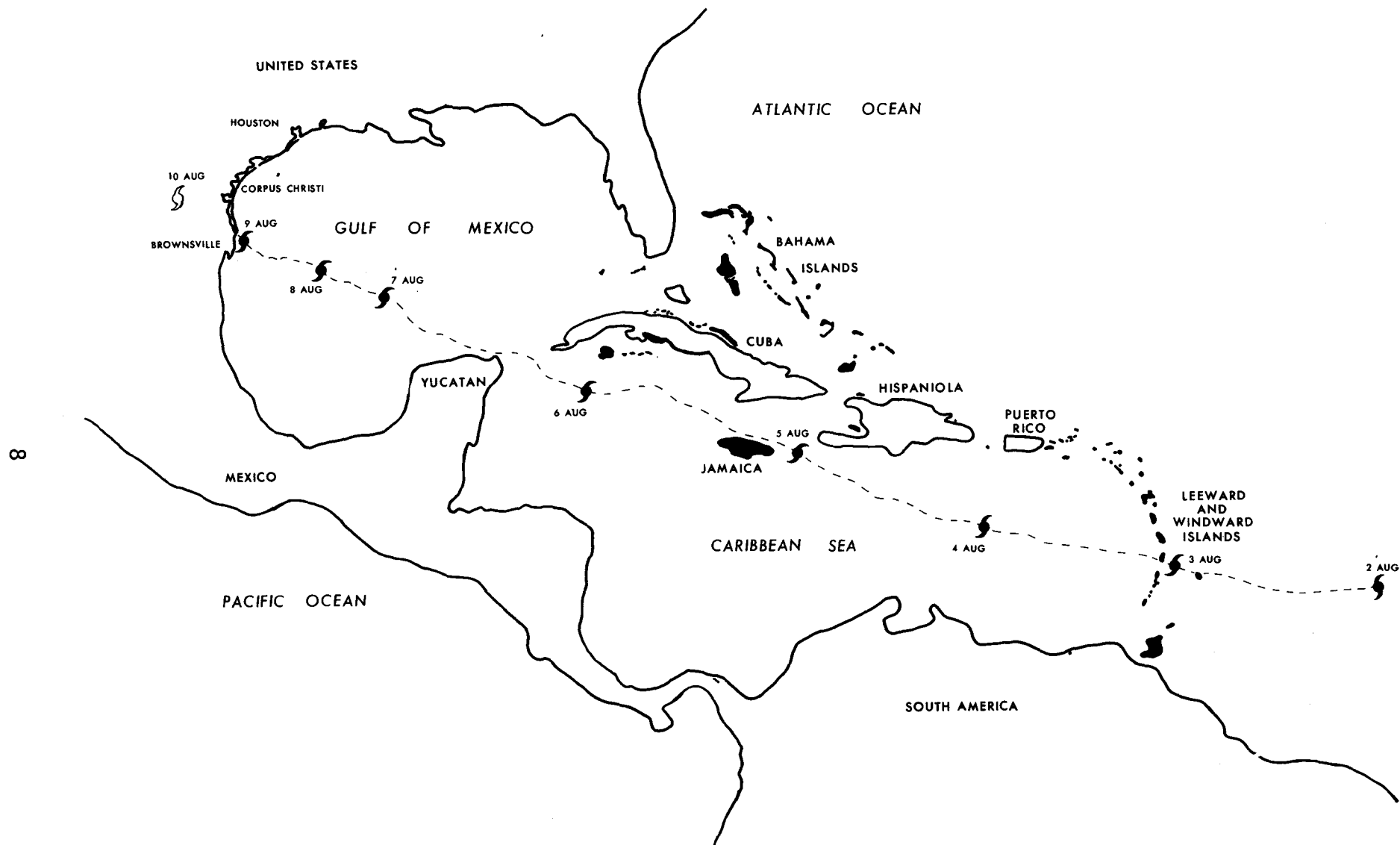


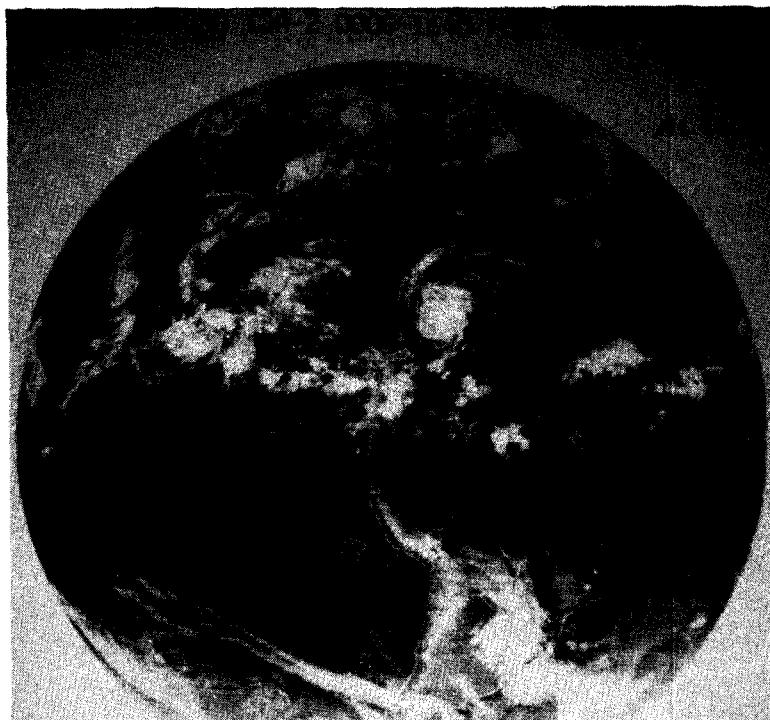
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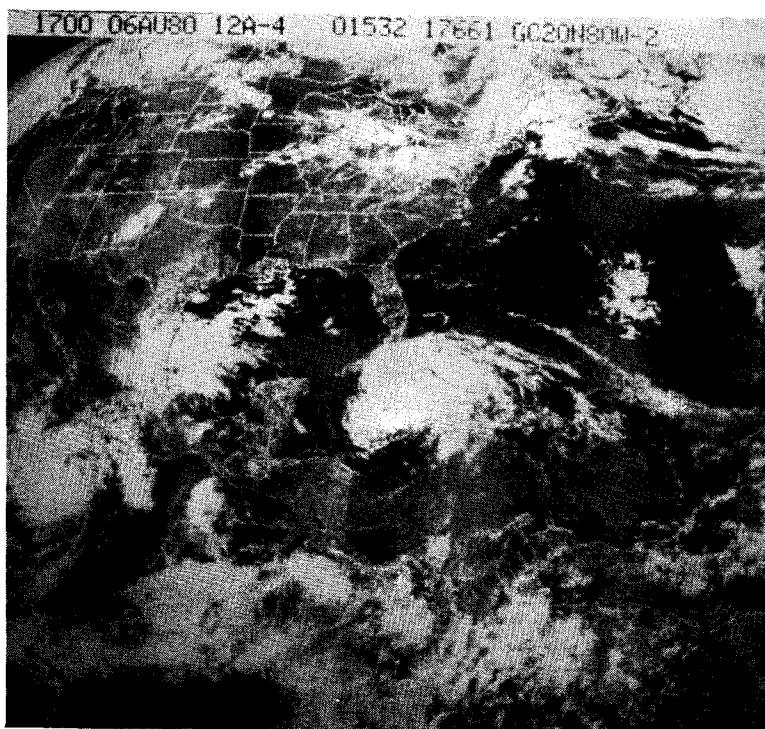
Satellite photo taken on 3 August as ALLEN passed near the Windward and Leeward Islands

Haiti and Jamaica. Winds and flash floods caused extensive damage on the island of Haiti. Sixty-seven people were killed on the island, hundreds of thousands were left homeless, and about one-half of the nation's coffee crop was destroyed. The furious storm raked Jamaica with 100-mile per hour winds and torrential rain. Extensive damage was reported along the immediate northeast coast, but only minor damage was reported elsewhere on the island. Eight people died in Jamaica, including five who were dragged out to sea from their homes.



Satellite photo taken on 5 August as ALLEN passed near the islands of Haiti and Jamaica

Cuba and the Cayman Islands. Cuba received only a glancing blow as ALLEN passed by, and, although three people died, there were no reports of significant damage. Cayman Brac, one of the Cayman Islands, was raked by winds in excess of 115 m.p.h. and sustained considerable property damage; however, there were no casualties reported.



Satellite photo taken on 6 August as ALLEN passed near Cuba and the Cayman Islands

Mexico. The extreme northeast coast of the Yucatan Peninsula and the northeast Mexican Gulf coast were on the storm's weaker side as it passed through the Yucatan Channel and into the Gulf. Both of these areas are sparsely populated, and there were no reports of significant damage.



Satellite photo taken on 7 August as ALLEN passed through the Yucatan Channel and into the Gulf

BAROMETRIC PRESSURES AND WIND VELOCITIES

As ALLEN moved inland at about 1 a.m. on 10 August, lowest land pressures of 28.62 and 29.26 inches of mercury were recorded at Brownsville and Corpus Christi, respectively. The highest winds reported at land stations were gusts of 138 m.p.h. at Port Mansfield, 109 m.p.h. at Aransas Pass, and 92 m.p.h. at the Corpus Christi Airport. Highest sustained winds of 138 m.p.h. were recorded at an oil rig 50 miles east of Brownsville. The peak gust at the Brownsville Airport was 78 m.p.h.

STORM SURGE AND WAVES

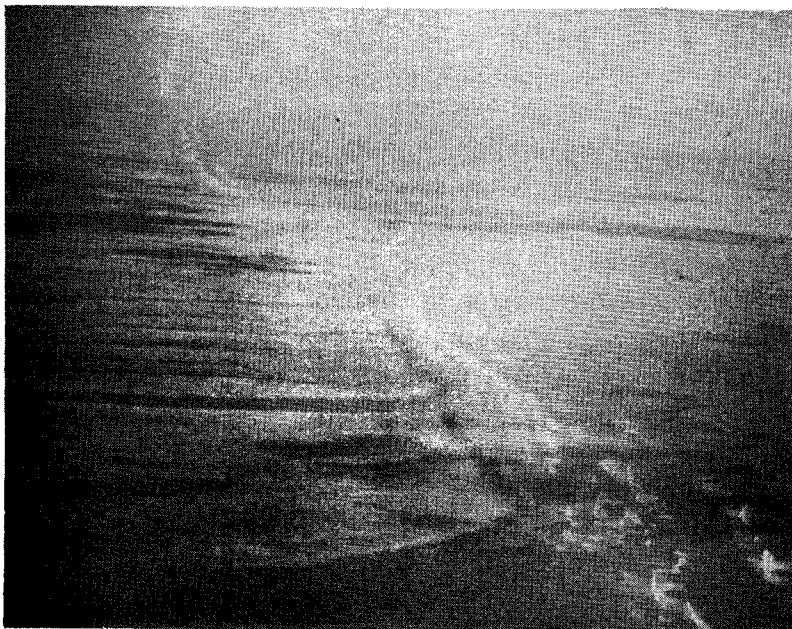
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Dune Damage - North Padre Island



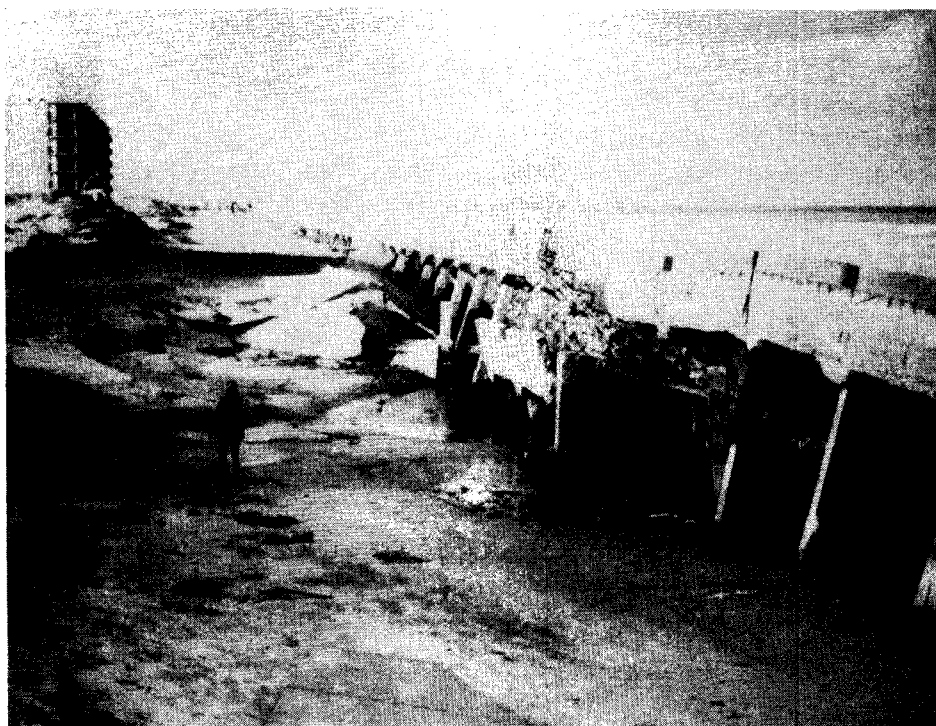
Washover Channels - South Padre Island



Washover Channels - South Padre Island



Seawall Damage - North Padre Island



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The surges and waves accompanying Hurricane ALLEN had only a moderate impact on the Corpus Christi Beach Project, completed in February 1978. The project, jointly constructed by the City of Corpus Christi and the Federal government, consists of a 1.4-mile stretch of restored beach which was a popular recreation area in the early part of the century and as late as the 1940's. ALLEN produced a surge of approximately 8 feet in this area with additional wave height. The beach was inundated for several hours to a maximum of approximately 4.5 feet. About 7,600 cubic yards of sand were lost; however, the beach held up exceptionally well under the circumstances. The beach's utility has not decreased although some surface area has been lost.

Nearshore wave heights were not recorded; however, based on damages to structures near the coastline, wave heights of six feet or greater were common. Tremendous wave heights were recorded at some distance from the center of the storm. For example, a 49.5-foot wave was recorded offshore of Cameron, Louisiana, a distance of about 190 miles from the storm center.

RAINFALL

As Hurricane ALLEN approached the coast and moved inland, torrential rains fell on south Texas and northeast Mexico. Storm rainfall totals ranged from 5 to 10 inches over much of the area; however, totals exceeded 15 inches in some areas.

The isohyetal map (lines of equal rainfall) for the period 9-12 August is shown on Figure 2.

The heaviest concentration of rainfall reported during the period 9-12 August was 20 inches at Faysville, located about 10 miles north of Edinburg. Other locations reporting rainfall totals in excess of 15 inches were Kingsville (18.96); Linn, about 32 miles north of Edinburg (18.00); Aransas Pass (17.50); McAllen (16.05); and Alice (15.65). Table 1 presents accumulated rainfall totals in excess of 10 inches at various locations affected by ALLEN.

TORNADOES

There were at least a dozen tornadoes reported around south and central Texas. More than 8 were observed over inland areas west and north of Corpus Christi. Two were confirmed in Brownsville which damaged several homes and businesses. In Bishop (about 32 miles southwest of Corpus Christi), two tornadoes touched down and demolished several mobile homes and businesses and heavily damaged part of a high school where town residents had huddled for safety. Fortunately no one was injured at the school; however, a tornado roared through a campground near San Marcos and injured about 15 people who had left the coastal area seeking refuge. San Marcos' radio station was knocked off the air for three hours, and buildings at the airport, several mobile homes, an apartment complex, a

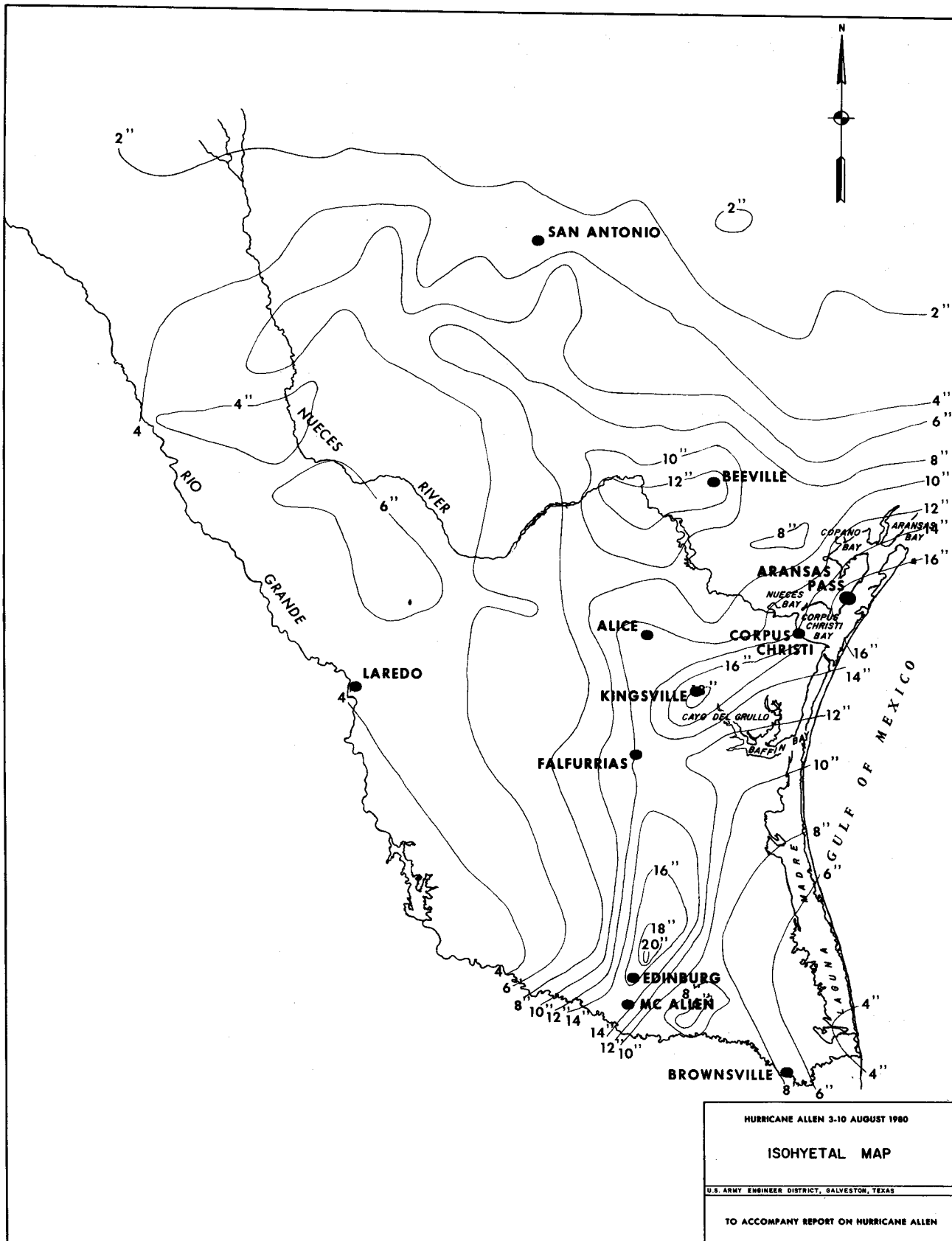


FIGURE 2

nursing home, an elementary school, and several businesses sustained damage. Heavy damage also occurred at the Austin Airport where a tornado ripped apart several hangars and damaged several corporate jets. Several more smaller tornadoes were observed in southeast Texas, but only minor damage was reported.

TABLE 1
HURRICANE ALLEN RAINFALL
STATIONS RECORDING MORE THAN 10 INCHES
9-12 AUGUST 1980

<u>LOCATION</u>	<u>AMOUNT (Inches)</u>
Alice	15.65
Aransas Pass	17.50
Beeville	13.55
Bishop	12.62
Callallen	10.95
Calliham	10.05
Choke Canyon Reservoir	11.00
Corpus Christi	13.27
Edinburg	14.51
Falfurrias	12.49
Faysville	20.00
George West	13.09
Kingsville	18.96
Linn	18.00
McAllen	16.05
Monte Alto Reservoir	10.75
Odem	11.30
Pharr	12.60
Riviera	11.26
San Diego	12.18
Sarita	11.20
Simmons	13.90
Three Rivers	10.55

DATA COLLECTION

HYDROLOGIC DATA COLLECTION

Hydrologic data were collected from four sources: (1) high-water marks on or in various structures; (2) continuous recording tide gages; (3) crest gages; and (4) portable surge gages. The following paragraphs contain a description of each method.

High-water Marks

On 12 August, four teams of hydrologists were dispatched to specific areas where flooding had been reported in the coastal area of south Texas. The primary function of each 2-man team was to identify reliable high-water marks, and adequately mark, photograph, and describe the location for surveyors to establish the elevation. High-water marks must be set as soon after the flood event as possible, because additional rain or clean-up operations often destroy water marks and debris lines. Later the District survey parties established the elevations of the high-water marks, and this information was used in plotting flood profiles and in the delineation of flood plains. The flood plains developed from data collected during Hurricane ALLEN are shown in Attachment 1.

Tide Gages

The Galveston District has 43 continuous-recording tide gages located at various locations along the Texas coast and connecting bays. The motion of a float, which is triggered by the rise and fall of the water-surface elevation, moves a pen across a clock-driven chart, thus producing a water height-time relationship referred to as a hydrograph. The float well, usually about 12 inches in diameter, has small openings to dampen out the effects of waves. The instruments are mounted at elevations nearing 20 feet so that they will be above the surge and most of the wave attack during severe storms. Because they are mounted so high, even with substantial bracing, the high winds and strong waves cause significant vibrations on the instruments and often cause the instruments to fail. However, those instruments that were operational throughout the storm provided a continuous record. Attachment 2 contains tabulated hourly tide heights from the continuous-recording tide gages for the period 8-11 August 1980. Figure 3 shows their locations and identifies the peak recorded by each gage.

Crest Gages

About 60 crest-type gages have been located throughout the District. These gages are "homemade" and have no complicated internal parts; however, they have proven to be very effective in recording peak surges. Each gage consists of a 2-inch

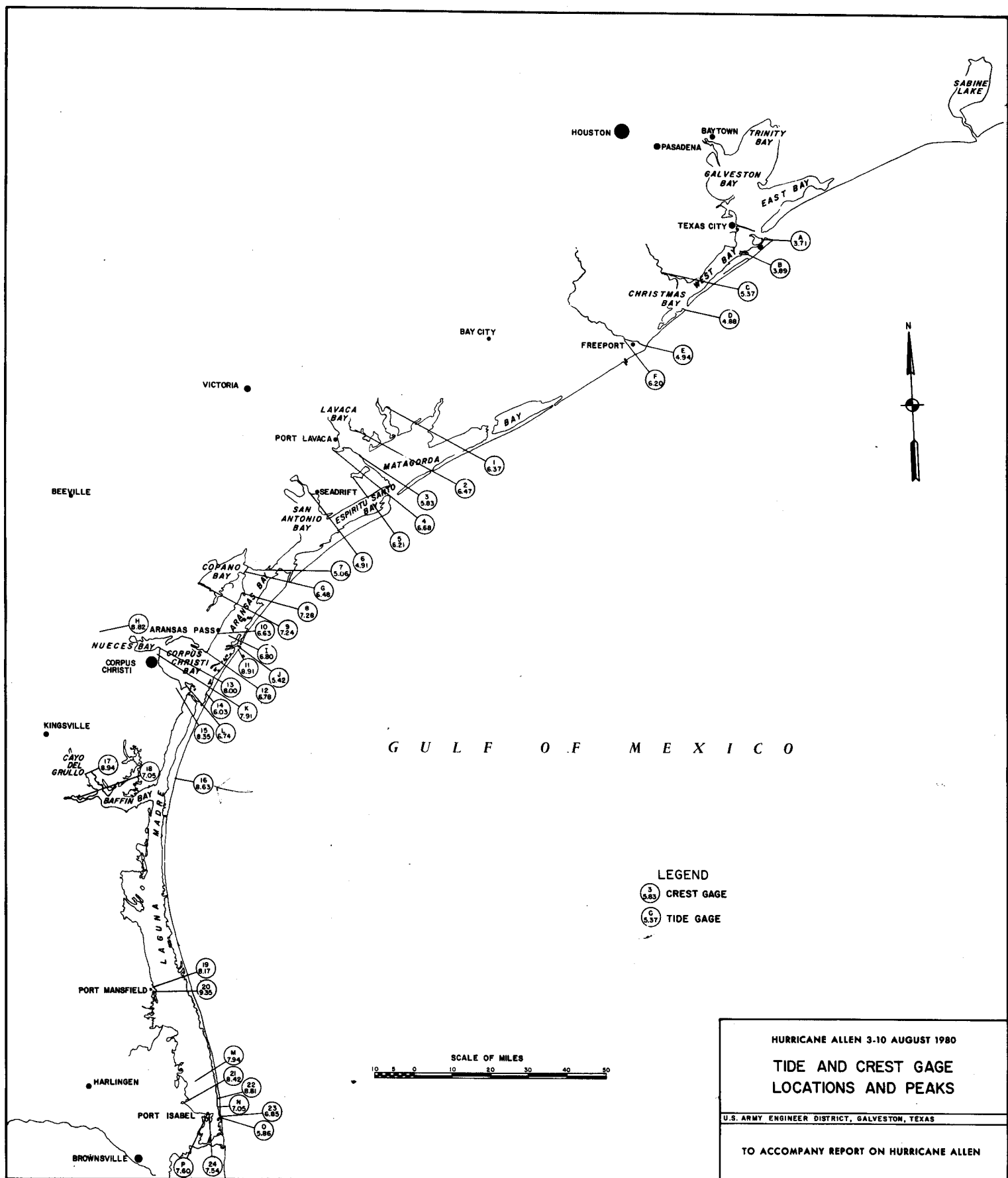


FIGURE 3

galvanized pipe with a cap on each end. Both caps have two, 1/4-inch holes through the sides. The bottom cap has a piece of screen wire on which a small amount of powdered cork is put. Just above the bottom cap a small bolt is placed through the pipe. A stick, approximately 3/4" x 3/4", is pre-cut to the exact length from the bolt to just inside the top cap when tightened. The assembled pipe is then attached to an available stable structure, such as a telephone pole, piling, etc. The principle involved is that as the water rises, the cork floats, and as the water recedes, particles of cork remain on the stick, much like a bathtub ring. After the storm, the top cap is unscrewed, and the height that the cork rose on the stick is measured and added to the elevation of the bolt to obtain the surge elevation. The small holes dampen out the effect of waves. Crest gage data from various locations along the coast are shown in Table 2, and are also shown on Figure 3.



Crest Gage

TABLE 2
HURRICANE ALLEN
3-10 August 1980
CREST GAGE DATA FROM VARIOUS LOCATIONS
ALONG THE TEXAS COAST

<u>Gage No.</u>	<u>Location</u>	<u>Peak Elevation in Feet Above Mean Sea Level</u>
1	Carancahua Bay	6.37
2	Point Comfort	6.47
3	Magnolia Beach	5.83
4	Chocolate Bay	6.68
5	Powderhorn Lake	6.21
6	Long Mott	4.91
7	Goose Island	5.06
8	Rockport	7.28
9	Copano Bay	7.24
10	Aransas Pass	6.63
11	Port Aransas	8.91
12	Port Ingleside	6.78
13	North Beach	8.00
14	Mustang Island	6.03
15	Oso Bay	8.35
16	North Padre Island	8.63
17	Cayo Del Grullo	8.94
18	Laguna Salada	7.05
19	Port Mansfield North	8.17
20	Port Mansfield South	9.35
21	Bayview	8.42
22	Andy Bowie Park	8.81
23	Brazos-Santiago	6.85
24	East Port Isabel	7.54

Surge Gages

The Galveston District has 6 portable surge gages. Eight traverse lines with 3 permanent surge gage supports on each line have been established at several locations along the Texas coast shown on Figure 4. Several hours prior to arrival of ALLEN's storm surge, a two-man team from the District was dispatched to install portable surge gages on the supports of the traverse lines in the predicted landfall area. Two gages each were installed on the most Gulfward supports at Port Mansfield, Aransas Pass, and Indianola. After the storm the gages were retrieved and the data collected and analyzed. The data are used to document the time-elevation relationship of the onshore wind generated surge level as it moves inland. Unlike the tide gages, the portable surge gages are placed on land and just above the ground surface. They record the hydrostatic pressure or depth of water over the gages. They depend on battery power to run the complex instrumentation and to drive the chart paper. Surge gage locations and hydrographs plotted from the data collected for three sites along the middle and lower Texas coast are shown in Figure 5.

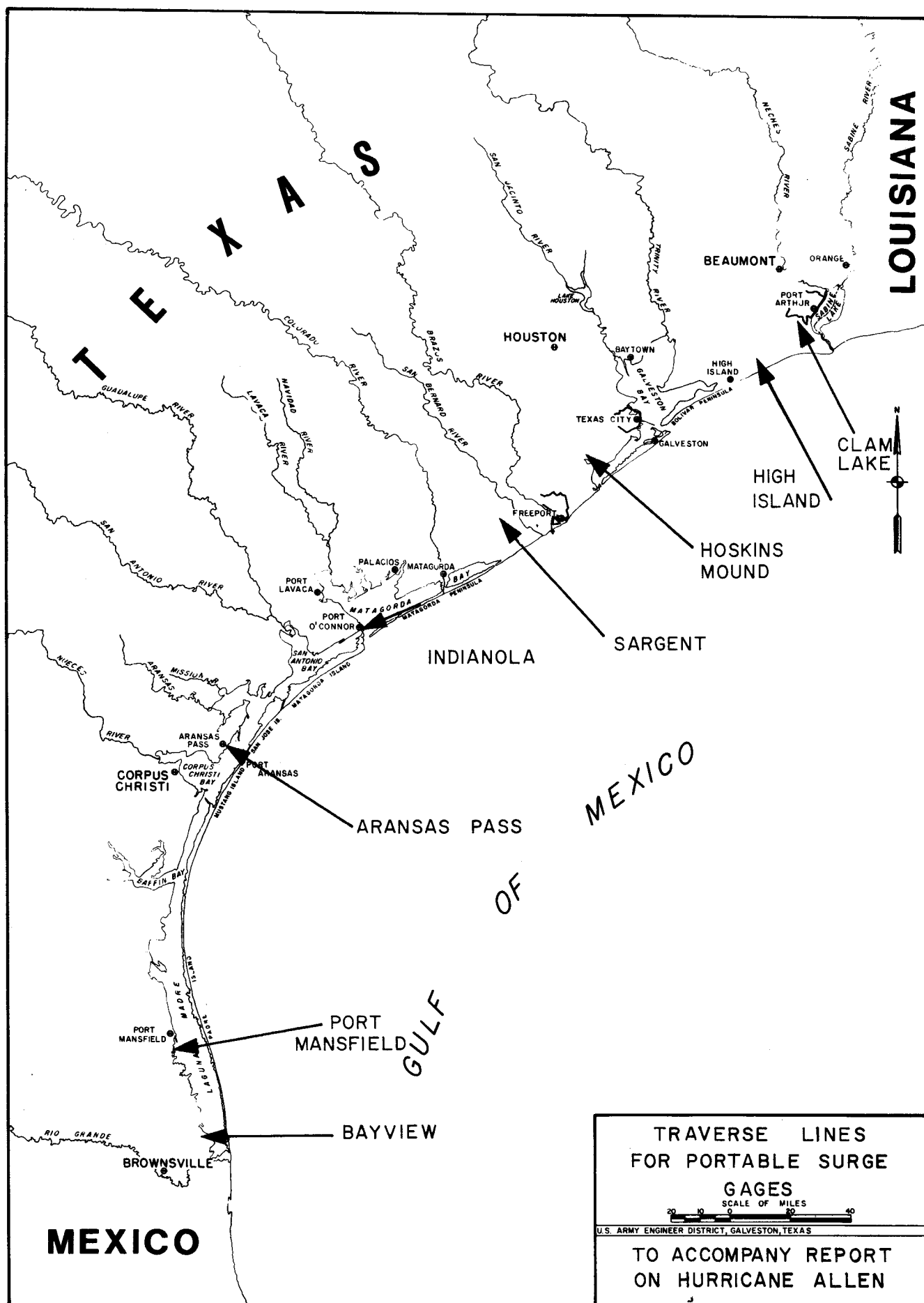
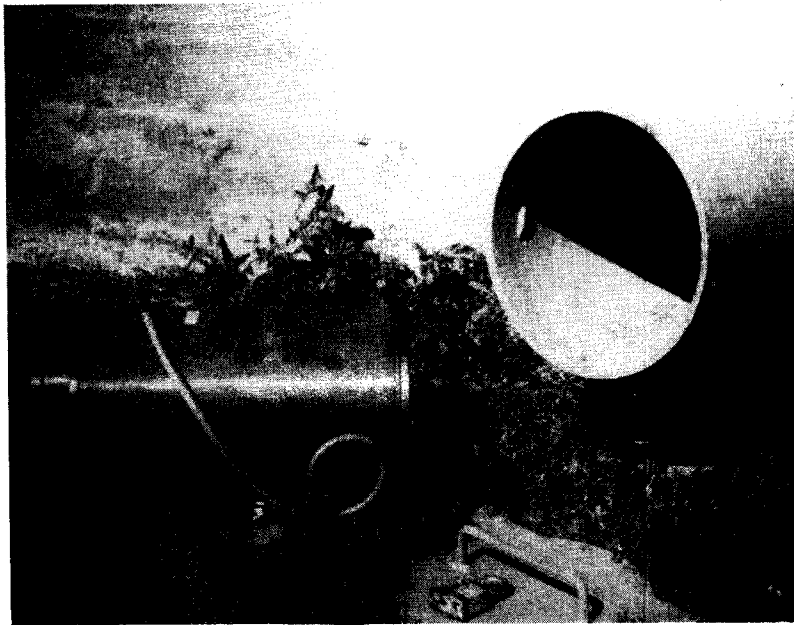


FIGURE 4



Surge Gage



Surge Gage

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STORM DAMAGE DATA COLLECTION

The damage data were collected by nine, two-man teams over a period from 12 through 15 August. Each team was assigned a specific area to estimate flood damages. These estimates included damages to residences, commercial establishments, schools, churches, summer homes, recreation buildings, and public buildings. The damage survey involved describing the location of the property, estimating the property value, identifying the type of structure, and determining the depth of inundation. Periodic checks were made with property owners on inundation depths and property values, particularly with specialized businesses.

The relative value of the residential structures in the flooded areas was determined by consulting developers and real estate agents in each area. Gross appraisals of damage were made by driving through the affected areas and recording the property values and the depths of flooding. Depth-damage relationships for various types of structures, previously developed by Galveston District staff, were used to estimate the damages to the structures and their contents. The values of commercial properties were evaluated in the field through the use of a previously developed schedule of values for the different types and sizes of commercial establishments. The procedure described provides a reasonably accurate evaluation of damages within a short time and with a minimum of manpower.

Since the area affected by ALLEN was so large, all areas could not be covered by the field surveys. The field surveys were conducted where damages were concentrated and supplemented by data from other sources. These sources included telephone contacts with other Federal agencies such as the Federal Emergency Management Agency (FEMA), state agencies, county representatives, city officials, and industry representatives.

EVALUATION OF DAMAGES

The damages resulting from Hurricane ALLEN were from wind, rain, and storm surge. No differentiation of these three factors has been attempted because of the numerous judgments that have to be made, particularly in the coastal area directly in the storm path. For example, if there was total destruction or significant damage to a structure located on the barrier island or very near the coast, trying to assess the percentage of the damage caused by wind and the percentage caused by the surge and waves is strictly conjecture. Generally, it can be said that the damages which are incurred in a narrow band along the Gulf or bay shorelines and near the point of landfall of the storm will be caused principally by the storm surge and accompanying waves and by wind.

Damages to other properties along Gulf and bay shorelines some distance from the point of landfall, particularly to the left side of the storm track, are caused by the abnormal rise of the water surface (inundation damages) with some damages from waves. Properties outside of the hurricane flood plain could still be susceptible to wind damage and flood damage caused by excessive rainfall amounts. Other areas some distance from the storm path could be affected indirectly by the hurricane from tornadoes and extreme rainfall amounts.

A precise estimate of the total storm damages will never be known. In addition to the inherent inaccuracies with any estimate of this nature, variables such as decreased crop quality and unknowns such as structures which may have been weakened by the storm, cannot be accurately assessed.

In this report, the damages from ALLEN have been categorized by property damage, agricultural damage, and recovery and assistance.

PROPERTY DAMAGE

Property damages have been divided into residential, commercial, industrial, vehicular, marine, roads and highways, and utility damage. Residential structures were damaged during ALLEN from storm surge, waves, rainfall, and wind. These structures included conventionally constructed wood frame, brick, and brick veneer permanent dwellings; condominiums; high-raised summer homes; and mobile homes.

The damages ranged from a few shingles being blown off to total destruction. Some structures near the bay or Gulf shorelines had some undermining from the erosive forces of waves, while other structures farther inland had up to four feet of water in them. Several mobile homes were overturned and others were damaged or destroyed by wind and surge often containing debris.

Total residential damages were estimated to have amounted to \$43.8 million. Nueces, Hidalgo, and Cameron Counties sustained the majority of the residential damages; however, residential damages were recorded in Kleberg, Aransas, Willacy, Jim Wells, and Kenedy Counties.



Undermining Damage - Port Isabel



Residential Damage - Arroyo City



Residential Damage - Elsa



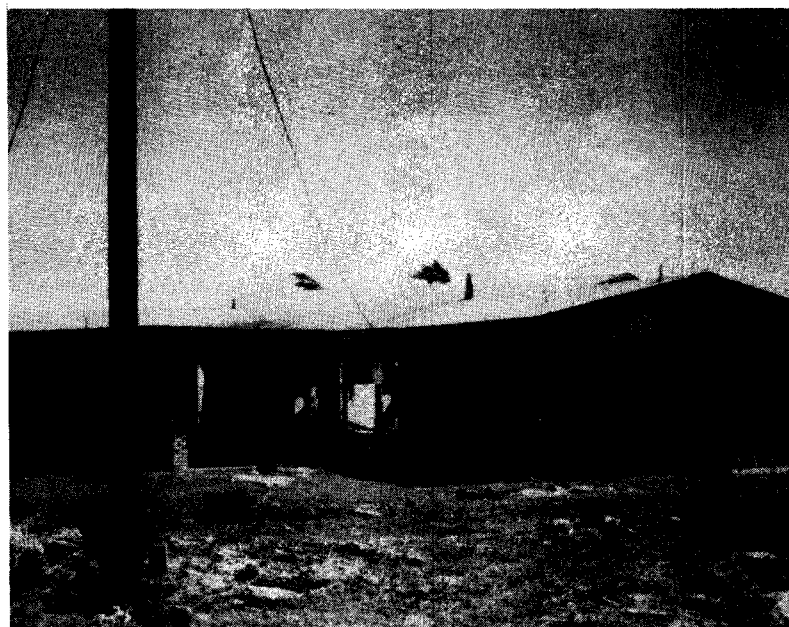
Residential Damage - Port Isabel



Residential Damage - Port Mansfield



Residential Damage - Port Mansfield



Residential Damage - Port Mansfield



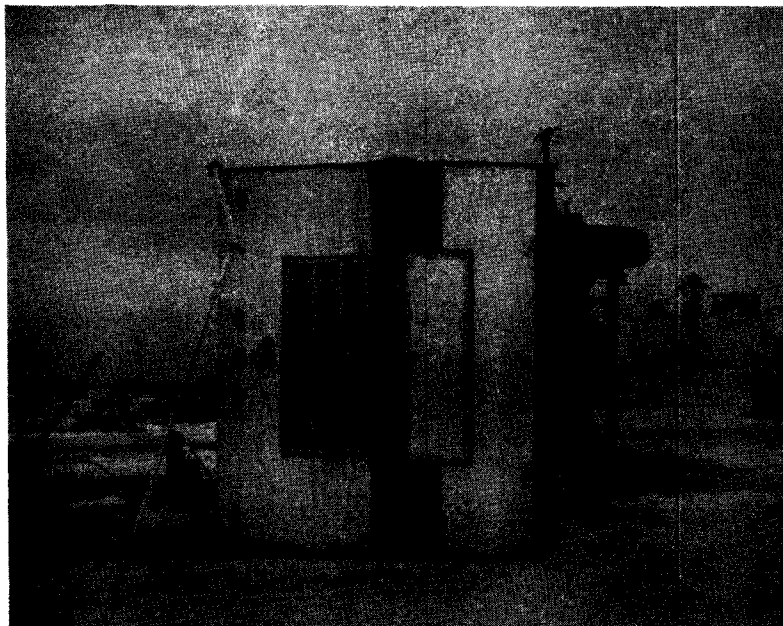
Residential Damage - Port Mansfield



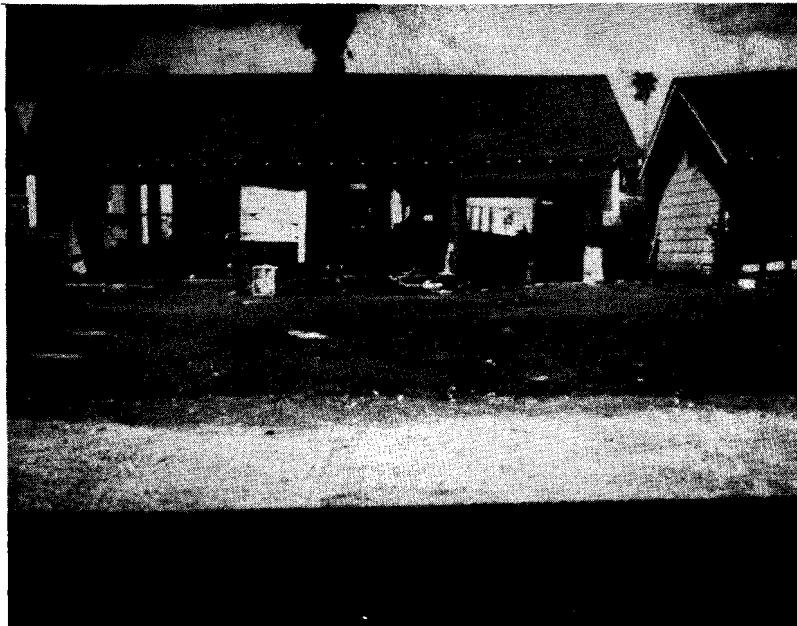
Residential Damage - Port Mansfield



Residential Damage - Port Mansfield



Residential Damage - South Padre Island



Residential Damage



Residential Damage

Commercial properties included retail, wholesale, and service buildings; hotels and motels; and restaurants. Structural damages to commercial properties were somewhat similar to residential damages in that they were also caused by the same destructive forces of the hurricane. The storm surge and waves probably caused most of the damages to commercial properties followed by wind and then rainfall. In addition to structural damages, commercial damages also involved the loss of merchandise and stock items, machinery damage, and unrecoverable business losses.

Total commercial damages were estimated to be \$66.2 million. Major commercial damages occurred in Cameron, Nueces, Aransas, and Hidalgo Counties with commercial damages of a lesser degree in Willacy, Jim Wells, San Patricio, and Kleberg Counties.



Commercial Damage - Corpus Christi



Commercial Damage - North Padre Island



Commercial Damage - Port Mansfield

Industrial damages or losses from ALLEN involved structural damages to petrochemical plants and associated equipment, nonrecoverable production losses, additional manpower requirements to "shut-down" and reestablish production, and emergency personnel required during the hurricane. The majority of the losses involved the tremendous costs for "shutdown" and "start-up" procedures at the various refining and chemical plants. Shutdowns occurred from the lower coast to several in the Galveston Bay area. This was necessitated because of the relatively rapid forward speed of ALLEN, the uncertainty of the point of landfall, and the 24 hours needed to effect shutdown status at several of the plants. At least a like amount of time would be required to get the plant back "on-line" and usually requires more time than for shutdown to attain proper functioning of the complex units. Total industrial losses were estimated at \$8 million.

Heavy losses were also sustained by the oil companies and the many contractors servicing their offshore production and explorational activities. Estimates as high as \$30 million were reported but were not confirmed and are therefore not included in the estimates of industrial damages contained in this report. These losses were from damages to the offshore rigs, cost of securing the platforms prior to arrival of the storm, production losses, evacuation of personnel, and the loss of several lives.



Industrial Damage - Port Mansfield

There were approximately \$3 million in vehicular damages throughout the south Texas area. An actual count of vehicles damaged was not made.



Vehicle Damage - Port Isabel

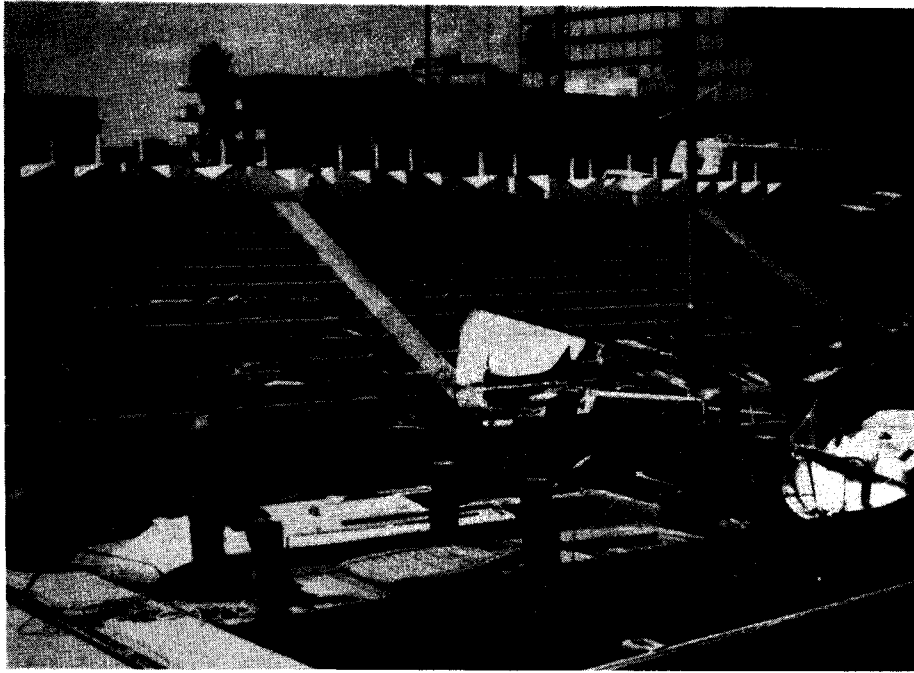
Marine damages included damages sustained to both private and commercial vessels and to facilities which house them. Private vessels included powerboats, yachts, sailing craft, and fishing boats. Commercial vessel damage was not significant as most sought refuge up various waterways along the Texas coast for protection from the wind and large waves. The damage to commercial craft was primarily to shrimp boats.

Three incidents involving large tankers occurred as a result of ALLEN. One tanker lost power and finally ran aground off of

Mustang Island. Another tanker, also trying to enter the Corpus Christi Ship Channel, ran aground off of the Aransas Pass Jetties. A third tanker ran aground while trying to enter the Matagorda Ship Channel. None of the incidents involved spillage or major damage to the vessels. Total marine damages were approximately \$4 million.



Ship Aground Off Port Aransas Jetty



Marine Damage - Corpus Christi Yacht Basin



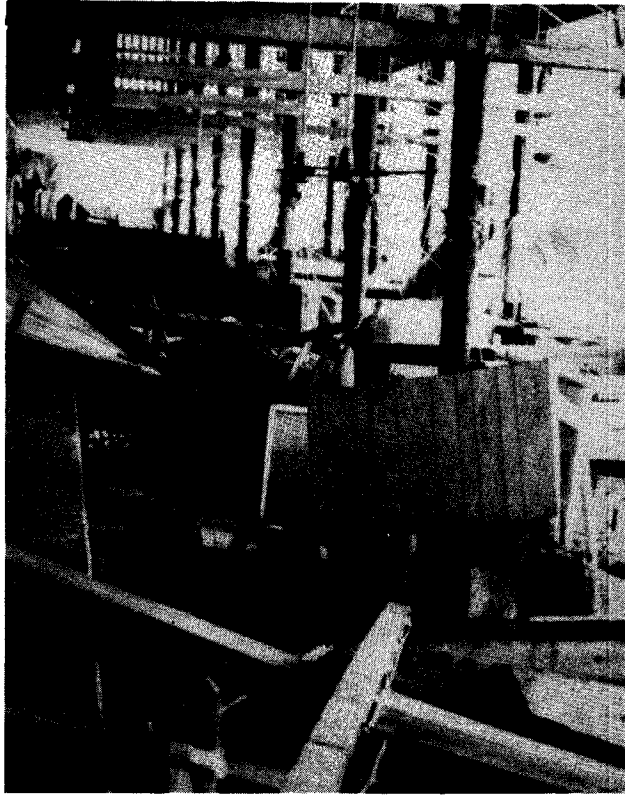
Marine Damage - Corpus Christi Yacht Basin



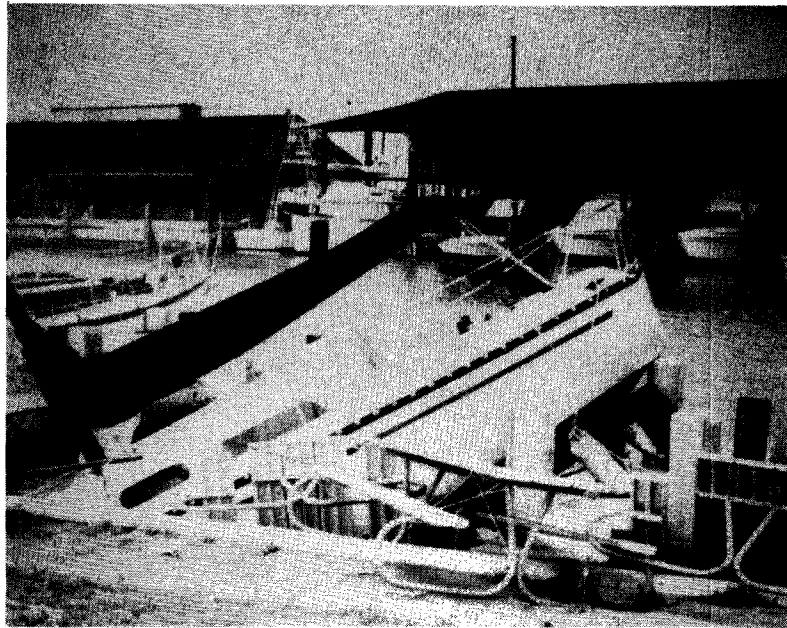
Marine Damage - Corpus Christi Yacht Basin



Marine Damage - Port Mansfield

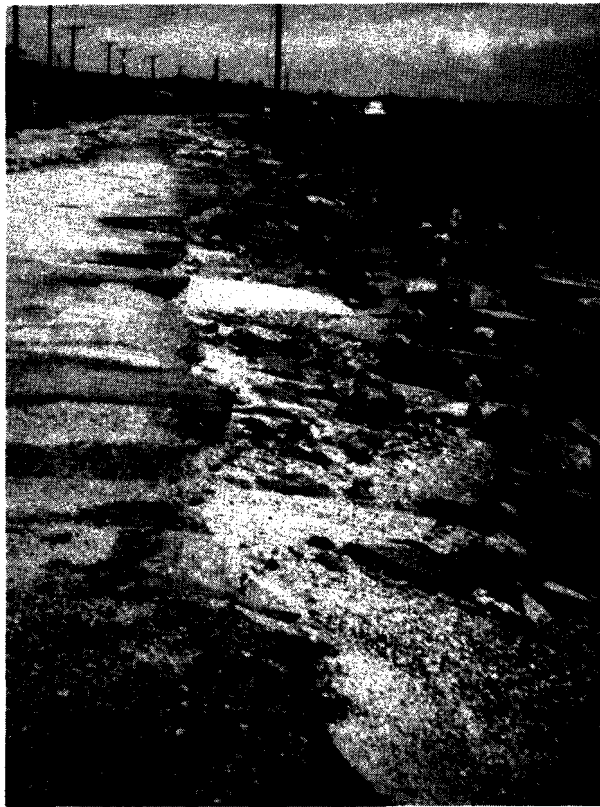


Marine Damage - South Padre Island

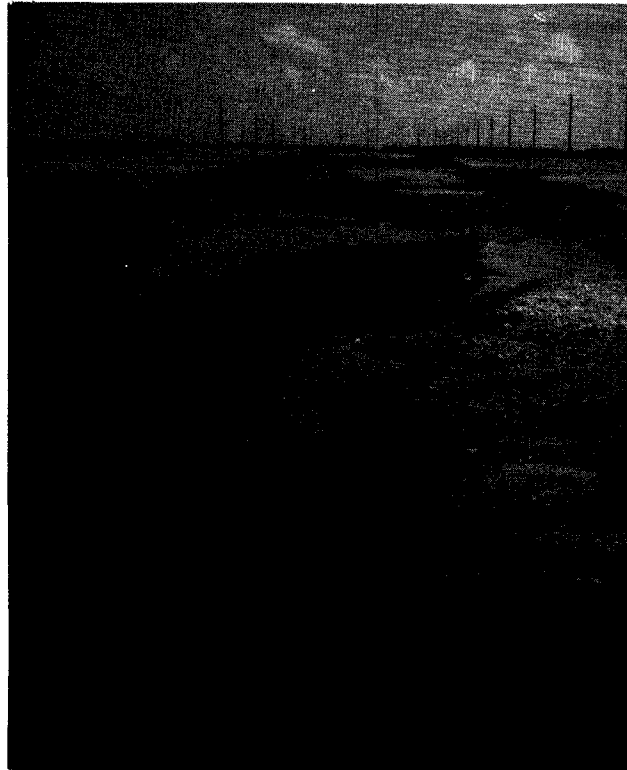


Marine Damage - South Padre Island

Road and Highway damages were most significant on the barrier islands or near the Gulf shore. These damages were caused by the erosive forces of the large waves as the barrier islands were breached or became inundated. The roadways most affected were on south Padre Island, Mustang Island, and along the Gulf shore between High Island and Sabine Pass on the upper Texas coast. Other highways and state, county, and private roads were also damaged.



Road Damage - Fulton Harbor



Road Damage - Mustang Island



Road Damage - Mustang Island

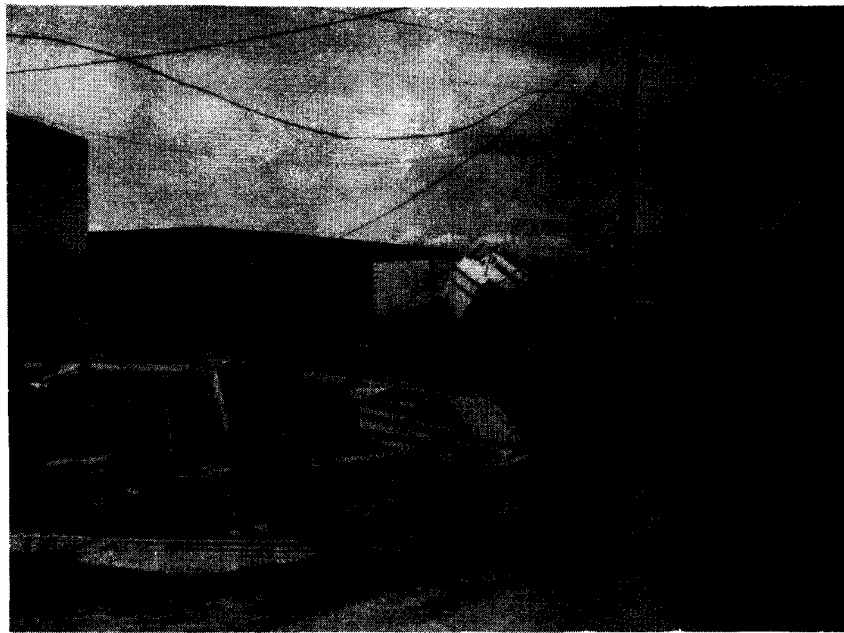


Road Damage - Mustang Island



Road Damage - Mustang Island

Utility damages were common throughout south Texas with downed power and telephone lines. Power outages occurred in an area roughly bounded by the triangle formed between Corpus Christi, Brownsville, and Laredo. The Central Power and Light Company estimated that 150 transmission structures and 900 distribution poles had been downed by the storm. Falling trees and flying debris also damaged many service wires. Repair crews were sent from various parts of the state immediately following the storm to restore power and telephone service to the valley. Utility damages were estimated at \$8 million.



Downed Power Lines - Port Isabel

Total property damages from ALLEN from the categories of residential, commercial, industrial, vehicular, marine, roads and highways, and utilities amounted to approximately \$139 million.

AGRICULTURAL DAMAGES

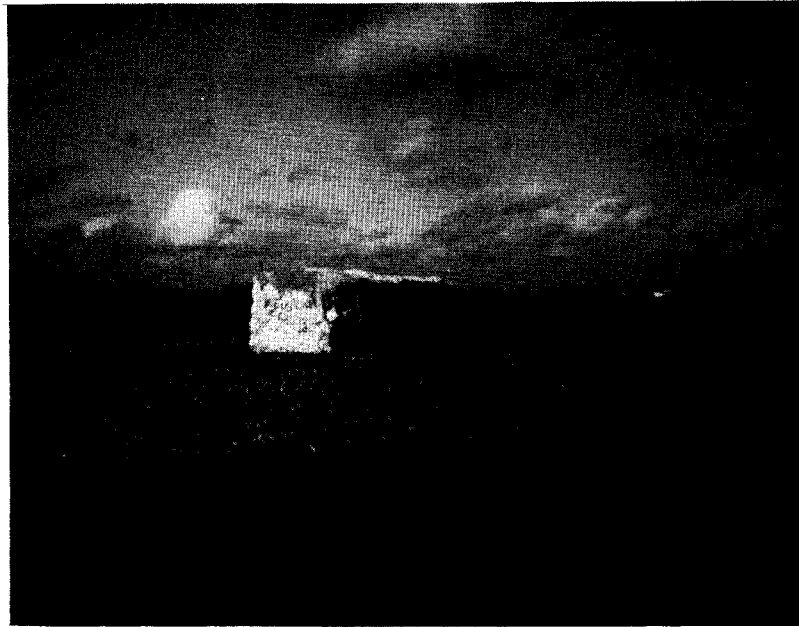
Information on damages to agricultural crops, livestock, farm buildings, and farm machinery was furnished by the Texas Agricultural Extension Service in Bryan and the State Department of Agriculture in Austin. Farmers and ranchers in San Patricio, Nueces, Kleberg, Kenedy, Willacy, Cameron, and Hidalgo Counties incurred substantial losses to their crops and livestock as a result of the violent winds and rains accompanying ALLEN. Hardest hit in the seven-county area were the cotton farmers. Several thousand acres of cotton that had been harvested and left in modules in the low-lying fields were subjected to the rains and in some cases floodwaters. The cotton was salvageable for the most part, but the cotton's quality, and in turn the market price, were reduced substantially.

Citrus growers were also hard hit by ALLEN's winds and driving rain. Oranges and grapefruits littered acres of the orchards. The sugar cane crop and other vegetable crops were severely damaged or lost. Farm machinery and farm building losses were also substantial. Table 3 is a tabulation of the losses incurred by the farmers and ranchers in south Texas. Estimates provided on losses to farm homes were not included in the estimates of agricultural damages to avoid duplication of estimates of residential property damage.

TABLE 3
AGRICULTURAL DAMAGES
CAUSED BY ALLEN

<u>Item</u>	<u>Number of Acres Affected</u>	<u>Damages</u>
Cotton	74,700	\$28,700,000
Citrus	78,000	26,700,000
Sugar Cane	31,600	9,000,000
Vegetables	2,800	2,200,000
Livestock	not applicable	1,600,000
Other*	not applicable	<u>13,800,000</u>
TOTAL Agricultural Damages		\$82,000,000

* Includes damages to other crops, farm buildings, and farm machinery.



Agricultural Damage - Loyola Beach



Agricultural Damage - Sarita

RECOVERY AND ASSISTANCE

Major items discussed in this section of the report are evacuation costs, emergency dredging, other recovery operations, and temporary housing. About 950,000 people left the low-lying Texas coastal area ahead of ALLEN. The estimated cost of the evacuation amounted to nearly \$41 million. This included transportation, food, and lodging costs. These costs were all borne by the individual families. Although it can be argued that these costs are not directly recovery and assistance costs, for purposes of this report they have been included in this major category. In any event, the evacuation costs were significant and were a direct result of ALLEN.

ALLEN caused significant shoaling problems in at least five areas along the Texas coast. The channels affected included Freeport Channel, Matagorda Ship Channel, Corpus Christi Ship Channel, Port Mansfield Channel, and a 5-mile reach of the Gulf Intracoastal Waterway between Corpus Christi and Brownsville. The 45-foot Corpus Christi Ship Channel had shoaled to 30 feet, the 38-foot Matagorda Ship Channel had shoaled to 28 feet, and a section of the Gulf Intracoastal Waterway with a project depth of 12 feet had shoaled to 3 feet, stopping all traffic between Brownsville and Corpus Christi. Two government-owned seagoing hopper dredges were brought in to open the shipping lanes. Emergency dredging contracts were awarded to private

companies with pipeline dredges to restore the shallow-draft channels to project depths. Approximately \$14.4 million was expended on emergency dredging operations. Other recovery operations included debris clearance; reimbursement for emergency protection measures to local entities for protection of life and property; repair and restoration of public-owned dikes, levees, irrigation works and drainage facilities, and repair and restoration of public-owned parks and recreation facilities. These costs amounted to approximately \$14.2 million. There were 120 mobile homes setup and 130 travel trailers with complete utility hookups provided for residents requiring temporary housing. Costs for providing the temporary housing amounted to approximately \$5.5 million.

SUMMARY

Hurricane ALLEN was one of the most intense hurricanes ever to develop in the Atlantic. ALLEN set at least one record for low pressure within the eye of the storm and had several other characteristics which were unique. As ALLEN moved through the Caribbean Sea, the central pressure of 26.55 inches of mercury was the lowest ever recorded in the western Caribbean Sea and the second lowest in the Atlantic, Caribbean, and Gulf of Mexico. The intensity of the storm was exceeded only by the 1935 Hurricane which struck Florida and had a central pressure of 26.35 inches of mercury.

ALLEN was unique in that the center of the storm appeared to weave in and out and around the various islands and landmasses in the Caribbean. While doing this, an almost constant forward speed of 20 miles per hour was being maintained. Had the big storm maintained its size and intensity and hit the Texas coast full force, those who, in retrospect, thought that evacuation was a wasted effort may now be reflecting on what a wise and lifesaving decision the evacuation effort was. There are always a lot of "ifs" associated with hurricanes.

However, for many people ALLEN will not be remembered by the records set, its unique behavior, or its meteorological

characteristics, but as the time when almost everybody tried to flee the coastal area and became involved in one of the biggest traffic jams ever seen along the Texas coast. Trips were requiring from three to four times normal travel time. Many aspects of the evacuation such as overheated automobiles, short tempers, "no vacancy" signs, and other special happenings that occurred at the particular spot where you were "parked", will be remembered a long time.

ALLEN's damages were significant even though the intensity of the storm diminished substantially and it miraculously found its way ashore in the most unpopulated area of the Texas coast. Natural processes will continue to repair the scars left by ALLEN through the closing of the numerous washover channels and reestablishing dune systems; however, there is always a net loss of beach building materials either offshore or in the bays, which equates to a repositioned shoreline further inland. Local interest groups have made attempts to accelerate the natural dune-building processes. One example is the use of discarded Christmas trees to trap sand and reestablish the dune system.

Table 4 presents a summary of the various categories of damage discussed in this report. Property damages were estimated to be \$139 million; agricultural damages, \$82 million; and

recovery and assistance, \$75 million. This estimate, like all other estimates of damages from a major storm event, does not address items such as bulkhead damages, lost wages from private businesses, irreplaceable personal effects, etc. Therefore, total damages for ALLEN were conservatively estimated to be in excess of \$296 million.

TABLE 4
SUMMARY OF HURRICANE
ALLEN DAMAGES

PROPERTY DAMAGE

Residential	\$ 43.8 million
Commercial	66.2 million
Industrial	8.0 million
Vehicular	3.0 million
Marine	4.0 million
Roads and Highways	6.0 million
Utilities	<u>8.0 million</u>
TOTAL PROPERTY DAMAGE	\$139.0 million

AGRICULTURAL DAMAGE

Cotton	\$28.7 million
Citrus	26.7 million
Sugar Cane	9.0 million
Vegetables	2.2 million
Livestock	1.6 million
Other (Includes damages to other crops, farm buildings, and farm machinery)	<u>13.8 million</u>
TOTAL AGRICULTURAL DAMAGE	\$82.0 million

RECOVERY AND ASSISTANCE

Evacuation	\$40.9 million
Emergency Dredging	14.4 million
Other Recovery	14.2 million
Temporary Housing	<u>5.5 million</u>
TOTAL RECOVERY AND ASSISTANCE	\$75.0 million
TOTAL DAMAGES	\$296.0 million

ATTACHMENT 1

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ATTACHMENT 2

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