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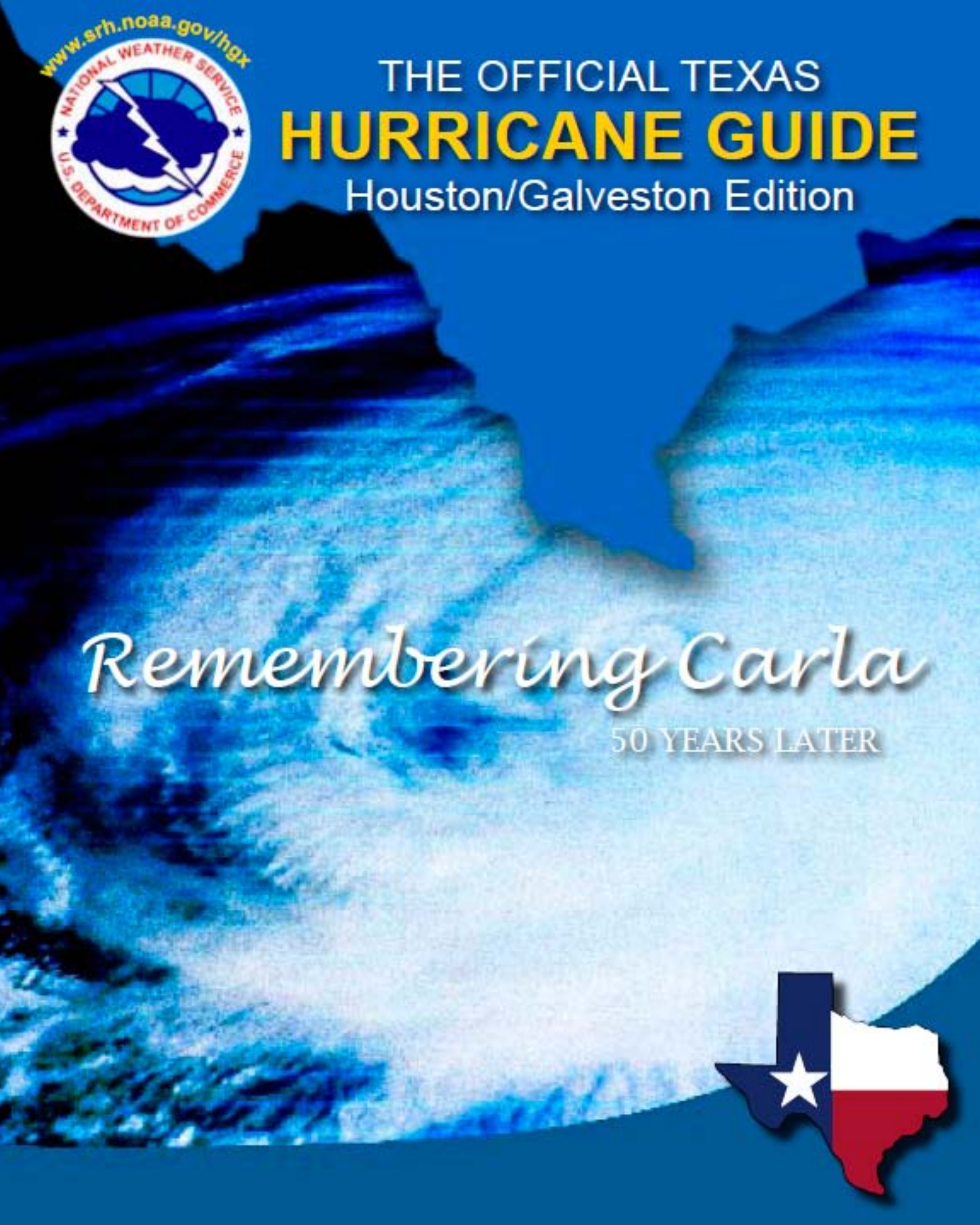
NATIONAL WEATHER SERVICE

U.S. DEPARTMENT OF COMMERCE

THE OFFICIAL TEXAS

HURRICANE GUIDE

Houston/Galveston Edition



Remembering Carla

50 YEARS LATER

Introduction

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Welcome to the 2011 Houston/Galveston Area Annual Hurricane Workshop. The purpose of our workshop is to increase public awareness of the hurricane hazards for our area and to give citizens useful information on how to prepare for and respond to a land falling hurricane.

The theme for the 2011 workshop is Tropical Milestones. We will be remembering storms from our past such as Hurricane Carla, with the 50th anniversary this year, and Tropical Storm Allison's 10th anniversary. Do we remember the lessons learned from these storms? Hurricane Carla was one of the largest hurricanes in history to strike the Texas coast, and at the time, led to the largest peacetime evacuation to take place in the United States. Carla had all the hazards a hurricane can bring including wind, rain, storm surge and even tornadoes. In Galveston 6 people were killed by a F4 tornado that was spawned by Carla. Only 10 years ago Tropical Storm Allison impacted all of southeast Texas with copious amounts of rainfall. Allison was the deadliest and costliest Tropical Storm ever to strike the United States with 43 deaths and over $5 billion dollars in damages. The workshop will communicate the many lessons learned from Hurricane Carla, Allison and the more recent Hurricane Ike.

CenterPoint Energy and the City of Houston have created a private/public partnership to assist the Houston/Galveston National Weather Service (NWS) in conducting the annual Houston/Galveston Hurricane Workshop for the last 6 years. In 2010, over 3000 citizens from throughout southeast Texas attended the event and we are expecting an even larger attendance for this year's workshop. In fact a free lunch is being provided for the first 2000 guests.

In 2011, we will continue to expand our efforts to make this workshop an event for the whole family. The kid's area will return for the fifth straight year and will be larger and more interactive. The workshop will be more engaging, with numerous opportunities to ask questions of the experts who are present. All activities will take place in one central location, making it easier to move from one venue to the next.

Our special guest this year will be Mr. Bill Read, the former Meteorologist-in-Charge of the Houston/Galveston NWS, and now the Director of the National Hurricane Center (NHC). Bill will inform the citizens of southeast Texas on some new products that will be available from the NHC in 2011 as the forecasts continue to become more accurate.

We believe you will find the workshop informative and helpful. Thank you for attending.

Sincerely,

Gene Hafele
Meteorologist in Charge
National Weather Service Houston/Galveston

About the Hurricane

Hurricanes form over warm ocean waters, like those found in the Gulf of Mexico. The hurricane season starts June 1 and ends November 30. The peak threat for the Texas coast exists from August through September. However, hurricanes can and have struck the Texas coast during every month of the hurricane season.

***Left**: High resolution satellite image of Hurricane Ike over the northwest Gulf of Mexico. Image--NASA*

*Since 1851, 63 hurricanes have struck the Texas coast. That is **one every three years** on average.*

Definitions to Know

TROPICAL DEPRESSION: An organized system of persistent clouds and thunderstorms with a closed low-level circulation and maximum winds of 38 mph or less.

TROPICAL STORM: An organized system of strong thunderstorms with a well defined circulation and maximum sustained winds of 39 to 73 mph.

HURRICANE: An intense tropical weather system with a well defined circulation and sustained winds of 74 mph or higher.

TROPICAL CYCLONE: A general term used to describe a tropical depression, tropical storm, or hurricane.

HURRICANE/TROPICAL STORM WATCH: Hurricane or Tropical Storm conditions are possible in the watch area within 48 hours.

HURRICANE/TROPICAL STORM WARNING: Hurricane or Tropical Storm conditions are possible in the warning area within 36 hours.

Saffir Simpson Hurricane Wind Scale

- Category 1 Winds 74 to 95 mph
- Category 2 Winds 96 to 110 mph
- Category 3 Winds 111 to 130 mph
- Category 4 Winds 131 to 155 mph
- Category 5 Winds greater than 155 mph

http://www.nhc.noaa.gov/aboutsshws.shtml

Storm Surge

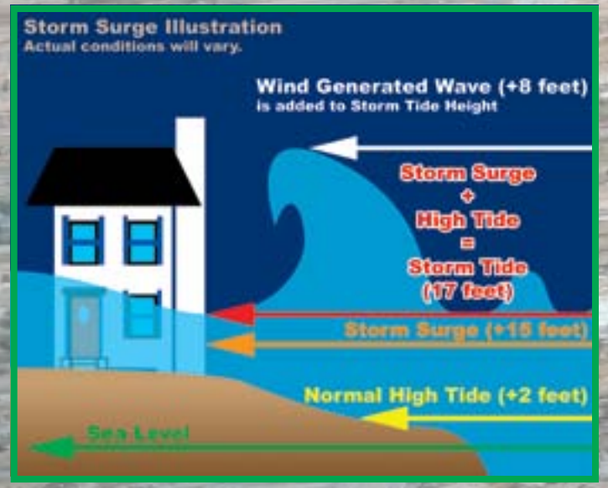
Storm surge is a large dome of water that sweeps across the coastline. The surge is greatest along and to the right of where the eye makes landfall and occurs generally where the highest wind speeds are located in the eye wall. Higher storm surge is correlate with stronger hurricane winds and larger hurricanes. Storm surge poses the greatest threat to life and property for coastal communities. Ninety percent of hurricane fatalities are related to the storms surge.

Some Damage Photos From the Storm Surge from Hurricane Ike

Home flooded by the storm surge from Hurricane Ike in Bridge City, TX. -- TX DPS

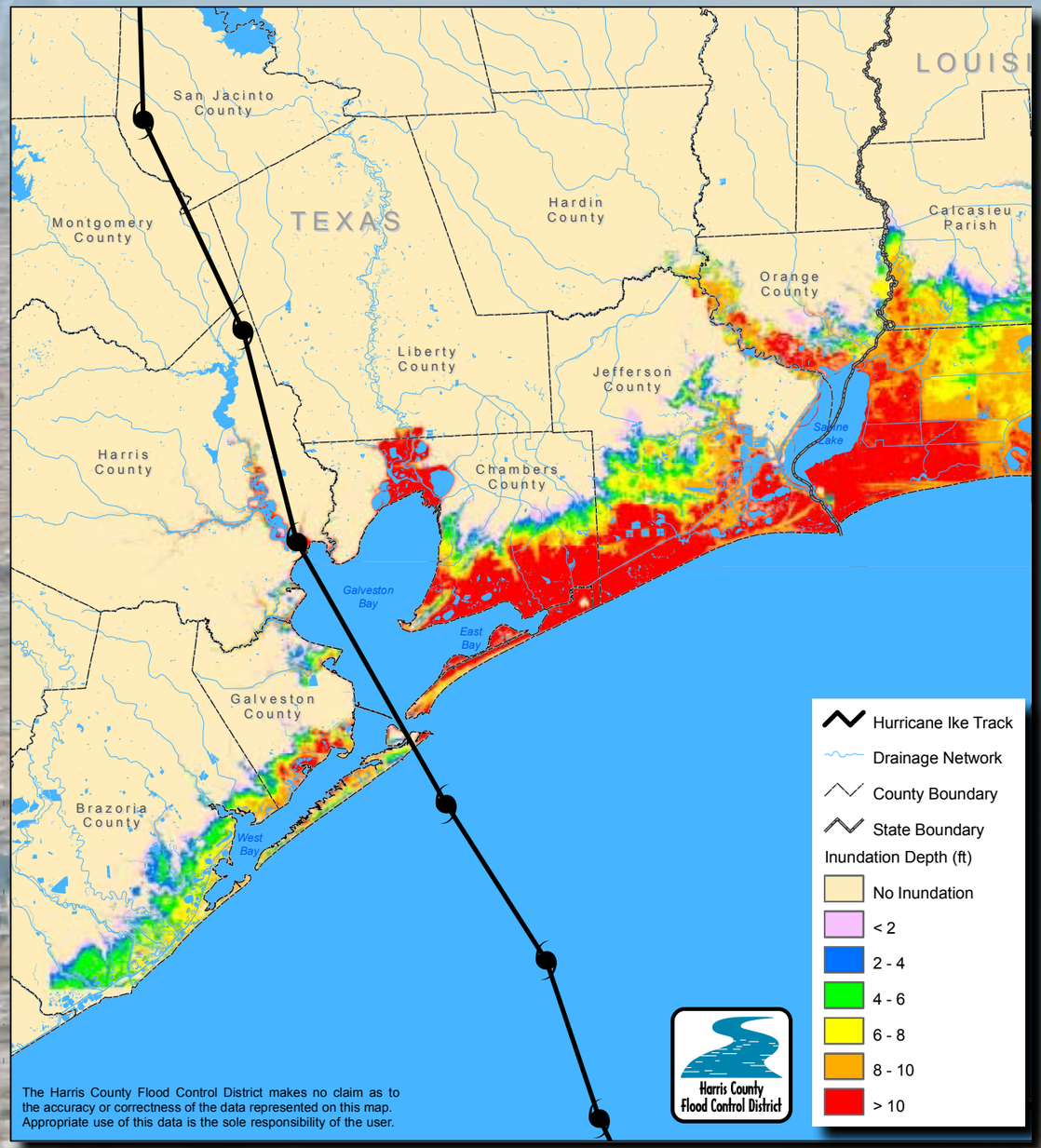
Home destroyed by storm surge from Hurricane Ike near Caplen, TX.

Computer simulations of a major hurricane landfall clearly show the huge impact a storm surge could have on a low lying coastal community for varying surge values. For Hurricane Ike, surge values were generally 10 to 15 feet over Galveston Island and along the western shore of Galveston Bay, and 14 to 18 feet across the Bolivar Peninsula and Chambers County, leading to widespread damage.



At least 12 people lost their lives, mainly on the Bolivar Peninsula, due to the storm surge. To avoid losing your life in surge prone areas, it is important to evacuate inland well before the hurricane strikes, when advised to do so by local officials.

Hurricane Ike Inundation



Inland penetration of the storm surge associated with Hurricane Ike showing depth of water above ground level.

Zip Zone Evacuation

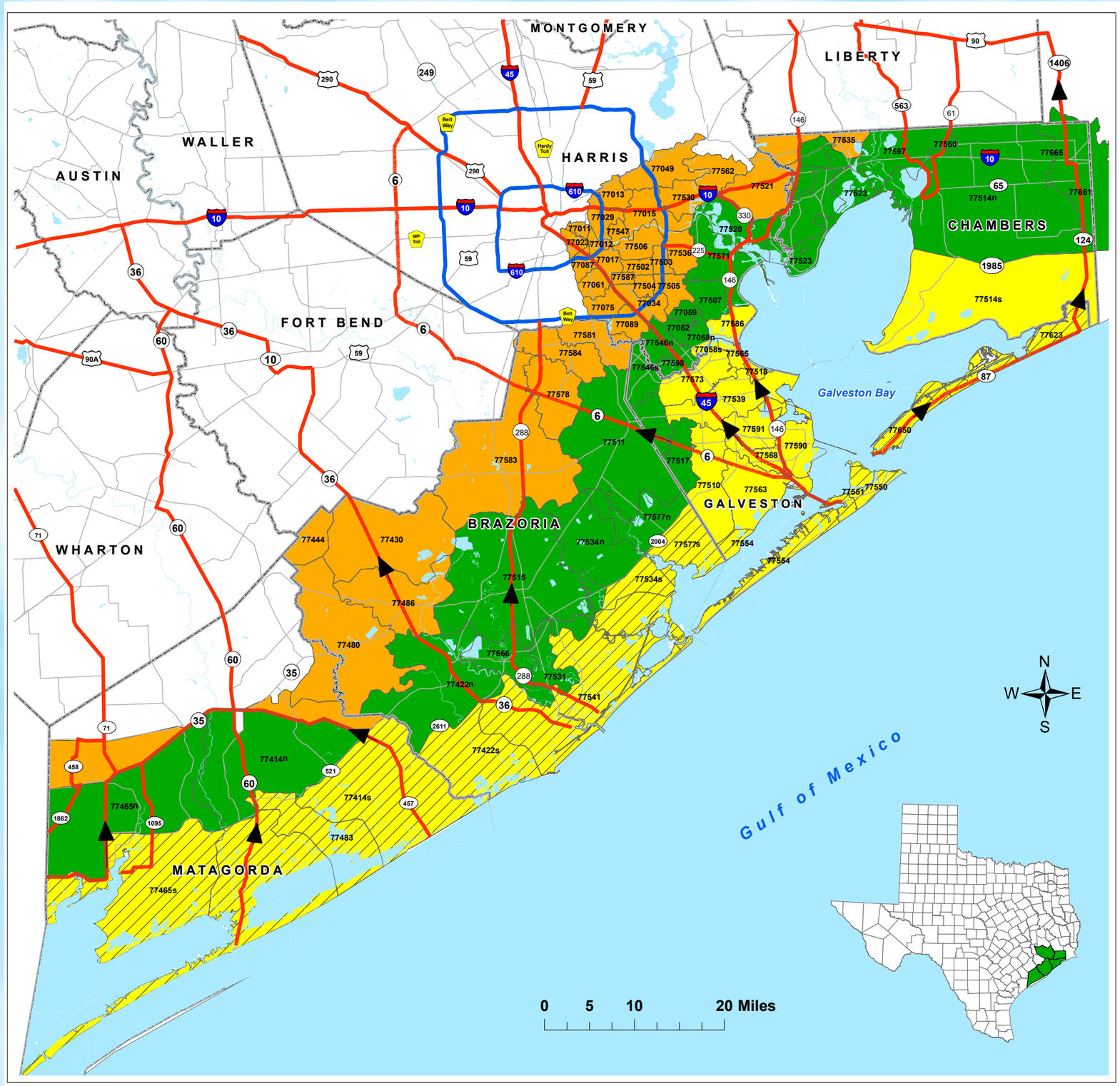
Brazoria, Chambers, Galveston, Harris and Matagorda Hurricane Evacuation Zip-Zones Coastal, A, B, C

Zip-Zone Coastal				
77414s	77483	77550	77577s	77650
77422s	77534s	77551	77617	
77465s	77541	77554	77623	
Zip-Zone A				
77058s	77518	77565	77586	
77510	77539	77568	77590	
77514s	77563	77573	77591	
Zip-Zone B				
77058n	77507	77522	77560	77661
77059	77511	77523	77566	77665
77062	77514n	77531	77571	
77414n	77515	77534n	77577n	
77422n	77517	77546n	77597	
77465n	77520	77546s	77598	
Zip-Zone C				
77011	77034	77444	77505	77562
77012	77049	77463	77506	77578
77013	77061	77480	77521	77581
77015	77075	77486	77530	77583
77017	77087	77502	77535	77584
77023	77089	77503	77536	77587
77029	77430	77504	77547	

Route Designation

- Evacuation Corridors
- Evacuation Connections
- Other Roads
- County Boundary

Expiration Date December 2011
Map Created by:
©Houston-Galveston Area Council



Flooding

Photo: *Harris County Flood Control District*

Inland Flooding

There are numerous examples of significant flooding caused by land-falling tropical cyclones in Texas. Storms with a slow forward motion are the most dangerous as heavy rains persist for a longer period of time. Tropical Storm Allison was such a storm. Allison meandered across Southeast Texas for several days in early June 2001, dumping 35 to 40 inches of rainfall in some areas. These extreme rainfall totals produced devastating flooding, especially across the Houston metropolitan area. Of the 23 deaths attributed to Allison in Texas, 20 were related to persons who drowned while driving or walking through flood waters.

Five Practical Ways to Protect Yourself and Others From the Dangers of Inland Flooding

- **Protect Your Personal Documents and Special Items**
  - ✓ *Store valuables in plastic tubs with locking tops*
  - ✓ *In case of evacuation, you should be able to secure and move all your valuables within 15 minutes*
- **Buy Flood Insurance: A Plan for Replaceable Items**
  - ✓ *The National Flood Insurance Program (NFIP) is available from an insurance agent or the NFIP*
  - ✓ *For more information see www.floodsmart.gov*
- **Flood Proof Your Home - Take Steps to Minimize Flood Damage**
  - ✓ *Shut off the main circuit breaker to prevent short circuiting and eliminate the threat of electrocution*
  - ✓ *Raise outside air conditioning units onto platforms above ground level*
  - ✓ *Store rarely used or expensive items in the attic or on high shelves*
- **Develop a Family Flood Plan**
  - ✓ *Develop a plan of action to keep from panicking during an emergency*
  - ✓ *Have an evacuation route and alternatives planned in the event you are asked to evacuate*
  - ✓ *Communicate your plans with friends or family outside of your home area*
  - ✓ *Battery powered radios or televisions can be used in the event of a power outage*
- **Never Drive on Flooded Roads**
  - ✓ *Driving into flooded roadways puts your life and the lives of others at risk*
  - ✓ *Unless told to evacuate, you are probably safest staying at your current location*
  - ✓ ***If you encounter flood waters when driving, Turn Around, Don't Drown!***

Destructive Winds and Tornadoes

Above: *Wind damgage to a billboard from Hurricane Lili in October 2002.*

Hurricane force winds of 74 mph or more can destroy buildings, mobile homes, trees and power poles. Debris such as signs, roofing material, siding, and small items left outside become flying missiles in a hurricane. The strongest winds occur in a region of the hurricane called the eyewall. Wind gusts in the right side of the eyewall are the most destructive. Hurricane force winds can be felt as far as 150 miles from the coast.

It is imperative to ensure your home or business is well constructed to minimize the damage from the wind. See the Planning and Preparing section in this guide for cost effective home improvement tips that can help you reduce your damage from a hurricane.

MOBILE HOME RESIDENTS MUST EVACUATE!

- No mobile home or manufactured home - no matter how new it is - can provide safe shelter from hurricane force winds.
- Straps or other tie-downs ***will not*** protect a mobile home from the high winds associated with a hurricane.
- Mobile home residents ***must evacuate*** when told to do so by local authorities.

Tornadoes

Tropical cyclones also produce tornadoes. These tornadoes most often occur in thunderstorms embedded in rain bands well away from the center of the hurricane; however, they can also occur near the eyewall. Tornadoes produced by tropical cyclones are relatively weak and short-lived, but still pose a threat.

Planning and Preparing

Preparing Your Home Before the Storm

Proper hurricane preparations made ahead of time will not completely protect your property from damage. However, following a few simple tips may greatly reduce the damage to your home and property.

Right: Hurricane clips attaching roof trusses to side walls.

Important Home Preparation Tips

Elevation Matters

- Know the elevation of your home! Are you in a flood and/or evacuation zone?

Mobile Homes

- Check tie-downs for rust or breakage.
- Residents of mobile homes *must evacuate* when told to do so!!

Landscaping

- Trim trees, shrubbery and dead limbs, especially ones close to your home.
- Repair or replace broken or damaged fences.
- Shredded bark is preferred instead of small gravel or stone bedding.

Roofing

- Inspect the roof for loose tiles, shingles or debris. Consider replacing old or damaged shingles with new ones rated for hurricane force winds.
- Check for and/or install hurricane clips to secure roof trusses to side walls.
- Clear loose and clogged rain gutters and downspouts.

Doors

- Reinforce garage doors and tracks or replace with a hurricane tested door. (See above image)
- Reinforce double entry doors with heavy duty foot and head bolts.
- Use a security dead bolt with a one inch minimum bolt length.
- Doors may be shuttered, but one entry must be left easily accessible.

Windows

- If possible, install tested/manufactured hurricane shutters.
- Inspect existing shutters to ensure they are in good working order.
- Alternative: Use 5/8" or greater exterior grade plywood secured by 2 1/2" screws and/or special clips. Obtain wood and fasteners, cut wood to size, pre-drill holes and place anchors on homes.
- Store shutters or plywood lying flat to avoid warping when not in use.

Planning and Preparing

Business and Employee Preparation

Tips for Businesses

- Establish a temporary location for business operations in case your facility is damaged.
- Give employees enough time to secure their homes and families.
- Consider paying employees before they leave to prepare their homes.
- Identify and protect vital records. Backup and store key files off site.
- Protect electronic equipment from possible water damage.
- Have extra cash and blank checks in case extra money is needed after the storm.
- Identify a safe room for employees who must remain in the building.
- Develop a 24-hour emergency contact with phone numbers of key employees.
- Set up telephone numbers for employees to check in and receive company information.

Protecting Your Boat - Marine Preparations

Tips for Boat Owners

- Check your marina contract for policies and procedures for hurricanes.
- Check with the manufacturer for proper ways to secure your boat during a storm.
- Consider moving arrangements well in advance of an approaching storm.
- Trailer boats should be removed from the water and securely stored at least 48 hours before a hurricane is expected to make landfall.
- Purchase necessary hurricane materials such as additional mooring lines, crew anchors, fenders, fender boards, chafing gear, and anchors.
- Safe storm moorings should consist of good condition ropes of sufficient diameter and length, with at least three or four substantial anchor points.
- Do not moor parallel to bank. Receding tides often capsize boats in this type of anchorage.

Functional Needs

General Preparations for People With Functional Needs

FEMA News Photo

Preparation in advance of hurricane season is essential, especially for people with special needs. It is essential that a destination is identified ahead of time that can accommodate people with special needs. Shelters should be considered as a **last resort** when people with special needs evacuate because many shelters cannot provide the attention required. Assisting elderly neighbors and acquaintances with pre-hurricane preparations is encouraged.

Important Special Needs Tips

- Identify with whom you will stay in the event an evacuation becomes necessary.
- Make arrangements for transportation in the event you evacuate. Make sure your transportation can accommodate any equipment or other supplies that need to be taken with you.
- Make sure you have the following items that should be stored in advance:
  - ✓ *Extra copies of your prescriptions in case your physician's office is damaged and not operational.*
  - ✓ *At least a 1 month supply of medications.*
  - ✓ *Identification.*

Transportation Assistance Registry

If you will need help evacuating when a hurricane threatens, dial 2-1-1 to register in advance

Dial 2-1-1 as soon as possible...

- Before the start of hurricane season (June 1)
- If you have a disability or special health care need and require assistance to get out
- If you cannot drive and cannot arrange transportation
- If you do not have a vehicle and you have no one else to help you evacuate

Is someone going to pick me up or call me when a hurricane threatens?

Emergency evacuations are handled different in every community. When a major hurricane threatens, local emergency managers will make every attempt to evacuate someone who does not have the ability to evacuate themselves, if there is enough time to do so safely. Once a hurricane enters the Gulf, individuals should pay close attention to local media to determine when and how evacuations will occur.

Pets and Livestock

Preparing for Your Pet's Safety

Your pet should be part of your overall hurricane preparation plans. Below are a few important things to help you prepare:

- Make sure your pet's vaccinations are current and have proof they are current. **DO NOT** assume that a public shelter or hotel will accept your pet.
- Be sure to have a current photo of your pet.
- Each animal should have a properly sized pet carrier. The carrier should be large enough for the animal to stand up and turn around.
- Make sure your pet has a proper ID collar.
- Pack enough food and bottled water for the duration of your evacuation. **DO NOT** let your pet eat food or drink water from outside that may have become contaminated.
- Be sure to pack all medications your pet may need along with a muzzle, collar, leash, paper towels, and trash bags.

Preparations for Livestock

- Ensure all animals have some form of visible identification.
- Evacuate animals whenever possible. Arrangements for evacuation, including routes and host sites, should be made in advance.
- The evacuation sites should have or be able to readily obtain food, water, veterinary care, handling equipment and facilities.
- Obtain vehicles and trailers needed for transporting each type of animal. Also make available experienced handlers and drivers.
- If evacuation is not possible, a decision must be made whether to move large animals to available shelter or turn them outside. This decision should be determined based on soundness and location of the shelter (structure).
- When necessary, move livestock to higher ground and deny access to flood prone pastures, barns, and other structures.
- It is important that livestock have plenty of food and clean water.

Insurance Tips

Insurance Tips - Before the Storm

- When shopping for insurance, get quotes from different companies and consider financial strength and history of complaints from each company.
- Ask agents for discounts if available.
- New and existing policies **will not be written or modified** when a storm nears the Gulf of Mexico.
- Make sure you fully understand what perils are covered and excluded in your policy.
- Make sure your coverage is adequate to replace your home and contents in today's dollar.
- Determine whether your policy covers additional living expenses for a temporary residence if you are unable to live in your home because of damage from a disaster.
- **DO NOT** cancel an old policy until you have a new policy in effect.
- Before hurricane season, prepare detailed written and/or photographic inventory of your home's contents and store it in a safe place with your policy.
- If you evacuate or choose to leave your home for safety, make sure to take the written and photo inventory with you, as well as all insurance policies (auto, home, life, etc.)
- If your insurance company does not cover flood or windstorm perils, ask about coverage through the Texas Windstorm Insurance Association or the National Flood Insurance Program.

Important Web Information

National Flood Insurance Program
www.floodsmart.gov
Texas Windstorm Insurance Association
www.twia.org
Texas Department of Insurance
www.tdi.state.tx.us/consumer
1-800-252-3539 (Consumer Help Line)

Insurance Tips - After the Storm

- Give prompt written notice to your insurance company.
- If you cannot be easily contacted, give your insurance company the contact information of a trusted friend or relative who can reach you if necessary.
- Photograph or videotape damaged structures and all damaged property. Make a list of damaged or lost items.
- **DO NOT** throw out damaged property before your adjuster has inspected the debris unless it is a health hazard or impedes local cleanup.
- Protect your property from further damage.
- Keep an accurate record of temporary repair and living expenses if a loss of use is suffered.
- Along with insurance adjuster estimate for repairs to home, obtain two or more contractor estimates. Estimates must be broken down per line item.
- Claim advancements are made to the policy holder for home repairs, personal property and living expenses. Final payments are made only after completed repairs and adjuster review.

Contact Info/Supply Kit

The Greater Houston Area Chapter of the American Red Cross recommends that you have the following items in your Hurricane Supply Kit. Do not forget to have a family meeting before hurricane season and review your communication information and evacuation plan. Make sure the contact information such as home, work, school, cell phone numbers, and your "Out of Town" contact person's information is current.

American Red Cross

Emergency Contact Information

Out of Town Contact Address: _____
Out of Town Contact Phone Number: _____
Work Telephone Number: _____
Cell Number/Spouse Cell Number: _____
Children Cell Number: _____
School Telephone Number: _____
Doctor Telephone Number: _____
Bank/Credit Card Telephone Number: _____
Insurance Company Information: _____

HURRICANE SUPPLY KIT

- At least a 7-day supply of non-perishable food and a manual can opener
- At least a 7-day supply of water. One gallon per person per day is recommended
- Battery powered portable television or radio with extra batteries
- Flashlight with extra batteries
- First Aid kit and manual
- Sanitation and hygiene items such as instant hand sanitizing gel, moist towelettes, toilet paper, and feminine hygiene products
- Matches in a waterproof container
- Whistle
- Kitchen accessories and cooking utensils
- Cash
- Extra clothing, blankets, and sleeping bags
- Photocopies of identification, insurance, prescriptions, household inventory, credit cards, and your latest utility bill
- CD or photocopies of important documents such as birth/marriage certificates and titles
- Prescription medications, eyeglasses, contact lens solution, and hearing aid batteries
- Formula, baby food, diapers, and pacifiers
- Pet carriers, leashes, shot records, and food for each animal evacuating with you
- A good map showing county roads and highways
- Tire repair kit, booster cables, pump, and flares
- White distress flag
- Toys and games for children
- List of family phone numbers and addresses outside the area

2011

- ☐ Arlene
- ☐ Bret
- ☐ Cindy
- ☐ Don
- ☐ Emily
- ☐ Franklin
- ☐ Gert
- ☐ Harvey
- ☐ Irene
- ☐ Jose
- ☐ Katia
- ☐ Lee
- ☐ Maria
- ☐ Nate
- ☐ Ophelia
- ☐ Philippe
- ☐ Rina
- ☐ Sean
- ☐ Tammy
- ☐ Vince
- ☐ Whitney

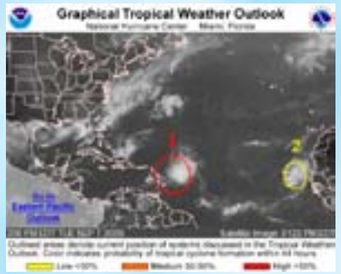
Hurricane Forecasts

The National Hurricane Center (NHC) in Miami, FL is the official source for tropical cyclone advisories and forecasts and is responsible for issuing tropical cyclone watches and warnings for the United States.

Weather Information

National Weather Service
www.weather.gov/houston

National Hurricane Center
www.hurricanes.gov



Graphical Tropical Weather Outlook

- New NHC product provides an overview of all tropical cyclone activity.
- Indicates areas of interest that have potential for tropical cyclone development.
- Moving the cursor over the highlighted areas will provide a more detailed text description.

NHC Forecast Advisory

- Most recent position for a storm along with all coastline watches and warnings. Includes a 3 or 5 day track with error cone.
- Error cone represents a 5 year average error. Storms only stay within the error cone 67% of the time.
- DO NOT focus too closely on the exact track forecast - the little black line.

Storm Wind Field Graphic

- This graphic illustrates the size and shape of the tropical cyclone wind field.
- Some hurricanes have a broad and extensive wind field, with hurricane force winds extending well away from the center, while others have small circulations with hurricane force winds confined near the center.

Graphical Hurricane Local Statement (HLS)

- Issued by local NWS offices to summarize local impacts expected from the tropical cyclone.
- A text version of the Hurricane Local Statement is also available from your local NWS office which provides more detailed information on the tropical cyclone's local impacts.

Final Checklists

Actions to Take When a Storm is in the Gulf

- Listen frequently to radio, TV, or NOAA weather radio for bulletins and forecasts of the storm's progress.
- Double check items in your emergency supply kit.
- Fuel and service your vehicles.
- Inspect and secure mobile home tie-downs.
- Make sure you have supplies to survive on your own for at least one week if you plan on staying.
- Board up windows (if shutters do not exist) in case storm moves quickly and you have to leave. **TAPE PROVIDES NO PROTECTION**!
- Store lawn furniture and other loose, light weight objects, such as garbage cans and garden tools.
- Get plenty of extra cash in case power goes out and ATMs do not work.
- Garage or store vehicles that are not being used.
- Follow instructions issued by local officials. **EVACUATE IMMEDIATELY IF ORDERED TO DO SO**!

Final Actions to Take if Leaving

- Turn off propane tanks.
- Unplug small appliances.
- Empty refrigerator and freezer.
- Turn off utilities if ordered to do so.
- Notify family members of your evacuation plans.
- Lower water level in swimming pool by one foot.
- Lock home securely.
- Board up remaining doors and brace garage door.
- Take pets with you.

Final Actions to Take if Staying

- Close storm shutters.
- Turn refrigerator or freezer to coldest setting and open only if necessary. (25 pounds of dry ice will keep a 10-cubic foot freezer below freezing for 3-4 days.)
- Follow instructions from emergency managers and be prepared to turn off utilities if ordered to do so.
- Board up remaining doors, brace garage door, and remain inside. Stay away from boarded up windows.
- Take refuge in a predetermined safe room, such as an interior closet, bathroom, or hallway.
- Beware of the calm winds in the eye of the storm and do not venture outside. Some of the strongest winds may occur shortly after the eye passes.
- **DO NOT EXPECT EMERGENCY RESPONDERS TO BE OF ANY ASSISTANCE DURING A LANDFALLING HURRICANE!**

A Look Back at Hurricane Carla

Fifty years ago during the summer of 1961 . . .

John F. Kennedy was in the first year of his Presidency. The international scene was dominated by the Cold War and was building up to the Cuban Missile Crisis that took us to the brink of war. It is not surprising that Civil Defense (as Emergency Management was called then) was focused on preparing for the survival of a nuclear attack. One plan they were working on was the evacuation of large segments of the population. The "conventional wisdom" was that it could not be done . . .

Above: Track of Hurricane Carla in 1961 and its associated intensity. Photo: NOAA

Hit songs that summer included Chubby Checker with "Lets Twist Again" and Ray Charles with "Hit the Road, Jack." Elvis was still King and The Beatles were a few years off the music scene.

On the technical front, the space race was on. Alan Shepard took the first manned American spaceflight in 1961. Plans were being made to build up NASA. It had not been decided exactly where the Manned Spaceflight Center would be . . . Lyndon B. Johnson was Vice President, and a large area of undeveloped land was available near Ellington AFB. The Weather Bureau had installed its first network of powerful weather radars. The first look at weather from space was achieved with the TIROS polar orbiters, but forecasters had yet to have access to this new tool. Hurricane reconnaissance was in its heyday with daily flights into the tropics by Air Force and Navy crews.

The 1961 hurricane season had been very quiet in June, July and August, with only Hurricane Anna taking an unusual July track through the Caribbean into Central America. Then, the first week of September saw three hurricanes light up the tropics. Betsy and Debbie will never be remembered on this side of the Atlantic, as both were Cape Verde storms that re-curved over the open ocean. Debbie was eventually one of the rare hurricanes to strike Ireland before transitioning to extra tropical.

Carla was a different story . . .

Chronology

Carla first formed as a depression from a large cluster of thunderstorms in the southwestern Caribbean between Colombia and Nicaragua on September 3rd. For forecasters tracking the storm, Carla moved erratically and slowly throughout her life over the Caribbean and Gulf of Mexico, but in hindsight it looked like she tracked almost inexorably northwest toward the middle Texas coast. The Bermuda-Azores subtropical high was weak and extended across the southern United States. Early season frontal systems were moving west to east across the northern and central States and would play a role in the eventual track of Carla.

The first advisory on Carla was issued on the 4th based on hurricane hunter reports. She slowly gained intensity and by late afternoon on the 6th she had attained hurricane force winds. While in the Yucatan channel on the 7th, Carla turned to north and grew in area to a very large size, which was noted in the advisory. Expecting the north motion to continue, forecasters posted a hurricane watch from the Florida panhandle to Morgan City, Louisiana. Of course, Carla immediately changed direction back to the northwest so forecasters were quick to extend the watch westward to include all of the Texas coast as well as Louisiana on September 8th. By morning on the 9th Carla was in the middle of the Gulf moving slowly northwest toward Texas with sustained winds of 135 mph. Forecasters still expected the storm to turn north and make landfall on the

A Look Back at Hurricane Carla

upper Texas coast or southwestern Louisiana on Sunday. A hurricane warning was issued from Freeport to Grand Isle, Louisiana. Late on the 9th the warning was extended further west to Port Aransas as the storm continued moving northwest.

Forecasters still thought Carla would turn north. However, high pressure over the eastern U.S. (in the wake of a front that had moved through on the 7th) was effectively blocking any north turn. On the 10th with Carla bearing down on the coast, forecasters began estimating landfall for that night between Port Aransas and Galveston. Once again Carla wobbled and slowed to a crawl and the next several advisories postponed the ultimate landfall. By now Carla carried sustained winds just below category 5 making her the strongest and largest known hurricane at that time to strike the Texas coast. She finally moved onshore at Port O'Connor on the afternoon of the 11th (Figure 1.). After landfall, the long awaited forecast turn to the north finally occurred. Carla slowly weakened over land dropping below hurricane strength the morning of the 12th while passing through central Texas near Waco.

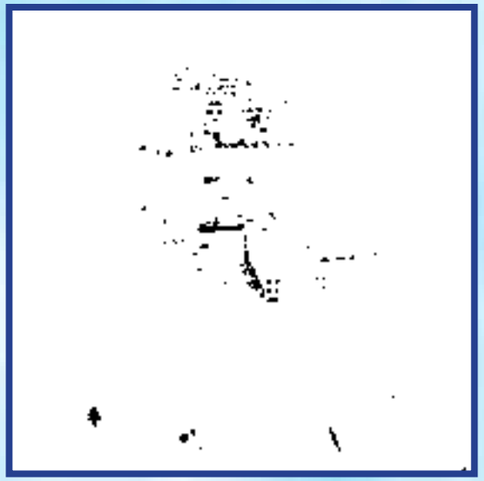
Above: Woman at Pt. Bolivar sits amid the ruins of her home.
Photo: Houston Chronicle Copyright © Houston Chronicle

Impact

Due to Carla's large size and near category 5 intensity, hurricane force winds were experienced along almost the entire Texas coast, with only extreme south Texas being spared. Highest sustained winds of more than 100 mph were experienced from near Freeport south to near Port Aransas. Measured gusts to more than 150 mph and estimated gusts to 170 mph were experienced in communities in Matagorda, Jackson and Calhoun counties as Carla came ashore. Gusts to more than 100 mph occurred from Galveston Bay to Corpus Christi. Gusts to hurricane force spread up to 100 miles inland as Carla slowly weakened.

Carla spawned a number of tornadoes, the most devastating of which touched down in Galveston and caused 5 fatalities. This tornado was unusual for its size and intensity, both greater than normally experienced in hurricane spawned tornadoes.

Rainfall from Carla was somewhat less than one would expect from such large and slow-moving storm. Average rainfall amounts occurring along and just east of the path of the center ranged from 5 to 10 inches with only isolated locations reporting around 15 inches.



Above: Flooding in Texas City from Carla.
Photo: Houston Chronicle Copyright © Houston Chronicle

By far the most significant impact from Carla was storm surge flooding. Because of its size and location in the south-central Gulf, Carla's winds began piling up water along the Texas and Louisiana coast lines as early as the 8th with tides running 2 feet above normal. By midday on the 9th tide levels were around 4 feet and minor flooding and beach erosion was well under way. Significant tide rises were confined to the Texas coast. From High Island to Port O'Connor tidal flooding began on the 10th and lasted close to 48 hours. Tides peaked as Carla made landfall on the 11th. Port Arthur experienced the highest tide on record for that location at just under 8 feet. Tides on Galveston Island and in communities along Galveston Bay reached 6 feet on the 10th. They rose to around 9 feet on the island and at 14 to 16 feet on the upper west side of Galveston Bay as Carla made landfall on the 11th some 100 miles down the coast. The highest storm surge was in the Matagorda Bay area, with the surge over 12 feet on the immediate coast and up to 22 feet in the upper reaches of Matagorda Bay near Port Lavaca. Even to the west of the point of landfall high tides were experienced with

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Corpus Christi recording a 6.5 foot maximum surge and well south at Port Isabel reaching 5.0 feet. More than 3000 square miles of land was flooded by Carla's surge along the Texas and Louisiana coasts.

Carla rates as the 9th most intense hurricane to make landfall in the U.S. since 1851 (by pressure). She was comparable in many aspects to the 1886 Indianola hurricane which followed a track similar to Carla. The area impacted by Carla was much greater than other historical storms to hit Texas and was likely the largest hurricane of record to make landfall in Texas. A total of 46 deaths were attributed to Carla in the United States, ranking her 36th on the list of deadliest hurricanes to strike the U.S. since 1851, and was the worst in Texas since the 1919 hurricane. At the time, the $400,000,000 in damages from Carla made it the 3rd costliest storm to hit the U.S. and costliest for Texas. When damages from Carla are adjusted to 2006 dollars, Carla's damage total rises to 2.6 billion dollars. It should be noted that half of the damage from Carla was attributed to wind and half to storm surge.

Several aspects of Carla were unique, including the massive evacuation that took place from the Louisiana and Texas coastal communities. An estimated 500,000 people evacuated, including 300,000 from the upper and middle Texas coasts. Prior to Carla, evacuations were very limited and generally not planned far in advance. Remember, in 1961 we were at the height of the cold war and civil defense officials were focused on planning for the possibility of a nuclear attack. Documents from that time indicate official pessimism as to whether people would actually go if ordered to evacuate in the event of an attack. The other reasons for an evacuation, including major explosions, fires and hurricanes were not as well documented for most areas. An exception was the Beaumont/Port Arthur area in Jefferson County, which just four years earlier had a very close call with Hurricane Audrey. Audrey was a category 4 hurricane that made landfall just east of Sabine Pass in southwest Louisiana. Few people heeded the warnings for that storm resulting in almost 400 people losing their lives. Partly due to Audrey, the County Judge in Jefferson County had put together a detailed evacuation plan that included cooperative efforts with the major cities within the county. The plan included who would make the decision to evacuate, under what conditions, how it would be conducted, how people would be notified, etc. Prior to Carla, local officials had serious doubts as to whether the plan would work.

On Saturday, September 9th, the 10:00 a.m. hurricane advisory mentioned a storm surge of 10 to 15 feet near landfall, which at that time was forecast to be on the upper Texas coast or in southwestern Louisiana during the day on Sunday. Jefferson County officials decided at this advisory to call for a complete evacuation of the southern half of the county. The message was delivered to each media outlet by telephone and the evacuation was underway. Between noon and 6:00 p.m. an estimated 108,000 people, 85% or greater of the population, in the southern half of the county had evacuated. Up to 100,000 more from the northern part of Jefferson County and neighboring Orange County also left. The evacuation was conducted while skies were clear and tides were still not up. Even though considerable flooding of low lying areas did eventually occur, it would have been much worse had Carla made landfall at High Island just to the west of Jefferson County. Civil Defense review of the event had extremely high praise for the actions taken by Jefferson County during Carla.

Citizens in Galveston County were given the option of staying or leaving and the result was only about half of the population threatened by Carla evacuated. Had Carla made a direct hit, the potential for large loss of life was great. Coastal areas in other more rural counties along the upper and middle Texas coast also evacuated. These rural county evacuations were easier to conduct on short notice and went successfully according to reports after the event. Although no call for evacuation was made for any inland locations, officials stated that many went, particularly from communities just inland from the evacuation zone. While no exact count was made, estimates of up to 500,000 people evacuated. Another important aspect of Carla was the increased live coverage of the storm by television. To a large extent, Carla coverage started the style and focus of coverage of breaking weather events that continues today.

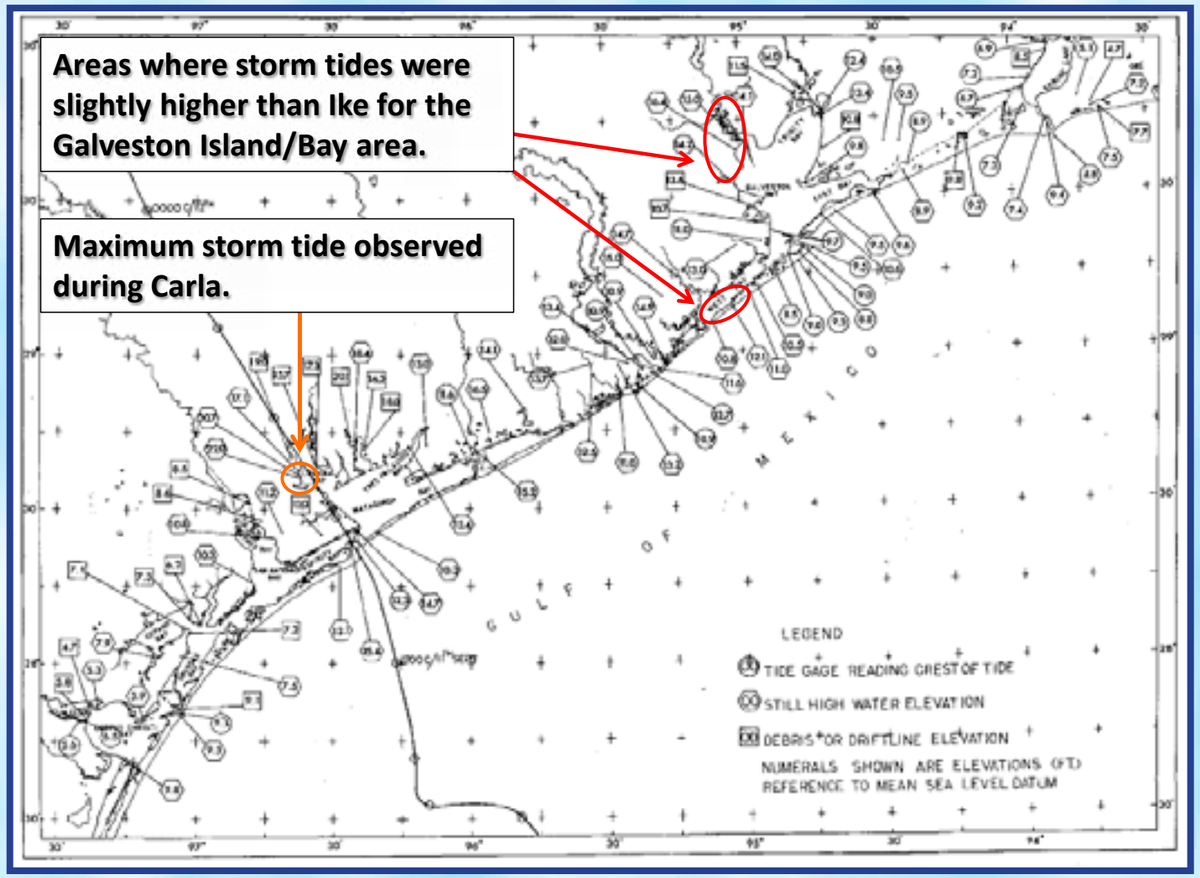
Carla vs. Ike

During the past 50 years, the two hurricanes that produced the highest storm tides across southeast Texas were Hurricane Carla (1961) and Hurricane Ike (2008). Both hurricanes were very large tropical cyclones as they approached the Texas coast. Although the size of the hurricanes was comparable, there were significant differences in the structure of the two hurricane wind fields. Carla had an intense eyewall and was very symmetrical; whereas, Ike was asymmetrical with an eyewall that was broad and still organizing as it approached the coast. Although Ike's maximum intensity at landfall was considerably less than

A Look Back at Hurricane Carla

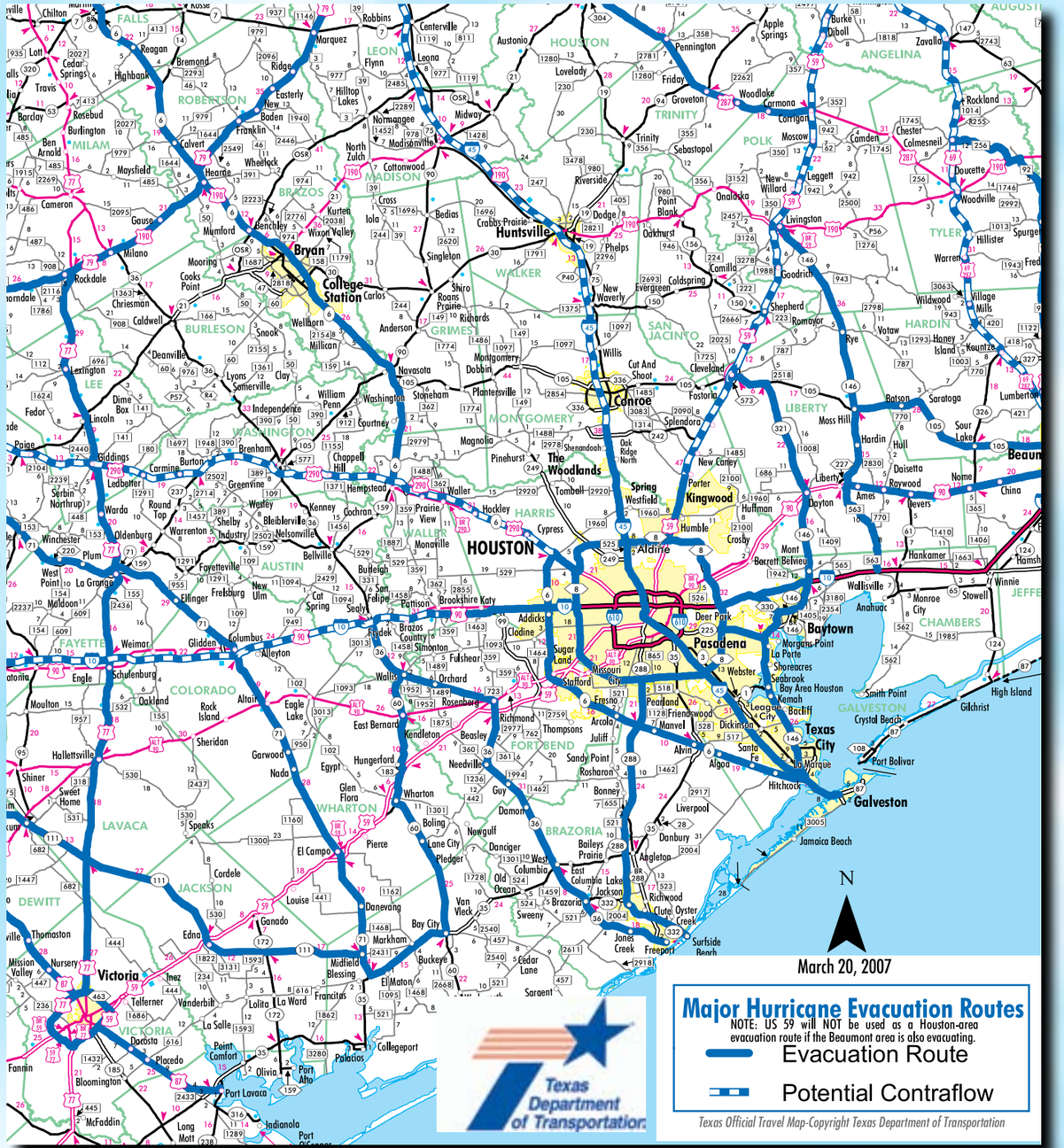
Carla, and peaked just under the wind speed criteria for a major hurricane (115 MPH or greater), the tropical cyclone had a comparable and possibly larger tropical storm force wind field. Therefore, from a total kinetic energy standpoint, Ike was similar to Carla and this explains why the magnitude of these storm surge events was similar.

Because Carla's Port Lavaca landfall was well south of Ike's Galveston landfall, the highest storm surge values were displaced further south near Matagorda Bay. However, Carla was a slower moving hurricane and the upper Texas coast was subjected to a longer period of strong onshore winds than during the approach of Ike. Ike also moved across Galveston Bay and this track spared the western shores of Galveston Bay and Galveston Island from the highest surge which occurred just east of the track. Therefore, when comparing storm tides in the Galveston Island and Galveston Bay area, there are two areas which experienced slightly higher storm tides during Carla than during Ike. These areas are highlighted in red in figure below.



Evacuation

Suggested Evacuation Routes



Evacuation

Evacuees need to consider the projected path of the hurricane when choosing an evacuation route and destination. Evacuation studies estimate that it takes between 23 and 42 hours to evacuate southeast Texas in advance of tropical storm force winds. This underscores the need for coastal residents to have an evacuation plan. When evacuating, be sure to check local weather and highway conditions before departing. When local authorities order an evacuation of your area, leave immediately!

Texas Road Information

TXDOT Road Conditions

1-800-452-9292 or www.txdot.gov

TXDOT Houston Office

1-713-802-5074

Final Actions before Evacuating

- Follow evacuation orders provided by your local officials. Once the evacuation order has been given, LEAVE IMMEDIATELY!
- Take your Hurricane Supply Kit with you (as described on page 13).
- Leave as early as possible to avoid heavy traffic and hazardous weather.
- See TXDOT map on the next page for an illustration of primary and alternate evacuation routes. Remember that the primary routes often become congested quickly.
- Do not stay in a mobile home near the coast under any circumstance.
- Remember that large boats and travel trailers may not be allowed to cross the Galveston Causeway or Hartman Bridge once high winds commence.
- Prepare to stay at your evacuation destination for a week or more, as re-entry into the affected area may be restricted.

Emergency Information

AUSTIN
- County Emergency Management
  979-865-5911 x2228

BRAZORIA
- County Emergency Management
  979-864-1064
- City of Alvin
  281-388-4230
- City of Angleton
  979-849-2383
- City of Brazoria
  979-798-2489
- City of Brookside
  281-485-4844
- City of Clute
  979-265-6194
- City of Freeport
  979-239-1211
- City of Jones Creek
  979-233-3091
- City of Lake Jackson
  979-415-2500
- City of Pearland
  281-652-1954
- City of Richwood
  979-265-8157
- City of Sweeny
  979-548-0697
- City of West Columbia
  979-345-5121

CHAMBERS
- County Emergency Management
  409-267-2445

COLORADO
- County Emergency Management
  979-733-0184

FORT BEND
- County Emergency Management
  281-342-6185
- City of Missouri City
  281-403-8500
- City of Richmond
  281-232-6871
- City of Rosenberg
  832-595-3710
- City of Simonton
  281-533-9809
- City of Stafford
  281-261-3950
- City of Sugar Land
  281-275-2853

GALVESTON
- County Emergency Management
  281-309-5002
- City of Bayou Vista
  409-935-0449
- City of Clear Lake Shores
  281-334-1034
- City of Dickinson
  281-337-0476
- City of Friendswood
  281-996-3335
- City of Galveston
  409-765-3710
- City of Hitchcock
  409-986-5559
- City of Jamaica Beach
  409-737-1142
- City of Kemah
  281-534-5414
- City of La Marque
  409-938-9260

GALVESTON
- City of League City
  281-554-1300
- City of Santa Fe
  409-925-3092
- City of Texas City
  409-643-5840
- City of Tiki Island
  409-935-1427

HARRIS
- County Emergency Management
  713-881-3100
- City of Baytown
  281-420-6556
- City of Bellaire
  713-662-8222
- City of Deer Park
  281-478-7298
- City of El Lago
  281-326-1951
- City of Galena Park
  713-672-2556
- City of Houston
  713-884-4500
- City of Jacinto City
  713-674-8424
- City of Humble
  281-446-4928
- City of Jersey Village
  713-466-2130
- City of La Porte
  281-470-0010
- City of Morgan's Point
  281-471-2171
- City of Nassau Bay
  281-333-4211

Emergency Information

HARRIS
- City of Pasadena
  713-475-5588
- City of Seabrook
  281-291-5700
- City of Shoreacres
  281-471-2244
- City of South Houston
  713-947-7700
- City of Taylor Lake Village
  281-326-2843
- City of Tomball
  281-290-1301
- City of Webster
  281-332-1826

JACKSON
- County Emergency Management
  361-782-3398
- City of Edna
  361-782-3122
- City of Ganado
  361-771-2800

LIBERTY
- County Emergency Management
  936-334-3219
- City of Cleveland
  281-592-2667
- City of Dayton
  936-258-7621
- City of Liberty
  936-336-8118

MATAGORDA
- County Emergency Management
  979-323-0707

MONTGOMERY
- County Emergency Management
  936-538-3590

POLK
- County Emergency Management
  936-327-6826

SAN JACINTO
- County Emergency Management
  936-653-3395
- City of Shepherd
  936-628-3305

WALLER
- County Emergency Management
  979-826-8282

WASHINGTON
- County Emergency Management
  979-277-6288
- City of Brenham
  979-337-7200

WHARTON
- County Emergency Management
  979-532-1123
- City of El Campo
  979-543-3335
- City of Wharton
  979-532-4811 x570

US Department of Homeland Security
www.ready.gov

National Red Cross
www.redcross.org

FEMA
www.fema.gov

Community Resource Information:
Do Not Call 911 for Non-Emergencies!

2-1-1 TEXAS
Connecting People and Services

Returning Home

IF YOU EVACUATED THE AREA, WAIT FOR AN ALL CLEAR FROM THE CITY OR COUNTY BEFORE ATTEMPTING TO RETURN TO YOUR HOME. BE PREPARED TO SHOW PROOF OF RESIDENCE BY HAVING A COPY OF YOUR LATEST UTILITY BILL.

FEMA News Photo

General Cleanup

- Be cautious of structural damage and downed power lines. Do not attempt to move structural supports or large pieces of debris.
- DO NOT run power generators indoors. Inhalation of carbon monoxide from the exhaust can cause death. Ensure exhaust is well ventilated.
- DO NOT use open flames indoors.
- Restrict your driving to emergency use only. Road conditions may not be safe until road debris is cleared.

Debris Cleanup

- Cities and counties will publish a schedule for debris pick-up and removal. Debris cannot be removed from private property.
- Construction materials, vegetative debris, household hazardous waste and household appliances will need to be placed into separate piles and moved to the curbside for pick-up.

FEMA News Photo

FEMA News Photo

Water

- Listen for instructions regarding public water supply. Use only bottled, boiled or treated water until you know that your water supply is safe.
- You can use household chlorine bleach to treat water for drinking or cleaning. Add 1/8 teaspoon of bleach per gallon of clear water or 1/4 teaspoon of bleach per gallon if water is cloudy. Allow water to stand for 30 minutes before using.

Returning Home

Utility Cleanup

FEMA News Photo

- Check for gas leaks. If you smell or hear gas leaking, leave immediately. DO NOT use the phone or turn on lights in your home. Call the gas company from a neighbor's phone.
- Report any visible damage of power lines to the electric company. Turn off power at main breaker if any electrical equipment or circuits have been exposed to water.
- DO NOT connect generators to your home's electrical circuits. If a generator is on line when electrical service is restored, it can become a major fire hazard. Also, line workers working to restore power will be endangered if a generator is hooked up to the home's circuits.
- It is likely that an electric company other than your own will reconnect the lines to your home; however, they can not turn the service back on. Only your electric company can actually turn the power back on to your house.

Sewage Cleanup

- If you suspect water or sewage lines are damaged, do not use your plumbing (toilets, sinks, etc.). Contact the water company or a plumber for repairs.
- A chemical portable commode can be created by the following:
  - ✓ Use 5 gallon buckets with tight lids, lined with heavy duty plastic garbage bags.
  - ✓ Add kitty litter to the bucket as a disinfectant and deodorizer. Keep lids on firmly.
  - ✓ Keep buckets in a cool, dark place. Clean and disinfect buckets immediately.
- Your toilet can also be used by flushing until the bowl has no water. Then, line with heavy duty trash bags and disinfect with chlorine bleach after each use. Remove waste to an outside location.
- If significant sewer outages have occurred, instructions for disposal of human wastes will be announced.
- DO NOT dispose of human waste through your regular trash!

Interior Cleanup

- Disinfect and dry interior buildings and items inside. This will prevent growth of some bacteria, viruses, mold, and mildew that can cause illness.
- Clean walls, floors, and counter tops with soap and water. Disinfect them with a solution of 1 cup of bleach to 5 gallons of water.
- Wash all clothes and linens in hot water. Air dry and spray all unwashable items with disinfectant. Steam clean carpets. Throw away all items touched by water that cannot be disinfected.

Rip Current Safety

Hurricane Surf

Hurricanes bring large waves to nearby beaches that are dangerous for beach goers. High waves, when combined with the high tide, storm surge, and wind and wave setup, can create a serious threat to both lives and property. Jetties and piers typically amplify the size of the waves, causing an even more dangerous situation. Hurricane waves can injure or drown those who enter the water, so **remember: If in doubt, don't go out!**

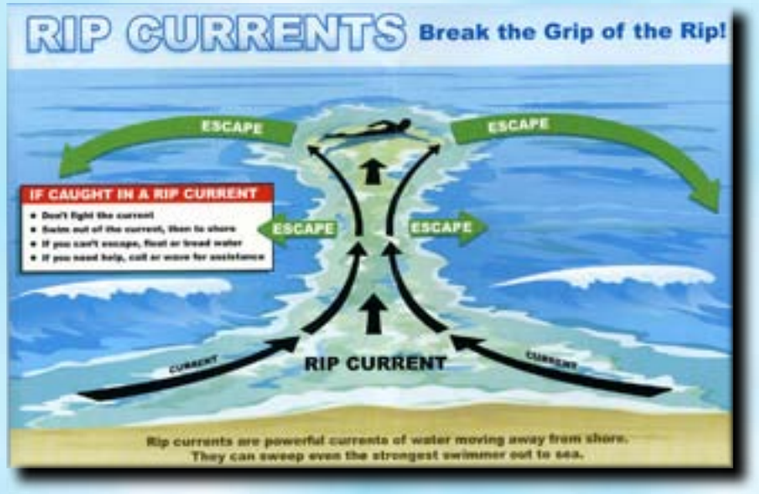


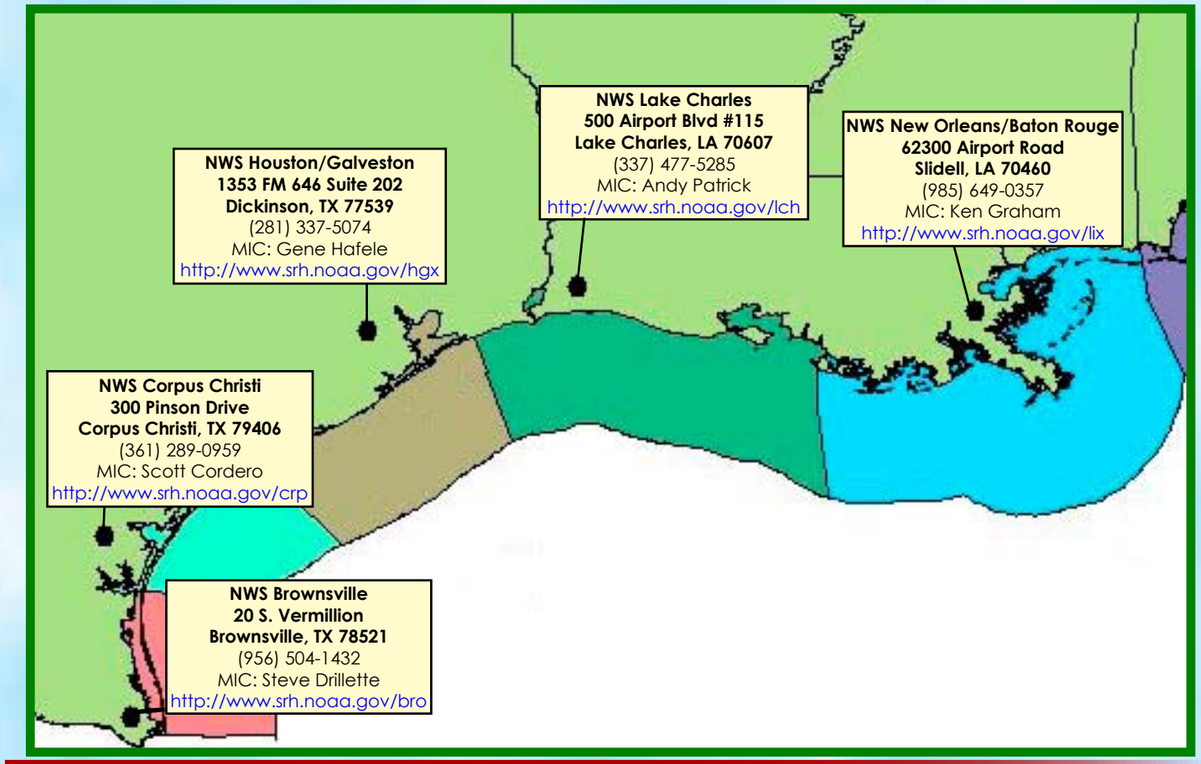
Photo: gscottimaging.com

Rip Currents

Along with big surf come strong rip currents. Rip currents are the leading surf hazard for all beach goers and result in over 100 drownings every year in the United States. The strength and size of rip currents are related to the size of the surf and wave period. Rip currents typically form at the low spots in the surf, at the breaks in the sandbars, and near jetties and piers.

If caught in a rip current, don't panic, but swim parallel to the shore. The current is usually only about 50 feet wide and you should be able to swim out of it. At that point, you can swim back to shore. If you are still unable to reach the shore, draw attention to yourself: face the shore, wave your arms, and yell for help.

Regional National Weather Service Offices



Hurricane Preparedness and Weather Sites on the Internet

National Hurricane Center
http://www.nhc.noaa.gov

NWS Southern Region Headquarters
http://www.srh.noaa.gov

Storm Prediction Center
http://www.spc.noaa.gov

Historical Hurricane Tracks
http://csc-s-maps-q.csc.noaa.gov/hurricanes

EMWIN Houston
http://houston.emwin.org

Klotzbach and Gray Hurricane Forecasts
http://hurricane.atmos.colostate.edu/forecasts

Federal Emergency Management Agency
http://www.fema.gov/hazard/hurricane

Harris County Homeland Security and Emergency Management
http://www.hcoem.org

City of Houston Office of Emergency Management
http://www.houstonoem.net

Galveston County Office of Emergency Management
http://www.gcoem.org

American Red Cross
http://www.redcross.org

Hurricane Workshop
http://hurricaneworkshop.com

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