Houston / Galveston National Weather Service

2007 Hurricane Workshop

Ready

OR NOT

Hurricane
Predictions

Evacuation
Plans

Power
Restoration

Welcome

Welcome to the 2007 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 landfalling hurricane.

We would like to thank the City of Houston for providing the George R. Brown Convention Center for the workshop.

We are excited to have CenterPoint Energy again this year as our financial sponsor and partner. CenterPoint Energy was the recipient of an International Association of Business Communicators Bronze Quill Award for their communications campaign efforts in support of the workshop in 2006. Responsible for delivering electricity and natural gas in the greater Houston area, CenterPoint Energy has a major stake in the response and recovery from a hurricane and a long history of community service. From educational initiatives, to financial support of worthy causes, to reconstruction projects for fixed-income senior citizens, CenterPoint Energy and their employees are leaders – and doers. CenterPoint Energy tailors outreach programs to meet the varying needs of its unique communities. Last year, CenterPoint Energy volunteers and their family members contributed more than 128,000 community service hours, and employees raised $1.4 million for non-profit organizations.

Each year, we focus on an important aspect of hurricane preparedness or look at lessons learned from significant events from the previous season. This year we chose to focus on being hurricane prepared – from the community, to the business or institution, and to the family and individual. Our speakers will reflect on various aspects of overall hurricane preparedness, while our breakout sessions will provide helpful information on how to prepare and respond to such a threat in our area. Additionally, Interfaith Ministries will present breakout sessions designed to meet the needs of the faith communities. Furthermore, we have a multitude of vendors in the exhibit area who can provide various products and services related to hurricane preparedness.

We believe you will find the workshop informative and helpful.

Thank you for attending!

Sincerely,

Bill Read
Meteorologist in Charge
National Weather Service Houston/Galveston

Acknowledgements

The National Weather Service would like to acknowledge the contributions of several agencies and organizations that have made the 2007 Hurricane Workshop the largest we have ever hosted.

Harris County Homeland Security and Emergency Management Office has been involved in the organization of the workshop and has provided manpower resources to help make this year's workshop a success.

Many thanks to Jill Hasling from the John C. Freeman Weather Museum for taking the lead on planning our first kids area. Her knowledge in educating our young people about weather was an invaluable asset in putting the pieces together for an area where kids will be able to learn about hurricanes.

In 2007, we also joined forces with Interfaith Ministries for Greater Houston. Interfaith Ministries provided an additional link to the faith-based communities that helped the 2007 Hurricane Workshop reach out to hundreds more citizens in our community.

HARRIS COUNTY HOMELAND SECURITY & EMERGENCY MANAGEMENT TEXAS

IM INTERFAITH MINISTRIES FOR GREATER HOUSTON

The John C. Freeman WEATHER MUSEUM

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Hurricane Evacuation - A Difficult Decision YOU Have to Make

Bill Read, Houston/Galveston National Weather Service Office

As the Texas experience with Hurricane Rita in September 2005 so graphically showed, one of the more complex issues facing highly urbanized coastal communities is the process of evacuation in advance of a major hurricane. Considerable progress has been made in the science of evacuation processes, but many factors require decisions of a subjective nature by various levels of government on down to the individual citizens. This article points out a few of the more pressing aspects of evacuation decision making.

Uncertainty in forecasting

One of the major variables in evacuation decision making is the uncertainty of forecast track and intensity of the hurricane. The problem arises in that most evacuation decisions need to be made well in advance of predicted landfall. Beyond 24 hours, there is still a degree of uncertainty in the forecast...sometimes a large degree of uncertainty! Some storms are embedded in well-behaved steering currents and stay on the forecast track quite well (e.g. Lili, 2002) so that meteorologists have greater confidence in their forecast. Others (e.g. Alicia, 1983) are in less well-defined steering currents and can track erratically, which lowers forecaster confidence in the track. The average track error for the National Hurricane Center forecasts for the 2007 season is roughly 65 statute miles per day. For a large and intense hurricane such as Rita, the official decisions for a mandatory evacuation need to be made by our elected officials about two days before landfall. The average track error at that time is around 130 miles. The two-day error for Rita was slightly under 100 miles. The point is that at the time we need to make official decisions, the range of possibilities run from direct hit to near miss. Intensity forecasting is another matter, with much still to be learned on the intensification mechanisms and how to forecast them. Examples abound of storms that intensified or weakened rapidly in the Gulf of Mexico (Audrey 1957, Opal 1995, Bret 1999, Lili 2002, Charley 2004, Wilma 2006) without being forecast to do so. In these cases, the storms intensified by up to two categories in less than 24 hours, some in less than 12 hours. Because of our uncertainty in forecasting rapid intensification, we advise decision making based on a storm one category higher than forecast.

Communication of weather and evacuation information

At the start of the 21st century, we have instant coverage of any weather change - a 24 x 7 television station devoted to weather and numerous other news outlets providing continuous weather coverage, plus constant real time updates via various web sites on the Internet. During the major hurricane threats from Katrina and Rita, accessing the web for weather information was the number one use of the Internet. Local officials now communicate evacuation decision information via electronic means in addition to traditional press releases and press conferences. These multiple paths of communication ensure that a larger percentage of the population gets the necessary evacuation information.

Advances in emergency management evacuation planning and decision making

Emergency managers and elected officials are charged with the responsibility for planning, calling for, and executing an evacuation. Many have taken advantage of such advancements as formal training, annual hurricane conferences, and local partnership initiatives to become better prepared for hurricane impacts. Computer-based tools for assessing the evacuation, detailed guidelines on hurricane planning, and better communication between officials and the media all have led to improved hurricane readiness. The use of e-mail, pagers, and conference calls has fostered an environment of teamwork. Before any mandatory or recommended evacuation comes to the public, the counties and cities in the potential evacuation areas have already discussed all the options and have attempted to reach a consensus. Since the Rita experience, elected officials through their emergency management have formed a regional committee, called the Multi Area Coordinating Committee (MACC), to ensure all impacted communities are on the same page and speaking with one voice when conveying evacuation decisions for a major hurricane to the public.

Demographic and infrastructure evacuation issues

The most important factor in the increasing complexity of hurricane evacuation is the rapid growth of cities in coastal areas. The Houston/Galveston/Brazoria area is a prime example. Since Hurricane Alicia in

1983, the population has grown by an astonishing 1,200,000 people…and it continues to grow! Our geography, low elevation coastal plains leading from the coastline, and Galveston Bay, result in a rather large area susceptible to storm surge flooding. Our area is not too different from the Mississippi coast that was flooded severely by Katrina or the southwest Louisiana coast flooded by Rita, except our coastal areas are much more densely populated. There are now over 850,000 people living in the areas along the upper Texas Gulf coast and Galveston Bay that are subject to storm surge flooding. Over half of these people have never experienced a hurricane! For Category 1 or 2 storms, only a small portion of the population would need to leave. Please refer to the evacuation maps in this booklet to see from which level storm you will need to evacuate. As Rita has shown, for a major hurricane threat (any Category 4 or 5 and most Category 3s), the evacuation of one million or more people from our area will commence. If everyone tries to go at once, massive congestion will occur (again) on our highways leading inland. Significant progress has been made to mitigate the traffic flow, but the simple fact is that there are only so many lanes of highway available and you will need to prepare yourself for a long, slow drive out of harm's way. The volume of traffic and limitations of our highway system dictates the long lead time necessary for calling for an evacuation. The somewhat utopian goal is to have everyone evacuate in phases; the immediate barrier island communities first, followed by the mainland communities in the surge zone in timed sequences. The last to leave should be those who chose to go even though not required to do so.

For most approaching hurricanes, the weather will consist of blue skies, sunshine, and light winds 42 to 48 hours before landfall. This was the case during Rita, where the biggest hazard weather wise for evacuating citizens was heat. The call to evacuate for Rita by our officials was fairly straightforward, given the strength of the storm and the vivid memory of the events of Hurricane Katrina just three weeks earlier. Our concern is that for many storms at approximately two days before landfall, it will be difficult for decision makers to call for evacuation and even more unlikely that citizens will evacuate - they will await more certainty. Again, the track forecast error is frequently more than 125 miles at 48 hours. Remember, each decision to wait means you have lost six hours, because you will not receive any new information upon which to base a decision until the next advisory six hours later.

The decision to evacuate is difficult as well as complex. Each person along the coast has a slightly different situation to consider. Evacuation experiences along the East Coast during Hurricane Floyd suggest that about 70 percent of those people who should have evacuated actually did. Applied to the Houston/Galveston/Brazoria area, that remaining 30 percent represents about 250,000 people! In a worst case scenario where we experience the direct hit of a large Category 4 or 5 hurricane, that means thousands of people will be left in their homes to experience flood waters being driven by winds in excess of 100 mph.

Another major concern is what to do about the special-needs population. An enormous amount of work has been done by our emergency management officials utilizing lessons learned from Katrina and Rita to improve our communities' capabilities to help folks who otherwise would not be able to evacuate on their own. Special-needs people include those who are disabled, ill, on low fixed income with no transportation, and the homeless - generally anyone who will need assistance if they are to evacuate. Just identifying all who fit into this category is a major task. Unfortunately, these people who are least likely to leave make up a disproportionate percentage of those who live in mobile homes and other non-hurricane resistant residences.

And now for the YOU part!

The success or failure of evacuation depends in large part on each and every one of us being prepared. Now is the time to decide under what conditions you would evacuate. Use the material in this booklet and advice from your local officials to determine if you are in a surge threat area. Also, consider whether your home would be safe from the high winds even if you live outside the surge area. As a starter, no manufactured home should be considered safe in a major hurricane. Once you determine whether to go or stay, make a plan. Use the Family Hurricane Plan Checklist in this booklet and develop a plan for your family...before we have a hurricane. Then, when the "Big One" threatens...follow your plan!

Atlantic Basin Tropical Cyclone Seasonal Forecasts

By Lance Wood, Science and Operations Officer

Introduction and Scope

Annual seasonal forecasts of tropical cyclone activity for the Atlantic basin have been produced for more than 20 years. The pioneer of these seasonal forecasts is Dr. William Gray from Colorado State University. He and his research team have been issuing forecasts since 1984. The National Oceanic and Atmospheric Administration (NOAA) has issued seasonal activity forecasts since 1999. Although there are many seasonal forecasts made by various entities, this review will focus on those made by NOAA and Dr. Gray, both of which are widely followed and publicly available. This review will also focus on the forecasts of the number of named storms and hurricanes, as opposed to the number and location of landfalls. The state of the science does not show sufficient skill in forecasting landfall location in a seasonal outlook time period to warrant a review or advocate using as a decision making tool. U.S. landfall climatology is a good indicator of relative risk and highlights which areas of the coastline have the highest risk of a landfalling hurricane. The landfall risk climatology is available in this booklet. What follows is a brief look at what parameters the above mentioned seasonal forecasts are based on, as well as a discussion of their skill and a summary of past forecasts versus actual seasonal activity.

Colorado State University Seasonal Forecast

Dr. Gray has recently appointed Dr. Philip Klotzbach as the lead scientist of the seasonal forecast team at Colorado State University. The team produces an early forecast for the upcoming Atlantic basin season in December of the previous year, which is then updated prior to and during the season. This December forecast is based on a couple of statistical prediction schemes, an analog scheme, and qualitative adjustments. What follows is a brief summary of the different schemes and predictors used to produce the December forecast. The December 2006 forecast is the first in which a new, relatively simple, three-predictor forecasting model is utilized. The relationships between individual predictors in this scheme and seasonal tropical cyclone activity occurring the following year are believed to be better understood using this new prediction scheme. The three predictors utilized are (1) October - November sea level pressure in the Eastern Atlantic, (2) October - November sea surface temperature (SST) in the North Atlantic, and (3) October - November sea level pressure in the Tropical Pacific. This scheme only predicts Net Tropical Cyclone (NTC) activity, and the other predictors are then derived from this NTC prediction. For example, if a typical season has 10 named storms and the predicted NTC value is 120%, the predicted number of named storms for the season would be 12 (10 x 120%) (Klotzbach, Gray, and Thorson, 2006). A more complicated 6-11 month extended range statistical forecast procedure which utilizes 52 years of past data and has been utilized operationally since 2002 is also consulted (see the reference above for details concerning this scheme.) The team also utilizes an analog year analysis. They found four hurricane seasons since 1949 with characteristics most similar to what they observed in October-November 2006: 1952, 1958, 1966, and 2003. They anticipate that an average of activity across these years will be a useful predictor for tropical cyclone activity in 2007. After examining these three prediction schemes and other qualitative factors, the team believes that above normal activity can be expected for the 2007 season. In fact, their forecast is for a more active year than any of the prediction schemes indicate. This is mainly due to qualitative factors not contained in the schemes. The main qualitative factor is the warm sea surface temperatures that are likely to continue across the Tropical and North Atlantic during 2007. This expectation is due to the continuation of the positive phase of the Atlantic Multidecadal Oscillation (AMO) (also termed Mutidecadal Signal - more on this later). They also note that there tends to be a warming of the Tropical Atlantic following a warm ENSO (El Niño Southern Oscillation) event through a weakening of the trade winds associated with the “atmospheric bridge” mechanism (Klein et al. 1999). In regards to ENSO, they state that the influence of El Niño conditions is contained in the predictor fields present in their statistical schemes; therefore, they do not utilize a specific ENSO forecast as a predictor. They do not expect El Niño conditions during the active part of the 2007 Atlantic basin hurricane season. This expectation has already been supported with the recent demise of El Niño during February 2007. Updated forecasts for the 2007 season will be issued in early April and on May 31st. See Table 1 for a summary of the results of the 3 prediction schemes and their final adjusted December 2006 forecast.

Forecast Parameter and 1950-2000 Climatology (in parentheses)	Statistical Scheme (Developed in 2002)	New Statistical Scheme (Developed in 2006)	Analog Scheme	Adjusted Final Forecast
Named Storms (9.6)	7.2	12.9	11.0	14
Named Storm Days (49.1)	36.1	65.6	59.6	70
Hurricanes (5.9)	4.5	7.9	6.8	7
Hurricane Days (24.5)	17.0	32.8	31.8	35
Intense Hurricanes (2.3)	0.9	3.1	3.3	3
Intense Hurricane Days (5.0)	2.9	6.7	9.3	8
Accumulated Cyclone Energy Index (94.7)	68	127	132	130
Net Tropical Cyclone Activity (100%)	72	134	135	140

Table 1. Summary of the early December statistical forecast, the new statistical scheme, the analog forecast and the adjusted final forecast for the 2007 hurricane season. (Klotzbach, Gray and Thorson, 2006)

NOAA's Seasonal Forecast

NOAA's 2007 seasonal forecast will be issued the week of May 21st. The lead scientist for NOAA is Dr. Gerald Bell from the Climate Prediction Center. His team of researchers include members of the National Hurricane Center and the Hurricane Research Division. The fundamental variable that NOAA's forecast has been predicated on since its inception is the continuation of the positive phase of the Muti-decadal Signal. In the current warm (positive) phase, which began in 1995, this pattern has favored above normal Atlantic basin seasons. In fact, all of the Atlantic basin hurricane seasons since 1995 have been above normal, with the exception of three moderate to strong El Niño influenced years (1997, 2002, and 2006). This contrasts sharply with the 1971-1994 period of generally below normal activity when the Multi-decadal Signal was in a cool (negative) phase (Goldenberg et al., 2001). Over the North and Tropical Atlantic, the key aspects of the positive phase of the Multi-decadal Signal (Figure 1) which are likely to persist include: (1) warmer SSTs; (2) a strong West African Monsoon; (3) an amplified ridge at upper levels across the central and eastern subtropical North Atlantic; (4) reduced vertical wind shear in the deep tropics over the central North Atlantic; and (5) weaker easterly winds in the middle and lower atmosphere, resulting in a configuration of the African easterly jet (wavy blue arrow) that favors hurricane development from tropical waves moving westward from the African coast. This signal is expected to again be the main factor guiding their upcoming seasonal outlook as it does not switch phases on the time scales of years, but rather decades. The second factor, which can change on the time scale of months, is the state of ENSO. As noted above, the only seasons (since 1995) that have experienced below normal activity coincided with moderate to strong El Nino events (warm phase of ENSO). When the ENSO state was one of Neutral or La Nina conditions, near and during the peak of the hurricane season, an above normal season has resulted. Therefore, while the Multi-decadal Signal remains in a positive phase, it is unlikely that the Atlantic basin season will experience below normal activity, unless influenced by a moderate to strong El Nino during the hurricane season.

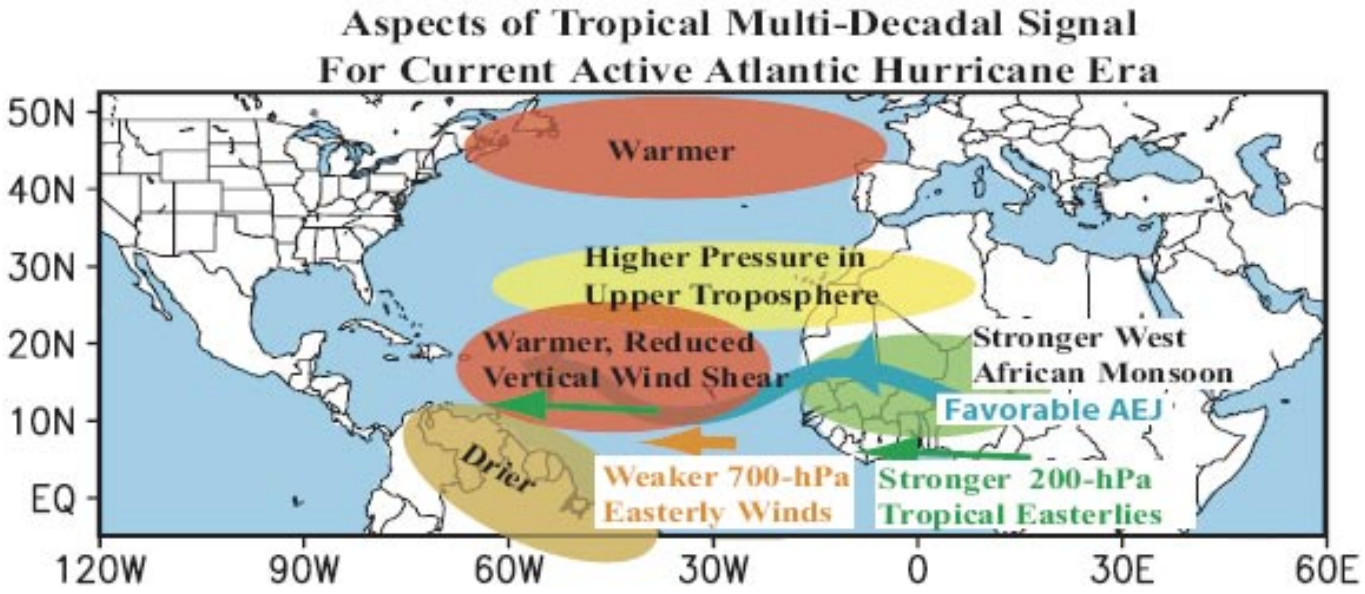

Figure 1. Schematic showing the regional conditions associated with the tropical multi-decadal signal during the current active hurricane era (Bell and Chelliah, 2006).

Although NOAA's outlook began in 1999, ranges of named storms, hurricanes and probabilities did not appear in the outlook until 2001. In addition to these ranges, NOAA now uses the Accumulated Cyclone Energy (ACE) index to categorize North Atlantic hurricane seasons as being above, near, or below normal. This index refers to the collective intensity and duration of Atlantic named storms and hurricanes occurring during a given season. Therefore, it is a measure of total seasonal activity and is computed as the sum of the squares of the maximum sustained surface wind speed (knots) measured every six hours for all named systems while they are at least tropical storm strength. See Table 2 for the definitions utilized by NOAA to categorize seasonal activity.

Season Type	Mean # of Tropical Storms (1950-2005)	Range of Tropical Storms	Mean # of Hurricanes (1950-2005)	Range of Hurricanes	Mean # of Major Hurricanes (1950-2005)	Range of Major Hurricanes	Accumulated Cyclone Energy Index (* 104 kt2)
Above-Normal	13.7	10 to 28	8.6	6 to 15	4.5	2 to 8	>103
Near-Normal	9.4	6 to 14	5.6	4 to 8	1.9	1 to 3	66-103
Below-Normal	6.9	4 to 9	3.7	2 to 5	1.1	0 to 2	<66
All Seasons	11	4 to 28	6.2	2 to 15	2.7	0 to 8	93.2

Table 2. The table shows the 1950-2005 seasonal means and ranges for named storms, hurricanes and major hurricanes during above normal, near normal, below normal, and all Atlantic hurricane seasons. This table highlights the marked differences in activity between the three season types.

Skill and Seasonal Activity Forecasts

Dr. Gray and his team's seasonal forecasts of activity ('84-'06) have proven to be skillful. Utilizing a regression analysis that compares the June forecast to observed activity, the results explain 30% of the variance in observed activity with a correlation coefficient of 0.55, which is statistically significant at the 95% confidence level (Figure 2). Even though these forecasts are skillful, it should be noted that forecast busts do occur. The 2006 season is a good example of a forecast bust, as the season was much less active than forecast by Klotzbach, Gray, and Thorson, or by NOAA. The main reason for the lack of activity can be attributed primarily to a surprising and late-developing El Niño. The difficulty in predicting the state of ENSO several months in advance is the primary reason that forecast busts occur.

NOAA's relatively short forecast period of record (1999-2006) coupled with the fact that the forecast is in terms of probability and ranges, creates a more qualitative assessment of skill. NOAA began forecasting ranges of expected named storms and hurricanes in 2001. During the past 6 seasons, the actual number of named storms fell within the NOAA forecast range on 2 occasions (33% of these seasons). Even though a majority of these seasons experienced activity outside of the predicted range, NOAA has

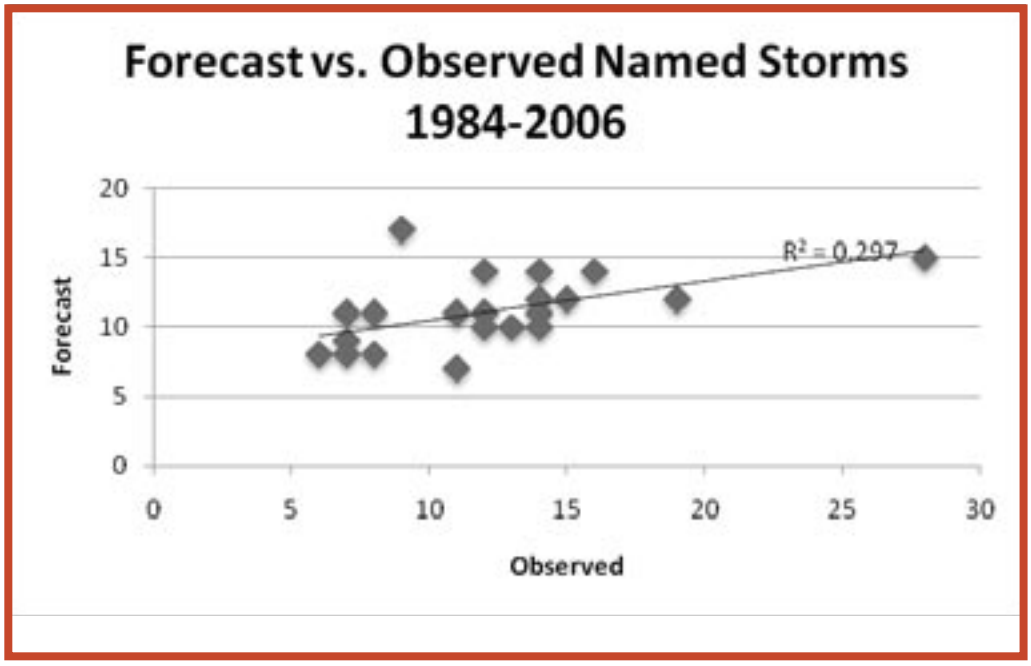

Figure 2. Scatter plot of Dr. Gray and team's June seasonal forecasts vs. observed activity with trendline included.

shown skill in terms of predicting the broader range of activity (above, near, or below normal). During the past 8 years, there are only 2 years where activity levels occurred out of this general expectation of activity. Table 3 is a complete summary of all of the forecasts issued since their inception, by NOAA and Dr. Gray and his team.

Year	Named Storms			Hurricanes			Major Hurricanes		
	NOAA	Dr. Gray	Actual	NOAA	Dr. Gray	Actual	NOAA	Dr. Gray	Actual
2006	13 to 16	17	10	8 to 10	9	5	4 to 6	5	2
2005	12 to 15	15	28	7 to 9	8	15	3 to 5	4	7
2004	12 to 15	14	14	6 to 8	8	9	2 to 4	3	6
2003	11 to 15	14	16	6 to 9	8	7	2 to 4	3	3
2002	9 to 13	11	12	6 to 8	6	4	2 to 3	2	2
2001	8 to 11	12	15	5 to 7	7	9	2 to 3	3	4
2000	Above	12	14	Above	8	8		4	3
1999	Above	14	12	Above	9	8		4	5
1998		10	14		6	10		2	3
1997		11	7		7	3		3	1
1996		10	13		6	9		2	6
1995		12	19		8	11		3	5
1994		9	7		5	3		1	0
1993		11	8		7	4		2	1
1992		8	6		4	4		1	1
1991		8	8		4	4		1	2
1990		11	14		7	8		3	1
1989		7	11		4	7			2
1988		11	12		7	5			3
1987		8	7		5	3			1
1986		8	6		4	4			0
1985		11	11		8	7			3
1984		10	12		7	5			1

Table 3. This table shows seasonal activity forecasts for the number of named storms, hurricanes, and major hurricanes for Atlantic Basin hurricane seasons beginning in 1984 (issued in June (Dr. Gray)), and beginning in 1999 (issued in May (NOAA)). Also shown is the actual activity that has occurred since 1984.

Conclusion

Perhaps the single most important outcome and use of seasonal activity forecasts is that they generate public interest and aid in public awareness of the tropical cyclone threat, especially just prior to the beginning of the hurricane season. However, regardless of the seasonal activity forecast, it is imperative that all potentially impacted residents prepare as if they could be impacted by a hurricane every year. Although history has shown that multiple landfalls are more likely along the Gulf coast in an above normal year, the probability of a hurricane landfall somewhere along the Gulf coast is still around 60% during a below normal year. 1983 is an example of one of those below normal years, and happens to be the year when Hurricane Alicia (the first named storm of the 1983 season) made landfall near San Luis Pass, Texas in mid August as a Category 3 hurricane.

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Hurricane Hazards: Hurricane Winds

Hurricane winds are a force to be reckoned with as coastal communities decide on building codes. As winds increase, pressure on objects increases at a disproportionate rate. Pressure against a wall increases with the square of the wind speed. For example, if the wind speed increases by a factor of three, the pressure on a structure increases by a factor of nine. Thus, a 25 mph wind generates about 1.6 pounds of pressure per square foot. For example, a four by eight sheet of plywood will be pushed by a weight of 50 pounds. In 75 mph winds, that force increases to 450 pounds. At 125 mph, the pressure force tops out at 1250 pounds. For some structures, this force is more than enough to cause failure.

In a hurricane, weaker winds are generally located in the outer rain bands with wind speeds increasing rapidly near the eye. Hurricane winds are most intense around the perimeter of the eye commonly referred to as the eye wall. As a hurricane moves inland, winds begin to rapidly decrease, but remain above hurricane strength well inland. A general rule of thumb is that wind speeds will decrease 50% within 12 hours of landfall. Thus, the faster the storm motion, the further inland hurricane force winds will be experienced.

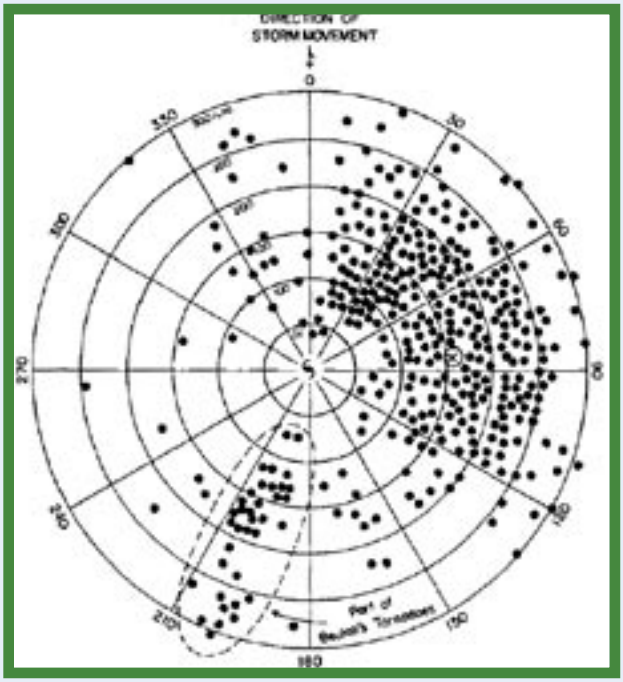
Wind damage patterns are often very different from storm to storm. In 1983, Hurricane Alicia made landfall on the west end of Galveston Island. Before Alicia had weakened below hurricane strength, hurricane force wind gusts extended to Huntsville, more than 100 miles from the coast. In 1989, Hurricane Hugo made landfall near Charleston, South Carolina. This fast moving storm cut a path of destruction from the coast to Charlotte, North Carolina, almost 175 miles from the coast. Hurricane Andrew slammed into south Florida in 1992. The compact, intense storm produced tremendous wind damage over a small but highly populated and developed area. In 2005, southern Louisiana was hammered with a one-two punch as Katrina and Rita produced widespread wind damage from New Orleans to the Sabine River.

Hurricane Hazards: Tornadoes

Tornadoes are frequently associated with land-falling hurricanes. Though the numbers of tornadoes vary with each hurricane, most tornadoes are located in the right-front quadrant of the hurricane. Tornadoes have been discovered to exist mainly within the outer rain bands; although, they have also been documented close to the hurricane's eye wall. Tornadoes can affect locations up to 300 miles from the center of the hurricane and can occur days after landfall.

Typically, the more intense a hurricane is, the greater the tornado threat. As a hurricane moves inland, the fast-moving air hits terrain and structures, causing a frictional convergence which enhances lifting. Frictional convergence may be at least a contributing factor to tornado formation in hurricanes. Other factors include low altitude instability and strong wind shear.

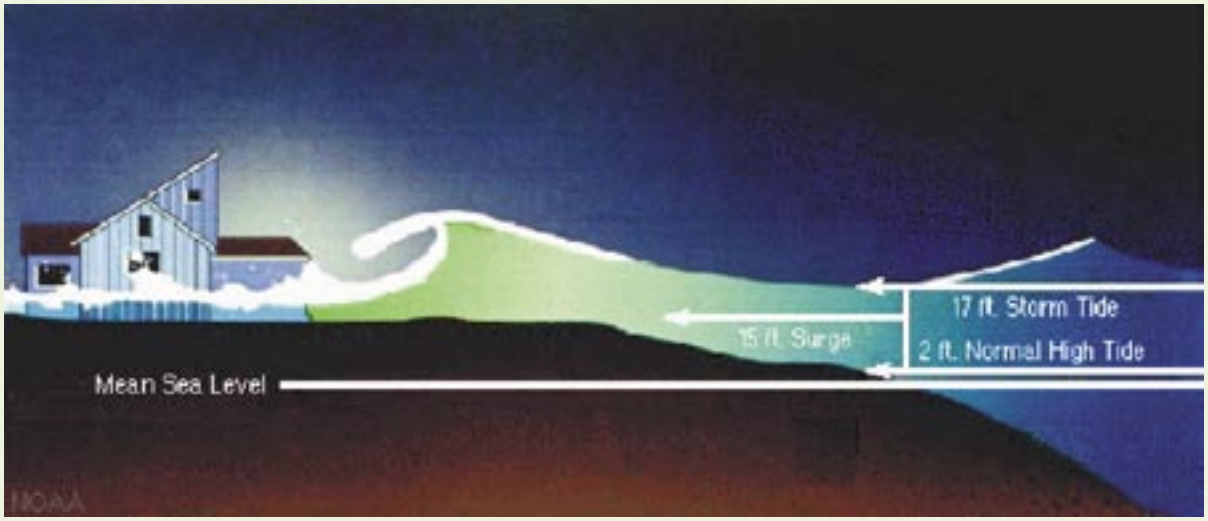
The largest known tornadic outbreak from a U.S. land-falling hurricane was Hurricane Ivan in 2004. Over a two-day period, Ivan produced 127 tornadoes from Florida up to Pennsylvania! Ivan's total broke the old record held by Hurricane Beulah. In 1967, Beulah spawned 115 tornadoes over South Texas.



A plot of 373 U. S. hurricane tornadoes between 1948 and 1972 with respect to the hurricane center and its direction of motion. The circled "x" located at 80 degrees azimuth and 150 nm from the hurricane center is the centroid point of all the plotted tornadoes. Image obtained from Novlan D. J., and W. M. Gray, 1974: Hurricane-spawned tornadoes. Mon. Wea. Rev., 102, 476-488.

Hurricane Hazards: Storm Surge

Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to generate the hurricane storm tide, which can increase the mean water level 15 feet or more. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm surge coincides with the normal high tides. Because much of the United States' densely populated Atlantic and Gulf Coast coastlines lie less than 10 feet above mean sea level, the danger from storm tides is tremendous.



The level of surge in a particular area is determined by several factors: the strength of the storm, the size of the storm (how far hurricane force winds extend out from the center), and the speed of the storm. Some local factors that influence the height of the storm surge are the shape of the coastline and the slope of the continental shelf. A shallow slope off the coast (similar to the upper Texas coast) allows a greater surge to inundate coastal communities. Communities with a steeper continental shelf (similar to the east coast of south Florida) would not see as much surge inundation, although large breaking waves could still present major problems. Storm tides, waves, and currents in confined harbors severely damage ships, marinas, and pleasure boats.

Storm Surge in Katrina… Despite decreasing from a Category 5 to a Category 3 hurricane in the last 24 hours prior to landfall, Katrina generated the highest storm surge ever measured along the United States coastline. Katrina produced a storm surge between 24 and 28 feet along a 20 mile swath on the Mississippi coast. The highest measured surge was 27.8 feet at Pass Christian, just east of St. Louis Bay. The data also indicated that the storm surge was 17 to 22 feet along the eastern half of the Mississippi coast, roughly from Gulfport to Pascagoula. The surge appears to have penetrated at least six miles inland in many portions of coastal Mississippi and up to 12 miles inland along bays and rivers. The surge crossed Interstate 10 in many locations.

Before Katrina

After Katrina

Before and after Katrina pictures of the house owned by David and Kimberly King in Waveland, MS. Pictures provided by David and Kimberly King.

The massive storm surge produced by Katrina can be generally explained by the huge size of the storm. On August 29th, Katrina had a large radius of maximum winds of about 25 to 30 nautical miles (nm). The storm also had a very wide swath of hurricane force winds that extended at least 75 nm to the east from the center. Katrina followed a similar track to that of Hurricane Camille in 1969. Although Camille was more intense than Katrina, Camille was far more compact and produced comparably high storm surge values along a much narrower swath. Katrina produced a record storm surge that exceeded Camille's surge. Katrina's surge was aided by the large northward-propagating swells which led to substantial wave setup along the northern Gulf coast. These were formed when the storm was at Category 4 and 5 strength during the 24 hours or so prior to its landfall.

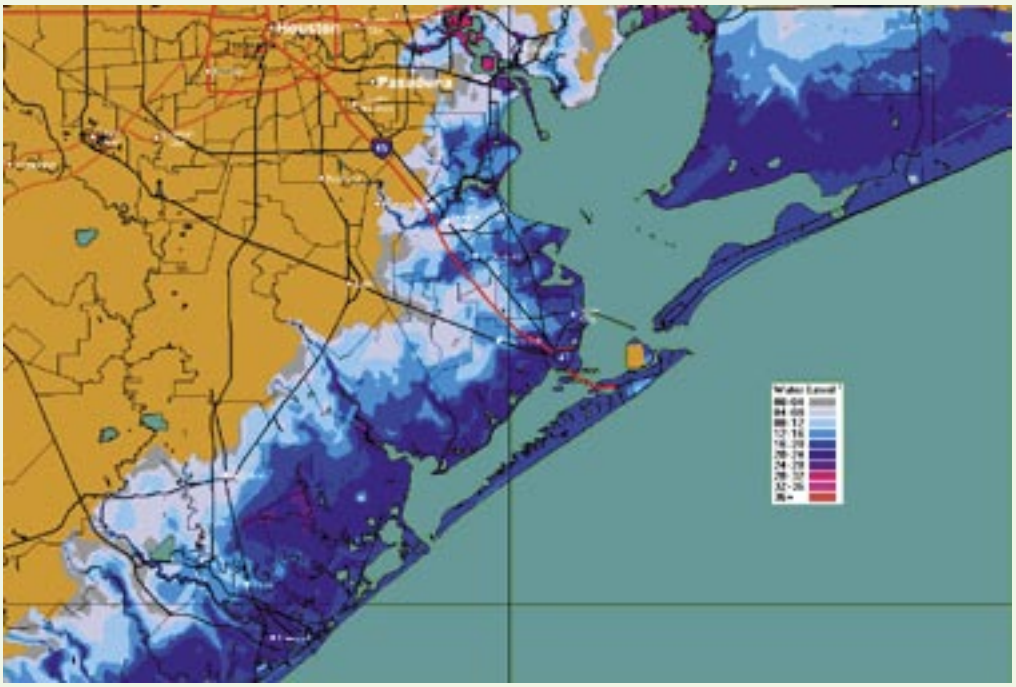
Hurricane Hazards: Storm Surge continued...

SLOSH... SLOSH (Sea, Lake and Overland Surges from Hurricanes) is a computerized model run by the National Hurricane Center (NHC) to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account

- Pressure
- Size
- Forward speed
- Track
- Winds

The SLOSH model is used by the National Weather Service to determine what areas of the coastline would be inundated by storm surge flooding for different category storms. This data is then used by the emergency management community to develop evacuation plans to determine first who must evacuate and then determine a timeline based on the number of citizens that must evacuate.

Houston/Galveston Storm Surge Potential… The Houston/Galveston region is in an area that could potentially experience a storm surge of 25 to 30 feet in Galveston Bay and 18-22 feet along the beach front. Approximately 750,000 people in Brazoria, Galveston and Harris counties live within the category 5 storm inundation areas. When you look at the potential storm surge heights and the large number of people that will be impacted by the storm surge, the potential for a large loss of life is very real.



Land inundation due to a Category 5 Hurricane (Worst case scenario)

The upper Texas gulf coast has a history of storms that have caused significant storm surge. Listed below are a few of the more memorable storms.

Name of the Storm	Height of the Surge	Number of lives lost
1900 Storm	18 -20 feet on Galveston Island	>8000
1915 Storm	15-18 feet	275
Carla 1961	22 feet in Matagorda Bay	46
Alicia 1983	8-12 feet Galveston Bay	21

The worst case scenario for the Houston/Galveston region is a Category 4 or 5 storm making landfall along the Brazoria County coastline and moving north-northwest, staying west of Galveston Bay and downtown Houston. This would put Galveston Bay and the highest concentration of population in the right-front quadrant of the storm. This scenario would produce the greatest storm surge in Galveston Bay for a landfalling hurricane on the upper Texas coast.

If you live along the upper Texas coast it is important to know your threat from storm surge for your home and your business. You need to know the elevation of your home and whether you are in an evacuation zone and when you will be asked to evacuate. This information is available from your local emergency manager. A list of emergency managers both for cities and counties is located on pages 38 and 39 in this publication.

Hurricane Hazards: Inland Flooding

By David C. Schwertz and Paul M. Lewis II

Southeast Texas Inland Flooding Dangers

As Tropical Storm Allison demonstrated in 2001, inland flooding from tropical systems can have devastating consequences. Inland flooding can be produced during any phase of a tropical system since the amount of rainfall is mainly proportional to the forward movement of the storm. The rule-of-thumb for estimating the maximum rainfall expected is to divide the storm's forward speed by 100. For example, a storm moving 10 mph would be forecast to produce a maximum rainfall of 10 inches (100/10 = 10). This means that the worst flooding comes from slow moving storms.

Although Tropical Storm Claudette in 1979 is among the most well known inland flooding events in Southeast Texas, three notable events have occurred over the past decade – Tropical Storms Frances in September 1998, Allison in June 2001, and Fay in September 2002. While they were not record rain producers like Claudette, all generated significant inland flooding. Frances dumped 4 to 6 inches of rain over most of southeast Texas with large areas receiving 8 to 10 inches of rain and some more than 12 inches. Flooding was exacerbated in many locations by tides of 4 to 6 feet above normal. Significant flooding occurred over Harris and Brazoria Counties in the cities of Houston, Jersey Village, Pasadena, and Alvin with more than 1400 homes and businesses damaged or destroyed. Allison meandered over Southeast Texas for four days and in two episodes produced 15 to 37 inches of rain over the eastern half of Harris County, causing 22 deaths and $5.1 billion in damage. Just over one year after Allison, Tropical Storm Fay dropped 8 to 12 inch rainfall totals over the Upper Texas Coast with as much as 20 to 24 inches over portions of Brazoria County. Unlike Frances and Allison, the flooding from Fay was not widespread; yet, there were almost 2000 homes flooded and the damage to infrastructure and public facilities reached into the millions of dollars.

Several factors which contribute to the Houston-Galveston area being prone to flooding include the proximity to the warm, moist air of the Gulf of Mexico, the nearly flat terrain which slows run-off, and a dense network of bayous, streams, and rivers. Added to these factors are the risks from tropical cyclones in the summer and stalled or slow-moving extratropical systems from fall through spring. In 1999, Ed Rappaport of the National Hurricane Center published a study which found that since 1970 inland flooding contributed to 57 percent of the deaths associated with tropical cyclones in the United States. Coastal populations have grown to the point that almost 60 percent of U.S. residents currently live in the coastal states from Maine to Texas and the state of Hawaii and Puerto Rico.

Recent Southeast Texas Notable Tropical Storm Inland Flooding Events
(rainfall amounts in inches)

Frances (1998)		Allison (2001)		Fay (2002)	
Angleton	19.47	Greens Bayou at Mt. Houston Pkwy	38.78	Sweeny	~22.00
Bay City	17.14	Port of Houston	36.99	Freeport	12.91
Houston-Heights	15.25	Hunting Bayou at I-10	35.83	Dow Chemical (Freeport)	10.27
Cypress	12.84	Greens Bayou at Ley Rd.	33.66	Angleton Courthouse	10.00
Sugar Land	2.58	Cowart Creek at Baker Road (Friendswood)	28.31	Clute	9.00
League City	11.49	Beaumont Research	27.24	West Columbia	6.89
Bush Intercontinental Airport	9.33	Deer Park	20.50	Jamaica Beach	5.76
Tomball	8.22	League City NWS	19.41	Garwood	5.15
Huntsville	6.87	Conroe	17.48	Galveston Causeway	4.96
Conroe	4.89	Huntsville	13.01	Galveston Scholes Field	4.09

Past major floods in Southeast Texas led to flood control projects to help mitigate the damage from flood events. For example, the 1935 flood on Buffalo Bayou was a catalyst for the formation of the Harris County Flood Control District (HCFCD). Other projects since have rectified the channels on White Oak, Brays, and Sims Bayous. This entailed deepening and straightening the channel, lining the channel with concrete, and building retention areas. HCFCD took another step in 1980 with a policy of "no downstream impact" for new development, requiring detention or metering systems to control runoff. Additional efforts such as the Brays Bayou Federal Project are ongoing and aim to further reduce the number of homes and businesses in the one hundred-year flood plain by 2012. In newer subdivisions, the streets are designed as floodways with homes built above grade. Floodways greatly reduce the damage to homes, but have serious implications for evacuation and personal safety.

Protecting Yourself and Others from the Dangers of Inland Flooding

There are practical ways which can nearly eliminate the risks of death, injury, and financial loss during an inland flood event. These can be summarized into five practical keys:

1. Protect Your Past – The 15-Minute Rule: A focus on personal records and special items
2. Protect Your Present – Buy Flood Insurance: A focus on replaceable items
3. Protect Your Future – Flood Proof Your Home: A focus on minimizing flooding impacts
4. Protect Your Peace of Mind – Save Your Life: A focus on planning and communication
5. Protect Yourself and Others – Never Drive on Flooded Roads: A focus on "Turn Around, Don't Drown!"

a. Protect Your Past – The 15-Minute Rule

Protecting your past involves taking care of valuables such as pictures, important documents, or collectibles. This can be accomplished by utilizing various sized plastic tubs with locking tops. Regular storage of valuables in these tubs can help greatly reduce the amount of time it takes to move them in the advent of a flood. The 15-minute rule means that it should be possible to secure and move all your valuables within fifteen minutes.

b. Protect Your Present – Buy Flood Insurance

Since a major financial asset for most people is their home, protecting the ability to repair or replace a home is important. ***Most homeowners' policies do not cover flood damage!*** Too often, homeowners discover this ***after*** they have been flooded. The irony is that the low cost of flood insurance is one of the best deals around.

Most homeowners live outside the 100-year, or one percent flood plain. This means that there is a one percent chance of flooding in any given year, or a 30 percent chance of flooding over a standard 30-year mortgage. Flood insurance is available from the National Flood Insurance Program (NFIP). This program is administered by the Federal Government, is available through your regular insurance agent or from the NFIP, is very reasonably priced, and ***it covers flood damage***. More than 25 percent of NFIP claims have come from structures outside identified flood plains – meaning those who had coverage got a great bargain. More information can be found on the NFIP website at:
http://www.fema.gov/about/programs/nfip/index.shtm

c. Protect Your Future – Flood Proof Your Home

There are simple, low-cost ways to prevent damage and minimize the disruption of normal activities which flooding usually causes. If water starts to enter your home, shutting off the power at the main circuit breaker will prevent appliances from short circuiting and eliminate the threat of electrocution to those in the home. Outside air conditioning units can be raised on platforms above ground level. Storing rarely used items in the attic, or expensive items on high shelves, will reduce the chance flood waters can cause damage.

d. Protect Your Peace of Mind – Save Your Life

Good decision making is essential in saving your life during a flood event. Gathering information and developing a plan of action in advance of a flood event can help keep you from panicking or withdrawing during an emergency. Good sources of information can be obtained from NOAA Weather Radios, cable and broadcast TV and radio, or the Internet. Be sure to have battery powered radios or televisions in the event of a power outage. An action plan can be started by checking a set of detailed maps for your county such as a key map. These allow you to plan an evacuation route and alternatives in case your primary route is blocked by flood waters or traffic.

e. Protect Yourself and Others – Never Drive on Flooded Roads

Despite consistent warnings to avoid flooded roads over the past thirty years, most people who lose their lives during a flood are swept away in their vehicles or drown after evacuating a stalled vehicle. During Tropical Storm Allison in 2001, nineteen of the twenty-two deaths and many of the emergency rescues were related to driving or walking through flood waters. To help amplify the flood awareness message, the National Weather Service in cooperation with the Federal Alliance for Safe Homes (FLASH) and others have instituted the **"Turn Around Don't Drown!"** program. This is similar to the "Stop, Drop, and Roll" fire safety technique that is taught to children.

Driving into flooded roadways puts your life and the lives of others at risk. Consider the impact driving into flood waters has on others, especially rescue workers whose lives are unnecessarily put at risk when trying to rescue stranded motorists. Emergency workers focused on *avoidable* flood rescue are not available in other needed areas such as medical emergencies or evacuating elderly or handicapped residents. During most flood events you are probably safest staying at your current location unless specifically told to evacuate.

If you encounter flood waters when driving, Turn Around, Don't Drown!

Industry's Response To The Hurricane Threat

Lew Fincher, Hurricane Consulting, Inc.

Just as coastal residents of Texas are prepared each year for a hurricane season, the same goes for any business or major industry facility or plant site. If a facility is not properly prepared when a hurricane makes landfall near its location, the impact from the forces of that storm could ring the death knell for product production for days, weeks, months, or much worse.

Over the 2004-2005 hurricane seasons, Industry learned numerous lessons, especially from those facilities that were directly or indirectly impacted by the landfalling hurricanes along the northern coastline of the Gulf of Mexico. Hurricanes Ivan, Katrina, and Rita's major impact staggered refining and production in the petrochemical industry. These storms made it very clear to all industries and business owners that if they wanted to re-open their doors when the next Major Hurricane threatened, they better have a workable plan and be better prepared than ever before. Even though Hurricane Rita still heavily impacted several industrial facilities in its direct path at landfall, with its storm surge and high damaging winds, many facilities were able to bring employees back to work quicker and experience less production downtime due to the hard lessons experienced in the earlier storms.

National, state, and local conferences and workshops have brought emergency managers from the federal, public and private sectors together to discuss how a better working relationship can mitigate damages and impacts from what this author considers a Tropical Terrorist – a landfalling major hurricane. Such organizations as the Texas Chemical Council, the National Petrochemical & Refiners Association, the American Petroleum Institute, along with the Louisiana Chemical Association have all shared information on key learnings from hurricane impacts to better prepare the industry for the next hurricane threat. The Petrochemical Industry understands that the threat is real and it needs to be prepared. Its future could depend on the standard of its preparedness and mitigation planning, as long range forecasts show that the Tropical Atlantic Basin, which includes the Atlantic, Caribbean, and the Gulf of Mexico, will experience above average hurricane activity for years to come.

All facilities should have a workable plan and a set of procedures that has been reviewed and tested with at least one drill before each hurricane season. This set of procedures and plan needs to be taught to every employee, with the directive for this education coming from the top, the Site Manager down, including the security, production, technical, engineering, and mechanical departments. It is a good idea to include an annual hurricane safety and awareness meeting for all employees that not only covers on-the-job, but off-the-job preparedness and mitigation planning. This way not only is the employee better prepared to assist and understand the need for preparedness at the facility, but can also go home and teach his or her family and friends a plan that could possibly save their lives, and home. The facility plans and procedures are to focus on protecting the viability of the facility, enabling its rapid return to operation and providing for their employees.

One of the first steps that a responsible facility needs to take is to establish an emergency management team that is chaired by a member of the site's senior staff or possibly someone higher up the corporate levels. The remaining team members should be representatives of all critical operating units: security, human relations, purchasing, contracting, government affairs, medical, mechanical, and the fire brigade. This team has a responsibility to develop a comprehensive crisis management plan; identify, assign, and supervise personnel responsible for implementing crisis operations; arrange for the necessary material support that the plan anticipates will be needed; and evaluate actions needed to address unanticipated consequences from a hurricane impact.

All facilities should have plans that cover such items as:

- Identify critical areas that require security.
- Ensure that all security and key operations personnel who need to return to the facility have company issued badges with proper authorization. This also includes the specially trained Site Hurricane Rideout Team that will stay behind after the site is completely shutdown and secured for the storm and that monitor the site during the storm, until they are relieved.
- Detailed steps to be taken to secure critical areas, gates, and equipment against the forces of the storm.
- Prepare and stock the supplies and equipment that will be needed to secure the facility before and during the hurricane, and to assist in the recovery operations.
- Comprehensive pre-hurricane logistical planning is essential to be able to respond during the response and recovery periods.
- Fuel! Fill up all vehicles before securing the facility and move them to a safe location above the elevation of the forecast storm surge and flooding level and also protect from flying debris.
- Anticipate the need for high water vehicles, not only for the recovery stage, but in case of an extraction of the hurricane rideout crew.
- Conduct a site pre-hurricane audit that includes:
    - o inspection of storage tank bolting systems that secure the tank to the pad
    - o inspect roof top equipment that may need to be better secured
    - o inspect instrument tubing and electrical equipment and trays that carry signals from control rooms through all areas of operating pads (high winds will cause major problems if these are not secured)
    - o Identify, furnish and fortify the safe and secure location of ride out team
        - Provide cots, dry bedding, chairs, tables, toilets, showers, and a food preparation area
        - Include all personal protection equipment needed, such as tools, plastic, plywood, duct tape, heavy weather gear, and air lines with masks connected to air cylinders as well as portable air equipment.

All of this is just the start of how an industrial facility prepares for a hurricane. If you would like to know more, attend your Local Emergency Preparedness Committee Meeting or call your local Office of Emergency Management for more information. By attending the 2007 Houston/Galveston NWS Hurricane Workshop you will leave better prepared for the next threat from the Tropical Terrorist. Now go share the information.

Scenario for Disaster: A Major Hurricane Striking The Upper Texas Coast

By Brian Kyle and Matthew Moreland

Only one major hurricane has directly impacted the Houston/Galveston region in the last 40 years: Hurricane Alicia in August 1983. Alicia produced significant damage in the Houston/Galveston area; yet, was rated a low-end Category 3 hurricane on the Saffir-Simpson scale as it made landfall and Category 2 as it moved into Harris County. Most recent Houston area residents have never experienced an extreme or catastrophic hurricane. What can we expect if a major hurricane were to make landfall along the upper Texas coast?

Forecast Track

Figure 1 depicts an example forecast track for a major hurricane heading toward the upper Texas coast. Because of the large number of people who need to evacuate, decisions on evacuation would need to be made by this forecast. If this track were to verify, it would be one of the worst case scenarios for the Houston/Galveston Bay area and Brazoria County.

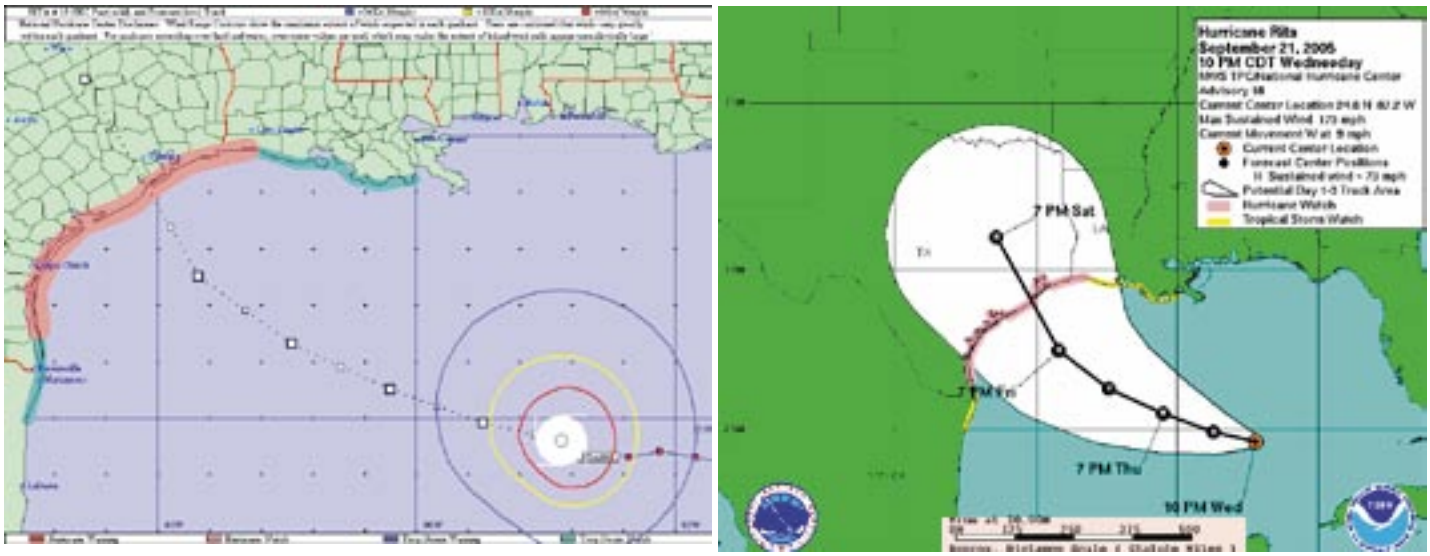


Figure 1: Example of a major hurricane track (Hurricane Rita in 2005). This track would present a worst-case scenario for the Houston/Galveston area. Source: HurrEvac.

What should one think when seeing this forecast track? First of all, it is important to remember that every forecast has some degree of uncertainty. In this example, expected landfall would not occur for another 60 hours. Forecast skill at 60 hours is such that landfall is just as likely to occur 135 miles either side of the line on this map as well as directly along the forecast track itself.

	Hours Before Landfall				
	24 hours	48 hours	72 hours	96 hours	120 hours
Forecast Error	70 miles	110 miles	160 miles	200 miles	280 miles

Table 1. Average Atlantic tropical cyclone track forecast error.

Given this forecast, everyone along the upper Texas and western Louisiana coasts from north of Corpus Christi to east of Lake Charles would need to prepare for a possible direct hit.

Storm Surge

Figures 2 through 5 illustrate what the storm surge would look like with a major hurricane making landfall along the upper Texas coast.

Storm surge, or a wall of water that is pushed toward the shore by the force of the winds swirling around the hurricane, can increase the□

With a major hurricane making landfall near Freeport, storm surge would inundate most or all of Galveston Island and the Bolivar Peninsula and flood the communities on the western side of Galveston Bay including Texas City, Kemah, League City and Dickinson. In Chambers County, storm surge would flood stretches along Interstate 10 and most of the southern half of the county. In Brazoria County, storm surge would flood Freeport and Surfside and could spread into parts of Lake Jackson and Angleton. Storm surge would spread into a large part of southeast Harris County, flooding La Porte and Baytown, and portions of Deer Park, Pasadena, Clear Lake and Webster. The surge would result in billions of dollars in damage just in this area and would greatly cripple the oil and chemical industries. In a worst-case scenario, up to 600,000 homes and businesses could be flooded in Harris County alone.

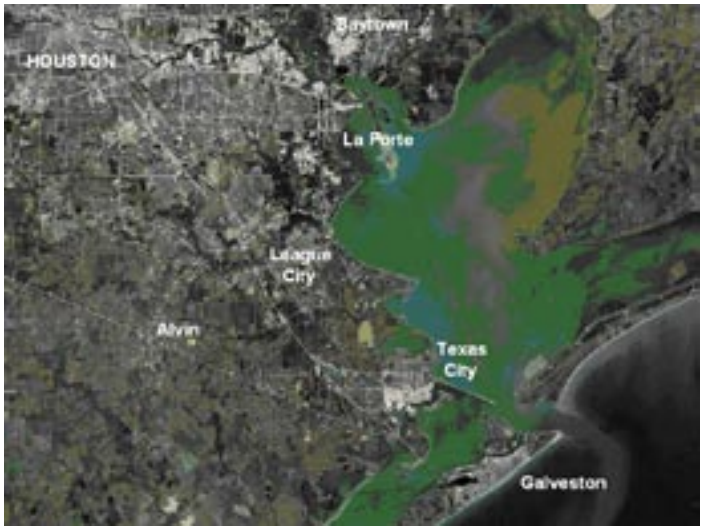


Figure 2. Base map with no hurricane activity

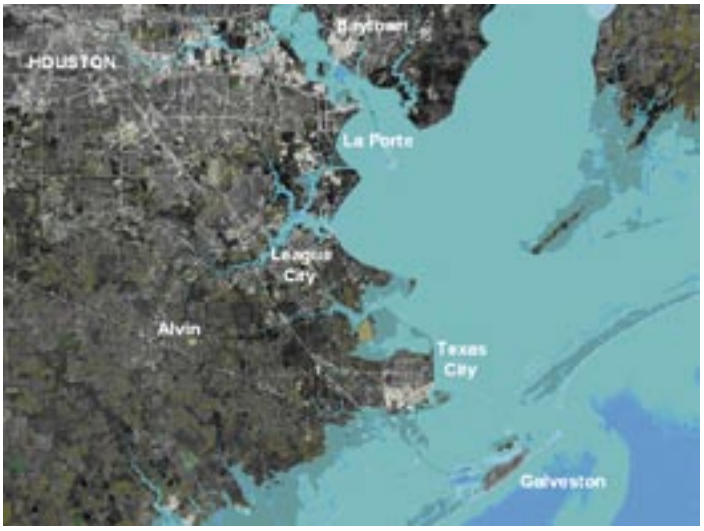


Figure 3. Category 3 hurricane with storm surge of 10.6 feet

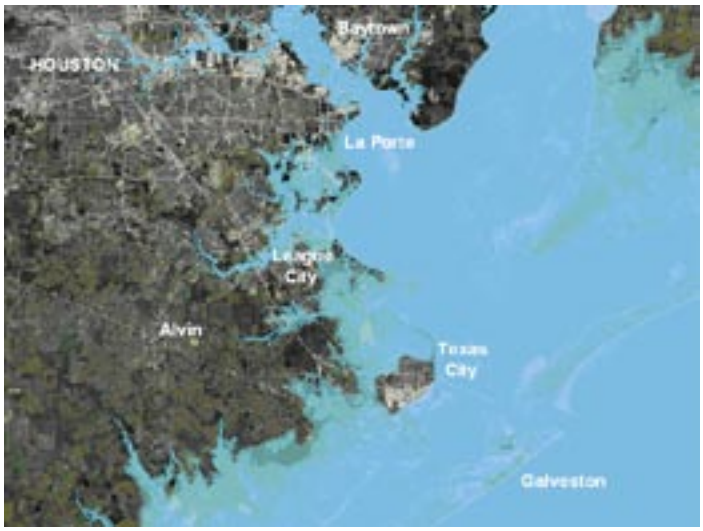


Figure 4. Category 4 hurricane with storm surge of 17.9 feet

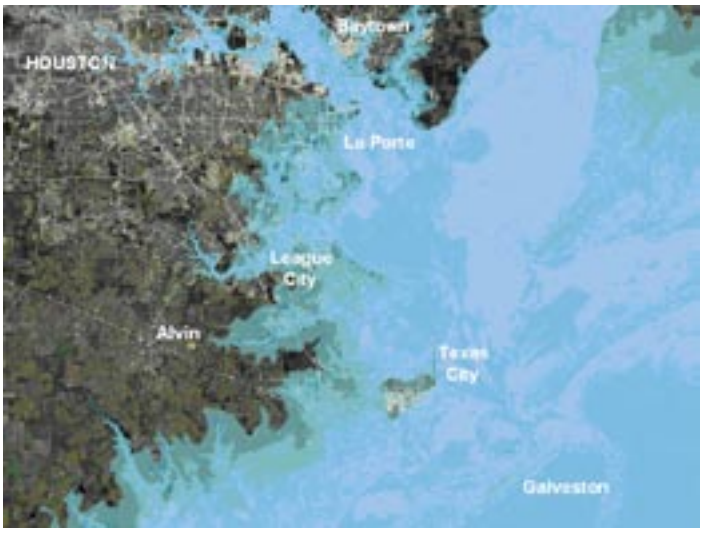


Figure 5. Category 5 hurricane with storm surge of 22.4 feet

Without hesitation, folks living in areas subject to surge flooding should evacuate to higher ground, even if it is only a few miles away! Historically, 90% of all hurricane deaths can be attributed to the storm surge.

Winds

Figure 6 depicts the expected peak wind gusts given the forecast track of a Category 4 hurricane (roughly the size and intensity of Hurricane Rita in 2005) as it moves through southeast Texas. Areas shaded in red would experience hurricane force winds (greater than 73 mph) and those in yellow would experience tropical storm force winds (39 to 73 mph).

Although hurricane force wind protection has been a requirement with home construction in southeast Texas since the late 1980s, many older and poorly constructed homes would have the potential to be severely damaged or completely destroyed.

Given this information, who should evacuate? If you are not in a mandatory evacuation area, it truly is a personal decision. How sturdy is your residence? Do you have an interior downstairs room away from windows where you can temporarily seek refuge in if it becomes necessary? Do you or your loved ones have medical issues that would be compromised if you lost power? Do you have enough supplies to live without electricity for at least three to seven days? It is important to remember that of all the hazards associated with hurricanes (surge, inland flooding, and winds), winds are the least likely element to cause death. Category 5 Hurricane Andrew, with winds measured in excess of 150 mph, destroyed or damaged nearly 100,000 homes in Southern Dade County in Florida, yet resulted in a loss of life of less than fifty.

People that live in poorly constructed homes, mobile homes, and high rises should strongly consider evacuating or moving to a shelter. Recent studies indicate that the strongest winds in the eyewall are found near 1600 feet elevation where speeds can be as much as a full category stronger than winds observed at the surface.

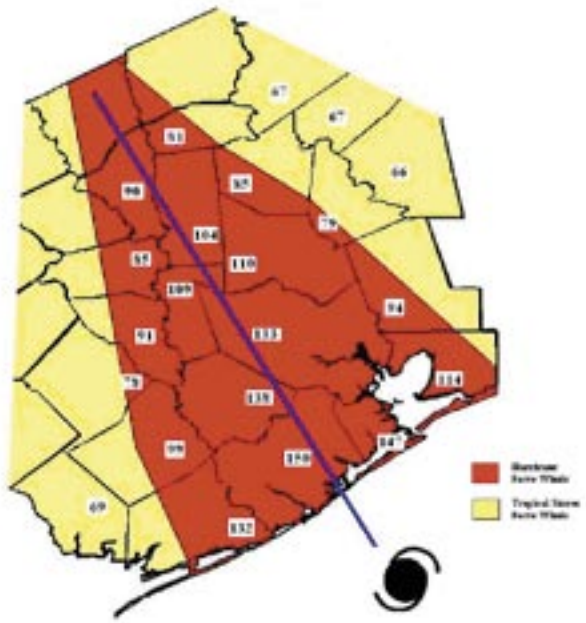


Figure 6: Forecast peak wind gusts by county, in mph, of a Category 4 hurricane the size of Rita (2005). Not everyone in the county would experience wind gusts this high – just locations closest to the eye of the hurricane. Source: HurrEvac.

Rainfall, Inland Flooding and Tornadoes
Inland flooding, rainfall and tornadoes can be the most difficult aspect of hurricanes to predict. Residents should not make their evacuation decisions based solely on these elements.

A good first guess into expected rainfall amounts is to divide the number 100 by the forward motion of the hurricane. If the hurricane is moving at 10 mph, expect 10 inches of rain (100 / 10 = 10 inches). A slower moving storm, say at 5 mph, could produce upwards of 20 inches of rain (100 / 5 = 20). Problems frequently arise when hurricanes speed up, or more importantly slow down. Estimates can then be off by several factors!

Inland flooding has risen to near the top of hurricane killers. Once moving inland, tropical cyclones can sometimes meander over the same geographic area for days at a time producing copious amounts of rain. In June 2001, Tropical Storm Allison made its way to the Lufkin area before drifting back over the Houston metro area. Allison produced upwards of 35 inches of rain across some areas. Widespread flooding caused $5 billion in damages and claimed 22 lives.

Unfortunately, these extreme events are difficult to pinpoint where they will occur far enough in the future to ensure an early evacuation that is safe and orderly. They could just as easily occur 200 miles inland as they can near the coast. Again, decisions to mass-evacuate should not be made based on rainfall estimates. Instead, residents that live in low lying areas that typically flood during an afternoon thunderstorm, or those that live near creeks or rivers should consider going to a nearby shelter to ride out the storm. If caught in rising water, evacuate vertically. Move upstairs or on your roof if a dire situation calls for such an action. Remain sheltered in a safe place and do not go out “sight seeing”. In Tropical Storm Allison no on drowned inside their home! All drowning deaths were in cars or people on foot.

Tornadoes are frequently associated with land-falling hurricanes. Though the numbers of tornadoes vary with each hurricane, the vast majority are located in the northeast quadrant. Tornadoes cannot be predicted ahead of time and evacuation decisions should not be based on this element whatsoever!

Preparations
Whether or not you decide to evacuate, please refer to the section in the back of this booklet labeled “Hurricane Preparation Checklist” for detailed information on what to do to prepare for the threat of a major hurricane.

The Aftermath
A recent engineering study conducted by Dodson & Associates in association with the Harris County Office of Homeland Security and Emergency Management determined that a strong Category 4 or 5 hurricane directly striking the Houston/Galveston area would cause over $40 billion in damage in Harris County alone. The Texas Governor’s Division of Emergency Management has stated that a Category 4 hurricane making a direct strike on the upper Texas coast would cause $70 to $75 billion in damage to a 31 county area of Southeast Texas *(Figure 7)*, destroy around 120,000 residences, and generate 124 million tons of debris.

A joint study was conducted in 1999 between the Harris County Office of Emergency Management, the Harris County Flood Control District, the National Weather Service, the Harris County Judges Office, Dodson & Associates, Inc. and EQE International, Inc. The goal of the study was to determine what would result in the aftermath of a hurricane like Rita or Katrina.

Critical facilities such as communication and health care could be interrupted or in some cases unavailable for days or weeks. The Medical Center could be severely crippled by flooding, damage, or a lack of power, and possibly even shut down for a long period of time. Critical services like fire, ambulance, and law enforcement will be overloaded for some time after the storm leaves. Power outages would be widespread (likely affecting millions), and the power could be out for days, if not weeks. Both major airports would be closed for an extended period.

The hurricane could result in health-related hazards such as release of toxic substances (from flooding and debris), a prolonged shortage of water and wastewater services (from damage, flooding, and a lack of electrical service), and a shortage of garbage and debris collection and disposal services.

Long-term effects from the hurricane could include the need for massive infrastructure repairs, and the relocation of population from heavily damaged parts of the city to less damaged areas. Business failures, especially to small businesses, could be widespread, resulting in a loss in the area's economic base. Property values could drop on all forms of property for a period of time following the hurricane.

While the upper Texas coast has seen a reprieve from hurricanes in recent years, there was a time when hurricane activity was much more active here. In the early part of the 20th century, the Houston area was directly hit by two Category 4 hurricanes 15 years apart – in 1900 and 1915. Each of these storms would have produced well over $30 billion in damage if they struck today. The last Category 4 hurricane to strike the Texas coast was Carla in 1961 – well before the economic and population boom we have seen in recent decades. To say that we are overdue is an understatement.

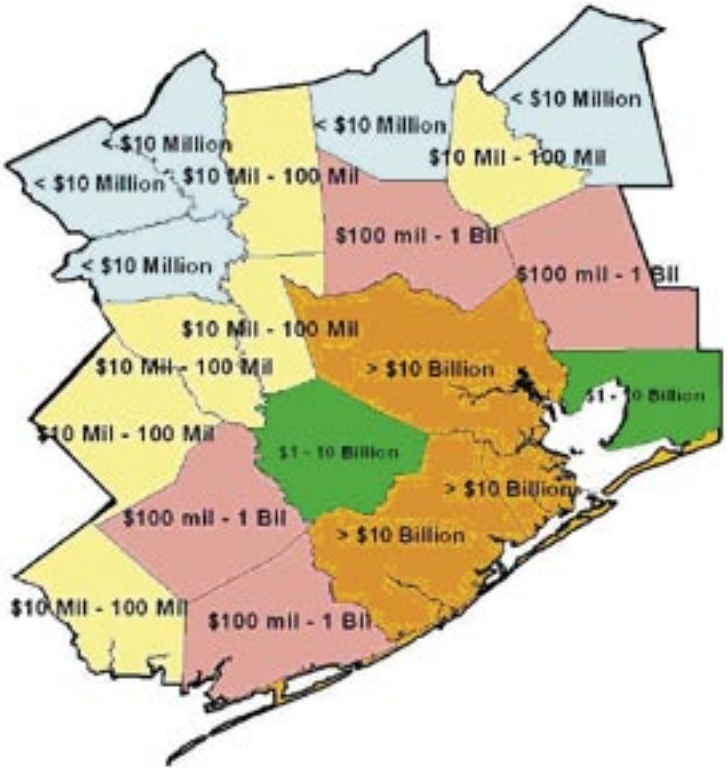


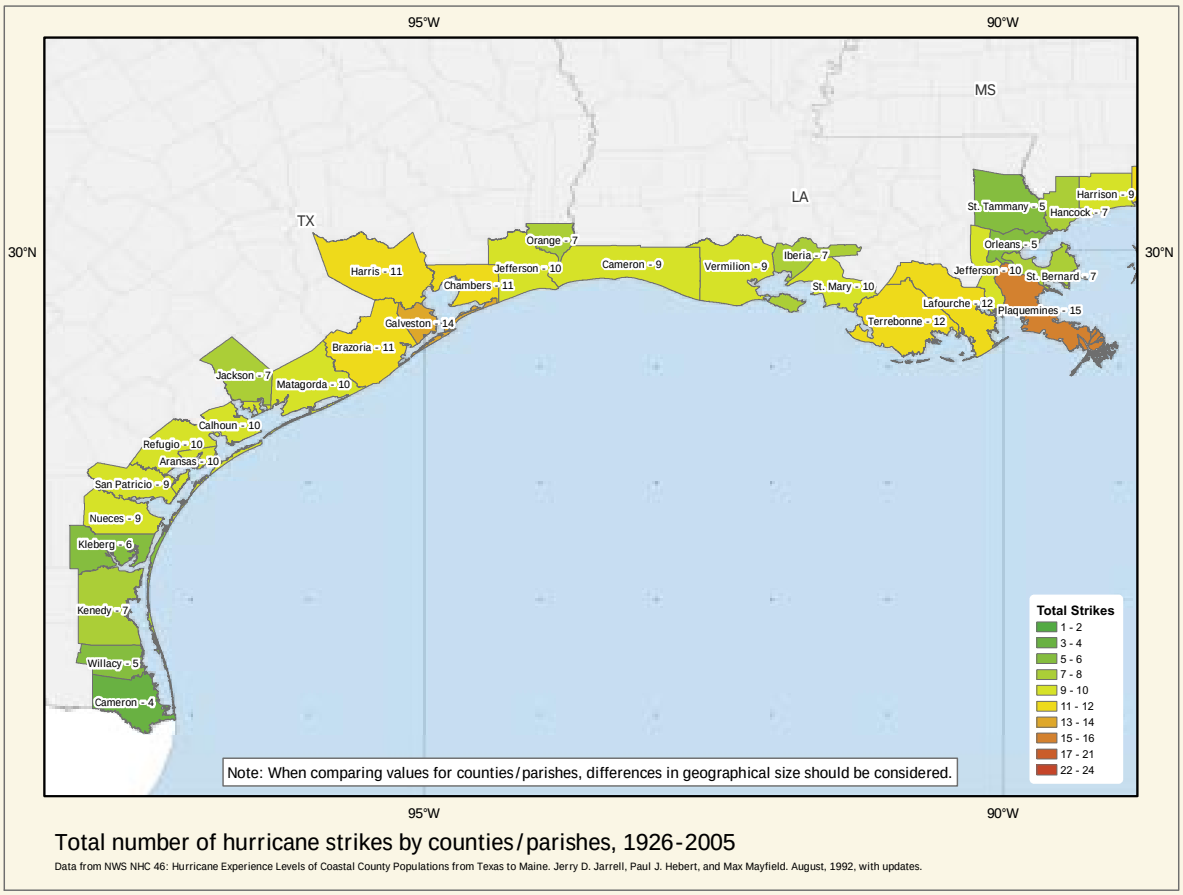
Figure 7: Estimated damage that would result from a direct strike by a Category 4 hurricane on the upper Texas coast (listed by county). Source: Texas Governor's Division of Emergency Management (2005).

Sources:

1 "Models Show 'Massive Devastation' In Houston" Eric Berger Feb. 20, 2005 Houston Chronicle
2 Texas Governor's Division of Emergency Management hurricane report (early 2005)
3 "Hurricane Mitch Scenario" (Joint Study) (http://www.hcoem.org/videos.htm) Harris County Office of Homeland Security and Emergency Management 1999

Footnote:
Similar graphics and scenarios in this article are also available for Category 4 and 5 hurricanes making landfall in the Matagorda Bay area. Contact the Houston/Galveston National Weather Service Office by phone or e-mail and we will be happy to provide you with that information.

Upper Texas Coast Tropical Cyclone Climatology



Total number of hurricane strikes by counties/parishes, 1926-2005

Data from NWS NHC 46: Hurricane Experience Levels of Coastal County Populations from Texas to Maine. Jerry D. Jarrell, Paul J. Hebert, and Max Mayfield. August, 1992, with updates.

Between 1926 and 2005, the upper Texas coast (Brazoria, Chambers, Galveston, Harris, Jefferson and Orange Counties) has received more hurricane strikes than any portion of the coastline. Fourteen hurricane strikes for Galveston County in this eighty-year period averages out to one hurricane strike every 5.7 years. The last hurricane to strike Galveston County was Jerry in 1989, almost eighteen years ago.

Saffir-Simpson Hurricane Scale

All hurricanes are dangerous, but some are more so than others. The way storm surge, wind, and other factors combine determines the hurricane's destructive power. To make comparisons easier, and to make the predicted hazards of approaching hurricanes more clear to emergency officials, hurricane forecasters use a disaster-potential scale, which assigns storms to five categories. Category 1 is a minimum hurricane; Category 5 is the worst case scenario. The criteria for each category is shown below. The winds are used in the determination of each category.

Category	Central Pressure (mb)	Winds (mph)	Upper Texas Coast Surge (Feet)		Damage	Storm Example
			Coast	Bays		Name/Year
1	980+	74-95	4-5	4-7	**Minimal:** No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery and trees.	Claudette (TX) 2003
2	965-979	96-110	6-8	8-12	**Moderate:** Some roofing material, door and window damage to buildings. Considerable damage to vegetation, mobile homes and piers.	Frances (FL) 2004
3	945-964	111-130	9-12	13-18	**Extensive:** Structural damage to small residences and utility buildings with minor curtain wall failures. Mobile homes destroyed.	Alicia (TX) 1983
4	920-944	131-155	13-18	19-24	**Extreme:** More extensive curtain wall failures with some complete roof structure failure on small residences. Major beach erosion.	Carla (TX) 1961
5	<920	>155	18+	24 +	**Catastrophic:** Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away.	Andrew (FL) 1992

American Red Cross

ATLANTIC HURRICANE TRACKING CHART

Always remember

If you live along the coast or in a low-lying area, if you live in a mobile home in an area subject to hurricane water or wind, or if authorities tell you to... Go!

Storm Surge

A storm surge is a dome of water often 50 miles wide that comes sweeping across the coastline near the area where the eye of the hurricane makes landfall. The surge, aided by the hammering effect of breaking waves, acts like a giant bulldozer sweeping away everything in its path. Nine out of ten hurricane deaths are caused by storm surge. That's why it's important to leave well before a hurricane may come your way.

Wind Damage

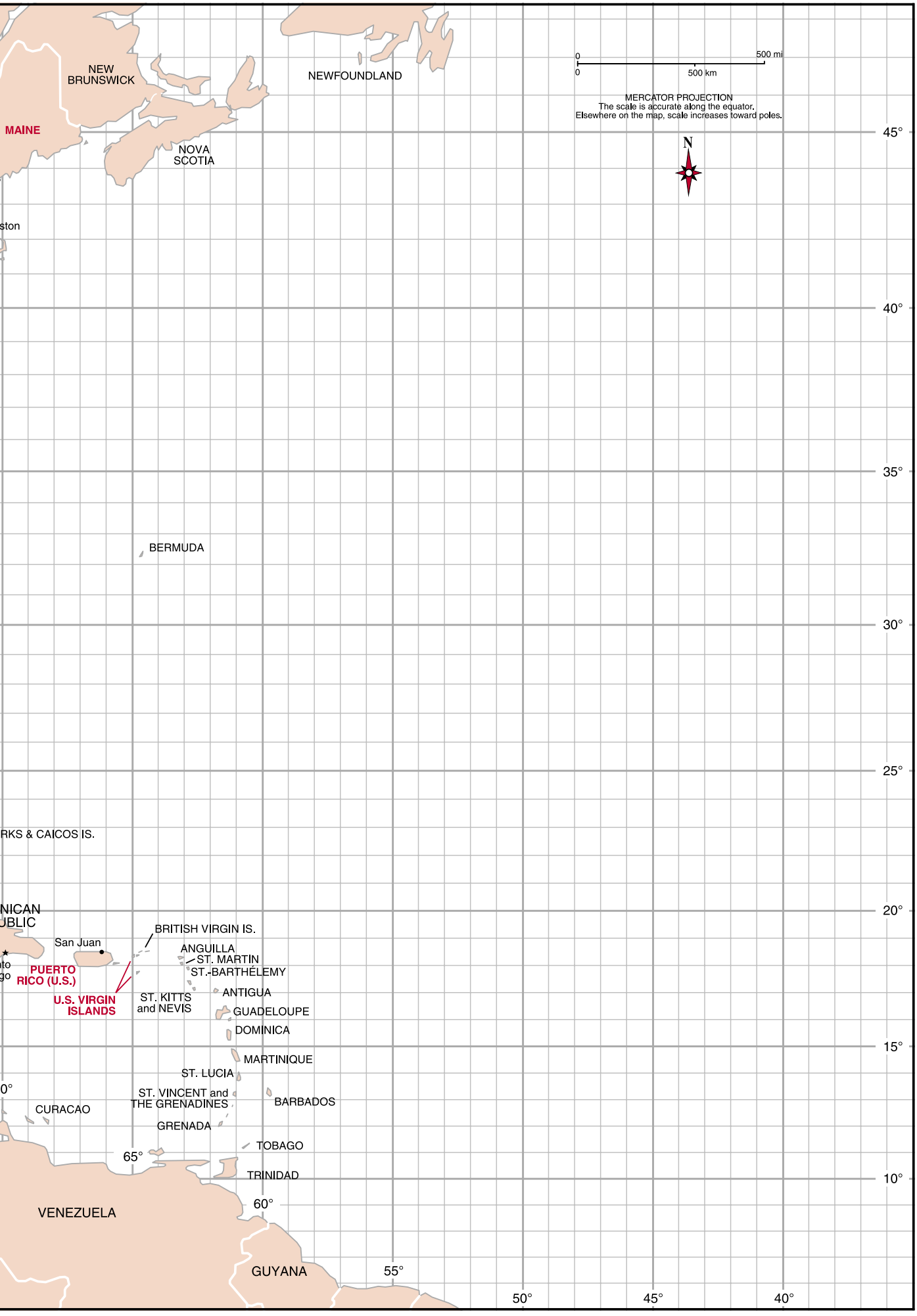
Hurricane winds can cause significant damage to homes and businesses far from the shore. If you live in an area anywhere near the path of a hurricane, you should take steps to protect property from high winds. Bring in anything from outside that may become airborne in high winds, including toys, lawn chairs, trash cans, coconuts, etc. Cover all windows of your home. If shutters are not installed, use 3/4" marine plywood panels. Tape does not work, so it is not recommended. Remain inside until authorities tell you the danger has passed.

Other Hurricane Effects

Hurricanes can produce flooding far inland, especially if the storm "stalls" or produces a lot of rain. Also, tornadoes can form when hurricanes come on shore. Ask your American Red Cross, National Weather Service, or emergency management office what to do in case of a flood or tornado.

More Information

More information about hurricanes, protection from wind damage, floods, and tornadoes is available from your local American Red Cross chapter, National Weather Service Office, or emergency management agency.


NEW BRUNSWICK
NEWFOUNDLAND
MAINE
NOVA SCOTIA
ston
0
500 mi
0
500 km
MERCATOR PROJECTION
The scale is accurate along the equator.
Elsewhere on the map, scale increases toward poles.
N
45°
40°
35°
BERMUDA
30°
25°
RKS & CAICOS IS.
NICAN
UBLIC
20°
BRITISH VIRGIN IS.
San Juan
ANGUILLA
ST. MARTIN
PUERTO RICO (U.S.)
ST.-BARTHÉLEMY
U.S. VIRGIN ISLANDS
ST. KITTS and NEVIS
ANTIGUA
GUADELOUPE
DOMINICA
15°
MARTINIQUE
ST. LUCIA
0°
ST. VINCENT and THE GRENADINES
BARBADOS
CURACAO
GRENADA
TOBAGO
65°
TRINIDAD
10°
60°
VENEZUELA
GUYANA
55°
50°
45°
40°

Naming of Hurricanes

The Tropical Prediction Center near Miami, FL keeps a constant watch on oceanic storm-breeding areas for tropical disturbances which may herald the formation of a hurricane. If a disturbance intensifies into a tropical storm (rotary circulation and wind speeds above 38 miles per hour), the Center will give the storm a name. A separate name set is used each year beginning with the first name of the set. The letters Q, U, X, Y and Z are not included because of scarcity of names beginning with those letters.

The name lists have an international flavor because tropical storms and hurricanes affect other nations and are tracked by the public and weather services of countries other than the United States. Names for these lists are agreed upon by nations involved during international meetings of the World Meteorological Organization.

For several hundred years, many hurricanes in the West Indies were named after the particular saint's day on which the hurricane occurred. Ivan R. Tannehill describes in his book "HURRICANES" the major tropical storms of recorded history and mentions many hurricanes named after saints. For example, there was "Hurricane Santa Ana" which struck Puerto Rico with exceptional violence on July 26, 1825, and "San Felipe" (the first) and "San Felipe" (the second) which hit Puerto Rico on September 13th in both 1876 and 1928.

Tannehill also tells of Clement Wragge, an Australian meteorologist, who began giving women's names to tropical storms before the end of the 19th Century.

An early example of the use of a woman's name for a storm was in the novel "STORM" by George R. Stewart, published by Random House in 1941 and since filmed by Walt Disney. During World War II, this practice became widespread in weather map discussions among forecasters, especially Air Force and Navy meteorologists who plotted the movement of storms over the wide expanses of the Pacific Ocean.

In 1953, the United States abandoned a confusing three-year old plan to name storms by phonetic alphabet (Able, Baker, Charlie) when a new, international phonetic alphabet was introduced. That year, this nation's weather service began using female names for storms.

The practice of naming hurricanes solely after women came to an end in 1978 when men's and women's names were included in eastern North Pacific storm lists. In 1979, male and female names were included in lists for the Atlantic, Caribbean, and Gulf of Mexico.

Experience shows that the use of short, distinctive names in written, as well as in spoken communications, is quicker and less subject to error than the older more cumbersome latitude-longitude identification methods. These advantages are especially important in exchanging detailed storm information between hundreds of widely scattered stations, airports, coastal bases and ships at sea.

The use of easily remembered names greatly reduces confusion when two or more tropical cyclones occur at the same time. For example, one hurricane can be moving slowly westward in the Gulf of Mexico, while at exactly the same time another hurricane can be moving rapidly northward along the Atlantic coast. In the past, confusion and false rumors have arisen when storm advisories broadcast from one radio station were mistaken for warnings concerning an entirely different storm located hundreds of miles away.

These lists are recycled every 6 years (the 2007 list will be reused in 2013). Several names have been changed since the lists were last used. For the 2006 season, Kirk replaces Keith which was retired after the 2000 season. For the 2007 season, Andrea, Ingrid and Melissa replace Allison, Iris and Michelle which were retired after the 2001 season.

Names of Atlantic Storms Through 2011

2007	2008	2009	2010	2011
Andrea	Arthur	Ana	Alex	Arlene
Barry	Bertha	Bill	Bonnie	Bret
Chantal	Cristobal	Claudette	Colin	Cindy
Dean	Dolly	Danny	Danielle	Don
Erin	Edouard	Erika	Earl	Emily
Felix	Fay	Fred	Fiona	Franklin
Gabrielle	Gustav	Grace	Gaston	Gert
Humberto	Hanna	Henri	Hermine	Harvey
Ingrid	Ike	Ida	Igor	Irene
Jerry	Josephine	Joaquin	Julia	Jose
Karen	Kyle	Kate	Karl	Katia
Lorenzo	Laura	Larry	Lisa	Lee
Melissa	Marco	Mindy	Matthew	Maria
Noel	Nana	Nicholas	Nicole	Nate
Olga	Omar	Odette	Otto	Ophelia
Pablo	Paloma	Peter	Paula	Philippe
Rebekah	Rene	Rose	Richard	Rina
Sebastien	Sally	Sam	Shary	Sean
Tanya	Teddy	Teresa	Tomas	Tammy
Van	Vicky	Victor	Virginie	Vince
Wendy	Wilfred	Wanda	Walter	Whitney

2006 Hurricane Season Summary

The activity level of the 2006 Atlantic hurricane season was near normal. The season had 10 tropical storms, 5 of which became hurricanes and 2 of which became major hurricanes (Category 3 or greater on the Saffir-Simpson Hurricane Scale). For the 40-year period of 1966-2005, the averages for named storms, hurricanes and major hurricanes are 11, 6 and 2 respectively. All of the 2006 hurricane activity occurred during a 37-day period between August 27 and October 2. The last tropical cyclone of any kind also occurred on October 2; since the beginning of the satellite era (1966), only two seasons have ended earlier, with activity in both 1983 and 1993 ending on September 30.

Some season highlights included…

Ten named storms formed during the season. This is the fewest named storms to form since 1997, when only seven named storms formed.

The first named storm, Alberto, formed early in the season on June 11. The climatological average date for the first named storm formation, based on 1944-2005 data, is July 10.

The first hurricane, Ernesto, reached Category 1 status on August 27. The climatological average date for the first hurricane, based on 1944-2005 data, is August 14.

Five hurricanes formed during the season. This is the fewest hurricanes to form since 2002, when four hurricanes formed.

Two major hurricanes formed during the season. The most recent year to have fewer than two major hurricanes to form was in 1997.

Only one hurricane formed in August. This represents the fewest hurricanes to form in August since 2002, when no hurricanes formed.

For the first time since 2002, no named storms formed in October. Prior to 2006, only eleven years since 1950 had no named storm formations in October.

For the first year since 1997, no Category 4 or 5 hurricanes formed in the Atlantic basin.

Three named storms made a landfall in the United States. This is the fewest named storms to make landfall in the United States since 2001 when three named storms made landfall.

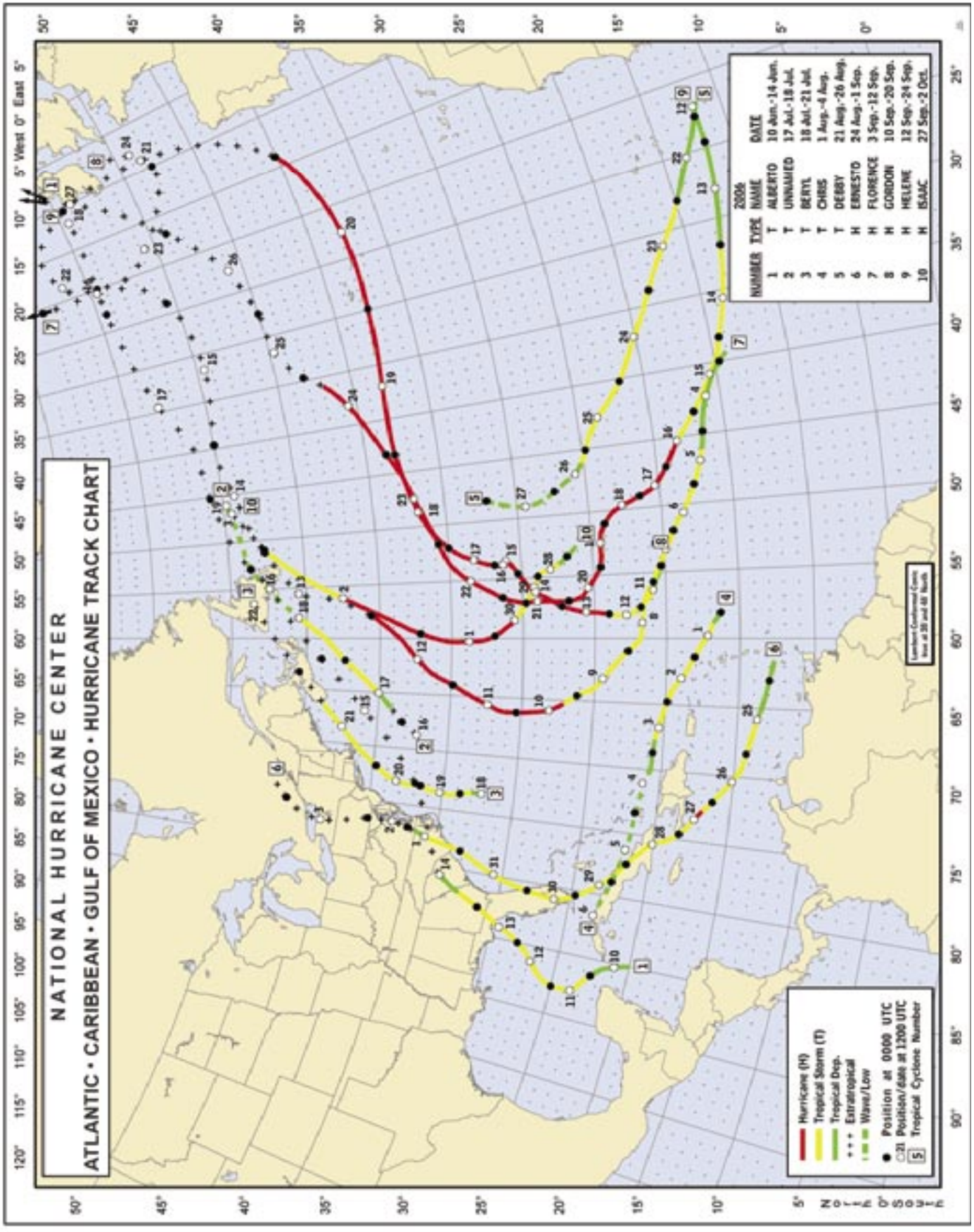
2006 marks only the 11th year since 1945 that no hurricanes have made a United States landfall.

2006 Hurricane Season Summary Table

Name	Class	Dates (UTC)	Winds/Pressure (mph/mb)	Deaths	U.S. Damage (millions)
Alberto	TS	June 10-14	70/995	0	minor
Unnamed	TS	July 17-18	50/998	0	0
Beryl	TS	July 18-21	60/1000	0	minor
Chris	TS	August 1-4	65/1001	0	0
Debby	TS	August 21-26	50/999	0	0
Ernesto	H	August 24 – September 1	75/985	5	500
Florence	H	September 3-12	90/974	0	0
Gordon	H	September 10-20	120/955	0	0
Helene	H	September 12-24	120/955	0	0
Isaac	H	September 27 – October 2	85/985	0	0

H = hurricane, TS = tropical storm

2006 Atlantic Basin Tropical Cyclone Track Map



Tips from CenterPoint Energy

ELECTRIC SERVICE

• Customers should plan to be without power for an extended amount of time following a hurricane landing:

- two to three days after a Category 1 storm
- two weeks after a Category 3 storm, and
- two months after a Category 5 storm.

• During Hurricane Rita in 2005, more than 700,000 of our 1.9 million customers in the Houston area lost power. It took five days to restore power to everyone. CenterPoint Energy crews will work around the clock until everyone's power is restored.

• CenterPoint Energy's Emergency Operation Plan is designed to efficiently restore electric facilities and service in an orderly and timely manner. We accomplish this through pre-planned, efficient and safe use of all company resources and outside assistance.

• The company's first priority in restoring service is to key facilities vital to safety, health, and welfare, such as hospitals, water treatment plants and public service facilities. Then we repair those major lines and circuits that will restore power to the greatest number of customers in the shortest amount of time.

• If you or someone in your home depends on electricity for a life-support system, you should make other arrangements for emergency circumstances. Develop an evacuation plan before a hurricane strikes in the event electric service cannot be restored for several days.

• Stay away from low-hanging or downed power lines. Treat all downed power lines as if they are energized. Stay away from standing water – energized power lines could be submerged in the water. Report any low-hanging or downed power lines to CenterPoint Energy.

NATURAL GAS SERVICE

• CenterPoint Energy strongly advises customers NOT to turn off their natural gas at the meter. The gas meter should be left on to maintain proper pressure in the gas piping within the house and to prevent water from entering the lines should flooding occur.

• If a customer wishes to discontinue gas service, it is suggested that the gas be turned off at each appliance. Later, to restore gas service to an appliance, it is only necessary to follow the written instructions located on the appliance for re-lighting. If unable to locate instructions, call a qualified plumber.

• Though our gas lines are buried underground and are not normally affected by strong winds, high water or other abnormal weather conditions, we are fully prepared to respond to any emergency situation that might arise due to a hurricane.

• Customers who have questions concerning natural gas-related hurricane precautions can visit: www.CenterPointEnergy.com.

Tidal Flooding Along the Upper Texas Coast

Introduction

Because of our very low elevation above sea level on the upper Texas coast, tidal flooding remains a significant hazard to waterfront communities. For tropical systems, ranging from tropical depressions to hurricanes, storm surge is the dominant factor. Storm surge is a large dome of water often 50 to 100 miles wide that sweeps across the coastline near and to the right of where the system makes landfall. The stronger the system, the slower its forward motion; the shallower the offshore water, the higher and more prolonged the surge will be.

However, even if the tropical system is not forecast to make landfall along the Texas coastline, it is important to continually monitor its size, position and strength. This is because abnormally high water levels along the Texas coast are highly dependent on meteorological conditions, more so than the astronomical conditions used to produce tide charts. In addition to storm surge itself, various factors lead to above normal tides including wind direction, wind speed, fetch and duration. These factors are described below.

Wind Direction

The initial transport of water near the surface is 45 degrees to the right of the wind direction. So, an east wind will actually transport more water in a northerly direction (toward Galveston) than a south wind which would "push" water more to the east of the region. Wind directions that are favorable for elevated water levels, assuming other variables that are also met, include NE, ENE, E, ESE, SE. An easy way to figure out which way the "push" of water is headed is to turn your back to the wind, then point 45 degrees to the right.

Wind Speed

Stronger wind speeds (out of the NE, ENE, E, ESE, or SE) correspond to a "stronger" push. In addition, there will be higher waves on top of the elevated water level. Higher winds speeds essentially "trap" water up along the upper Texas coast and bays as conditions are not conducive for the water to recede back into the Gulf.

Fetch and Duration

The fetch is the geographic distance that the wind travels. Duration corresponds to the amount of time a significant sustained wind prevails along the fetch. Both are important factors determining just how much water will "pile up" along the coast. For instance, a fetch of 25 mph easterly winds extending all the way to the west coast of Florida and maintaining itself for three days will transport more water toward Texas than, say, a fetch extending from just off the Louisiana coast that has only been prevailing for 24 hours.

Putting It All Together

When the conditions described above all come together, water levels along the Texas coast will rise above the astronomical levels that one would see in area tide tables. The lowest lying elevations and roads, especially Galveston Bay locations, begin flooding when *observed* tides reach around four feet. Structural damage to roads and personal property often results, but by far the most significant impact is usually the resulting beach erosion. Several million dollars worth of erosion has been estimated by such events in just the past five to eight years. In addition, many "front row" beach homes have been lost and/or involved in litigation due to the vegetation line being pushed back to behind their property. According to the Texas Open Beaches Act, the public beach is defined seaward of the vegetation line. Previous effects that tides have had on various communities are listed on the next page. Elevated water levels will continue until one of two things happen: the wind direction turns to more of a southerly, westerly or northerly direction, or wind speeds decrease.

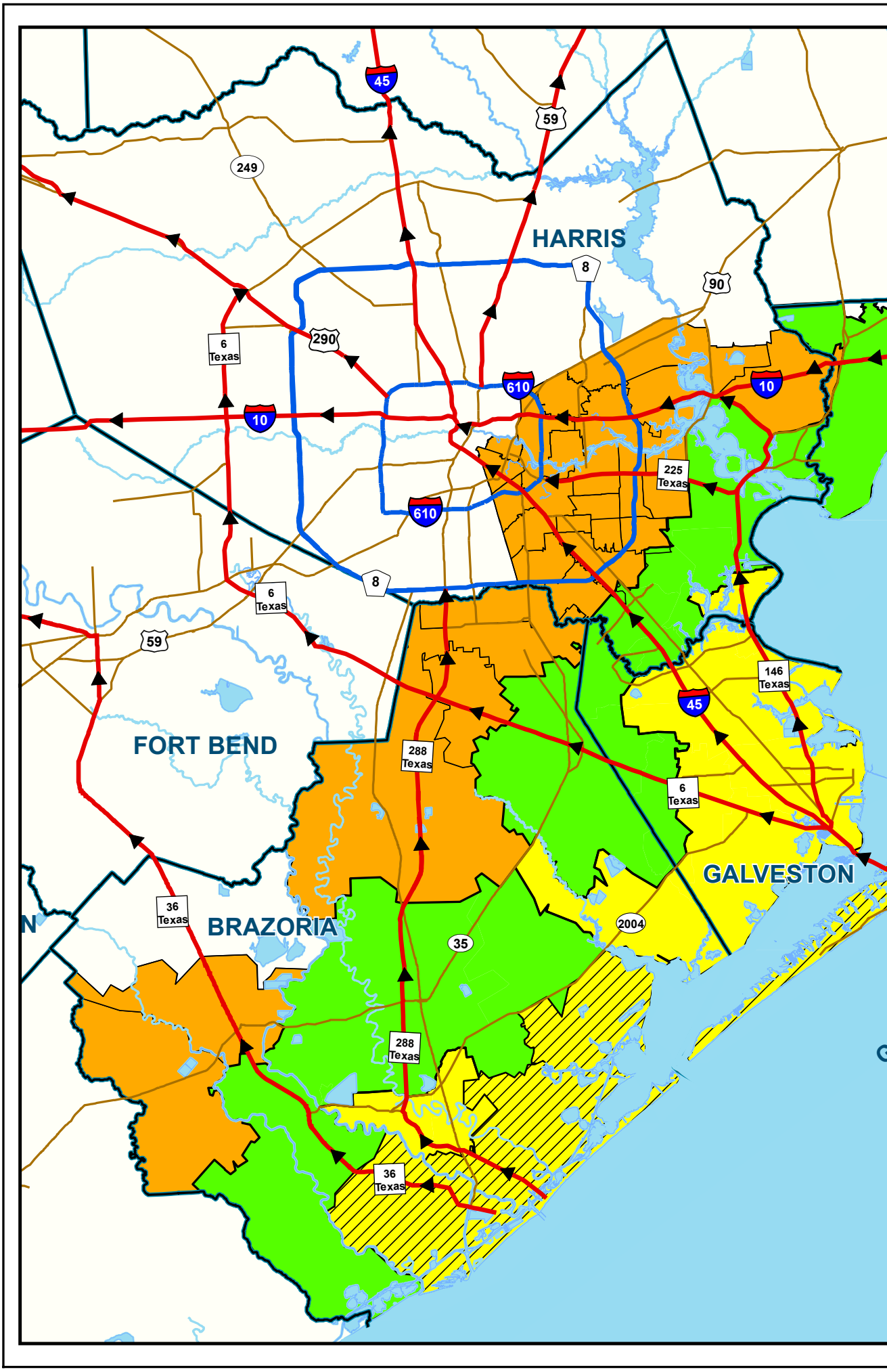
Where to Obtain Tide Levels

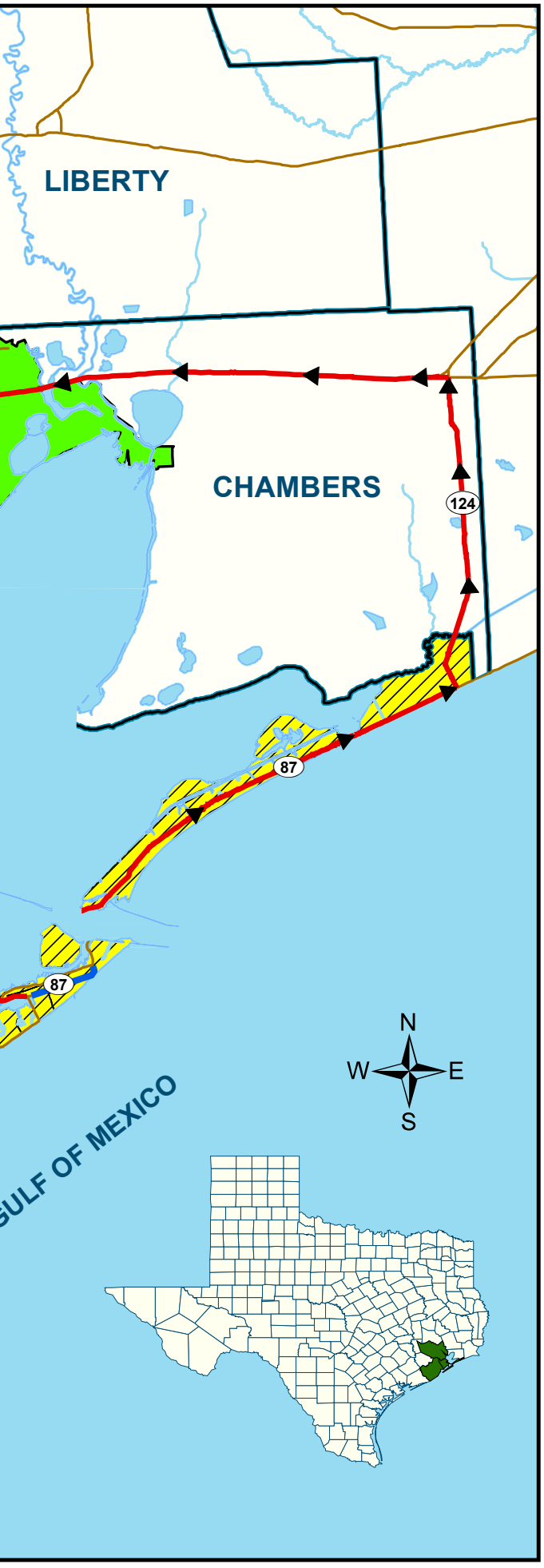
The Houston/Galveston NWS produces a daily tide forecast that is sent to the media and internet. The forecast is also put on NOAA Weather Radio each day. We particularly like the PORTS data, which shows real-time water levels at various locations versus the predicted astronomical level (tide table). You can find the link to the tide forecast and PORTS data off of our website at: www.srh.noaa.gov/hgx/marine.htm

Tidal Flooding Along the Upper Texas Coast

Critical Water Levels Along the Upper Texas Coast

	4.0 feet	4.5 feet	5.0 feet	5.5 feet	6.0 feet	6.5 feet
Galveston Bolivar Peninsula	Lowest streets begin to flood especially on the west end of Galveston. Portions of HWY 6 between I-45 and Hitchcock begin to flood.	Parts of HWY 87 become impassable.	Ferry service to and from Bolivar ceases. Many feeder roads near the bay begin to flood.			
Kemah Seabrook Clear Lake Texas City	Toddville Rd begins to flood. Lower portions of Red Bluff Rd between Bay Area Blvd & HWY 146 begin to flood.	Parts of Toddville Rd closed.	Water 3 feet deep and in homes along Toddville Rd.			
Chambers County	West Bayshore Rd. between Anahuac and Oak Island begins to flood. HWY 124 between High Island and FM 1985 begins to flood.	FM 562 northeast of Smith Point begins to flood.				FM 1985 between FM 562 and HWY 124 begins to flood.
Surfside			Water approaches dunes. Portions of FM 523 between HWY 332 and FM 2004 begin to flood. FM 2918 near the mouth of the San Bernard River begins to flood.	Streets near the beach begin to flood. Lowest lying portions of HWY 288 near Freeport begin to flood.	San Luis Pass Bridge may close depending on HWY 257 road conditions in Brazoria County.	
Jamaica Beach (bayside)	Lowest streets begin to flood.	Flooding moves further inland.		Half the village becomes inundated.		3-4 feet of water on streets and in homes.
Matagorda Area				Water on FM 2031.	Bridge is closed.	
Sargent Area					Bridge is closed.	


HARRIS
FORT BEND
BRAZORIA
GALVESTON
45
59
249
290
6
Texas
10
610
8
90
225
Texas
146
Texas
288
Texas
36
Texas
2004
35



Brazoria/Galveston/Harris County Hurricane Evacuation Zip-Zones Coastal, A, B and C

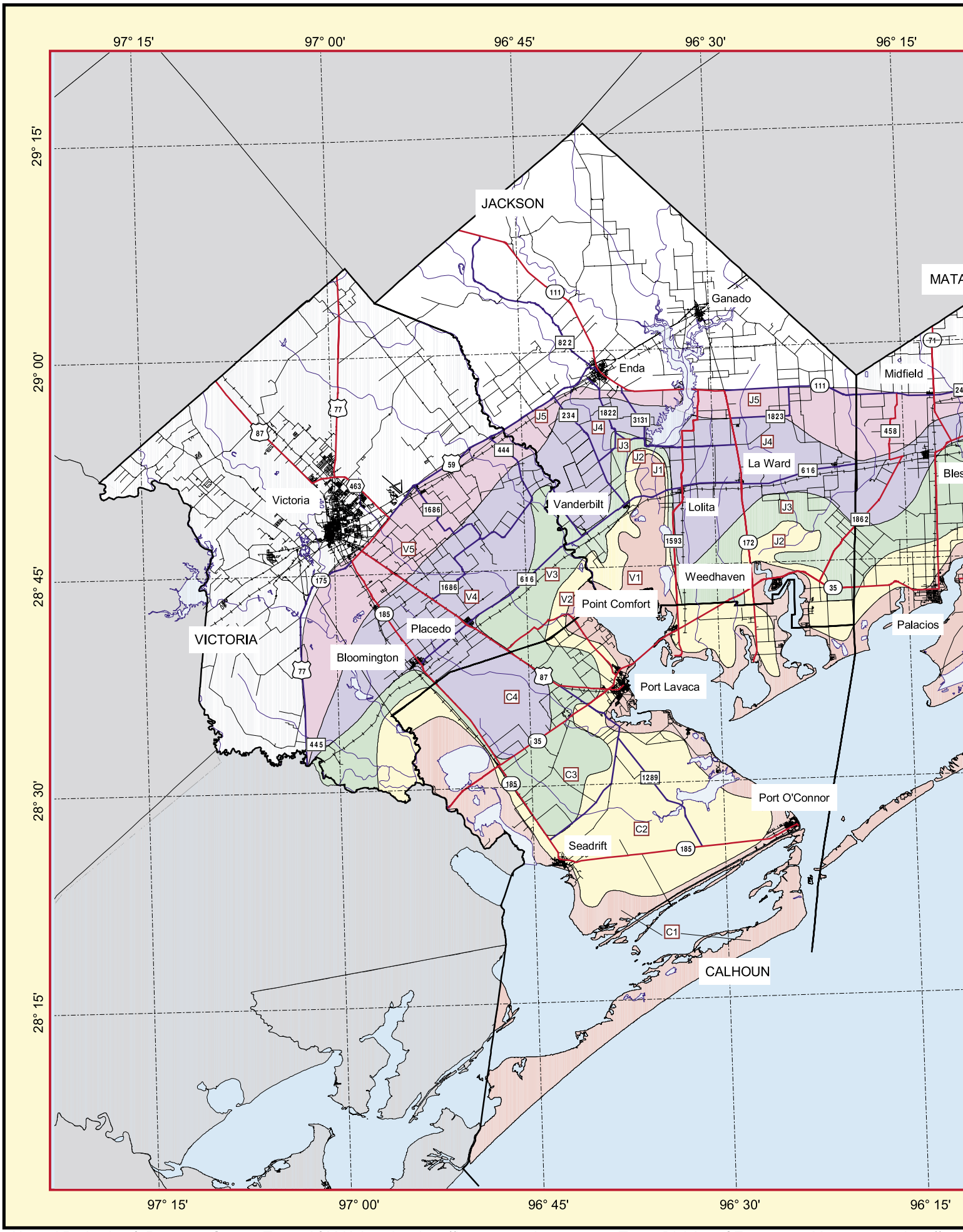
Route Designation

Evacuation Corridors

Feeder to the Evacuation

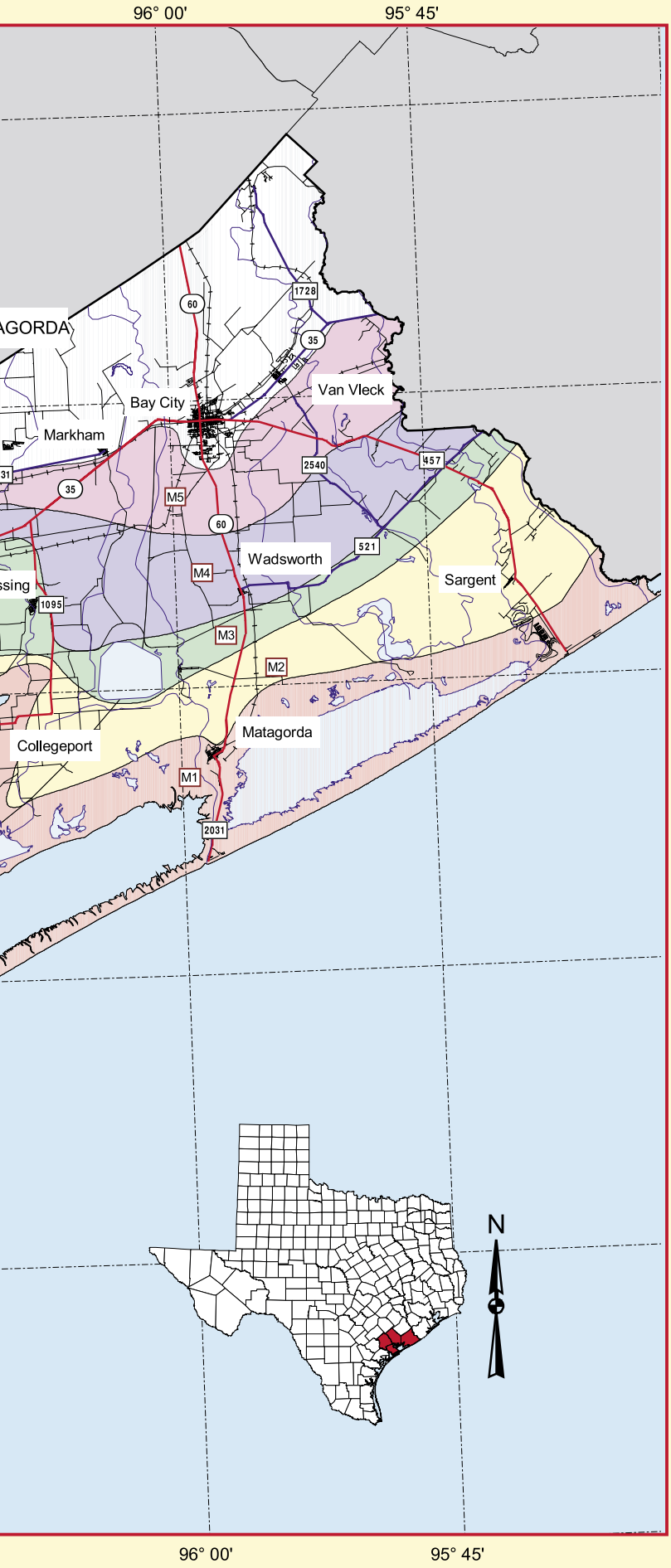
Zip-Zone Coastal				
77541	77550	77551	77554	77617
77623	77650			
Zip-Zone A				
77510	77518	77531	77539	77563
77565	77566	77568	77573	77577
77586	77590	77591		
Zip-Zone B				
77058	77059	77062	77422	77507
77511	77515	77517	77520	77534
77546	77571	77598		
Zip-Zone C				
77011	77012	77013	77015	77017
77023	77029	77034	77049	77061
77075	77087	77089	77480	77486
77502	77503	77504	77505	77506
77521	77530	77536	77547	77562

May 2007



Hazard Reduction & Recovery Center, Texas A&M University, http://hrrc.tamu.edu *Texas Division of Emergency Management, http://www*

Matagorda Study Area



8 0 8 16 Miles

Saffir-Simpson Scale	
Hurricane Category	Windspeed (MPH)
1	74-95
2	96-110
3	111-130
4	131-155
5	>155

Legend
- Primary Evacuation Route
- Secondary Evacuation Route
- County Boundary
- Risk Area 1
- Risk Area 2
- Risk Area 3
- Risk Area 4
- Risk Area 5

Risk Area numbers correspond to hurricane categories. For example, in the event of a Category 3 hurricane, Risk Areas 1, 2, 3 would be threatened.

What To Do When A Hurricane Threatens

Find the location of your home on the map and note the risk area where it is located. Plan to evacuate for any hurricane whose category is equal to or greater than the number of your risk area. Thus, those in Risk Area 5 need to evacuate only from a Category 5 hurricane, but those in Risk Area 1 should evacuate from all hurricanes.

If you live near a risk area boundary and are unsure of which risk area you are in, err on the side of caution. Assume that you are in the risk area that will be affected by a lower hurricane category (i.e., a risk area that has a smaller number and is nearer the coast). If you live in a mobile home in any of the five risk areas, plan to evacuate any time a hurricane threatens.

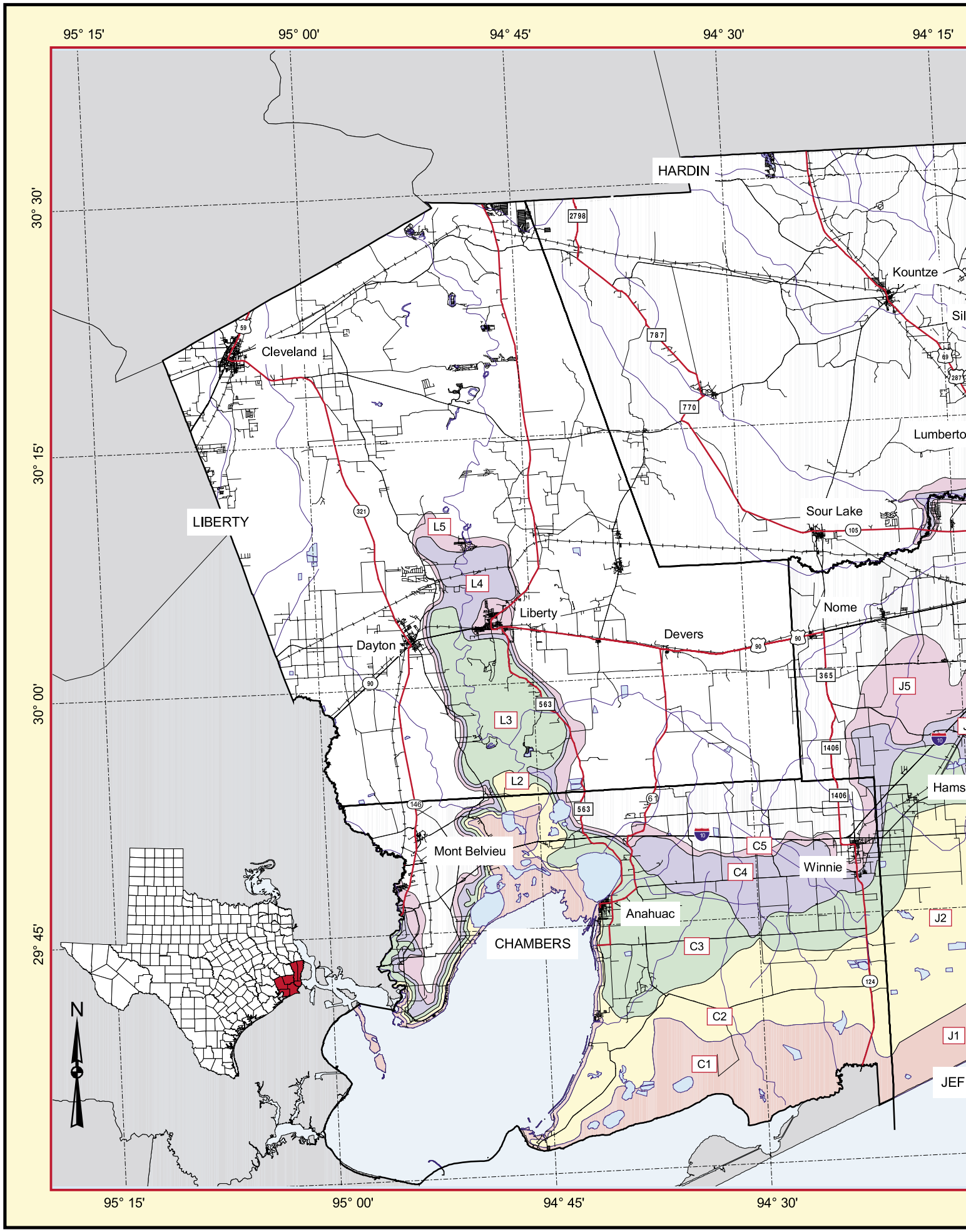
During a hurricane watch, listen to your radio or television constantly. The Emergency Alert stations for your area are KTRH 740 AM and KPRC 950 AM (Matagorda Co.), and KVIC 95.1 FM and KRNX 1340 AM (all other counties). The NOAA Weather Radio Stations are 162.475 megahertz (Port O'Conner), 162.400 (Victoria) and 162.425 (Bay City).

Begin evacuation preparations during the hurricane watch so you will be ready to leave when you receive a hurricane warning. If you will be traveling with young children, older family members, or people with special needs, consider leaving before you receive an official evacuation warning.

When local officials tell you to evacuate, do so immediately. Plan to take the nearest evacuation route (marked by a red line on the map), but be prepared to take an alternate route if your primary evacuation route is congested. Be sure to take plenty of bottled water and snacks with you because the trip may take longer than usual due to congested roads.

Identify a place to stay before you leave. If you plan to stay in a hotel or motel, call ahead to make reservations. If you need to stay in a public shelter, public officials in host cities will let you know where one is located when you arrive. Many hotels and most public shelters do not take pets, so make other arrangements if necessary.

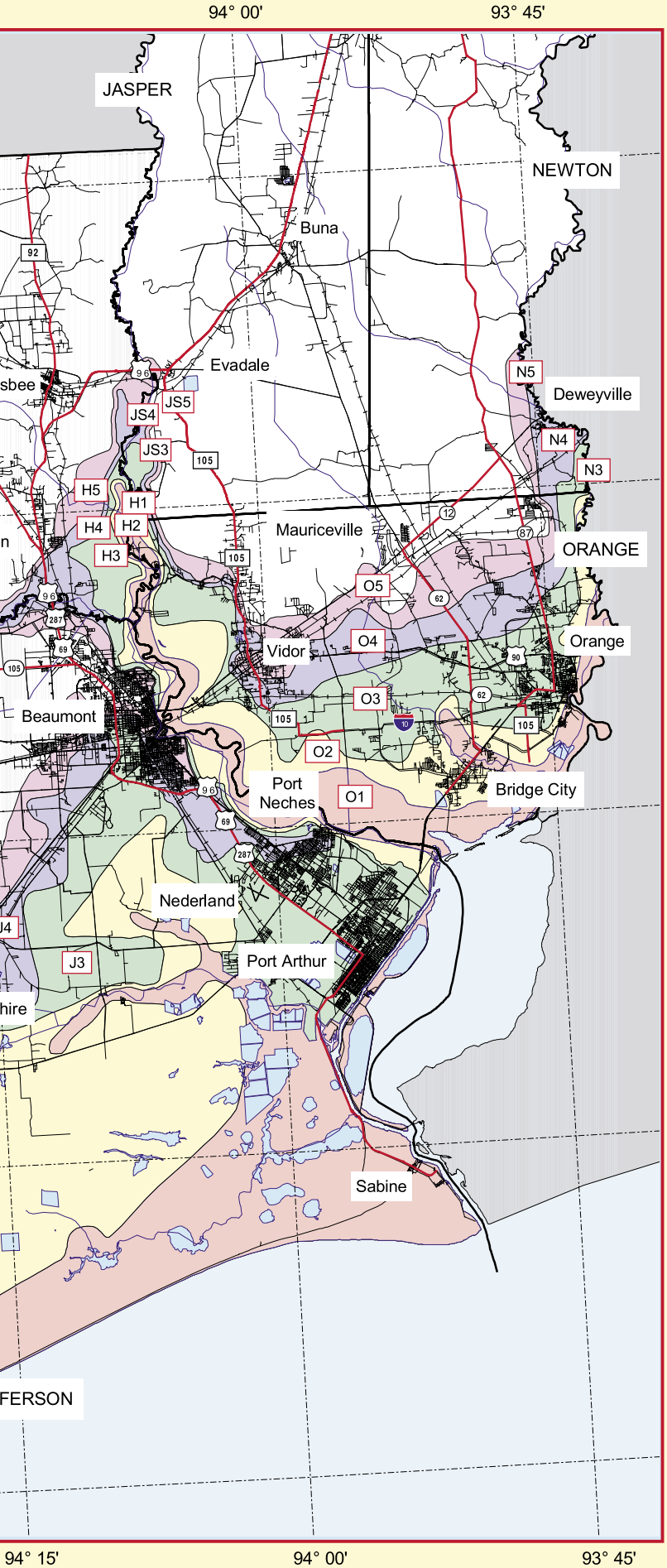
Funded through a grant from the Federal Emergency Management Agency (FEMA)



Hazard Reduction & Recovery Center, Texas A&M University, http://hrrc.tamu.edu *Texas Division of Emergency Management, http://*

Lake Sabine Study Area

7 0 7 14 Miles



Saffir-Simpson Scale		Legend
Hurricane Category	Windspeed (MPH)	
1	74-95	Evacuation Routes
2	96-110	County Boundary
3	111-130	Risk Area 1
4	131-155	Risk Area 2
5	>155	Risk Area 3
		Risk Area 4
		Risk Area 5

Risk Area numbers correspond to hurricane categories. For example, in the event of a Category 3 hurricane, Risk Areas 1, 2, 3 would be threatened.

What To Do When A Hurricane Threatens

Find the location of your home on the map and note the risk area where it is located. Plan to evacuate for any hurricane whose category is equal to or greater than the number of your risk area. Thus, those in Risk Area 5 need to evacuate only from a Category 5 hurricane, but those in Risk Area 1 should evacuate from all hurricanes.

If you live near a risk area boundary and are unsure of which risk area you are in, err on the side of caution. Assume that you are in the risk area that will be affected by a lower hurricane category (i.e., a risk area that has a smaller number and is nearer the coast). If you live in a mobile home in any of the five risk areas, plan to evacuate any time a hurricane threatens.

During a hurricane watch, listen to your radio or television constantly. The Emergency Alert stations for your area are KTRH 740 AM and KPRC 950 AM (Chambers Co.) and KLVI 560 AM and KFDM Channel 6 (all other counties). The NOAA Weather Radio Stations are 162.550 megahertz (Galveston), 162.400 (Houston), 162.500 (Lake Livingston), 162.475 (Beaumont) and 162.425 (Burkeville).

Begin evacuation preparations during the hurricane watch so you will be ready to leave when you receive a hurricane warning. If you will be traveling with young children, older family members, or people with special needs, consider leaving before you receive an official evacuation warning.

When local officials tell you to evacuate, do so immediately. Plan to take the nearest evacuation route (marked by a red line on the map), but be prepared to take an alternate route if your primary evacuation route is congested. Be sure to take plenty of bottled water and snacks with you because the trip may take longer than usual due to congested roads.

Identify a place to stay before you leave. If you plan to stay in a hotel or motel, call ahead to make reservations. If you need to stay in a public shelter, public officials in host cities will let you know where one is located when you arrive. Many hotels and most public shelters do not take pets, so make other arrangements if necessary.

Funded through a grant from the Federal Emergency Management Agency (FEMA)

Your Family Hurricane Plan Checklist

STEP I: PREPARING A DISASTER SURVIVAL KIT

The most important thing you and your family can do in preparation for a hurricane is be able to survive on your own after the storm. This means having enough food, water, and other supplies to last at least three days.

You may want to consider storing enough supplies to last up to two weeks. Local officials and relief workers will be on the scene after a disaster, but they can't reach everyone immediately. Basic services such as electricity, gas, water, sewage treatment, and telephones may be cut off for days or weeks.

You should store your kit in a designated place at home and have it ready in case you need to leave your home quickly.

Basic Disaster Supplies Kit:

(Keep items in airtight plastic bags and put your entire disaster supplies kit in one or two easy to carry containers)

- Water: three day supply - one gallon per person, per day (see below for further details)
- Food: three day supply - non-perishable (see below for further details)
- Portable, battery-powered radio or television and extra batteries
- Flashlight and extra batteries
- First aid kit and manual
- Sanitation and hygiene items (moist towelettes and toilet paper)
- Matches and waterproof container
- Extra clothing
- Kitchen accessories and cooking utensils, including a can opener
- Photocopies of credit cards and other identification cards
- Photocopies of important papers and phone numbers
- Cash
- Prescriptions
- Other medical needs items: eye glasses, contacts, hearing aid batteries
- Items for infants: formula, diapers, bottles, pacifiers

It's important to maintain your disaster supplies kit on a regular basis so that it is safe to use when needed. Change stored food and water supplies every six months. Canned foods should be kept in a dry place and boxed food should be stored in tightly closed plastic or metal containers to extend their shelf life. Replace food with fresh supplies when they go bad.

Water:

You should store at least one gallon of water per person per day. More water may be required for children, nursing mothers, ill people, and in cases of a medical emergency.

The safest and most reliable water supply would be made up of commercially bottled water. The water should be kept in its original container and not opened until it is used. Observe the expiration date.

If you choose to bottle your own water, it is recommended that you use food-grade water storage containers from surplus or camping supply stores. If not, you can use two-liter plastic soft drink bottles. Avoid using any containers that have had juice or milk in them: they can foster bacteria growth. Also avoid using cardboard or glass containers.

Before storing water, thoroughly wash the containers with dishwashing soap and water. Sanitize the bottles by adding one teaspoon of non-scented liquid household chlorine bleach to a quart of water. Swish around the solution so it touches every surface of the bottle. Thoroughly rinse out the sanitizing solution with clean water.

Fill the bottles with tap water and close the bottles with the original cap. Store the bottles in a cool dark place. Replace the tap water every six months.

Food:

Food should be non-perishable. Avoid foods that will make you thirsty. Choose salt-free crackers, whole grain cereals, and canned foods with high liquid content.

Stock canned foods, dry mixes, and other staples that do not require refrigeration, cooking, water, or special preparation. Include a manual can opener. Remember special dietary needs.

STEP II: PREPARATIONS AT THE START OF HURRICANE SEASON

__ Know whether or not your family lives in a designated evacuation zone (see the maps in this book). If you do live in an evacuation zone, plan ahead of time where you will go and where you will stay.

__ Know your children's school emergency plan. Ask how the school will communicate with families during a crisis.

__ Find out your workplace evacuation and emergency plan.

__ Learn how to shut off utilities (such as water and electricity) in your home.

Preparations around your property:

- Permanent storm shutters offer the best protection for windows. A second option is to board up windows with 5/8-inch marine plywood.
- Roof clips or straps (fastening roof to frame structure) can help reduce roof damage.
- Trim trees and shrubbery around the home.
- Clear clogged rain gutters.
- Determine how and where to secure your boat.
- Find a central room on the lowest floor of your home away from windows to serve as a shelter during the storm.

Inventory/Records:

- Make copies of important documents: Insurance policies (Property, Life, Health, etc.), credit cards, identification cards, property deeds. Keep copies in your disaster supplies kit.
- Make inventory of personal property for insurance purposes.
- Make video of your personal property – furniture, pictures, appliances, clothes, tools, etc.
- Consider storing important documents in a safety deposit box away from your home.
- Have an emergency fund (savings account) that could be tapped into in a crisis.
- Keep a small amount of cash in a safe place that can be quickly accessed during evacuation.

Plan for Those with Special Needs:

If you or someone close to you has special needs, you may have to take additional steps for protection in an emergency. The following special needs should be considered: the hearing or mobility impaired, the critically ill, the single working parent, non-English speaking persons, people without vehicles, and people with special dietary needs.

A special needs person should register with the office of emergency management for assistance so that required help can be provided in a time of crisis. Create a network of contacts to aid the person in an emergency. Be sure each knows how to operate necessary equipment. Keep specialized items available, including extra batteries, oxygen, medication, and any other items that might be needed. Make provisions for medications that require refrigeration. In an apartment or high-rise building, ask management to make arrangements to help the person leave the building.

Sheltering Pets:

Plan ahead on where you will board your pets during a hurricane. Some emergency shelters do allow pets now, but only certain shelters. Check ahead with a local emergency management office or animal shelter on which shelters, motels or hotels will allow pets, and where boarding facilities are located. Be prepared to make sure your animal is properly identified and to take veterinary records with you to prove vaccinations are current if you are asked to evacuate.

Sheltering Larger Animals (such as horses or cattle):

Ensure all animals have some form of identification. Make available vehicles and trailers for transporting each type of animal. Be prepared to evacuate the animals if necessary. Ensure that destinations have food, water, veterinary care, and handling equipment.

STEP III: WHEN A HURRICANE THREATENS

__ Frequently monitor radio, TV, NOAA Weather Radio, Internet or hurricane hotline telephone numbers for official bulletins of the storm's progress.

__ Fuel and service family vehicles.

__ Inspect and secure mobile home tie downs.

__ Prepare to cover all window and door openings with shutters or plywood.

__ Check prescription medicines — obtain at least a ten day to two week supply.

__ Store and secure outdoor lawn furniture and other loose, lightweight objects, such as garbage cans, garden tools, potted plants, etc.

__ Stock up on extra batteries for radios, flashlights, and lanterns and check for ample first aid supplies.

__ Get an extra supply of cash to last two weeks. Banks may be closed and ATM machines may not work after the storm.

__ Make sure you have a full disaster supplies kit (see list in Step I).

Plan to evacuate if you...

__ Live in a designated evacuation zone (see maps in this book). If so, you may be directed by local authorities to evacuate. Be sure to follow their instructions.

__ Live in a mobile home or temporary structure. Do not stay in a mobile home under any circumstances.

__ Live on the coastline or on an offshore island, or live near a river or in a flood plain.

__ Live in a high-rise building. Hurricane winds are stronger at higher elevations.

If you are evacuating:

__ Disconnect utilities (including phone and electricity) as a precaution to prevent further damage.
Electricity: remember to shut off individual circuits before shutting off the main circuit breaker.
Gas: turn off gas at each appliance but do not turn off main gas line to the house.

__ Leave early and if possible, during daylight hours.

__ Notify neighbors and family members outside of the warned area of your evacuation plans.

__ Stay with friends or relatives or at a low-rise inland hotel or motel outside of flood zones. Leave early to avoid heavy traffic, roads blocked by early flood waters, and bridges made impassable due to high winds.

__ Hurricane shelters will be available for people who have no other place to go. Shelters may be crowded and uncomfortable, with no privacy and no electricity. Do not leave your home for a shelter until government officials announce that a particular shelter is open.

What to bring to a shelter:

__ First-aid kit, medicines, baby food and diapers, cards, games, books, toiletries, battery-powered radio, flashlights, extra batteries, blankets or sleeping bags, identification, valuable papers (insurance) and cash.

__ Pets: remember that only certain emergency shelters will allow pets. Keep veterinary records with you to prove vaccinations are current.

If you are staying in a home:

(Reminder! Only stay in a home if you have not been told to leave. If you ARE told to leave, DO SO IMMEDIATELY.)

__ Make sure all windows and doorways are covered by hurricane-proof shutters or 5/8-inch plywood

__ Turn refrigerator to maximum cold and open only when necessary.

__ Turn off utilities if told to do so by authorities. Turn off propane tanks. Unplug small appliances.

__ Stay inside your home at all times and away from windows and doors.

__ If you lose power, use flashlights rather than candles or open flames to move around in the darkness.

If winds become strong:

__ Take refuge in an interior room, closet, or hallway on the lowest floor away from doors or windows. Take a battery-powered radio, a NOAA Weather Radio and a flashlight with you.

__ Lie on the floor under a table or another sturdy object.

__ Close all interior doors. Secure and brace external doors. Keep curtains and blinds closed.

__ If you are in a multiple-story building and away from the water, go to the first or second floors and take refuge in the halls or other interior rooms away from windows. Interior stairwells and the areas around elevator shafts are generally the strongest part of a building.

NOTE: Be alert for tornadoes which often are spawned by hurricanes. Also, if the "EYE" of the hurricane should pass over your area, be aware that the improved weather conditions are only temporary and that the storm conditions will return with winds coming from the opposite direction sometimes in a period of just a few minutes.

STEP IV: AFTER THE STORM

__ Stay in your protected area until announcements are made on the radio or TV that the dangerous winds have passed. Stay off the streets unless absolutely necessary.

__ If you have evacuated, do not return home until officials announce your area is ready. Remember, proof of residency may be required in order to re-enter the evacuation areas.

__ Be aware of the surroundings when returning as extreme damage could render a familiar landscape unrecognizable.

__ If your home or building has structural damage, do not enter until it is checked by officials. Do not enter your home if you smell gas, floodwaters remain around the building, or if authorities have declared it unsafe. In a damaged home, have the electrical system checked out by an electrician before turning it back on. If water pipes are damaged, turn off the main water valve. Check with authorities before using any water as it may have become contaminated during the storm.

__ Beware of outdoor hazards such as downed power lines and any water they may be lying in, poisonous snakes driven from their dens by high water, weakened bridges, washed out roads, weakened limbs on trees and/or damaged overhanging structures.

__ Do not use the telephone unless absolutely necessary. The system is usually jammed with calls during and after a hurricane.

__ Guard against spoiled food. Use dry or canned food. Do not drink or prepare food with tap water until you are certain it is not contaminated with flood waters. Throw out any food, water, or supplies that have been contaminated or come in contact with flood waters.

__ When cutting up fallen trees, use caution, especially if you use a chain saw. Serious injuries can occur when these powerful machines snap back or when the chain breaks.

__ Call your insurance agent. Take video or still pictures of damaged property. Keep records of your repair and clean up costs.

Coping with post-disaster stress:

__ Maintain a normal family and daily routine, limiting responsibilities on yourself and your family.

__ Seek help from professional counselors for yourself and your family if needed. Talk to someone about your feelings even though it may be difficult. Make sure to get help for your children as well.

__ Use existing support groups of family, friends, and religious institutions.

__ Take steps to promote physical and emotional well-being such as healthy eating, rest, relaxation, and meditation.

NOTE: These lists are not intended to be all-inclusive. You must decide what supplies are best suited for you and your family's survival. These lists contain only suggestions for your consideration.

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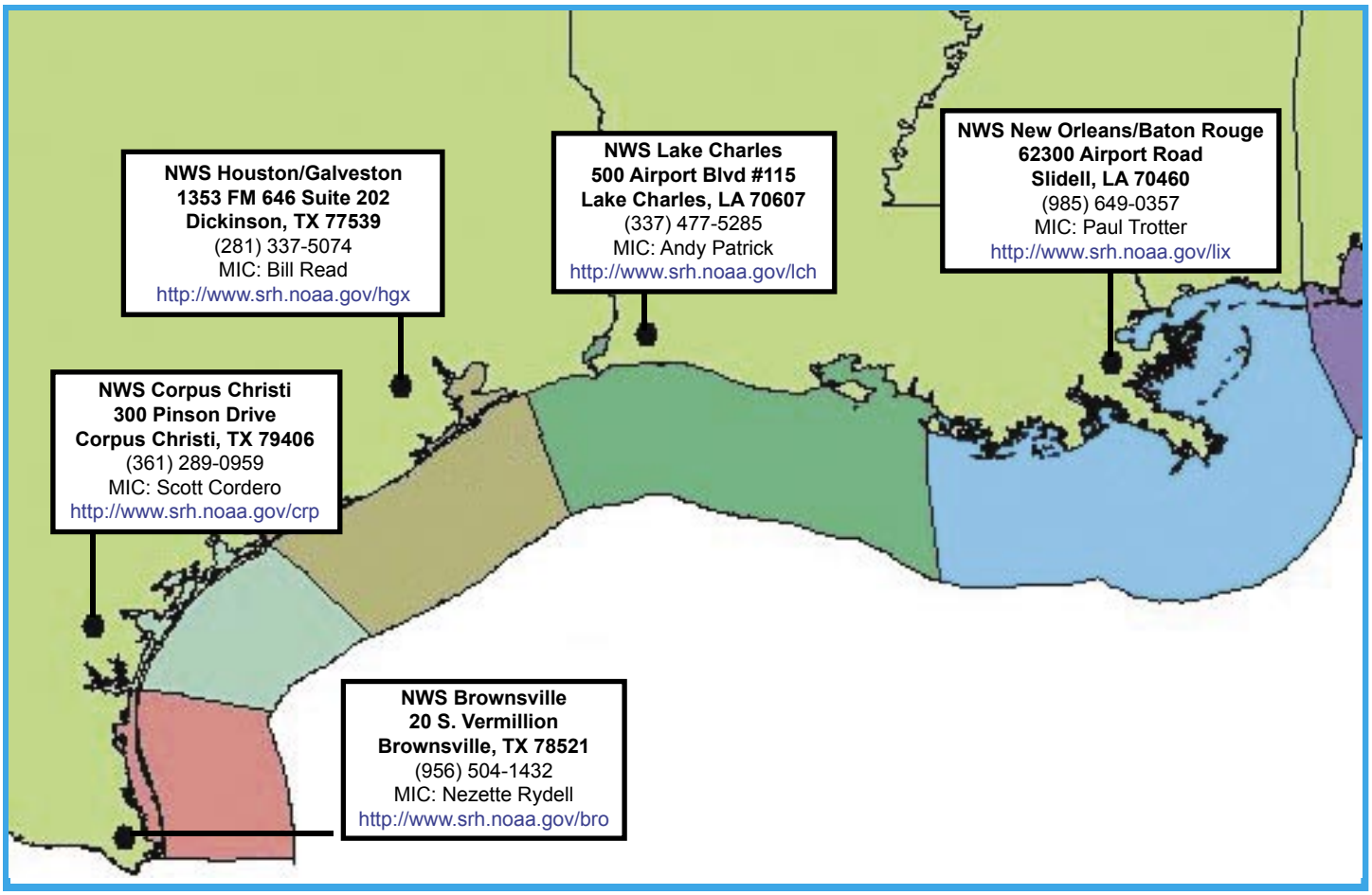
Regional National Weather Service Offices



Hurricane Preparedness and Weather Sites on the Internet

Tropical Prediction Center
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://maps.csc.noaa.gov/hurricanes/index.htm

EMWIN Houston
http://houston.emwin.org

Dr. William Gray's 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.houstontx.gov/oem/hurricane.html

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

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

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Houston / Galveston National Weather Service
2007 Hurricane Workshop

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