Section 5. Hurricanes

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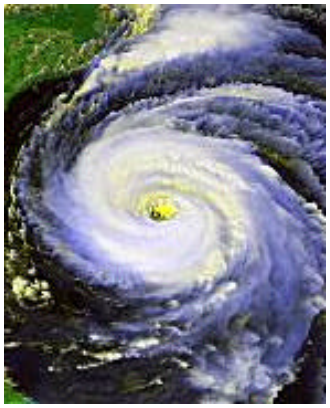
Why Hurricanes Are a Threat

According to the National Oceanic and Atmospheric Administration,[1] a hurricane is an intense tropical weather system of strong thunderstorms with a well-defined surface circulation and maximum sustained winds of 74 mph or higher. A hurricane is a type of tropical cyclone, a low pressure system that generally forms in the tropics. A hurricane is accompanied by thunderstorms and, in the Northern Hemisphere, a counterclockwise circulation of winds near the earth's surface.[2] Hurricanes are categorized according to the strength of their winds using the Saffir-Simpson Hurricane Scale. A Category 1 storm has the lowest wind speeds, while a Category 5 hurricane has the strongest. These are relative terms, because lower category storms can sometimes inflict greater damage than higher category storms, depending on where they strike and the particular hazards they bring. In fact, tropical storms can also produce significant damage and loss of life, mainly due to flooding.



The ingredients for a hurricane include a pre-existing weather disturbance, warm tropical oceans, moisture, and relatively light winds aloft. If the right conditions persist long enough, they can combine to produce the violent winds, incredible waves, torrential rains, and floods we associate with this phenomenon.

[1] This information is taken from the National Oceanic and Atmospheric Administration, http://www.noaa.gov/.
[2] Hurricane Basics, May 1999, National Oceanic and Atmospheric Administration, http://www.noaa.gov/.

Each year, an average of ten tropical storms develops over the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico[3]. Many of these remain over the ocean and never impact the U.S. coastline. Six of these storms become hurricanes each year. In an average 3-year period, roughly five hurricanes strike the US coastline, killing approximately 50 to 100 people anywhere from Texas to Maine[4]. Of these, two are typically "major" or "intense" hurricanes (a category 3 or higher storm on the Saffir-Simpson Hurricane Scale).

Windows falling from a high building.

When the winds from these storms reach 39 mph, the cyclones are given names. Years ago, an international committee developed names for Atlantic cyclones. In 1979, a six year rotating list of Atlantic storm names was adopted — alternating between male and female hurricane names. Storm names are used to facilitate geographic referencing, for warning services, for legal issues, and to reduce confusion when two or more tropical cyclones occur at the same time. Through a vote of the World Meteorological Organization Region IV Subcommittee, Atlantic cyclone names are retired usually when hurricanes result in substantial damage or death or for other special circumstances.

The Saffir-Simpson Hurricane Scale classifies hurricanes according to the following:

- **Tropical Storm—**Winds 39-73 mph

- **Category 1 Hurricane**—winds 74-95 mph (64-82 kt)
  No real damage to buildings. Damage to unanchored mobile homes. Some damage to poorly constructed signs. Also, some coastal flooding and minor pier damage.
  - Examples: Irene 1999 and Allison 1995

- **Category 2 Hurricane**—winds 95-110 mph (83-95 kt)
  Some damage to building roofs, doors and windows. Considerable damage to mobile homes. Flooding damages piers and small craft in unprotected moorings may break their moorings. Some trees blown down.
  - Examples: Bonnie 1998, Georges(FL & LA) 1998 and Gloria 1985

- **Category 3 Hurricane**—winds 111-130 mph (95-113 kt)
  Some structural damage to small residences and utility buildings. Large trees blown down.

[3] Hurricane Basics, National Oceanic and Atmospheric Administration, May 1999, http://www.noaa.gov/.
[4] Hurricane Basics, National Oceanic and Atmospheric Administration, May 1999, http://www.noaa.gov/.

Mobile homes and poorly built signs destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris. Terrain may be flooded well inland.
- Examples: Keith 2000, Fran 1996, Opal 1995, Alicia 1983 and Betsy 1965

- **Category 4 Hurricane**—winds 131-155 mph (114-135 kt)
  More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.
  - Examples: Hugo 1989 and Donna 1960

- **Category 5 Hurricane**—winds 156 mph and up (135+ kt)
  Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.
  - Examples: Andrew(FL) 1992, Camille 1969 and Labor Day 1935

Hurricane hazards come in many forms: storm surge, high winds, tornadoes, and flooding.

Storm Surge

The greatest potential for loss of life related to a hurricane is from the storm surge, according to the National Hurricane Center.

Storm surge is 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 create 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 tide 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.

High Winds

The intensity of a landfalling hurricane is expressed in terms of categories that relate wind speeds and potential damage. According to the Saffir-Simpson Hurricane Scale, a Category 1 hurricane has lighter winds compared to storms in higher categories. A Category 4 hurricane would have winds

between 131 and 155 mph and, on the average, would usually be expected to cause 100 times the damage of the Category 1 storm. Depending on circumstances, less intense storms may still be strong enough to produce damage, particularly in areas that have not prepared in advance.

Tropical storm-force winds are strong enough to be dangerous to those caught in them. For this reason, emergency managers plan on having their evacuations complete and their personnel sheltered before the onset of tropical storm-force winds, not hurricane-force winds. Hurricane-force winds can easily destroy poorly constructed buildings and mobile homes. Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, water and underground utility lines (from uprooted trees), and fallen poles cause considerable disruption.

Tornadoes

Hurricanes can also produce tornadoes that add to the storm's destructive power. Tornadoes are most likely to occur in the right-front quadrant of the hurricane. However, they are also often found elsewhere embedded in the rainbands, well away from the center of the hurricane.

Some hurricanes seem to produce no tornadoes, while others develop multiple ones. Studies have shown that more than half of the landfalling hurricanes produce at least one tornado; Hurricane Beulah (1967) spawned 141 according to one study. In general, tornadoes associated with hurricanes are less intense than those that occur independently. Nonetheless, the effects of tornadoes, added to the larger area of hurricane-force winds, can produce substantial damage.

Inland flooding from Tropical Storm Allison in 2001

Inland Flooding

Reports to the National Weather Service indicate that inland flooding has been responsible for more than half the deaths associated with tropical cyclones in the United States over the last 30 years.[5]

[5] Hurricane Basics, National Oceanic and Atmospheric Administration, May 1999, http://www.noaa.gov/.

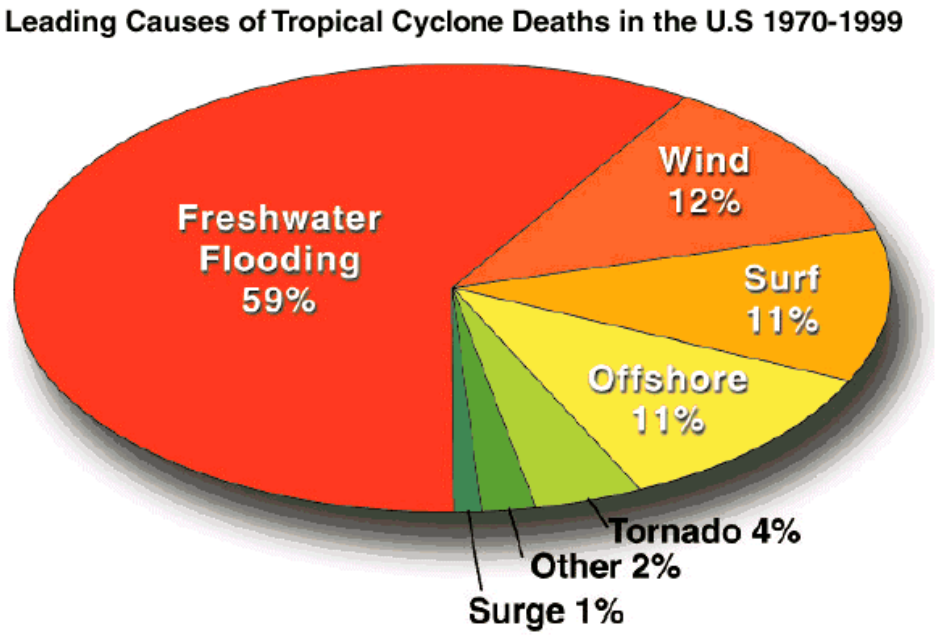
When it comes to hurricanes, wind speeds do not tell the whole story. Hurricanes produce storm surges, tornadoes, and often the most deadly of all - inland flooding.

Intense rainfall is not directly related to the wind speed of tropical cyclones. In fact, some of the greatest rainfall amounts occur from weaker storms that drift slowly or stall

Inland flooding can be a major threat to communities hundreds of miles from the coast as intense rain falls from these huge tropical air masses. Freshwater floods accounted for more than half (59 percent) of U.S. tropical cyclone deaths over the past 30 years[6].

The Guadalupe River Basin is not immune to the death and destruction that tropical systems can bring. Indeed, almost 60 percent of deaths in the U.S. from tropical cyclones have been from inland, freshwater flooding.

Figure 5-1. Tropical Cyclone Deaths 1970-1999



Source: Edward Rappaport—Chief, Technical Support Branch, Tropical Prediction Center

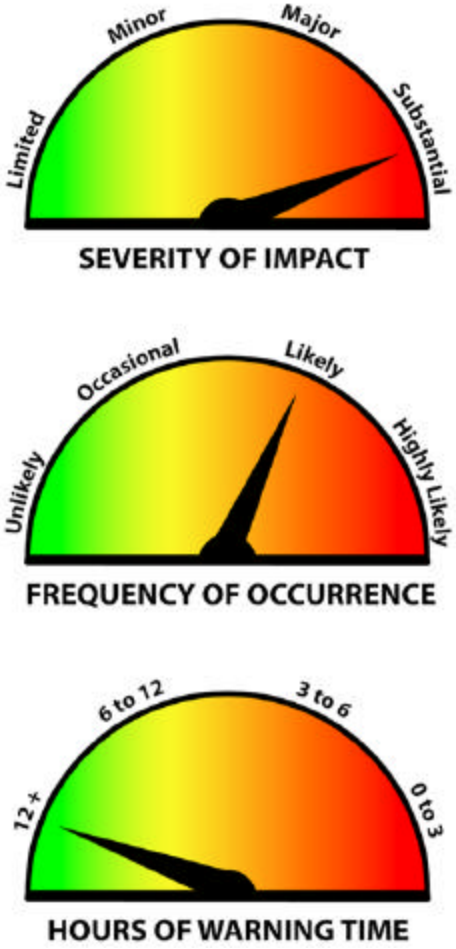
[6] Edward Rappaport, Chief, Technical Support Branch, Tropical Prediction Center

Hazard Profile

Hurricanes can have a substantial severity of impact. They can cause multiple deaths, completely shut down facilities for thirty days or more, and cause more than fifty percent of affected properties to be destroyed or suffer major damage.

The frequency of occurrence of flooding is likely, with an event probable in the next year. Hurricanes occur in seasonal patterns, with hurricane season occurring between June 1 and November 30.
Warning time for hurricanes is long, thanks to modern warning technology.

Figure 5-2. Hurricane Hazard Profile



History of Hurricanes

Between 1900 and 2000, thirty-seven hurricanes made landfall in Texas. Of these, six were Category 4, ten were Category 3, nine were Category 2, and thirteen were Category 1.

Hurricane Claudette, labeled by the National Hurricane Center as a Category 1 hurricane, hit in July 2003, causing $180 million in damage and caused two deaths. When it made landfall, winds were measured at 92 miles per hour, at the high end of a Category 1 storm. However, a storm chaser in Port O'Connor and a National Weather Service measurement in Seadrift indicated unconfirmed winds of 96 mph to 110 miles per hour. Port Lavaca was one of the first coastal cities hit by the eye of Hurricane Claudette. Further inland, the City of Victoria suffered damage as well.

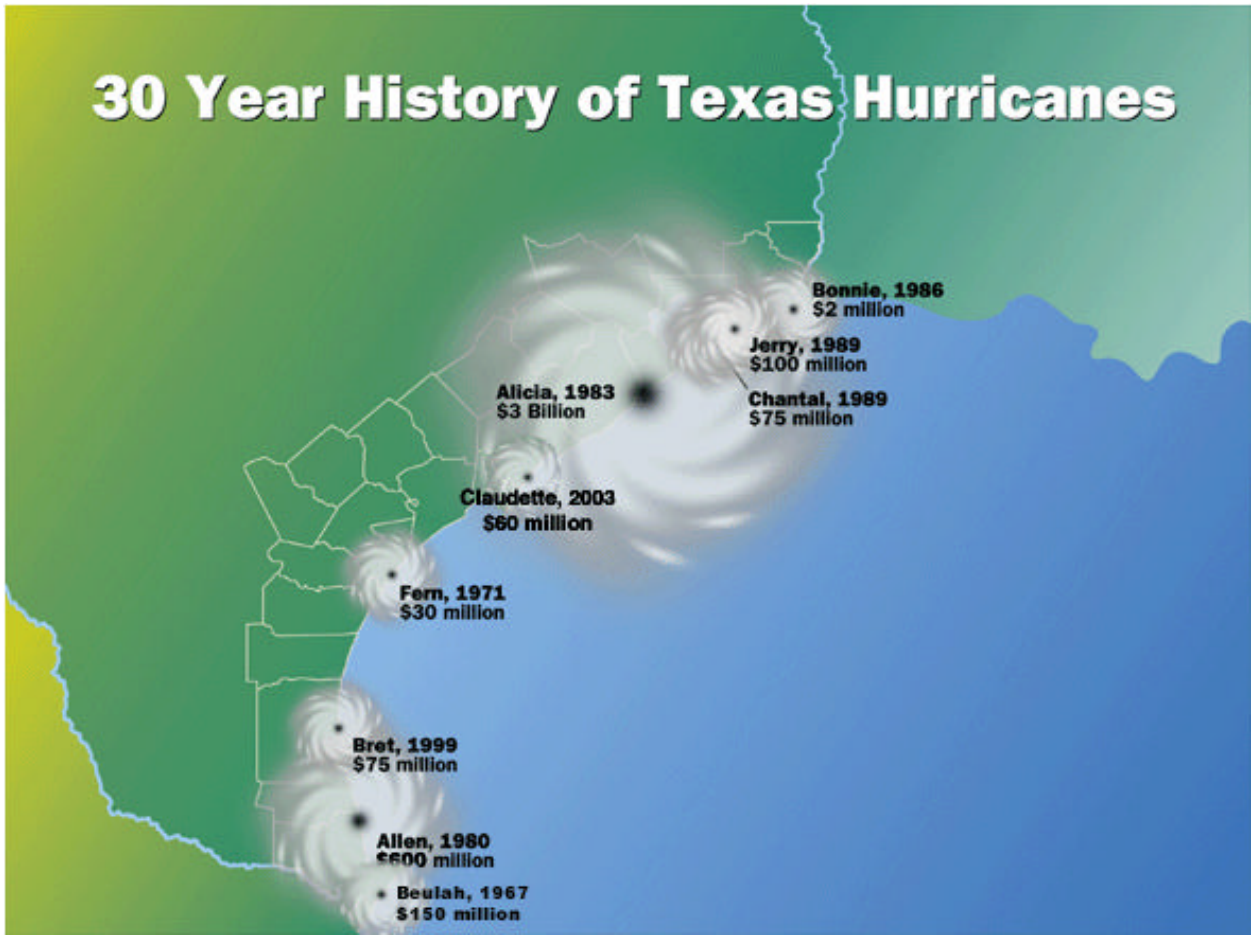
Table 5-1. Hurricane Landfalls on the Texas Coastline 1900-2000[7]

Location	Category 1	Category 2	Category 3	Category 4	Category 5
North Texas Coast	7	3	3	4	0
Central Texas Coast	3	2	1	1	0
South Texas Coast	3	4	6	1	0
Total by Category	**13**	**9**	**10**	**6**	**0**

Texas was hit by sixteen hurricanes and tropical storms from 1975 to 1998 and, after a period of relative quiet, is overdue for another big hurricane. Below is a thirty-year history of selected Texas Hurricanes and the dollar damages they caused.

[7] The Deadliest, Costliest, and most intense United States Hurricanes From 1900 to 2000, National Weather Service

Figure 5-3. Thirty-Year History of Texas Hurricanes[8]



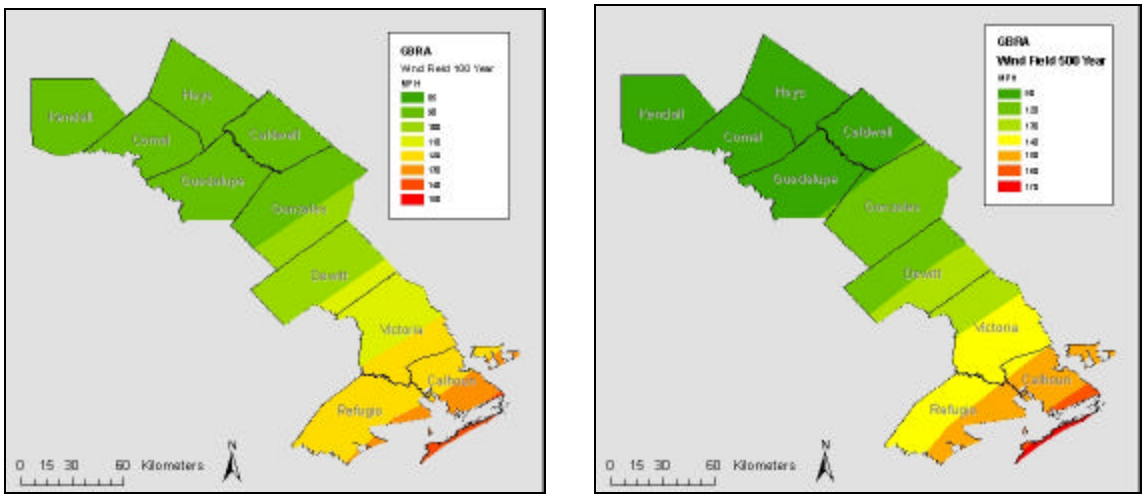
Despite the potential for GBRA counties to incur damages from hurricanes, none of the counties in the Basin reported damages to the National Weather Service from hurricanes between 1950 and June 30, 2003.

[8] Texas Department of Insurance

Location of Hazardous Areas

The geographic location of the Guadalupe River Basin in relation to the Gulf of Mexico makes the area vulnerable to damage from hurricane winds and to inland impact from coastal storms. Calhoun, Refugio and Victoria Counties are at highest risk to hurricane winds. **Figure 5-4** shows the areas potentially at risk to 100- and 500-year hurricane winds.

Figure 5-4. Areas Potentially at Risk to 100- and 500-year Hurricane Winds



100-year Wind **500-year Wind**

Table 5-2 profiles the hurricane wind speeds (in miles per hour) that can be expected in GBRA counties.

Table 5-2. Average Hurricane Wind Speeds in GBRA Counties

	Wind Speed (Mile per Hour)					
COUNTY	10-year	20-year	50-year	100-year	200-year	500-year
Caldwell	39	55	73	85	95	108
Calhoun	66	87	111	125	137	152
Comal	36	51	69	81	92	105
Dewitt	51	68	86	98	109	121
Gonzales	45	61	79	90	101	113
Guadalupe	38	54	72	84	95	107
Hays	36	51	69	81	91	104
Kendall	30	45	64	76	87	101
Refugio	62	83	106	120	131	143
Victoria	60	79	100	112	123	136

People and Property at Risk

The entire building stock in the Guadalupe River Basin, valued at over $11.4 billion, is exposed to the threat of hurricane winds. Table 5-3 shows the potential impact in terms of the number of people exposed to hurricane winds. Table 5-4 shows the potential damage to critical facilities by county.

Table 5-3. Number of People exposed to the threat of hurricane winds

Jurisdiction	Hurricane Wind
Caldwell	32,194
Calhoun	20,647
Comal	78,021
DeWitt	20,013
Gonzales	18,628
Guadalupe	89,023
Hays	97,589
Kendall	23,743
Refugio	7,828
Victoria	84,088
TOTAL	**471,774**

Table 5-4. Critical Facilities Potentially Damaged by 100- and 500-Year Hurricane Winds, by County

Jurisdiction	Critical Facilities	100-year Severe Wind		500-year Severe Wind		
	Total Number	Slight	Negligible	Moderate	Slight	Negligible
Caldwell	33	33	0	0	10	23
Calhoun	75	1	74	5	70	0
Comal	70	70	0	0	0	70
DeWitt	33	33	0	0	31	2
Gonzales	26	26	0	0	17	9
Guadalupe	77	77	0	0	22	55
Hays	64	64	0	0	0	64
Kendall	23	23	0	0	0	23
Refugio	22	2	20	0	22	0
Victoria	69	20	49	0	67	2
TOTAL	**492**	**349**	**143**	**5**	**239**	**248**

Potential Damages and Losses

Annualized expected property losses from hurricane winds in the Guadalupe River Basin total over $38 million per year. Potential annualized losses and annualized loss ratios are shown in Table 5-5, by County, for residential and commercial properties. Annualized loss ratios are presented to show the relative risk between Counties. Closest to the Gulf of Mexico, Refugio has the highest annualized loss ratio of 0.2779 percent, followed by Calhoun County, the second highest annualized loss ratio of 0.2707 percent.

Table 5-5. Potential Annualized Losses and Loss Ratios, by County, for Hurricane Winds

Jurisdiction	Total Exposure	Potential Annualized Losses for Residential Buildings at Risk ($)	Potential Annualized Losses for Commercial Buildings at Risk($)	Annualized Expected Property Losses ($)	Annualized Percent Loss Ratio
Caldwell	2,806,776,000	724,286	86,730	851,503	0.0303%
Calhoun	2,681,601,000	5,878,579	760,752	7,258,197	0.2707%
Comal	11,640,775,000	3,027,152	274,208	3,442,066	0.0296%
DeWitt	2,021,890,000	777,260	126,659	1,026,694	0.0508%
Gonzales	1,637,234,000	434,519	68,793	540,649	0.0330%
Guadalupe	10,376,784,000	2,035,074	220,699	2,410,603	0.0232%
Hays	14,756,866,000	3,124,108	353,971	3,642,970	0.0247%
Kendall	3,728,076,000	428,265	52,929	504,581	0.0135%
Refugio	740,701,000	1,779,669	151,412	2,058,418	0.2779%
Victoria	11,424,428,000	13,634,703	2,241,436	16,537,975	0.1448%
Total	61,815,131,000	31,843,615	4,337,589	38,273,654	

GBRA facilities (described on pages 4-18 and 4-19) are also at risk from this hazard. However, no estimate is currently available of potential damages and losses to those facilities.