GREATER HOUSTON FLOOD MITIGATION CONSORTIUM

6 Fact Sheet
What is storm surge?

What is a storm surge?

Storm surge is the rise of seawater level pushed towards land by the high winds of a storm. Storm surge typically accounts for the deadliest and most destructive outcomes of a hurricane, tropical storm, or depression. The highest death tolls in the largest hurricanes are caused by surge. Due to the shapes of our coastline and Galveston Bay, the Houston area's storm surge risk is quite high.

In the open ocean, counter-clockwise winds push water ahead of the storm, causing vertical circulation within the ocean as if the winds were rolling water forward. As the storm moves towards the coast, where the water is shallow, the vertical circulation of the ocean continues its momentum and raises the level of the water. Figure 1 illustrates the basic dynamics of storm surge. In addition, compound flooding may occur when storm surge or high tides prevent rainwater from draining and exiting a waterway, causing waterways to overflow and flood adjacent areas.

Key differences between surge and pluvial flooding

Storm surge and rainfall can both cause flooding, but there are key differences. **Storm surge** can begin to rise a day or so before the storm hits (see Figure 3), which can flood low-lying highways and cut off escape routes. When storm surge hits land, water can rise several feet within minutes, and pound buildings with a force powerful enough to destroy them entirely. **Rainfall flooding** is caused by extreme amounts of rainfall that cause waterways or areas meant for water retention, such as reservoirs, to pool and overflow. Rainfall flooding can be large-scale or localized, depending on the storm event. Sometimes storm surge and heavy rainfall occur at the same time; this is referred to as a **compound flood**. In a compound flood, high water levels from the surge can block floodwaters from draining into the ocean, causing more flooding inland, or extreme rainfall can amplify an existing flood from storm surge.

What affects storm surge?

Storm surge is dependent on several storm characteristics and geographical features, including:

Storm Size - Larger wind fields increase surges.

Storm Intensity - High wind speeds increase surges.

Forward Speed - Slow storms increase surge in inland bays and estuaries. Fast storms increase surge along coasts.

Central Pressure - Low pressures increase surges.

Approach - Perpendicular approach to the coast increases surge.

Astronomical Tide - High tide increases surge height.

Local Features - Complex coastal and inland features (e.g. bays, estuaries) affect surge behavior.

Ocean Bottom - Wide shelves and gentle slopes increase total surge height, but produce smaller waves. Narrow shelves and steep slope decrease surge height but produce larger waves.

Slight alterations in storm path coupled with any of these factors make storm surge height difficult to predict. The right amalgamation of these factors could cause the "perfect storm" or worst-case scenario.

The category of a hurricane is not a good predictor of the intensity of the surge. For example, Hurricane Katrina was a category 3 storm with surges up to 28 feet tall, while Hurricane Charley was a category 4 storm but had surges up to only 8 feet. The National Weather Service has now begun to predict surge separately from the category of the storm which is based only on wind speed.

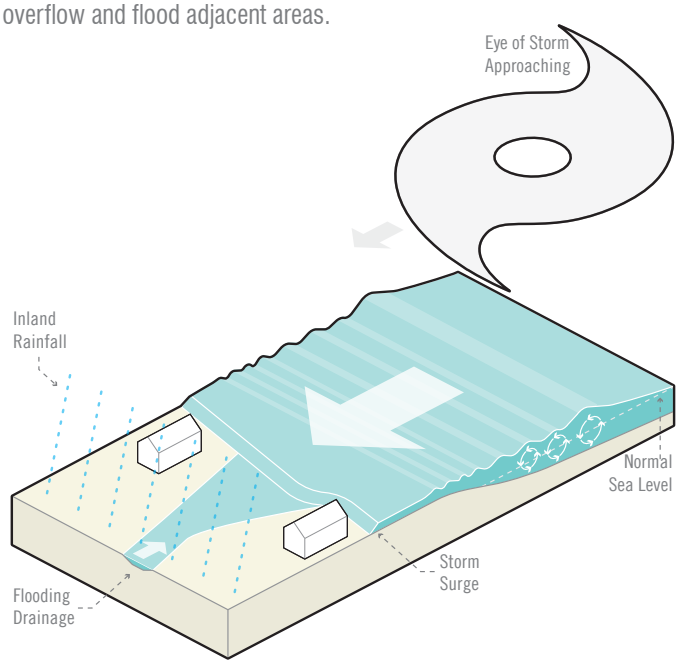

Figure 1 Storm Surge Basics

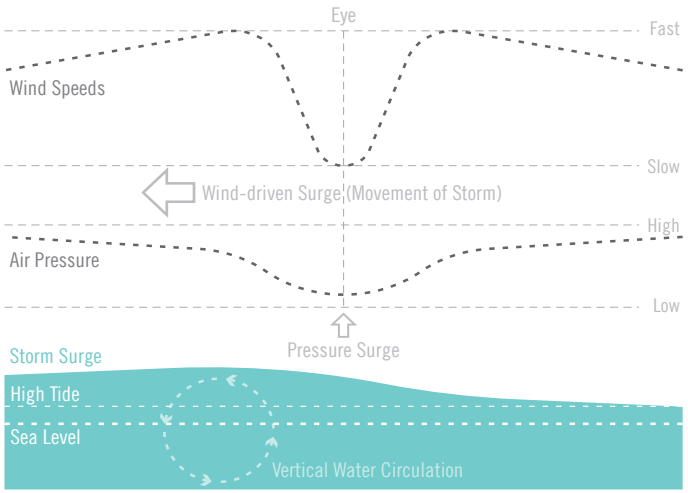

Figure 2 Section of a Storm Surge in Open Ocean

"Adding to the destructive power of surge, battering waves may increase damage to buildings directly along the coast. Water weighs approximately 1,700 pounds per cubic yard; extended pounding by frequent waves can demolish any structure not specifically designed to withstand such forces. The two elements work together to increase the impact on land because the surge makes it possible for waves to extend inland."

National Hurricane Center (NHC).

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What effects do storm surges have?

According to the National Hurricane Center (NHC), storm surges flooding accounts for nearly half of all deaths during a hurricane, tropical storm, or depression in the US since 1963.

Before a storm makes landfall, water levels along the coast increase. Figure 3 shows water levels at three feet above average as early as 24 hours before the landfall. These levels can potentially flood evacuation routes and strand people from reaching essential supplies, family members, or safety on higher grounds. In addition, the water rises in waves increasing the risk of damage. Six inches of rushing flood water can trip a person and two feet of rushing water can move a car according to the National Weather Service (NWS).

Storms surge may also increase inland flooding due to elevated levels in bays and estuaries, impeding natural drainage for rainfall. This causes flooding in areas otherwise thought to be high enough in elevation to avoid water intrusion. On the Gulf Coast, if the eye of the storm comes ashore south of the pass between Galveston Island and the Bolivar Peninsula (Bolivar Roads), the highest winds and surge will enter Galveston Bay and the coastal surge elevation within the bay will be further increased by the shape of the bay.

In Houston, Harvey's storm surge only reached around 3 to 6 feet high in Galveston Bay. However, at its highest, Hurricane Harvey produced a storm surge level of more than 12 feet, near Aransas Wildlife Refuge. Port Lavaca experienced over 10 feet of storm surge, and Port Aransas at least 6 feet. While the Houston area has seen multiple extreme rainfall flooding events in recent years, the heart of Houston has not had a bad storm surge event in decades. Hurricane Ike in 2008 produced a 20 foot storm surge and caused catastrophic damage in the Galveston area, particularly around Bolivar Peninsula (see Figure 4), and this was still not the worst possible scenario.

How to find storm surge information?

In anticipation of a storm event, the National Weather Service (NWS) releases warnings and statements about storm surge. This information is relayed by news outlets via internet, television and radio. The NWS has two designations for a surge warning:

Storm Surge Watch which is the possibility of life-threatening surges in specified areas, generally within 48 hours.

Storm Surge Warning which is the danger of life-threatening surges in specified areas, generally within 36 hours.

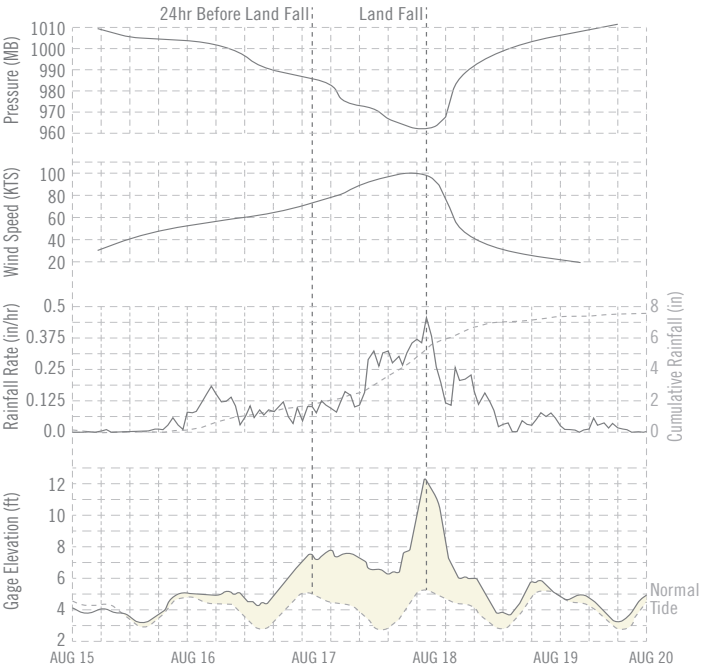

Figure 3 Sample graphs of pressure, rainfall and surge data

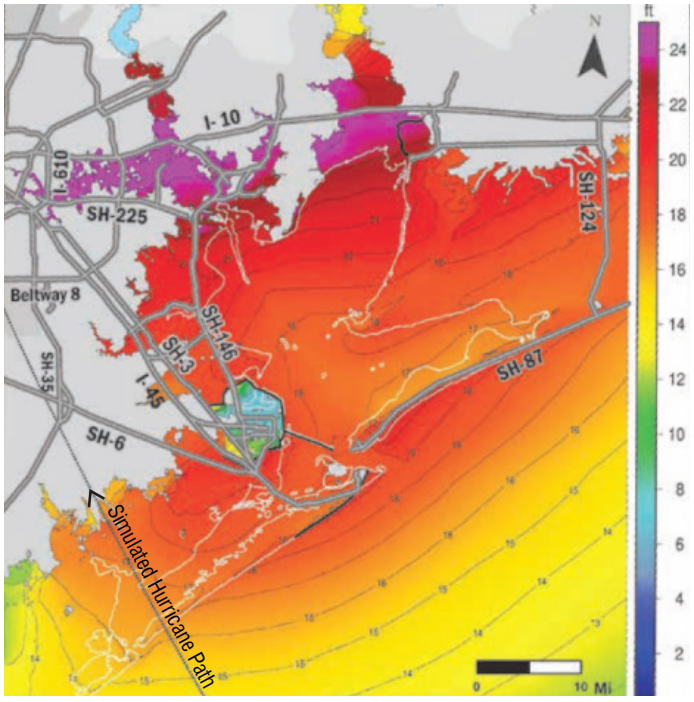

Figure 4 Category 3 simulated storm surge by SSPEED Center

KEY POLICY QUESTIONS

How much should be invested in major infrastructure to resist surge?

To what extent should new development in surge prone areas be limited?

How can critical infrastructure located in surge areas be protected?

For more information visit

National Weather Service
Weather.gov

NOAA National Hurricane Center Info
nhc.noaa.gov/surge/

Greater Houston Flood Mitigation Consortium
HoustonConsortium.com