

H-GAPS



H-GAPS PLAN

Houston-Galveston Area Protection System

October 2016

Benefits and Costs

The table provides a preliminary economic overview of the H-GAPS Plan, with input from researchers at Rice, Texas A&M-Galveston and the University of Houston. It summarizes the damages resulting from a major hurricane, such as industrial and residential damages, in order to evaluate the associated benefits and costs of each line of defense proposed in the H-GAPS Plan.

H-GAPS Plan Scenario		Cost Estimate	Cost Estimate (with 20% contingency)
M	Mid-Bay Gate	\$0.5 B	\$0.6 B
E	In-Bay Berms	\$1.4 B	\$1.7 B
G	Galveston FM-3005	\$0.075 B	\$0.09 B
F	Bolivar SH-87	\$0.06 B	\$0.07 B
G'/F'	Small Sand Dunes ¹	-	-
H	Galveston Levee	\$0.25 B	\$0.3 B
T	Raising Texas City Levee ¹	-	-
Phase I SUB-TOTAL		\$2.3 B	\$2.8 B
L	Lower-Bay Gates	\$4.5 B	\$5.5 B
Phase II SUB-TOTAL		\$4.5 B	\$5.5 B
TOTAL		\$6.8 B	\$8.3 B

¹This cost estimate does not include the cost of raising of the Texas City Levee and the construction of small sand dunes at F' and G'.



Model of Mid-Bay Gate as outlined in the H-GAPS Plan

The Severe Storm Prediction, Education and Evacuation from Disasters (SSPEED) Center (2007-2016) was formed as a university-based research and education organization. Led by Rice University, the SSPEED Center organizes leading universities, researchers, and private and public entities. SSPEED promotes Multiple Lines of Defense in reducing storm surge impacts in the Gulf Coast region (H-GAPS).

Researchers and Partners

Faculty Researchers

- Dr. Philip B. Bedient, Director | Rice University
- Mr. Jim B. Blackburn, Co-Director | Rice University
- Dr. John B. Anderson | Rice University
- Dr. Samuel D. Brody | Texas A&M University-Galveston
- Dr. Clint N. Dawson | University of Texas at Austin
- Dr. Jennifer Proft | University of Texas at Austin
- Dr. Jamie E. Padgett | Rice University
- Dr. Hanadi Rifai | University of Houston
- Dr. John Pardue | Louisiana State University
- Dr. Zheng (Nick) Fang | University of Texas-Arlington

SSPEED Collaboration with TU Delft

SSPEED researchers and students have formalized its relationship with TU Delft in the Netherlands through a \$3.5 million grant over five years from the National Science Foundation (NSF)-Partnerships of International Research & Education (PIRE). As a part of the Flood Risk Reduction Program (FRRP), researchers will be supported to investigate flood risk, community vulnerability, and flood mitigation in Texas and the Netherlands. This grant will fund faculty from the disciplines of architecture, planning, engineering, and economics at Rice University, Texas A&M University at Galveston, Jackson State University, and the University of Houston. As an extension of the existing partnership with researchers at TU Delft, it will also provide opportunities for students from these universities to participate in site-based research in the Netherlands.

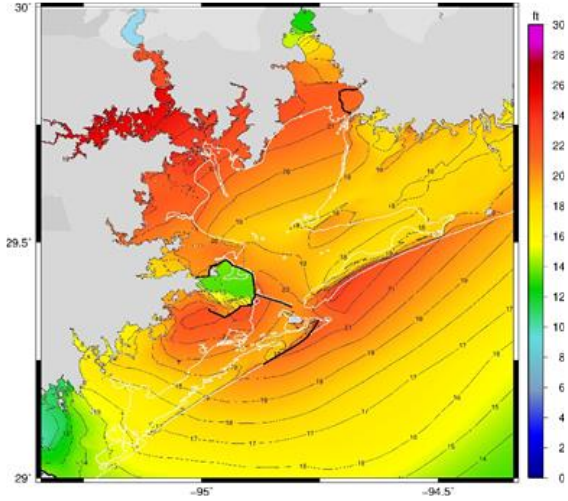
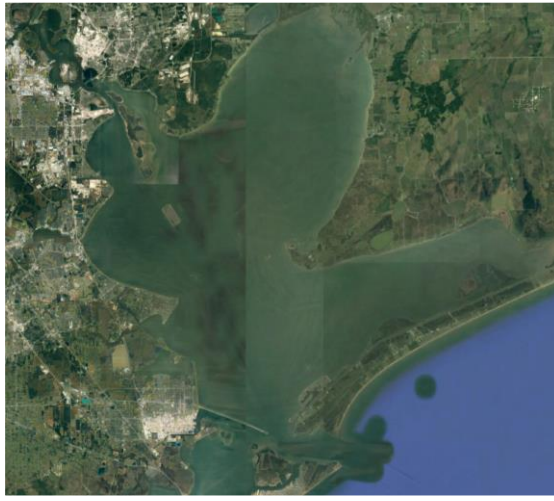
This past summer, four PhD students from Rice University were awarded research fellowships to travel to the Netherlands to conduct field-based research on coastal flood risk reduction.

Consultants

- Charles Penland | Walter P. Moore
- Joseph Cibor | Cibor Geoconsultants, Inc.
- Larry Dunbar | Lawrence G. Dunbar, P.E
- Elizabeth Winston Jones | Resource Strategy Partners
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Contact Us

For more details regarding SSPEED Center research or the H-GAPS Plan, specifically, please contact us at sspeed@rice.edu or visit our website at sspeed.rice.edu.



Satellite image of the West Side and Galveston. | Baseline surge (36) without protection. | Photograph of Kemah's Lighthouse District inundated during Hurricane Ike. | Photograph of Eastern Scheldt storm surge barrier in the Netherlands, an example of an environmental gate system.

Multiple Lines of Defense

Overview

The Severe Storm Prediction, Education and Evacuation from Disasters (SSPEED) Center was established in 2007 as a response to the need to better address severe storm prediction and its impact on the Gulf Coast area. Since receiving full support from the Houston Endowment in 2009, the SSPEED Center has engaged in a long-term study to investigate and develop a potential regional surge protection system, known as the Houston-Galveston Area Protection System (H-GAPS). As a result of this study, the H-GAPS Plan was developed as a series of structural and non-structural mitigation techniques to protect the coastal areas from storm surge. SSPEED promotes Multiple Lines of Defense in reducing storm surge impacts in the Gulf Coast region (H-GAPS).

Areas of Focus

Houston Ship Channel

The United States' largest petrochemical complex and some of its most critical industrial facilities are located along the Houston Ship Channel (HSC); however, many of the facilities are not well protected against major flooding events. A large storm or hurricane could inundate the industrial area, affecting hundreds of storage tanks, which could cause severe damage to the Houston-Galveston region and the national economy. The SSPEED Center is proposing the construction of an in-bay gate and levee system to help protect the HSC. This major structural alternative has a high benefit-cost ratio compared to other mitigation proposals.

The City of Galveston

Galveston is protected from storm surge flooding with the existing Seawall at the coastline; however, during Hurricane Ike, the backside of the city flooded from surge in the bay. Thus, part of the H-GAPS Plan is to construct a ring levee around the city and raise the Seawall to provide complete protection from surge flooding.

The West Side

The west side of the bay is heavily developed and most vulnerable to surge flooding due to the hurricane-force winds that push water in the bay towards the western shoreline. As a result, under the H-GAPS Plan, the In-Bay System of the gate and berms provide enhanced surge flood protection for the communities on the west side of the bay, such as Morgan's Point, La Porte, Clear Lake, Seabrook, and Kemah.

Houston-Galveston Area Protection System

The H-GAPS Plan consists of Multiple Lines of Defense (Fig. 1), a concept currently being employed in the Netherlands. It is hoped that this regional system will be implemented by some governmental entity, such as the U.S. Army Corps of Engineers (USACE), with funding from local, state, and/or federal sources. This project would have to comply with various applicable laws and regulations in order to get permitted for construction.



The H-GAPS Plan includes a variety of structural measures, such as navigation gates, levees, dikes, and elevated roadways. In addition, some nonstructural measures are also being investigated for reducing storm surge-related flood damages, such as preserving and enhancing existing marshlands and other ecologically valuable habitat areas.

H-GAPS Plan

Plan Components

In-Bay System

The In-Bay System consists of constructing in-bay levees along the HSC as well as a navigation gate across the main channel (Mid-Bay Gate). Additionally, the plan would raise a portion of the existing Texas City Levee and provide for a ring levee around the City of Galveston. This system was initially evaluated using ADCIRC modeling for major storm surge protection. These components significantly reduce storm surge flooding in the northern and western segments of Galveston Bay, including the HSC, Cedar Bayou, and Baytown.

Coastal Spine System

The Coastal Spine System includes land features, such as elevated roadways designed to serve as an evacuation route and a levee, and water features, such as a navigational gate and an environmental gate across the main channel at Bolivar Roads. This system is similar to the "Ike Dike" plan, but differs in the location and type of land features.



It is clear from our analysis that elements of both a coastal spine and in-bay structures are needed in the long term to protect against a very large hurricane event, especially when combined with sea level rise.

Phasing Plan

The H-GAPS Plan includes components that can be implemented quickly to provide both interim as well as comprehensive, long-term protection from storm surge. The H-GAPS Plan can be divided into two phases:

Phase I

Phase I focuses on the components of the H-GAPS Plan that can provide the most protection for the least cost. It aims for a speedy implementation of the in-bay components that focus on protecting the Houston area and its industrial complexes along the HSC as well as residents and communities in the region. It is likely that Phase I could be constructed using local and/or existing funding mechanisms. In addition, each of these components could be funded separately if necessary. Phase I is split into two distinct parts:

Part A

- Construct the Mid-Bay Gate
- Create in-bay berms
- Build Galveston Levee
- Form small sand dunes

Part B

- Raise HW-87
- Raise FM 3005
- Raise Texas City Levee

Phase II

Phase II focuses on the completion of the more expensive and complex coastal spine gate components of the H-GAPS Plan (Similar to "Ike Dike").

- Construct the navigational gate at the Boliver Roads
- Construct the environmental gate at the Boliver Roads

