

Proposed Ike Dike Project In Galveston, Texas

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ABSTRACT

On September 13th, 2008, Hurricane Ike made landfall along the southeast coast of Texas, devastating Galveston Island, the city of Galveston and the Bolivar peninsula. Ike was a category 2 hurricane when it made landfall in Galveston and consisted of 200 km/h hour winds at the hurricane eye and storm surges of up to six metres in height. The hurricane resulted in \$25 billion in damages and left 1,500 people homeless. [1]

A 17-foot high seawall currently protects the city of Galveston, while a 27-kilometre network of levees protects Texas City. The levees were designed to withstand a 100-year storm event, but were damaged as a result of Hurricane Ike. North of Texas City is the Port of Houston, which is the second largest port in the country and an important economic centre. The Texas City Dike was nearly topped during Hurricane Ike and future storm surges present a threat to the Port of Houston. [2]

To address the threat of future hurricanes, Dr. William J. Merrell and the Texas A&M University in Galveston have proposed the construction of the "Ike Dike". This project would consist of strengthening the existing Galveston seawall, protecting the rest of Galveston and Bolivar by adding revetments and raising coastal highways, and constructing sea gates at the San Luis Pass and Bolivar Roads. [3]

The following paper will overview the existing storm surge infrastructure and provide a brief analysis of the cost, benefits, and challenges associated with the proposed Ike Dike. It will also examine the environmental impacts of the Ike Dike, as it will alter the water exchange between Galveston Bay and the Gulf of Mexico.

1 INTRODUCTION

On September 13th, 2008, Hurricane Ike made landfall at Galveston Island and the Bolivar Peninsula, along the southeast coast of Texas. The storm was classified as a category 2 hurricane when it hit the Texan Coast and most citizens of the City of Galveston were warned to evacuate the city. Storm surge from Hurricane Ike inundated the City of Galveston and left no structures intact along the Bolivar Peninsula.

Fortunately, Texas City and the Port of Houston, which are located north of Galveston, were not damaged as a result of Hurricane Ike. The existing protective barriers and seawalls along the coast of Galveston Island prevented the storm surge from creating further damage. However, if the storm surge had penetrated through the Bolivar inlet, into the bay, or if the Texas City Dike had been overtopped, there could have been devastating consequences to Texas City and the Port of Houston. [2]

As a result of Hurricane Ike, Dr. William J. Merrell of Texas A&M University has been advocating for the construction of a large project called the “Ike Dike”, which aims to increase storm surge protection along the coast in order to ensure no future flooding in Galveston or the Port of Houston. This project is still in the proposal phase, but has received both positive and negative criticism from the public. [4]

2 SITE DESCRIPTION

Galveston Bay is a large estuary on the southeast coast of Texas, which provides a transition between the fresh water of the Trinity River and the saline water of the Gulf of Mexico. Galveston Island and the Bolivar Peninsula are located at the Bay entrance and act as barrier islands, separating the Gulf of Mexico from Galveston Bay. Galveston Island is home to the City of Galveston; during storms and hurricanes, these barriers take the biggest impact from storm surge.

In addition to the City of Galveston, Texas City, home to a large petrochemical complex, is located on the west end of Galveston Bay. The Port of Houston is located north of Texas City, at the top of Galveston Bay. Houston is the second largest port in the United States and directly contributes more than \$175 billion a year to the US economy. If either city were to be compromised as a result of a storm or hurricane, it would result in large economic repercussions. [2]



Figure 1: Galveston Bay Area

2.1 Existing Infrastructure

Following a hurricane in 1900, the Galveston seawall was commissioned to protect the City of Galveston from storm surge during future storm events. The seawall still exists and has gone through many extensions over the years. However, the seawall has sustained significant damage and is in need of rehabilitation. The structure currently extends along the coast of Galveston Island for more than 10 miles. The curved-face concrete structure is approximately 17 feet high and has a thickness of 16 feet. [5] Although the seawall was topped during Hurricane Ike, it is estimated that the structure prevented

approximately \$100 million in further damages. [6] However, had the hurricane made landfall 30 miles to the south, current infrastructure would not have been adequate to protect the surrounding area from the resulting storm surge which would have been catastrophic. [7]

In addition to the Galveston Seawall, the Texas City Dike is a 5-mile levee that extends from Texas City into Galveston Bay towards the channel between Galveston Island and the Bolivar Peninsula. While the Texas City Dike was originally constructed to reduce sediment accumulation in Galveston Bay and the Houston Shipping Channel, it is currently part of a 27-kilometre network of levees that protects the surrounding area from storm surge from Galveston Bay and the Gulf of Mexico. The dike was also overtopped during Hurricane Ike and was heavily damaged. [8]

3 PROJECT DESCRIPTION

The Ike Dike Project proposed by Merrell will consist of three main activities; strengthening the existing Galveston seawall, protecting the rest of Galveston and Bolivar by adding revetments and raising coastal highways, and constructing sea gates at the San Luis Pass and Bolivar Road. [3]



Figure 2: Proposed Ike Dike Project

3.1 Galveston Seawall

The existing Galveston Seawall offers protection from storm surge on the exterior side of Galveston Island, adjacent to the Gulf of Mexico; however, there is no storm surge protection from Galveston Bay on the interior side of Galveston Island. The top of the seawall consists of a 4-lane thoroughfare, which then drops several feet, leaving Galveston City vulnerable to flooding. Merrell proposes to strengthen and extend the Galveston Seawall, but not to construct a seawall on the Bay side of the island as the construction of the Ike Dike will protect against any storm surge in Galveston Bay. [9]

3.2 Revetments

The Galveston Seawall extensions proposed by Merrell will be realized either by constructing land-based revetments along the beaches of Galveston Island and the Bolivar Peninsula or by raising coastal highways, located further away from the beach. The Galveston Seawall would be extended for another 18 miles to the San Luis Pass on Galveston Island and a 35-mile coastal barrier would be constructed along the Bolivar Peninsula. This will be achieved either through 17-foot high coastal barriers along the beach, or by raising the existing highway on Galveston Island and Highway 87 on the Bolivar Peninsula by 12 feet.

In order to minimize disturbance to beaches, a popular attraction for many tourists, sloped revetments composed of natural materials are proposed for the coastal barriers. Revetment design includes adding sand and encouraging vegetation growth on both sides of the barrier, sloping down from the top in order to provide beach access. Towards the end of the barrier on either side, it may be necessary to continue to wrap around the island to ensure total protection from storm surge. [9]

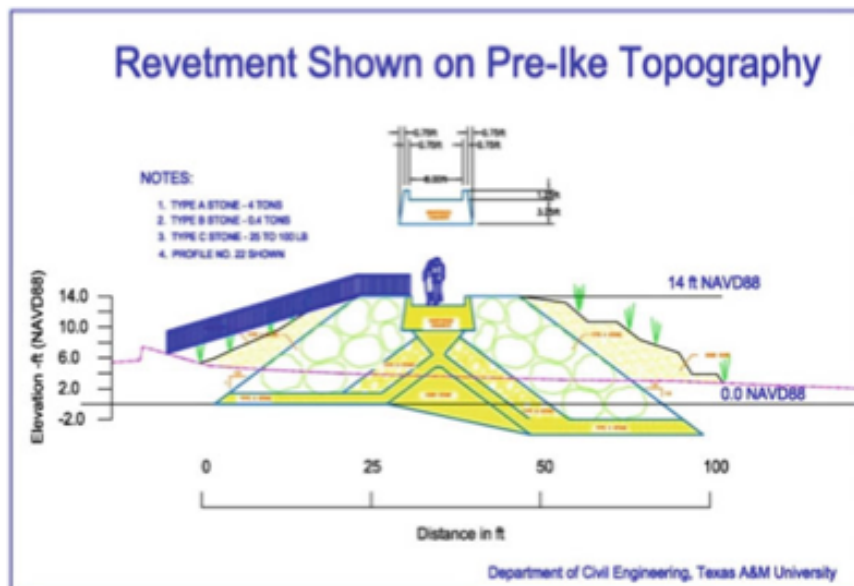


Figure 3: Proposed revetment for coastal barriers

3.3 Sea Gates

The final component of Merrell's proposed Ike Dike is a set of gated barriers, called the "Galveston Gates", at both the Bolivar Roads and the San Luis Pass. These gates would be the most costly part of the project. They would remain open except during hurricane events, in which case they would be closed to prevent storm surge in Galveston Bay. These barriers would also remain at a height of 17-feet, the same as the coastal barriers. Bolivar roads is a larger and busier waterway than the San Luis Pass and therefore would involve a larger gate. [9]

Much of the technology to construct the Galveston Gates already exists; technology used to design the Rotterdam flood gates in the Netherlands was used in preliminary designs of the Galveston Gates. The most constricting factor of this phase of the Ike Dike project is the cost. Rough cost estimates suggest that the Galveston Gates would cost approximately \$3 billion. [2]



Figure 4: Model of Bolivar Roads Barrier and Gates

4 COST ESTIMATE

The total cost of the project is estimated at approximately \$6 billion. However, at this stage in the design and decision making process, it is likely that many changes will be made before the Ike Dike project will ever be built. While the project is expensive, the cost is small in comparison to the \$25 billion in damages caused as a result of Hurricane Ike. [4] Along the Texan coast it is not a question of whether another hurricane will eventually strike, but when.

The gate barriers are the most expensive part of the project. It is estimated that the sea barriers would cost approximately \$1 to \$2 million per metre width of the barrier and the lift gates would cost between \$0.5 and \$1.5 million per metre width. The total cost of the sea barriers and gates is estimated between \$2.1 and \$3.4 billion. [2]

The cost of constructing the levee system was estimated based on the cost of Dutch levees constructed in the Netherlands. These levees are approximately 16.5 metres in height. The Ike Dike levees are estimated to cost between \$6,000 and \$10,000 per metre width. The total cost of design and materials is estimated at approximately \$3 to \$4.5 million, placing the final cost of the Ike Dike at approximately \$6 billion. [2]

5 PROJECT BENEFITS

The greatest threat currently posed in the event of another category 2 hurricane or higher is flooding of the Port of Houston. As the second largest port in the United States, any damage caused to Houston could result in expensive consequences. The port generates more than \$175 billion a year and directly contributes to the US economy. If the port were forced to close for even a month, it would result in a \$60 billion loss to the national economy. [2]

The construction of the Ike Dike would protect the Port of Houston against such losses, in addition to protecting Texas City and the City of Galveston against flooding. This area experiences a category 3 hurricane or higher every 15 years on average, making it likely that similar events to Hurricane Ike will occur again in the future [9]. This likelihood increases with global warming and changing weather patterns, which increase the number of storm events and severity. The Ike Dike will prevent future economic losses related to damaged infrastructure and loss of life as a result of hurricane damages and storm surge in Galveston Bay.

6 PROJECT CHALLENGES

Special considerations need to be made when designing the Bolivar Roads and San Luis Pass barriers, as well as the coastal barriers, to ensure that tidal patterns and the Galveston Bay ecosystem are not disrupted.

6.1 Tidal Prism

Constructing sea barriers across Bolivar Roads and San Luis Pass will significantly reduce the inlets to Galveston Bay. While the gates would remain open except in hurricane events, it is likely that the barriers would alter current patterns, changing the flow velocities in the bay and around the inlets [10]. The Bolivar Roads Barrier would decrease flow into Galveston Bay by 40 to 60%, increasing the likelihood of impacting the tidal prism. [2]

Tidal prism refers to the average volume of water in Galveston Bay between high and low tides [11]. The Galveston Gates have the potential to disrupt the tidal patterns in the bay by decreasing the tidal range. The barriers would result in lower flow velocities around the inlet, which would subsequently result in more sedimentation around the barriers and inlets. Therefore, the sediment exchange between the Gulf of Mexico and Galveston Bay would be affected and there would also be an increase in the residence time of the water. [10]

In addition, this increase in residence time would result in a decrease in the salinity of the water and can affect other factors such as temperature, pH level, and nutrients, which affects plant growth. These factors greatly influence the current patterns and ecosystem in Galveston Bay. [10]

6.2 Coastal Barriers

There are several design options to consider for the coastal barrier extension from the Galveston Seawall. This includes “levee in dune” barriers, natural dune barriers, or raising coastal highways. The “levee in dune” barrier is described as a revetment with sand and vegetation sloping from the levee, whereas a natural dune is formed solely of natural materials. Both options have advantages and disadvantages.

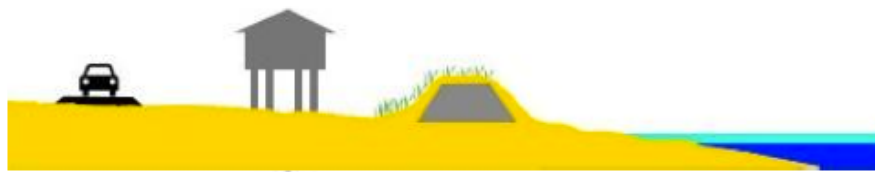


Figure 5: “Levee in Dune” Barrier



Figure 6: Natural Dune Barrier

Both barriers have the advantage of looking natural in order to encourage beach use and tourism, but the “levee in dune” barrier has the advantage of having a solid core. Natural dunes are easily affected by erosion and sedimentation from high waves and there is a large degree of uncertainty in

how the barrier will behave in storm events. Both options change the beach topography along the coast and over time it is expected that the surface area and height of the barriers will be reduced.

The third option for coastal barriers is to instead raise coastal highways to act as storm surge barriers. The main advantage of raising coastal highways is to ensure safe evacuation in the event of a major hurricane event. The barrier would also be constructed on materials substantially stronger than that used in the revetments. The main disadvantages of this option are cost and safety. Raising coastal highways would be much more expensive than revetments and they are located further back from the coast, leaving a greater area vulnerable to storm surge. [2]



Figure 7: Raised Coastal Highway

7 ENVIRONMENTAL CONCERNS

The Galveston Gates will alter the water exchange between Galveston Bay and the Gulf of Mexico and the extension of the Galveston Seawall will change the coastal landscape of Galveston Island and the Bolivar Peninsula. It is essential to analyse both the short-term construction impacts and long-term environmental impacts as a result of the construction of the Ike Dike.

In addition to tidal prism, a decrease in salinity in Galveston Bay will also result in a decrease in water quality. Slower flow velocities in the channel make it easier for contaminants, bacteria, and pollutants to accumulate and increase, which can affect the large variety of species found in the bay. Increased sedimentation can affect sensitive habitats, seagrasses, and oyster reefs and have a negative impact on plant growth and the natural food chain. [10]

The construction of the Galveston Gates and coastal barriers can also have an adverse effect on Galveston Bay's estuaries and tributaries, as well as bay marshes and coastal wetlands. The construction of coastal barriers will greatly change the topography of coastal beaches and much of the area would be disturbed during construction. In order to ensure sustainable development and minimal environmental impact, it is necessary to conduct additional studies on how the Ike Dike will affect the coastal environment and mitigate any adverse effects in the project design. [12]

8 CONCLUSIONS

At this stage, the Ike Dike remains a concept for hurricane mitigation, pioneered primarily by Merrell. In order for the Ike Dike to be considered as a viable option, the concept needs to be better developed, a more detailed cost needs to be estimated, storm surge needs to be analysed, and further studies need to be conducted on the environmental impact of altering natural water exchange between Galveston Bay and the Gulf of Mexico.

While the project would be expensive, the costs associated with another hurricane passing through Galveston Bay are much higher. Much of the current infrastructure was damaged in Hurricane Ike and it is necessary to strengthen infrastructure in order to protect against future economic losses and loss of life. As population continues to increase and economic centres, such as the Port of Houston, continue to grow, it becomes increasingly important to protect coastal areas from future hurricane events.

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