THE COASTAL SPINE: IDEAS ON MOFIFYING THE USACE's TENTATIVELY SELECTED PLAN.

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On October 26th 2018, the United States Army Corps of Engineers (USACE) released their report entitled "Coastal Texas Protection and Restoration Feasibility Study." This report was the result of a joint effort between the USACE and the Texas General Land Office (GLO) that began in November 2015 and examined the feasibility of alternatives that enhance, restore, and sustain the environment, economy, and culture along the Texas Coast. The report recommends a number of ecosystem restoration (ER) projects along the coast and a system of coastal storm risk management (CSRM) features to protect the upper Texas coast. With the report's release, the USACE began a comment period, which ended in February 2019, specifically designed to solicit public comment on the Tentatively Selected Plan (TSP).

As the basis for its TSP, the USACE and GLO examined 5 CSRM alternatives and chose the option that has, as its principal protection feature, a coastal spine that extends the protection of the Galveston Seawall east and west through a system of levies, floodwalls and gates. The alternative chosen is very similar to the Ike Dike concept first proposed by researchers at Texas A&M University at Galveston over a decade ago. So our support of the USACE's basic protection strategy, a coastal spine, should come as no surprise. However, Texas A&M and its partner research organizations, Delft Technical University and Jackson State University, have studied and refined the Ike Dike concept for a number of years, so there is a rich store of knowledge available for developing beneficial modifications to the USACE TSP. We believe these modifications would result in a coastal spine design better suited to protect and enhance the Texas Coast – a locally-preferred option that would blend protection into a spine design that fits better into the economic, environmental, social and recreational fabric of our coastal communities. Our aim is to convince the USACE to seriously consider and adopt our proposed changes and urge other stakeholders to do the same with the shared goal of making our coastal protection the best possible.

The coastal spine as proposed by the USACE starts at San Luis Pass in the west and proceeds eastward along Galveston Island as a line of levees or floodwalls just behind the coastal highway until it reaches a ring levy around the eastern part of the City of Galveston now protected by the Seawall. The Seawall extends to Bolivar Roads, where a series of environmental gates and a large navigation gate provide a sea barrier. On the Bolivar side levee and floodwall protection again extends eastward just behind the coastal highway until it reaches an eastern section that heads northward with a small gate at the GIWW. In addition to the Galveston Ring levee, supplements to the basic coastal spine protection are proposed for the west side of Galveston Bay including gates at Clear Creek and Dickinson Bayou.

The USACE concept is a sound start in that it provides protection by stopping surge near the coast and keeping most water out of Galveston Bay. But we at Texas A&M's Center for Texas Beaches and Shores believe that it can be improved and provide the following nine possible changes for consideration.

Change # 1 "Move the USACE-proposed levee and floodwall land barriers from behind the coastal highways to the coast and construct the protection needed as natural appearing fortified dunes."

The present plan of placing the land barrier as a levee or flood wall right behind the coastal highways has properly caused a number of people to be upset. It is an example of making an unnecessary "Devil's choice" of who is put behind and who is put in front of the protective barrier. The barrier would cause takings of property to build and place even more properties on the seaward side of the barrier subject to increased surge, thereby lowering property values and increasing insurance rates. The "Ike Dike" coastal spine concept can be the only surge protection option that avoids the Devil's Choice of protecting some while harming others. Why not protect everyone by moving the protection as far forward as possible – to the beach – and placing everyone behind it.

It is interesting that, on its page 14, the USACE report states, "For planning purposes for the DIFR-EIS, the team evaluated a levee/floodwall system across Bolivar Peninsula and Galveston Island; however, the team recognizes that there are opportunities to optimize the design and alignment to minimize impacts to existing structures and the environment on the peninsula and island. Future design efforts would focus on where engineered dune systems may be appropriate versus levees and floodwalls."

We agree and think the future design efforts on engineered dune approaches should be mandatory. Engineered dune systems such as those now existing in the Netherlands would be a much more appropriate solution to a land barrier than walls and levees near the coastal highways of Bolivar and west Galveston Island. Dr. Jens Figlus, a coastal engineer is designing and laboratory testing hybrid structures appropriate for the Texas coast. Information on Dr. Figlus' work is on the TAMUG Ike Dike website. We are in discussions with the City of Galveston to conduct field tests of some of Dr. Figlus' designs.

Surge protection using dune technology is proven and visually attractive, allows for recreation opportunities and provides a natural environment for dune ecosystems. Strategically, it allows all residences and businesses to be behind the barrier not in front of it, exposed to additional risks because of the barriers presence. Also, because it is located on the public beach no property owners are displaced and no wetlands are disturbed.

On the other hand, it does mean that we would have to deal with stopping erosion now. But, if not now, when? Allowing erosion to run free without dune and beach maintenance allows the coast to retreat to hard surfaces such as the coastal highways. The ultimate result is seawall-like structures covering the entire coast of upper Texas – an outcome none of us wants. We applaud the USACE for its inclusion of beach and dune nourishment on Bolivar, Galveston Island and Follet's Island in its TSP. We further note that the USACE's ERDC has also produced a comprehensive report on beach nourishment opportunities on Galveston Island. We urge the USACE to carefully consider

the use of natural appearing engineered dune systems near or on the beach as the primary land barriers and to include beach and dune maintenance in the final plan.

Change # 2 Add a western section as fortified dunes on Follet's Island and gate San Luis Pass.

The USACE TSP western boundary is now at the Galveston Island side of San Luis Pass. This leaves the Bay open to surge events even when the gates at Bolivar Roads are closed. An open San Luis pass allows both surge and fore-surge a "backdoor" into Galveston Bay, which can cause increased water levels and increased storm surge in the Bay. This approach is counter to the coastal spine basic strategy of stopping the surge at the coast and keeping water out of the Bay to minimize surge in the Bay. On the Ike Dike website, we provide surge water level comparisons with and without a western segment that shows significantly increased water levels without a gate a San Luis pass. Using ADCIRC modelling, surge from 8 storms was simulated to test the surge levels with and without San Luis Pass closed. For all of the models, having a sea barrier at San Luis Pass reduced storm surge, and the greatest reduction was seen on the West side of Galveston Island, but the whole Houston-Galveston region can benefit from reduced surge. As an example, a 100-yr storm with 102 mph winds, approaching the region from the Southeast and had a peak storm surge greater than 15 ft. The modelling shows that closing San Luis Pass reduced the storm's peak storm surge by 7ft near the Pass and prevented early storm surge from entering the bay before the hurricane made landfall. The ADCIRC modeling used in this work was analyzed by Jackson State University and performed by the USACE Engineering Research and Development Center (ERDC). We have made it fully available to the USACE.

Change # 3 institute and account for best practices for Bay water management in estimating Bay surge.

Having San Luis Pass ungated also disallows important strategies such as sealing the Bay at low tide to minimize water levels before the onset of a hurricane. There are other ways we can take advantage of the fact that the gates are an active system, for example by opening the Bolivar gates to direct a return surge out of Galveston Bay after a hurricane passes.

The water levels allowed in the Bay directly impact a number of protection design issues including the heights of or even the need for secondary barriers such as the Galveston Ring Levy and structures at Clear Creek and Dickinson Bayou.

Changes # 4, 5 and 6. Rethink the size, complexity and even need for the Galveston ring levee and gates and structures at Kemah and Dickinson Bayou.

These additions to the basic coastal spine are designs that evolved from rejected non-spine options that attempted to deal with the full force of storm surge in unprotected areas as opposed to a surge that is already reduced by a properly designed and operated Ike Dike. With the presence of a coastal spine these additional features may not be needed or can be reduced in size and complexity.

The proposed Galveston ring levee is a ring around the eastern part of the City of Galveston now protected by the Seawall. The seawall would be heightened and the proposed ring levee would have a substantial height of 18ft on the backside of the City.

The proposed levy is expensive and would require high maintenance. It has many points of potential failure – 46 2-lane highway gates, 6 4-lane highway gates, 4 railroad gates, and 3 pumping stations. Its 18ft height creates a nightmare overflow scenario if it or the seawall were ever breached. Suitable protection can be achieved by less intrusive means.

In addition to the Galveston Ring levee, supplements to the basic coastal spine protection are proposed for the west side of Galveston Bay including the possibility of 17ft high gates at Clear Creek/Kemah and Dickinson Bayou.. Large gates will be expensive, high maintenance, and require considerable additional infrastructure to reduce flooding. As proposed, a gate at Kemah would divert the Clear Creek flooding path through Shoreacres unless a barrier is built there.

In its TSP, the USACE wisely notes that nonstructural alternatives might be considered (note that the USACE includes raising individual structures in its non-structural alternatives) for the west side of Galveston Bay. This combined with modest structural improvements would provide suitable protection from surge and nuisance flooding for Galveston Bay's west side as well as the back side of the City of Galveston.

Change # 7 Reduce or eliminate the North-South Eastern Barrier running up from High Island. Recent modeling shows that any water getting into Galveston Bay from hurricane surge generated east of the coastal barrier enters an eastern Bay region with low water heights. This is because Bay waters in eastern Galveston Bay have already been reduced by the approaching hurricane's outlying winds, which blow the Bay water from the east to west. For now, we believe the barrier can be eliminated or greatly reduced in height.

Change # 8 Modify the Bolivar Roads Water barrier to reduce the size of the ship gates and allow more flow through the environmental section. The TSP's navigation gates are too large and certainly too deep. The TSP gates are designed at 1200ft width and 60 ft depth. This for a 530 ft wide channel (800ft wide with shallower barge lanes) with a present water depth of 43 to 45 ft. Plans for improving the navigation in the channel seem concentrated on deepening some shallower areas in the upper channel to the 43 to 45 ft design depth and improving mobility by taking out some curves and kinks. Any significant deepening would require dredging the channel for many miles out onto the Texas shelf as well as dealing with the myriad of pipelines crossing the channel. The navigation gate is the single most expensive part of the TSP (about $5B), and while some allowance for widening and deepening is understandable, the present design can be usefully downsized.

The environmental gates allow for two major functions, assuring sufficient flow in and out of the Bay to maintain conditions in the Bay necessary for ecosystem health and allowing exchange of sea life between the Gulf and Bay, especially larvae. The present plan can be improved to allow more flow by substituting barge gates with larger flow openings for some gates in the present design. Also, accordion or inflatable gates could be used near Bolivar**.** This would allow totally open waters in the eastern section of Bolivar Roads where most larvae exchange occurs.

Change # 9 Clarify costs for different activities and work on reducing costs. Although the USACE has clearly stated that the total cost estimates in the TSP include much more than upper coast protection, its total project costs estimates of $23,106,582,000 to $43,825,875,000 have been assumed by many to be the cost of the upper coast protection.

The USACE does estimate the upper coast protection at a whopping $14,170,440,000 to $19,871,300,000 and states it used the Gulf Coast Community Protection and Recovery District's costs as a basis for their analysis but the GCCPRD total estimated costs for a similar configuration is about $9.5B. Seems like a lot of difference. An independent Dutch analysis of our Ike Dike configuration with gates at San Luis pass and protection on Follet's Island but no ring levee at Galveston or gates at Kemah or Dickinson Bayou came in at about $9.2B. The public needs to understand the differences in the total cost estimates of the USACE and other groups. The USACE also needs to present cost estimates of individual features such as the Galveston Ring Barrier instead of lumping all barriers together. The lumping of costs creates a false take it all or leave it impression. We estimate the Ring Barrier costs as presently designed at about $2B and I also believe we could achieve more neighborhood and port friendly backside protection for the eastern part of The City of Galveston at much less cost. The USACE report structure makes it difficult to understand how to take advantage of features that can be usefully reduced or eliminated to reduce project costs.

Comments on the need for a more adaptive approach. We live in interesting times. Our population is moving to the coast and the seas are rising to meet us. The United States is beginning to follow other nations in moving to strategies of protecting people and infrastructure from storm-induced damage instead of allowing damages and then assisting in recovery.

A protection strategy is being developed for Texas' Upper Gulf Coast, where hurricane-induced surge has the potential to claim thousands of lives and cause well over S100B in economic losses. However necessary and useful here, it isn't a simple process at this point. We citizens are dealing with trying to make sense of and properly comment on a massive costly protection plan immersed in an inflexible USACE process, obviously designed for smaller, more straightforward projects.

The relatively inflexible USACE process also limits it, in how it deals with the great uncertainties in planning conditions over the next decade. Instead of a fixed process, some form of adaptive management makes sense. We need to continuously monitor conditions and change our plans as conditions change. For example, we need to adapt to relative sea level rises that are faster or slower than expected by hurrying additional protection or delaying it. Working with the federal government and state, we need to set up a regional institution(s) that can effectively monitor changes in natural environmental conditions and the built environment and, using the latest technologies, modify coastal barrier planning appropriately.

For now, we need to remember the USACE controls the planning and is constrained by their own process to design and build a barrier that would eliminate surge damage on the 100 yr flood plain in 2084. This will naturally lead to some pretty hefty protection as they a try to account for major uncertainties over decades, such as rate of sea level rise, nature of the development of our human settlements and changes in storm intensity and frequency. And, although understanding that better technologies will be developed, they have to use present technologies to design a project expected to remain operational until at least 2084.

Given USACE planning constraints, they've done a good job designing a strong spine and, although the plan is tentative as far as final detail, it provides plenty of detail for citizen response. Also, the design team has wisely alluded to areas where more non-structural approaches might be

appropriate and even pointed out that engineered dunes could be examined for the land barrier. I believe that the USACE and their funding partner the GLO will seriously address our comments. That's why I'm commenting publically through this series of articles and my comments and hundreds of backup pages to the USACE.

The TSP is a good plan in that it uses the correct overall strategy of a coastal spine as the main component of protection. But it can be tweaked to be a better plan. We've tried to outline a modified version of a coastal spine design that fits better into the fabric of our coastal communities. It leaves no one in harm's way in front of the barrier by placing an engineered dune land barrier directly on the beach. It gives more flexibility to managing transport of water and larvae through the water barrier by modifying the gates at Bolivar Roads to allow more open-water flow, especially on its far eastern portion. By extending the barrier to the west and gating San Luis pass, the design takes full advantage of the active gate system's ability to reduce water levels, hence surge in the Bay. This surge reduction allows one to question the complexity, costs and even need for additional protection in the form of large gates at Clear Creek and Dickinson Bayou, the Galveston Ring Levee and the portion of the barrier that runs north from High Island. As a plug for adaptive management, it is useful to point out that these features can always be added or strengthened if changing conditions over the years warrant it. Working to protect our region from coastal hazard is not a one-time fix but rather a continuous process.