



Packery Channel Restoration (H17019) Preliminary Design Report

Corpus Christi, Texas

HDR Project 10130118

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Prepared for the City of Corpus Christi



Executive Summary

This report provides preliminary design recommendations for maintenance, repairs, and improvements at Packery Channel, Texas following impacts from Hurricane Harvey in August 2017. Features at Packery Channel that were damaged include the rock jetties, bank armoring, sections of concrete walkway, and other related appurtenances. Observed damage and repair recommendations have been categorized by channel reach as follows:

- Reach 1: Observed damage primarily consisted of displaced armor stone blocks along the outer portion of the jetties extending into the Gulf. Although most of this damage appears to have been a result of cumulative impacts from previous hurricanes, re-setting all of the stones is recommended to prevent more significant damage during future storms.
- Reach 2: Observed damage primarily consisted of displaced armor (1-3 ton stone) along the landside jetties. Recommended repairs include re-setting and replacing stone to restore the original design template and provide an improved toe that is more resilient to undermining.
- Reach 3: Observed damage primarily consisted of undermining, separation, and displacement of the articulating block mats (ABMs) that protect the channel bank between the inner portion of the jetties and the SH361 bridge. The damage resulted in sections of ABM that are now free-hanging across areas where the foundation has been compromised. In addition, several sections of the concrete walkway that runs along the crest of the ABM collapsed due to the foundation being washed away. Sections containing significant ABM damage are recommended to be removed and replaced with a riprap revetment along the north bank, and either a riprap revetment or a steel sheetpile bulkhead along the south bank. The concrete walkway and other related appurtenances are also recommended for repair. Progressive damage to the bank and walkway is expected to continue until the bank protection is repaired.
- Reach 4: Scour and erosion within an unprotected section of shoreline along the north side of the channel between the Packery Channel parking lot and the SH361 bridge resulted in exposure and damage to an underground water transmission line. Although the pipeline has since been repaired, a low-crested rock breakwater is recommended for this area to help protect the channel bank and landward area from future erosion, including along the base of the City's boat ramp parking lot. If this option is carried forward to permitting and/or detailed design, hydrodynamic numerical modeling is recommended to better assess interaction of the breakwater with discharge flows during a Harvey-level storm surge event, and to possibly consider additional breakwater configurations and/or alternatives.

This project does not include inspection or assessment of scour protection under the SH361 bridge.

The preliminary-level opinion of probable construction cost for repairs and maintenance, excluding recommended Hazard Mitigation items, is approximately \$7,060,000. Adding the recommended Hazard Mitigation components would increase the total construction cost to \$11,518,000. The bank protection repairs would require a permit and Section 408 authorization from the U.S. Army Corps of Engineers (USACE) that would likely require approximately 12 months to obtain. Detailed engineering design for the repairs would likely require approximately four to six months. Based on anticipated timelines for permitting and design, the project could likely be ready for bidding in December 2019 if the City proceeds with permitting immediately. Construction would likely require approximately 6 to 9 months after bidding and contract award. Repairs are unlikely to require any extended closure of the channel to recreational vessel traffic.

Note that Packery Channel is a federal project and the City is the local sponsor. The Packery Channel operations and maintenance manual (USACE 2007) states that repairs and rehabilitation performed by the City should be coordinated with USACE. The City should plan on engaging USACE during the planning stages of the repair effort, and for design review. Record drawings of the completed repairs should be provided to USACE upon project completion.

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Attachments

Attachment A – Kickoff Meeting Notes

Attachment B – Site Visit Report

Attachment C – Opinions of Probable Construction Costs

1. Introduction

This report provides preliminary design recommendations for repairs at Packery Channel, Texas to address damages caused by storm surge, strong currents, and waves produced by Hurricane Harvey on August 25-26, 2017. Harvey was a Category 4 hurricane that made landfall approximately 30 miles northeast of Packery Channel near Rockport, Texas.

Packery Channel is a navigable tidal inlet that was constructed by the U.S. Army Corps of Engineers (USACE) in October 2006. The inlet is maintained by the City of Corpus Christi as a recreational boat channel connecting Corpus Christi Bay to the Gulf of Mexico at the juncture of North Padre Island and Mustang Island (Figure 1). The preliminary design recommendations provided in this report are focused on the eastern portion of Packery Channel extending from the SH361 bridge to the Gulf of Mexico. This portion of the channel consists of various structural elements including jetties, bank protection, concrete walkways, a boat ramp, and related appurtenances that are exposed to significant hydrodynamic loads during coastal storms.



Figure 1 – Project Location Map.

For the purposes of this assessment, Packery Channel was divided into four reaches which experienced varying ranges of damage during Harvey. These reaches are shown in Figure 2 and are generally described as follows:

- Reach 1 is characterized by 10-ton armor stone (granite blocks) extending along the jetties into the Gulf of Mexico. Reach 1 spans approximately 1,450 ft from the jetty head on the east to the transition between the granite blocks and irregular riprap (Reach 2).
- Reach 2 consists of 1-3 ton quarystone supported by 1,000 lb core stone that extends roughly 850 ft along the inner (landside) section of the jetties from the end of the granite blocks to the beginning of the articulating block mat (ABM) revetment section (Reach 3).
- Reach 3 consists of ABM revetments that consist of cabled concrete block units that serve as bank protection from the inner ends of the jetties towards the SH361 bridge. Reach 3 is the longest section, extending approximately 3,000 ft.
- Reach 4 consists of the unprotected section of shoreline along the north side of the channel extending approximately 315 ft from the northwest corner of the boat ramp parking lot to the SH361 bridge abutment.



Figure 2 - Channel Reaches Representing Characteristic Damage Areas at Packery Channel.

Characterization of project damage was performed through review of aerial photography; observations from multiple site visits; review of design drawings from original project construction; and review of survey data, side-scan sonar data, and magnetometer data provided by the City. HDR's initial damage assessment (HDR 2018) was based on a site visit performed on August 27, 2017. As part of the current effort, an updated damage assessment was performed on August 28, 2018 (see Attachment B). Although no additional damage elements were identified during the updated assessment, the extent of damage has increased along the ABMs and concrete walkway along the south bank in Reach 3. In addition, voids have formed under two sections of the concrete walkway along the north bank. A summary of the damage by channel reach is provided in Table 1. The repair concepts and cost estimates presented in the current report are based on the updated damage extents.

Table 1 – Updated Damage Summary.	
Location	Damage Description
Reach 1	Displaced jetty stone (granite blocks). Loss of navigation aids at seaward ends of jetties.
Reach 2	Damage along landside jetties (loss and displacement of stone that serves as bank protection along the channel).
Reach 3	Damage to bank protection (undermining, separation, and displacement of ABMs).
Reach 4	Erosion of unprotected bank between parking lot and SH361 bridge, resulting in exposure and damage of a water transmission line during Hurricane Harvey. This area was repaired by the City in September 2017, but remains unprotected and exposed to erosion during future storms.
Miscellaneous	- Walkway damage along south bank. - Voids under walkway along north bank. - Debris in channel. - Damage to post/cable barriers along north and south bank. - Development of voids around storm drains.

This report provides a description of the failure mechanisms for the most significantly-damaged areas during Hurricane Harvey, as well as preliminary design recommendations for the following three repair categories:

1. **Harvey Repair:** Damage caused by Harvey would be repaired to original (or equivalent) condition.
2. **Hazard Mitigation:** Damage caused by Harvey would be repaired to an improved condition designed to withstand Harvey-level impacts.
3. **Maintenance:** Damage caused prior to Harvey would be repaired to original or improved condition.

Preliminary design, opinions of probable construction costs, permitting requirements, and recommendations for proceeding to detailed design have been developed for needed repairs in Reaches 1 through 4 as outlined in Table 2.

Table 2 – Summary of Damage and Repair Alternatives.			
Location (Reach)	Repair Category and General Description		
	Harvey Repair	Hazard Mitigation	Maintenance
Reach 1	- <i>Re-Set Displaced Stone at Gulf Jetties</i>	- <i>N/A</i>	- <i>Re-Set Displaced Stone at Gulf Jetties</i>
Reach 2	- Repair Bank Protection (Replace/Re-Set Stone in Landside Jetties)	- Repair and Improve Bank Protection (Replace/Re-Set Stone in Landside Jetties)	- Repair Bank Protection (Replace/Re-Set Stone in Landside Jetties)
Reach 3	- Repair Bank Protection (ABM) - <i>Concrete Walkway</i>	- Repair and Improve Bank Protection (Two Stone Alt's, One Bulkhead Alt) - Drainage Along S. Bank	- <i>N/A</i>
Reach 4	- <i>N/A</i>	- <i>Rock Breakwater</i>	- <i>N/A</i>
Misc.	- <i>Post/Cable Repairs</i> - <i>Fill Voids at Storm Drain Outfalls</i> - <i>Debris Removal</i>	- <i>N/A</i>	- <i>Post/Cable Repairs</i> - <i>Handrail Repairs</i>
Notes: (1) Items in blue/bold have been evaluated as part of the current preliminary design effort. Evaluation of the repair items in <i>italics</i> remains as presented in HDR (2018); these items have not been re-evaluated under the current effort, with the exception of updating damaged quantities (length, area, volume, etc.) as applicable. (2) Repairs to navigation aids are being performed by the City and are not included in this assessment. (3) Inspection of the scour protection under the SH361 bridge was not included in this assessment.			

2. Failure Mechanisms

This section provides a description of the primary failure and/or damage mechanisms for the ABM revetment in Reach 3, riprap bank protection in Reach 2, and the adjacent concrete walkways. These features were the most heavily damaged components of the project. Figure 3 provides a schematic cross section of the ABM revetment, concrete walkway, and channel as originally constructed. Note that the toe of the ABM revetment terminated at elevation -2.0 ft and did not extend to the bottom of the channel. Although not shown in Figure 3, the toe stone for the bank protection (landside jetty) in Reach 2 rested on a sand bench at elevation -6.0 ft.

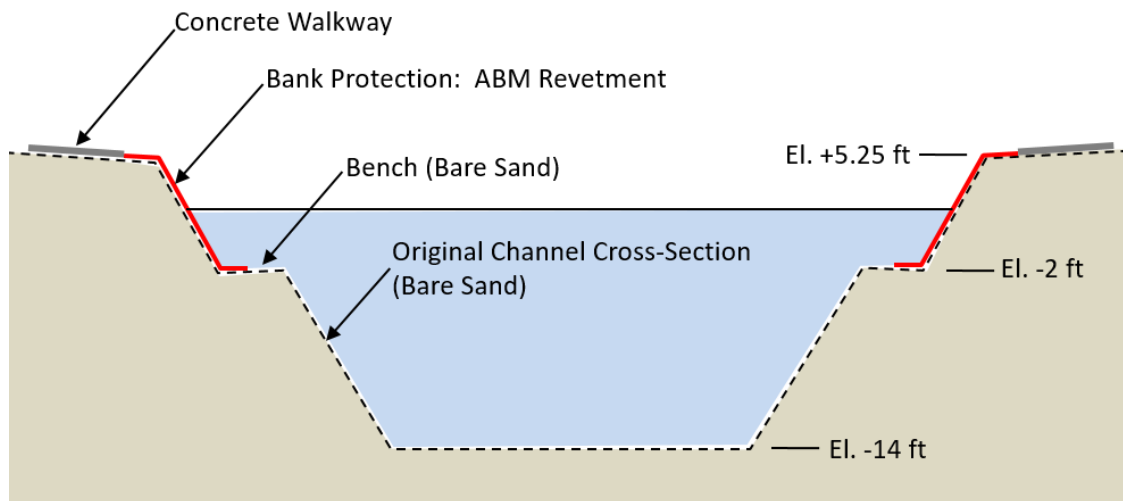


Figure 3 – Original Channel Cross-Section (Reach 3).

As depicted in Figure 4, Hurricane Harvey forced water into Corpus Christi Bay through Aransas Pass, creating elevated water levels (storm surge) in the bay. Strong north winds then pushed the storm surge towards Packery Channel, where the surge was rapidly forced out of the bay as the hurricane shifted inland. The discharging surge caused strong currents of approximately 5 fps in Packery Channel as water flowed from the bay to the Gulf (Williams and Tissot 2018). Based on review of post-Harvey bathymetric surveys performed by the City, these strong currents caused erosion and scour to depths exceeding -18 ft NAVD along the lower, unprotected portions of the channel (Figure 5), resulting in loss of the original bench that supported the toe of the ABM revetment, particularly along the south bank in Reach 3 where the strongest currents were focused. Erosion also occurred beneath the toe of the landside jetty in Reach 2, where currents caused erosion and scour of the bench to depths of approximately -8 ft NAVD.



Figure 4 – Storm Surge Flow Pathway During Hurricane Harvey.



Figure 5 – Survey Showing Bottom Elevations in Packery Channel after Hurricane Harvey (Survey performed by Naismith Marine Services, Inc. during September 2017).

Tide measurements by the National Oceanographic and Atmospheric Administration at Station 8775792 showed that water levels in Packery Channel reached approximately +5.5 ft NAVD during Hurricane Harvey, exceeding the bank elevation of +5.25 ft in Reaches 2-4. Coupled with rainwater runoff, return flow of overtopped water back into the channel as the storm surge receded likely led to seepage through the bank and localized washouts. This seepage through, and flow across, the bank likely caused additional erosion of the bench and bank foundation, resulting in undermining of the walkway and revetment in Reach 1 (Figure 6) and displacement of stone in Reach 2.

Figure 7 provides a schematic comparison of the channel cross section before and after Harvey, illustrating the significant loss of foundation soils under the walkway and revetment that appears to have resulted in their collapse as depicted in Figure 8. The updated damage assessment in Appendix B provides evidence of continued loss of foundation soils from waves and rainwater runoff that has led to additional undermining and collapse of the walkway since Hurricane Harvey.

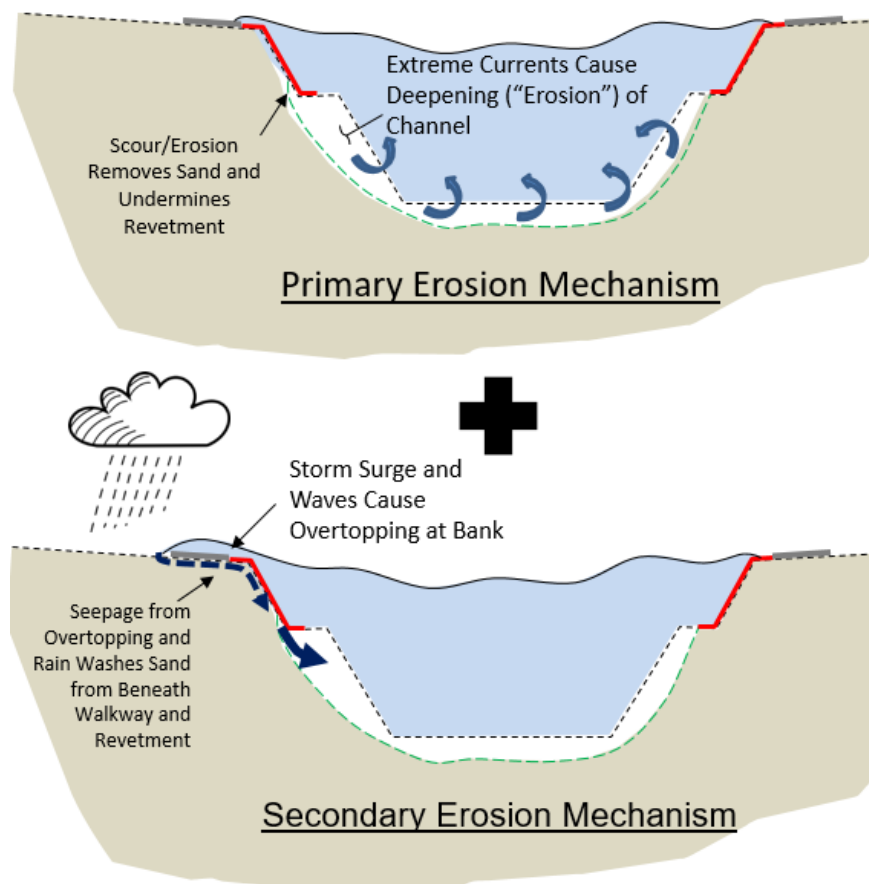


Figure 6 – Erosion Mechanisms During Harvey.

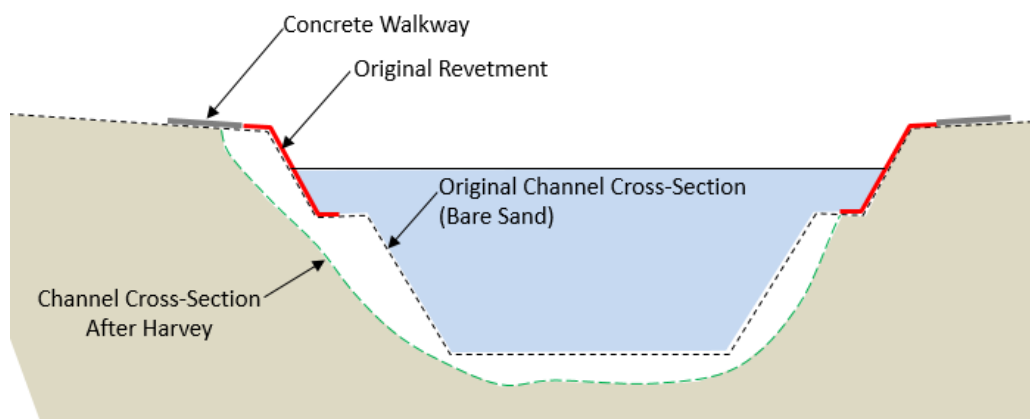


Figure 7 – Channel Cross-Section After Harvey.

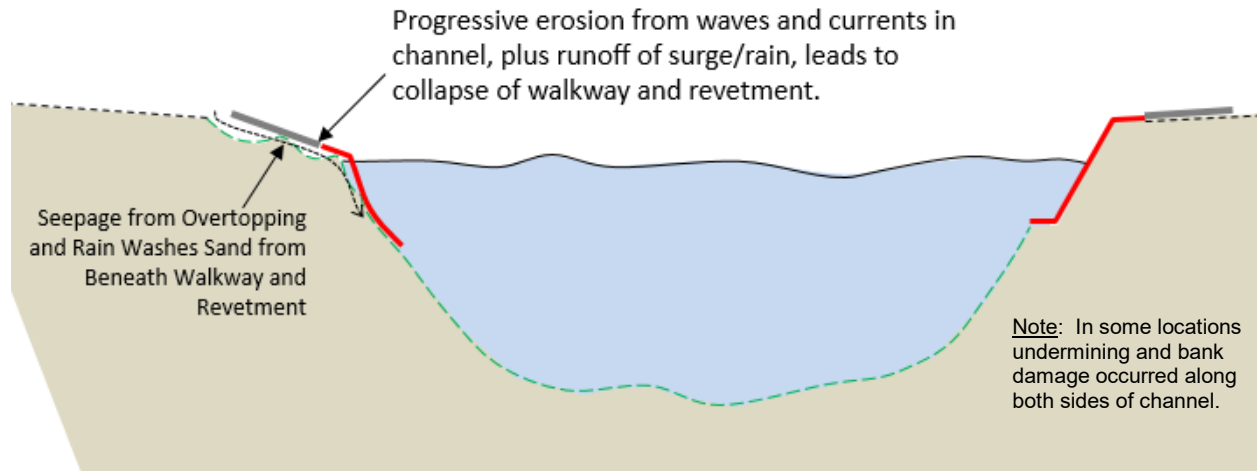


Figure 8 – Walkway and Revetment Failure after Harvey.

3. Design Criteria

As discussed in Section 1, one of the repair categories being considered at Packery Channel is the “Hazard Mitigation” option. For this repair category, damage caused by Hurricane Harvey would be repaired to an improved condition designed to withstand approximate Harvey-level impacts, assuming they exceeded the original design criteria.

The original design criteria for Packery Channel are stated in the Design Documentation Report prepared by USACE (URS/Dames & Moore 2003) prior to project construction. The criteria relevant to Hazard Mitigation design alternatives in Reaches 2 and 3 are summarized in Table 3. With the exception of the current velocity, which was approximately 5 fps during Hurricane Harvey (refer to Section 2), the conditions during Hurricane Harvey do not appear to have exceeded the original design criteria.

Table 3 – Original Project Design Criteria.	
Parameter	Criteria
Storm Intensity	50 yr return period.
Water Level	50 yr still water elevation = +7.6 ft NAVD (in Gulf of Mexico) 50 yr still water elevation = +8.3 ft NAVD (in Packery Channel)
Waves	For Reach 3, wave height = 3 ft and wave period = 2.2 sec. For inner jetty section (Reach 2), design wave criteria not documented.
Currents	Less than 5 fps.

As discussed in Section 2, the primary failure mechanisms during Hurricane Harvey appear to have been driven by:

1. Loss of the exposed sand bench beneath the toe of the ABM revetment (Reach 3) and stone (Reach 2) from strong currents in the channel.
2. Loss of foundation soil caused by localized washouts and seepage from bank overtopping and rainwater runoff (Reach 3).

Because the damage was caused by undermining of the bank protection rather than direct displacement of the protective structural elements by waves and currents, addressing these failure mechanisms can be accomplished with an improved toe design coupled with a drainage system to help control land-side drainage along the bank. Therefore, in developing the design concepts for the Hazard Mitigation options, the original project design criteria will be largely maintained. However, the configuration and/or layout of the bank protection system(s) will be modified to reduce the potential for foundation loss from currents, seepage, and localized washouts. As noted in Section 2, numerical modeling by Williams and Tissot (2018) suggested that peak currents during Harvey were approximately 5 fps in Packery Channel. In comparison, as part of an investigation of previous bank damage near the Packery Channel boat ramp, Reed and Lin (2007) recommended applying a current of 8.2 fps for riprap design. This higher value will be applied as the minimum current velocity for design of bank protection improvements.

4. Design Alternatives

Design concepts were prepared for the following three repair categories as discussed in Section 1:

1. Harvey Repair: Damage caused by Harvey would be repaired to original (or equivalent) condition.
2. Hazard Mitigation: Damage caused by Harvey would be repaired to an improved condition designed to withstand up to Harvey-level impacts.
3. Maintenance: Damage caused prior to Harvey would be repaired to original or improved condition.

The design alternatives and/or recommendations for each repair category are presented below. In Reach 3, the ABM damage areas were divided into two general types as shown in Figure 9 and described below.



Figure 9 – ABM Damage Areas and Repair Classifications in Reach 3.

1. Smaller, more isolated damage areas, and damage along areas that are less exposed to daily wave and current action, are recommended to be repaired by capping the damaged ABM in place with riprap. This repair approach has been successful for previous repairs to short sections of the ABM revetment by the USACE and the City (for example, see Figure 10). This approach should include placement of geotextile fabric and riprap along the exposed slope below the ABM to help prevent future toe scour and undermining.



Figure 10 – Example of previous repairs constructed by capping damaged ABM in-place with riprap.

2. Longer sections of damaged ABM, and/or damaged ABM in areas more exposed to daily wave and current action, are recommended to be repaired by removing the ABM and replacing it with either new ABM (for the Harvey Repair category), or with other alternative bank stabilization methods (for the Hazard Mitigation category).

4.1 Harvey Repair

A description of the recommended repair items under the “Harvey Repair” category is provided in Table 4, and the damage locations are shown in Figure 11 (for Reach 2) and Figure 9 (for Reach 3). Although the intent of this repair option is to reconstruct the damaged features to their original condition, varying degrees of erosion of the bench that supported the landside jetty toe in Reach 2 and ABM toe in Reach 3 will require the new bank protection to extend further downslope. For purposes of preliminary design, the proposed elevation for keying the toe into natural grade was set at -8 ft NAVD (see Figure 12 and Figure 13). This toe key elevation was based on review of the September 2017 survey data, and information on historical scour depths provided by Texas A&M University-Corpus Christi¹. The actual toe elevation may vary along the length of the repairs depending on variations and changes in the channel cross-section that may have occurred since September 2017. The channel side slopes should be re-surveyed prior to final design to confirm the required toe elevations and material volumes. Other than the toe configuration, the repair details would match the original design.

For repair of the landside jetties in Reach 2, review of aerial photography indicates that some of the damage along the upper slope occurred during previous storms such as Hurricanes Emily,

¹ Personal communication, Ms. Deidre Williams, Texas A&M University – Corpus Christi, Conrad Blucher Institute for Surveying and Science, October 24, 2018.

Katrina, and Rita in 2005 and Hurricane Ike in 2008. For estimating stone quantities, it was assumed that approximately one third of the observable damage along the upper slope was caused by Hurricane Harvey, with the remaining two thirds attributable to previous storms. This percentage was based on comparison of stone locations in high-resolution aerial photography taken before and after Hurricane Harvey.

Table 4 – Harvey Repair Recommendations (Return Project to Approximate Pre-Harvey Condition).		
Location	Repair Description	Approximate Quantity
Reach 1	- Re-Set Jetty Armor Stone.	5 Stones
Reach 2 (Figure 11)	- Re-set/replace 1-3 ton stone along upper slope of landside jetty. - Place 1,000 lb core stone to repair toe protection to approximate elevation -8 ft NAVD (see Figure 12).	1,070 LF
Reach 3 (Figure 9)	- Cap damaged ABM in-place with riprap. Also place riprap on geotextile fabric along exposed slope below bottom edge of damaged ABM to approximate elevation -8 ft NAVD.	530 LF
	- Replace ABM Revetment - Extend new ABM downslope to approximate elevation -8 ft NAVD (see Figure 13).	2,400 LF
Miscellaneous	- Fill Voids under Concrete Walkway (North Bank, Reach 3)	360 LF
	- Replace Concrete Walkway (South Bank, Reach 3)	1,780 LF
	- Remove Debris from Channel	15 Items
	- Replace Post/Cable Barriers (South Bank) (see Figure 14)	2,600 LF
	- Replace Cables in Post/Cable Barriers (North Bank) (see Figure 14)	4,000 LF
	- Repair Voids at Storm Drain Outfalls (North Bank)	2 Locations



Figure 11 – Landside Jetty Damage Areas in Reach 2.

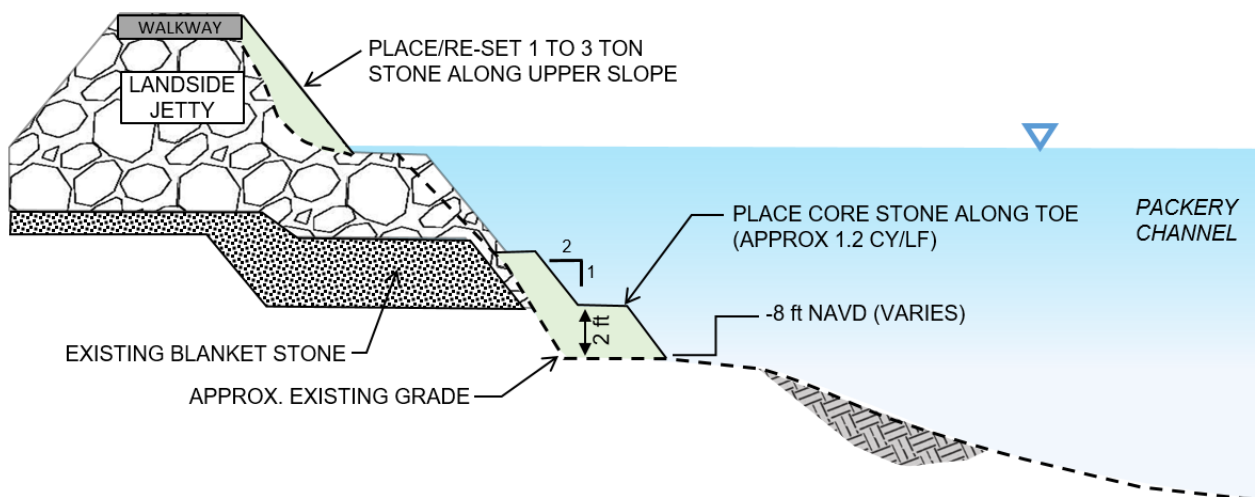


Figure 12 – Harvey Repair Option for Reach 2 (Landside Jetty).

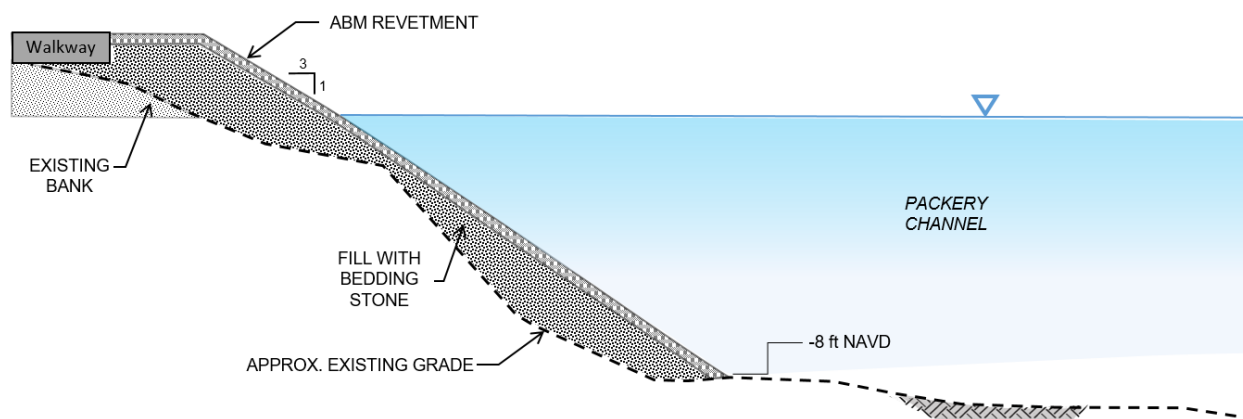


Figure 13 – Harvey Repair Option for Reach 3 (ABM Revetment).



Figure 14 – Harvey Repair: Post/Cable Barriers.

4.2 Hazard Mitigation

A description of the repair items included under the “Hazard Mitigation” category is provided in Table 5. The following considerations were applied in developing these repair concepts:

- *Reach 2 – Landside Jetty Repairs*

During original project construction, the stone in Reach 2 was placed on a sand bench at -6 ft NAVD, but the bench eroded to elevations of approximately -8 ft NAVD during Hurricane Harvey. The improved template would provide a larger toe apron designed to help prevent undermining to a depth of -14 ft NAVD, which is the full channel depth.
- *Reach 3 – Revetment Repairs*

In Reach 3, two riprap revetment options and a bulkhead option are presented to replace the original ABM revetment. The second of the two riprap options would provide an increased level of resiliency against toe scour by incorporating a “launching toe” design. The launching toe would provide additional riprap that would be available to settle into deeper scour areas without causing separation of the riprap along the upper slope. For the bulkhead option, steel sheet piling is recommended as a more constructible solution than concrete panels because of the relatively deep elevation (approximately -30 ft NAVD) to which the piles would need to be driven.
- *Reach 4 – Shoreline Protection Between Parking Lot and SH361 Bridge*

During Hurricane Harvey, strong currents flowing over SH361 discharged into Packery Channel between the parking lot and the SH361 bridge approach. Erosion and scour from these currents exposed and damaged an underground water transmission line and eroded areas around the parking lot. This area is also exposed to chronic erosion from daily boat wake, wave, and current action. A rock breakwater is proposed to help reduce loss of sediment during future storm surge discharge from water flowing over SH361, and to protect the shoreline from chronic erosion. If this option is carried forward to permitting and/or detailed design, hydrodynamic numerical modeling is recommended to better assess interaction of the breakwater with discharge flows during a Harvey-level storm surge event, and to possibly consider additional breakwater configurations and/or alternatives.
- *Drainage System Along South Bank*

As discussed in Section 2, localized washouts and seepage from surface runoff likely contributed to loss of foundation material under the sidewalks and beneath the ABMs. A drainage system is proposed along the south bank to help prevent this failure mechanism during future storms. The drainage system would extend approximately 2,500 LF adjacent to the south side of Reach 3 as shown in Figure 25. The drainage system would consist of a continuous 12-ft wide swale lined with geotextile fabric and riprap to capture and route surface drainage to inlet structures spaced approximately 500 feet along the swale. As a potential cost-saving measure, the swale could be lined with crushed concrete from the demolished walkway or recycled ABM from the revetment. The inlet structures would discharge water from surface drainage through 24” aluminum (or other corrosion-resistant material) pipes penetrating through the bank protection to the channel.

Table 5 – Hazard Mitigation Options (Repair Project to Improved Condition).

Location	Repair Description	Approximate Quantity
Reach 2	Landside Jetty Repairs - Re-set/replace quarrrystone along landside jetty (see Figure 15 for location and limits). - Extend quarrrystone downslope and provide improved toe to accommodate scour to elevation -14 ft NAVD (see Figure 16).	1,070 LF
Reach 3	Option 1 – Riprap Revetment - See Figure 17 for location and limits. - Replace ABM revetment with riprap revetment, improving on the “Harvey Repair” ABM design by providing a system that can better accommodate and adjust to variable bottom elevations during construction and toe scour during future storms. - Extend riprap downslope and provide improved toe to accommodate scour to elevation -8 ft NAVD (see Figure 18).	2,400 LF
	Option 2 – Riprap Revetment - See Figure 19 for location and limits. - Replace ABM revetment with riprap revetment designed to be more resilient to storm impacts than Option 1. Design to withstand Hurricane Harvey scour conditions along full length of repair area. - Extend riprap downslope and provide launching toe to accommodate scour to elevation -16 ft and -20 ft NAVD (see Figure 20).	2,830 LF
	Option 3 – Bulkhead - See Figure 21 for location and limits. - Replace ABM revetment along south bank with steel sheetpile bulkhead (see Figure 22) designed to withstand Harvey conditions.	2,180 LF
Reach 4	- Quarrrystone breakwater between parking lot and SH361 Bridge (see Figure 23 and Figure 24).	315 LF
Miscellaneous	- Construct drainage system along south bank (see Figure 25).	2,500 LF



Figure 15 – Landside Jetty Damage Areas in Reach 2.

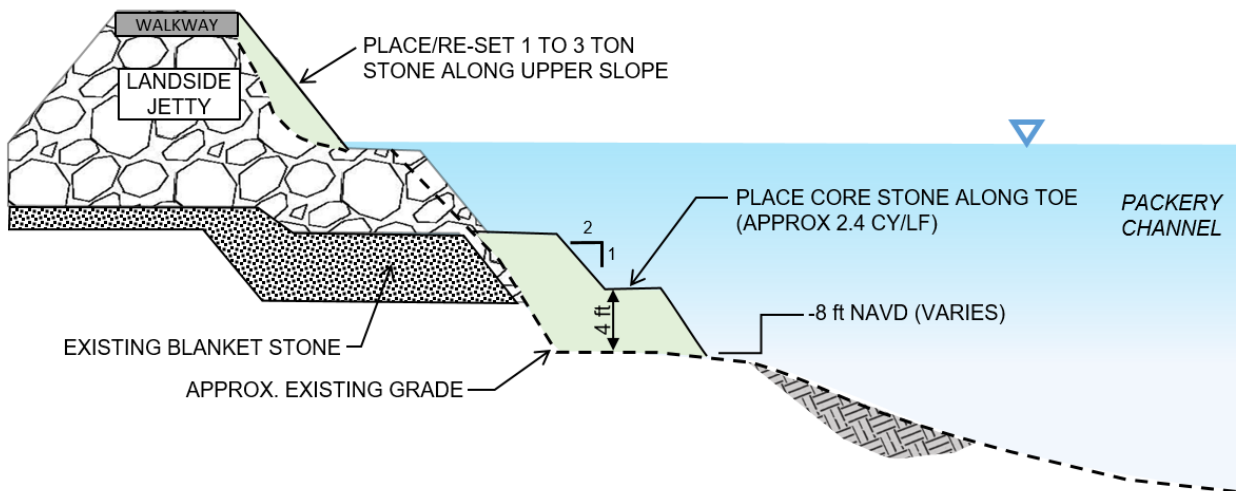


Figure 16 – Hazard Mitigation, Reach 2 (Landside Jetty).



Figure 17 – Hazard Mitigation, Reach 3, Option 1 (Replace ABM with Riprap Revetment).

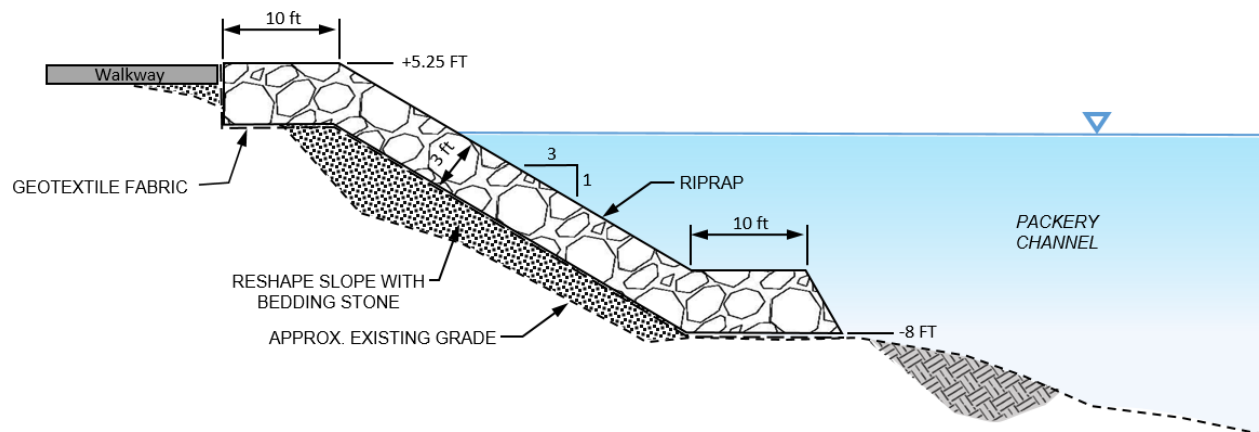


Figure 18 – Hazard Mitigation, Reach 3, Option 1 (Replace ABM with Riprap Revetment to -8 ft).



Figure 19 – Hazard Mitigation, Reach 3, Option 2 (Replace ABM with Riprap Revetment).

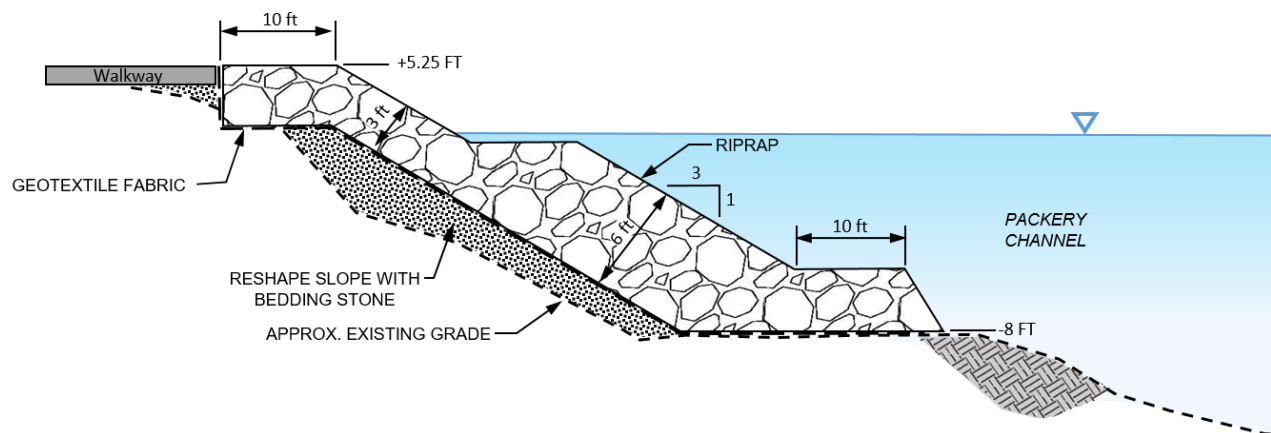


Figure 20 – Hazard Mitigation, Reach 3, Option 2
(Replace ABM with Riprap Revetment, provide launching
toe to accommodate scour to -16 ft and -20 ft).



Figure 21 – Hazard Mitigation, Reach 3, Option 3 (Replace ABM with Bulkhead).

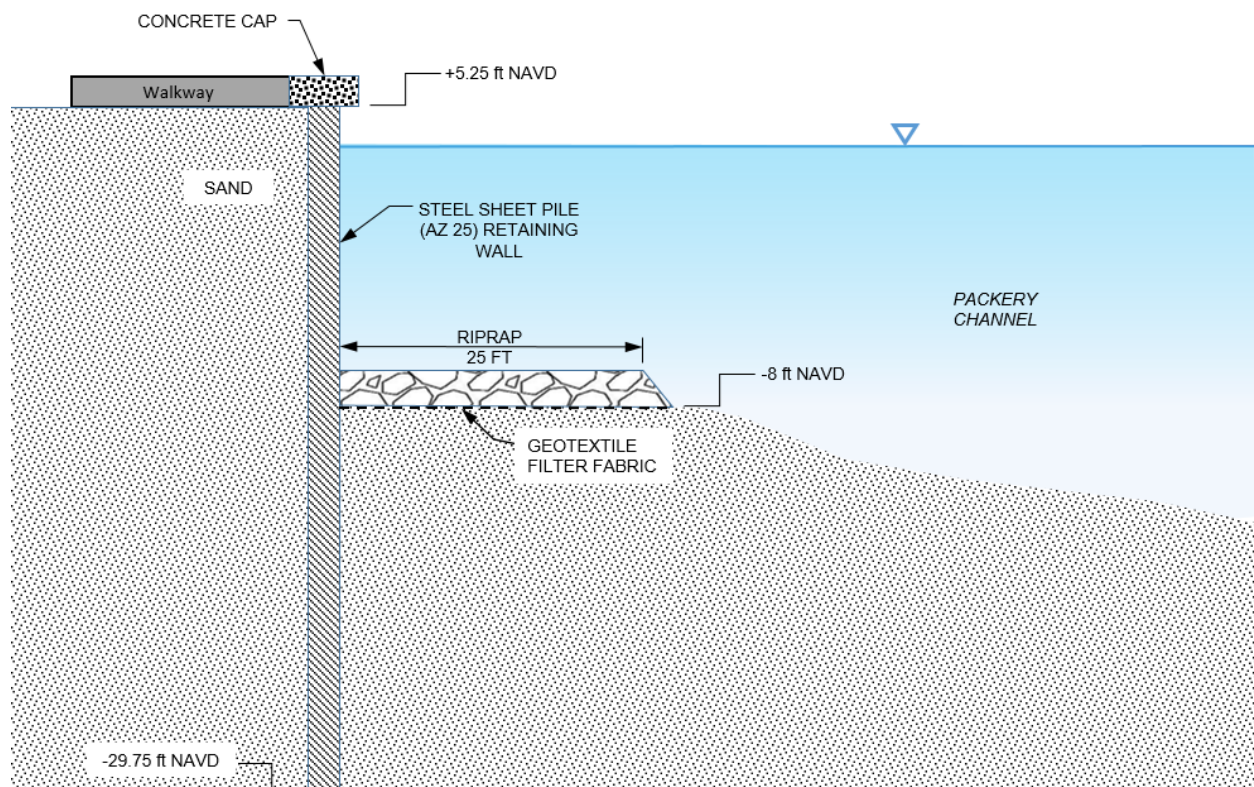


Figure 22 – Hazard Mitigation, Reach 3, Option 3.



Figure 23 – Approximate alignment of riprap breakwater concept in Reach 4 (breakwater gap locations and dimensions to be determined).

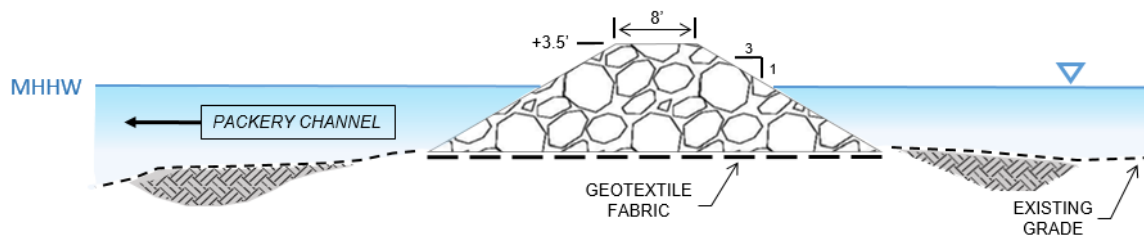


Figure 24 – Hazard Mitigation, Reach 4, Breakwater Concept.

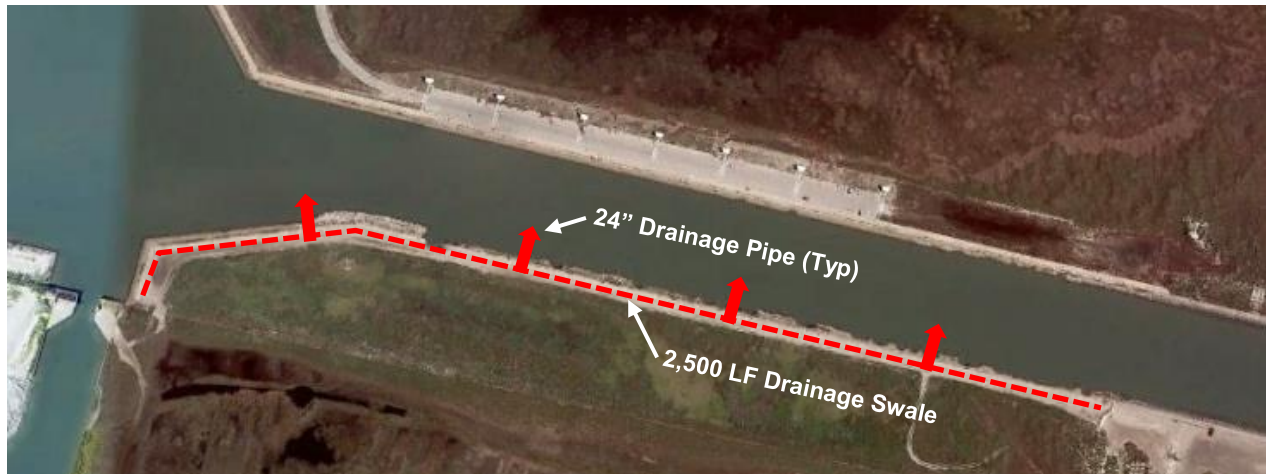


Figure 25 – Drainage System Concept.

4.3 Maintenance

Maintenance is recommended for several components of the Packery Channel project that were damaged prior to Hurricane Harvey. The items recommended for maintenance are summarized in Table 6.

Table 6 – Maintenance Recommendations.		
Location	Repair Description	Approximate Quantity
Reach 1 (Figure 26)	– Re-Set Jetty Armor Stone	82 stones
Reach 2 (Figure 11)	– Re-set/replace 1-3 ton stone along upper slope of landside jetty (only include stone displaced by previous storms). – Place 1,000 lb core stone to repair toe protection to approximate elevation -8 ft NAVD (see Figure 12).	1,070 LF
Miscellaneous	– Replace Wire Rope in Post/Cable Barriers along South Bank (see Figure 27).	3,000 LF
	– Replace Missing Section of Handrail at North Jetty (see Figure 28).	30 LF

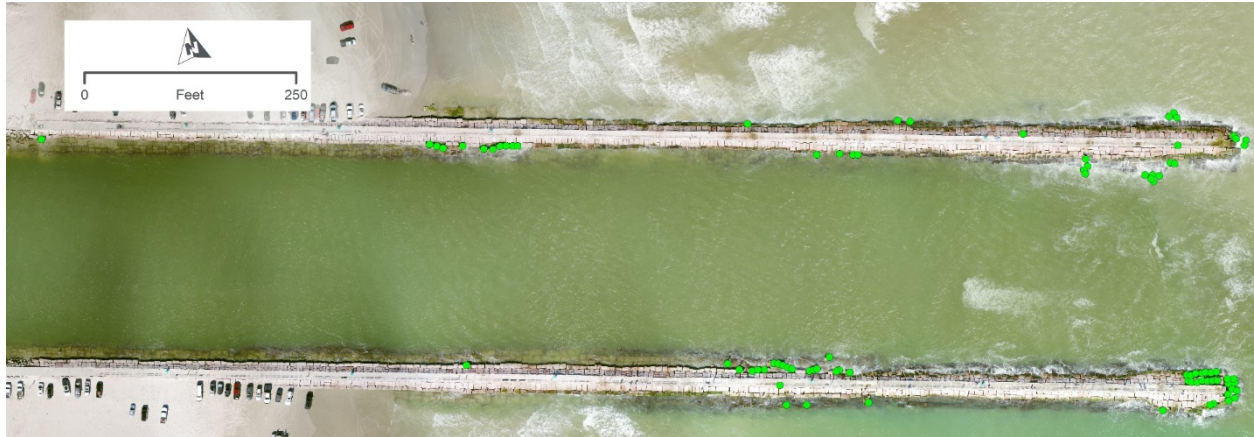


Figure 26 – Maintenance Repairs in Reach 1: Re-Set Jetty Armor Stone.



Figure 27 – Maintenance Repair: Replace Wire Rope in Post/Cable Barriers.



Figure 28 – Maintenance Repair: Replace Handrail.

5. Permitting Requirements

Construction of Packery Channel was originally authorized through the Water Resources Development Act (WRDA) of 1999, Section 556, as the “North Padre Island Storm Damage Reduction and Environmental Restoration Project.” The City of Corpus Christi assumed non-federal responsibilities for the project in 2000. Construction was initiated in 2003 after the approval of the Final Environmental Impact Statement (FEIS) and was completed in 2006. Packery Channel is a traditional navigable water that is subject to the ebb and flow of the tide, making it a water of the U.S. (WOTUS) that is subject to USACE jurisdiction under Section 10 of the Rivers and Harbors Act. Packery Channel is also subject to USACE jurisdiction under Section 14 of the Rivers and Harbors Act (also referred to as Section 408) because it is a federal project.

This section outlines potential permitting requirements for the various project repair alternatives under Section 408, Section 10 of the Rivers and Harbors Act, and Section 404 of the Clean Water Act. Additionally, a summary of permitting considerations and recommendations are included, which also take in consideration results from the FEIS.

5.1 Section 408 Review

Through Section 408, the USACE reviews proposed activities that may result in alterations to federal civil works projects to determine if the proposed work would undermine the benefits of the existing federal project or result in negative impacts to the public. Because Packery Channel is a federal project, any type of repair work in Reaches 1, 2, 3, and 4 would be subject to Section 408 review. As the local sponsor for the federal project, the City would submit the repair plans for the project to the USACE for their Section 408 review. Depending on results from the Section 408 review, the USACE may prepare a Categorical Exclusion-level document, or may require an Environmental Assessment instead. A USACE regulatory permit for the proposed repairs would not be issued until the Section 408 review is complete, which could take up to 6 months.

5.2 Section 10/404 Permits

Through Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act, the USACE regulates certain activities located within waters of the U.S., including special aquatic sites, like wetlands, seagrass, and oyster reefs. Listed below are the potential Section 10/404 permits that would be required for the proposed repairs at each reach of Packery Channel.

5.2.1 Reach 1

Resetting the armorstone within Reach 1 to meet the original design could be covered by a USACE Nationwide Permit (NWP) 3 as maintenance work. NWP 3 allows for the repair, rehabilitation, or replacement of any previously authorized, currently serviceable structure or fill, provided that the structure or fill is not to be put to uses differing from those uses specified or contemplated in the original permit or most recently authorized modification. This NWP also authorizes the repair, rehabilitation, or replacement of those structures or fills destroyed or damaged by storms, provided the repair, rehabilitation, or replacement is commenced, or is under contract to commence, within two years of the date of the destruction or damage. In cases of catastrophic events, like Hurricane Harvey, the two-

year limit may be waived by USACE's District Engineer, provided the permittee can demonstrate funding, contract, or similar delays. NWP 3 also authorizes the removal of accumulated sediments and debris outside the immediate vicinity of existing structures.

Because Packery Channel is a federal project, a pre-construction notification (PCN) would be required. The NWP PCN approval could take between 3 to 6 months.

5.2.2 Reach 2

Restoring Reach 2 by placing stone along the previously-authorized landside jetty slope to meet the original design could be covered by a USACE NWP 3 as maintenance work. The addition of stone outside the original design footprint could also be covered by a USACE NWP 3. NWP 3 authorizes minor deviations in the previously authorized structure's configuration or filled area, including those due to changes in materials, construction techniques, requirement of other regulatory agencies, or current construction codes or safety standards that are necessary to make the repair, rehabilitation, or replacement.

If the District Engineer determines the proposed repairs are more than minor deviations from the previously authorized design, repairs located outside the previously authorized footprint could be authorized by a USACE NWP 13 for bank stabilization. NWP 13 authorizes bank stabilization activities necessary for erosion control or prevention provided the activity is not in excess of the minimum needed for erosion protection; is no more than 500 feet in length along the bank and no more than one cubic yard per running foot, unless waived by the District Engineer; does not include discharge into special aquatic sites; does not impair surface water flow into or out of waters of the U.S.; will not erode by normal or expected high flows; is not stream channelization; and the project is properly maintained and repaired, as needed. If the District Engineer does not waive a length greater than 500 feet and more than one cubic yard per running foot, repairs located outside the previously authorized footprint would require an Individual Permit (IP).

Because Packery Channel is a federal project, a PCN would be required for all the above mentioned NWPs. The NWP PCN approval could take between 3 to 6 months. If it is determined an IP is required, approval could take between 6 to 12 months.

5.2.3 Reach 3

Harvey Repair Option: Restoration of Reach 3 includes removal and replacement of damaged articulating block mattresses (ABMs). ABMs would start at the walkway and extend down the side slopes to approximately -2 to -3 ft NAVD. Bedding stone would be placed along the slopes to reshape the upper bank to the approximate configuration that existed prior to installing the ABMs. Similar to Reach 1, restoration of Reach 3 using ABMs could be covered under NWP 3 and/or NWP 13. If the District Engineer determines the proposed repairs are more than minor deviations from the previously authorized design (NWP 3), repairs located outside the previously authorized footprint could be authorized by a USACE NWP 13 for bank stabilization. If the District Engineer does not waive a length

greater than 500 feet and more than one cubic yard per running foot, repairs located outside the previously authorized footprint would require an IP.

Hazard Mitigation Options 1 and 2: Restoring Reach 3 could also be achieved by removing the damaged ABMs and replacing them with graded riprap as armor. The slopes would be reshaped using bedding stone prior to the placement of graded riprap. Similar to the Harvey Repair option, this restoration could be covered by NWP 3 and/or NWP 13. If the District Engineer determines the proposed repairs are more than minor deviations from the previously authorized design (NWP 3), repairs located outside the previously authorized footprint could be authorized by a USACE NWP 13 for bank stabilization. If the District Engineer does not waive a length greater than 500 feet and more than one cubic yard per running foot, repairs located outside the previously authorized footprint would require an IP.

Hazard Mitigation Option 3: Restoring Reach 3 by removing the previously authorized revetment slope and installing a bulkhead would likely require an IP. The proposed footprint with the bulkhead option is more than minimally outside the existing footprint of Packery Channel authorized by NWP 3 for maintenance and it exceeds the linear feet and cubic yard per running foot restrictions authorized by NWP 13 for bank stabilization.

Because Packery Channel is a federal project, a PCN would be required for all the above mentioned NWPs. The NWP PCN approval could take between 3 to 6 months. If it is determined an IP is required, approval could take between 6 to 12 months.

5.2.4 Reach 4

Reach 4 experienced significant scour as water flowed across the north bank during Hurricane Harvey. Erosion in this area caused damage to an underground water transfer pipeline, which was subsequently repaired by the City. A riprap breakwater is recommended to help protect the shoreline against future erosion. Depending on the type of shoreline protection, the below permitting options have been considered.

Option 1: Breakwater Only: The proposed rock breakwater in Reach 4 would require an IP. The breakwater would not qualify for a NWP 13 for bank stabilization due to the proposed location away from the current shoreline. Based on historical imagery, the shoreline has been receding prior to Hurricane Harvey and no special aquatic sites, such as seagrass and oyster, appear to be within the proposed breakwater footprint. An IP for the proposed breakwater could take between 3 to 12 months. However, because the breakwater would result in only minimal impacts to a Section 10 water, an IP would most likely be issued in 3 to 6 months.

Option 2: Breakwater with Habitat: The addition of restoration, enhancement, or establishment of a wetland behind the proposed breakwater could allow the breakwater to attract cost-share funding opportunities from entities such as the Texas General Land Office (GLO). Adding an environmental enhancement component would also allow the breakwater to be covered by NWP 27 for aquatic habitat restoration, enhancement, and

establishment activities. NWP 27 authorizes restoration, enhancement, and establishment of tidal and non-tidal wetlands and riparian areas, and the rehabilitation or enhancement of tidal stream, tidal wetland, and tidal open waters, provided those activities result in net increase in aquatic resource functions and services. NWP 27 requires the proposed habitat restoration, enhancement, or establishment activity to be planned, designed, and implemented so that it results in aquatic habitat that resembles an ecological reference. If the USACE determines the proposed habitat and breakwater activity does not meet the intent of NWP 27, the proposed activity would require an IP.

A PCN would be required for authorization under NWP 27. The NWP PCN approval could take 3 to 6 months. If it is determined an IP is required, approval could take between 6 to 12 months. In addition, coordination with GLO would be recommended to determine if a long-term lease is required.

Option 3: Living Shoreline and Breakwater: Designing the breakwater as a “living shoreline,” or with a living shoreline component, could also attract funding partners and would allow the breakwater to be covered by NWP 54. NWP 54 authorizes structures and work in navigable waters and discharges of dredged or fill material into WOTUS for the construction and maintenance of living shorelines to stabilize bank and shores in coastal waters along shores with small fetch and gentle slopes that are subject to low- to mid-energy waves. The footprint of the living shoreline must be made up mostly of native material, incorporate vegetation or other living, natural “soft” elements alone or in combination with some type of harder shoreline structure for added protection and stability, and have a substantial biological component, such as fringe wetlands or oyster reef structures.

Under NWP 54 the structures and fill area cannot extend into the waterbody more than 30 feet from the mean low water line (MLLW) in tidal waters and is no more than 500 feet in length along the bank, unless the District Engineer waives this criterion based on the finding of minimal adverse environmental effects. All structural material must be adequately anchored to prevent destabilization in wave action, except during extremely severe storms, and if breakwaters must be constructed to protect fringe wetland for the living shorelines, those structures must be the minimum size necessary to protect those fringe wetlands. Furthermore, living shorelines consisting of tidal fringe wetlands must use native plants appropriate for current site conditions. NWP 54 also requires the activity to be designed, constructed, and maintained so that it has no more than minimal adverse effects on water movement and the movement of aquatic organisms between the waterbody and the shore. If the District Engineer does not waive a length greater than 500 feet and a distance more than 30 feet from the MLLW line, or determines the activity results in more than minimal individual and cumulative adverse environmental effects, the proposed living shoreline activity would require an IP.

A PCN would be required for authorization under NWP 54. The NWP PCN approval could take up to 6 months. If it is determined an IP is required, approval could take between 6 to 12 months.

5.3 National Environmental Policy Act (NEPA)

The original Packery Channel Project required NEPA review and approval because it met the conditions of a major federal action defined in 40 CFR 1508.18. The Project was determined to significantly affect the quality of the human environment, thus requiring an Environmental Impact Statement. Based on the FEIS, Packery Channel was constructed to provide restoration of the eroding Gulf beach resulting in storm damage reduction, and to create a water exchange pass that will periodically reduce hypersaline conditions in the Laguna Madre. The channel location and the design of each reach of Packery Channel considered avoidance and minimization of impacts to natural resources. Unavoidable impacts were mitigated for and these and beneficial use areas were considered to have ameliorated the overall impacts.

Impacts to waters of the U.S. that would require Section 10/404 permits is only one component of the NEPA process. Since the repairs would impact Section 10 waters of the U.S., USACE authorization would be required. Through the USACE permitting process, the USACE would determine which NEPA review would be appropriate for the repairs; either a Categorical Exclusion-level document or an Environmental Assessment. The proposed repairs to Packery Channel align with the original purpose and need of the project and do not significantly differ from the previously reviewed human and environmental impacts described in the FEIS. Therefore, a Categorical Exclusion would most likely be developed by the USACE for the proposed repairs to Packery Channel as part of the USACE permitting process.

5.4 Permitting Summary and Recommendations

Pursuit of a NWP must take into consideration specified thresholds on impacts to waters of the United States, including wetlands and special aquatic sites, as well as various general and regional conditions. The proposed repair recommendations are not anticipated to result in significant impacts to waters of the U.S., including wetlands.

USACE NWP General Conditions state that the use of more than one NWP for a single and complete project is prohibited, except when the acreage loss of waters of the United States authorized by the NWPs does not exceed the acreage limit of the NWP with the highest specified acreage limit. A single and complete project for non-linear activities is defined as the total project proposed or accomplished by one owner/developer or partnership or other association of owners/developers. A single and complete non-linear project must have independent utility, and may not be “piecemealed” to avoid the limits in a NWP authorization.

Although Packery Channel is divided into separate reaches for the purpose of this post-storm damage assessment, activities within Reaches 1, 2, and 3 would most likely be considered a single and complete project. Therefore, HDR considered permitting requirements for Reaches 1, 2, and 3 as a whole, but separately from Reach 4. Based on the above mentioned repair recommendations and permitting considerations, repair activities for Reaches 1, 2, and 3 located within the existing footprint of Packery Channel could likely be covered by NWP 3 for maintenance. With the exception of the bulkhead option in Reach 3, additional repair activities beyond the existing footprint appear to be minimal, and could be covered by NWP 13 for bank stabilization. Authorization for the repair activities under NWP 3 and 13 could take up to 6 months. If the District Engineer determines to not waive the length and cubic yards per linear foot

thresholds outlined in NWP 3 and 13, or determines the proposed activities located outside the existing footprint are not minimal, the proposed repairs would require an IP. The bulkhead option in Reach 3 would be more than minimally outside the existing footprint of Packery Channel, and could require an IP for authorization. Authorization for the repair activities under an IP could take between 6 and 12 months. Prior to developing permit applications, HDR recommends the City requests a Joint Evaluation Meeting (JEM) with USACE South Unit in Corpus Christi to obtain better clarity on the permitting requirements for Reaches 1, 2, and 3. Specifically, to discuss NWP versus IP options, which should be considered to help streamline and expedite the overall permitting process.

Proposed activities for Reach 4 would have separate utility from, and are not dependent upon, the other reaches. As such, the proposed activity at Reach 4 could likely be supported by a different permitting strategy. The proposed breakwater-only project would likely require an IP rather than a NWP. Authorization of the breakwater-only activity under an IP could take between 3 to 6 months. In comparison, if the proposed activity included a restoration or enhancement component (NWP 27) or was designed as a living shoreline (NWP 54), authorization by USACE could take between 6 to 12 months. NWP 27 and 54 require specific supporting documents that could increase the amount of time to develop the USACE permit application and gain authorization from the USACE District Engineer. Unless the City decides to pursue a cost-sharing opportunity with a third-party funding entity (such as GLO) that supports habitat restoration projects, HDR recommends the City submits an IP with no mitigation requirements for the breakwater-only activity in Reach 4.

Because Packery Channel is a federal project, the City should request a meeting with USACE Operations to discuss approaches for the Section 408 process. This would be a separate meeting from the Regulatory JEM and would likely take place at the USACE Galveston office. The Section 408 process would likely require approximately 6 months.

The City is currently seeking a USACE IP to conduct maintenance dredging within Packery Channel and subsequent beach nourishment along the Gulf beach on Padre Island for up to ten years. Due to effects from Hurricane Harvey, maintenance dredging is unlikely to be scheduled until channel repairs and debris removal have been completed. The proposed repairs and debris removal could be authorized in 6 to 12 months, depending on the USACE regulatory process. Once authorized, maintenance dredging under the separate IP could commence. In order to keep the projects from being considered a single and complete project, construction of the breakwater within Reach 4 should occur separate from all other repair activities. If the USACE determines activities within all four reaches of Packery Channel constitute a single and complete project, all the proposed repair recommendations would have to be authorized under a single IP, which may take up to 12 months.

6. Opinion of Probable Construction Cost

Opinions of probable construction costs (OPCC's) with detailed cost breakdowns for the three repair categories discussed in Section 5 are provided in Attachment 1, with summaries provided in Table 7 and Table 8. The OPCC's include a 30% contingency to cover potential variability in the costs related to the preliminary nature of this assessment. The contingency covers factors such as the potential for ongoing damage to the partially-protected channel bank; variations in required material quantities; variations in the actual repair methods from the developed concepts; cost escalation with time; materials testing requirements; and variability in market conditions (such as fuel prices) at the time of bidding.

Table 7 – Cost Summary for Harvey Repair and Maintenance Work.

Repair Category	OPCC
Harvey Repair	\$6,675,000
Maintenance	\$385,000
Total:	\$7,060,000
<u>Note:</u> Repairs to navigation aids are being performed by the City and are not included in this OPCC.	

Table 8 – Cost Summary for Hazard Mitigation Alternatives.

Repair Item	OPCC
Reach 2 – Upgrade Landside Jetties (1,070 LF)	\$815,000
Reach 3 – Bank Protection Upgrade with Riprap (Option 1) (2,400 LF)	\$4,502,000
Reach 3 – Bank Protection Upgrade with Riprap (Option 2) (2,830 LF)	\$7,698,000
Reach 3 – Bank Protection Upgrade with Bulkhead (Option 3) (2,180 LF)	\$5,896,000
Reach 3 – Drainage System Along South Bank (2,500 LF)	\$203,000
Reach 4 – Quarystone Breakwater Between Parking Lot and SH361 Bridge (315 LF)	\$423,000
<u>Note:</u> The costs shown for the Hazard Mitigation Alternatives in this table are not stand-alone project costs; they represent alternative costs for individual Harvey Repair items assuming an upgraded/improved level of resilience is desired by the City.	

Table 9 provides a comparison of the various bank protection alternatives in terms of cost per linear foot.

Table 9 – Unit Cost Comparison of Bank Protection Alternatives.		
Description	Repair Category	OPCC
Reach 2		
Replace/Reset Stone (Upper and Lower Slope)	Harvey Repair	\$365/LF
Replace/Reset Stone (Upper and Lower Slope) with Improved Toe	Hazard Mitigation	\$585/LF
Replace/Reset Stone (Upper Slope Only)	Maintenance	\$60/LF
Reach 3		
Replace ABM Revetment with ABM	Harvey Repair	\$1,150/LF
Replace ABM Revetment with Riprap (Option 1)	Hazard Mitigation	\$1,440/LF
Replace ABM Revetment with Riprap and Improved Toe (Option 2)	Hazard Mitigation	\$2,090/LF
Replace ABM Revetment with Bulkhead (Option 3)	Hazard Mitigation	\$2,080/LF
Note: Unit costs shown exclude contingencies.		

Note that the costs for the Hazard Mitigation alternatives shown in Table 8 would replace and/or be additive to the costs shown in Table 7 depending on which combination of repair and improvement options are selected. Table 10 provides an example of total construction costs for a hypothetical range of repair, improvement, and maintenance combinations, with the total construction costs ranging from \$7,486,000 to \$12,004,000. Note that the Reach 2 bank protection upgrade, Reach 3 drainage improvements, and Reach 4 breakwater could be combined and added to any of the three bank protection upgrades for Reach 3, yielding a greater total construction cost than \$12,004,000.

Table 10 – Example Construction Costs for Range of Repair and Improvement Combinations.				
Harvey Repairs	+	Hazard Mitigation Upgrades (Cost Increase)	+	Maintenance Work = Total Cost
Reach 2				
\$6,675,000	+	Reach 2 Bank Protection Upgrade Quarystone with Improved Toe (1,070 LF) (See Figure 15 for Location) \$426,000	+	= \$7,486,000
	+	Reach 3	+	
	+	Reach 3 Bank Protection Upgrade Option 1 (2,400 LF Riprap) (See Figure 17 for Location) \$1,748,000	+	= \$8,808,000
	+	Reach 3 Bank Protection Upgrade Option 2 (2,830 LF Riprap) (See Figure 19 for Location) \$4,944,000	+	= \$12,004,000
	+	Reach 3 Bank Protection Upgrade Option 3 (2,180 LF Bulkhead) (See Figure 21 for Location) \$3,888,000	+	= \$10,948,000
	+	Reach 3 Bank Improvements Drainage System Along South Bank (2,500 LF) (See Figure 25 for Location) \$203,000	+	= \$7,263,000
Reach 4				
	+	Reach 4 Bank Protection Rock Breakwater (315 LF) (See Figure 23 for Location) \$423,000	+	= \$7,483,000
			\$385,000	

7. Summary and Recommendations

This report provides preliminary design recommendations for repair of the damage at Packery Channel caused by Hurricane Harvey in August 2017. A summary of the damage is provided in Table 1. Much of the damage was a result of unanticipated erosion from strong currents along the edge of the channel bank and toe of the structures. This erosion was likely exacerbated by erosion from water seeping through the bank and below the structures as it drained from the surrounding area, which resulted in undermining of the bank protection. The combined erosion led to displacement and damage to structural elements such as the ABM revetments and sections of concrete walkway. The most severe damage occurred along the south bank where the channel was scoured to depths of -20 ft NAVD.

Design recommendations for repairs and improvements at Packery Channel were developed for the following three categories:

1. **Harvey Repair:** Damage caused by Harvey would be repaired to original (or equivalent) condition.
2. **Hazard Mitigation:** Damage caused by Harvey would be repaired to an improved condition designed to withstand Harvey-level impacts.
3. **Maintenance:** Damage caused prior to Harvey would be repaired to original or improved condition.

Summaries of the proposed repairs for the “Harvey Repair” and “Maintenance” categories are provided in Table 4 and Table 6, respectively. As shown in Table 7, the costs for the Harvey Repair and Maintenance work is approximately \$6,675,000 and \$385,000, respectively, for a combined cost of approximately \$7,060,000. This cost would not include Hazard Mitigation work.

To help reduce the potential for similar levels of damage during future hurricanes, various Hazard Mitigation concepts were developed (Table 5). In Reach 2, the improvement concept consists of repairing the landside jetty with more extensive toe protection. In Reach 3, the improvement concepts include replacing the damaged ABM revetment with riprap (Option 1), replacing the damaged ABM revetment with riprap having more extensive toe protection (Option 2), replacing a section of the damaged revetment along the south bank with a bulkhead (Option 3), and constructing a drainage system along the south bank. These upgrades in Reach 3 could increase the cost of the repairs by as much as \$4,944,000 (for bank repairs) and \$203,000 (for drainage improvements) (see Table 10), for a total increase of \$5,147,000, depending on which combination of repairs is chosen. However, as discussed below, the recommended combination of Harvey Repair, Maintenance, and Hazard Mitigation options would increase the construction cost by \$4,458,000 for a total construction cost of \$11,518,000.

Potential cost reductions of approximately \$50,000 to \$100,000 could be realized by recycling material from the damaged concrete walkway as riprap, and by salvaging the damaged ABM's for construction of the drainage system along the south bank. Unused sections of the original jetty walkway that were stockpiled adjacent to Packery Channel by USACE could also be crushed into riprap, but the potential availability of this material should be confirmed with USACE. Based on

previous communication with USACE, HDR understands that the unused sections of walkway were strategically placed adjacent to the channel to help prevent flanking of the jetties by waves and surge during hurricanes.

As mentioned, the most extensive damage during Hurricane Harvey occurred in Reach 3. Hazard Mitigation upgrades are recommended for this reach to help prevent recurrence of the damage that occurred during Harvey and previous hurricanes. Along the north side of the channel where scour depths were less, Option 1 is recommended. Along the south side of the channel where scour depths were greater, Option 2 (riprap revetment) or Option 3 (bulkhead) is recommended. Options 2 and 3 have a similar cost and are expected to have similar performance and service life.

A potential disadvantage of the bulkhead Hazard Mitigation option in Reach 3 is that it would reflect more wave energy than the revetment alternative(s), creating rougher conditions for boats in the channel. The bulkhead alternative is therefore not recommended for construction along both the north and south bank, only along the south bank as shown in Figure 21. The less-reflective riprap revetment (Option 1 or 2) is recommended along the north bank as shown in Figure 17.

As discussed in Section 5, the breakwater proposed for Hazard Mitigation in Reach 4 (Figure 23 and Figure 24) is recommended to be permitted through USACE as a separate action than the other repairs. It is also recommended to be included as an additive bid option in the construction procurement package that will be prepared during detailed design.

A summary of HDR's recommendations for the repairs, and associated costs, is shown in Table 11 and Figure 29. The overall timeframe for USACE permitting is estimated to be approximately 6 to 12 months. Detailed design and preparation of construction procurement documents (including plans and specifications) will likely require approximately 8 months. Based on the City's project partnering agreement with USACE and review of the Packery Channel Operations and Maintenance Manual (USACE 2007), any design for project repairs, maintenance, or improvements will require review and approval by USACE prior to construction. This coordination should occur as part of the Section 408 approval process. Based on anticipated timelines for permitting and design the project could likely be ready for bidding in December 2019 if the City proceeds with permitting immediately. Construction would likely require approximately 6 to 9 months after bidding and contract award.

As discussed during the preliminary design kickoff meeting held at the City on August 20, 2018, surveys performed by the City showed that portions of Packery Channel directly adjacent to the SH361 bridge experienced significant scour during Hurricane Harvey. It is HDR's understanding that the Texas Department of Transportation (TxDOT) performs regular structural inspections of the bridge as a public safety measure. HDR's assessment did not include bridge stability analysis or inspection of the scour protection under the bridge. The City should continue to share its channel monitoring surveys with TxDOT to assist with TxDOT's bridge inspection program.

Table 11 – Repair Recommendations Including Hazard Mitigation.		
Item	OPCC	Repair Category
Reach 1		
Re-Set Jetty Armor Stone	\$10,000	Harvey Repair
	\$214,000	Maintenance
Reach 2		
Repair/Upgrade Landside Jetties	\$625,000	Hazard Mitigation
	\$63,000	Maintenance (Upper Slope Only)
Reach 3		
Bank Protection – Cap Damaged ABM In-Place	\$320,000	Harvey Repair
Bank Protection Upgrade (North Bank) – Option 1 (Riprap)	\$938,000	Hazard Mitigation
Bank Protection Upgrade (South Bank) – Option 2 (Riprap) or Option 3 (Bulkhead)	\$4,536,000	Hazard Mitigation
Drainage System Along South Bank	\$153,000	Hazard Mitigation
Reach 4		
Breakwater Between Parking Lot and SH361 Bridge	\$323,000	Hazard Mitigation
Miscellaneous		
Mobilization/Demobilization	\$450,000	N/A
Demolition/Removal of Damaged Walkway & ABM Revetment	\$350,000	Harvey Repair
Place Fill and Replace Concrete Walkway (North Side)	\$121,000	Harvey Repair
Place Fill and Replace Concrete Walkway (South Side)	\$596,000	Harvey Repair
Remove Debris from Channel	\$45,000	Harvey Repair
Replace Post/Cable Barriers (Reach 3, South Bank)	\$64,000	Harvey Repair
	\$12,000	Maintenance
Replace Wire Rope in Post/Cable Barriers (Reach 3, North Bank)	\$16,000	Harvey Repair
Repair Voids at Storm Drain Outfalls	\$20,000	Harvey Repair
Replace Section of Handrail Along North Jetty	\$6,000	Maintenance
Contingencies (30%):	\$2,656,000	
Total:	\$11,518,000	
Notes:		
(1) The City’s Beach Operations Department is procuring and installing replacement Aids to Navigation at Packery Channel, including the ATon’s at the ends of the jetties. At the request of the City, HDR has not included these items in this OPCC.		
(2) Costs shown do not include professional services such as engineering and permitting.		

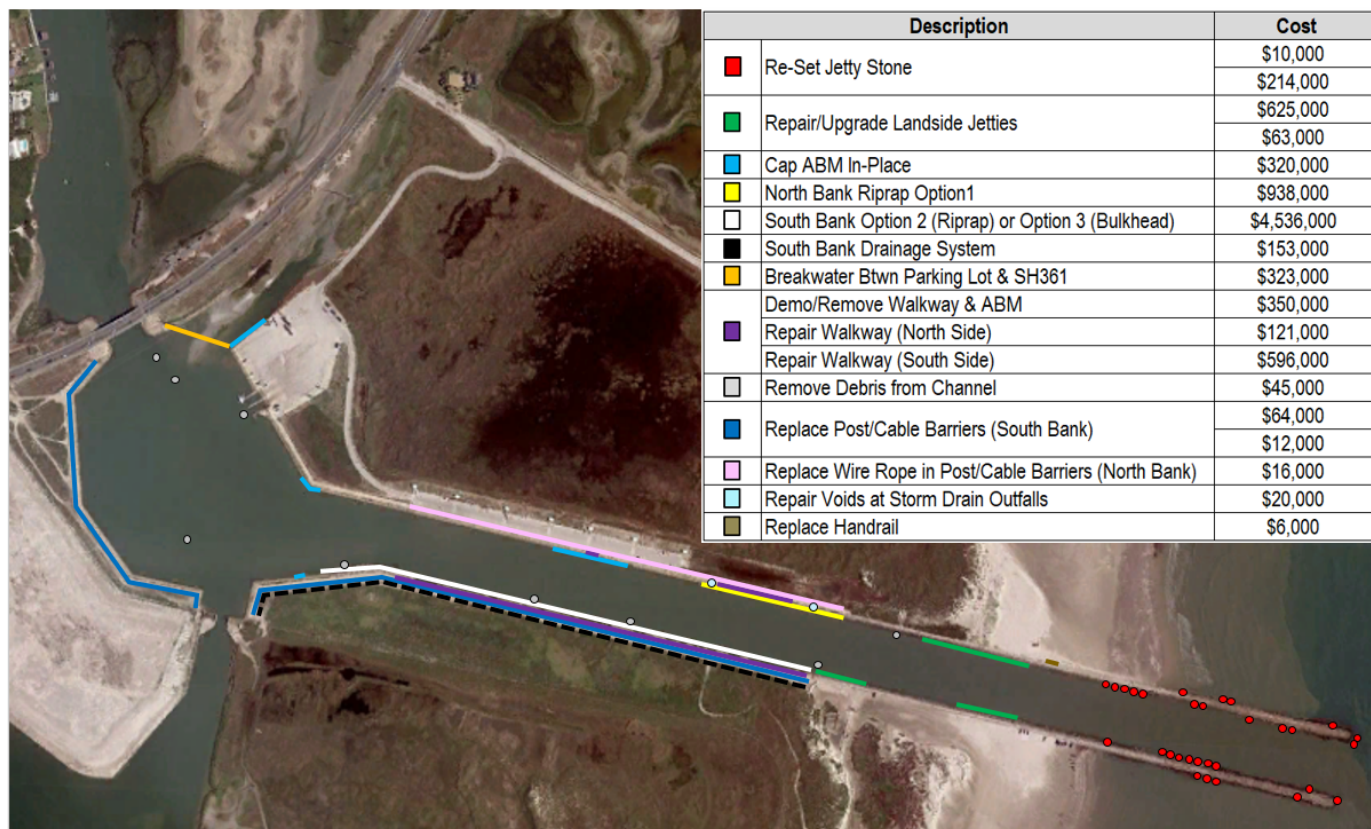
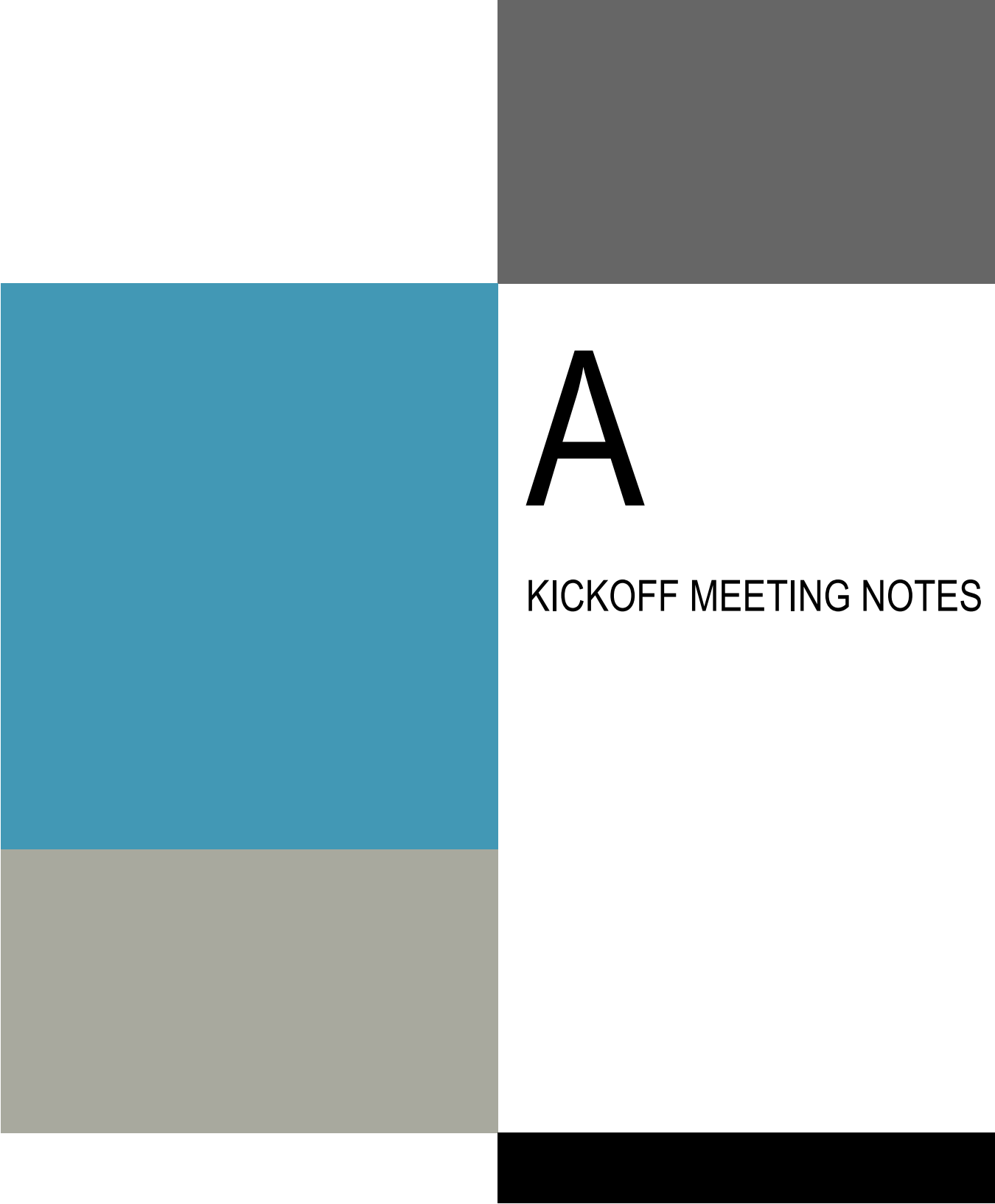


Figure 29 – Overall Summary of Recommended Repair Plan
 (Note: Costs shown exclude contingencies. Refer to Table 11 for total costs.)

8. References

- Reed, C.W. and Lin, L. 2011. Analysis of Packery Channel Public Access Boat Ramp Shoreline Failure. *Journal of Coastal Research*, SI59, pp. 150-155.
- URS/Dames & Moore, 2003. Design Documentation Report. Packery Channel – Project Design, Corpus Christi, Texas. Report Prepared for the U.S. Army Corps of Engineers, Galveston District, in Two Volumes. URS Project No. 39362-013. Misc. paginated.
- U.S. Army Corps of Engineers, 2007. North Padre Island (Packery Channel) Operations, Maintenance, Repair, Replacement and Rehabilitation Manual. North Padre Island Storm Damage Reduction and Environmental Restoration Project. 145 pages (with appendices).
- Williams, D.D. and Tissot, P. 2018. Application of Packery Channel Hydrodynamic Model (PCH-Model) to Understanding Damage during Hurricane Harvey. Texas A&M University-Corpus Christi, Conrad Blucher Institute for Surveying and Science, CBI-TAMUCC-2018_PC03, 7 p.



A

KICKOFF MEETING NOTES



Meeting Minutes

10130118

Project: **Packery Channel Restoration (Project No. H17019)**

Subject: Preliminary Design Kickoff Meeting

Date: August 20, 2018

Location: City Hall, Engineering Smartboard Room

Attendees: Sarah West (COCC)
Jay Ellington (COCC)
Linda Gurley (COCC)
Darren Gurley (COCC)

Sharon Lewis (COCC)
Dan Heilman (HDR)
Philip Blackmar (HDR)
Christine Magers (HDR)

RE: NOTES FROM PRELIMINARY-DESIGN KICKOFF MEETING

This memorandum documents key information exchanged during the preliminary-design kickoff meeting held at City Hall on August 20, 2018.

1. HDR previously performed an emergency damage assessment following Hurricane Harvey which is documented in the report dated March 27, 2018 (*Post-Storm Damage Assessment and Repair Recommendation, Packery Channel Jetty Slope Protection and Appurtenances*). The damage assessment evaluated three repair concepts: (1) Harvey Repair which is repaired structures to their original design condition, (2) Hazard Mitigation which would be repair structures to an improved condition designed to withstand approximate Harvey-level impacts, and (3) Maintenance in which damage caused prior to Harvey would be repaired to original or improved condition.
2. The current scope of work will focus on the Harvey Repair and Hazard Mitigation Concepts for Reach 2 and 3. Repair concepts documented in HDR's March 27, 2018 report for Reaches 1 and 4 do not require updating.
3. FEMA disaster recovery coordination is being performed by the City. It is anticipated that FEMA will provide reimbursement for certain aspects of the project, but the administrative process is still being completed.
4. HDR is currently working under a small A/E contract which only covers preliminary design. The City is processing a large A/E contract for HDR to perform the final design, permitting, bidding, and construction-phase services.
5. HDR will provide recommendations and opinions of probable construction cost for the Harvey Repair and Hazard Mitigation concepts in addition to the expected level of improvements the Hazard Mitigation concept will provide.



6. HDR's scope includes evaluation of drainage relief systems for water that accumulates behind the bank protection and needs to be routed into the channel. This may have been one of the factors that contributed to walkway failures during Hurricane Harvey.
7. The City would like HDR to consider whether the concrete panels that were previously stockpiled north and south of the jetties can be repurposed for the design. The panels were left from construction of the original walkway along the jetties and are not tied into the current structures. Design concepts should also consider whether the articulated block mats that are removed from the damaged sections can be salvaged and repurposed.
8. HDR will be performing regulatory coordination for the repairs project. USACE Section 404 permitting will be required for impacts to the jurisdictional waters. USACE Section 408 coordination is also required because Packery Channel is a federal project.
9. Section 408 coordination may take 6 to 12 months and requires an administrative fee from the project sponsor (the City). The fee is not a set amount but is determined by the USACE project manager after reviewing the permit application.
10. An Individual Permit (IP) for Section 404 coordination could potentially be substituted with a Nationwide Permit (NWP) if repairs can be considered maintenance or if impacts to jurisdictional waters are less than 1/3 of an acre. If the repairs are determined to fall outside of the USACE's definition of a NWP, an IP will be required. It is unknown if the project can be permitted under a NWP until a design concept is chosen. USACE recommends applicants anticipate 3 to 6 months for processing of NWP's and 6 to 12 months for procession of IP's.
11. Section 408 and Section 404 permit applications can be submitted simultaneously but USACE cannot complete the Section 404 permitting process until Section 408 coordination is complete. It is anticipated that obtaining a NWP could require a total of 6 to 12 months, but an IP would likely require 12-18 months.
12. HDR will be reviewing the Environmental Impact Study (EIS) performed during the original design to see how it could be applied or impact the permitting process for the repairs.
13. The City asked HDR to note during the site visit any critical areas that require immediate action to address safety issues and/or rapid progressive damage. HDR noted that a void is visible beneath the light pole at the western corner of the boat ramp parking lot. In addition, it appears the articulating block mat in this area has experienced loss of foundation material. HDR recommends the City post signs/barriers to prevent the public from parking in the corner parking space, and that the City perform a more formal investigation of the area.
14. The City would like to consider whether the construction bid packages for the repairs and dredging projects should be combined to reduce mobilization and ancillary costs, with an option to award the work as one or two contracts. HDR will consider this option and provide recommendations to the City, and noted potential for contractor conflicts and delay claims if the work is awarded as two separate but concurrent contracts.
15. The City's construction budget is currently based on HDR's March 27, 2018 report which showed an opinion of probable construction cost of \$7,600,000 to \$7,930,000.
16. HDR will be performing a site visit and will coordinate scheduling with the City.



17. The City anticipates FEMA will provide reimbursement for design costs, but the City is not aware of any special invoicing requirements for HDR.
18. HDR's report will include schematics and discussions on the failure modes for the structures.
19. The City Beach operations Department is procuring and installing the Aids to Navigation (including the AToN's at the ends of the jetties). HDR will not include these features in their report or opinion of probable construction cost.
20. HDR's report will include a design current velocity in Packery Channel. HDR's scope does not include a numerical model of the area so the velocity will be developed using analytical methods and assumptions where required. HDR will review the original USACE design documentation for comparison of design criteria.
21. The detailed design phase of the project does not include a separate kickoff meeting, but will include progress meetings.
22. Sarah West is the City Project Manager and should be copied on all correspondence.
23. HDR's scope of work does not include an assessment of the Highway 361 Bridge or scour protection. This is understood to fall under TxDOT's responsibility and the City understands an inspection was performed by TxDOT following Hurricane Harvey.

Attachments: Sign-In Sheet



SIGN-IN SHEET

Project: Packery Channel Restoration (Project No. H17019)

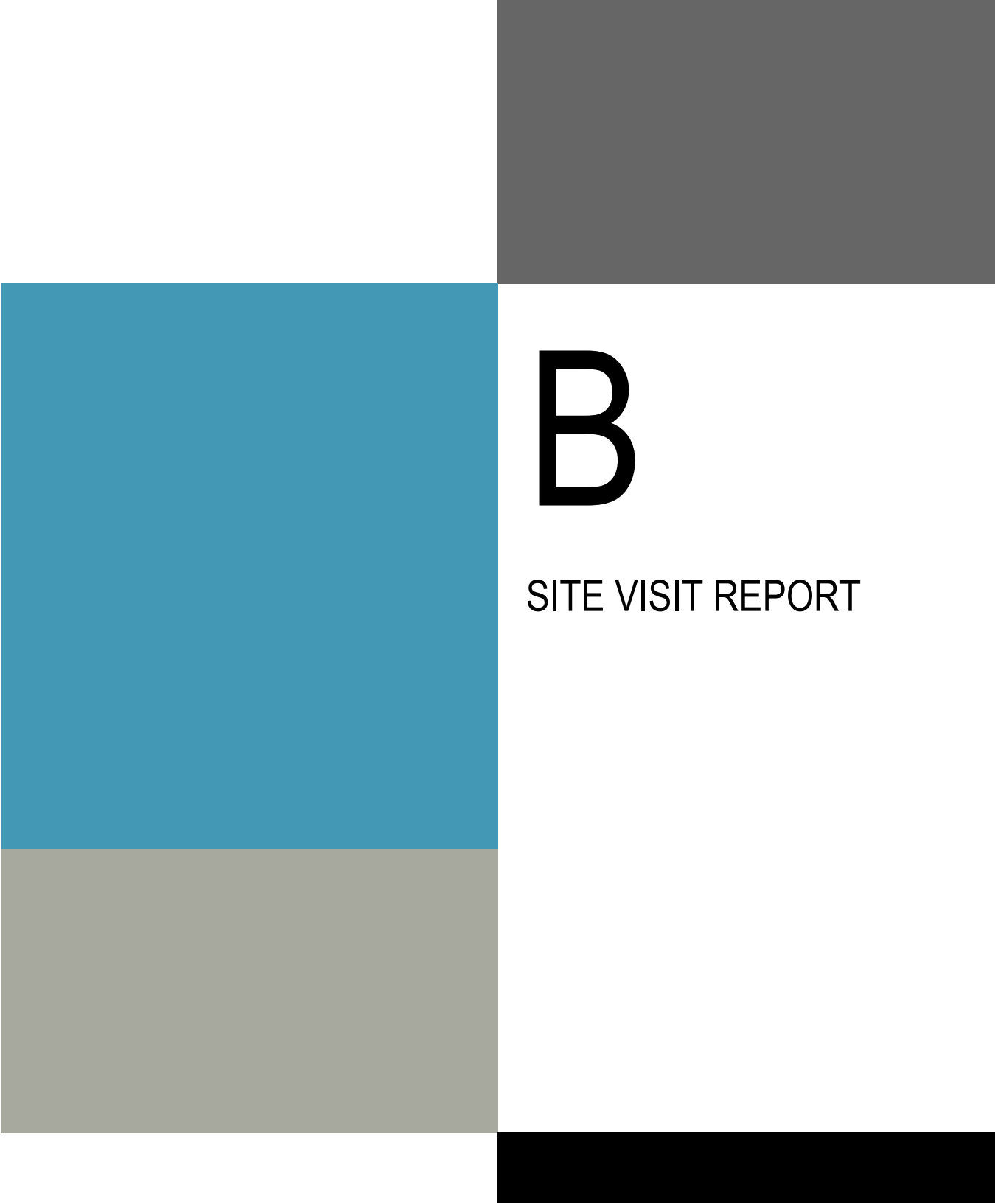
Subject: Preliminary Design Kickoff Meeting

Date: August 20, 2018

Location: City Hall (Engineering Smartboard Room)

NAME	AFFILIATION	PHONE	EMAIL
✓ Sarah West	City of Corpus Christi	361-826-3676	SarahW2@cctexas.com
Jeff Edmonds	City of Corpus Christi	361-826-3851	JeffreyE@cctexas.com
✓ Dan Heilman	HDR	361-696-3344	daniel.heilman@hdrinc.com
✓ Philip Blackmar	HDR	361-696-3311	philip.blackmar@hdrinc.com
✓ Christine Magers	HDR	361-696-3341	christine.magers@hdrinc.com
✓ Linda Gurley	City of Corpus Christi	361-856-3529	LindaG@cctexas.com
✓ Jay Ellington	City of Corpus Christi	361-826-3042	JayEll@cctexas.com
✓ Sharon Lewis	City of Corpus Christi	426-4066	SharonL@cctexas.com
✓ Darren Gurley	City of Corpus Christi	361-826-1434	CharlesGu@cctexas.com

HDR Project #10130118

A decorative graphic on the left side of the page, consisting of a large blue rectangle, a smaller grey rectangle above it, and a larger grey rectangle below it. To the right of these rectangles is a vertical black bar.

B

SITE VISIT REPORT

Heilman, Daniel

From: Heilman, Daniel
Sent: Thursday, August 30, 2018 5:12 PM
To: Sarah West
Cc: Blackmar, Philip; Cressman, Luke; Magers, Christine M
Subject: Packery Channel Restoration (H17019) -- Site Visit Notes

Hi Sarah,

Below are notes from our site visit to Packery Channel on Tuesday, 8/28/18:

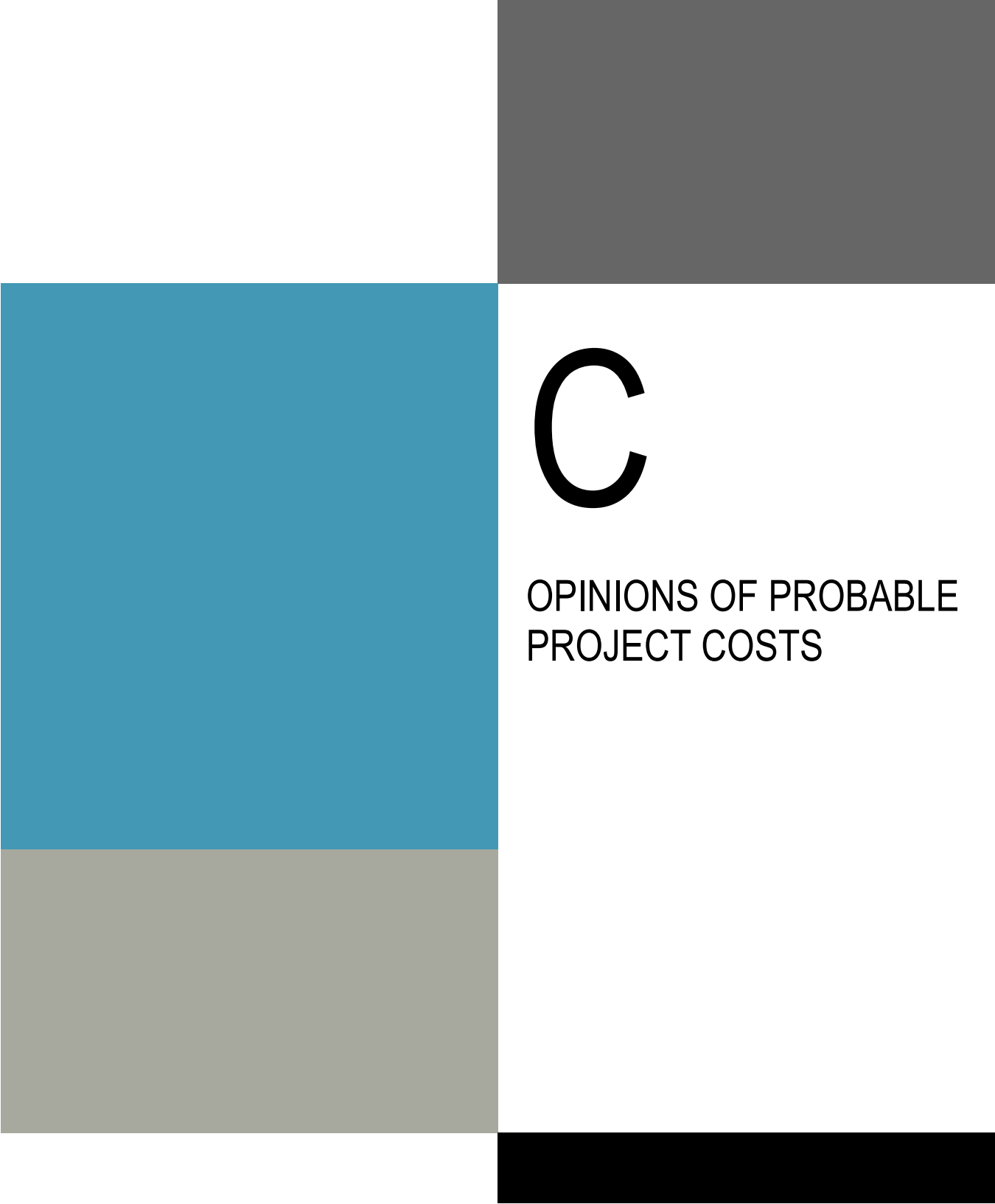
- Sharon Lewis, Darren Gurley, and Dan McGinn met with HDR at the project site to observe the damage and discuss HDR's scope.
- Sharon indicated the replacement of damaged cables and bollards was included in the FEMA reimbursement request and should be included in the design.
- City staff and HDR reviewed the undermining at the westernmost corner of the boat ramp parking lot. Darren Gurley indicated he had previously reviewed this area and was considering adding limestone to fill the voids. HDR is not including an investigation of this area.
- HDR noted the species of flora and fauna present as well as the potential areas that would require delineation for the permit application. Where operation of landside construction equipment may be needed, the potential for temporary impacts will need to be included in the permit application.
- Reach 1: HDR observed jetty stones that had been displaced in Reach 1 and recorded the locations using RTK GPS. There are no significant changes to the Reach 1 recommendations from HDR's 3/27/18 report.
- Reach 2: HDR reviewed the damaged areas in Reach 2. There did not appear to be any significant changes from the observations documented in HDR's 3/27/18 report.
- Reach 3:
 - o South side of channel: The damage along the south side of Reach 3 has progressed since previous site visits. Based on current conditions **the entire 1,720 LF section of ABM revetment extending west from the end of Reach 2, including the concrete walkway, will likely need to be completely repaired/replaced.** Sand in this area has continued to erode from the bank into the channel, further undermining the damaged revetment and walkway. Placement of fill material will be required to return the bank to grade. Although the channel bank in this area is expected to continue losing material until repairs are completed, interim/temporary measures to control the material loss are likely to be expensive and would require a USACE permit. Repairs to this area should be given a priority over other areas. Below are several photos showing the damage in this area.
 - o North side of channel: Damage along the north side of the channel does not appear to have significantly changed from the conditions documented in HDR's 3/27/18 report.



Daniel J. Heilman P.E.
*Coastal Program Technical Leader
Sr. Professional Associate*

HDR
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daniel.heilman@hdrinc.com

hdrinc.com/follow-us



C

OPINIONS OF PROBABLE
PROJECT COSTS



11/26/2018

**CITY OF CORPUS CHRISTI
PACKERY CHANNEL RESTORATION (H17019)
POST HURRICANE HARVEY REPAIRS**

CONCEPTUAL-LEVEL OPINION OF PROBABLE CONSTRUCTION COST

HARVEY REPAIR COST: RETURN PROJECT TO APPROXIMATE PRE-HARVEY CONDITION

<u>ITEM</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT PRICE</u>	<u>EXTENSION</u>
1. Mobilization / Demobilization	1	LS	\$ 450,000	\$ 450,000
2. Reach 1 -- Gulfside Jetties Re-Set Jetty Armor Stone	5	EA	\$ 2,000	\$ 10,000
3. Reach 2 -- Landside Jetties Replace 1-3 Ton Stone Along Upper Slope (1,070 LF)	300	TON	\$ 115	\$ 35,000
Re-Set 1-3 Ton Stone Along Upper Slope (1,070 LF)	100	TON	\$ 25	\$ 3,000
Replace/Add Core Stone Along Lower Slope & Toe (1,070 LF)	3,000	TON	\$ 115	\$ 345,000
Geotextile Filter Fabric Along Toe (1,070 LF)	1,000	SY	\$ 6	\$ 6,000
			Subtotal:	\$ 389,000
4. Reach 3 -- Bank Protection (Damaged ABM to be Capped In Place) Place Graded Riprap on ABM (530 LF)	1,570	TON	\$ 75	\$ 120,000
Place Graded Riprap for Toe Protection (810 LF)	2,400	TON	\$ 75	\$ 180,000
Geotextile Fabric Under Toe Protection (810 LF)	3,200	SY	\$ 6	\$ 20,000
			Subtotal:	\$ 320,000
5. Reach 3 -- Bank Protection (Damaged ABM to be Replaced) Geotextile Filter Fabric (2,400 LF)	14,000	SY	\$ 6	\$ 84,000
Place Bedding Stone to Restore Subgrade (2,400 LF)	10,000	TON	\$ 75	\$ 750,000
Replace ABM Revet (8" thick blocks); Extend Toe to -8 ft (2,400 LF)	120,000	SF	\$ 16	\$ 1,920,000
			Subtotal:	\$ 2,754,000
6. Miscellaneous Demolition/Removal of Damaged Walkway & ABM Revetment	1	LS	\$ 350,000	\$ 350,000
Place Fill and Replace Concrete Walkway (North Side)	360	LF	\$ 335	\$ 121,000
Place Fill and Replace Concrete Walkway (South Side)	1,780	LF	\$ 335	\$ 596,000
Removal & Disposal of Debris from Channel	15	EA	\$ 3,000	\$ 45,000
Replace Post/Cable Barriers (Reach 3, South Bank)	2,550	LF	\$ 25	\$ 64,000
Replace Wire Rope in Post/Cable Barriers (Reach 3, North Bank)	4,000	LF	\$ 4	\$ 16,000
Repair Voids at Storm Drain Outfalls	2	EA	\$ 10,000	\$ 20,000
			Subtotal:	\$ 1,212,000
			CONTINGENCIES (30%):	\$ 1,540,000
			TOTAL:	\$ 6,675,000

Notes:

- Costs shown are approximate and are based on 2018 prices. Actual costs may vary based on market conditions at time of bidding/construction.
- Potential salvage/re-use value of concrete blocks from damaged ABM, and for crushing concrete walkway debris to create riprap, was not included in this estimate.
- Costs shown are based on quantities estimated from field observations and preliminary review of survey data provided by the City. Actual conditions at time of detailed design and construction may vary, possibly requiring greater quantities if damaged features continue to degrade (e.g., bank erosion and walkway damage may continue where ABM's have been damaged).
- The Reach 3 repairs include approximately 160 LF of ABM along the west side of the Packery Channel parking lot.

PRELIMINARY

THIS DOCUMENT IS RELEASED FOR THE
PURPOSE OF INTERIM REVIEW AND IS NOT
INTENDED TO BE USED FOR CONSTRUCTION,
BIDDING, OR PERMIT PURPOSES.

ENGINEER: DANIEL J. HEILMAN

REGISTRATION NO.: 29755

DATE: 11/26/2018



11/26/2018

**CITY OF CORPUS CHRISTI
PACKERY CHANNEL RESTORATION (H17019)
POST HURRICANE HARVEY REPAIRS**

CONCEPTUAL-LEVEL OPINION OF PROBABLE CONSTRUCTION COST

HAZARD MITIGATION OPTIONS⁽¹⁾

<u>ITEM</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT PRICE</u>	<u>EXTENSION</u>
1. Reach 2 -- Upgrade Landside Jetties				
<i>Replace 1-3 Ton Stone Along Upper Slope (1,070 LF)</i>	300	TON	\$ 115	\$ 35,000
<i>Re-Set 1-3 Ton Stone Along Upper Slope (1,070 LF)</i>	100	TON	\$ 25	\$ 3,000
<i>Replace/Add Core Stone Along Lower Slope & Toe (1,070 LF)</i>	5,000	TON	\$ 115	\$ 575,000
<i>Geotextile Filter Fabric Along Toe (1,070 LF)</i>	2,000	SY	\$ 6	\$ 12,000
			<i>Subtotal:</i>	\$ 625,000
			CONTINGENCIES (30%):	\$ 190,000
			ITEM 1 TOTAL:	\$ 815,000
2. Reach 3 -- Bank Protection Upgrade (Option 1)				
<i>Geotextile Filter Fabric (2,400 LF)</i>	17,000	SY	\$ 6	\$ 102,000
<i>Place Bedding Stone (2,400 LF)</i>	8,000	TON	\$ 75	\$ 600,000
<i>Quarystone Revetment (toe at -8 ft) (2,400 LF)</i>	24,000	TON	\$ 115	\$ 2,760,000
			<i>Subtotal:</i>	\$ 3,462,000
			CONTINGENCIES (30%):	\$ 1,040,000
			ITEM 2 TOTAL:	\$ 4,502,000
3. Reach 3 -- Bank Protection Upgrade (Option 2)				
<i>Geotextile Filter Fabric (2,830 LF)</i>	23,000	SY	\$ 6	\$ 138,000
<i>Place Bedding Stone (2,830 LF)</i>	8,000	TON	\$ 75	\$ 600,000
<i>Quarystone Revetment (toe at -16 and -20 ft) (2,830 LF)</i>	45,000	TON	\$ 115	\$ 5,180,000
			<i>Subtotal:</i>	\$ 5,918,000
			CONTINGENCIES (30%):	\$ 1,780,000
			ITEM 3 TOTAL:	\$ 7,698,000
4. Reach 3 -- S Bank Protection Upgrade (Option 3)				
<i>Steel Sheetpile (Cantilevered Wall)</i>	2,180	LF	\$ 1,450	\$ 3,161,000
<i>Concrete Cap</i>	2,180	LF	\$ 140	\$ 305,000
<i>Riprap Scour Protection Along Toe of Wall</i>	7,000	TON	\$ 115	\$ 810,000
<i>Geotextile Fabric Under Scour Protection</i>	5,000	SY	\$ 6	\$ 30,000
<i>Riprap Transitions/Overlaps at Lateral Ends</i>	2,000	TON	\$ 115	\$ 230,000
			<i>Subtotal:</i>	\$ 4,536,000
			CONTINGENCIES (30%):	\$ 1,360,000
			ITEM 4 TOTAL:	\$ 5,896,000
5. Reach 3 -- Drainage System Along 2,500 LF of South Bank				
<i>Grading/Surface Prep</i>	2,300	CY	\$ 2	\$ 5,000
<i>Geotextile Filter Fabric</i>	4,800	SY	\$ 6	\$ 29,000
<i>Place ABM (Salvage from Bank Demo)</i>	3,700	SF	\$ 5	\$ 19,000
<i>Inlet Structures and 24" Discharge Pipe</i>	4	EA	\$ 25,000	\$ 100,000
			<i>Subtotal:</i>	\$ 153,000
			CONTINGENCIES (30%):	\$ 50,000
			ITEM 5 TOTAL:	\$ 203,000
6. Reach 4 Upgrade -- Quarystone Breakwater (315 LF)				
<i>Geotextile Filter Fabric</i>	1,600	SY	\$ 6	\$ 10,000
<i>Riprap</i>	2,500	TON	\$ 125	\$ 313,000
			<i>Subtotal:</i>	\$ 323,000
			CONTINGENCIES (30%):	\$ 100,000
			ITEM 6 TOTAL:	\$ 423,000

Notes:

- Costs shown are not stand-alone project costs; they represent alternative costs for individual repair items shown in the "Harvey Repair Cost OPCC" assuming an upgraded/improved level of resilience is desired.
- Costs shown are approximate and are based on 2018 prices. Actual costs may vary based on market conditions at time of bidding/construction.
- Costs shown are based on quantities estimated from field observations and preliminary review of survey data provided by the City. Actual conditions at time of detailed design and construction may vary, possibly requiring greater quantities if damaged features continue to degrade (e.g., bank erosion and walkway damage may continue where ABM's have been damaged).

PRELIMINARY

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PURPOSES.

ENGINEER: DANIEL J. HEILMAN

REGISTRATION NO.: 29755

DATE: 11/26/2018



11/26/2018

**CITY OF CORPUS CHRISTI
PACKERY CHANNEL RESTORATION (H17019)
POST HURRICANE HARVEY REPAIRS**

CONCEPTUAL-LEVEL OPINION OF PROBABLE CONSTRUCTION COST

MAINTENANCE WORK

<u>ITEM</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT PRICE</u>	<u>EXTENSION</u>
1. Reach 1 -- Gulfside Jetties				
Mobilize Barge-Mounted Crane	1	LS	\$ 50,000	\$ 50,000
Re-Set Jetty Armor Stone	82	EA	\$ 2,000	\$ 164,000
			<i>Subtotal:</i>	\$ 214,000
2. Reach 2 -- Landside Jetties				
<i>Replace 1-3 Ton Stone Along Upper Slope (1,070 LF)</i>	500	TON	\$ 115	\$ 58,000
<i>Re-Set 1-3 Ton Stone Along Upper Slope (1,070 LF)</i>	200	TON	\$ 25	\$ 5,000
			<i>Subtotal:</i>	\$ 63,000
3. Replace Wire Rope in Post/Cable Barriers (S. Bank of Inner Basin)	3,000	LF	\$ 4	\$ 12,000
4. Replace Missing Section of Handrail at North Jetty	30	LF	\$ 200	\$ 6,000
			CONTINGENCIES (30%):	\$ 90,000
			TOTAL:	\$ 385,000

Notes:

1. Costs shown are not stand-alone project costs; they represent additional costs for maintenance repair items and should be added to the costs shown in the "Harvey Repair Cost OPCC."
2. Costs shown are approximate and are based on 2018 prices. Actual costs may vary based on market conditions at time of bidding/construction.
3. Costs shown are based on quantities estimated from field observations and preliminary review of survey data provided by the City. Actual conditions at time of detailed design and construction may vary, possibly requiring greater quantities if damaged features continue to degrade (e.g., bank erosion and walkway damage may continue where ABM's have been damaged).

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