

City of Port Aransas Shoreline Analysis and Improvements



FINAL Technical Report

August 24, 2016

**Submitted To:
City of Port Aransas**



Prepared for:

City of Port Aransas

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Respectfully Submitted,

Aaron Horine
Senior Coastal Engineer
Coast & Harbor Engineering, a division of Hatch Mott MacDonald
711 North Carancahua, Suite 909, Corpus Christi, Texas 78401
361-661-3061
Aaron.Horine@mottmac.com

Contributing Authors:
Scott Fenical, P.E., D.CE
Arpit Agarwal, P.E.
Kirsten McElhinney, E.I.T

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August 24, 2016

City of Port Aransas Shoreline Analysis and Improvements

Technical Report

EXECUTIVE SUMMARY

The shoreline along the Corpus Christi Shipping Channel (CCSC) in Port Aransas has been experiencing negative impacts from passing ship traffic and potential threat to public safety. The passing tankers produce surge waves which destroyed the City of Port Aransas fishing pier in 2008. After reconstructing the fishing pier at a higher elevation, the structure was damaged again in 2010 by waves produced by another passing vessel. The resulting hydrodynamic effects also cause overtopping of the bulkhead which creates a safety hazard for visitors walking along the bulkhead, as well as impacts to the concrete path and parking lot.

The purpose of the analysis was to understand the hydrodynamics of the site, evaluate potential locations for a new fishing pier, evaluate potential improvements to enhance public safety at the bulkhead, and evaluate potential conditions inside a proposed marina basin.

Vessel induced hydrodynamics were evaluated and simulated using the Vessel Hydrodynamics Longwave Unsteady (VH-LU) model. The VH-LU model calculates water level and current velocity fluctuations generated by moving deep-draft vessels. Observed conditions from site photos and videos were collected in order to characterize the vessel induced hydrodynamics seen in the project area. The model results were compared with observed site photos and videos and documentation of pier damage and shown to provide a reasonable representation of the spatial patterns and magnitude of hydrodynamics affecting the shoreline.

Vessel hydrodynamic modeling was used to evaluate water level and current velocity conditions surrounding the existing fishing pier, the existing bulkhead, and the proposed marina and breakwaters. Results from the modeling were then used to evaluate potential new locations for the fishing pier, measures to prevent overtopping of the bulkhead, and performance of breakwater alternatives in minimizing ship wave impacts inside the proposed marina.

Maximum predicted water levels along the bulkhead were used to determine the possible locations of the fishing pier, and recommended elevation to avoid damage. The existing bulkhead was analyzed to determine both its current condition and stability, which is subject to scour. The maximum predicted water level along the bulkhead was also used to evaluate alternatives intended to minimize. Finally, several different entrance jetty and interior configurations were tested in order to minimize water level fluctuations in the proposed marina.

Table of Contents

1 Introduction	1
2 Data Collection	3
3 Ship Hydrodynamic Modeling	4
3.1 Grid Setup	5
3.2 Input Parameters	5
3.3 Comparison of Modeling Results with Anecdotal Information.....	6
3.4 Development of Design Conditions.....	8
4 Alternative Development and Analysis.....	10
4.1 Fishing Pier	10
4.2 Bulkhead	12
4.3 Proposed Marina Basin	14
5 Conceptual Level Cost Estimates	16
5.1 Fishing Pier	16
5.2 Bulkhead	17
5.3 Marina Entrance.....	17
6 Conclusion.....	17
7 References.....	18

List of Figures

Figure 1. Project vicinity.....	2
Figure 2. Examples of ship wave damage to fishing pier in 2008 (left) and 2010 (right).....	2
Figure 3. Project site.....	3
Figure 4. NMS hydrographic survey transects (green) and area of additional NMS topographic survey (purple).....	4
Figure 5. VH-LU grid bathymetry for existing conditions.....	5
Figure 6. VH-LU water surface elevation results. Note: Red contours on land signifies when a dry node has turned wet due to resulting water surface elevations, i.e. when overtopping has occurred.....	7
Figure 7. Extracted water surface elevation time series. Location of extracted data shown inset at blue dot.....	7
Figure 8. Comparison of overtopping extents for outbound case between observed (left) and modeled (right). Note: Arrow shows the approximate location and view point of the observed conditions.....	8

Figure 9. Maximum water surface elevation for inbound route (top) and outbound route (bottom) with vessel speed 10 knots.....9

Figure 10. Maximum water surface elevation for 10 knot vessel speed (top) and 12 knot vessel speed (bottom) moving outbound.10

Figure 11. Fishing pier design. Note: Conceptual designs are not shown to scale. **Error! Bookmark not defined.**

Figure 12. Conceptual fishing pier locations and design. Note: Conceptual designs are not shown to scale.11

Figure 13. Conceptual bulkhead alternatives. Note: not shown to scale.13

Figure 14. Example of transparent flood barriers.13

Figure 15. Maximum water elevation along existing bulkhead (top) and associated distance along bulkhead (bottom).....14

Figure 16. Permitted marina design.15

Figure 17. Conceptual jetty configurations.....15

Figure 18. Maximum water surface elevation generated by passing ship effects for alternative entrance channel and jetty configurations.....16

List of Tables

Table 1. Tidal datum at Port Aransas Station references to NAVD88 datum in feet.4

Table 2. Conceptual level fishing pier construction costs.17

Table 3. Bulkhead modification construction costs.....17

City of Port Aransas Shoreline Analysis and Improvements

Final Technical Report

June 30, 2016

1 INTRODUCTION

This report describes analysis conducted by Coast & Harbor Engineering, (CHE), a division of Hatch Mott MacDonald, for the City of Port Aransas (City).

The shoreline along the Corpus Christi Shipping Channel (CCSC) in Port Aransas has been experiencing negative impacts from passing ship traffic, such as damage to the fishing pier and overtopping of the bulkhead and public access walkway. Figure 1 shows the location of the impacted shoreline near Port Aransas Nature Preserve (formerly known as Charlie's Pasture). The resulting ship wakes overtop the bulkhead which creates a safety hazard for visitors walking on the path along the top of the bulkhead. Tanker induced waves have also damaged the fishing pier. Approximately 25 feet of the pier was severely damaged in 2008 (Parker, 2008), as shown in Figure 2. When repairing the damaged pier, the deck elevation was raised in order to avoid future damage of the pier. Unfortunately, the new deck elevation was not sufficient to protect the pier as it was damaged again due to passing ship effects in 2010, also shown in Figure 2.

CHE evaluated tanker induced hydrodynamics in order to characterize the impacts passing vessels have on the project site. Resulting hydrodynamics were analyzed at the location of the existing fishing pier and along the existing bulkhead. Using this analysis, alternative locations and modifications to these structures were evaluated to minimize impacts to the structures and public safety from passing ship effects. Additionally, a permitted marina concept was analyzed with alternative entrance protection and interior features with the goal of developing a marina conceptual layout with lesser impacts from passing ship effects. Figure 3 shows the project area including the existing fishing pier, existing bulkhead and proposed conceptual marina basin.



Figure 1. Project vicinity.



Figure 2. Examples of ship wave damage to fishing pier in 2008 (left) and 2010 (right).



Figure 3. Project site.

2 DATA COLLECTION

Bathymetry data was compiled from various sources in order to create a numerical modeling grid for passing vessel hydrodynamic modeling. A single-beam hydrographic survey was performed for the project by Naismith Marine Services (NMS). The survey transects were focused along the project site, as shown in Figure 4. NMS also collected elevation data along the bulkhead and fishing pier, with the area of detail shown in Figure 4 within the purple outline. Additional data for the modeling grid was gathered from US Army Corps of Engineers (USACE) hydrographic surveys (USACE 2015) and USGS topographic survey data (USGS 2011). The hydrographic surveys were used to complete areas of missing in-water data while the topographic contours were used for upland elevations.

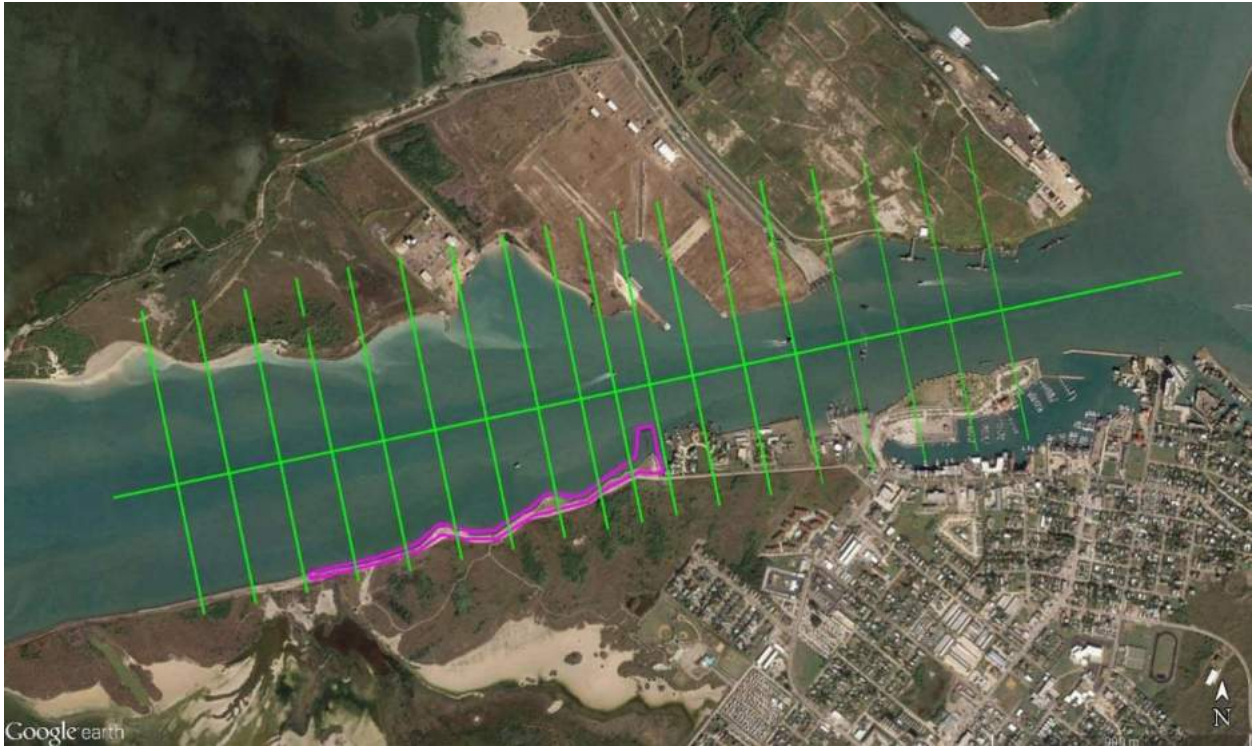


Figure 4. NMS hydrographic survey transects (green) and area of additional NMS topographic survey (purple).

The tidal datums used for this project were obtained from the Port Aransas Station published by Texas Coastal Ocean Observation Network (TCOON, 2014) and are shown in Table 1.

Table 1. Tidal datum at Port Aransas Station references to NAVD88 datum in feet.

DATUM	ELEVATION [FT. NAVD88]
Mean Higher High Water (MHHW)	1.00
Mean High Water (MHW)	0.96
Mean Sea Level (MSL)	0.62
Mean Low Water (MLW)	0.09
Mean Lower Low Water (MLLW)	-0.04

3 SHIP HYDRODYNAMIC MODELING

Deep-draft vessel-induced surge analyses were performed to provide an evaluation of water level fluctuations and surge-induced current velocities generated within the project site by passing vessels. The VH-LU model was used to simulate water level and velocity fluctuations generated by passing deep-draft tankers within the project area moving inbound and outbound in the ship channel.

3.1 Grid Setup

The bathymetry grid was developed using all relevant data available with priority given to the 2016 survey data collected by NMS. The grid used for the VH-LU model is approximately 2.3 miles by 0.8 miles with a uniform grid spacing of 3.3ft (1m). The bathymetry contours and grid boundary are shown in Figure 5.



Figure 5. VH-LU grid bathymetry for existing conditions.

3.2 Input Parameters

Two different sets of input parameters were used in order to evaluate the performance of the VH-LU model. One set of simulations utilized a conservative, typical scenario with the largest vessel that traverses the CCSC and the water level at Mean Higher High Water (MHHW). A second set of simulations utilized conditions during an actual historical event from 2008 that caused extensive damage to the fishing pier. CHE gathered all available information about the incident in order to replicate the historical hydrodynamic conditions.

One design vessel was the Godavari Spirit, a crude oil tanker with length, beam, and draft of 900ft, 157ft and 45ft, respectively. This design vessel represents the typical largest tanker that travels the CCSC. The routes modeled for the passing vessel were along the channel centerline for both inbound (from Gulf of Mexico to Corpus Christi Bay) and outbound vessels. Passing speeds were 10 knots.

Historical simulations utilized the ship that caused the damage in 2008, the SKS Tiete, a crude oil tanker with length, beam, and draft of 800ft, 138ft, and 45ft, respectively. The ship was traveling outbound when the damaging event occurred. A speed of 10 knots was selected as a conservative estimate (speed was unknown). The water level the ship passed the fishing pier according to the Port Aransas station (NOAA 2016) was approximately 0.7ft above MHHW.

3.3 Comparison of Modeling Results with Anecdotal Information

In order to qualitatively confirm the results of the VH-LU model, model results were compared with anecdotal information (photos, videos and observations). Videos and photos have shown the characteristics of the ship induced hydrodynamics, including wave patterns and overtopping locations. Anecdotal and photo/video observations were compared to the water surface elevation data from the VH-LU simulations.

During the 2008 damage event, witnesses reported that the wave overtopped the bulkhead and traveled “more than 150 feet across the pier parking lot” (Parker, 2008). VH-LU water surface elevation results during this event (shown in Figure 6) show overtopping along the bulkhead and inundation of the entire parking lot. The furthest extent of over wash was up to 300 feet away from the bulkhead. The water surface elevations at the fishing pier were also compared to the known fishing pier deck elevation at the time of the accident. Figure 7 shows the VH-LU calculated maximum water surface elevation at the fishing pier which was approximately 1 foot above the deck elevation, indicating that damage would be likely to occur.

Site videos showing bulkhead overtopping during outbound events were also compared with model results. A video taken from the fishing pier looking southwest (Urban, 2014) showed extensive overtopping along the bulkhead, as shown in Figure 8. Similarly, the VH-LU model results indicate very similar overtopping along the bulkhead (in Figure 8).

For all scenarios tested, the VH-LU model qualitatively replicated the ship-induced hydrodynamic conditions observed at the site. Both the spatial patterns and magnitudes of the modeling results are in general agreement with the site observations. Based on these results, the VH-LU model is considered to be a reliable tool for evaluation of proposed project alternatives.

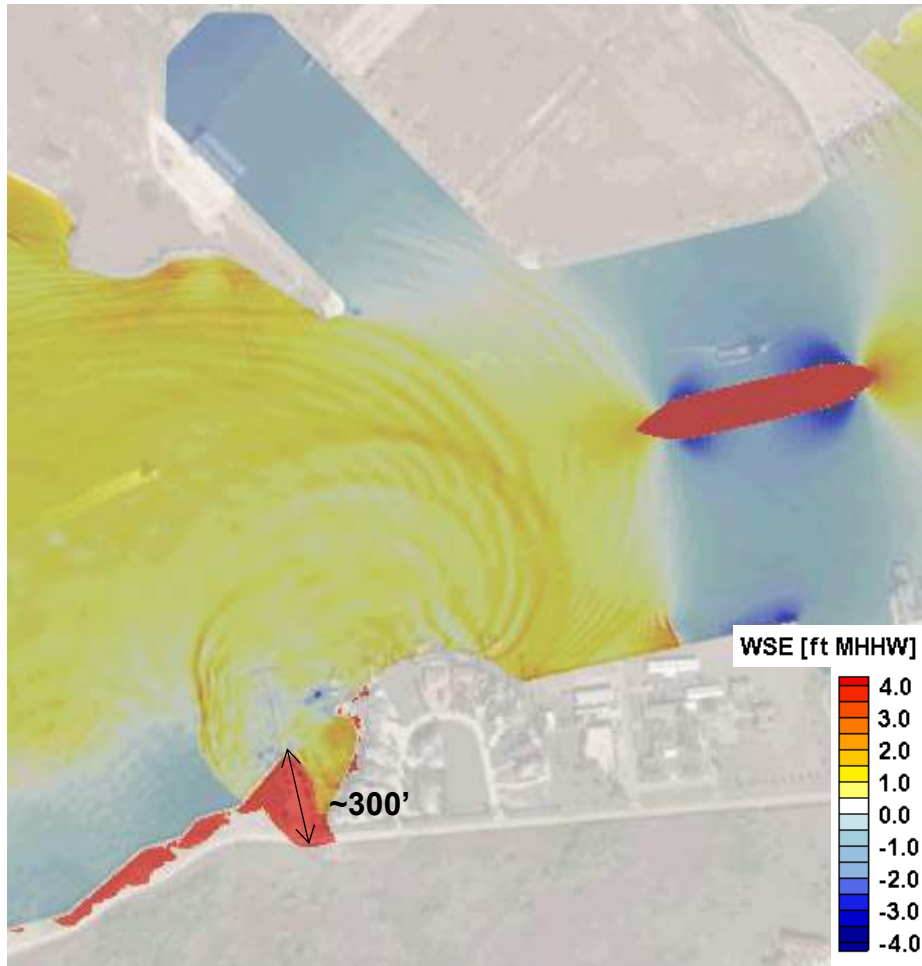


Figure 6. VH-LU water surface elevation results. Note: Red contours on land signifies when a dry node has turned wet due to resulting water surface elevations, i.e. when overtopping has occurred.

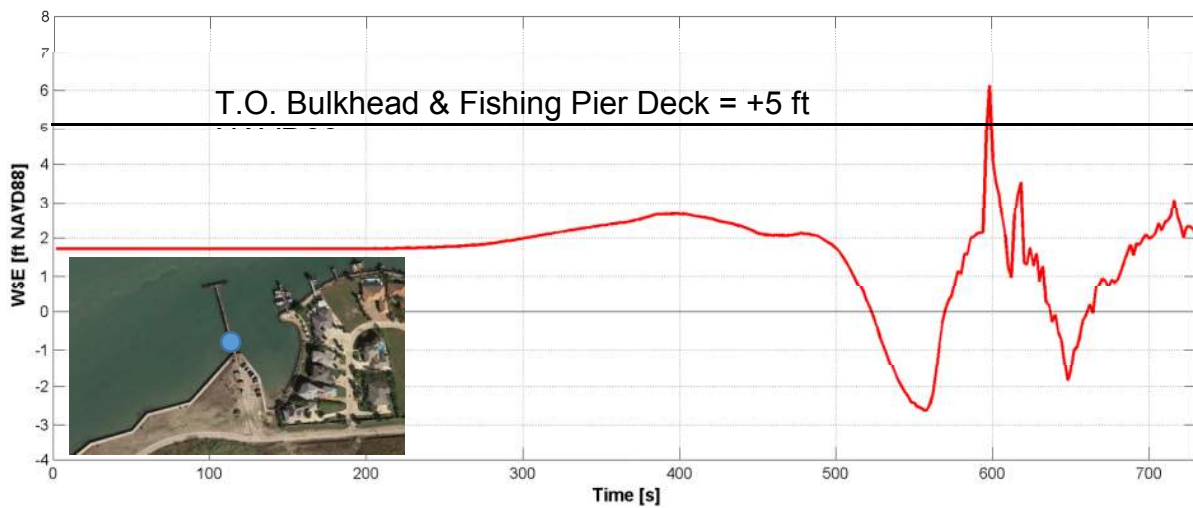


Figure 7. Extracted water surface elevation time series. Location of extracted data shown inset at blue dot.



Figure 8. Comparison of overtopping extents for outbound case between observed (left) and modeled (right). Note: Arrow shows the approximate location and view point of the observed conditions.

3.4 Development of Design Conditions

The ship hydrodynamic modeling results were used to develop design conditions for evaluating different alternatives and locations for the fishing pier, bulkhead and marina basin.

Inbound and outbound passing ship routes were compared to determine which is more appropriate to use in evaluating alternatives. Figure 9 shows the difference in overtopping along the bulkhead and at the fishing pier between inbound (top) and outbound (bottom) passing vessels (with a vessel speed of 10 knots). The outbound route allows more development of the bore wave along the bulkhead due to a shallow shelf present just seaward of the bulkhead. Due to the more destructive nature of the outbound results, the outbound passing route was used for testing of alternatives.

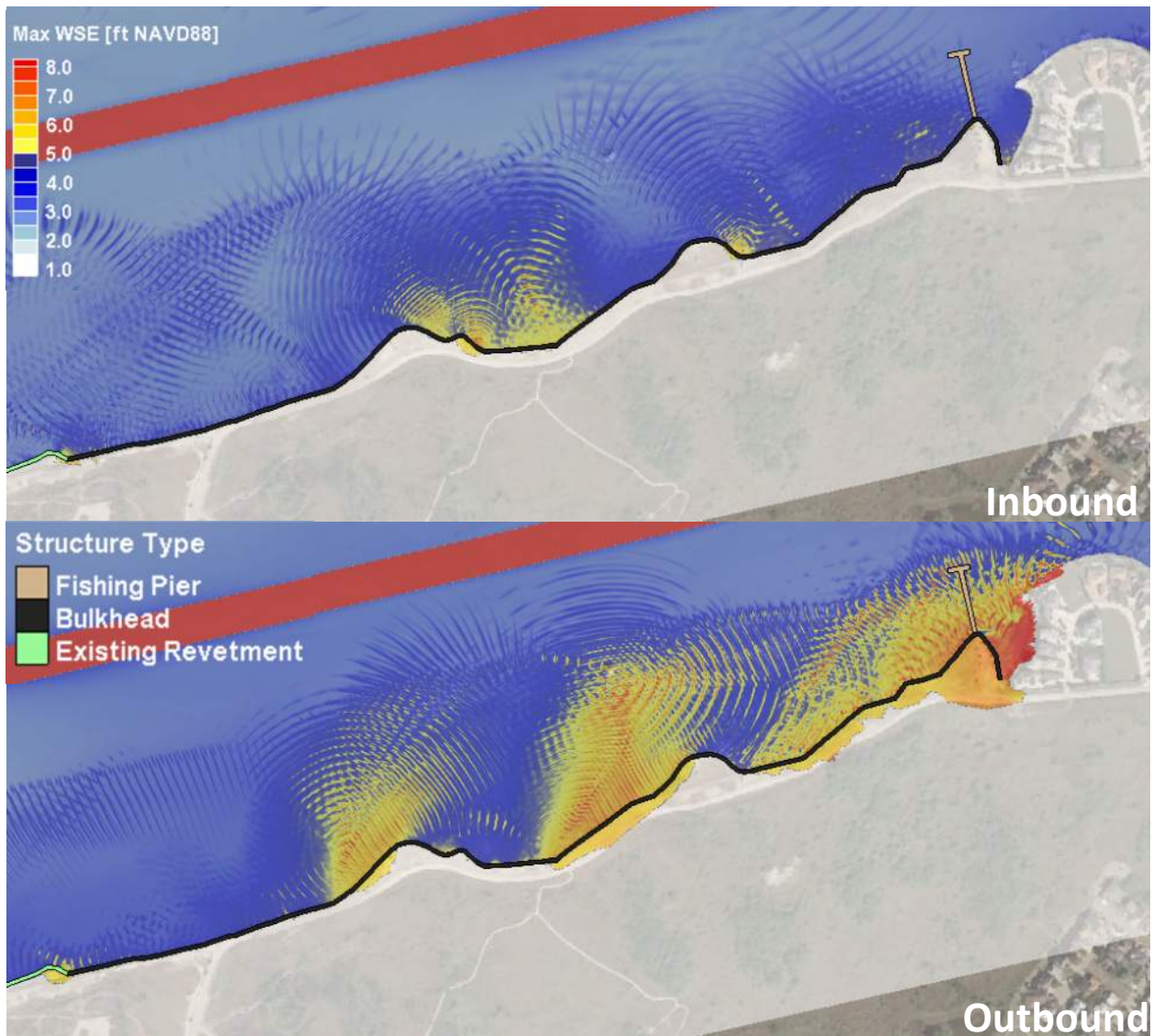


Figure 9. Maximum water surface elevation for inbound route (top) and outbound route (bottom) with vessel speed 10 knots.

Simulations indicated that passing ship impacts are not necessarily worse at higher speeds due to stronger bore formation earlier along the ship channel, and higher dissipation of the bore prior to reaching the project features of interest. Therefore to determine the worst-case condition for evaluating alternatives, two possible maximum speeds at 10 and 12 knots were tested in the VH-LU model. Figure 10 shows that the 12 knot vessel (bottom) caused more overtopping at the western end of the bulkhead but resulted in almost no inundation at the fishing pier. In comparison, the 10 knot vessel (top of Figure 10) gives similar overtopping along the bulkhead, but also completely overtopped and inundated the fishing pier and associated parking lot. Therefore, 10 knot passing speed was chosen for evaluation of project alternatives.

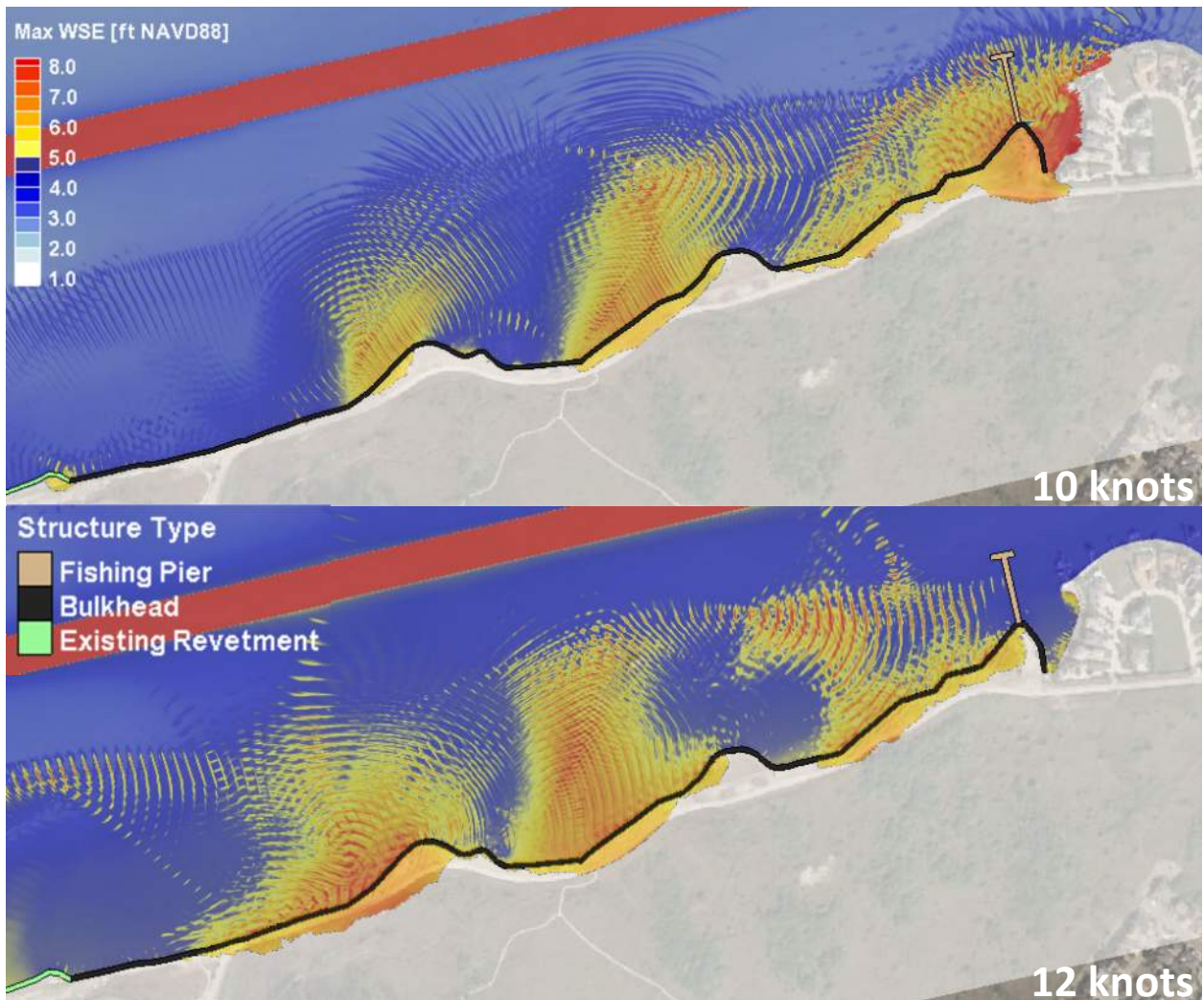


Figure 10. Maximum water surface elevation for 10 knot vessel speed (top) and 12 knot vessel speed (bottom) moving outbound.

Design water level is also required for testing alternatives. In order to test the structures during worst case conditions, the water level from the day of the 2008 pier damage event (+0.72' MHHW) was used for the alternatives analysis.

4 ALTERNATIVE DEVELOPMENT AND ANALYSIS

Both the existing structures (the fishing pier and bulkhead) and proposed structures (permitted marina and entrance protection) were analyzed to develop project alternatives that would maximize public safety and provide the desired recreational benefits. The ship hydrodynamic model results were used to develop alternative concepts for improving conditions at the existing and proposed structures. The following sections detail the design conditions used and the resulting designs for the fishing pier, bulkhead, and marina.

4.1 Fishing Pier

The alternative fishing pier designs were assumed to be similar overall. The three design features that vary between the alternatives are location along bulkhead, length of catwalk,

and pile bent elevation. The variation of these designs are due to differences in maximum water elevation and bathymetry for the different locations along the bulkhead during design conditions.

The locations were chosen based on the spatial extents of maximum water surface elevation for a vessel traveling outbound at 10 knots (shown in top of Figure 10). At these locations, the maximum water surface elevation at the bulkhead was extracted (shown in Figure 14) and analyzed in order to determine an appropriate pier elevation that would avoid contact with the pressure field waves. Finally, pier lengths were prescribed in order to provide depths similar to those at the seaward end of the existing fishing pier. Figure 11 shows the alternative fishing pier locations, elevations, and lengths. In general, the fishing pier deck elevation can be lower in locations farther west due to lower water surface elevations during passing ship events, but the pier lengths increase due to the orientation of the bulkhead relative to the bottom contours (deeper water).



Figure 11. Conceptual fishing pier locations and plan view design. Note: not shown to scale.

4.2 Bulkhead

Several bulkhead modifications were considered to reduce or prevent overtopping. One modification considered was addition of a concrete barrier to the top of the existing bulkhead (Alternative A in Figure 12). While suitable for eliminating overtopping, more analysis is required to determine whether the existing bulkhead could support the additional load.

Another alternative analyzed was addition of a transparent barrier to the top of the bulkhead (Alternative B in Figure 12). Using a lighter material makes this a more feasible option than Alternative A as the load on the bulkhead would be significantly reduced. Also, using transparent materials would avoid obstructing channel views and provide a more aesthetically pleasing option than the concrete barrier (example structures are shown in Figure 13).

Alternative C in Figure 12 consists of installing a new, taller bulkhead in front of the existing bulkhead. The final conceptual alternative is a rock revetment in front of the existing bulkhead (Alternative D in Figure 12). This rock revetment would help reduce the overtopping, and also provide scour protection along the toe of the bulkhead.

The top elevation of Alternatives A, B, and C were computed in order to prevent overtopping by the peak water levels during the design passing ship event. Figure 16 shows the maximum water surface elevation along the bulkhead, and the existing bulkhead elevation. From the data shown in Figure 14, it was determined a top elevation of +8.5 ft NAVD88 would likely preclude significant overtopping. The top elevation of Alternative D was developed only to ensure the rock structure was emergent during the design condition, or above MHHW (which is approximately 1.72' NAVD88). Therefore, Alternative D is not intended to eliminate overtopping by acting as a barrier. Alternative D could reduce overtopping due to its roughness and porosity, which would help break up the traveling bore wave and allow water passage through the structure.

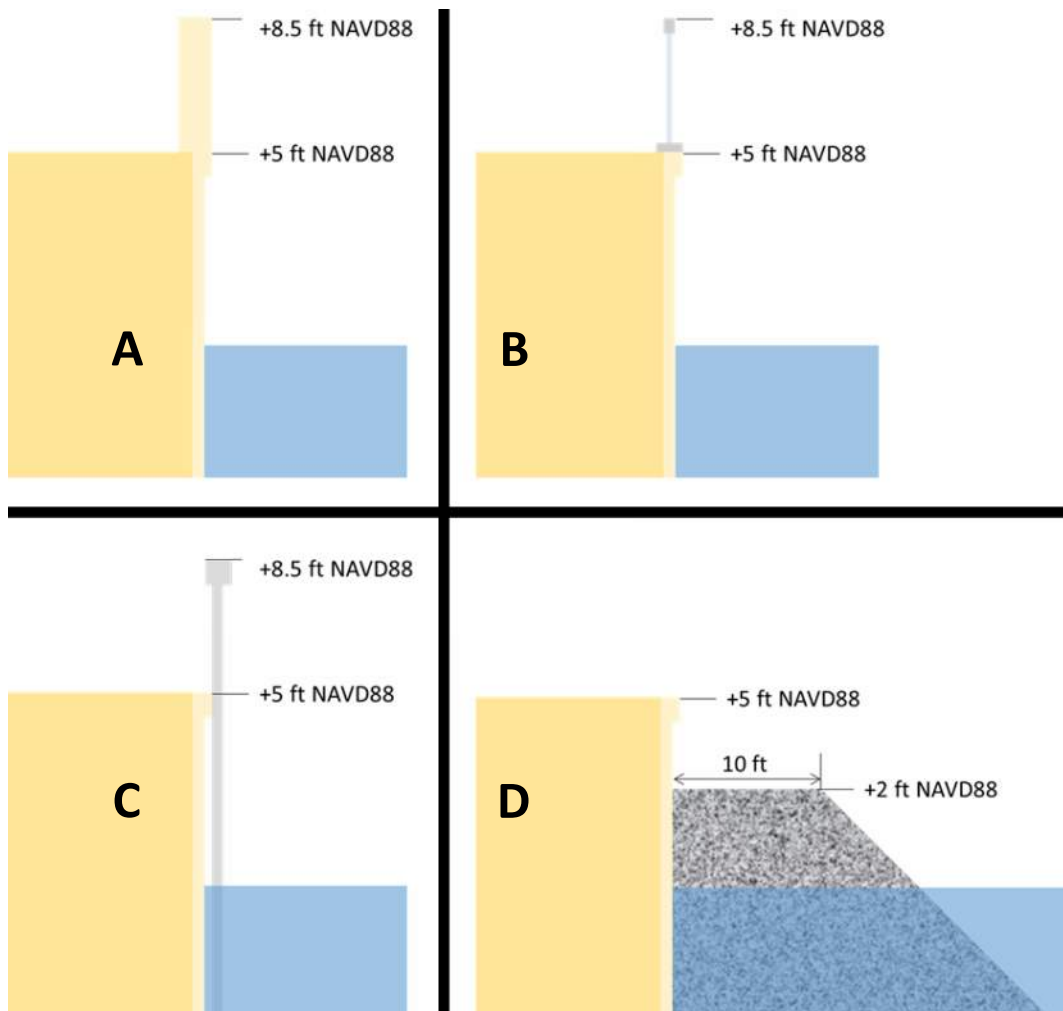


Figure 12. Conceptual bulkhead alternatives. Note: not shown to scale.



Figure 13. Example of transparent flood barriers.

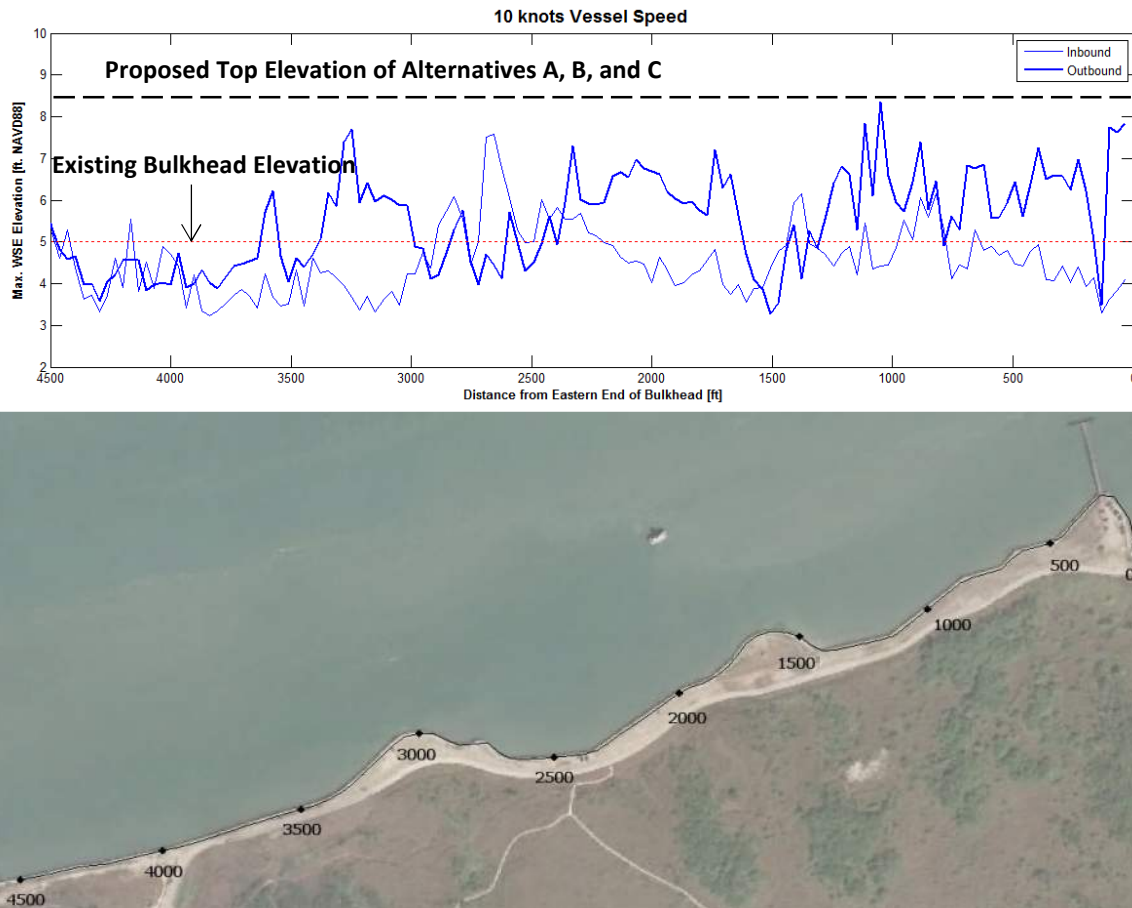


Figure 14. Maximum water elevation along existing bulkhead (top) and associated distance along bulkhead (bottom)

4.3 Proposed Marina Basin

In addition to analyzing potential improvements/replacements for the existing structures (pier and bulkhead), a proposed marina basin conceptual layout was also analyzed in order to evaluate the potential conditions inside during passing vessel events. Figure 15 shows the permitted marina design with angled jetties.

Both the interior basin configuration and entrance jetty configuration were modified to evaluate their influence on conditions inside the harbor. The goal of the modifications was to minimize wave reflections and concentrations of stronger currents during passing ship events. Initial results determined that the marina basin interior should not include side slopes, where ship waves tend to shoal and break, and should avoid sharp edges to minimize strong currents and toe scour at interior bulkheads. Those interior basin modifications, while not intended to represent an optimized harbor, were further used when evaluating various entrance and jetty configurations.

The primary intent of entrance modifications was to minimize the water level fluctuations within the marina. Figure 16 shows four of the different jetty configurations considered while Figure 17 shows the maximum water surface elevation for each of the alternatives. As shown in Figure 17, Alternatives 3 and 4 resulted in the lowest maximum water elevations within the marina due to the angle of the jetties. Alternatives 1 and 2 have larger long-period water

level fluctuations inside the basin since the entrances are wider than Alternatives 3 and 4. Alternatives 2 and 3 have no overtopping of the existing bulkhead on the east side of the harbor, whereas Alternatives 1 and 4 have overtopping on both sides of the entrance.

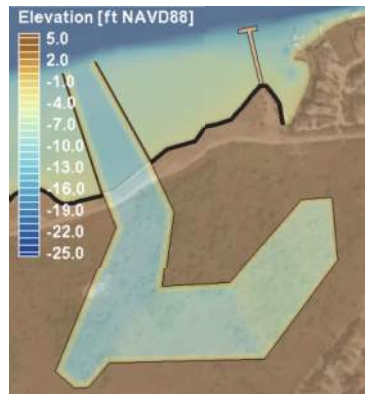


Figure 15. Permitted marina design.

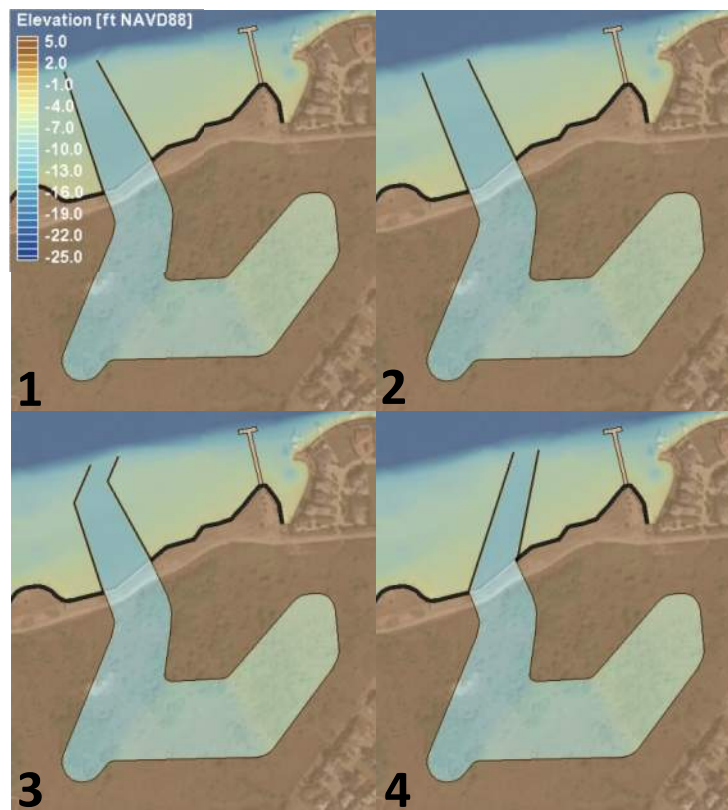


Figure 16. Conceptual jetty configurations

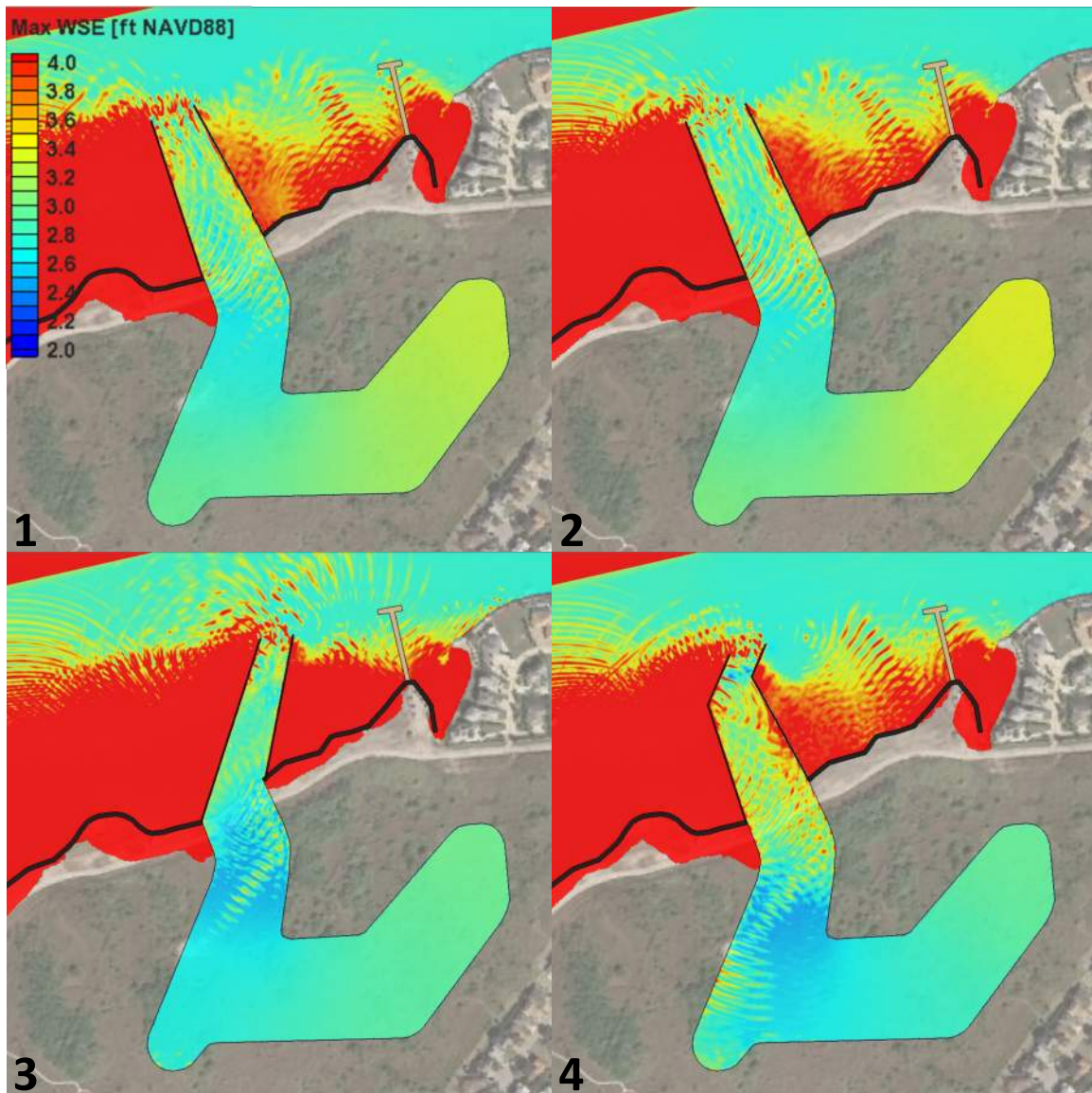


Figure 17. Maximum water surface elevation generated by passing ship effects for alternative entrance channel and jetty configurations.

5 CONCEPTUAL LEVEL COST ESTIMATES

The following sections present conceptual level cost estimates for the conceptual alternatives including the fishing pier, bulkhead modifications, and marina entrance jetties. These costs are intended to be conceptual in nature, are approximate and are subject to change during preliminary and final engineering design. Costs are exclusive of permitting, data collection and engineering. These estimates assume typical equipment is used by contractors who commonly perform marine construction activities in the region.

5.1 Fishing Pier

Two different type of fishing piers were considered in order to give a range of cost information for each alternative design and location. The cost for both concrete and timber fishing piers are presented in Table 2 for Locations 2 through 4. Location 1 (the location of the existing fishing pier) is known to be in a vulnerable location, therefore only costs for a

concrete pier are provided. As shown in Table 2, concrete piers are more costly than timber piers; however, concrete is more durable and less likely to be damaged.

Table 2. Conceptual level fishing pier construction costs.

Structure Location	Concrete – Approximate Total Cost	Timber – Approximate Total Cost
Location 1	\$1,200,000 to \$1,600,000	--
Location 2	\$2,200,000 to \$2,600,000	\$250,000 to \$300,000
Location 3	\$2,200,000 to \$2,600,000	\$250,000 to \$300,000
Location 4	\$3,000,000 to \$3,400,000	\$300,000 to \$350,000

5.2 Bulkhead

Conceptual level costs to improve the existing bulkhead were estimated and shown in Table 3. While Option 1 is the lowest cost, additional analysis is necessary in order to determine if the existing wall can withstand the additional forces of the concrete barrier. It should also be noted that the new bulkhead option (Option 3) includes the possibility of either steel or concrete sheet pile to be used to construct the new bulkhead.

Table 3. Bulkhead modification construction costs.

Bulkhead Improvement	Approximate Cost/LF
Option 1: Concrete Addition to Existing	\$60 - \$75/LF
Option 2: Glass Addition to Existing	\$450 - \$510/LF
Option 3: New Bulkhead	\$2,500 - \$3,000/LF
Option 4: Revetment	\$500 - \$650/LF

5.3 Marina Entrance

A conceptual level cost estimate was also developed for the proposed marina entrance which includes the construction of sheet pile type jetties. The cost doesn't include dredging for the entrance channel or the interior basin excavation. The conceptual level cost estimate is in the range \$2.0M to \$4.0M, assuming a steel sheet pile jetty structure, the current bathymetry and is applicable for all alternatives presented.

6 CONCLUSION

The shoreline along the CCSC in Port Aransas is experiencing detrimental conditions due to passing ship traffic. The existing structures (fishing pier and bulkhead) are vulnerable to damage and unsafe conditions and need to be addressed immediately to avoid future damage and safety hazards.

The fishing pier, which has been destroyed in the past decade, needs to be relocated and elevated in order to avoid impacts from ship-induced waves. The bulkhead requires modification to eliminate the overtopping that is creating a safety hazard. The proposed marina needs adequate

protection to prevent waves generated by outbound vessels in the HSC from causing damage and safety hazards in the basin.

Results indicate that an angled jetty configuration with narrower entrance is most efficient at minimizing the resulting wave action from the passing vessels inside the basin. However, the issues with the existing structures (fishing pier and bulkhead) need to be addressed prior to the design and construction of the marina and entrance jetties to ensure public safety.

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