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1. INTRODUCTION

This appendix is prepared in accordance with the Water Resources Council’s Economic and Environmental, Principles and Guidelines for Water Related Land Resource Implementation Studies, dated March 1983 (P&G, 1983). It presents an evaluation of the benefits that would result from the proposed plan of improvement for Lake Montauk Harbor. This appendix presents relevant information used in determining the impact of channel modification. The Tentatively Selected Plan (TSP) recommends deepening the authorized channel from 12 feet mean lower low water (MLLW) to 17 feet MLLW.

Categories of Benefits

There are two ways that the deepening of the channel will provide National Economic Development (NED) benefits. First, a deeper channel enables higher levels of production from existing fishing resources by allowing depth-limited vessels to operate in an optimal way. Second, coastal storm risk management (CSRM) benefits are produced as a necessary incident of the least cost method of placing the dredged material from the channel deepening and subsequent maintenance on the adjacent shoreline.

The next several sections will set forth the analysis that describes the way that these benefits have been calculated. First, the manner in which the depth-limited vessels are operated in the currently authorized channel is illustrated. The next section presents analysis of the manner in which those vessels would be operated given various alternative improved channels. The final section describes the evaluation of the damages in the without project condition and the damages and benefits in the with-project condition in terms of: (a) the increase in economic efficiency that the various alternative improved conditions would make possible in terms of production of marketable fish and costs avoided, and (b) the incidental benefits as measured by U.S. Army Corps of Engineers (USACE) risk analysis produced during the time that this study was pursued under Public Law Number 113-2.1

2. DATA COLLECTION

Data on the commercial fishing operations detailed in the following analysis was collected from a variety of sources. Existing condition information reflects the actual fleet currently in Lake Montauk Harbor. Commercial fishing operations and vessel activity are informed by survey evidence of 10 fishing vessel owners/captains using a survey approved by the Office of Management and Budget, Approval Number 0710-0001. The survey was conducted in 2011 and updated in 2019. USACE followed up with 10 of the 11 vessels that identified as being constrained by the depth of the channel in the original 2011 survey. The owners/captains were asked their best estimates of the effect of the various depths on several key commercial outcomes. The purpose of the survey

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1 Public Law 113-2 is the disaster relief appropriations bill in response to Hurricane Sandy, under which potential CSRM benefits were quantified for the Lake Montauk Harbor study. Coordination with non-federal interest and key stakeholders led the study team to focus on navigation improvements rather than CSRM measures, however, the information developed under PL 113-2 can still be used to explain incidental benefits to the proposed navigation improvements.
is to help determine if the benefits derived from the project will outweigh the costs. The survey focuses on the additional revenue or cost savings that may be derived from a channel maintained at various depths: -12, -13, -14, -15, -16, and -17 feet MLLW. Information on existing conditions in terms of vessel specifications and typical commercial activity was collected. This information included the time spent fishing, the size of the vessel, the speed of the vessel, the size and type of crew on board, and the average amount of fish landings.

The data collected from 10 vessel owners and captains yielded reliable responses based on the following three survey questions. All of Question 1 has been reproduced here for illustrative purposes; Questions 2 and 3 are constrained to the question content for brevity.

1. Reduction in vessel repair and maintenance

Based on records from the US Coast Guard as of 6 June 2005, there have been three reported groundings at Lake Montauk Harbor: F/V Jason & Daniele, 1/14/2000; F/V Wonder Lust, 1/14/2000; and F/V First Lady 1999. After speaking with some F/V owners, there was a consensus amongst them that not all the vessel groundings are reflected in the US Coast Guard records. There have been incidences where the vessels have scraped the channel bottom causing hull and propeller damage. There may also be savings in stretching out the time period from general maintenance such as hull repainting if the channel was deepened. We would like you to place a dollar value on the avoided vessel repair and maintenance costs if the channel was deepened and maintained at 13 feet, 14 feet, 15 feet, 16 feet, and 17 feet. If you feel there is no savings until the channel is at least 14 feet, you can so indicate. Perhaps the savings is the same for 14 feet and 15 feet and the next increase in savings is for 15 feet. Please see Example 1 for an illustration. This example shows that the savings will begin at 14 feet-15 feet with an annual savings of $25,000. The savings at 16 feet and beyond is $30,000 a year.

<table>
<thead>
<tr>
<th>Channel depth at mean low water</th>
<th>Estimated annual savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 feet (current depth)</td>
<td>$0</td>
</tr>
<tr>
<td>13 feet</td>
<td>$0</td>
</tr>
<tr>
<td>14 feet</td>
<td>$25,000</td>
</tr>
<tr>
<td>15 feet</td>
<td>$25,000</td>
</tr>
<tr>
<td>16 feet</td>
<td>$30,000</td>
</tr>
<tr>
<td>17 feet</td>
<td>$30,000</td>
</tr>
</tbody>
</table>

Table 1: Survey Question Data Entry Example

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2 The reader may think of additional potential benefits which are not quantified here. The approved survey requests that the captains estimate the effect of channel depth on two additional attributes: (1) reduction in total loss of fishing vessel, and (2) additional commerce from additional landings of non-quota fish. In these three categories, there was insufficient information for a reliable quantitative assessment. For the first category, vessel operators have no experience with the other channel depths and could not therefore provide reliable evidence of the incremental benefits at various channel depths. Responses are not provided for the second category.
For your vessel, please fill in the information in Table 2.

Table 2. Reduction in repairs and maintenance

<table>
<thead>
<tr>
<th>Channel depth at mean low water</th>
<th>Estimated annual savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 feet (current depth)</td>
<td></td>
</tr>
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<td>13 feet</td>
<td></td>
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<td>14 feet</td>
<td></td>
</tr>
<tr>
<td>15 feet</td>
<td></td>
</tr>
<tr>
<td>16 feet</td>
<td></td>
</tr>
<tr>
<td>17 feet</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Survey Question Data Entry

2. Reduction in fuel and supplies used per trip

Because of weather conditions that may prevent a fishing vessel from entering or exiting the channel, a fishing trip will be extended and extra fuel and supplies such as ice and food will be used. If a deeper channel will eliminate this loss of fishing time and result in a shorter fishing trip, we would like you to place a dollar value on this savings. This savings in fuel and supplies will also apply if you off-load your catch at a harbor farther than Lake Montauk because your vessel could not enter the harbor due to lack of channel depth. This would also apply if you have a vessel that is currently based at another harbor (for example, New Bedford), and you would save money by fishing out of Lake Montauk if the channel depth was deeper. We would like you to place an estimated dollar value on this savings for different channel depths.

3. Increase in income by commanding a higher value per pound for ex-vessel landings due to timeliness to market, freshness of fish and other market factors

If the channel at Lake Montauk Harbor is dredged and maintained at deeper depths, your vessel may be able to bring the catch in port in a timely fashion and not occasionally miss the market for that day. For example, due to weather conditions, your vessel is unable to transit the current channel, and you have to wait several hours before coming into port and will therefore be unable to truck your finfish to the Fulton Fish market for that day. You would have to keep your catch on ice for an extra day and this may result in a lower price for your finfish. If this scenario does exist, we would like you to place a dollar value on your annual increase in revenue from this factor for different channel depths.

The responses were consistent across vessel owners/captains in terms of the substantial gains that could be achieved if the channel were maintained -17 feet MLLW. The information collected from the survey was further verified by site visits and field observations of vessels utilizing the inlet. Details on the survey outcomes and their use in the derivation of project benefits are provided in Section 4.2.
2.1 Existing Navigation

Lake Montauk Harbor can accommodate recreational craft, fishing boats. There are currently 18 marinas and five temporary docking and ramp facilities within Lake Montauk Harbor. The marinas have a total of approximately 1,235 dockside slips. Currently, the largest slip is 70 feet long. A few of the marinas have slips designated for transient boats and fishing and charter boats. Lake Montauk Harbor has two town docks, one named Star Island with 23 slips and the other named Montauk Dock with 17 slips. Nearly all of these slips are occupied.

The heavy volume of vessel traffic using the federal channel consists primarily of pleasure and commercial fishing boats. The channel is used on average by 500 boats per day during the warmer months. The commercial fleet has consisted of up to 30 trawlers, 12 inshore and 7 offshore lobster boats and 53 long liners, including as many as 32 transient commercial fishing boats from other areas of the east coast. Within the fleet, approximately 11 of the largest vessels are constrained by the current authorized channel depth of -12 feet MLLW.

The contract costs for recent U.S. Army Corps of Engineers maintenance dredging operations are shown in Table 3. These costs are used to develop the future without project conditions below. Approximately $350,000 for construction supervision and administration and 25% overall contingency were added to the contract cost to obtain the estimated overall maintenance cost in the last column of the table.

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume (cy)</th>
<th>Contract Cost</th>
<th>Estimated Overall Maintenance Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>12,000</td>
<td>$400,000</td>
<td>$937,500</td>
</tr>
<tr>
<td>2014</td>
<td>19,000</td>
<td>$530,000</td>
<td>$1,100,000</td>
</tr>
<tr>
<td>2018</td>
<td>37,000</td>
<td>$780,000</td>
<td>$1,412,500</td>
</tr>
</tbody>
</table>

2.1.1 Problem statement

There are two water resources problems in the study area.

1. Insufficient channel and harbor depth at various times, such as low tide, due to both the channel’s currently authorized depth and it regularly being shoaled in above this depth.

2. In addition, erosion damages due to a combination of (a) navigation inlet jetties blocking some sediment flow and (b) coastal storm surge and wave attack, resulting in failure of bulkheads and damage to homes and businesses, and also damage to roads.

The existing federally-authorized 12-foot-channel and harbor depths cause some vessels to operate in a sub-optimal way through restricted channel use, longer-distance operations, and risk of damage. Further, maintaining the channel depth and width has become more difficult with the accretion of sand on the eastern side of the east jetty. The sand migrates through and around the east jetty and continues westward into the federal navigation channel. Experience shows that
maintenance dredging has been necessary every four to five years. As described in Section 2.1 above, maintenance dredging in the past several years has been necessary as often as every three to four years (2011, 2014, and 2018). In recognition of a need for maintenance dredging at least every 4 years, the U.S. Army Corps of Engineers determined that its maintenance work planned for the fall of 2018 should include advance maintenance of an additional 2 feet of depth to extend the estimated maintenance cycle from 4 years to 8 years.

Even with the advanced maintenance, some of the commercial vessels must still transit the channel during high tide periods, must sail light-loaded (that is, at less than their full carrying capacity) or some combination of the two. This has the effect of reducing the productivity of the commercial fisherman in terms of the market value of the fish caught. Further, in the year leading up to the most recent maintenance operation, 9 vessels bumped the bottom of the channel even on departure when they were not loaded, including the For example, Jason & Danielle which has a fully loaded design draft of 16 feet must be operated with some combination of delays in commercial activity, intentional light-loading both in- and out-bound, and risk of hull damage. Vessel damages from these groundings have occurred. Finally, Lake Montauk Harbor is the easternmost harbor of refuge in New York and the only harbor of refuge on the south coast of Long Island for vessels westbound to New York Harbor and the New Jersey Coast, or eastbound to the open Atlantic.

In addition, beach erosion along the shoreline west of the western jetty of the federally-authorized navigation channel is an issue of concern to the local interests. The area of erosion extends for approximately 5,100 feet along this shoreline. The least cost disposal method of the dredged material is placement on the downdrift beach, and this disposal method produces incidental CSRM benefits.

In addition, at the eastern end of this shore adjacent to the western jetty, there is 500 feet of stone revetment along West Lake Drive. The eroding shoreline is endangering West Lake Drive, the 35 residential properties behind the bulkheads, and the structures behind narrow dunes or bluffs in the unbulkheaded reach.

Experience from past maintenance cycles supports the proposition that this method of placement of the dredged material on the downdrift beach has favorable CSRM effects. Based on a comparison of historical shorelines, the average long-term erosion on the downdrift shoreline was approximately 2 feet per year up through jetty construction in 1926. Following jetty construction, the shoreline erosion rate increased to approximately 3.3 feet per year until 1980, but recent placement of dredged material every 4 to 5 years since 1980 in combination with shoreline property owners hardening the shoreline in front of their development has, in effect, decreased this erosion rate to 2 feet per year again. Storm erosion and wave attack forces from recent nor’easters and Hurricane Sandy has caused additional rapid and extreme shoreline losses, bulkhead failures, and even damages to structures. Very little beach area remains even at low tide.

2.2 Socioeconomic Conditions

A formal census update of post-Hurricane Sandy demographic information is not currently available, however information from the American Community Survey provides detailed socioeconomic information for the Town of East Hampton, Suffolk County, and New York State.
The population of the Town of East Hampton has grown quickly for the area and has experienced relatively strong economic conditions. The population of the Town of East Hampton grew at 3.6% from 2010 to 2017 to 21,935 people. The population of Suffolk County grew at a slower pace of 1.0% from 2010 to 2017, while the population of New York State grew 3.0% over the same period. Employment trends from 2010 to 2017 follow the same pattern as growth in population; the Town of East Hampton experienced a 7.0% increase in employment, while Suffolk county employment grew at 2.1% and employment in New York State grew at 4.6%. Finally, real median household income is a third measure of the Town’s socioeconomic status, and has grown by 5.8% to $92,516 over 2010 – 2017. Conversely, real median household income fell by 3.6% in Suffolk County and by 1% in New York State.

2.2.1 Economic Justice

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” requires Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its program, policies, and activities on minority and low-income populations in the U.S., including Native Americans. Executive Order 13045, “Protection of Children from Environmental Health Risks and Safety Risks,” requires Federal agencies to identify and assess environmental health risks and safety risks that may disproportionately affect children. The 2017 combined minority population is 7% in the Town of East Hampton and 20% in Suffolk County. Moreover, 9.3% of individuals and 6.1% of families were living below the poverty line in the Town of East Hampton in 2017. These figures are of the same magnitude as the 7.2% of individuals and 5% of families who were living below the poverty line in Suffolk County in the same year.

2.3 Future Without-Project Conditions

The future without-project condition serves as the basis of comparison in the analysis of all with-project alternatives.

In the future without-project condition over the period of analysis of 2021-2071, the navigation channel operations and maintenance cycle is unchanged. Currently and into the future without the project, fishing production is not fully realized. The depth of the channel is assumed to be maintained at -12 feet MLLW. The 2011 survey evidence suggests that the sub-optimal production level occurs because the commercial fishing vessels are constrained by the depth of channel.

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3 Real median household income is measured in 2017 dollars using the CPI: All Items Less Food and Energy.
4 The definition of the without-project condition, according to ER 1105-2-100, is “the most likely condition expected to exist in the future in the absence of a proposed water resources project. Proper definition and forecast of the future with-out project condition are critical to the success of the planning process. The future without-project condition constitutes the benchmark against which plans are evaluated. Forecasts of future without conditions shall consider all other actions, plans and programs that would be implemented in the future to address the problems and opportunities in the study area in the absence of a Corps project. Forecasts should extend from the base year (the year when the project is expected to be operational) to the end of the period of analysis.” From the same engineering regulation, the with-project condition is defined as “the most likely condition expected to exist in the future with implementation of a particular water resources project. Comparison of conditions with the project to conditions without the project will be performed to identify the beneficial and adverse effects of the proposed plans. These with and without-project comparisons provide the framework for the evaluation of alternative plans.”
These 2011 survey results were updated in 2019 by captains of 10 of the 11 whose operations are constrained by the channel. The survey evidence suggests that current operations occupy the nation’s scarce resources in a sub-optimal way. Due to the depth of the channel, the surveyed captains estimated that they currently forego additional commerce in terms of: (1) getting fish to market fresher, (2) savings in fuel and supplies used per trip, and (3) avoidable costs for vessel maintenance and repair. Up to $2,266,000 of annualized navigation benefits would not be not realized in the future without-project condition attributable to these factors.

Littoral material estimated to be 10,000 to 12,000 cubic yards per year on average that is transported westward along the beaches east of the jetties will continue to supply the inlet system with sediment at a rate of 7,000 to 8,000 cubic yards per year, which will be dredged and bypassed. Following the maintenance cycle that started in the fall of 2018 and will be complete in 2026, the U.S. Army Corps of Engineers estimated in 2018 that maintenance dredging will be required more often to maintain the authorized channel depth, producing 32,000 cubic yards every 4 years. This estimate is based on dredging history including the past several years, engineering analysis, and sediment budget. There will also be increased disturbance caused by more frequent channel maintenance. Further, the annualized maintenance costs (100% federal) would rise significantly beginning in approximately 2026 because maintenance dredging would be required every three years in the future without-project condition.

West of the inlet, the shoreline will continue to recede at approximately 2 feet per year. The existing erosion of the shores downdrift of the west jetty will continue to worsen due to storm waves and surges, the natural condition in which less sediment arrives on the western shoreline than is being transported away past Culloden Point, and the littoral sediment depravation of the western shores from the blocking effects of the jetties at the stabilized inlet channel, as described in 2.1.4 above. There will be an increased threat of undermining of West Lake Drive immediately adjacent to the inlet, and engineering models predict that after 20 years this road will be undermined along any reach that is not hardened. Therefore, it is anticipated that the remaining 700 feet of road would receive riprap protection as the shoreline narrows. Eventually, the entire 1,200-foot-long stretch of road would end up being bulkheaded. In the future without project condition, the continuing erosion, along with future storm damage, would require repairs to the bulkheads and even the road itself.

3. NAVIGATION IMPROVEMENT MEASURES

Plans are composed of measures. A measure is an activity or a feature that can be implemented at a specific geographic site to address one or more planning objectives. They can be used individually or combined with other management measures to form alternative plans. The following measures were developed to address problems and to capitalize upon opportunities. They were derived from a variety of sources including prior Lake Montauk Harbor studies, the public scoping process, and the project delivery team. The following measures were considered in the Lake Montauk Harbor Navigation Improvement Feasibility Study. The table at the end of this section shows the results of screening the identified measures.
1. **Unconventional drafts.** Use of larger vessels with shallower drafts was considered, but this is not the present trend. It is not projected that the commercial fishing fleet at Lake Montauk Harbor will deviate from the general trend of using larger, deeper draft vessels. This measure was removed from further consideration because it does not meet study objective 1. Specifically, Measure 1 does not provide adequate channel depths for the existing fleet. Rather, the measure would call for the replacement of the existing fleet and meets no other study objective.

2. **High water transit; Waiting for high tide to traverse the inlet for deeper draft vessels.** Astronomical tides in the study area are semi-diurnal, flooding and ebbing twice a day. The mean and spring tides range from 2.0 to 2.4 feet. Waiting for the tide leads to costly delays for commercial fishing vessels as estimated by local fishing captains. The U.S. Coast Guard reports that potentially unsafe navigation practices result from the limited channel depth. This measure was removed from further consideration because it does not meet study objective 1; the measure does not provide reliability nor is it cost effective, based on, for example, at least a portion of the without project commerce not realized.

3. **Relocation of the Existing Fleet.** Relocation of the existing fleet would be to the nearest major commercial fishing fleet, which is at Shinnecock Inlet. This measure was removed from further consideration because it is not cost effective. Indeed, boats still calling at Lake Montauk Harbor would relocate to another harbor if it were cost effective.

4. **Channel Extension East and West of Star Island.** Extending the channel into the former yacht basin area, east of Star Island, was also given consideration. The use of the area which is maintained by the Town of East Hampton was investigated for the purposes of including a turning basin for transient vessels and for access to southern portions of the lake. The presence of sea grass beds and productive shellfish areas in the shallow portions of Lake Montauk, south of Star Island, would require a detailed evaluation of potential environmental impacts associated with such extension. The option would likely be less cost effective than other viable plans as there is no advantage for the large fishing boats to transit further into the harbor. Generally, only recreational vessels would benefit from a channel extension and Corps projects cannot be formulated with recreation as a purpose. The federal government is restricted from participating in maintenance of private marinas, berthing areas, and access points. In addition, extending the federal channel into the Coonsfoot Cove area, west of Star Island, was given consideration. However, the large percentage of silts and clays in the sediment would make this material unsuitable as beach fill and would require further environmental testing. This measure was removed from further consideration because it does not meet study objective 1 in that it does not provide adequate channel depths. The requirement for detailed environmental evaluation also makes this measure likely technically not feasible.

5. **Channel Widening.** The present authorized channel width of 150 feet was determined to be sufficient for two-way vessel traffic clearances. Since channel deepening would inevitably lead to a wider channel also, this option was not given further consideration. It also meets no other study objective.

6. **Channel Realignment.** Any major shift in the authorized channel due to its large initial costs would likely be not feasible. Shifting the outer channel west of its present position would temporarily improve the present shoaling condition resulting from east jetty leakage, but this plan
would not solve the deeper draft requirements of the larger vessels per Objective 1. It also would not provide a long-term safeguard against shoaling because, without jetty rehabilitation, sand bars would begin to form again. This option was not considered as an effective use of resources. It also meets no other study objective, and it was not considered further.

7. Deepening of Boat Basin. Sediment sample analyses indicated the presence of many silts and clays in this area, which is currently authorized at -10 feet MLLW. This may be a disposal hindrance, pending further testing. The area is currently used primarily by shallow draft recreational craft. Based on boating survey conducted in 2005, there are not enough transient vessels or turning basin needs to deepen the existing depth. Further, this measure does not address the channel. It also meets no other study objective. As a result, this option was not considered further.

8. Sand-Bypassing. Based on the results of sediment budget analysis, there is an approximately 12,800 cubic yard per year sediment supply from the updrift (east) shoreline. Of the total supply, approximately 7,000 cubic yards per year is bypassed to the downdrift beach via channel dredging and approximately 800 cubic yards per year is lost to deep water offshore. The remaining 5,000 cubic yards per year continues to accumulate to the east of the inlet. The east sediment fillet is close to saturation and the accumulated sediment is shoaling the entrance channel both around the east jetty and by migration into the inner channel via gaps in east jetty. The accumulated updrift sediment fillet could be bypassed to the downdrift beach via trucking or hydraulic pumping across the channel to reduce future channel shoaling and maintenance dredging costs. Due to the small bypassing rate, temporary hydraulic pumping equipment or trucking would be more cost-effective than using a fixed bypassing plant which requires a high investment cost (close to $1,000,000) and annual operation, maintenance, and equipment depreciation, which may double the unit trucking cost of $15 to $20 per cubic yard to $30 to $40 per cubic yard. Further, mechanical dredging has been determined to not be engineeringly feasible based on previous experience in a similar study area at Mattituck, New York.

9. Jetty Rehabilitation. Rehabilitation of the eastern jetty could play an essential role in improving navigation through the channel for the vessel fleet. A large portion of the shoaling material that enters the channel results from leakage through the eastern jetty. Accordingly, this plan component could reduce the future operation and maintenance costs for the navigation channel. The without-project future condition would mean continued deterioration of the eastern jetty and a mandate for more frequent dredging (shorter dredging cycles). Since the shoal that results from leakage tends to be localized but quite intrusive at certain channel points, this component could help enhance navigation maneuverability. The U.S. Army Corps of Engineers New York District, under a separate operations and maintenance authority, rehabilitated a section of the eastern jetty from Station 5+55 to 9+55 together with a tie-in at the inshore end in year 1999. Despite this, it is projected that seepage of sand into channel through the voids of the east jetty would continue without further rehabilitation. The jetty rehabilitation component is not included for further consideration because previous analyses showed that it would not be cost effective in reducing the need for navigation maintenance, and it is assumed that future rehabilitations will be conducted under O&M authority.

10. Deepening of the Federal Navigation Channel. There is a trend toward larger, deeper draft commercial fishing vessels. In 1993, there were 24 vessels overall with a loaded draft of 12 to 13
feet that listed Lake Montauk Harbor as a homeport. According to local fishing captains who were recently interviewed, there are approximately 15 large fishing vessels that operate out of the harbor. The vessels range from 50 to 100 feet in length with loaded drafts of 10 to 16 feet. When considering squat requirements, wave allowance requirements, and safety clearances, deepening would be necessary under present guidance and would meet concerns of local interests. Deepening would improve navigation through the channel for the existing and future fleet and would enhance navigation maneuverability. This measure is considered further.

11. Removal of shoal at the inshore end of the East Jetty. A large sand shoal has been developing near the inshore end of the eastern jetty, just northeast of Star Island. It has been infringing upon the authorized channel width. In 1995, 2000, 2004, 2009, 2011, and 2014 the U.S. Army Corps of Engineers New York District removed part of this shoal during maintenance dredging. Local interests have indicated however that it has already begun to shoal in again because the jetty has not been rehabilitated enough to prevent further leakage into this area. However, due to the construction of a bulkhead, complete removal of the shoal will result in flanking of the structure; therefore this measure is no longer technically feasible and does not meet technical constraints.

12. Advance maintenance dredging outside the channel limits as a deposition basin. Over the past several dredging cycles (1991, 1995, 2000, 2009, 2011, and 2014), advanced maintenance dredging measures have been employed. Essentially, for a length of channel approximately equal to the existing east jetty length, an additional 50 feet (outside and to the east of the existing channel) is dredged. This additional cut serves as a deposition basin to protect the authorized channel. This is also done for economic reasons because removing larger quantities is more efficient, given the high dredging mobilization and demobilization costs. This practice could be permanent and extended around the bend and into the inner channel, approximately an additional 1,800 feet length. The width of the deposition basin could be extended from 50 feet to 100 feet to increase the capacity. This measure is carried forward for further consideration.

3.1 Initial Set of Alternatives

Measures that remained after the initial screening were considered for the initial set of alternatives. In the final set of alternatives, navigation improvement measures were combined to arrive at two alternatives for further evaluation and consideration. Alternative 1, for these evaluations, is the future without project condition.

Alternative 2: Uniform dredging of the 150-foot-wide channel and 50-foot-wide deposition basin:

This alternative includes Measures 10 and 12. The depths considered for a new congressional authorization to be considered range from -14 to -18 feet MLLW for the channel and the deposition basin. The expected maintenance cycle would be 4 years. All dredged material would be placed on the downdrift beach, but with no design.

Alternative 3: Uniform dredging of the 150-foot-wide channel and 100-foot-wide deposition basin:

This alternative includes Measures 10 and 12 with the option in 12 to widen the deposition basin to 100 feet. The depths considered for a new congressional authorization to be considered range from -14 to -18 feet MLLW for the channel and the deposition basin. The expected maintenance
cycle would be 7 years. All dredged material would be placed on the downdrift beach but with no design.

Figure 1 shows the channel and deposition and the stationing to be used. The 150-foot navigation channel and 50-foot deposition basin are shown in red. The eastern 50-foot deposition basin extension proposed in Alternative 3 is shown in blue.
## Table 4: Measure Screening Summary

<table>
<thead>
<tr>
<th>Measure</th>
<th>Benchmarks</th>
<th>Carried Forward</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Provides adequate channel depths for reliable navigation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provides for efficient navigation maintenance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efficiently utilizes all dredged material</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Unconventional drafts</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2. High water transit</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3. Relocation of the existing fleet</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4. Channel Extension East and West of Star Island</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5. Channel Widening</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6. Channel Realignment</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>7. Deepening of Boat Basin</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>8. Sand-Bypassing</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9. Jetty Rehabilitation</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td>10. Deepening of the Federal Navigation Channel</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>11. Removal of Shoal at the Inshore End of the East Jetty</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>12. Advance Maintenance Dredging Outside the Channel Limits as a Deposition Basin</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figures 2 – 5 show typical cross-sections of the alternatives at select depths. The angle of elevation of the sides of the channels are defined by their side slopes and are the standard 1 vertical on 3 horizontal.

Figure 2: Select Channel Alternatives at Station 0+00

Figure 3: Select Channel Alternatives at Station 6+00

Figure 4: Select Channel Alternatives at Station 14+00
3.2 The Federal Objective

Per the 1983 Principles and Guidelines, the federal objective of water and related land resources project planning is to “contribute to national economic development consistent with protecting the Nation’s environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements”. Table 8 shows the the costs for construction of Alternatives 2 and 3 at the depths ranging from -14 feet to -18 feet MLLW (October 2020 price level and using the fiscal year 2019 interest rate of 2.875%).

Principles and Guidelines Criteria, 1983

The 1983 Principles and Guidelines require that plans are formulated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability.

Completeness is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other federal and non-federal entities. For the Lake Montauk Harbor navigation improvement feasibility study, an alternative had to provide benefits to all similarly-situated commercial fishermen to be considered complete.

Effectiveness is the extent to which the alternative plans contribute to achieve the planning objectives. Effectiveness of the alternatives was measured by the benefits that the alternative would provide to the commercial fishermen. Alternatives that have a benefit cost ratio (BCR) lower than one will be eliminated from consideration.

Efficiency is the extent to which an alternative plan is the most cost effective means of achieving the objectives. Efficiency will be measured through a comparison of BCRs and benefits. Plans that provide the same benefits, but at higher cost, will be eliminated from consideration.

Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies. The alternatives were formulated to be in accord with applicable laws and regulations.
4. ESTIMATION OF DAMAGES AND BENEFITS

4.1 Without-project Damages

The without-project damages follow from the future without-project condition as described in Subsection 2.2. USACE risk analysis based on Monte Carlo simulation using @Risk Software of the continuing erosion, future storm damage, and required maintenance and repairs provides an estimate of $1,840,000 in terms of equivalent annual damages in FY 2019 price levels.

4.2 With-project Damages and Benefits

The with-project damages and benefits are based on risk analysis using Monte Carlo simulation and survey evidence of the captains of vessels operating in the study area, with consideration of the alternative plans. The survey evidence contains sufficient information to perform cost effectiveness and incremental cost analysis. Incidental CSRM benefits are calculated for a Tentatively Selected Plan (TSP) following the optimization.

4.2.1 Additional Fish Production and Costs Avoided

It is necessary to know the preliminary benefits and costs of the alternatives in order to assess their effectiveness and efficiency. Benefits of each alternative come directly from the additional production that commercial fishermen can realize at the incremental channel depths as they reported on the study survey approved by the Office of Management and Budget. Survey results updated in 2019 reliably report benefits in three categories: (1) additional commerce (or income) from getting fish to market fresher, (2) savings in fuel and supplies used per trip, and (3) reduction in vessel maintenance and repair.

Table 5 contains the increase in additional income that captains and vessel owners have forecasted that they would earn from getting fresher fish to market at various channel depths. The largest increase in benefits attributable to this variable occurs at 16’ with $460,000 more income. At -17 feet MLLW, no further benefits are realized in terms of getting fresher fish to market.

Table 6 contains the estimated savings in fuel and supplies at various channel depths. Savings in fuel in supplies may occur at various channel depths by: (1) allowing vessels to transit the channel at optimal timing as opposed to high tide, and (2) availing depth-limited vessels the lesser-cost option of operating out of Lake Montauk Harbor. Benefits are realized at each channel depth greater than -12 feet MLLW, derived from using the nation’s scarce resources in an optimal way. If the channel is deepened to -17 feet MLLW, $707,000 will be saved in terms of fuel and supplies among the 10 vessels surveyed.

Captains’ and vessel owners’ estimates of the reduction in vessel repair and maintenance required at various channel depths is organized in Table 7. Vessel repair and maintenance is required after the documented channel groundings. Survey evidence indicates that the captains and vessel owners would realize $25,000 in reduced repairs and maintenance if the channel were dredged and maintained at -12 feet MLLW. This reflects that shoaling is sufficiently problematic at the current nominal depth to cause scraping of the channel bottom, propeller damage, and groundings. As the authorized depth of the channel becomes greater, captains and vessel
Table 5: Increase in Additional Income from Fresher Fish to Market at Various Channel Depths

<table>
<thead>
<tr>
<th>Fishing Vessel</th>
<th>Design Draft (ft)</th>
<th>Draft entering harbor (ft)</th>
<th>12 feet</th>
<th>13 feet</th>
<th>14 feet</th>
<th>15 feet</th>
<th>16 feet</th>
<th>17 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel A</td>
<td>12</td>
<td>12-13</td>
<td>$0</td>
<td>$0</td>
<td>$80,000</td>
<td>$125,000</td>
<td>$225,000</td>
<td>$225,000</td>
</tr>
<tr>
<td>Vessel B</td>
<td>10</td>
<td>10</td>
<td>$0</td>
<td>$46,000</td>
<td>$69,000</td>
<td>$69,000</td>
<td>$69,000</td>
<td>$69,000</td>
</tr>
<tr>
<td>Vessel C</td>
<td>9.5</td>
<td>9.5</td>
<td>$0</td>
<td>$0</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$20,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>Vessel D</td>
<td>13</td>
<td>11-13</td>
<td>$0</td>
<td>$25,000</td>
<td>$25,000</td>
<td>$25,000</td>
<td>$25,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>Vessel E</td>
<td>16</td>
<td>10-16</td>
<td>$0</td>
<td>$0</td>
<td>$150,000</td>
<td>$300,000</td>
<td>$450,000</td>
<td>$450,000</td>
</tr>
<tr>
<td>Vessel F</td>
<td>15</td>
<td>15</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>Vessel G</td>
<td>10.5</td>
<td>10.5</td>
<td>$0</td>
<td>$40,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
<td>$60,000</td>
</tr>
<tr>
<td>Vessel H</td>
<td>13.5</td>
<td>13.5</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$200,000</td>
<td>$200,000</td>
<td>$200,000</td>
</tr>
<tr>
<td>Vessel I</td>
<td>11.7</td>
<td>11.7</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel J</td>
<td>12.4</td>
<td>12.4</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total Income</td>
<td></td>
<td></td>
<td>$0</td>
<td>$111,000</td>
<td>$394,000</td>
<td>$789,000</td>
<td>$1,249,000</td>
<td>$1,249,000</td>
</tr>
</tbody>
</table>

Table 6: Estimated Savings in Fuel and Supplies at Various Channel Depths

<table>
<thead>
<tr>
<th>Fishing Vessel</th>
<th>Vessel Design Draft (ft)</th>
<th>Vessel Draft entering harbor (ft)</th>
<th>12 feet</th>
<th>13 feet</th>
<th>14 feet</th>
<th>15 feet</th>
<th>16 feet</th>
<th>17 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel A</td>
<td>12</td>
<td>12-13</td>
<td>$0</td>
<td>$0</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$80,000</td>
<td>$80,000</td>
</tr>
<tr>
<td>Vessel B</td>
<td>10</td>
<td>10</td>
<td>$0</td>
<td>$5,000</td>
<td>$9,000</td>
<td>$12,000</td>
<td>$12,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>Vessel C</td>
<td>9.5</td>
<td>9.5</td>
<td>$0</td>
<td>$0</td>
<td>$2,000</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$3,000</td>
</tr>
<tr>
<td>Vessel D</td>
<td>13</td>
<td>11-13</td>
<td>$0</td>
<td>$0</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Vessel E</td>
<td>16</td>
<td>10-16</td>
<td>$0</td>
<td>$0</td>
<td>$45,000</td>
<td>$150,000</td>
<td>$250,000</td>
<td>$300,000</td>
</tr>
<tr>
<td>Vessel F</td>
<td>15</td>
<td>15</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$90,000</td>
<td>$120,000</td>
</tr>
<tr>
<td>Vessel G</td>
<td>10.5</td>
<td>10.5</td>
<td>$0</td>
<td>$6,000</td>
<td>$8,000</td>
<td>$10,000</td>
<td>$12,000</td>
<td>$12,000</td>
</tr>
<tr>
<td>Vessel H</td>
<td>13.5</td>
<td>13.5</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$90,000</td>
<td>$120,000</td>
<td>$120,000</td>
</tr>
<tr>
<td>Vessel I</td>
<td>11.7</td>
<td>11.7</td>
<td>$0</td>
<td>$0</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Vessel J</td>
<td>12.4</td>
<td>12.4</td>
<td>$0</td>
<td>$0</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$5,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Total Income</td>
<td></td>
<td></td>
<td>$0</td>
<td>$11,000</td>
<td>$174,000</td>
<td>$374,000</td>
<td>$627,000</td>
<td>$707,000</td>
</tr>
</tbody>
</table>
owners anticipate larger savings in vessel repair and maintenance, up to $310,000 at -17 feet MLLW.

Two captains, for Vessel F which draws 15 feet and Vessel E which draws 16 feet, were the two respondents to report incremental benefits in any of these three categories from a newly Congressionally authorized depth from -16 to -17 feet MLLW. Thus, 20% of the survey respondents realize further benefits from the marginal increase in depth to -17 feet MLLW. The benefits are realized in savings in fuel and supplies and reduction vessel repair and maintenance. Further, both reported in follow-up telephone interviews conducted by New York District staff that they would not have additional benefits quantifiable if the channel were to be newly congressionally authorized at -18 feet MLLW or any greater depth.

Table 7: Reduction in Vessel Repair and Maintenance at Various Channel Depths

<table>
<thead>
<tr>
<th>Fishing Vessel</th>
<th>Vessel Design Draft (ft)</th>
<th>Vessel Draft entering harbor (ft)</th>
<th>Channel Depths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12 feet</td>
<td>13 feet</td>
</tr>
<tr>
<td>Vessel A</td>
<td>12</td>
<td>12-13</td>
<td>NA</td>
</tr>
<tr>
<td>Vessel B</td>
<td>10</td>
<td>10</td>
<td>$10,000</td>
</tr>
<tr>
<td>Vessel C</td>
<td>9.5</td>
<td>9.5</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel D</td>
<td>13</td>
<td>11-13</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel E</td>
<td>16</td>
<td>10-16</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel F</td>
<td>15</td>
<td>15</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel G</td>
<td>10.5</td>
<td>10.5</td>
<td>$15,000</td>
</tr>
<tr>
<td>Vessel H</td>
<td>13.5</td>
<td>13.5</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel I</td>
<td>11.7</td>
<td>11.7</td>
<td>$0</td>
</tr>
<tr>
<td>Vessel J</td>
<td>12.4</td>
<td>12.4</td>
<td>$0</td>
</tr>
<tr>
<td>Total Income</td>
<td></td>
<td></td>
<td>$25,000</td>
</tr>
</tbody>
</table>

The cost structure of the two alternatives and the FWOPC is organized in Table 8 according to the various channel depths. Construction duration is listed in the second column. The following columns contain operations and maintenance (O&M), O&M contingency, interest during construction (IDC), the total present value cost of the project, and costs in annualized terms. Interest during construction and discounting are based on the 2.875% interest rate. The detailed derivation of these costs can be found in the cost engineering appendix. The final column contains annual total cost and this will be used for the evaluation of alternatives. The total cost is the sum of first cost and the marginal O&M costs. The marginal O&M costs are those O&M costs above the FWOPC O&M costs, which amount to $6,000 for Alternative 2. Alternative 3 has annual O&M $50,000 lower than the FWOPC. As a result, this line item is zero and the margin is recorded as costs avoided. Observe that annual costs are increasing with greater channel depths generally, and Alternative 3 has a slightly higher total cost due to construction of the 100-foot deposition basin. Table 9 contains a summary of the estimated benefits together with the estimated total
annual cost for Alternatives 2 and 3 at channel depths of 14 feet through 18 feet. The fourth column presents the net benefits as calculated by the difference of benefits and costs. The fifth column contains the ratio of benefits to costs. Based on having the greatest net navigation improvement benefits of $2,178,000, Alternative 3 with a 100-foot-wide deposition basin authorized to a depth of 17 feet MLLW is identified as the Tentatively Selected Plan. This plan best alleviates the problem of a group of vessels having to change their operations in a suboptimal way. The benefits of more than $2M come from the savings of the nation’s scarce resources that result from operating these vessels in an optimal way.

Table 8: Cost Breakdown by Alternative

<table>
<thead>
<tr>
<th>Alt</th>
<th>Months</th>
<th>First Cost w/ Cont</th>
<th>O&amp;M</th>
<th>O&amp;M-Cont</th>
<th>IDC</th>
<th>Total PV</th>
<th>Annual First Cost</th>
<th>Annual O&amp;M</th>
<th>Annual Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT 1: FWOP</td>
<td></td>
<td>$4,123,000</td>
<td>$1,030,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALT 2 (14' +2')</td>
<td>0.6</td>
<td>$1,737,000</td>
<td>$4,266,000</td>
<td>$1,065,000</td>
<td>$5,000</td>
<td>$7,068,000</td>
<td>$66,000</td>
<td>$202,000</td>
<td>$72,000</td>
</tr>
<tr>
<td>ALT 2 (15' +2')</td>
<td>1</td>
<td>$2,279,000</td>
<td>$4,266,000</td>
<td>$1,065,000</td>
<td>$6,000</td>
<td>$7,610,000</td>
<td>$86,000</td>
<td>$202,000</td>
<td>$92,000</td>
</tr>
<tr>
<td>ALT 2 (16' +2')</td>
<td>1.3</td>
<td>$2,723,000</td>
<td>$4,266,000</td>
<td>$1,065,000</td>
<td>$6,000</td>
<td>$8,053,000</td>
<td>$103,000</td>
<td>$202,000</td>
<td>$109,000</td>
</tr>
<tr>
<td>ALT 2 (17' +2')</td>
<td>1.6</td>
<td>$3,105,000</td>
<td>$4,266,000</td>
<td>$1,065,000</td>
<td>$7,000</td>
<td>$8,436,000</td>
<td>$118,000</td>
<td>$202,000</td>
<td>$124,000</td>
</tr>
<tr>
<td>ALT 2 (18' +2')</td>
<td>1.9</td>
<td>$3,527,000</td>
<td>$4,266,000</td>
<td>$1,065,000</td>
<td>$8,000</td>
<td>$8,858,000</td>
<td>$134,000</td>
<td>$202,000</td>
<td>$140,000</td>
</tr>
<tr>
<td>ALT 3 (14' +2')</td>
<td>1</td>
<td>$2,212,000</td>
<td>$3,070,000</td>
<td>$766,000</td>
<td>$6,000</td>
<td>$6,048,000</td>
<td>$84,000</td>
<td>$146,000</td>
<td>$84,000</td>
</tr>
<tr>
<td>ALT 3 (15' +2')</td>
<td>1.4</td>
<td>$2,779,000</td>
<td>$3,070,000</td>
<td>$766,000</td>
<td>$7,000</td>
<td>$6,615,000</td>
<td>$105,000</td>
<td>$146,000</td>
<td>$105,000</td>
</tr>
<tr>
<td>ALT 3 (16' +2')</td>
<td>1.7</td>
<td>$3,242,000</td>
<td>$3,070,000</td>
<td>$766,000</td>
<td>$8,000</td>
<td>$7,078,000</td>
<td>$123,000</td>
<td>$146,000</td>
<td>$123,000</td>
</tr>
<tr>
<td>ALT 3 (17' +2')</td>
<td>2</td>
<td>$3,633,000</td>
<td>$3,070,000</td>
<td>$766,000</td>
<td>$9,000</td>
<td>$7,469,000</td>
<td>$138,000</td>
<td>$146,000</td>
<td>$138,000</td>
</tr>
<tr>
<td>ALT 3 (18' +2')</td>
<td>2.3</td>
<td>$4,080,000</td>
<td>$3,070,000</td>
<td>$766,000</td>
<td>$10,000</td>
<td>$7,916,000</td>
<td>$155,000</td>
<td>$146,000</td>
<td>$155,000</td>
</tr>
</tbody>
</table>

4.2.2. Incidental CSRM Benefits

USACE performs risk analysis of the expected future damages using Monte Carlo simulation in the same way that the without-project damages are estimated. The Monte Carlo simulation is performed using @Risk software based on the cost of rip rap and backfill, RSLC, and characteristics of erosion and structures at the coast. The model is based on data from three reaches.

- Reach 1 consists of approximately 1,200 feet of shoreline with an approximately 20-foot wide beach on the Long Island Sound side, an armored dune/revetment with elevation +12.5 feet NAVD, and a paved road along the shore line immediately landward of the dune.

---

5 Cost-benefit analysis was not performed for a depth of 13 feet. In practice, the fixed costs associated with a channel deepening project far outweigh the expected benefits for such little increases in channel depth.
### Table 9: Annual Costs and Benefits for Final Set of Alternatives

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Depth</th>
<th>Total Cost Annualized</th>
<th>Benefits Annualized</th>
<th>Net Benefits Annualized</th>
<th>Benefit-to-Cost Ratio (BCR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 2: Channel &amp; Deposition Deepening</td>
<td>14' +2'</td>
<td>$72,000</td>
<td>$743,000</td>
<td>$671,000</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>15' +2'</td>
<td>$92,000</td>
<td>$1,388,000</td>
<td>$1,296,000</td>
<td>15.1</td>
</tr>
<tr>
<td></td>
<td>16' +2'</td>
<td>$109,000</td>
<td>$2,161,000</td>
<td>$2,052,000</td>
<td>19.8</td>
</tr>
<tr>
<td></td>
<td>17' +2'</td>
<td>$124,000</td>
<td>$2,266,000</td>
<td>$2,142,000</td>
<td>18.3</td>
</tr>
<tr>
<td></td>
<td>18' +2'</td>
<td>$140,000</td>
<td>$2,266,000</td>
<td>$2,126,000</td>
<td>16.2</td>
</tr>
<tr>
<td>Alternative 3: Channel &amp; Deposition Deepening + 100-Foot-Widened Basin</td>
<td>14' +2'</td>
<td>$84,000</td>
<td>$793,000</td>
<td>$709,000</td>
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<tr>
<td></td>
<td>15' +2'</td>
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<td>$1,438,000</td>
<td>$1,333,000</td>
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<td></td>
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<td>$2,211,000</td>
<td>$2,088,000</td>
<td>18</td>
</tr>
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<td>$138,000</td>
<td>$2,316,000</td>
<td>$2,178,000</td>
<td>16.8</td>
</tr>
<tr>
<td></td>
<td>18' +2'</td>
<td>$155,000</td>
<td>$2,316,000</td>
<td>$2,161,000</td>
<td>14.9</td>
</tr>
</tbody>
</table>

- Reach 2 consists of approximately 1,800 feet of shoreline with an approximately 20-40-foot wide beach on the Sound side backed by bulkheads with an average crest elevation of +10 feet NAVD. Behind the bulkhead line exist 19 residential structures with an average depreciated structure replacement value of $457,000 and an average offset from the bulkhead line of 70 feet.
- Reach 3 consists of approximately 1,800 feet of shoreline, a narrow beach on the Sound side that is backed by bulkheads, and an elevation of +12.5 feet NAVD. Landward of the bulkhead line are 21 residential structures with an average depreciated structure replacement value of $362,000 and an average offset from the bulkhead line of 60 feet.

Damages are based on emergency services and clean-up that result from a major overtopping, bulkhead failure, or minor overtopping or still water.

With the deeper dredging project at -17 feet MLLW, additional dredged material beyond that which would arise from the current maintenance schedule would be available. The dredged material would be placed within 3,000 feet of the western jetty, creating a berm 44 feet wide. The benefits would be greatest in the first year of placement and decay linearly through the tenth year. The simulation of the with-project scenario projects that the continuing erosion, future storm damage, and required maintenance and repairs lead to $45,958,000 in damages over the 50-year period of study. This means that the TSP provides $175,000 in annualized incidental CSRM benefits.
The annual net benefits of the TSP taking into account the incidental CSRM benefits are $2,353,000.

4.2.3 Operations and Maintenance Costs Avoided

Advance maintenance dredging outside the channel limits is a key component of both alternative plans. The advance maintenance dredging serves as a deposition basin; a dredged area outside the channel where sediment accrues and allows the channel to maintain its authorized depth longer. The use of a 100-foot deposition basin with Alternative 3 stretches out the required maintenance dredging schedule from every four years to every seven years. The same effective level of operations and maintenance of the channel can therefore be provided at a lower cost, accruing benefits to Alternative 3. The operations and maintenance costs avoided with Alternative 3 are $50,000 per year. That is to say, the channel would be maintained at its authorized depth for $50,000 less than what the costs would have been in the future without-project condition.

The deposition basin proposed in Alternative 2 is 50 feet wide. This deposition basin is not large enough to stretch out the operations and maintenance schedule. As such, dredging would be required every four years with Alternative 2 as with the future without-project condition. What's more, the operations and maintenance schedule begins in 2025 with Alternative 2, one year before the first cycle of the future without-project condition. As a result, annual costs of operations and maintenance following Alternative 2 would be $6,000 higher than what they would have been in the future with-out project condition. As it cost more with Alternative 2 to achieve the same effective level of operations and maintenance, this component of Alternative 2 incurs $6,000 in additional costs.

4.2.4 Sensitivity Analysis

The sensitivity of the formulation and conclusion of the TSP can be assessed across three factors. First, as identified in Section 3.3 in the main report, RSLC is a key uncertainty. Second, the choice of discount factor matters for the weighing of future benefits against upfront costs. Third, the magnitude of the benefits derived from the survey evidence are projections and inherently subject to error.

4.2.4.1 Relative Sea Level Change

Relative sea level change will impact the operations and maintenance cycle for dredging the channel and the incidental CSRM benefits realized as the result of the least-cost placement of dredged material on the adjacent downdrift beach. The intermediate (high) scenario for RSLC for this area is projected to be 3 (7) feet over 100 years. Higher relative sea levels have the effect of extending the required maintenance cycle. This effect would translate into a monotonic shift of the cost curves because the rate of littoral build-up is 8,000 cubic yards for each alternative, and one RSLC scenario would be applied to each set of alternatives at a time. All else equal, this would not change the net benefits ranking of the alternatives for the various channel depths.

The incidental CSRM benefit depend in a small way on the RSLC scenario. It is reasonable to assume with faster rising sea level, erosion happens quicker. However, the benefits are realized during the first 10 years of the analysis period during which time the sea levels across all three scenarios are similar, even while the rates of sea level change are not. Despite the small reduction
expected for the incidental CSRM benefits with higher rates of sea level change, this effect would not change the formulation of the TSP. The plan was formulated for navigation improvements. The CSRM benefits derived from the least cost placement of the dredged material are incidental to the evaluated benefits and are therefore evaluated ex post facto.

4.2.4.2 Benefits Magnitude

The magnitude of the benefits derived from the survey evidence are projections based on a sample of captains’ and vessel owners’ projections for benefits at various channel depths. Due to the nature of the estimate and the small sample, error is inherent to the magnitude identified. An assessment of the sensitivity of the conclusions to this error can be made by varying the size of the benefits by a margin of 10%. Table 10 contains the benefits and costs of the two alternatives at various channel depths, where a margin of 10% has been added to the magnitude of the survey outcomes.

Table 10: Sensitivity Analysis---Benefits Magnitude

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Total Cost Rounded</th>
<th>Benefits</th>
<th>Net Benefits</th>
<th>BCR</th>
<th>Benefits 10% Lower</th>
<th>Net Benefits 10% Lower</th>
<th>BCR 10% Lower</th>
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</thead>
<tbody>
<tr>
<td>ALT 2 (14’ +2’</td>
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<td>$2,493,000</td>
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<tr>
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<td>$2,039,000</td>
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<td>$2,493,000</td>
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<td>$2,542,000</td>
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<td>$2,542,000</td>
<td>$2,387,000</td>
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</tbody>
</table>

The benefits, net benefits, and benefit-cost ratio are organized in Columns 2—5 for 10% lower benefits, and the same attributes are organized in Columns 6—9 for 10% higher benefits. The margin of error is applied only to the survey evidence outcomes; Alternative 3 retains the $50,000 O&M cost avoided. Alternative 3 at -17 feet MLLW remains the plan with the highest net navigation benefits within the range of +/- 10% of the surveyed outcomes. The net navigation benefits range between $1,951,000 and $2,404,000 with benefit cost ratios ranging between 15.1 and 18.4 for the TSP.