Town of North Topsail Beach

North Carolina

North Topsail Beach Shoreline Protection Project

Phase I Contingency Plan

(Aerial Photo dated Oct. 5 2014, Provided by Dr. William Cleary)

March 2, 2015

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EXECUTIVE SUMMARY

The Town of North Topsail Beach completed Phase 1 of its beach and inlet management plan in February 2013. Phase 1 included relocating the main bar channel of New River Inlet to a preferred position and alignment with deposition of the dredged material along approximately 7,730 feet of the Town's shoreline south of New River Inlet. The intent of the bar channel relocation was to induce a build-up of material on the south side of New River Inlet which would eventually result in accretion along the northern portion of the Town's shoreline. CPE-NC stated in the engineering report associated with the Final Environmental Impact Statement (EIS) that predictions of the actual time for the shoreline between stations 1140+00 and 1160+00 (area from between Buildings #5 and #6 of Topsail Reefs to the south shoulder of New River Inlet) to respond to the new channel cannot be made with a high degree of certainty; however, significant accretion should occur within 5 years with full recovery occurring within 15 years following the channel relocation (CPE-NC, 2009). These projections were based on the implementation of a channel maintenance program that would maintain the channel in the preferred location.

Since completion of Phase 1, the northern portion of the project from baseline station 1140+00 north to the inlet has experienced inordinate erosion with most of the fill material placed in this area being eroded. The loss of the fill material placed the homes north of Topsail Reef in imminent danger requiring interim erosion response measures to protect threatened homes until such time as long term protection is established.

The Town began pursuing an emergency permit in August 2014 to install a sand bag revetment along the portion of the Phase 1 project north of the Topsail Reefs. The state permit was received in late November and federal authorizations were received in early December. Construction of the sand bag revetment project began on December 9, 2014 and is scheduled to be complete on February 24, 2015.

As part of the Town's long-term beach and inlet management program, the Town has a permit that allows repositioning the main bar channel of New River Inlet every 4 years providing one of two thresholds is met. One threshold involves shoaling of the new channel and the other is associated with the movement of the channel outside the preferred channel corridor. At present, both thresholds have been satisfied. However, given the inlet and shoreline response to the initial channel realignment, modifications to the original plan should be considered.

On August 15, 2014, the Town authorized CPE-NC to develop a contingency report to consider modifications to the existing long-term inlet management strategy associated with the Town's long-term beach and inlet management program. The modification considered are presented in detail below and include (1) re-directing the bar channel during navigation dredging to induce by-passing, (2) utilization of navigation channel maintenance material as beach fill along the north end, (3) modifications for the 2nd channel realignment event presently scheduled for the 2016-17 environmental dredging window, and (4) installation of a terminal groin structure on the south side of New River Inlet. This report describes CPE-NC's assessment and provides a recommended contingency plan for consideration by the Town.

ALTERNATIVE MANAGEMENT STRATEGIES CONSIDERED

Alternative 1: Federal Channel Maintenance Dredging To Induce By-Passing

This alternative involves close coordination with the USACE Wilmington Navigation Branch in an attempt to influence their routine maintenance of the ocean bar channel using USACE sidecast and hopper dredge plants in such a way as to possibly have some positive impact on sediment movement around the inlet from north to south. Analysis of changes in the ebb shoal as shown on satellite and aerial photographs as well condition surveys of the inlet conducted by the USACE may provide guidance on preferred channel alignments that could assist in a preferential reconfiguration of the ebb shoal.

Alternative 2: Utilization of Navigation Channel Maintenance Material

This alternative includes placement of material dredged during channel maintenance events on North Topsail Beach. Likely navigation maintenance material would include: 1) The portion of the New River channel to Jacksonville north of the AIWW; 2) The crossing of the Atlantic Intracoastal Waterway (AIWW) and the New River; and 3) The southern portion of Cedar Bush Cut that is regularly dredged. Some navigation material could possibly come from the outer bar channel of New River Inlet; however, this would require a different dredge than the one used to maintain the interior channels in order to operate seaward of the COLREG demarcation at the inlet.

Alternative 3: Modified Construction Plan for Maintenance of Channel Realignment Project

This alternative includes modifying the channel position and size to be dredged during the maintenance event scheduled for the 2016/2017. The first channel alignment project was constructed between November 2012 and February 2013. Since that time, beach profile surveys, a survey of the ebb shoal, and aerial photos have been used to monitor the performance of the project. Given the dynamic nature of New River Inlet and the observed response of the inlet to the Phase 1 channel, evaluations of additional channel alignment alternatives should be conducted using modern numerical modeling programs such as Delft3D. Delft3D has the capability of simulating changes in inlet morphology in response to man-induced changes and could be used to evaluate a full range of possible channel positions and alignments.

Alternative 4: Construction of a Terminal Groin

This alternative would include the installation of a terminal groin at the north end of the island to stem the high erosion rates experienced along the northern portion of the Island. The exact locations and dimensions of a terminal groin would depend on the portion of shoreline that the structure was designed to influence. Substantial data collection, modeling, and engineering design would be required to make such determinations.

A summary of the engineering and environmental analysis costs, cost to construct, and the date of implementation are included in the table below.

Alternative:	Date of Implementation	Engineering & Environmental Analysis Cost	Cost to Construct
1. Preferred Channel Alignment Dredging to Induce By-Passing	February 2015	$0	$0
2. Utilization of Navigation Channel Maintenance Material	November 2015	$0	$423,625 *
3. Modified Construction Plan for Maintenance of Channel Realignment Project	November 2016	$510,000	$4 Million *
4. Construction of a Terminal Groin	February 2018	$500,000	$5.6 Million - $7.5 Million

* - Denotes Town Portion of a Cost Shared Project

RECOMMENDATIONS

CPE-NC makes the following recommendations based on the evaluation of the alternatives presented herein as well as our understanding of the long term goals of the Town to provide sustained long-term beach nourishment for the North Topsail Beach ocean shoreline.

1. Implement Alternative 1 immediately. Request a meeting at the USACE Wilmington District office with staff from the Navigation Branch. The meeting should focus on requesting that the USACE coordinate with the Town regarding the channel alignment they intend to dredge during upcoming events. Discuss recent surveys and describe the process of sand bypassing to the south. Recommend that the USACE preferentially dredge channel alignments that may benefit the realignment strategy at times when an obvious deep-water channel is not present.

   The USACE was recently appropriated $500,000 for dredging of New River Inlet for FY 2015. The USACE has tentatively scheduled dredging, using the government plant (*Merritt*) in February, March, April, May, and June 2015. The Town should also request that if possible, the *Murden* or *Currituck* be used to dredge instead of the Sidecast dredge *Merritt*. Currently both vessels have open dates in April.

2. Schedule and conduct monitoring surveys of the Phase 1 project, Onslow Beach, and the Inlet to assess the reconfiguration of the ebb shoal in April 2015. This would be a duplication of the surveys conducted in April 2014 and should provide much needed information on assessing the performance of the channel realignment strategy.

3. Continue to coordinate with Onslow County and the state on a navigation maintenance project for November 2015. The project as described in Alternative 2 above, would use a contract cutterhead suction dredge to clear material from permitted channels in the Channel to Jacksonville, the AIWW, and Cedar Bush Cut. Initial estimates suggest approximately 100,000 cy of sand may be available in these channels. Sand would be placed along the northern 4,000 ft of beach depending on the amount of actual sand available at the time of dredging.

   Coordination and planning should include submitting a request for funding to the Division of Water Resources through the Shallow Draft Inlet Fund and developing bidding documents for the project.

4. Initiate model setup, calibration, and verification for assessing alternative channel designs and terminal groin. CPE-NC proposes the use of a number of analytical and numerical modeling tools. The primary tool recommended for these types of assessments is the Delft3D morphological model. The packages consists of two models, which are coupled together to determine changes in a topographic and bathymetric surface based on the effects of waves, water levels, winds, and currents. This effort would include obtaining existing data including those collected by CPE-NC and the USACE Field Research Facility staff during the RIVET I study. Additional oceanographic data would also need to be collected including additional tide, current, and bathymetric data.

5. Continue planning and coordination for the 2nd channel realignment project in 2016/2017, which would provide initial construction of an approximate 7,500 ft. of shoreline south of Phase 1. Planning would include coordination with the State to secure the matching funds needed to conduct the project, assessing alternative channel realignment options, obtaining additional vibracore data and cultural resource data to support permit modification requests, and obtaining permit modification to the existing permits to allow for an alternative channel configuration.

6. Initiate initial design analysis for a terminal groin at the north end. This includes using the Delft3D morphological model to assess terminal groin alternatives. This design work is the first step in an estimated 3-year process to design and permit a terminal groin. Proceeding with this recommendation would allow the Town to make a decision 1 year later as to the feasibility of pursuing a terminal groin without losing any time if they do chose to proceed. The additional year would also allow more time to assess the channel realignment project to determine its effectiveness.

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INTRODUCTION

The Town of North Topsail Beach completed Phase 1 of its beach and inlet management plan in February 2013. Phase 1 included relocating the main bar channel of New River Inlet to a preferred position and alignment with deposition of the dredged material along approximately 7,730 feet of the Town's shoreline south of New River Inlet. The intent of the bar channel relocation was to induce a build-up of material on the south side of New River Inlet which would eventually result in accretion along the northern portion of the Town's shoreline. CPE-NC stated in the engineering report associated with the Final Environmental Impact Statement (EIS) that predictions of the actual time for the shoreline between stations 1140+00 (area from between Buildings #5 and #6 of Topsail Reef) and 1160+00 (south shoulder of New River Inlet) to respond to the new channel cannot be made with a high degree of certainty; however, significant accretion should occur within 5 years with full recovery occurring within 15 years following the channel relocation (CPE-NC, 2009). These projections were based on the implementation of a channel maintenance program that would maintain the channel in the preferred location.

Beach profile monitoring has showed that the area outside the influence of the New River Inlet, from U.S. Army Corps of Engineers (USACE) baseline station 1140+00 (between Buildings 5 and 6 of the Topsail Reefs) south to station 1090+00 (end of fill placement for Phase 1), has performed as expected. The 2014 monitoring report showed the foreshore position between stations 1130+00 and 1090+00 retreated an average of approximately 14 feet between May 2013 and April 2014 (CPE-NC, 2014). The foreshore position at station 1140+00 retreated approximately 117 feet in the same timeframe; however, observations since the April 2014 survey were made suggest station 1140+00 may be stabilizing following initial profile equilibration.

In contrast, since completion of Phase 1, the northern portion of the project from baseline station 1140+00 north to the inlet has experienced inordinate erosion with most of the fill material placed in this area being eroded as of September 2014. The loss of the fill material placed the homes north of Topsail Reef in imminent danger requiring interim erosion response measures to prevent the loss of homes and roads until such time that long term protection is established.

The Town began pursuing an emergency permit in August 2014 to install a sand bag revetment along the portion of the Phase 1 project north of the Topsail Reefs. The state permit was received in late November and federal authorizations were received in early December. Construction of the sand bag revetment project began on December 9, 2014 and is scheduled to be complete by February 25, 2015.

As part of the Town's long-term beach and inlet management program, the Town has a permit that allows repositioning the main ocean bar channel of New River Inlet every 4 years providing one of two thresholds is met. One threshold involves shoaling of the new channel and the other is associated with the movement of the channel outside the preferred channel corridor. At present, both thresholds have been satisfied. However, given the inlet and shoreline response to the initial channel realignment, modifications to the original plan should be considered.

Again, the primary purpose for relocating the channel was to effect positive shoreline changes along the extreme north end of North Topsail Beach, i.e., the channel relocation was not

permitted to provide a source of beach nourishment material. Hence, the two channel relocation thresholds, mentioned above, were incorporated into the permit conditions to limit channel maintenance activities to those needed to maintain the preferred channel position and alignment.

On August 15, 2014 the Town authorized CPE-NC to develop a contingency report to consider modifications to the existing long-term inlet management strategy associated with the Town's long-term beach and inlet management program. The modification considered are presented in detail below and include (1) re-directing the bar channel during navigation dredging to induce by-passing, (2) utilization of navigation channel maintenance material as beach fill along the north end, (3) modifications for the 2nd channel realignment event presently scheduled for the 2016-17 environmental dredging window, and (4) installation of a terminal groin structure on the south side of New River Inlet. This report describes CPE-NC's assessment and provides a recommended contingency plan for consideration by the Town.

ALTERNATIVE MANAGEMENT STRATEGIES TO CONSIDER

Alternative 1: Federal Channel Maintenance Dredging To Induce By-Passing

Description:

This alternative involves close coordination with the USACE Wilmington Navigation Branch in an attempt to influence their routine maintenance of the ocean bar channel using USACE sidecast and hopper dredge plants (Figures 1 and 2) in such a way as to possibly have some positive impact on sediment movement around the inlet from north to south. Analysis of changes in the ebb shoal as shown on satellite and aerial photographs as well condition surveys of the inlet conducted by the USACE may provide guidance on preferred channel alignments that could assist in a preferential reconfiguration of the ebb shoal. Depending on budgetary constraints, the USACE surveys the channel several times per year to identify the deep water channel and provide mariners with Waypoints to locate the channel position. An example of the surveys performed by the USACE is provided on Figure 3 which shows the bathymetry data collected between January 21st and February 4th, 2015 in the vicinity of the New River Inlet complex.

Observations from recent aerial photos of the inlet (Figure 4) as well as the February 2015 bathymetry shown on Figure 3 suggest there may be a shore perpendicular channel located close to the north end of North Topsail Beach that if it is connected to deep water in the ocean, could induce sand bypassing to the southern half of the ebb tide delta. This possible channel breach is shown on Figure 4 labeled "Potential Alternative Alignment."

Figure 1. US Sidecast dredge *Merritt* used to maintain navigation channels in Cedar Bush Cut and the Ocean Bar Channel at New River Inlet (Courtesy of USACE Wilmington District Website).

Figure 2. Self-propelled hopper dredge (*Murden*) used to maintain navigation channels in Cedar Bush Cut and the Ocean Bar Channel at New River Inlet (Courtesy of USACE Wilmington District Website).

Regardless of where channel maintenance dredging is performed, the Town should encourage the USACE to utilized one of its ocean certified hopper dredges to dump the dredged material in the nearshore area off of the northern end of Topsail Beach. This was done during a recent maintenance dredging operation at New River conducted in November 2014 in which material was deposited in the nearshore area offshore of the Topsail Reef condominiums (Potter, pers. comm., 2007). Although the volume to be removed is likely to be relatively small, any material added to the littoral system south of New River Inlet would have the potential to slow the rate of shoreline erosion and could possibly shorten the timeframe for ebb shoal reconfiguration.

Requirements for Permitting and Design: The implementation of this alternative would not require the Town of North Topsail Beach to obtain any additional permits. The USACE currently has all authorizations required to maintain the ocean bar channel at a depth of -6 MLW +2 feet of overdepth.

This work is anticipated to be conducted under the MOA between the State of North Carolina and the USACE for maintenance dredging and would not require any additional design work on the part of the Town. The USACE would conduct all design work and survey work and such costs would be included in the total requested by the USACE under the conditions of the MOA to conduct the work.

Timeframe to Implement: This alternative could be implemented immediately. In this regard, a meeting between Town officials, representatives of Onslow County, CPE-NC and the USACE was conducted on February 13, 2015 to discuss the possibility of performing maintenance dredging along one of the two alignments shown on Figure 3. While the USACE was receptive to the idea, they are constrained by physical limitations of their dredges. In the case of the sidecast dredge, they can only work in areas that have at least 5.5 feet of water over the shoal area. Similarly, the hopper dredges require at least 6 to 7 feet of water. Based on the water depths shown by the January 2015 survey, water depths in each of the two channel corridors on Figure 3 appeared to be too shallow and the USACE was looking at possibly dredging along an alignment which would position the bar channel closer to the south end of Onslow Beach. The USACE did indicate they would be conducting additional surveys of the bar before making a final decision on where to dredge. In any event, this initial coordination meeting opened the dialogue with the USACE and provided both the Town and the USACE information on the goals and objectives of each party. The USACE Wilmington District Navigation website indicates a tentative scheduled for maintenance dredging in New River Inlet in February, March, April, May, and June of 2015, therefore, coordination meetings should be planned prior to the initiation of any future maintenance operations.

Estimated Cost to Implement: The USACE FY-15 Work Plan was released February 2, 2015. The Wilmington District was allocated $500,000 to conduct navigation maintenance. Therefore, we do not anticipate any additional cost to implement this strategy in FY 2015.

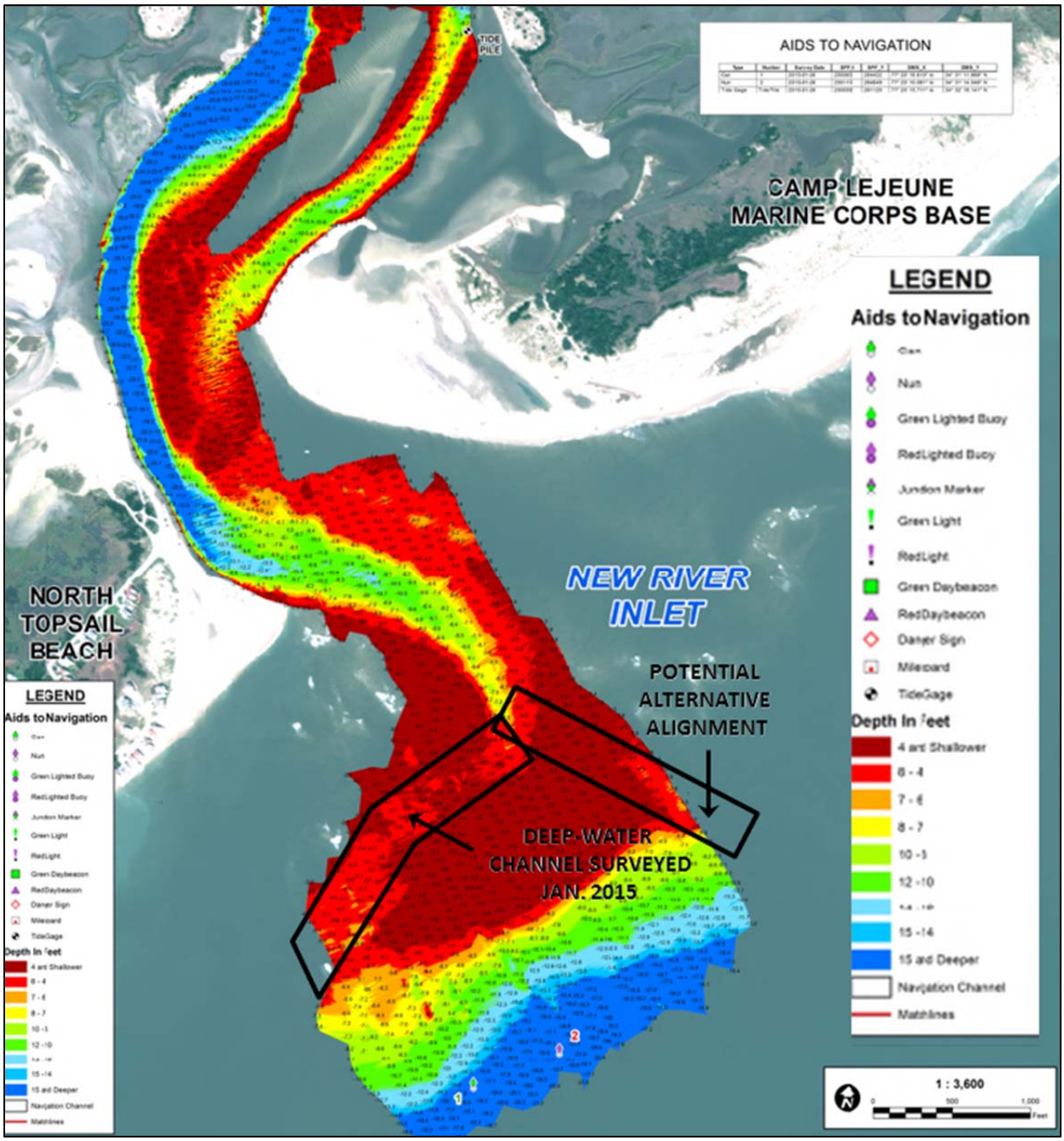

Figure 3. USACE Navigation Chart based on January 2015 surveys showing the surveyed deep-water channel, and a potential alternative alignment. (USACE Wilmington District Navigation Website).

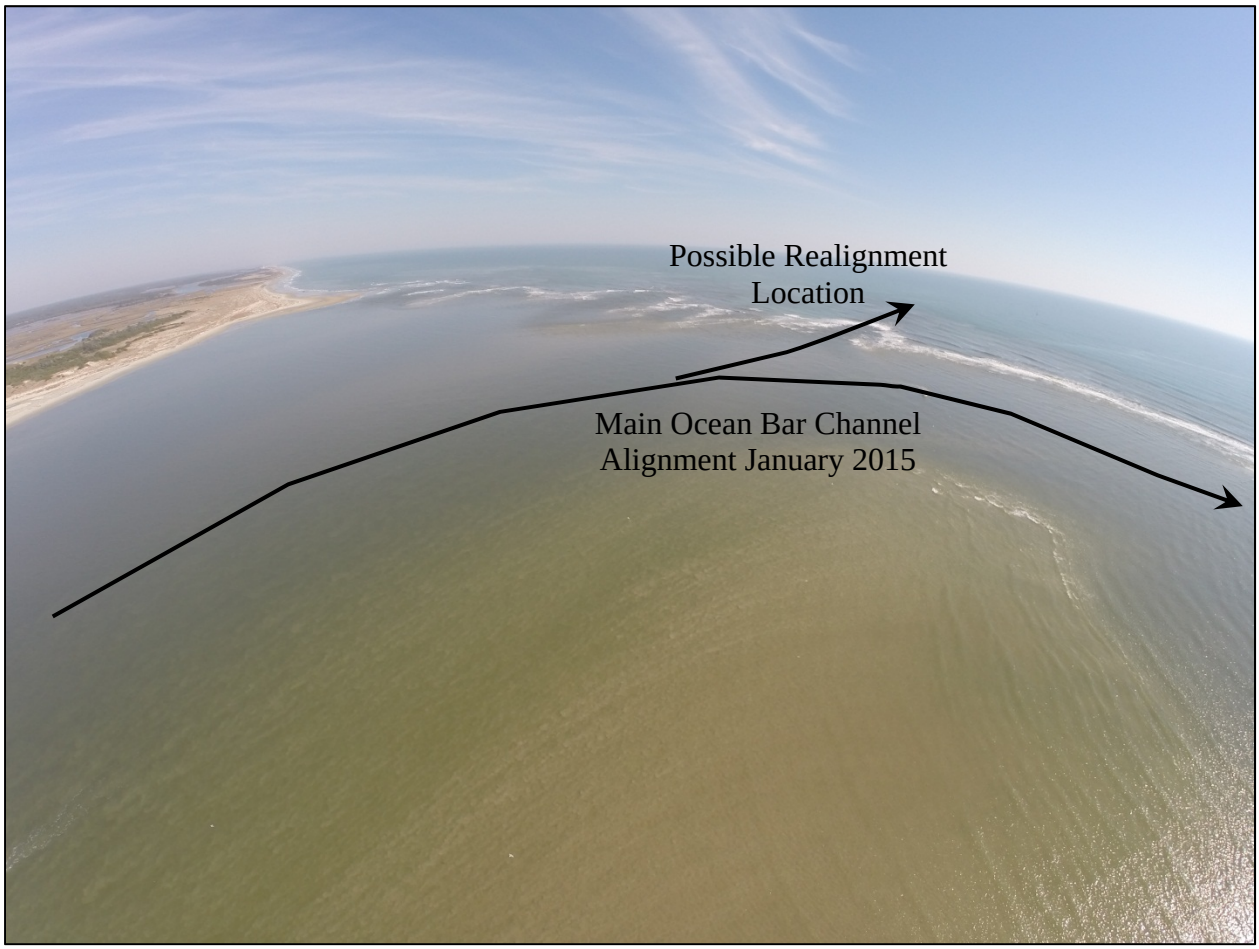

Figure 4. Oblique aerial photograph of the Ocean bar channel taken January 21, 2015 (Courtesy Mike Capuano).

Alternative 2: Utilization of Navigation Channel Maintenance Material

Description: This alternative includes placement of material dredged during channel maintenance events on North Topsail Beach. Likely navigation maintenance material would include: 1) The portion of the New River channel to Jacksonville north of the AIWW; 2) The crossing of the Atlantic Intracoastal Waterway (AIWW) and the New River; and 3) The southern portion of Cedar Bush Cut that is regularly dredged (Figure 5). Some navigation material could possibly come from the outer bar channel of New River Inlet; however, this would require a different dredge than the type that would be used for the interior channel in order to operate seaward of the COLREG demarcation at the inlet (Figure 5). Dredging of these four channel elements will be collectively referred to as the "New River Navigation System."

Historically, the U.S. Army Corps of Engineers (USACE) has been responsible for maintaining the federally authorized navigation channels in New River, the AIWW, Cedar Bush Cut and the ocean bar channel of New River Inlet as shown in Figure 5. Maintenance of the Channel to Jacksonville and the AIWW crossing has historically been accomplished using cutterhead suction dredges similar to the one shown in Figure 6.

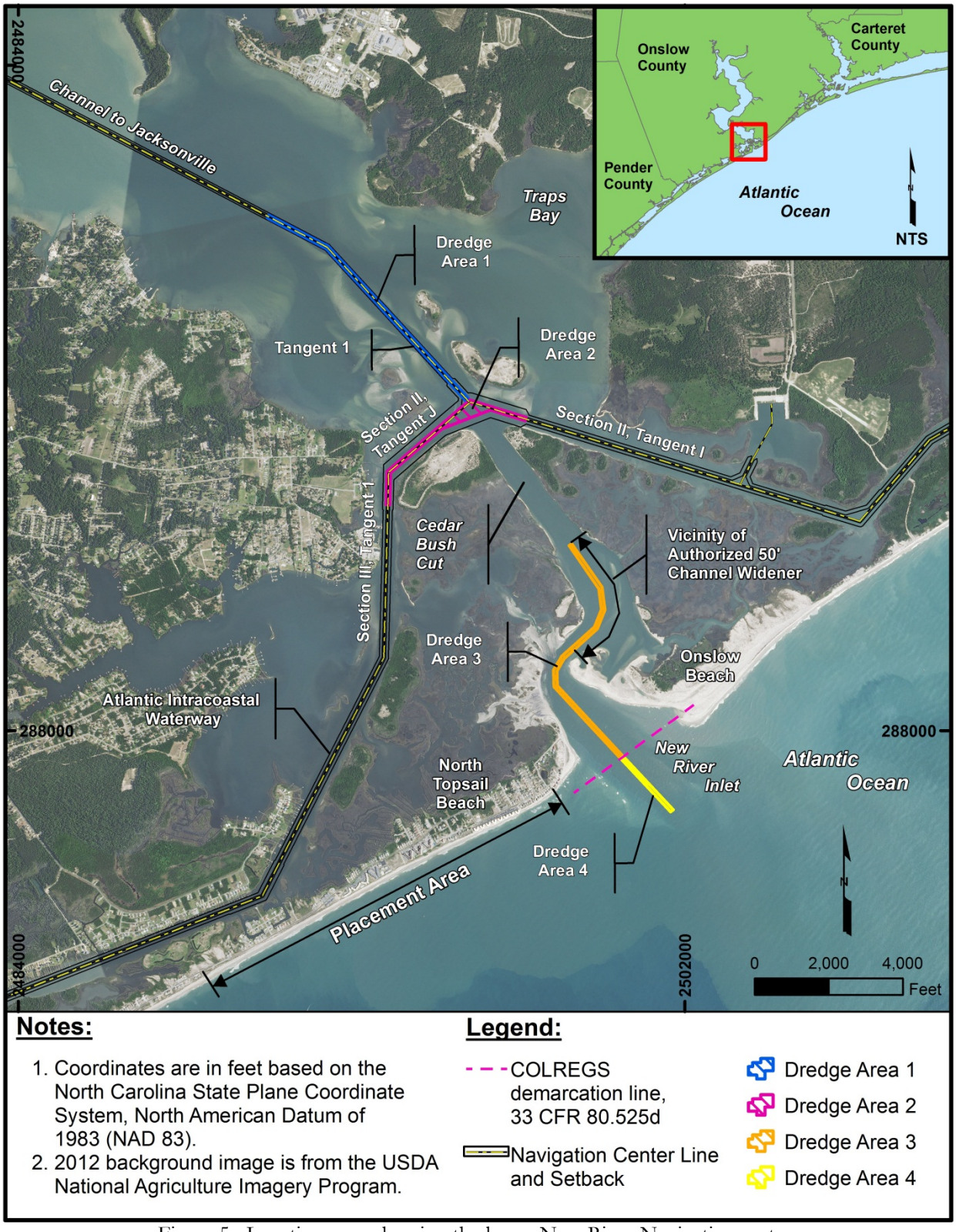

Figure 5. Location map showing the lower New River Navigation system.

This type of dredge allows for beach disposal of dredged sand. Maintenance of Cedar Bush Cut and the ocean bar channel have historically been accomplished using a combination of self-propelled hopper dredges, side cast dredges, and occasionally contract cutterhead suction dredges (Figures 1 and 2).

Figure 6. Cutterhead suction dredge comparable to the type used to maintain navigation channels in the AIWW and Channel to Jacksonville (Courtesy Cottrell Contracting Corporation: *Dredge Richmond*)

The USACE has routinely placed maintenance material removed from the AIWW and the portion of the New River channel to Jacksonville directly north of the AIWW along the northern 2 miles of North Topsail Beach. In a study conducted for Onslow County in 2013, CPE-NC identified ten (10) maintenance events conducted by the USACE from 1997 to 2013 that removed material from these channels and placed it on the beach at the north end of North Topsail Beach. There was some indication that other undocumented events may have occurred during that same time frame. The portion of the record between 2010 and 2013 is believed to be complete and indicated an average annual dredged volume of approximately 89,000 cy.

Since 1964 the southern portion of Cedar Bush Cut and the outer bar channel at New River Inlet have been maintained using primarily specially designed USACE-owned sidecast dredges or hopper dredges capable of working in shallow draft inlets. These operations have historically occurred multiple times per year. However, despite the frequency of events, the channels are rarely maintained to the authorized depths.

Recent cuts to the USACE budget to maintain shallow draft navigation channels has resulted in even less dependable conditions for commercial and recreational boaters in many of the channels associated with the New River. Given these Federal funding shortfalls, the County of Onslow recently took the initiative to obtain state and federal permits to maintain portions of the New River Navigation system. The permits would allow the County to maintain the AIWW and channel to Jacksonville at the currently authorized depths of -12 ft. MLW + 2 ft. overdepth and -10 ft. MLW + 1 ft. overdepth, respectively. Currently, Cedar Bush Cut and the Ocean Bar Channel are only authorized to be dredged to -6 ft. MLW + 2 ft. overdepth. The permits being

sought by the County would allow for Cedar Bush Cut to be dredged to -8 ft. MLW + 2 ft. overdepth out to the COLREG line and to -12' + 2 ft. overdepth seaward of the COLREG line across the ocean bar. These proposed changes to the depths of Cedar Bush Cut and the Ocean Bar Channel would allow for a cutterhead suction dredge to perform the maintenance and place the sand on the beach.

Based on recent surveys of the channels (January 2015), CPE-NC has estimated that at present approximately 44,000 cy of beach compatible sand is available in the AIWW near the crossing with the New River Inlet (Figure 7). Likewise, approximately 37,000 cy of material are estimated to be present in the authorized channel at Cedar Bush cut. Recent survey data was not available for the channel to Jacksonville, however, given past shoaling trends, CPE-NC estimates approximately 19,000 cy of sand may be available from the channel in November 2015. In total, CPE-NC estimates approximately 100,000 cy of sand could be dredged from these channels in the winter of 2015/2016. The permits being pursued by Onslow County would allow this material to be placed along the northern 2 miles of the Town of North Topsail Beach.

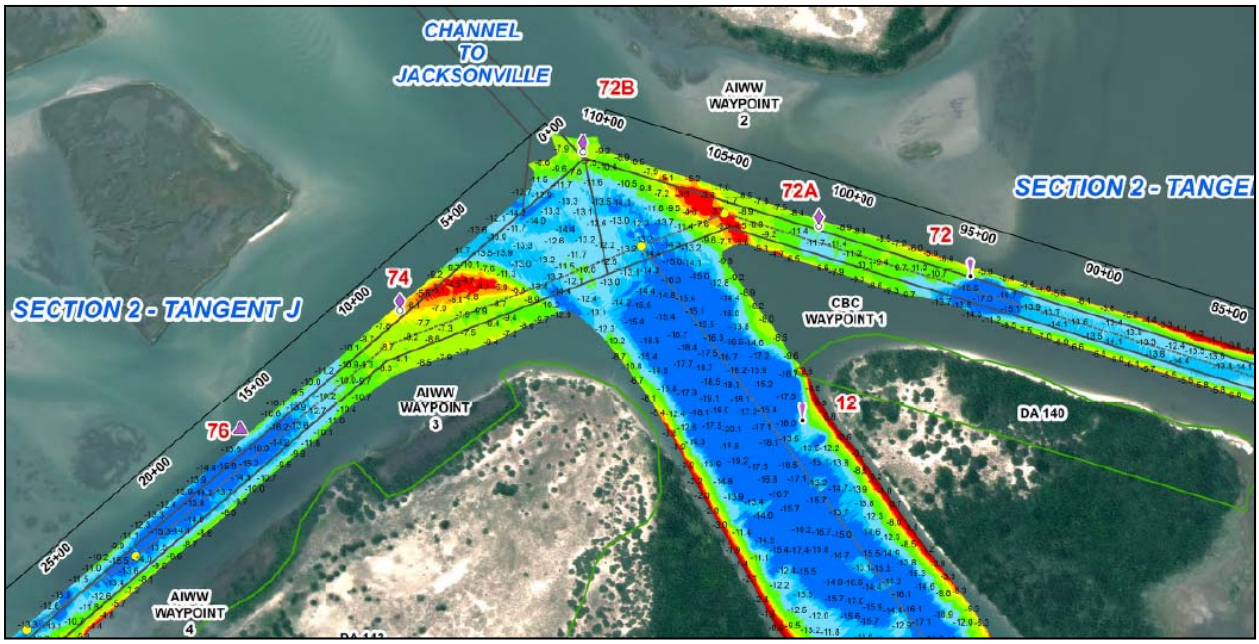

Figure 7. January 2015 bathymetric map of the AIWW showing locations where shoaling requires maintenance dredging (red, orange, and yellow colors). USACE Wilmington District Navigation Website.

Requirements for Permitting and Design: The implementation of Alternative 2 would not require the Town of North Topsail Beach to obtain any additional permits as Onslow County is currently working on obtaining the necessary permits. The permitting is being cost shared between the State of North Carolina (50%), Onslow County (25%), and the Town of North Topsail Beach (25%). The Town of North Topsail Beach and Onslow County have had extensive discussions regarding cooperative efforts regarding maintenance dredging.

Once permits are in hand, the County would likely require engineering services to develop bidding documents to bid the navigation maintenance project. This may include the need for

pre-construction surveys of the channels. Likewise, during construction operations, the County would likely require engineering services for construction oversight and administration.

Timeframe to Implement:
Onslow County anticipates having permits in hand to conduct navigation maintenance dredging of the New River Channel System by October 2015. Realistically a project could be constructed during the winter dredge season of November 2015 through April, 2016 that would dredge 100,000 cy of sand from the New River Channel system and place it along the northern 2 miles of North Topsail Beach.

Estimated Cost to Implement:
A cost estimate was developed for construction of this alternative including development of bidding documents and contractor coordination, dredge mobilization, cost to pump sand to beach, and construction observations. The cost to implement this alternative is estimated at $1,694,500. The State, County, and North Topsail Beach are cost sharing in the permitting and there are verbal commitments by all three entities to cost share the construction. Therefore, this report assumes the Town of North Topsail Beach would be responsible for 25% of the total cost or $423,625.

Alternative 3: Modified Construction Plan for Maintenance of Channel Realignment Project

Description: This alternative includes modifying the channel position and size to be dredged during the maintenance event scheduled for the 2016/2017. The first channel alignment project was constructed between November 2012 and February 2013. Since that time, beach profile surveys, a survey of the ebb shoal, and aerial photos have been used to monitor the performance of the project.

The intent of the channel realignment project was to induce reconfiguration of the ebb delta by redistributing material from the north side of the delta to the south side. A build-up of material on the south side of the ebb tide delta would provide a higher degree of wave sheltering to the north end of North Topsail Beach which should eventually lead to a reduction in shoreline erosion rates immediately south of the inlet in the short term and possibly some widening of the beach in the long term. Figure 8 shows a schematic diagram of the expected ebb shoal reconfiguration. This figure was obtained from Appendix B – Engineering Analysis of the Final EIS for the North Topsail Beach Shoreline Protection Project (CPE-NC, 2009a).

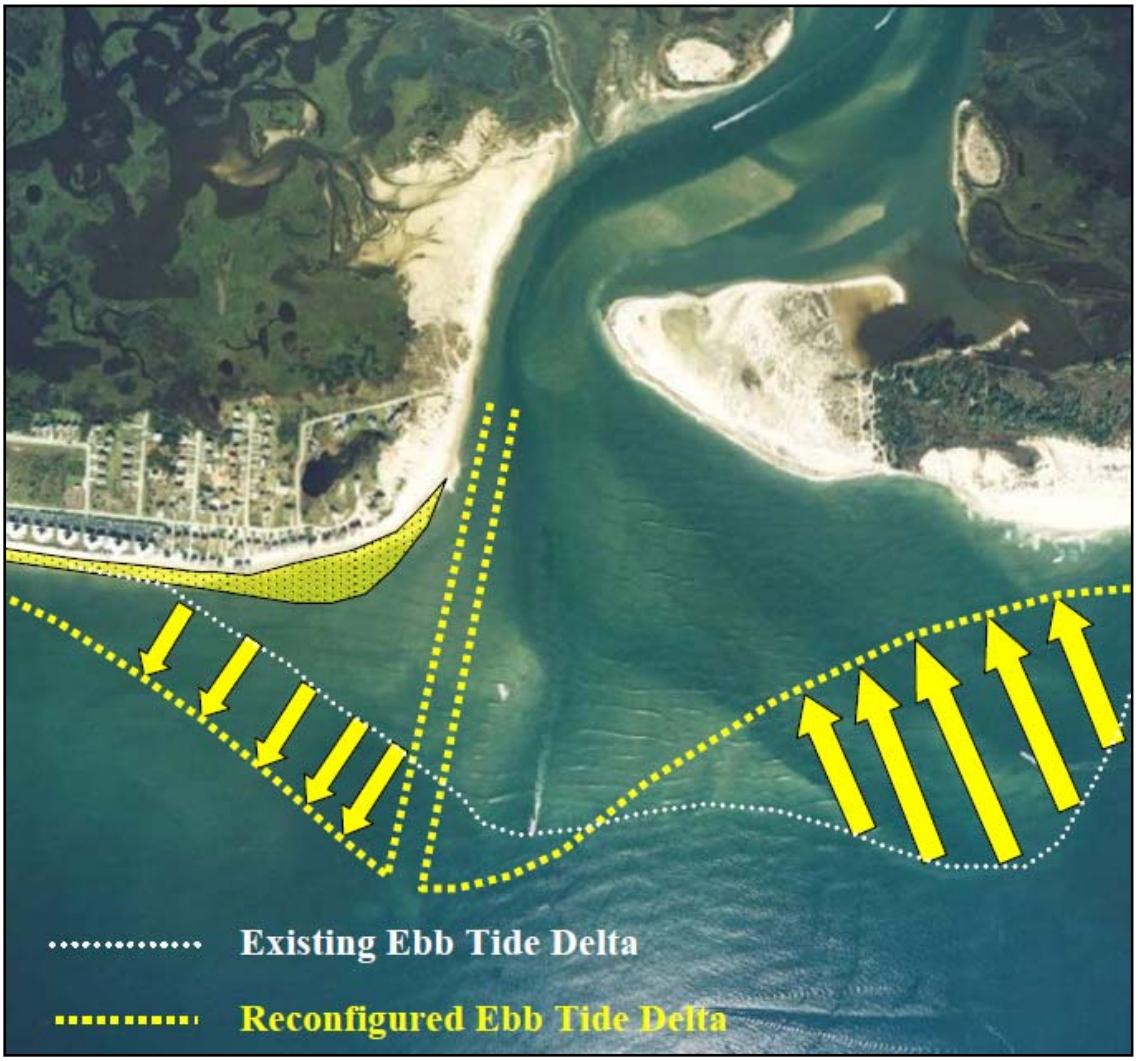

Figure 8. Schematic diagram showing the intended reconfiguration of the ebb tide delta as a result of the channel realignment project (Photo from October 2003) (From CPE-NC, 2009a).

The 2014 Phase 1 monitoring report, prepared by CPE-NC, concluded that the reconfiguration of the ebb shoal is taking place as expected (CPE-NC, 2014). The MHW contour along the Onslow Beach shoulder (north of the inlet) moved southward toward the channel while the -10 ft. NAVD88 contour continued to move landward (Figure 9). This trend suggests that the ebb shoal offshore of Onslow Beach is deflating.

Profile comparisons of the May 2013 and April 2014 profile surveys along the North Topsail Beach shoulder (south of inlet) show an increase in the volume of sand between the -7 ft. NAVD88 and -20 ft. NAVD88 contour (Figure 10). The results suggest that this material is being deposited in this area in response to the realignment of the channel. Comparison of the May 2013 and April 2014 beach profile surveys also show that the pre-construction ocean bar channel that appears in the May 2013 survey off the south end of Onslow Beach has filled in, which is generally seen as a positive sign that the ebb shoal is reconfiguring as expected.

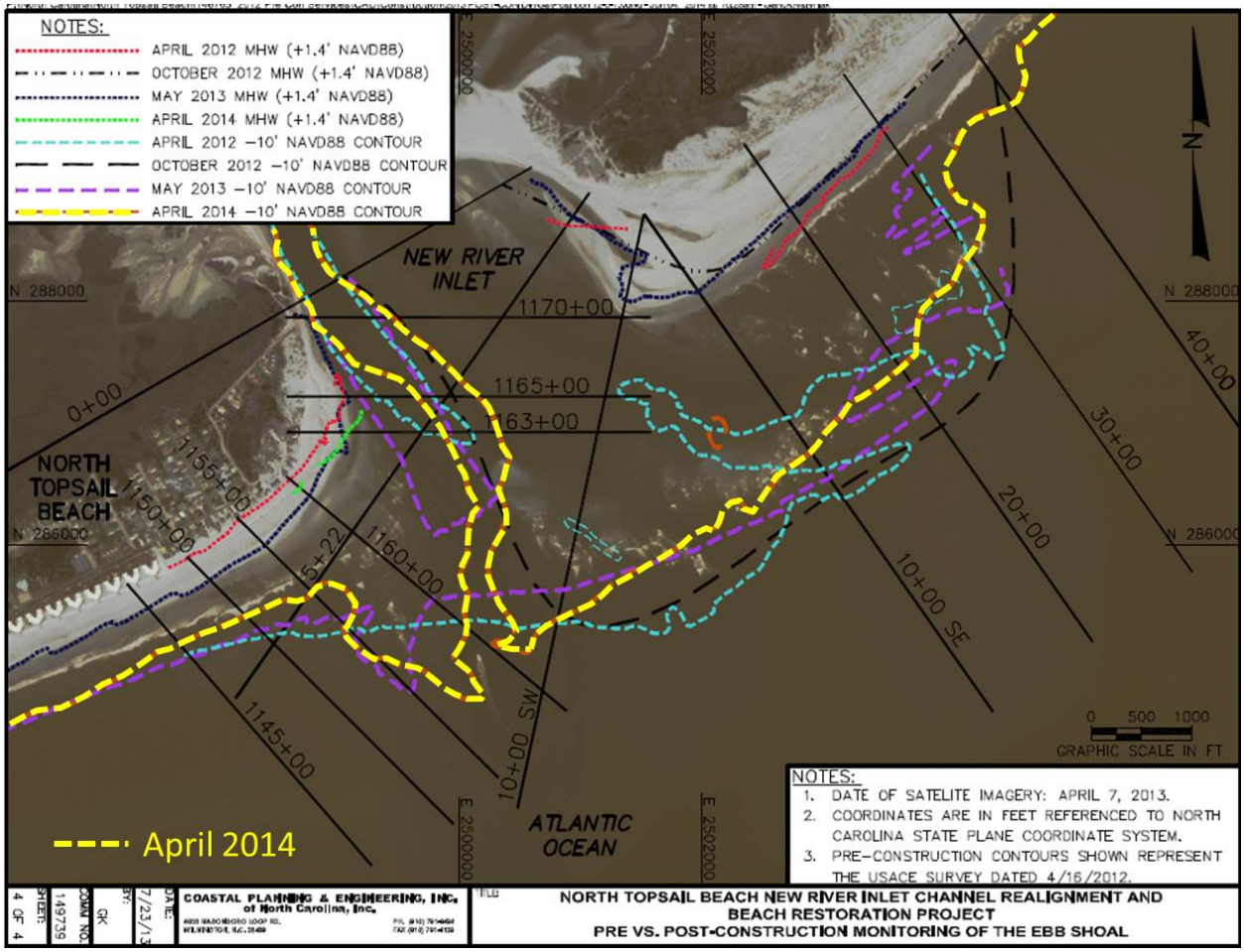

Figure 9. New River Inlet ebb shoal extent (From CPE-NC, 2014).

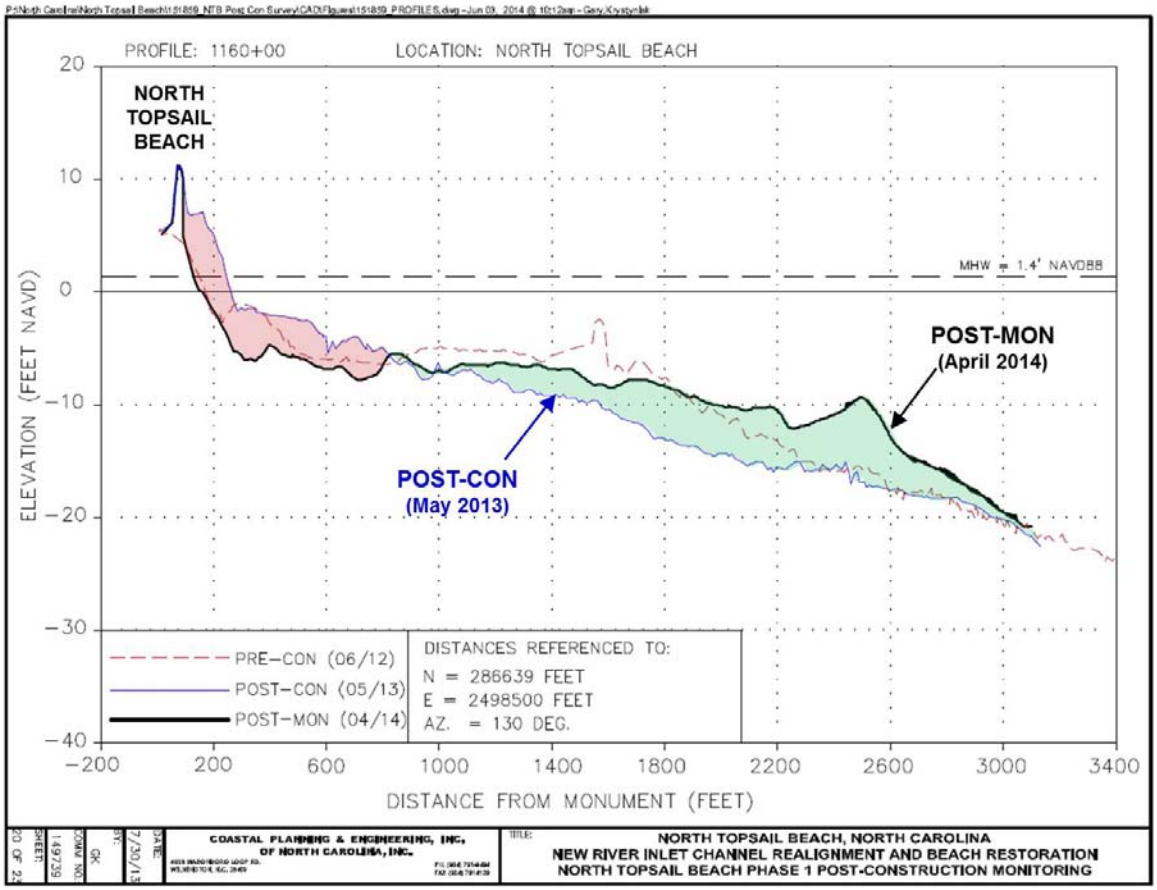

Figure 10. North Topsail Beach Inlet Shoulder – ebb shoal profile. (From CPE-NC, 2014).

Although there is evidence that the ebb shoal is reconfiguring in a manner predicted, alternative channel configurations should be considered for future maintenance events. The original design depth of the channel of -18 ft. NAVD88 was based on 2 primary assumptions; 1) -18 ft. NAVD88 was the minimal depth in which dredge plants certified to work in the open ocean could safely and efficiently operate; and 2) that material below this depth was unsuitable for beach fill. Based on discussions with potential dredge contractors, advances in technology may now allow some dredge equipment to construct a channel at a shallower depth.

Observations from site visits and aerial photos clearly suggest that the inlet and the ebb shoal are still in a state of flux. Using the pre-construction (April 2012) and post-construction (April 2014) ebb shoal surveys, the volume of sand above the -10.0 ft. NAVD88 contour was calculated to determine the percentage of sand on the North Topsail Beach and Onslow Beach side of the channel, respectively. Figures 11 and 12 show the position of the -10.0 ft. NAVD88 contours for the two surveys and the boundaries used to determine % sand north and south of the channel. The April 2012 ebb shoal survey shows that 83.4% of the volume of the shoal above the -10.0 ft. NAVD88 contour was north of the channel and 16.6% of the volume was south of the channel. In contrast, the April 2014 survey shows that 74.3% of the volume of the shoal above the -10.0 ft. NAVD88 contour was north of the channel and 25.7% of the volume was south of the channel. This suggests that the channel realignment has resulted in the redistribution of the shoal material from the north side of the channel to the south side as anticipated.

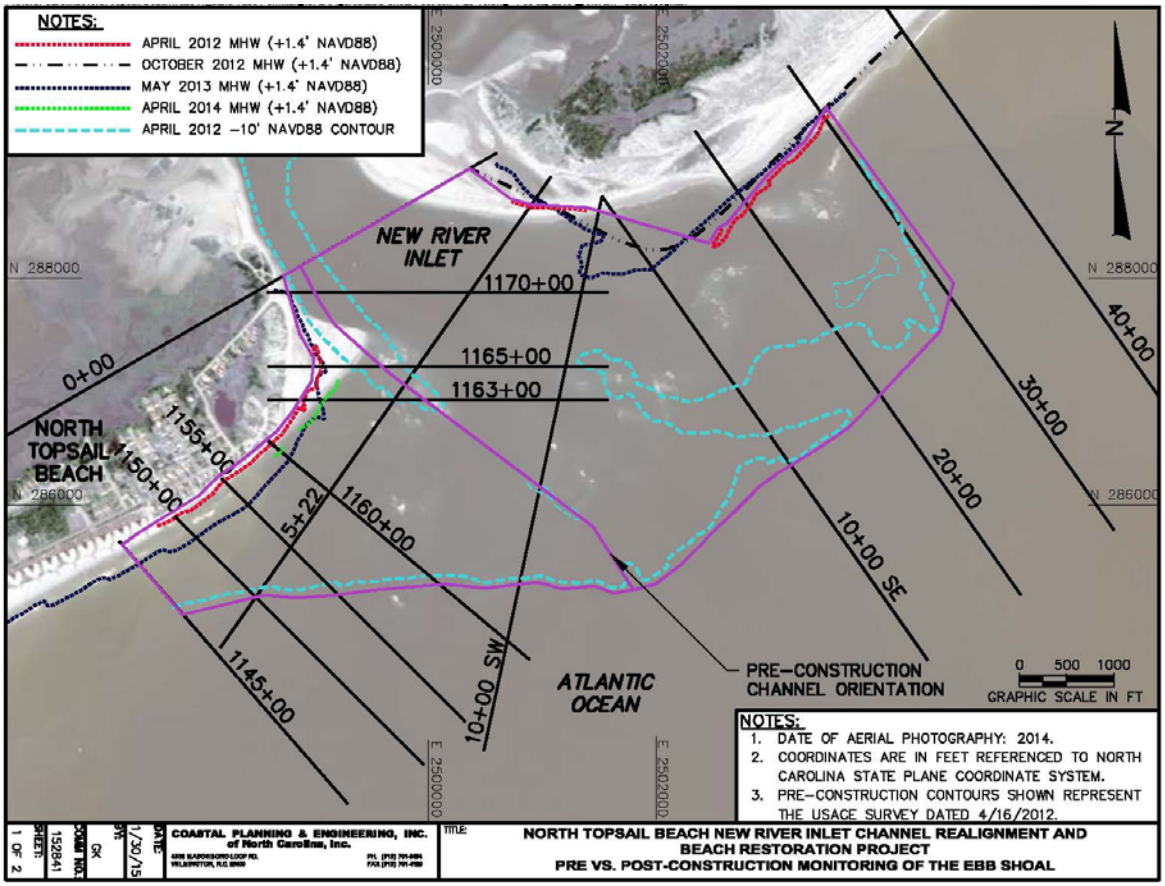

Figure 11. New River Inlet ebb shoal showing the pre-con (April 2012) -10.0 ft. NAVD88 contour and the boundaries of the shoal used to determine percentage of volume north and south of the channel.

Given the dynamic nature of New River Inlet and the observed response of the inlet to the Phase 1 channel, evaluations of additional channel alignment alternatives should be done using modern numerical modeling programs such as Delft3D. Delft3D has the capability of simulating changes in inlet morphology in response to man-induced changes and could be used to evaluate a full range of possible channel positions and alignments. While there are some indications the new channel dredged in 2013 is tending to induce the desired changes in the configuration of the ebb tide delta, altering the alignment of the channel from the one presently permitted without detailed supporting analysis is not recommended.

Requirements for Permitting and Design: The implementation of this alternative would first require design work to determine a preferred channel realignment. Again, this would involve detailed numerical modeling as well as additional geotechnical investigations associated with the initial construction of the realigned channel. In this regard, geotechnical investigations preformed in support of Phase 1 identified 2 areas within the recommended channel corridor that contained incompatible material above the -18 ft. NAVD88 design depth (Figure 13).

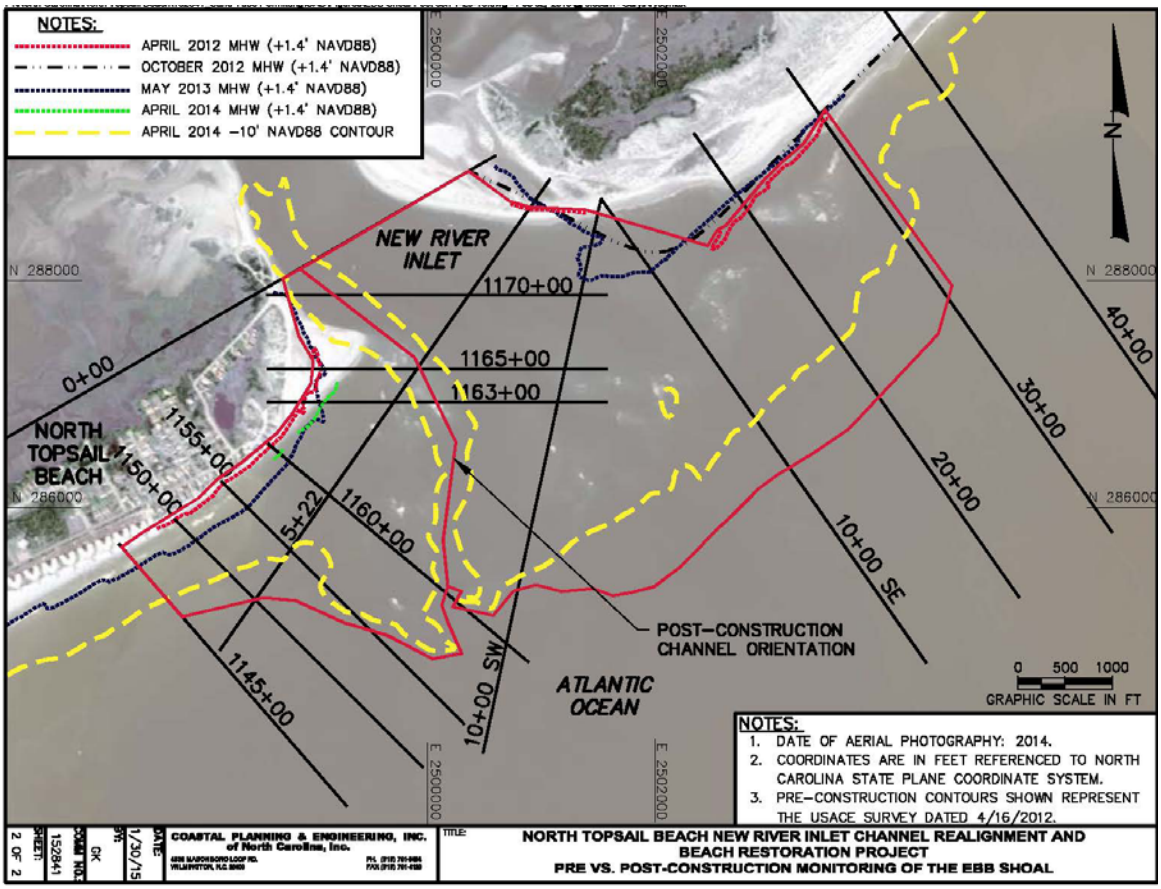

Figure 12. New River Inlet ebb shoal showing the pre-con (April 2012) -10.0 ft. NAVD88 contour and the boundaries of the shoal used to determine percentage of volume north and south of the channel.

During the cultural resource investigations associated with the initial construction of the realigned channel, a magnetic anomaly was identified east of the channel, which was characterized as a moderate priority. The resulting cultural resources report recommended additional investigations to identify and assess the material generating the signature unless the channel design could avoid impacts (Tidewater Atlantic Research, 2005). The channel alignment adopted for Phase 1 was specifically laid out to avoid impacts to the area (Figure 13). However, if the Town wants to pursue consideration of a new channel alignment, the recommended cultural resource survey should be conducted. Should this survey confirm the magnetic anomaly is a low priority, i.e., of little historic significance, or is below the design depth of the channel, one of the constraints dictating the position of the channel would be removed.

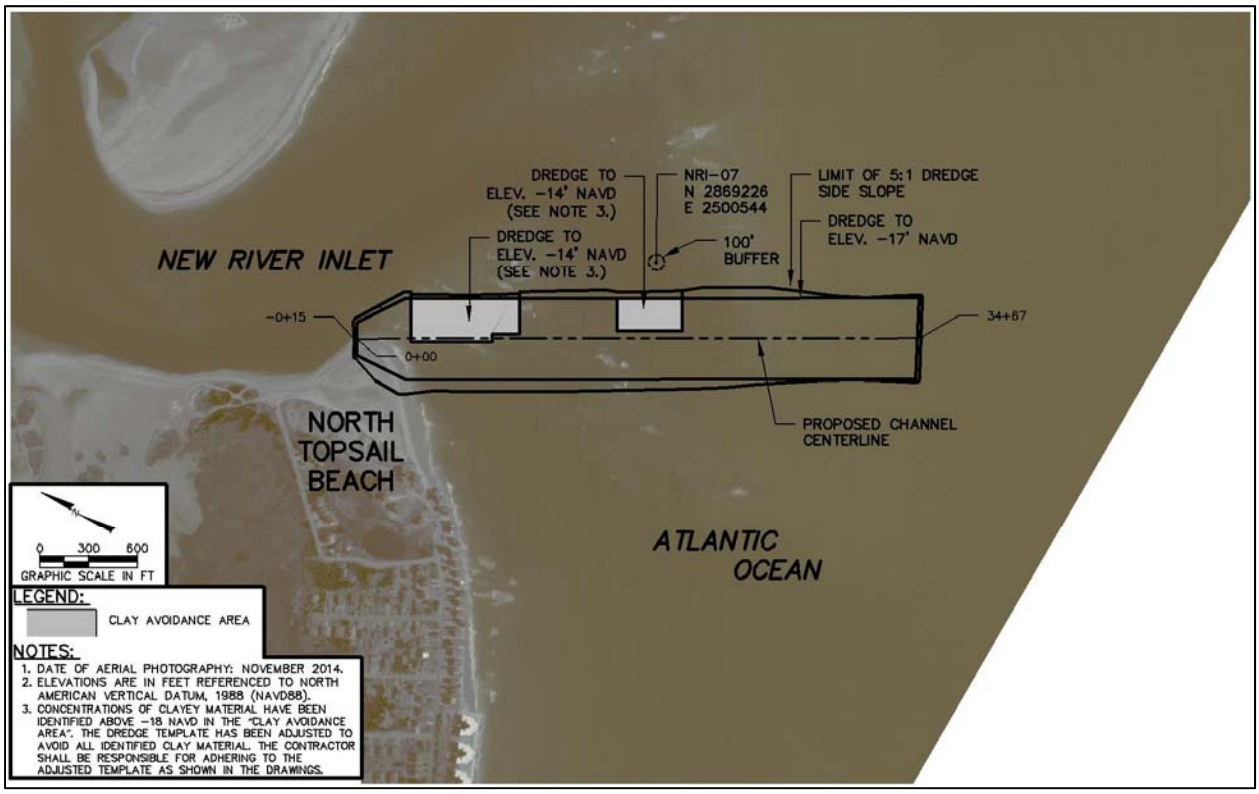

Figure 13. Map of New River Inlet showing the location of the realigned channel and the magnetic anomaly identified during the cultural resource survey.

Once a preferred channel alignment configuration has been developed, a permit modification would likely be required. Based on discussions with USACE Regulatory staff, a permit modification is unlikely to require any supplement to the EIS (Sugg, Pers. Comm., 2015).

The estimate to design and obtain any additional permit modifications associated with an alternative channel design is $510,000. This cost includes surveys required for Phase 1 physical monitoring (Onslow Beach, North Topsail Beach, and the New River Inlet); numerical model setup, calibration, and verification; channel design alternative modeling; additional vibracore collection and processing; cultural resource investigations; and coordination and submittals associated with permit modifications.

Timeframe to Implement:
Assuming the Town initiates model setup, calibration and verification by the end of March 2015, the channel analysis, geotechnical and cultural resource surveys, and permit modifications could all be completed and or obtained in time to construct the project during the winter dredge season of November 2015 through April 2016.

Estimated Cost to Implement:
A cost estimate of $8,000,000 was previously provided to the Town of North Topsail Beach for the construction of the second channel maintenance event. This cost estimate is still valid and includes the development of bidding documents and contractor coordination, dredge mobilization, cost to pump sand to the beach, and construction observations. The Town has been

coordinating with the state of North Carolina to secure matching funds for this project. To date, $1.5 million has been secured. This report assumes the Town of North Topsail Beach would be responsible for 50% of the total cost or $4,000,000.

Alternative 4: Construction of a Terminal Groin

Description:
This alternative would include the installation of a terminal groin at the north end of the island to stem the high erosion rates experienced along the northern portion of the Island. A terminal groin, as defined by North Carolina Legislature Session Law 2011-387, Senate Bill 110, is:

> ***"****a structure that is constructed on the side of an inlet at the terminus of an island generally perpendicular to the shoreline to limit or control sediment passage into the inlet channel****"***

The exact locations and dimensions of a terminal groin would depend on the portion of shoreline that the structure was designed to influence. Substantial data collection, modeling, and engineering design would be required to make such determinations. Figure 11 shows a conceptual diagram of a terminal groin at the north end of North Topsail Beach. The structure would likely be composed of two distinct sections. The seaward section (red) would be a rubble mound structure composed of stone with a low enough crest elevation to allow sediment to pass over the top of the structure during periods of high tide. The stone structures would also be constructed with relatively large voids between the stones to facilitate sediment movement through the structures. The landward section or shore anchorage section (green) would be constructed with sheet piles (either steel or concrete).

During the original formulation of the North Topsail Beach inlet and shoreline protection program, a terminal groin was not a viable option as it was illegal based on state statute. In 2011 the state passed legislation allowing for the permitting of 4 terminal groins within the State. Currently one permit has been issued to Bald Head Island and three additional permits are being considered by Figure Eight Island, Holden Beach, and Ocean Isle Beach. Given the level of effort completed by each of these 3 applicants, it is unlikely that the Town could apply for and obtain a permit prior to 4 permits being issued. Therefore, in order for the Town of North Topsail beach to pursue this alternative it is likely that the state statute would need to be amended to allow a fifth terminal groin to be permitted.

Figure 14. Conceptual rendering of a terminal groin at the north end of North Topsail Beach.

Requirements for Permitting and Design:

In order to apply for a terminal groin, the Town would be required to work with the USACE to develop an Environmental Impact Statement (EIS). It is possible that the EIS developed for the Town's comprehensive inlet and shoreline management program could be supplemented; however, this would require additional field data collection, modeling, engineering design, and environmental documentation. Numerical modeling would be done using the state of the art Delft3D modeling package. As stated previously, Delft3D has the capability of simulating changes in inlet morphology in response to man-induced changes. The model would be used to evaluate different design configurations of the terminal groin as well as other alternatives mandated to be assessed through the National Environmental Protection Act (NEPA).

Based on CPE-NC's involvement in the permitting and design of both the Figure Eight Island terminal groin and the Ocean Isle Beach terminal groin, we anticipate that the engineering design and permitting would require 3 years. The cost to permit and design the terminal groin is estimated to range from $500,000 to $800,000. The low end cost assumes that the numerical model used to develop the terminal groin design and evaluate alternatives is already setup, calibrated, and verified. If these steps have not already been taken, the cost would be more in line with the high estimate. These estimates also take into account the fact that the Town already

has an existing EIS and that, the required environmental documents could supplement existing documents.

Timeframe to Implement:
As mentioned above, the permitting and design phase is anticipated to take approximately 3 years. Therefore, the earliest anticipated date for construction of a terminal groin would be between February and April of 2018.

Estimated Cost to Implement:
Until the design parameters of the terminal groin is better established, an accurate estimate of the cost to construct a terminal groin is difficult to provide. The estimate provided assumes similar unit costs as those used to develop cost estimates for terminal groin projects at Figure Eight Island and Ocean Isle Beach. The cost to implement this alternative is estimated to range between $5.6 million and $7.5 million. This estimate includes the cost to construct a structure between 1,200 and 1,500 ft. in length and place approximately 200,000 cy of sand to fill the fillet.

A summary of the engineering and environmental analysis costs, cost to construct, and the date of implementation are included below in Table 1.

Table 1. Costs and schedule to implement the four (4) alternatives presented in the contingency report.

Alternative:	**Date of Implementation**	**Engineering & Environmental Analysis Cost**	**Cost to Construct**
1. Preferred Channel Alignment Dredging to Induce By-Passing	February 2015	$0	$0
2. Utilization of Navigation Channel Maintenance Material	November 2015	$0	$423,625 *
3. Modified Construction Plan for Maintenance of Channel Realignment Project	November 2016	$510,000	$4 Million *
4. Construction of a Terminal Groin	February 2018	$500,000	$5.6 Million - $7.5 Million

* - Denotes Town Portion of a Cost Shared Project

RECOMMENDATIONS

CPE-NC makes the following recommendations based on the evaluation of the alternatives presented herein as well as our understanding of the long term goals of the Town to provide sustained long-term beach nourishment for the North Topsail Beach ocean shoreline.

1. Implement Alternative 1 immediately. The first meeting with the USACE was held on February 13, 2015 which resulted in a positive exchange between the Town, Onslow County and the USACE. Given the positive feedback from the USACE, future meetings should be held prior to scheduled ocean bar channel maintenance events to determine the optimal channel location agreeable to all parties.

The USACE was recently appropriated $500,000 for dredging of New River Inlet for FY 2015. The USACE has tentatively scheduled dredging, using the government plant (*Merritt*) in February, March, April, May, and June 2015. The Town should also request that if possible, the *Murden* or *Currituck* be used to dredge instead of the Sidecast dredge *Merritt*. Currently both vessels have open dates in April.

2. Schedule and conduct monitoring surveys of the Phase 1 project, Onslow Beach, and the Inlet to assess the reconfiguration of the ebb shoal in April 2015. This would be a duplication of the surveys conducted in April 2014 and should provide much needed information on assessing the performance of the channel realignment strategy.

3. Continue to coordinate with Onslow County and the state on a navigation maintenance project for November 2015. The project as described in Alternative 2 above, would use a contract cutterhead suction dredge to clear material from permitted channels in the Channel to Jacksonville, the AIWW, and Cedar Bush Cut. Initial estimates suggest approximately 100,000 cy of sand may be available in these channels. Sand would be placed along the northern 4,000 ft of beach depending on the amount of actual sand available at the time of dredging.

   Coordination and planning should include submitting a request for funding to the Division of Water Resources through the Shallow Draft Inlet Fund and developing bidding documents for the project.

4. Initiate model setup, calibration, and verification for assessing alternative channel designs and terminal groin. CPE-NC proposes the use of a number of analytical and numerical modeling tools. The primary tool recommended for these types of assessments is the Delft3D morphological model. The packages consists of two models, which are coupled together to determine changes in a topographic and bathymetric surface based on the effects of waves, water levels, winds, and currents. This effort would include obtaining existing data including those collected by CPE-NC and the USACE Field Research Facility staff during the RIVET I study. Additional oceanographic data would also need to be collected including additional tide, current, and bathymetric data.

5. Continue planning and coordination for the 2nd channel realignment project in 2016/2017, which would provide initial construction of an approximate 7,500 ft. of shoreline south of Phase 1. Planning would include coordination with the State to secure the matching funds needed to conduct the project, assessing alternative channel realignment options, obtaining additional vibracore data and cultural resource data to support permit modification requests, and obtaining permit modification to the existing permits to allow for an alternative channel configuration.

6. Initiate initial design analysis for a terminal groin at the north end. This includes using the Delft3D morphological model to assess terminal groin alternatives. This design work is the first step in an estimated 3-year process to design and permit a terminal groin. Proceeding with this recommendation would allow the Town to make a decision 1 year later as to the feasibility of pursuing a terminal groin without losing any time if they do

chose to proceed. The additional year would also allow more time to assess the channel realignment project to determine its effectiveness.

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Sugg, M.T. (2015). U.S. Army Corps of Engineers Wilmington District Regulatory Project Manager. Personal communication regarding permit modification project for modified channel design at New River Inlet.

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