SECTION 3.0 – PROJECT ALTERNATIVES

3.1 SCREENING OF ALTERNATIVES

Based upon the stated project purpose and need, the USACE, in consultation with the Project Review Team (PRT), developed a range of alternatives to be considered in the DEIS. The range of alternatives includes considerations of various means by which to respond to the project need and associated objectives. The preliminary list of alternatives was screened via the scoping process and PRT input. An initial alternative identified during scoping, but not advanced further in the DEIS analysis included consideration of construction of a terminal groin without beach nourishment. As this alternative is not compliant with the provisions of SB 151 and is not preferred from an engineering standpoint, it has been eliminated from further consideration. The remaining alternatives evaluated within this document are identified in Table 3.1 below.

Table 3.1. List of Project Alternatives

Alternative #1	**No-Action (includes component of Status-Quo)**
Alternative #2	**Retreat**
Alternative #3	**Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place**
Alternative #4	**Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal**
Alternative #5	**Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining)**
Alternative #6	**Terminal Groin with Beach Nourishment/Disposal (Removal of Sand Tube Groinfield)**

3.2 DESCRIPTION OF ALTERNATIVES

3.2.1 No Action/Status Quo Alternative (Alternative #1)

Under the No-Action Alternative, the Village would not implement any comprehensive action (or actions) to offset the on-going erosion of the western end of South Beach. The No-Action Alternative takes into consideration the existing or status quo condition. As such, disposal events occurring under the existing Wilmington Harbor Sand Management Plan (SMP) may occur. The current SMP calls for 2/3 of the total volumetric sand dredged from the channel to be placed on Bald Head Island. Under the No-Action Alternative, short-term stabilization measures such as the placement of emergency sand-bags for protection of structures imminently threatened by erosion (in compliance with current state regulations) and the maintenance of the existing sand-tube groinfield would occur (as they have over the last decade or more). Furthermore, the no-action or status quo alternative would include use of beach scraping during the winter months to help rebuild and stabilize foredunes in critically-eroded areas. In similar regard, the Village would continue its program of sand fencing to promote dune formation and stabilization.

3.2.2 Retreat (Alternative #2)

Under the Retreat Alternative, the Village would identify high-risk areas for the development and implementation of a Managed Shoreline Retreat Plan that would ultimately provide for the unimpeded recession of the shoreline. The Plan would provide for the systematic removal of the sand tube groinfield and the demolition or relocation of residences, roads, and infrastructure, if land and funds are available, in advance of the shoreline recession. Thresholds would be indentified to trigger the demolition or relocation of specific structures. As part of the retreat strategy, undeveloped lots of the interior sections of Bald Head Island would be identified and acquired for the explicit use of relocating homes. Unimproved lots potentially available for acquisition and structure relocation have been identified (refer to Figure 3.1). These lots were identified based upon several factors, including: distance from nine-year predicted shoreline position under the Retreat Alternative; condition of lot (i.e.

unimproved); and relocation logistics (e.g. avoiding areas in maritime forest that would require additional clearing along narrow right-of-ways for structure transport).

Based upon Delft 3D modeling results (described in Section 5.0), relocation efforts would need to be initiated rather quickly, as roads and several residences would be susceptible to loss within the first three years. Much of the demolition and relocation would need to be completed by Year 9 of the implementation of this alternative (refer to Section 5.2 for predicted shoreline positions). It can be expected that retreat measures would need to be implemented over the 30-year period under consideration. Where necessary and feasible, new right-of-way corridors would be acquired for the relocation of roads and utilities. It is expected that all or portions of secondary right of ways in the permit area (including Sandpiper Trail, Water Thrush Court, and Cape Fear Trail) would need to be abandoned, while the primary route along South Beach (South Bald Head Wynd) would need to be relocated. Detailed information regarding the number of lots (both improved and unimproved) and the specific right of ways and infrastructure that would be subject to relocation or demolition is provided in Section 5.0.

As part of the overall strategy, temporary stabilization methods may be employed to prolong the life of homes, buildings, roads, and infrastructure to provide adequate time for relocation or demolition. For instance, placement of temporary sand bags in accordance with state regulations may be utilized seaward of imminently threatened structures. Use of sand bags would be for a defined period to provide for adequate planning and implementation of retreat measures. In a similar manner, it is expected that the existing sand tube groinfield would be left in place until such time as sufficient retreat measures (e.g. demolition or relocation of infrastructure and homes) have been employed to minimize the risk of potential environmental and safety hazards associated with rapid shoreline recession. Upon completion of the necessary retreat measures, the sand tube groinfield would be removed at a cost to the Village.

While not relied upon to prolong the life of any structure, it is assumed that under the Retreat Alternative sand disposal would continue to occur per the federal SMP and contingent upon federal funding. However, it is likely that removal of the sand tube groinfield would influence the location and extent of future federal sand disposal on South Beach.

3.2.3 Beach Nourishment/Disposal with Existing Sand Tube Groinfield to Remain in Place (Alternative #3)

Under Alternative #3, it is assumed that beach disposal would continue per the terms of the existing SMP. The Village would continue to design and implement independently-sponsored beach nourishment and beach disposal projects on an as-needed basis. While FEMA funds may be available to the Village to address sand losses subsequent to a declared disaster, FEMA support is not available for scheduled renourishment events. Note that the levels of federal and/or state contribution for prior disposal and nourishment events on Bald Head Island are identified in Table 1.2 (Section 1.0). As described further in Section 5.0, costs associated for Village-sponsored nourishment under this alternative are considered to be borne wholly by the Village.

In light of calculated volumetric losses provided by the Applicant (see Section 5.0), it is anticipated that the volume and frequency of Village-sponsored nourishment/disposal events required to effectively reduce the risk of further shoreline erosion is on the order of magnitude of 1.5 Mcy of sand beginning at Year 3 post federal SMP disposal and continuing every nine years for the life of the project (30 years). The sand tube groinfield would be maintained so as to continue its beneficial effect on sand losses which are most evident for two years after a large scale sand placement event.

Potential sand sources that may be considered under this alternative include the following. Note that the locations of each of the potential sand source sites identified below are depicted in Figure 3.2.

A. Wilmington Harbor Entrance Channel

Prior federal channel maintenance and disposal events conducted under the Wilmington Harbor SMP have demonstrated that the innermost segment of the Ocean Entrance Channel is a suitable source of beach-compatible material. Navigation channel surveys for three channel reaches (Smith Island Range, Baldhead Shoal Channel 1, and Baldhead Shoal Channel 2) continue to be conducted on bi-monthly intervals. Condition surveys performed in 2012, preceding the Spring 2013 maintenance dredging contract, indicate the occurrence of continued shoaling in the western side of the Smith Island Channel and the eastern side of Baldhead Shoal Reach 1 and 2. The most recent pre-dredging hydrographic surveys for these channel reaches are provided for reference in Appendix D. Areas of pronounced decreases in channel depth resulting from shoaling represent suitable high quality sources for beach nourishment material.

Per the Wilmington Harbor Dredged Material Management Plan (USACE 1996) and the SMP (USACE 2000), beach quality sand can be found within the interior reaches north of the Smith Island Channel. According to sediment composition data, dredged material from Horseshoe Shoal and Reaves Point contained 98% sand and 99% sand, respectively (USACE 1996). The SMP contains a section dedicated to the management of sediments dredged from the Inner Harbor channels (Snows Marsh and Horseshoe Shoals channels). Based upon investigations conducted in support of the development of the SMP, it was estimated that 0.6 Mcy of beach quality material would be removed from these channels as part of the proposed Wilmington Harbor Deepening Project. Prior to 2000, maintenance dredging operations for these reaches utilized the ODMDS. Subsequent to the development and implementation of the SMP, placement of dredged material from these reaches may occur on adjacent beaches including Carolina Beach, Kure Beach, the Fort Fisher area, Bald Head Island, or Caswell Beach (when such options are deemed the least costly and environmentally acceptable alternatives that are consistent with the engineering requirements of the project) (USACE 2000).

B. Jay Bird Shoals

Jay Bird Shoals is a linear, ebb tidal feature of the Cape Fear River and is situated immediately west of the confluence of the current Wilmington Harbor entrance channel and the former, abandoned channel. Suitable sediment (i.e. beach compatible by North Carolina sediment standard criteria) has been previously identified throughout much of the shoal feature to an average depth of -22 ft NGVD. In 2009, the Village of Bald Head Island received federal and state authorizations (Department of Army (DA) Permit No. 2007-02699 and CAMA Major Permit No. 67-09, respectively) to dredge up to 2 Mcy of material from Jay Bird Shoals. The permitted borrow site was approximately 158 acres and was located at the seaward end of the shoal. Prior to authorization of the final borrow site footprint, boundaries were refined to avoid and minimize disturbance to potential cultural and environmental resources. For instance, a 200-ft buffer was maintained around two groupings of magnetic anomalies exhibiting signatures consistent with potential shipwreck material. In addition, the final authorized borrow limits avoided shallow subtidal and intertidal habitat (Land Management Group, 2009).

Approximately 1.85 Mcy of material (measured volume from borrow site) was excavated and pumped to South Beach and West Beach during the Village-sponsored 2009/2010 Beach Restoration Project at a Village cost of approximately $17M. As indicated in Section 1.0, this project was funded entirely by the Village with no federal or state contribution. Note that the contract pay volume measured on the beach via as-built survey was 1.55 Mcy. Based upon geotechnical evaluations completed in 2007, the Jay Bird Shoals borrow area that was investigated contained over 3 Mcy of beach quality material (Olsen 2007). However, as indicated above the final volume permitted for the 2009/2010 project was 2 Mcy for a one-time nourishment event. Nonetheless, geotechnical, cultural, and environmental resource investigations were completed for the larger shoal formation as part of the Environmental Assessment (EA) prepared by the Village at that time.

C. Bald Head Creek Shoals

The depositional shoal feature located at the mouth of Bald Head Creek (BHC) represents a smaller volume sand source in the immediate vicinity of the Island. The creek mouth is located approximately 1600 lf north of the entrance to Bald Head Marina. BHC, itself, is a relatively small saltwater creek system (approximately 3.5 km from headwaters to mouth) subject to semidiurnal tidal flows. It is bordered to the south by Bald Head Island and to the north by Middle Island.

In November 2010, the Village received federal and state authorization (DA Permit No. 198000291 and CAMA Major Permit No. 139-10, respectively) to dredge 100,000 cy of material from an approximate 21-acre borrow site at the mouth of BHC for the purpose of providing supplemental sand to a severely eroded segment of western South Beach. The permit was subsequently modified to allow for up to 140,000 cy of material to be excavated. The Village completed the dredge and nourishment work in March 2012 at a Village cost of approximately $1.25M. Physical monitoring of the borrow site is on-going for a period of up to 3 years post-construction. Given the relatively short-time period since project construction (one year), there has been no significant infilling or adjustment of the borrow site dredged to date. However, the borrow limits may be expanded to the north to allow for the potential excavation of approximately 200,000 cy of beach quality material.

D. Frying Pan Shoals

Frying Pan Shoals is a submerged extension of a cuspate foreland (i.e. accretional feature formed by processes of longshore drift and prevailing wind and wave conditions). The shoals extend nearly 20 miles offshore from the eastern end of Bald Head Island. Early reconnaissance level sand resource evaluations conducted for the Cape Fear Region (Meisburger 1977) identified that “modern sediment accretion on the inner shelf appears to be largely restricted to the shoal fields off Cape Lookout and Cape Fear, and to inlet shoals along the coast.” It included exploratory density type seismic lines, as well as a limited number of cores and surficial grab samples. Based upon sediment core data collected as

part of this study, the most appropriate beach quality sand identified within the Cape Fear shoal field was some sixteen (16) nautical miles offshore of Bald Head Island. It should be noted that sediment sampling for the study was relatively limited given the expansive area of Frying Pan Shoals. Other suitable borrow areas have been tentatively identified closer to shore.

More recent evaluations conducted by the USACE as part of the General Reevaluation Report (GRR) for the Brunswick County Beaches Coastal Storm Damage Reduction Project indicate the presence of substantial volumes of "beach-compatible" material. A Notice of Intent (NOI) to prepare an EIS for the project was published in the Federal Register on February 24, 2012. The USACE has identified Frying Pan Shoals as a potential sand source for this 50-year project. Updated geotechnical information from recent USACE site investigations is provided in Section 4.0 of this document.

3.2.4 Beach Nourishment/Beach Disposal and Sand Tube Groinfield Removal (Alternative #4)

Under this alternative, beach disposal would continue per the terms of the existing SMP, and the Village would implement supplementary beach nourishment and/or beach disposal projects on intervals sufficient to accomplish the stated Purpose and Need. In addition, the Village would terminate maintenance of the sixteen (16) sand-filled tube groinfield or seek means by which it would be removed. Note that information regarding the existing sand-tube groinfield (including dates of installation and replacement) is provided in Section 1.0 of the DEIS.

Removal of the sand-filled geotextile tubes and associated underlayments would require excavation with heavy machinery and sand tube clearing via hydraulic means (*i.e.* washing of sand from each tube structure). Although solid in appearance when full, the geotubes have no integral strength due to the limited strength of the geotextile fabric of which they are comprised. As a result they cannot be lifted, and the sand must be emptied in place. The

tubes can be physically removed relatively easily, as demonstrated in previous sand tube groin reconstruction projects, where tube removal occurred before replacement. Sand tube removal can occur only subsequent to a beach fill operation in order to ensure a sandy shorefront immediately upon removal. Similarly, excavation of the structures – essentially in the "dry" after a fill project – ensures both complete and relatively cost-effective removal.

The residual shoreline after groin removal would be subject to littoral transport rates unaffected by stabilizing structures. In doing so, the frequency and extent of Village-sponsored sand placement events will likely be greater than that of Alternative #3, as substantiated by the applicant's Delft 3D modeling results discussed in Section 5.0.

The potential sand sources required for this Alternative are the same as those identified under Alternative #3.

3.2.5 Terminal Groin with Beach Nourishment/Beach Disposal (Sand Tube Groinfield Remaining) (Alternative #5)

3.2.5.1 Description of Alternative #5 (Applicant's Proposed Action)

Alternative #5 includes the construction of a 1,900 lf terminal groin concurrent with, and following a federal beach disposal operation on Bald Head Island. Note that design drawings of the proposed terminal groin are provided in Appendix E. The structure would be constructed in two phases (as discussed below) and would serve as a "template" for fill material placed eastward thereof. In other words, the structure would help to form the three-dimensional limits (length, width, and height) of the sand placement or updrift fillet. Note that federal beach disposal activities on South Beach generally proceed from west to east. The typical westernmost limit of direct federal beach disposal in proximity to the channel (by design specification) is South Beach baseline station 44+00 (refer to Sheet 7 of Appendix E for station location relative to the proposed structure).

The primary function of a permanent terminal structure is to limit the rapid loss of fill material. Over the long-term, the principal area of benefit from such an approach is anticipated to be the westernmost segment of South Beach (an identified hot spot for erosion). The placement of beach quality sand with concurrent installation of a groin structure is anticipated to reduce the volume of material otherwise lost via longshore drift and tidal currents. The extent to which this may occur is discussed in greater detail in Section 5.0.

According to the applicant's engineer, an advantage of a singular, relatively long terminal structure should be its ability to reorient the South Beach shoreline (through updrift impoundment, or sand retention) closest to the Cape Fear River navigation channel so as to reduce the rate of transport of beach sand from the island. This is a design goal that has been subsequently modeled (results of which are discussed in Section 5.0 of this document). The applicant's engineer states that a single terminal groin is intended to do what the existing sand tube groinfield cannot satisfactorily accomplish due to its limited scope, configuration and composition, that is to control sand losses in a more effective manner. As indicated above, the terminal structure is to serve as a "template" for comprehensive sand fill projects placed eastward thereof. The design goal is to reduce inlet-directed sand loss (both short-term and long-term) and to allow for a more stable condition (particularly post sand placement).

As required by current North Carolina General Statute, the construction of a terminal groin would necessarily involve the placement and maintenance of a concurrent beach fillet (NC Session Law 2013-384). For the full 1,900-ft structure, a concurrent beach fillet would be achieved via disposal from the identified Jay Bird Shoals borrow site. Sand source sites identified for fillet creation or maintenance as well as future Village-sponsored nourishment are: (1) Jay Bird Shoals; (2) reaches of the Wilmington Harbor Channel demonstrated to contain beach-compatible material (i.e. Baldhead Shoal Channel 1, Baldhead Shoal Channel 2, and Smith Island Range); (3) Bald Head Creek Shoals; and (4) Frying Pan Shoals. The

extents of the proposed borrow sites for Jay Bird Shoals, reaches of the Wilmington Harbor Channel, and Bald Head Creek Shoals are depicted in Appendix E (Sheets 15-19).

Under this alternative, the existing sand tube groinfield would remain in place. It is predicted that a number of groins will be located in the upland portion of the sand fillet created by the terminal groin and therefore essentially become non-functional. The estimated limit of that phenomenon is the westernmost six (6) groins. Eastward thereof, the remaining sand tube groins may provide benefit during some portion of the life cycle of each sand placement operation (presently assumed to vary from two to three years). Periodic maintenance and modification to the groinfield would be anticipated (as it has over its existence to date). Example maintenance activities would include the replacement of damaged sand tubes or repair to the field via sand placement around tubes susceptible to flanking. Example of modification activities would include the relocation of one or more sand tubes. Groinfield modification may also include the removal of one or more sand tubes while leaving a majority of the field intact and functional. Alternative 6 (below) considers the scenario of the removal of the entire sand tube groinfield in conjunction with, or subsequent to, the installation of a terminal structure.

Construction Phasing: In order to expedite beneficial post-groin shoreline equilibration conditions (both updrift and downdrift of the structure, and including formation of the sand fillet), the applicant proposes that the terminal groin would be constructed in two phases. Phase I would involve the construction of an approximate 1,300-lf structure (approximately 2/3 of the structure's overall design length) coincident with construction of the fillet. Phase II would extend the seaward end of the structure to complete the structure's overall design length. Refer to Sheet 8 of the design drawings (Appendix E) for the proposed phases. It is estimated that the timing of the Phase II groin construction would be based upon an estimated two to four years of performance monitoring. The implementation of Phase II would be coordinated with resource agencies subsequent to the submittal of physical monitoring data. Physical monitoring is described in more detail in Section 6.0.

It is presently estimated that a Phase I (1,300 ft. long) terminal groin, constructed without the need for a hydraulically placed fillet (i.e. a scenario in which the federal disposal event satisfactorily achieves the desired fillet condition), could theoretically begin in November or December of the construction season but would in all probability extend at least 3 months past the 1 May 2015 moratorium in place for sea turtle protection. Certain construction activities associated with terminal groin construction can begin prior to beach disposal operations. They are principally limited to stone transport and stockpiling at the site, installation of a construction trestle (if deemed necessary), excavation and limited placement of structure foundation mattresses and armor rock (above the Mean Low Water Line (MLWL)). The most active construction of the groin stem cannot proceed, however, until updrift beach disposal on South Beach has been underway for at least 30 days. This will theoretically allow for sand to be transported westward toward the structure and is intended to help minimize its lee side effects.

The approximate proposed maximum physical extent of an updrift fillet for both the Phase I and Phase II structure, constructed through sand placement from the Jay Bird Shoals borrow site, is depicted by Sheet 7 (Appendix E).

If implemented concurrently with a federal disposal, it is possible that the Phase I structure may not require any additional sand from a supplemental source site (i.e. Jay Bird Shoals). At the least, a Phase I structure would reduce both the initial volume of sand required, as well as potentially the timing of updrift fillet enhancement (if necessary) by approximately six months to one year. The location and extent of the Phase I structure relative to the applicant's expected beach condition subsequent to federal disposal is depicted in Sheet 9 of Appendix E. It is likely that a Phase I groin construction operation can benefit from the creation of sand work pads on the structure's updrift side with the source of sand being the federal disposal berm. The purpose of the work pads is to minimize, or ideally eliminate, the

need for a construction trestle. Any work pad sand placement likewise beneficially contributes to the expedited formation of an updrift fillet.

3.2.5.2 Terminal Groin Design Goals and Precepts

A number of design parameters influence the effectiveness of a terminal structure. Under this alternative, varying options related to structure length and permeability have been evaluated to determine the level of performance relative to the project objectives (see Appendix F.

Specific design goals and precepts are identified below.

Terminal Groin Design Goals

The following is a list of the design goals developed to evaluate predicted performance:

(1) Reduce sediment transport rates from the westernmost segment of South Beach to the Cape Fear River;

(2) Minimize the potential for adverse impacts to a downdrift shoreline (e.g. West Beach) which is presently both highly dynamic and erosional;

(3) Establish an updrift (easterly) impoundment fillet with the goal of protecting currently endangered residential structures and public infrastructure (water, sewer, roads, etc.);

(4) Protect an important upland evacuation route which parallels South Beach;

(5) Protect and stabilize beachfront along the western end of South Beach ;

(6) Provide potential benefits to an adjacent navigation project via reduced shoaling;

(7) Preclude impacts to other coastal barrier islands;

(8) Require little to no structural maintenance;

(9) Minimize or reduce future maintenance requirements for portions of an existing sand tube groinfield located along South Beach;

(10) Provide an improved beach condition conducive to the facilitation of future federally-constructed beach disposal projects; and

(11) Extend the effective life and benefit level associated with future beach improvement projects (updrift of the structure).

Terminal Groin Design Precepts: In order to achieve the design goals as outlined above, the following design precepts have been considered and evaluated:

(1) Porosity – the structure should be sufficiently permeable (or "leaky") as to limit its effectiveness in the long-term impoundment of sand.

(2) Template (length and width) – the direct, as well as synergistic effects of the groin structure should provide an equilibrated profile or template for the stabilization of the updrift South Beach shoreline sufficient to last between federal beach disposal events, *i.e*., nominally two to three years. The beach profile is expected to progressively reduce in size between sand placement events.

(3) Elevation – portions of the groin should be sufficiently low such that wave overtopping and resultant sediment transport can occur past the structure during periods of energetic wave conditions.

(4) Settlement – the structure should have a foundation designed to be highly resistant to long-term settlement so as to substantially reduce future maintenance requirements.

(5) Adjustment – the structure should be capable of post-construction "tuning" if deemed necessary to refine performance characteristics.

(6) Constructability – the structure should be adequately robust so as to resist damage during low probability storm events, but at the same time sufficiently straight forward in design to assure cost-effective constructability in a highly energetic and dynamic environment.

The precepts above have been used by the applicant's engineer to develop a structural design that meets the applicant's goals regarding optimal performance. The proposed groin is designed as a low-crested, semi-permeable (i.e. "leaky") structure so as to not totally disrupt sand transport to either the "Point" or West Beach. In order to foster structure

permeability, the cross-section and crest of a terminal groin would be constructed with a large (and atypical) void ratio. This is accomplished through the use of large and relatively uniformed-diameter quarried granite stone. No core stone is specified, and the use of any mix of stones is discouraged. As a result, the uppermost one meter (or more) of the rock terminal structure will be subject to some level of sediment transport through the section during occasions of wave wash. For illustrative purposes, oblique aerial photography of a permeable groin of similar design to that of the proposed structure on Bald Head Island is provided in Appendix G. The photographs depict a chronology of shoreline conditions on South Amelia Island (at Amelia Island State Park in Nassau County, Florida) from construction (August 2004) to two years post construction (March 2006).

An important design characteristic of a permeable terminal groin structure is the continued opportunity for spit formation on its downdrift (channel facing) side. The applicant's engineer believes that the latter feature would be conducive for continued northward sand transport along the Point toward West Beach. It should be noted however that since both the Point shoreline and West Beach shorefront are both highly erosive and dynamic, the forces which control those processes would be expected to result in a shoreline and spit configuration which may be different from those of the past. That is to say, the terminal structure is *not* expected to necessarily resolve ongoing erosion issues on its downdrift side. As noted previously, a design goal is to neither exacerbate existing erosion trends nor result in a condition which cannot be remediated in a manner similar to the pre-project condition – which in this instance is direct sand placement along the affected West Beach shorefront on an as-needed basis.

The design process itself considers various structural characteristics that ultimately define performance relative to the design goals. Evaluations of design characteristics such as permeability and length are described in Appendix F and within the Engineering Report (Olsen 2013).

3.2.5.3 Terminal Groin Design Details

Design drawings are provided in Appendix E. The terminal groin can be defined by three principal sections: (1) the upland tieback; (2) the groin stem; and (3) the structure head. The latter segment is generally more robust structurally since it experiences the highest levels of incident wave energy (particularly during storms). The stem comprises the majority of the structure and is typically the segment of greatest sediment transmissivity above a certain elevation. The tieback is defined herein as the "root" of the structure higher in elevation and therefore not necessarily subject to sand loss due to daily or monthly tide and wave conditions. It therefore defines the template for the minimum level of updrift beach impoundment and resultant beneficial shoreline alignment (due to its relative non-permeability and higher crest elevation).

Note that Sheet 3 of the design drawings (Appendix E) depicts a "no-construction" area associated with a 150-ft buffer located around the remains of a wooden sailing vessel considered to be from the late 19th or early 20th century. The shipwreck was located and documented by Tidewater Atlantic Research, Inc. (T.A.R) under contract to the Village of Bald Head Island. The investigation carried out by T.A.R. was part of the design due-diligence associated with the siting of the proposed terminal structure seaward of the westernmost segment of South Beach shoreline. Following consultation with NC Department of Cultural Resources (NCDCR) personnel at Fort Fisher it has been determined that the shipwreck is potentially significant and eligible for nomination to the National Register of Historic Places (NRHP). NCDCR recommended a 150-ft buffer to protect the wreck. In order to accommodate a 150-ft buffer, the original conceptual design for the terminal structure was modified as to both its footprint and its orientation. In addition, the identified wreck is located updrift of the proposed structure. It is the intent of the design engineer for accreting sediment to afford some protection for the surviving hull remains. Per the findings of the T.A.R. archaeological study, burial of the remains as a result of the accretion updrift of the structure would be considered a positive impact. The final report of

findings of the archaeological survey and shipwreck assessment prepared by T.A.R. is enclosed (refer to Appendix H).

Sheet 4 (Appendix E) depicts the spatial footprint or "plan" of the proposed groin structure relative to a May 2012 survey and aerial photography. Hence, the shoreline shown relative to the groin is in an eroded condition. All survey information is relative to NGVD 29. As shown, the present-day elevation of the seabed near the terminus of the groin is -10 ft NGVD. The approximate 1900-ft structure has a curvilinear orientation toward the east in order to account for the proximity of the depths associated with the navigational project channel to the west and the existence of a shore-attached shoal formation extending southward from the existing shoreline in the vicinity of the terminal structure's root. The current groin structure and fillet location is intended to avoid the shoal feature (i.e. the shoal will remain outside or westward of the groin). Although the overall structure length is 1,900 ft, its terminus is only 700 ft offshore (or southward) of the 2012 MLW location. Subsequent to filling of the structure through sand placement, the post-fill location of the MLW will initially be at, or in the proximity of, the structure head. The latter condition would likely represent the maximum level of sand impoundment by the structure.

Sheet 5 (Appendix E) depicts the design characteristics of the three (3) typical structural sections associated with the proposed rock structure. The general locations of the cross sections are noted on Sheet 4. Similarly, the general profile of the terminal groin is presented on Sheet 6. As shown, the *specified elevation* of the crest (top of stones) for the section of the groin conducive to westward sand transport is +4.5 ft NGVD. Due to the resultant formation of large voids (between large similarly sized armor stone), the "effective" crest elevation will typically be about one-third to one-half an armor stone diameter below the specified elevation. In the present case, the specified crest elevation is +4.5 ft NGVD and the requisite cap stones average 3 to 5 ft in diameter.

The terminal structure under this alternative is not intended to eliminate the need for nourishment events on West Beach. West Beach (downdrift of the proposed terminal structure) is not presently in a stable condition and will remain prone to sand losses, which may be exacerbated by the presence of the groin structure.

Predicted shorelines and physical conditions resulting from the terminal groin (and its associated design characteristics) are discussed further in Section 5.0 of this Draft EIS.

3.2.5.4 Terminal Groin Construction Methods

Rock-filled marine mattresses would be utilized as a foundation for the seawardmost section of rock groin structure in order to ensure that long-term settlement would be minimized and that the project's design intent and unique performance characteristics would be maintained over time. In the more landward section of the rock groin, a composite geogrid/geotextile fabric would in all probability be used as an underlayment (where settlement is less of an issue).

The terminal groin alternative would be constructed of relatively large granite armor rock of varying size (weight and dimensions). Rock would be transported to Bald Head Island by barge from an upland location. Typically rock is transported from the quarry to the waterside transfer site by rail and/or truck. Placement of the foundation mattresses and rock is generally by crane from a barge, from the upland and/or from a temporary trestle or pier constructed in close proximity to the groin structure. Such a pier is typically pile-supported and necessitates the driving or jetting of steel pile which are later retracted and removed from the site once the rock structure is completed. Note that for construction of Phase 1, use of a temporary trestle may be minimized or avoided entirely. Instead, equipment may be operated from sand work pads on the updrift side of the structure (with the applicant's preferred source of the sand being the federal disposal). Upland portions of the structure tieback necessitate excavation and backfilling of beach sand in order to place the groin foundation and rock at their prescribed elevations (normally below existing grade).

Since the construction of the structure is best performed subsequent to sand placement (via either federal disposal of Village-sponsored nourishment), it is likely that construction activities as described above would extend into environmental moratorium periods (including periods of sea turtle nesting). The effects of such actions during these periods of time are further described in Section 5.0.

Future performance of the rock structure may be readily modified by adjusting its crest elevation. Raising or lowering of structure elevation necessitates only the removal or addition of armor rock in order to modify its transmissivity to sand transport. Some level of post-construction tuning may be warranted and advantageous to structure performance based upon the results of physical monitoring and/or other physiographic issues identified by the project engineer or appropriate resource agencies.

3.2.6 Terminal Groin with Beach Nourishment/Disposal and Removal of Sand Tube Groinfield (Alternative #6)

Alternative #6 would involve the construction of a single, low-profile terminal groin as described in Alternative #5 above. However, upon completion of the installation of the terminal groin, the Village would begin the systematic removal of the existing sand-tube groinfield on South Beach. Sand placement via Village-sponsored nourishment projects and federal beach disposal would continue on periodic intervals. Note that to accurately characterize potential costs and environmental consequences of this alternative, it is anticipated that nourishment would occur on a greater frequency than that of Alternative #5. The Delft 3D modeling results associated with future physical performance are further discussed in the applicant's Engineering Report (Olsen Associates 2013).