

APPENDIX B

INLET MANAGEMENT PLAN

(Prepared by the Village of Bald Head Island, Applicant)

VILLAGE OF BALD HEAD ISLAND, NC TERMINAL GROIN PROJECT

INLET MANAGEMENT PLAN

I. SETTING

In order to comply with the requirements of SB110, an applicant for a permit to construct a terminal groin must formulate a plan for the management of the inlet, estuarine and ocean shorelines immediately adjacent to and under the influence of the inlet.

The requisite inlet management plan shall do all of the following relative to the terminal groin and its accompanying beach fill project:

1. Describe the post-construction activities that the applicant will undertake to monitor the impacts on coastal resources.
2. Define the baseline for assessing any adverse impacts and the thresholds for when the adverse impacts must be mitigated.
3. Provide for mitigation measures to be implemented if adverse impacts reach the thresholds defined in the plan.
4. Provide for modification or removal of the terminal groin if the adverse impacts cannot be mitigated.

Inlet management plan formulation is different for an inlet improved for navigation versus one which is in a relatively unimproved condition. Also influencing various potential management precepts is the size of the inlet, its history and any associated disposal operation which presently benefits one, or both, of the abutting coastal barrier shorelines. Such is the case with the entrance to the Cape Fear River where a proactive Sand Management Plan has been in effect for over a decade. The subject Wilmington Harbor Sand Management Plan (WHSMP) is implemented by the Wilmington District, United States Army Corps of Engineers (“USACOE”) during routine maintenance of the innermost three (3) segments of the Ocean Entrance Channel which comprise a portion of the Wilmington Harbor Navigation Project.

Up until 1999, the Wilmington Harbor navigation project had historically not included the disposal of littoral sand on the adjacent beaches, or in the active littoral zone. This had been primarily due to the maintenance practices that were established with the inception of the project

in the late 1800's. As a result, standard practice for maintaining the ocean entrance channel segments of the project was offshore disposal in water depths of 30 ft or more.

With the last harbor deepening project and coincident reorientation of the ocean entrance channel, the Wilmington District established a new standard for the disposal of littoral sediment. From an engineering perspective, a purpose of the Wilmington Harbor maintenance program was to avoid or mitigate potential erosion of the adjacent beaches by conserving the limited natural resource, sand, through deposition directly on the adjacent coastal barrier beaches.

Pursuant to the adopted Plan, the initial ratio of distribution of littoral sand excavated during routine maintenance operations between Bald Head Island and East Oak Island – Caswell Beach was proposed by the District in the ratio of two-thirds to one-third, respectively. The WHSMP was initiated as part of the first maintenance project following initial improvements of the deepening project. Beach quality sand originating from project widening, deepening and channel reconfiguration was likewise distributed between the two islands with sand being placed westward on Oak Island as far as Holden Beach.

The Cape Fear River Entrance is a historically federally improved tidal inlet which includes a deep draft commercial navigation project channel authorized by Congress intended to serve the Port of Wilmington Harbor, N.C. None-the-less, both the interior flood shoals, the exterior ebb shoals as well as portions of the navigation channel which are subject to shoaling with beach quality sand, all serve as potential sand sources necessary to meet the performance requirements of SB110 regarding terminal groin mitigation – as well as supplemental beach fill necessary to prefill a terminal groin. Moreover, the regularly scheduled disposal of large quantities of high quality sand (typically 1 Mcy, or more) associated with the WHSMP offers opportunities for the applicant for a terminal groin permit to strategically schedule groin construction in such a manner so as to utilize beach disposal sand to meet the beach fill requirement of the enabling terminal groin legislation.

II. PHYSICAL MONITORING PLAN

A. Background

The Village of Bald Head Island, NC (Village) has performed comprehensive beach monitoring of South Beach, The Point and West Beach since 1999. Prior to that date, less formal surveys of the “dry” beach (only) were also accomplished at varying dates in time. In 2008, East

Beach was added to the current monitoring plan. Elements of the present day survey program under the WHSMP include the nearshore portions of Bald Head Shoal and the abutting federal navigation project. Borrow sites are likewise monitored for a minimum period of 3 years after any Village sponsored excavation required for shore protection.

A detailed report of findings is issued annually by the coastal engineering firm Olsen Associates, Inc., on behalf of the Village, which generally addresses:

1. Recent volume and shoreline position changes measured over the prior twelve (12) months.
2. Comparisons of existing and long-term conditions relative to pre-fill conditions documented since November 2000 by annual surveys.
3. Monitoring of the sand tube groinfield last reconstructed in 2010 and repaired in 2013.
4. Discussions of the performance of each last major sand placement project, (federal as well as non-federal).
5. Recent navigation channel changes including those at/or abutting “The Point” – an area of chronic shoaling and highly dynamic shoreline change.

B. Plan Purpose

The monitoring plan discussed herein is intended to meet the requirements of State and Federal law addressing a.) beach restoration activities on Bald Head Island including borrow site creation, b.) reconstruction and maintenance of a sixteen (16) structure sand tube groinfield, as well as c.) permits for a terminal groin structure proposed for construction at the western end of South Beach – along with any attendant borrow site excavation (if necessary) and sand fill.

Specific elements of new work associated with the monitoring of the terminal groin will be directed toward the identification of and quantification of any detrimental project related downdrift changes to the Point and/or West Beach which could potentially warrant mitigation. Interpretation of post-construction surveys will be influenced by historical data detailing ongoing erosional trends at these two locations. For example, documented beach erosion at West Beach over the last decade (in the absence of the terminal structure) has necessitated several protection sand fills with the most recent occurring in early 2013. The latter occurred as part of a federal maintenance dredging operation with sand disposal totaling 1.8 Mcy placed at Bald Head Island. Hence, an important component of the expanded monitoring program will be to not only evaluate

structure performance, but also to discern any differences in downdrift erosion that could be associated with the construction of a terminal groin.

Additionally, the Applicant for a terminal groin is charged with preparing a plan for the management of the inlet and the estuarine and ocean shorelines immediately adjacent to and under the influence of the inlet. The Division of Coastal Management has taken the position that, despite the presence of the three (3) mile distance and maintained navigation channel, some monitoring is required at the easternmost end of Oak Island at Caswell Beach.

C. Beach Surveys

i. Bald Head Island

For purposes of documenting both future beach disposal and terminal groin project performance and shoreline change, The Village will continue to perform comprehensive annual beach monitoring as carried out over the past thirteen (13) years at Bald Head Island. The survey baseline for this work is depicted by **Figure 1**. Profiles are surveyed twice annually (seasonally) on approximately 400-ft. intervals. Profiles generally extend some 2400-ft. or more offshore and include the depth of closure for natural beach conditions – except where intersected by the federal navigation channel, or a major shoal feature. All surveys are performed by a certified hydrographic surveyor registered in the State of North Carolina.

Several additional profile lines will be added to the existing survey program in the vicinity of the terminal structure (see **Figure 2**). In addition, the project surveyor will be required to annually perform an approximate MHWL survey between Sta. 0+00 and 75+00 (see **Figure 3**). Each survey will be compared to prior surveys and utilized for trend analysis. Digitally controlled aerial photography taken at approximate 6-month intervals will likewise be used to supplement analysis of the post-terminal groin shoreline condition.

The first post-construction MHWL survey will be performed within 30 days of the completion of the proposed terminal groin and beach fill, thereby documenting the as-built shoreline condition. The entire island-wide monitoring surveys will be performed on a six-month basis at the same approximate time as previous seasonal survey program addressed by the existing (pre-groin) comprehensive island-wide beach monitoring program.

ii. Oak Island

For approximately the past 12 years, the Wilmington District has performed comprehensive physical monitoring which included both the Oak Island and Bald Head Island shorelines. The purpose of this program has been to examine the response of adjacent beaches, entrance channel shoaling patterns and the ebb tidal delta to the Wilmington Harbor channel deepening and realignment project. As a result, a comprehensive data base has been developed which portrays shoreline changes at both locations for over a decade. For purposes of assessing post-construction shoreline conditions on the eastern end of Oak Island, the Village's coastal engineering consultant will utilize survey data acquired by the Wilmington District, USACOE. Similarly, the consultant shall access and utilize relevant federal aerial photography of the Oak Island area of interest.

Should the federal physical monitoring program be terminated for fiscal or other reasons, the Village will perform limited beach monitoring (one survey per year) at 12 survey stations located at baseline stations mutually acceptable to both the Village and Caswell Beach. The Village will likewise provide aerial photography coverage of the survey area at or close to the time of the Caswell Beach survey. The Village's responsibility for post-groin physical surveying on Oak Island will terminate if three (3) years of monitoring subsequent to terminal groin structure completion fails to indicate any level of cause or effect relationship between structure installation and shoreline change at Oak Island.

D. Borrow Site Monitory Surveys

The existing permitted borrow area located on Jay Bird Shoals was surveyed both immediately prior to and after construction of the 09/10 Village sponsored 1.8 Mcy beach restoration project (see **Figure 4**). Subsequent surveys are being performed at 12-, 24- and 36-months and biennially thereafter. The area surveyed includes a minimum of 500-ft. of coverage outside the permit limits of the borrow site. The survey is performed by single beam sonar on a density line spacing of 100-ft. Due to emergent portions of Joiner Shoal at the north, up to 72-acres of shallow seabed may need to be surveyed by non-sonar methods. In this area the surveyor may use single beam sonar on a shallow draft boat, or wading profiles at low tide using RTKGPS. A 100-ft. grid spacing will continue to be maintained at this location, irrespective of methodology required. Subsequent to a Post-Irene emergency dredging project at South and

West Beach constructed in 2011/12, a Bald Head Creek borrow site is subject to annual surveys beginning in January 2013 (see **Figure 4**). The project fill volume was 120,000 cy.

Borrow sites utilized for locally funded sand placement operations at Bald Head Island shall be monitored in accordance with the Permit Condition associated with each project. Should locally funded sand placement required by the construction of the terminal groin necessitate the borrowing of sand from within the remaining (1 Mcy) unexcavated (permitted) portion of the Jay Bird Shoal borrow site; the entrance to Bald Head Creek; the Smith Island Range of the federal navigation channel, or any other permitted site, annual monitoring of that site shall be performed – pursuant to the terms of the associated permit. Monitoring results shall be addressed in each subsequent annual monitoring report.

E. Hydrographic Survey Standards

In general, the following will apply to *all* surveys:

- Surveys will be performed to meet or exceed the Minimum Performance Standards for the USACOE Hydrographic Surveys. Specifications manual EM 1110-2-1003, January 2002 (or its successor).
- All data will be corrected for tide and heave.
- The survey vessel will be positioned using RTKGPS. Soundings will be in feet and 10th's.
- Vertical Datum will be local NGVD29.
- Horizontal Datum will be NC NAD83.

F. Aerial Photography

The Village of Bald Head Island will continue to perform controlled (color) rectified digital aerial photography of the island shoreline(s) twice a year – usually coincident with the timing of each seasonal beach survey. The present minimum areas of coverage are the West Beach, South Beach and East Beach shorelines. Oblique low altitude photography is likewise performed periodically as required to document the occurrences of any storm, or man-made event of interest. Any repair of the sand tube groinfield is likewise documented by ground level digital photography.

As noted above, aerial coverage of the easternmost 3 miles of Oak Island shoreline shall be performed (coincident with each beach survey) – should ongoing federal physical monitoring cease at that location.

G. Reporting

A comprehensive report-of-findings will continue to be issued annually which presents, analyses and discusses all data acquired over the prior twelve (12) month period. Of particular interest will be beach and borrow site changes which occur over time and any potential effects downdrift of the proposed terminal structure. Each report will likewise discuss, consider and compare the relevant portions of the historical database as it relates to the most current survey(s).

All patterns of erosion, accretion or shoaling will be documented, quantified and graphically depicted. For any project borrow site, map differencing will be performed annually (and cumulatively over time) for purposes of visually demonstrating spatially occurring changes in elevations due to shoaling. For the Point and West Beach downdrift shorelines, comparative MHWL and aerial mapping will be presented subsequent to terminal groin construction along with volumetric analyses currently being computed every 6 months.

The consultant will maintain and expand the present day comprehensive monitoring report format and deliverables to include specific Sections which specifically address borrow site construction and all subsequent changes over time, as well as terminal groin and sand fillet performance and downdrift (post-structure) shoreline history, in addition to shoreline changes occurring at Caswell Beach.

H. Deliverables

Annual monitoring reports will be delivered to the Village of Bald Head Island, Caswell Beach and all relevant State or Federal regulatory agencies within 90-days of completion of the last survey performed for the reporting period of interest. Additionally, digital data acquired or addressed by each Annual Report can be transferred to an Agency or Stakeholder, upon request.

III. MITIGATION THRESHOLDS

A. Baselines for Evaluation

Both the West Beach updrift shorelines and the cross-inlet Oak Island – Caswell Beach shorelines have over 12 years worth of post-deepening (1999-present) survey data to document shorefront conditions. Most data take the form of cross-shore profiling at intervals sufficient to document volumetric change and contour location along the shorefront of interest. Supplementary aerial photography is likewise available to assist with the interpretation of survey data.

The more recent (decadal) data will be the most relevant due to changes in navigation project dimensions, corresponding episodic dredging operations within the entrance channel and, most importantly, the equilibration of beach disposal projects which seeks to improve shoreline conditions. Interpretation of the latter phenomena will be extremely important since the temporal variation in shoreline change (volume and location) – after a beach fill – is typically significant. Both Oak Island and Bald Head Island have received, and will continue to receive, large scale beach disposal projects (typically exceeding 1 Mcy per event) in accordance with the Wilmington Harbor Sand Management Plan.

B. Impact Determination – West Beach

Both West Beach and the depositional spit feature known as the Point lie downdrift of the terminal structure proposed at the westernmost limit of South Beach. As a result, both are subject to change as the downdrift shorefront seeks a post-structure equilibrium condition. Currently, it is expected that a portion of the West Beach shorefront will require beach disposal on a 3-year basis – with or without structure implementation. The assignment of impact on West Beach to a terminal structure will therefore need to weigh the following site specific downdrift conditions:

- Interval between sand placement projects?
- Have shoreline recession rates (volumes and MHWL) increased by over 50%?
Has beach fill equilibration been accounted for?
- Can a documented cause and effect relationship be assigned to downdrift shoreline reconfiguration, or is any newly developed “hot spot” isolated and therefore not the result of a quantifiable trend?
- Do numerical modeling results support or refute the observed shoreline erosion trends?
- Can extraordinary meteorological conditions be defined as a cause of accelerated erosion?
- Have navigation channel maintenance operations changed in frequency or scope?

C. Impact Determination – Oak Island (Caswell Beach)

Although neither numerical modeling analyses nor historical monitoring data support the possibility of terminal groin project related impacts to the eastern end of Oak Island, relevant

determination criteria are none-the-less required. The most recent, published USACOE survey monitoring data for Oak Island (through 2010) indicates a near term general trend of fill stability with very modest average annual sediment losses. One exception is at baseline monitoring stations 35 and 40 where a localized “hot spot” has been in existence over the last decade. Recent back beach or dune erosion at this location has been of recent concern to interests associated with Fort Caswell.

The assignment of impact to the easternmost segments of Oak Island (*i.e.* Caswell Beach) will need to weigh the following conditions:

- Are changes in shoreline conditions isolated, or are they the result of a clear reversal in trend?
- Has recent beach disposal occurred? Is fill equilibration affecting rates of shoreline translation?
- Can extraordinary meteorological conditions be defined as a cause of accelerated erosion?
- Has the pre-existing erosional hot spot identified on the eastern Oak Island shorefront increased in magnitude (*i.e.* either volumetrically or spatially)?
- Does numerical modeling of terminal groin project related borrow site construction activities (for purposes of obtaining beach fill) refute or support a cause and effect relationship?
- Have navigational channel maintenance operations changed in frequency or scope?

IV. MITIGATION

A. West Beach

The highest priority for any required mitigation on West Beach would be alongshore sand placement sufficient to protect endangered residential structures. It is probable however that the timing of an expeditious (and sizeable) sand placement project may be adversely affected by other factors such as permitting, dredge availability, and public project bid requirements. As a result, interim actions may be considered: (1) sand bag revetment construction along the section of shorefront where threatened structures exist, (2) temporary borrowing of sand mechanically

from the updrift impoundment fillet of the terminal groin – with placement along the chronically eroded shorefront, or (3) both actions.

Coincident with any level of remedial action should be consideration of structure modification. In most instances, such an action would consist of rock removal from the structure crest sufficient to increase its transmissivity to sand transport. That is to say, its permeability (or “leakiness”) would be increased. Such an action would not be expected to result in immediate benefits. Hence, it should be considered to be a secondary response in the hierarchy of remedial actions.

B. Oak Island

Although difficult, if not impossible, to verify, any recorded increase in erosion on the Caswell Beach section of Oak Island that is attributed to the proposed Bald Head Island terminal groin would need to be mitigated through direct sand placement. The most logical source of beach quality sand is the WHSMP. Accordingly, mitigation would occur through a reappportionment of some portion of the federal disposal sand to that hot spot, rather than placement of the sand at a more stable or accreting location. The Village may consider, in consultation with the Town of Caswell Beach, other measures to address the erosion, such as a sand push, sandbag revetment or relocation of sand via truck..

V. TERMINAL STRUCTURE ALTERATION

As discussed previously, the proposed terminal groin is to be constructed as a “leaky” structure with some level of reduced sediment transport continuing to occur either through and/or over the structure crest. As a rubble mound structure, sand permeability can be physically increased through the removal of stones. Any reduction in effective structural elevation will increase sediment transport across the groin. Increased transport would be conducive to spit or dry beach growth on the downdrift side of the structure which, in effect, would be expected to increase sediment transport to West Beach. Such “tuning” of a permeable structure is often desirable even if mitigation is not required. Normally, tuning would not occur without the benefit of significant post-construction monitoring, since the transmissivity of such a structure varies over time – dependent upon the condition (*i.e.* size and elevation) of the updrift sand fillet.

In the limit, the elimination of such a structure is possible so as to return the subject shoreline to pre-project hydrodynamic and littoral transport conditions. Pragmatically, lowering

of the structure to grade through armor rock removal would constitute “effective” structure elimination.