

# **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 (as subsequently amended by SB151), an applicant for a permit to construct a terminal groin must formulate 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 inlet management plan monitoring and mitigation requirements must be reasonable and not impose requirements whose costs outweigh the benefits. The inlet management plan is not required to address sea level rise. The inlet management plan shall do all of the following relative to the terminal groin and its accompanying beach fill project:

- a. Describe the post-construction activities that the applicant will undertake to monitor the impacts on coastal resources.
- b. Define the baseline for assessing any adverse impacts and the thresholds for when the adverse impacts must be mitigated.
- c. Provide for mitigation measures to be implemented if adverse impacts reach the thresholds defined in the plan.
- d. Provide for modification or removal of the terminal groin, if the adverse impacts cannot be mitigated.” G.S. § 113A-115.1(e)(5).

On Bald Head Island, the section of shorefront subject to continuing monitoring and impact analysis as a downdrift shoreline potentially subject to structure induced damage and resulting mitigation is West Beach. On the Oak Island side of the inlet, the section of shorefront subject to similar project related monitoring is the Fort Caswell oceanfront shoreline from Sta. 60 to Sta. 30. The latter is under the influence of the inlet – but outside the limits of sand disposal routinely performed by the Wilmington District, USACOE at Oak Island.

Inlet management plan formulation will be significantly different for an inlet improved for commercial navigation versus one which is in a relatively unimproved condition or which provides only for recreational navigation. Also influencing various potential management

precepts is the size of the inlet, its history and any associated sand disposal operation(s) which presently benefits one, or both, of the abutting coastal barrier shorelines. That is to say, beneficial inlet management must involve multiple considerations. 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 (Smith Island Reach and Bald Head Reaches 1 and 2) which comprise a portion of the Wilmington Harbor Navigation Project.

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 feet 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 on Oak Island, as far westward as Holden Beach. It did not however include the Fort Caswell oceanfront shoreline. In addition, the N.C. Beach and Inlet Management Plan (BIMP) established for Region 1 – Brunswick County, specifically earmarks the use of Jay Bird Shoals and Middle Ground at the Cape Fear River Entrance as borrow areas for Region 1 shore stabilization projects – and in particular for Bald Head Island given its proximity to the two depositional features. The latter are predominately comprised of beach quality material.

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. Both the inlet's 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 (as amended) regarding terminal groin mitigation – as well as supplemental beach fill necessary to prefill a terminal groin. Depending upon the timing of groin construction, the regularly scheduled disposal of large quantities of high quality sand (typically 1 Mcy per event, or more) associated with the WHSMP offers the opportunity for the applicant for a terminal groin permit to strategically schedule groin implementation in such a manner so as to utilize beach disposal sand to meet, or at least supplement the initial beach fill requirements of the enabling terminal groin legislation. This would not however, obviate potential alternate sand source requirements associated with long-term updrift fillet maintenance, downdrift mitigation at West Beach, etc.

## **II. PHYSICAL MONITORING PLAN**

### **A. Existing Monitoring Programs**

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 Village monitoring plan. In 1999, the Wilmington District USACOE likewise initiated physical monitoring of Oak Island and Bald Head Island shorelines – prior to the construction of the last authorized channel deepening project. Elements of the present day federal survey program under the WHSMP have also included portions of the ebb shoal delta as well as annual condition surveys within the federal navigation project. Borrow sites have likewise been monitored by the Village for a minimum period of 3 years after any non-federally sponsored dredging project required for shore protection. Borrow site monitoring typically includes both physical and biological surveys.

A detailed Island-wide Monitoring Report 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. Discussions of the performance of each last major sand placement project, (federal as well as non-federal).
4. Recent navigation channel changes including those at/or abutting the Point – an area of chronic shoaling and highly dynamic shoreline change.
5. Commentary regarding borrow site recovery (physical and biological) for three years following each Village sponsored dredging contract.

Long-term average annual shoreline change rates (1938-2000) for Oak Island/Caswell Beach portray, for the most part, a highly erosional condition, averaging slightly less than -5ft./yr. of recession. Conversely, during the same period of time the extreme easternmost end of the island near the inlet was determined to be increasingly accretional.

Both the ongoing (2000 - present) beach monitoring plans for Oak Island and Bald Head Island being implemented by the Village and the Wilmington District, quantitatively well-describe shoreline changes along both shorefronts. On Oak Island, all of the shorefront subject to episodic beach disposal from the channel is highly improved – relative to its pre-project condition. One exception (where disposal sand placement does *not* occur because of lack of public access) is at Fort Caswell where a section of oceanfront shoreline has experienced a documented persistent erosional hot spot since 1996. At that location, published average annual shoreline erosion “trend rates” between August 2000 and September 2010 have ranged between -4.5 ft/yr. and -8.8 ft/yr. Localized computed annual shoreline change rates at survey profiles 35 and 40, however, have been as high as -90 ft/yr and -200 ft/yr, respectively.

On Bald Head Island, shoreline conditions are much more spatially variable relative to the 1999 baseline survey condition. As expected however, the highest rates of documented shoreline change at any one time occur along the western end of South Beach nearest the inlet. Additionally, Bald Head Island has experienced more frequent sand placement from not only the navigation project pursuant to the WHSMP, but also from two (2) borrow sites – located at the entrance to Bald Head Creek to the north, and Jay Bird Shoals to the south. Ongoing erosion

experienced on West Beach has likewise necessitated sand placements in 2006, 2009, 2012 and 2013.

## **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, as well as b.) permits for a terminal groin structure proposed for construction at the western end of South Beach – along with any attendant borrow site excavation (as necessary) and resultant sand fill(s). The plan is likewise intended to be reasonable and cost-effective as provided by the enabling legislation (G.S. 113A-115.1(e)(5)).

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 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 protective sand fills at that location, with the most recent event 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 – and that warrant near term attention by the Village or which can be addressed by a reliably scheduled pending federal disposal operation.

Additionally, the Village as 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 (DCM) has taken the position that, despite the presence of the approximately two (2) mile distance between islands, the spatial extent of the intervening ebb tidal shoal formations represented by Middle Ground and Jay Bird shoals, the intervening impacts of Western Channel and an episodically dredged navigation channel, some monitoring is required at the easternmost end of Oak Island. The shoreline immediately adjacent to and under the influence of the inlet is the oceanfront

shorefront of Fort Caswell. Both the historical database and ongoing comprehensive beach monitoring program being implemented by the Wilmington District at Oak Island more than adequately meet the requirement for monitoring. Redundant surveying by the Applicant would therefore be both unreasonable and not cost-effective.

### **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 updrift 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-terminal groin) comprehensive island-wide beach monitoring program.

#### **ii. Oak Island**

For approximately the past 12 years, the Wilmington District, USACOE 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 oceanfront shoreline conditions on the eastern end of Oak Island, the Village's coastal engineering consultant will utilize publicly available survey data acquired by the Wilmington District, USACOE (see **Figure 4**). Similarly, the consultant shall access and utilize relevant federal aerial photography of the Oak Island area of interest.

Should the USACOE terminate the annual acquisition of survey data on Oak Island, the Village shall survey annually the east end of the island from Sta. 60 through Sta. 30, including half stations. The number of beach profiles surveyed shall not exceed seven (7). That data shall be added to the database acquired by the Wilmington District beginning in 2000. Note – Sta. 60 is the easternmost limit of beach disposal by the Wilmington District on Oak Island. It is essentially synonymous with the westernmost boundary of Fort Caswell.

The Village's responsibility for analysis of post-groin physical surveying on Oak Island will terminate if six (6) years of monitoring subsequent to terminal groin structure completion fails to indicate a cause and effect relationship between structure installation, or borrow-site utilization, and oceanfront shoreline change at the eastern end of Oak Island immediately adjacent to and under the influence of the inlet.

#### **D. Borrow Site Monitoring 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 5**). 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 shallow water portions of Jay Bird Shoal northward of the borrow area, 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. A100-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 5**). The project fill volume was 120,000 cy.

Permitted 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. Subsequent to sand placements required by the construction of the terminal groin based upon the borrowing of sand from within the remaining (1 Mcy+) unexcavated (permitted) portion of the Jay Bird Shoal borrow site; the northward expansion of the borrow site at 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(s). Monitoring results shall be addressed in each subsequent Village 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 10<sup>th</sup>'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.

## **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 Village 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, on Bald Head Island. A separate Memorandum-of-Findings regarding oceanfront shoreline changes occurring along the eastern end of Oak Island shall be formulated annually. The latter will be based upon publicly accessible federal survey data provided by the Wilmington District, or additional data acquired by the Village, if necessary.

## **H. Deliverables**

Each Annual Monitoring Report and Memorandum-of-Findings will be delivered to the Village of Bald Head Island, off-island Stakeholders 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 or Memorandum-of-Findings can be transferred to an Agency or Stakeholder, upon request.

### III. MITIGATION THRESHOLDS

#### A. Baselines for Evaluation

Both the West Beach downdrift shoreline and the cross-inlet Oak Island oceanfront shoreline immediately adjacent to and under the influence of the inlet have over 12 years' worth of post-deepening (1999-present) survey data sufficient to document present day 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 on Bald Head Island.

The post-1999 survey data are considered most relevant due to associated changes in navigation project dimensions, corresponding episodic dredging operations within the entrance channel storm events and, most importantly, the equilibration of multiple beach disposal projects intended to improve shoreline conditions on both barrier islands. 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. Segments of both Oak Island and Bald Head Island have received, and will continue to receive, large scale beach disposal projects (often exceeding 1 Mcy per event) in accordance with the Wilmington Harbor Sand Management Plan (WHSMP).

#### B. Impact Determination – West Beach (Bald Head Island) (Sta 0+00 to Sta 24+00)

Both West Beach and the depositional spit feature known as the Point lie downdrift of the terminal structure proposed for construction 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 (and supported by in-depth modeling) that a portion of the West Beach shorefront will potentially require beach disposal on a 3-year basis – *with or without* terminal structure implementation. The principal borrow source for interim small scale sand placement at that location (if necessary) will be the expanded Bald Head Creek borrow site. The assignment of “impact” on West Beach due to a terminal structure will therefore need to weigh the following site specific factors potentially affecting shoreline conditions downdrift of the groin:

- Interval between sand placement projects?
- Have average annual shoreline recession rates (volumes and MHWL location) increased by over 50%? Has beach fill equilibration been accounted for? Is the duneline being impacted?
- 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. Baseline for Action – West Beach, Bald Head Island**

The baseline for action along West Beach (Sta 0+00 – Sta 24+00 by definition) shall be determined by analysis of historical surveys along this reach acquired on almost a 6-month basis since 2000. Over this 14 year period, either the Village or the Corps have placed sand when the limit of erosion reached “critical” condition portions – in most cases where the limit of erosion was located at/or within the primary dune. All such landward limits of erosion locations are well documented by survey. Hence, the “baseline” for remedial actions by the Village along West Beach is the point at which the limit of upland erosion reaches its historical worst case condition – as documented by survey since 2000 – or is projected to reach such a condition in the next 6 months.

### **D. Impact Determination – Oak Island (Fort Caswell)**

In depth numerical modeling analyses of Oak Island predict *no quantifiable impact* to littoral transport patterns or rates and associated shoreline change at that location due to either terminal groin construction or the continued use of the Jay Bird Shoal borrow area (to the limits of excavation permitted in 2008). The latter sand source was only partially dredged by the

Village in 09/10, however all modeling analyses (including the most recent DELFT 3D model) have assumed the borrow area has been excavated in its entirety. Similarly, the model predicts no changes in inlet hydrodynamics of significance to any stakeholder, be they federal or non-federal. Historical shoreline documentation included in the first USACOE physical monitoring report required for the deepening of the Wilmington Harbor Navigation Project depicted a strong trend of accretion for both the oceanfront and inlet facing shorelines located on the easternmost mile of Oak Island – for the period 1933 - 1983. Most of that segment is located within the privately held Fort Caswell parcel. Between 1983 and 1996, the same COE report documents a general trend of recession along the Fort oceanfront (E-W) shorefront and continuing modest accretion along the majority of the inlet facing (N-S) shoreline. Subsequently, the Corps likewise has documented (by survey) Post-Harbor Deepening annualized shoreline change rates of -90 and -200 ft/yr at survey profiles 35 and 40, respectively – for the survey period 2000 – 2010. Those profiles extend seaward of the Fort Caswell oceanfront shoreline.

The most recent, *published* USACOE survey monitoring data for Oak Island (through 2010) indicates a near term general trend of beach stability (after two disposal projects) on Oak Island with very modest average annual sediment losses. The littoral transport processes supporting such a condition are corroborated by the DELFT3D model. One *exception* to the measured trend is at Corps baseline monitoring stations 35 and 40 where the above discussed localized “hot spot” clearly continues to be in existence. Both back-beach and dune erosion at this location have been of recent concern to local interests associated with the Fort Caswell property. The latter shoreline is outside the limits of sand placement from navigation channel maintenance. It is likewise adjacent to a large scale marginal flood channel. Both the lack of direct beach disposal and the effects of the marginal flood channel can be considered to be two of several contributors to the present day erosional hot spot.

The comprehensive DELFT3D modeling performed on behalf of the Applicant demonstrates *no level of potential impact on any segment of Oak Island shoreline*. Nonetheless, the Village herein proffers a “baseline” for the initiation of “mitigation” pursuant to SB110 from Sta. 60 to Sta. 30, the oceanfront shoreline immediately adjacent to and under the influence of the inlet. The Village shall deliver annually to DCM a report of its monitoring results. In the event the monitoring results disclose any potential shoreline change exceeding a baseline trigger, a Technical Advisory Committee (TAC) shall be consulted. The latter shall be comprised of a

NC licensed professional engineer with substantial expertise and employment experience in coastal engineering from the Village, Oak Island Stakeholders and DCM (one from each, for three (3) total engineers) to review the results of the monitoring and analyses and to consider whether there is any terminal groin related impact on shoreline change exceeding the baseline trigger. The TAC shall be formally established prior to the completion of construction of the terminal groin project.

It shall be the responsibility of the TAC to confirm or refute any potential effects attributable to any element of the terminal groin project, including borrow site excavation. In no event shall the terminal groin be deemed responsible for any impacts or shoreline change from storms or other natural phenomena; including, without limitation, the influences of the adjacent shipping channel or Western Channel, channel maintenance dredging, federal beach disposal design, or any delay or absence of sand placement from channel maintenance dredging. The analysis by the TAC regarding potential impacts to the easternmost segments of Oak Island (*i.e.* Fort Caswell) will at a minimum need to weigh, without limitation, the following site specific factors:

- Are changes in oceanfront shoreline conditions isolated, or are they the result of a clear reversal or acceleration in trend?
- Has recent beach disposal occurred on Oak Island? Was the federal disposal project continuous and adequately tapered at its eastern end? Did it continue to exclude the Fort Caswell property? Is fill equilibration affecting rates of shoreline translation? Are there dissimilarities in disposal sediment composition, compared to the native beach at Fort Caswell?
- Can regionally experienced meteorological or other natural conditions be defined as a potential 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, location or scope?

If the majority of the TAC finds that a shoreline impact exists because of the terminal groin, and not because of other causes, the Village shall work with the TAC and affected interests at Fort Caswell to determine and implement appropriate adaptive response measures, consistent with the reasonableness and cost-benefit precepts of SB151, or subsequent law. These response measures are below described in Section IV(B). The TAC may likewise recommend changes to the design of the federal disposal project on Oak Island which would seek to strategically maximize benefits to all properties at that location.

#### **E. Baseline for Action – Oak Island (Fort Caswell)**

The baseline for consideration of action by a TAC from Sta. 60 to Sta. 30, the shoreline immediately adjacent to and under the influence of the inlet, shall be determined by analysis of surveyed beach profiles first initiated by the Wilmington District, USACOE in 2000. As discussed elsewhere, in this Plan, that data shall be updated at least once annually by either the Corps or the Village (if required).

The expanded database shall likewise be analyzed annually by the Village consultant and a determination as to recent changes in shoreline location reported in a Memorandum-of-Findings. Similarly, both an “annual profile by profile shoreline change” rate and an updated “trend rate” shall be computed for purpose of comparison with published annual and long term trend rates measured by survey since 2000 between oceanfront survey Stations 60-30. These are inclusive of the area of persistent observed recession (i.e. mol @STA 35 and 40). **Table 1** provides a summary of historical data for Sta 60 to Sta 30.

Should annual computed shoreline recession rates exceed by 50%, or more, the maximum measured annual recession rate (since 2000) at one or more of the designated survey locations, the TAC shall be requested to evaluate and determine the source of the additional erosion. Similarly, if the updated long term trend rate varies by 50%, or more from its last published value, the TAC shall be requested to evaluate and determine the source of the additional erosion or reduction in accretion (since 2000). In either event, a specific determination shall be made, and a report submitted to DCM, regarding any expectation that the causation of additional erosion is related to the terminal groin project.

## **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 and the total loss of protective dune formations. It is probable however that the timing of an expeditious (and sizeable) sand placement project may be adversely affected by other factors such as design document formulation, dredge availability, and public project bid requirements. As a result, the following interim actions may likewise need to 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, as noted above, and as discussed in Section V.

### **B. Oak Island – Fort Caswell**

As previously discussed, *no probability of shoreline change* at Oak Island is predicted by the comprehensive numerical modeling analyses performed on behalf of the Village. Hence, the previously discussed recommendation of the TAC if necessary – authorized to make a shoreline impact determination – in lieu of just the Applicant. Any recorded increase in erosion on the Eastern section of Oak Island that exceeds the baseline and is determined by the TAC to be caused by the Bald Head Island terminal groin project, would most likely need to be mitigated through direct sand placement. The most cost-effective future source of beach quality sand is the WHSMP, or sand dredged from within the limits of the federal navigation project by the Applicant. Alternately, the Village may consider, in consultation with the TAC, other measures to address the erosion, such as a sand push, sand stockpiling and transport of disposal sand, sandbag or other revetment, sand placement redesign of the federal disposal project limits of fill,



or, in an extreme circumstance and absent more reasonable, cost-effective alternatives, reduction in size or removal of the terminal groin.

## **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, seasonal wave climatology, storm effects and other site specific factors. In an extreme circumstance, and absent more reasonable, cost-effective alternatives, effective “removal” or major dismantling of the structure may be required.

To that end it should not be automatically assumed that if the Phase I terminal groin fails to meet its design goals that it should be completely removed from the shorefront. It is entirely likely, that the subject rock structure could be lowered to the point that it is almost entirely transparent to littoral transport – such that is posed no threat to the downdrift West Beach shoreline or other interests located on Oak Island. At the same time however, a very low level structure would serve to benefit the updrift – South Beach profile – albeit at a significantly lower level than originally proposed. That is to say, even without the creation of a protective updrift fillet, a low level rock structure could serve to beneficially act as a “template” to the overall updrift beach profile – thereby continuing to provide some level of benefit to both the island and the navigation project.

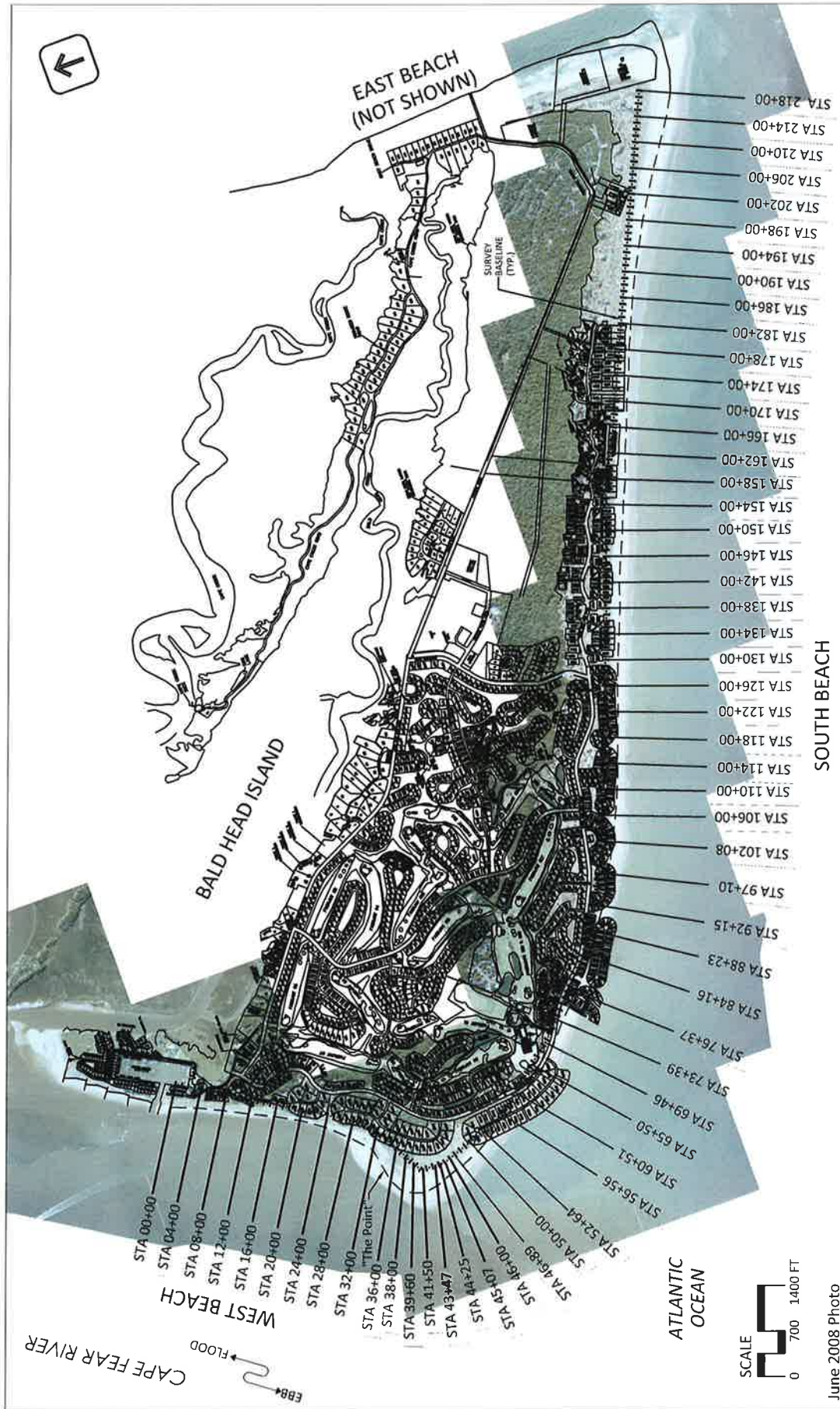
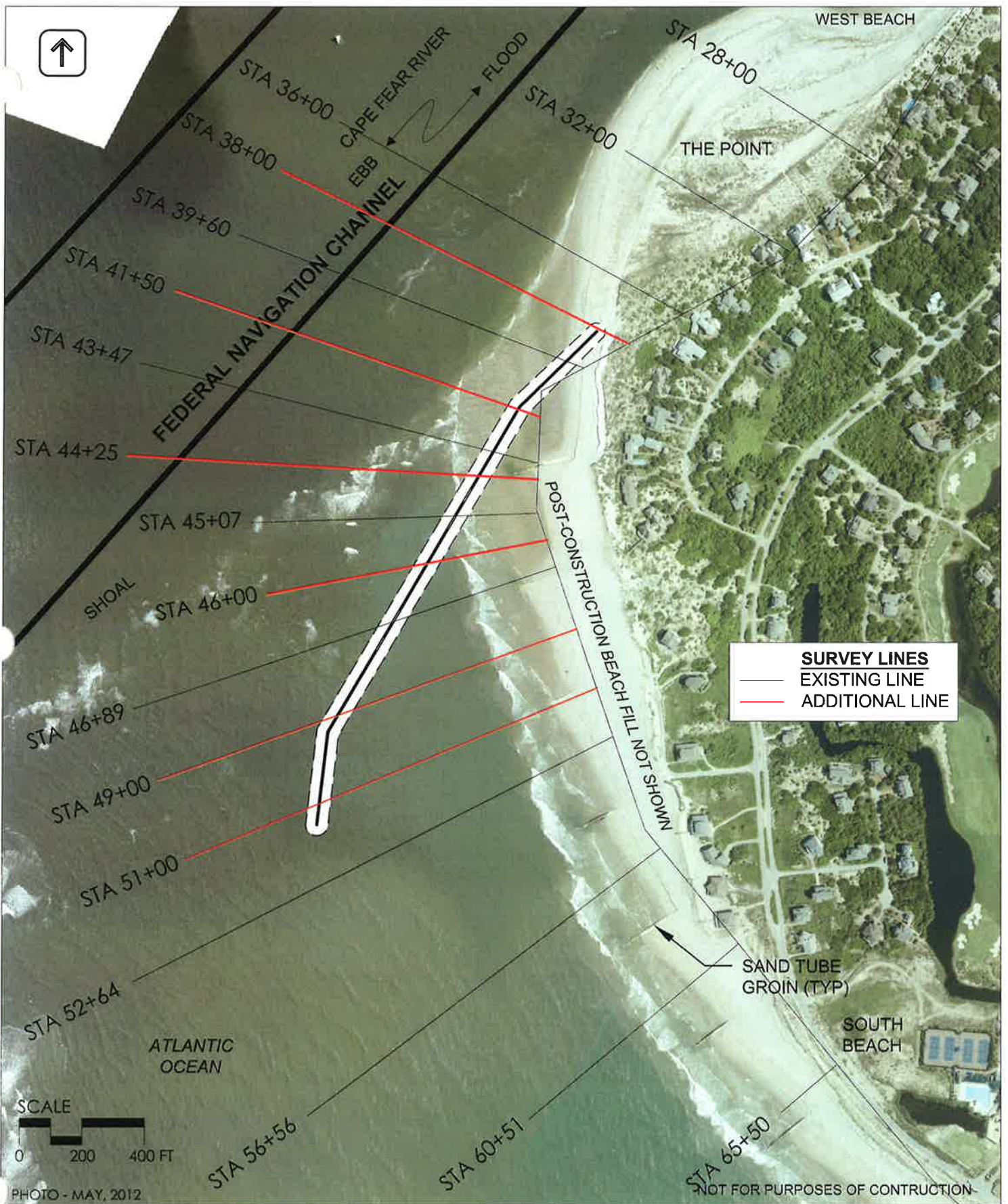


Figure 1: Island-wide beach monitoring baseline. olsen associates, inc.

June 2008 Photo  
Physical Monitoring Program



**Figure 2:** Survey Profile Lines in the Vicinity of the Terminal Structures



**Figure 3:** Location of Annual MHWL Surveys

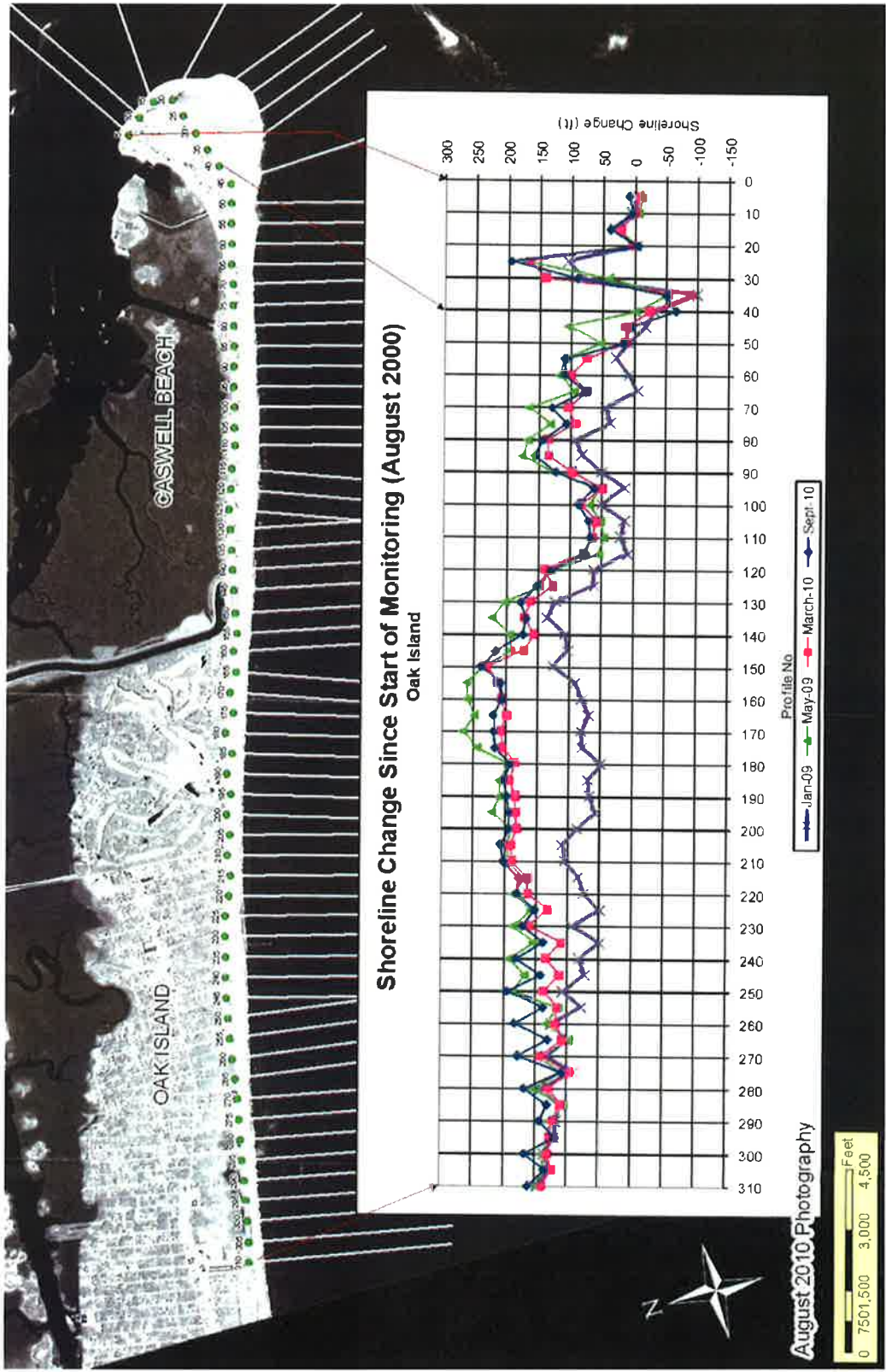
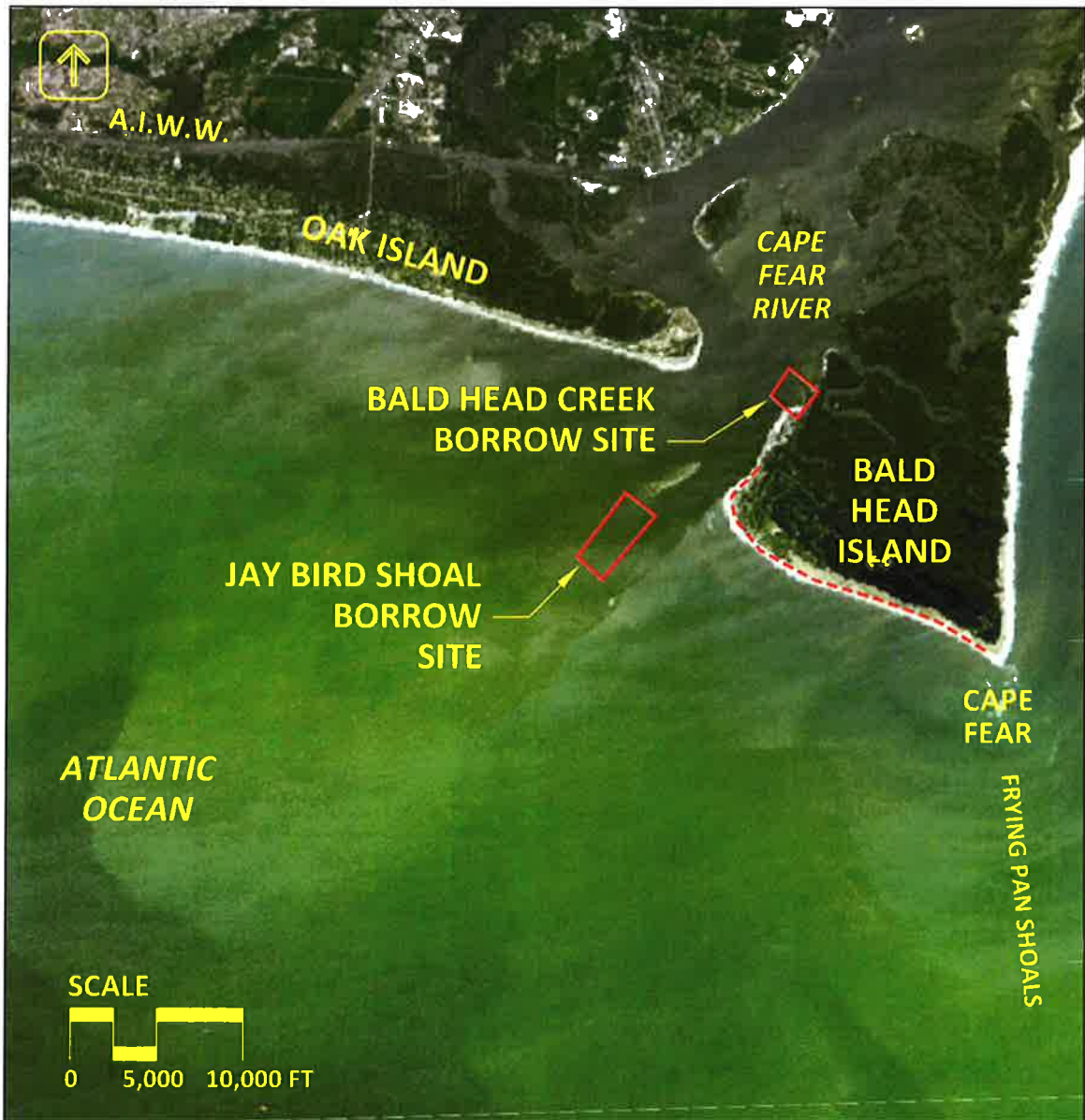
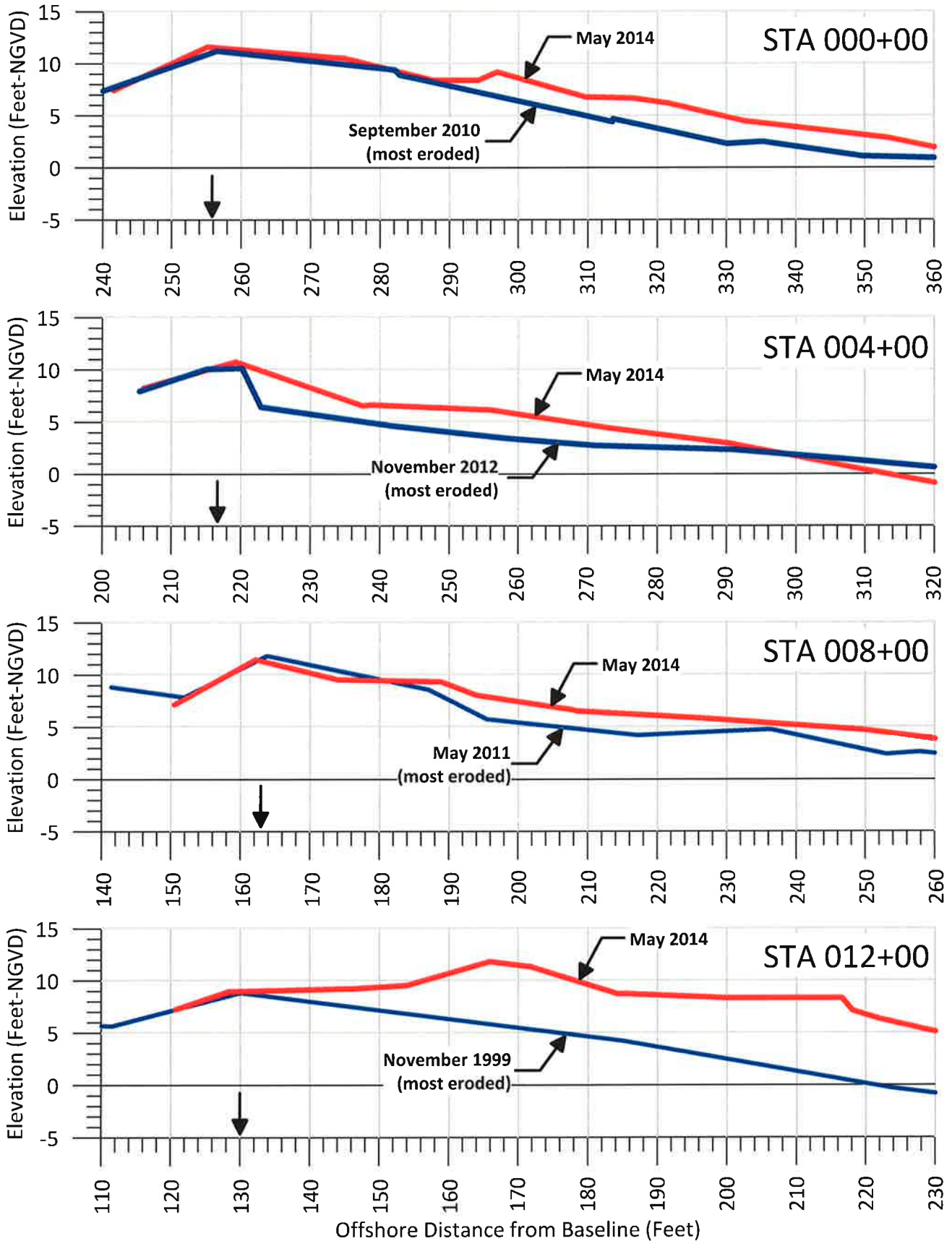


Figure 4: Example -- Federal Monitoring Program for Oak Island.



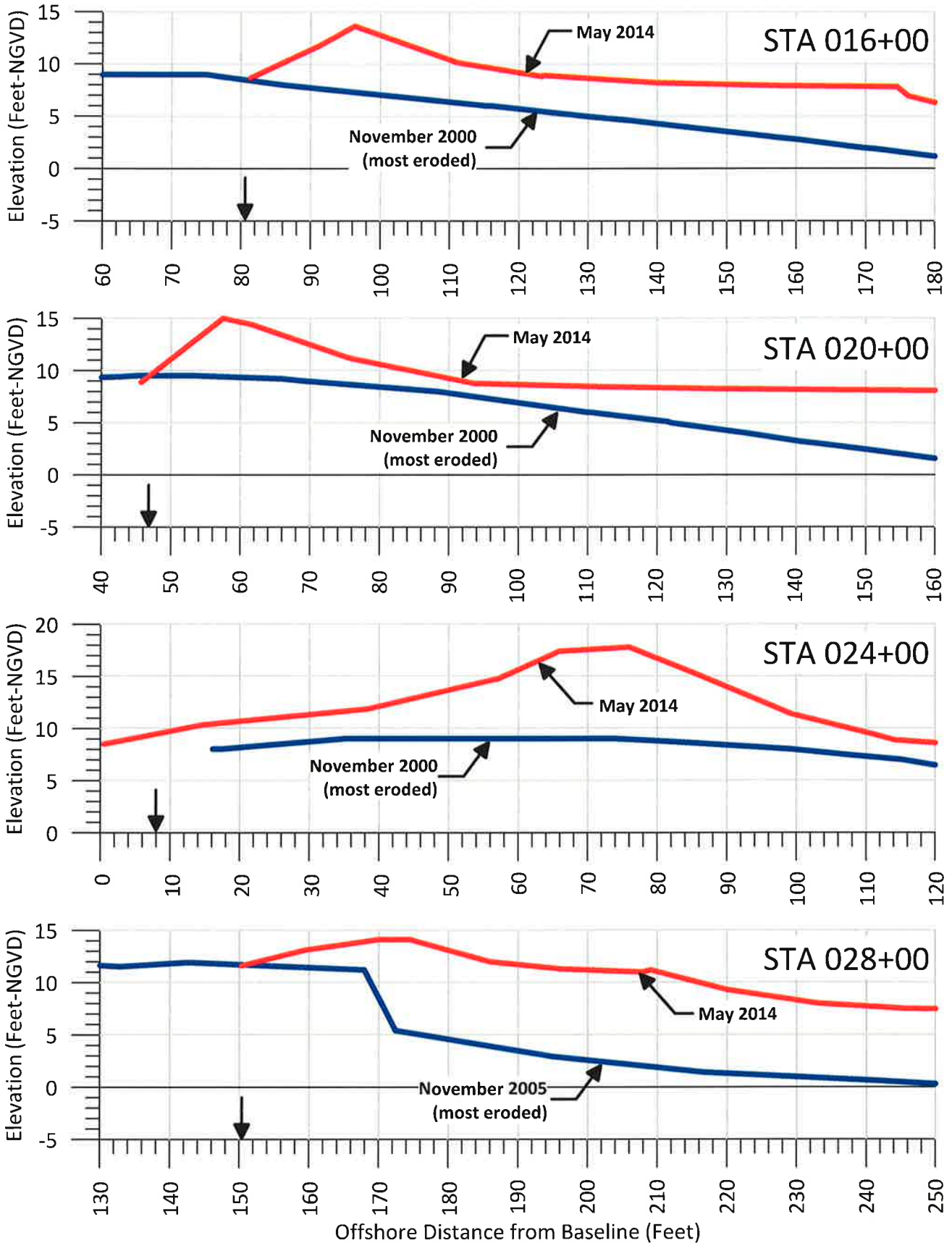
**Figure 5:** Borrow Sites Subject to Permit Required Monitoring

# WEST BEACH



**Figure 6:** Location of maximum erosion at West Beach (2000-present).

# WEST BEACH



**Figure 7:** Location of maximum erosion at West Beach (2000-present).



**TABLE 1**  
**CASWELL BEACH MONITORING DATA<sup>1</sup> (STA 30 – 60)**

<b>Survey Station</b>	<b>Trend Long Term Rate <sup>(1)</sup></b>	<b>Shoreline Maximum Annual Recession Rate <sup>(2)</sup></b>	<b>Date of Occurrence</b>
STA 60	+10.4 ft/yr.	-90 ft/yr.	2002
STA 55	+9.3 ft/yr.	-94 ft/yr.	2003
STA 50	+4.8 ft/yr.	-120 ft/yr.	2005
STA 45	+5.6 ft/yr.	-80 ft/yr.	2009
STA 40	-4.5 ft/yr.	-200 ft/yr.	2006
STA 35	-8.8 ft/yr.	-90 ft/yr.	2006
STA 30	+12.4 ft/yr.	-150 ft/yr.	2004

<sup>(1)</sup> Source – Wilmington District USACOE (2000-2010 – last published monitoring data – Report No. 8)

<sup>(2)</sup> Computed from COE survey data (6 mo. or 12 mo. Survey intervals)