Implementation of Geotextile T-Groins in Pinellas County, Florida

By

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ABSTRACT

Since the late 1970s, nourished sand provided by the federal shore protection project at Upham Beach, Florida, has routinely eroded within two years of placement. The erosion problem is a result of the location of the beach immediately downdrift of a total littoral barrier and pre-control line construction in a seaward-advanced position. This 2,400-ft-long nourishment project is considered a "feeder beach" because fill is placed along the updrift end of a 2.5-mi region intended to receive sediment. The need to retain a protective beach and to address the negative public perception of a rapidly eroding project gave rise to the structural solution described in this paper. The geotextile T-groin project that was installed in 2005 included advance downdrift mitigation and a long-term monitoring plan. The structures were also designed to withstand extended exposure, high wave energy, and significant scour that typically occur at this location. Although construction of the $1.5 million project was challenging, the preliminary performance of the T-groins is promising. As a result of the structures, the public beach at the project site was 100 ft wider two years after the 2004 nourishment project, as compared to two years after the 2000 nourishment project. The T-groin project has successfully maintained Upham Beach with no downdrift impacts. Based on the performance of the temporary structures over the next several years, an application for similar rock structures may be submitted in the future.

Poorly located construction seaward of coastal dunes often destabilizes the coastal system, creating an erosional hot spot that requires periodic renourishment. These frequently renourished beaches have drawn substantial criticism as a waste of public funds to protect private property in vulnerable coastal areas (e.g. Pilkey and Young 2005). Because coastal development is a way of life, environmental managers are charged with maintaining coastal habitat and protective beaches along eroding coastlines. In Florida, federal, state, and local governments partner to approximate the natural system in areas that were developed before the implementation of comprehensive building regulations. A good example of improperly sited structures built prior to the implementation of Florida's Coastal Construction Control Line (CCCL) exists in Pinellas County on Upham Beach. Beach nourishment alone has not been sufficient to maintain a sandy beach at this hot spot. Rapid post-nourishment erosion led to criticism as a "cost-ineffective" project.

ADDITIONAL KEYWORDS:
Beach erosion, coastal armoring structures, beach nourishment, coastal management, erosional hot spot, Upham Beach.

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A structural solution that included T-head groins was proposed to hold the valuable sand on the beach. This paper outlines the history of the erosion problem at Upham Beach, the coastal management plan that was developed, and the final structural solution that was successfully implemented.

PROJECT AREA

The project area, Upham Beach, is located on the west coast of Florida in southern Pinellas County (Figure 1). It is located at the north end of the barrier island of Long Key, which makes up the municipality of St. Pete Beach. The majority of Upham Beach is a public park and is bordered on the north by Blind Pass. In the project area, net annual littoral drift is from north to south. Figure 2 illustrates the former, typical condition of Upham Beach and Blind Pass. Upham Beach is sediment starved due to the combined effect of sediment trapping by the Blind Pass jetties, a minimal ebb shoal, and periodic dredging of the inlet. Thus, sediment bypassing around Blind Pass to Upham Beach has been largely eliminated (Davis 1989; CPE 1992). The only sediment supplied to Upham Beach is via beach nourishment. If nourishment did not occur, the sand deficit in the littoral system at the project site would result in an unstable downdrift shoreline that would threaten development and public infrastructure.

Upham Beach has been nourished every four to five years since 1975. The need for periodic nourishment or mechanical bypassing has been clearly recognized by the local, state, and federal governments involved in the coastal management of this region. Mechanical bypassing is achieved when Blind Pass is

utilized as the borrow area, as in 1980, 1991, 2000 (USACE 1999), and for the next planned nourishment of Upham Beach, scheduled for 2009. Although the need for nourishment is clearly recognized, the amount and frequency of bypassing present a sand management problem (FDEP 2002).

VIDEO OBSERVATIONS OF RAPID EROSION

After construction of the 1996 Upham Beach nourishment project, an early model of an Argus video station (Aarninkhof and Holman 1999) was installed on the roof of a high-rise condominium on the north end of the island (Figure 2). Due to the rapid post-nourishment erosion rates, the site was chosen as a proof-of-concept test of video for monitoring nourishment project evolution. This unique methodology provided nearly continuous high-resolution video images of the relatively short project area. By comparing video- and survey-derived shorelines, video methodology was verified as a worthy complement to traditional beach profiles for post-nourishment monitoring (Elko *et al.* 2005). Viewing to the south, snapshot images were taken hourly for 18 months, from 10 October 1996 to 13 April 1998 (Figure 3).

The first image in the Figure 3 sequence (961010) illustrates that the downdrift seawall was exposed following the completion of nourishment. Longshore transport to the south, and accompanying downdrift deposition, was rapid following nourishment. Accretion at the downdrift seawall was evident, particularly over the first year of the project. One year after nourishment, 50 percent of the fill had eroded and the northern seawall was exposed (Figure 3, 970624). During the low-energy summer months, the shoreline fluctuated about a relatively stable position. The public park that is located downdrift of the northern seawall typically experiences increased erosion rates once the nourished shoreline erodes to the seawall. During the 1997-98 El Niño winter, several storm events caused significant shoreline erosion at the park. The erosion rate during this winter was 1.4 ft/day (Elko *et al.* 2005).

Less than two years after nourishment, 83 percent of the nourished fill had eroded; however, the downdrift beaches benefited from this erosion. Upham Beach is an excellent example of a "feeder beach" where sediment is placed on the updrift end of a region intended to receive fill (USACE 1999; Gravens *et al.* 2003). The fill erodes rapidly from the 2,400-ft-long placement area, but supplies sediment to 2.5 mi of downdrift beaches (Elko 2006).

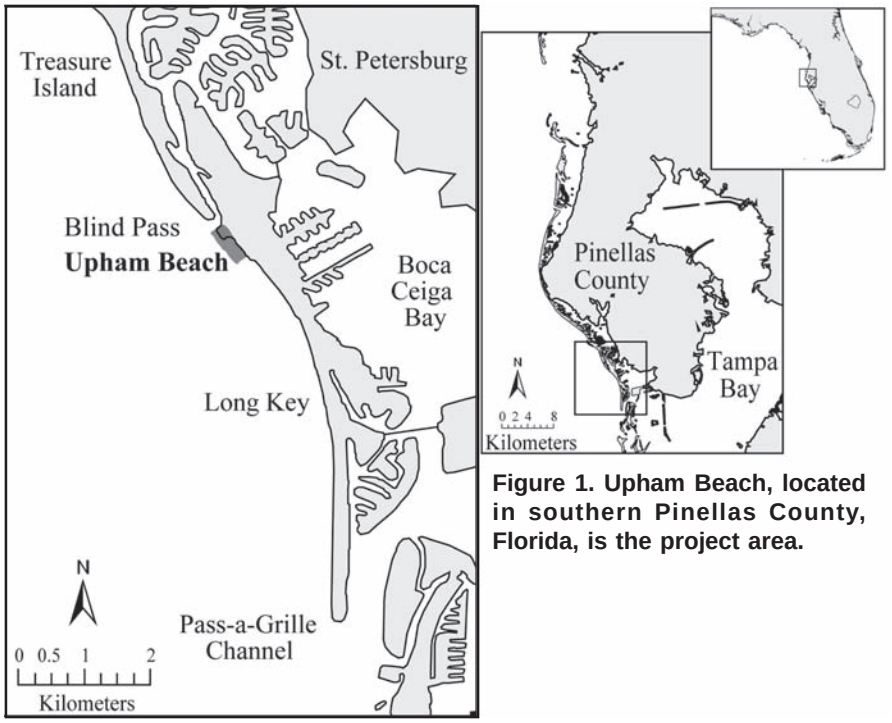

Figure 1. Upham Beach, located in southern Pinellas County, Florida, is the project area.

COASTAL MANAGEMENT OPTIONS

Continued nourishment of Upham Beach will be required for the foreseeable future. Closure of Blind Pass would likely achieve natural, continual bypassing, but pass closure is not an option. Interference with the feeder beach could threaten the stability of the downdrift shoreline which is an unarmored, commercial area. Understandably, the property owners on the north end of Long Key were concerned that no beach existed seaward of their property for the majority of the duration between nourishment projects. This is due, in part, to the advanced-seaward position of the condominiums relative to the line of construction to the south (Figure 2).

The U.S. Army Corps of Engineers studied various structural and nonstructural alternatives for the project site (USACE 1999). Because continued nourishment will be required to maintain the stability of the downdrift beaches whether or not stabilizing structures are installed on Upham Beach, structural alternatives were deemed not economically feasible for the federal project interests.

To summarize the scenario at Upham Beach, the localized erosion problem is a result of its location directly downdrift of a total littoral barrier and the seaward-advanced location of the condominiums on northern Long Key. With no significant natural sediment supply, nourishment in perpetuity is likely. The imprudent seaward location of upland development is a political reality that cannot be changed.

LOCAL POLITICS

The property owners on Upham Beach have been writing letters to the president, governor, and other public officials since the early 1990s. They often referred to themselves as "frustrated taxpayers" and frequently complained that, "the only interests being served are the renourishment companies." The residents were not impressed with the feeder beach. A 1993 petition for renourishment was submitted to the federal, state, and local governments with 253 signatures. Groins were first recommended for Upham Beach in the Blind Pass Inlet Management Plan (CPE 1992). Shortly thereafter, Pinellas County began the first state permit application to construct groins. As early as 1997, Jim Terry, Pinellas County's late coastal manager, was promising groin installation soon.

Figure 2. Oblique aerial photo looking north at Upham Beach and Blind Pass in October 2003, illustrates the typical condition of the project area prior to T-groin installation. Note the gap between the southern Blind Pass jetty and the detached breakwater. The condominium with the star housed the Argus video camera on its roof.

Another petition from 475 property owners in favor of installing structures was submitted in 2004, and is testament to the lengthy planning and permitting phase for this project. The federal nourishment project also endured repeated public criticism for sand that rapidly washed away (Headrick 1999). Negative public perception and frustrated private property owners have contributed to the coastal management challenge at Upham Beach for over a decade.

ENVIRONMENTAL PERMITTING

A structural design that was acceptable to all parties was not achieved with ease. The Bureau of Beaches and Coastal Systems of the Florida Department of Environmental Protection (herein referred to as FDEP) held the opinion that the installation of structures at Upham Beach would transfer the erosion problem to the beaches immediately downdrift. Two previous permits that included groins, in addition to fill placement, were withdrawn in 1996 and 1999 due to FDEP concerns regarding adverse impacts of the structures on the downdrift beaches.

In 1999, Pinellas County was advised that FDEP was not necessarily opposed to a structural alternative for this project area as long as it could be demonstrated with reasonable assurance that there would be no downdrift impacts. They confirmed that clear and realistic design goals would be required. FDEP restated that moving the natural shoreline fluctuations, which occur between fill placements, to other areas along the beach was not consistent with the Florida Statutes.

The FDEP permit for the subject Upham Beach Geotextile T-Groin Project was issued on 28 February 2003. The project was intended to maintain the public beach and protect property along the beachfront. The project included the construction of a 330,000 cu yd beach nourishment project, five geotextile T-head groins, and the closure of the gap in the jetty/breakwater system on the south side of Blind Pass.

DESIGN AND ENGINEERING

The final permitted project involved both nourishment and structure installation (Figure 4). The beach was filled with approximately 330,000 cu yd of material along 3,800 ft south of Blind Pass. This increased the previous Upham Beach project length by 1,400 ft. The additional fill was necessary to maintain the design shoreline of 40 ft from the Erosion Control Line (ECL) and to mitigate possible downdrift erosion caused by the structures. By Florida Statues, an ECL is required to be established prior to a public nourishment project. The line is surveyed at mean high water to separate the upland property from the newly created public beach. The ECL typically represents the most eroded shoreline position.

The project included two distinct structural components: 1) to close the gap between the south Blind Pass jetty and the detached breakwater and 2) to install five, temporary sand-filled geotextile T-head groins. The first structural component was to modify the south jetty at Blind Pass by placing additional armor stone to close an existing 40-ft gap between it and the detached breakwater. These structural modifications to an existing littoral barrier were not expected to increase adverse impacts to the downdrift beaches; rather, it was expected to reduce sediment losses into the inlet and to protect the beach from wave attack that may have previously approached through the open gap.

The second structural component was the construction of five sand-filled geotextile (polyester) T-head groins along 2,400 ft of Upham Beach. Due to FDEP concerns about potential downdrift impacts, the project was designed to be constructed with geotubes, which are considered relatively easy to remove as compared to rock. Generally, the T-groins were designed to aid in the transition from a structured shoreline to an unstructured shoreline (Figure 4). The groins would be pre-filled, or installed immediately following nourishment to further avoid downdrift impacts. Of the 330,000 cu yd nourishment, 85,000 cu yd of fill was placed downdrift of the structures as advance mitigation. Detailed performance monitoring was proposed for the life of the structures, or for 10 years, whichever was greater.

COMPREHENSIVE PROJECT PLANNING

The goal of the Upham Beach geotextile T-groin project was to main-

tain the mean high water line 40 ft seaward of the ECL while avoiding downdrift erosion of the pre-construction beach. The T-head groins were intended to maintain the beach, allow for a greater interval between nourishment projects and eventually allow for the use of Blind Pass as the lone sediment source for future nourishment projects.

The project goals were determined via the following rationale. Sand transported south along Treasure Island (Figure 1) is removed from the littoral system and stored in the Blind Pass channel. The shoaling rate of Blind Pass has been calculated to be between 42,000 and 50,000 cu yd/yr (CPE 1992; USACE 1999). When sand is dredged and reintroduced into the littoral system, the fill placed at Upham Beach erodes and supplies the remainder of Long Key.

Figure 5 illustrates the longshore transport rate for Long Key from May 1996 to June 1999. The longshore transport rate has a downward slope from the south end of Upham Beach to R-160 (Pass-a-Grille Beach). The decreasing longshore transport gradient indicates downdrift accretion. The difference in the transport rates at the south end of Upham Beach and R-160 is 40,000 cu yd/yr. To maintain a stable downdrift beach over the long term with a renourishment interval of four years, 160,000 cu yd of sediment must be available to erode from Upham Beach and be transported to the south.

The greatest erosion on Upham Beach occurs in the first year following a beach nourishment project. The large positive transport gradient during the first year after the 1996 project (Figure 5), suggests that approximately 85,000 cu yd of sand will be removed from Upham Beach in the first year following construction

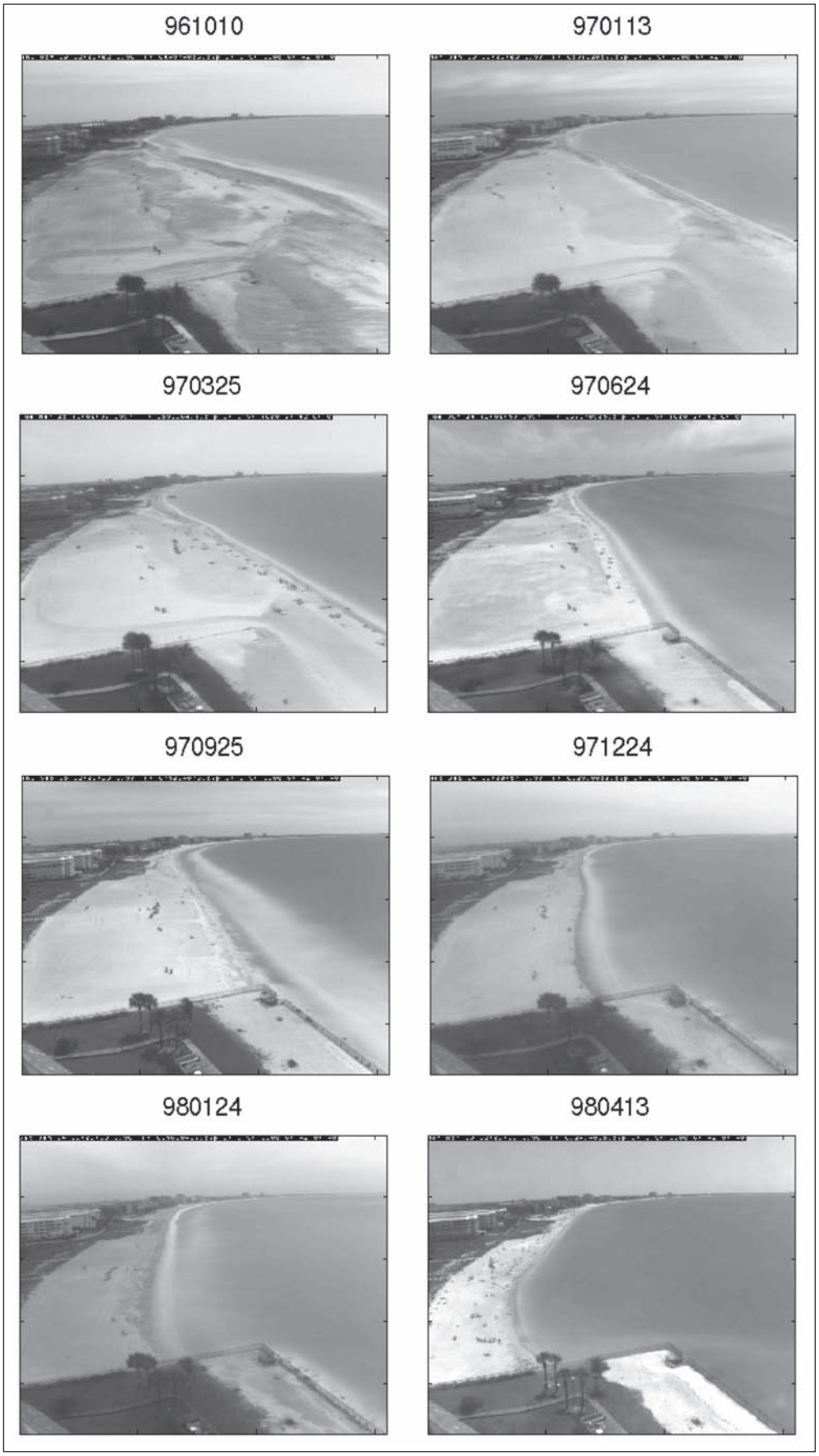

Figure 3. Video image time series showing the evolution of the 1996 nourishment over 18 months. The images are separated roughly by three-month intervals.

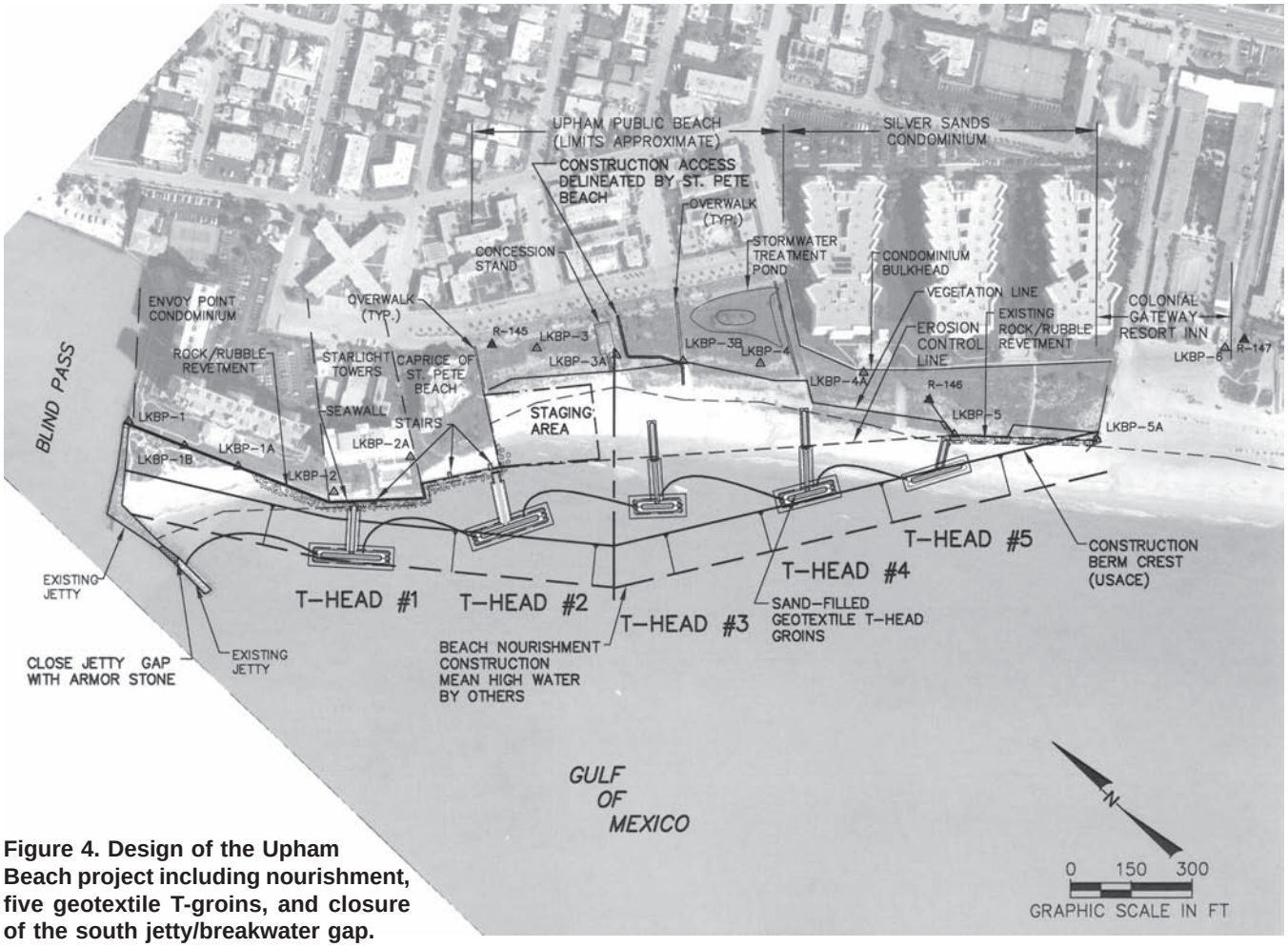

Figure 4. Design of the Upham Beach project including nourishment, five geotextile T-groins, and closure of the south jetty/breakwater gap.

with decreasing erosion in subsequent years.

The temporary T-groin field was designed to retain 170,000 cu yd of material while allowing the remaining 160,000 cu yd of advance fill to supply the downdrift beaches. Given that the downdrift requirement is 40,000 cu yd/yr, there is sufficient fill within the project to avoid downdrift impacts for approximately four years. To account for the typical rapid erosion rate during the first year following nourishment, 85,000 cu yd of this advance fill was proactively placed downdrift of the structures.

INNOVATIVE STRUCTURAL DESIGN

Due to the rapid erosion following nourishment along the northern seawall on Upham Beach (Figure 3), the beach profile tended to become steeper over the course of the nourishment interval. By the time the beach was renourished, a scour pit in excess of 10 ft below sea level often existed at the base of the proposed structures. Structures installed in this area would have to be designed to withstand this degree of scour.

To account for scour, the "heads" (shore-parallel sections) of the T-groins were designed as stacked pyramid structures (Figure 6). The structures included three geotubes in the base layer, two in the center, and one on top. This design provided sufficient depth and elevation for shore protection while maintaining the structural integrity of the T-groins (i.e. prevent slumping).

Finally, a significant drawback to the use of geotubes in the coastal environment is their lack of resistance to the elements and vandalism. In this project design, the top geotube of each structure was above mean sea level; therefore, it had the largest potential for wear and tear. In an effort to increase the durability of the exposed geotubes, this top tube was sprayed with a polyurea coating after installation. The polyurea coating not only enhanced durability, but it also protected the polyester fabric from ultraviolet radiation damage.

CONSTRUCTION

The federal nourishment of Upham Beach was completed in October 2004 (Elko 2005). The T-groins were intended to be installed after nourishment, using the recently-placed sand to fill the tubes. The T-groins were to be installed "in the dry," or buried within the fill, and the beach would eventually erode, exposing the structures. Pinellas County issued the notice to proceed for this $1.5 million, non-federally-funded project in December 2004. The contractor's projected completion date was June 2005.

The project required the installation of 44 geotubes making up the five T-groin assemblages. By June 2005, only the T-head of the northernmost structure was completed, for a total of 6 of 44 geotubes. The remaining 38 geotubes were installed in the next six months. Pinellas County granted substantial completion of the project in March 2006.

Installation of the northernmost T-head structure was difficult because the structure was not installed in the dry, but in the open Gulf of Mexico at the loca-

tion of the highest wave energy in Pinellas County. Rapid erosion following the 2004 nourishment reduced the beach width at the northernmost T-groin location. When placing geotubes or the base "scour apron" layers (Figure 7A), calm water conditions are desired. A set of black, temporary geotubes were installed seaward of the work area, to act as a cofferdam or breakwater, in an attempt to achieve calm water conditions. The temporary geotubes were slashed and deflated by vandals in February 2005. After this vandalism incident, the cofferdam could not be rebuilt in the correct configuration. Consequently, excavation of this single section took four months and the scour apron was not installed until April 2005. The cofferdam was continuously overtopped by wave energy, carrying sand into the work area. This was a problem both during excavation and during geotube placement. Sand that washed into the work area had to be removed by hand in order to place the next geotube. The last geotube of the first T-head structure was finally installed in June 2005 (Figure 7B).

At this point, it was evident that installation "in the dry" would be the most successful construction method. With the northern section of beach shored up, the contractor installed the remaining T-groins before returning to complete the shore-perpendicular portion of the first T-groin in September 2005 (Figure 7C).

Installation of the third, fourth, and fifth structures took place from June to September 2005, during the tumultuous 2005 hurricane season. These structures were installed "in the dry"; however, an excavation pit that is 10 feet below sea level immediately fills with seawater. Consequently, the majority of the geotubes were filled by a diver in zero-

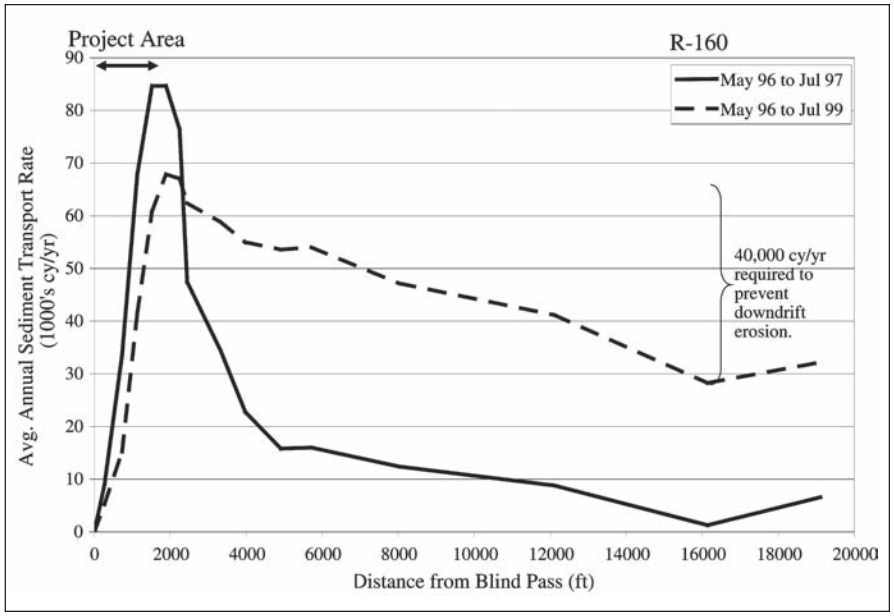

Figure 5. Short- and long-term net longshore sediment transport rate for Long Key following the 1996 nourishment project.

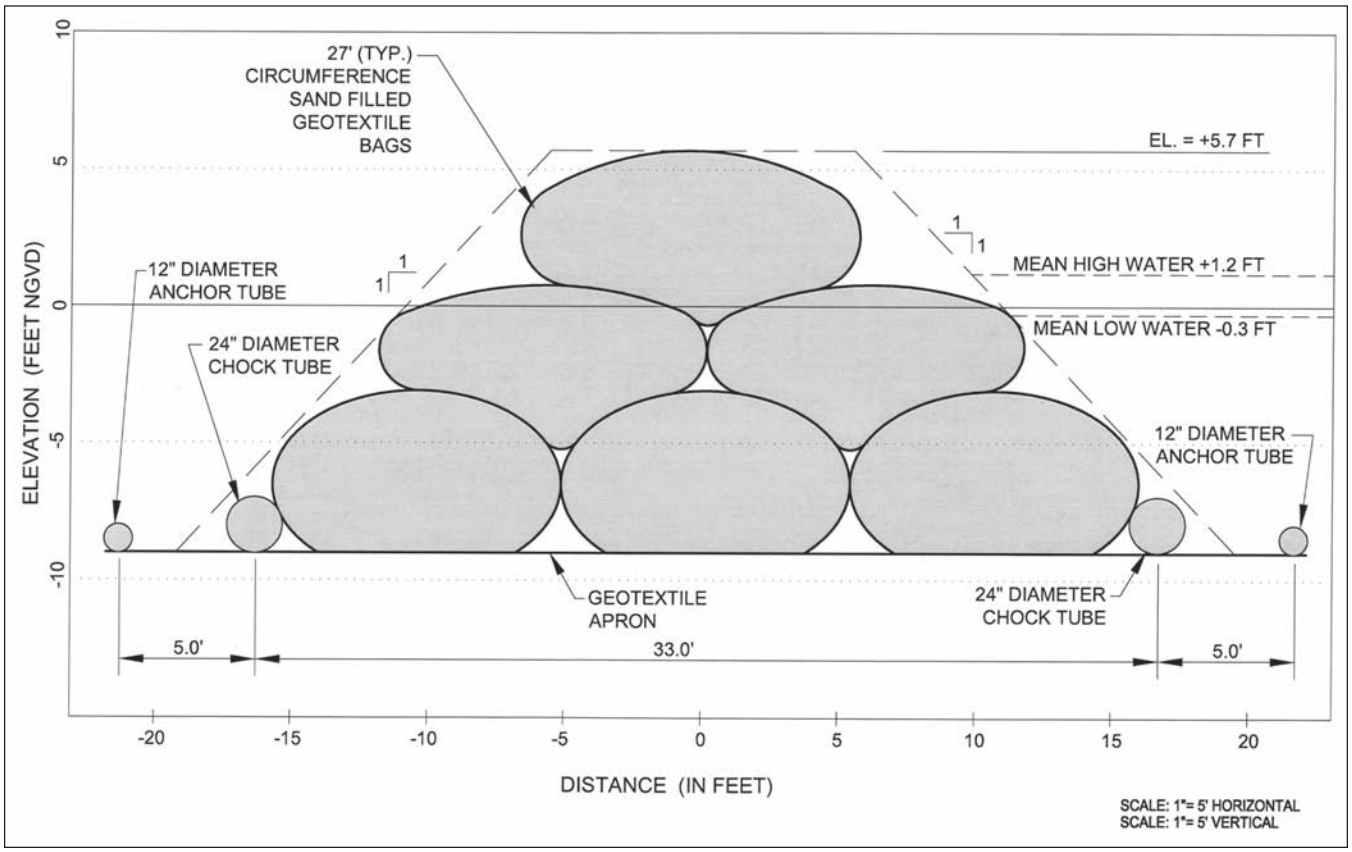

Figure 6. Cross-sectional view of the typical T-head illustrating the massive base of the structures, and the interlocking between geotextile layers.

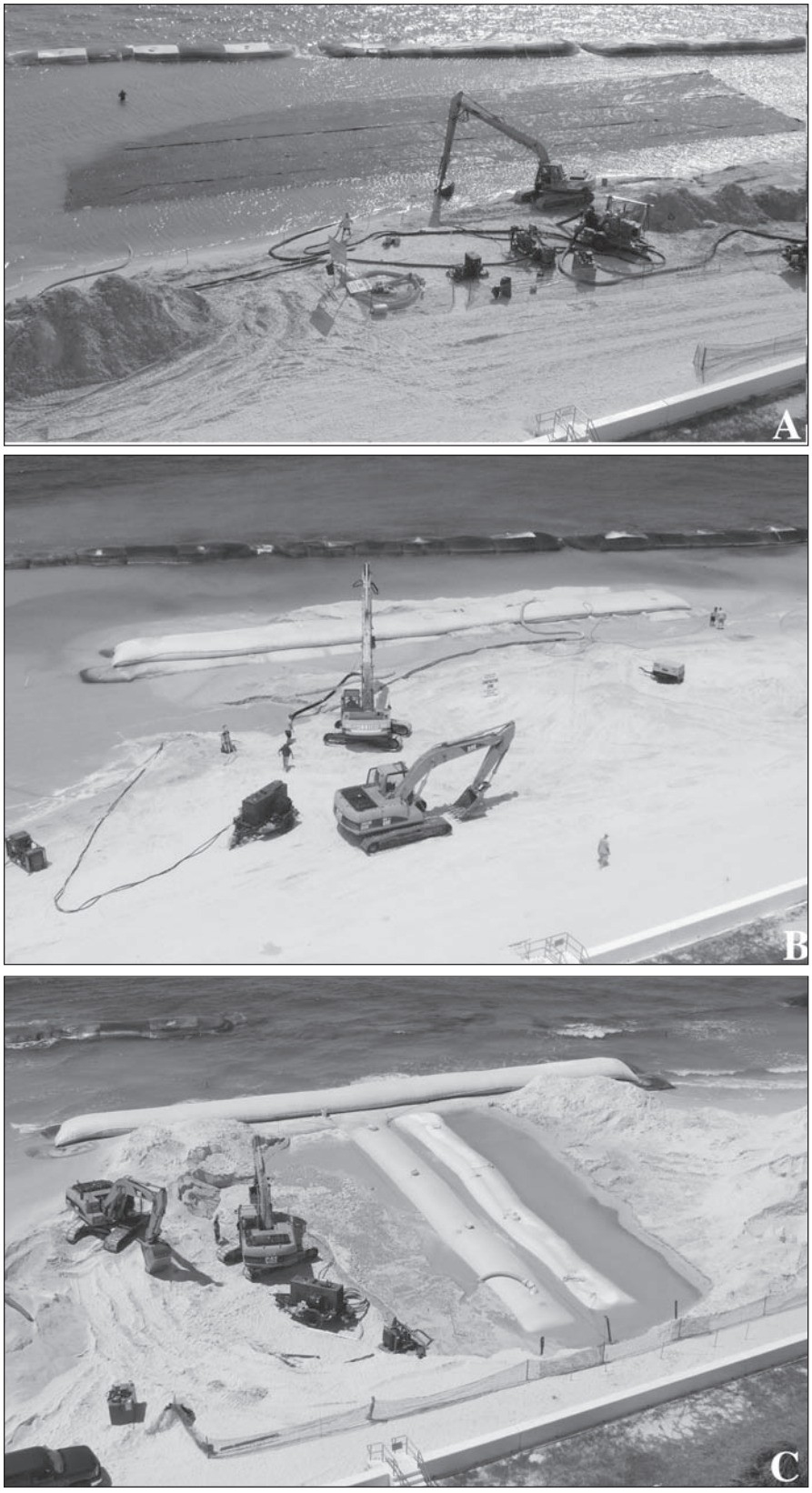

Figure 7. Construction of the first T-head on: A) 19 April 2005, B) 16 June 2005, and C) 13 September 2005.

visibility water. During the following four months, the contractor reclaimed land such that the final (second) T-groin could also be installed in the dry.

PERFORMANCE

Several cold fronts and tropical systems have impacted the area since project completion, providing a good initial performance test of the T-groins. The qualitative results are promising as illustrated by photos taken 22 months after the 1996 and 2004 nourishment projects (Figure 8). The inset is the last image from the sequence in Figure 3. Twenty-two months after the 1996 nourishment, 83 percent of the fill had eroded (Elko *et al*. 2005). Twenty-two months after the 2004 nourishment, the T-groins were maintaining a substantial beach in front of the fence as compared to 1998. The fifth T-groin is not yet exposed and the sea oats and buried seawall are fronted by a wide beach as a result of the advance downdrift mitigation.

Aerial photos comparing Upham Beach two years after the 2000 and 2004 projects also show positive qualitative results (Figure 9). Two years after nourishment, all of the fill would normally erode from in front of the northern seawall. Presently, the T-groins have stabilized this beach. Beach widths measured from survey data indicate that in 2006 the beach at the public park is over 100 ft wider than it was in 2002.

The T-groin project has achieved the goal of maintaining a 40-ft wide beach in the project area with no downdrift impacts. The downdrift beach is actually wider than it has been in two decades. Overall, the T-groin project is performing as designed.

FUTURE PERFORMANCE

Upham Beach qualified for federal emergency rehabilitation funding due to damage that occurred during the 2005 hurricane season. Sediment that eroded during 2005 was replaced in September 2006. This interim nourishment was conducted independent of the T-groin project. At the time of publication, the T-groins were completely buried within the recently-placed fill (Figure 10). Detailed physical monitoring will continue as the beach erodes and the structures eventually become exposed again. Pinellas County is planning for the structures to remain intact throughout this nourishment interval and to be covered again during the upcoming 2009 project. Depending on the performance, another permit application for similar rock structures may be submitted in the future.

CONCLUSIONS

The Upham Beach erosion problem is a result of its location directly downdrift of a total littoral barrier and the seaward-advanced location of the

Figure 8. Photos taken from the roof of one of the condominiums 22 months after the 1996 and 2004 nourishment projects. Note the wide beach stabilized by the T-groins in front of the fence and sea oats in 2006 as compared to 1998.

condominiums on northern Long Key. In an effort to improve the longevity of the federal nourishment project, a locally-funded structural solution was implemented. Over a decade of political criticism and environmental permitting finally resulted in a project that was acceptable to all parties. The non-federal project included the construction of a 330,000 cu yd beach nourishment project, five geotextile T-head groins, and the closure of the gap in the jetty/breakwater system on the south side of Blind Pass. This project provided sediment to be transported to the downdrift beaches, maintaining the "feeder beach" effect of Upham Beach. In addition, the innovatively designed T-groins are intended to withstand exposure and scour. Preliminary performance indicates that the T-groin project has succeeded in maintaining a beach at the project site while avoiding downdrift impacts.

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REFERENCES

Aarninkhof, S. and R.A. Holman 1999. "Monitoring the nearshore with video," *Backscatter*, 10 (2), 8-11.

Coastal Planning and Engineering, Inc. 1992. *Blind Pass Inlet Management Plan.* Boca Raton, FL: Coastal Planning and Engineering. Inc., 69 pp.

Davis, R.A., Jr. 1989. "Management of drumstick barrier islands," *Proc. of the 6th Symposium on Coastal and Ocean Man., Charleston, SC, ASCE,* 16 pp.

Elko, N.A. 2005. "Management of a Beach Nourishment Project during the 2004 Hurricane Season," *Shore & Beach*, 73 (2&3), 49-54.

Elko, N.A. 2006. *Storm-Influenced Sediment Transport Gradients on a Nourished Beach,* Tampa, FL: University of South Florida, doctoral dissertation, 194 pp.

Elko, N.A., R.A. Holman, and G. Gelfenbaum 2005. "Quantifying the rapid evolution of a nourishment project with video imagery," *J. Coastal Res.*, 21 (4), 633-645.

Florida Department of Environmental Protection 2002. *Consolidated Notice of Intent to Issue Joint Coastal Permit, Variance and Authorization to Use Sovereign Submerged Lands,* Pinellas County Upham Beach Stabilization Project, File No. 0198739-001-JC, Variance No. 0198739-002-EV, 23 December 2002, 13 pp.

Gravens, M.B., B.A. Ebersole, T.L. Walton, and R.A. Wise 2003. *Beach Fill,* In: Curtis, W. (editor), Coastal Eng. Manual, Part V, Coastal Project Planning and Design, Chapter 4, Engineer Manual 1110-2-1100, USACE, Washington, DC.

Headrick, C. 1999. "Sand Dollars," *The St. Petersburg Times*, 8 December 1999.

Pilkey, O.H. and R.S. Young, 2005. "*Editorial: Will Hurricane Katrina Impact Shoreline Management? Here's Why It Should,"* J. Coastal Res., 21(6), iii-ix.

USACE 1999. *Pinellas County, Florida, Beach Erosion Control Project, Design Memorandum, Long Key (Upham Beach Park) Segment,* Jacksonville, FL, USACE pub., 52 pp.

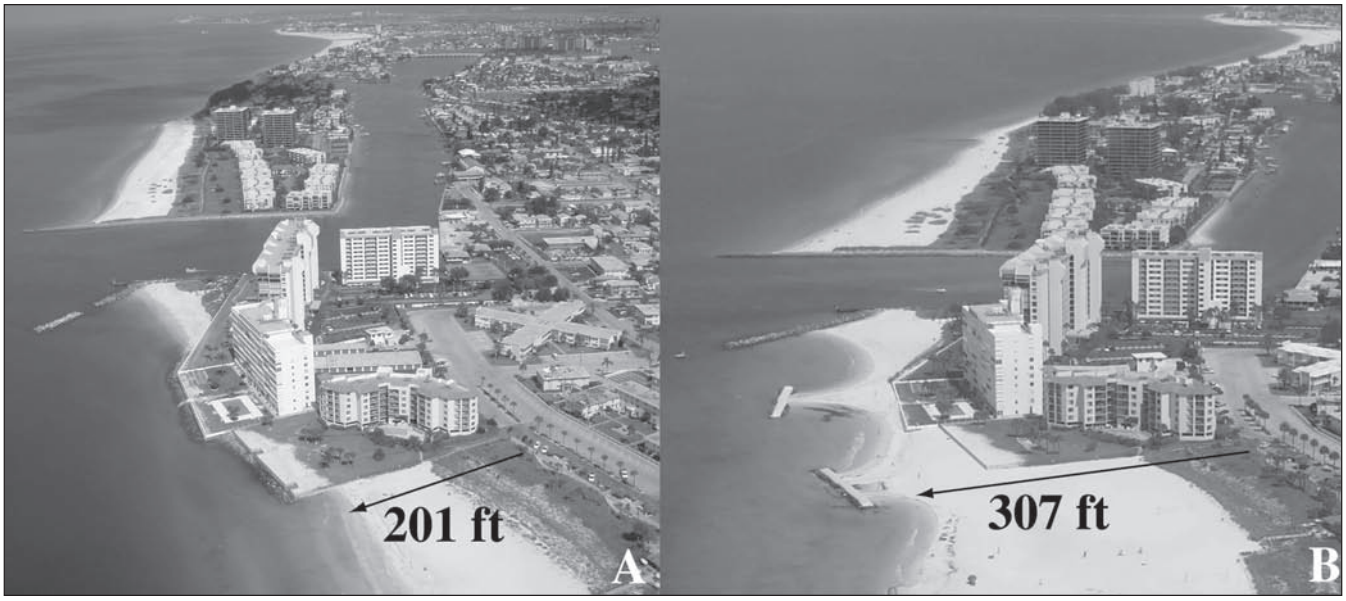

Figure 9. Aerial photos taken two years after the 2000 and 2004 nourishment projects in: A) October 2002 and B) August 2006. Survey data indicate that the beach is now over 100 ft wider than it was two years after the 2000 project.

Figure 10. Recently renourished beach in September 2006 (compare to Figure 8). The T-groins are buried and are expected to become exposed gradually as the feeder beach erodes.