Twin Rivers Shoreline Restoration: Getting the Most out of Florida's Publicly Accessible Shorelines

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ABSTRACT

This paper discusses the permitting and design of a unique shoreline protection and habitat creation project along Martin County's Twin River property situated at the crossroads of the Indian River, St. Lucie River and St. Lucie Inlet. The property was historically a dredge spoil site that has experienced chronic erosion over a period of several decades resulting in a receding and generally degraded shoreline. The passage of two hurricanes within 10 miles of the project during the summer of 2004 had significant impacts to the project's planning and construction – not all of them negative.

The project will establish both high quality shoreline habitat and a high value amenity for the public. The construction of the stone sill and mangrove planting areas will create nearly one acre of valuable estuarine habitat. Additionally, the combination of the stone sill, revetment and bulkhead will provide over 1,000 linear feet of shoreline protection / wave attenuation. As a key park amenity, 870 linear feet of pier has been incorporated into the design to provide controlled public access and recreational fishing and viewing opportunities.

Given the continued threats to natural shoreline habitats and public access to the shoreline within Florida, this project provides an excellent example of an approach to address both issues.

INTRODUCTION

Background

Martin County contains more than 150 miles of waterways. The intracoastal and riverine / estuarine coastlines are comprised of the Indian and St. Lucie Rivers. The Indian River Lagoon stretches 156 miles from Ponce Inlet to Jupiter Inlet and is a part of the US EPA's National Estuary program, supporting one of the greatest species diversity of any estuary in North America. The south fork of the St. Lucie River connects to the Okeechobee Waterway – an Army Corps of Engineers project that helps control the water levels of Lake Okeechobee, as well as provides east to west navigable access across the state. The St. Lucie River meets the Indian River and the St. Lucie Inlet at what is commonly referred to as the "crossroads."

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The Martin County Parks and Recreation Department manages and operates 69 park facilities, including 22 waterfront facilities (Figure 1). With public access to water becoming an increasingly popular topic within Florida, Martin County is striving to enhance existing facilities for improved access. The County's most recent efforts have focused on the Twin Rivers property located at the crossroads of the Indian River Lagoon, the St. Lucie River and the St. Lucie Inlet. The property was historically a dredge spoil site for material excavated from the ICWW, and has been under County management since 1996.

Due to chronic erosion problems, the County installed over 480 linear feet of bulkhead to protect the northernmost shoreline in 2001/2002. Following completion of the original bulkhead, continued erosion problems persisted along most of the remaining property shoreline. As evidenced in Figure 3, undermining had led to a substantial loss of property.

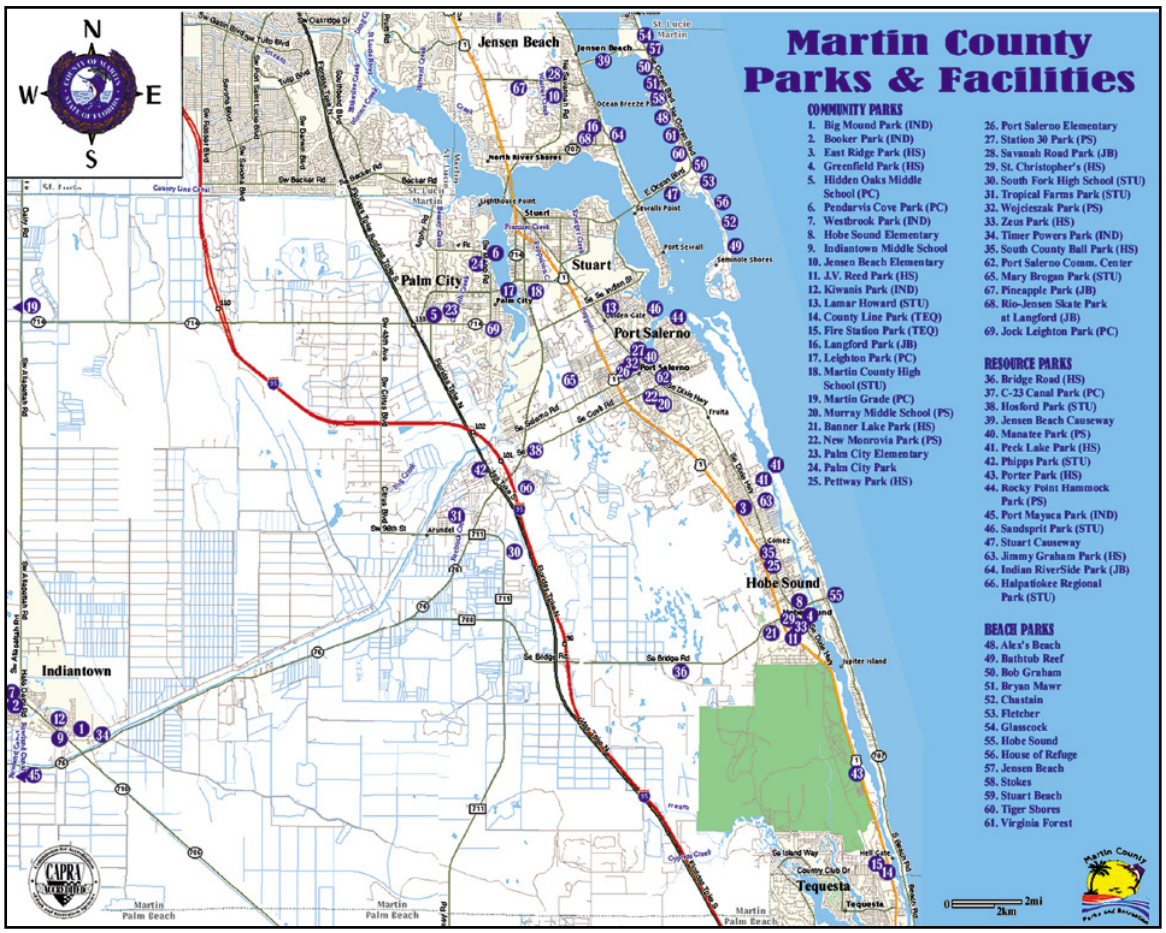


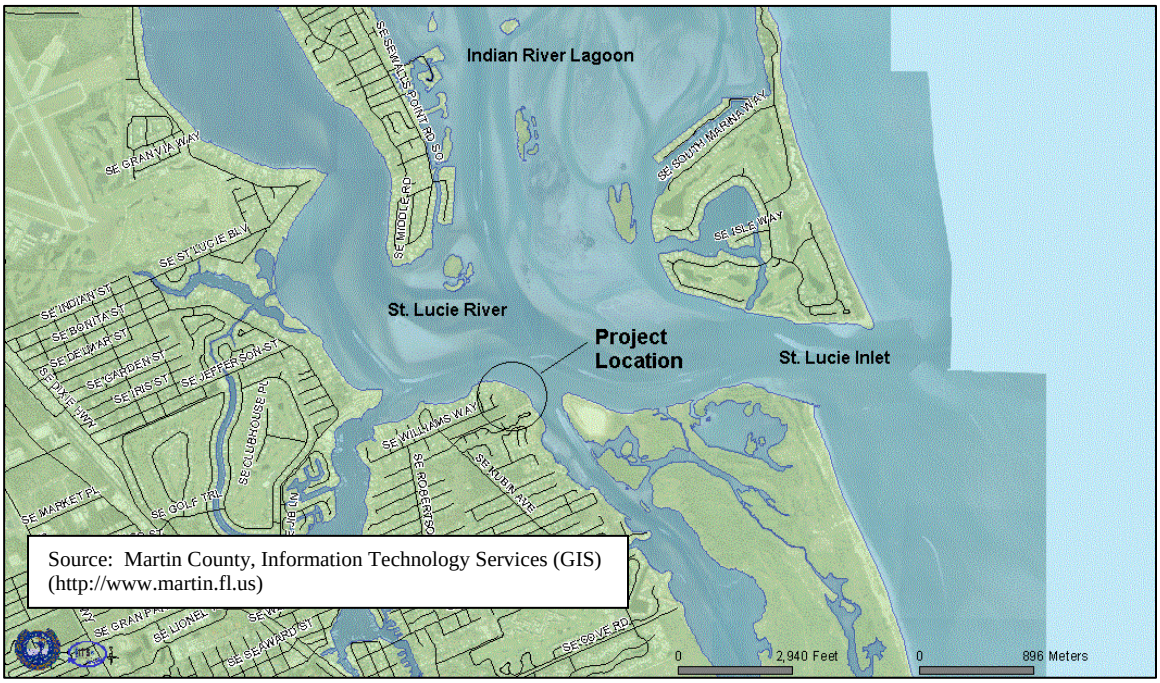
Figure 1 – Martin County, FL Parks Location Map

To protect their investment, and to enhance the potential environmental and aesthetic value of the property, Martin County teamed with Applied Technology & Management to begin concept development of the park's shoreline features. Collaborative design charettes enabled the designers and park planners to be creative with various combinations of traditional erosion control and stabilization structures that together would create sustainable mangrove habitat which would be enjoyed by park visitors.

Twin Rivers Park

Location

The Twin Rivers park is located at the junction of the Indian River Lagoon, St. Lucie River, and St. Lucie Inlet. As reflected in Figure 2, the property is exposed to wind and wave activity from the east and north to northwest. A series of existing shoals within the Indian River Lagoon and east of the property towards the inlet provide natural buffers to wind-generated waves. More problematic is the property's location relative to local navigation corridors. The location of the property at the headwaters of the St. Lucie River and Indian River Lagoon, within close proximity to an ocean inlet, exposes the property to a high volume of boat traffic.



Source: Martin County, Information Technology Services (GIS) (http://www.martin.fl.us)

Figure 2 – Project Location Map

Pre-Construction Site Conditions

The park property totals 26 acres, and is chiefly comprised of heavy vegetation including Australian Pines, and other invasive plant species. Pre-construction environmental surveys indicated the presence of gopher tortoises which were quarantined and relocated

on the property. There is approximately 1,400 feet of shoreline along the property, 465 feet of which had been bulkheaded prior to more recent construction efforts. The shoreline has retreated under erosive wind/wave and boat wake attack. As such, there were numerous trees and other remnants scattered along the shoreline. Figure 3, below, provides several perspectives of the pre-construction site condition, including the near vertical bluff feature standing eight to ten feet high in some areas.

Figure 3 -Pre-Construction Conditions: Oblique Aerial of Twin Rivers Park Looking West from St. Lucie Inlet (Top). Oblique Aerial of Park Looking Southeast from "Crossroads" (Left). Eroded Shoreline Bluff (Above).

The southern end of the property's shoreline has historically been stable, due to more protection from wind-generated waves, a shallower more mildly sloping nearshore platform, and an established area of mangroves. As such, this area did not fall under the proposed shoreline protection scheme.

Concept Development

To alleviate shoreline recession and to create a user-friendly waterfront park facility, Martin County park staff and ATM engineers collaborated in a conceptual design charrette. The results of the charrette reflected the County's desire to not only provide waterfront access, but to enrich the shoreline habitat through the construction of several lagoon features which would be planted with mangroves or other native shoreline plant species.

Tides, Winds, Waves and Currents

The project area is subject to tidal currents, storm surge, wind-generated waves, and boat wakes. The mean tidal range is approximately 0.9 feet, and the mean tide range during a spring tide is approximately 1.2 feet. The St. Lucie Inlet Management Plan (ATM, 1994) presents a summary of storm surge values for a 20-year storm, and the still-water elevation ranges from the NOAA-predicted 4.2 feet MSL to the Bruun, *et. al.*-predicted 6.4 feet MSL (note that the MSL is approximately 0.26 feet NGVD). The 2002 FEMA Flood Insurance Study for Martin County reports still-water storm surge values of 4.3 feet NGVD for a 10-year storm and 6.3 feet NGVD for a 50-year storm.

The wind-generated waves at the site are limited by both fetch and depth. The project area is generally exposed to waves propagating from the northwest through the east directions. The fetch lengths generally range from 2,800 feet to 16,400 feet. The longest fetch is from the north. The fetch lengths were measured from a USGS quad map and do not account for effects of any emergent or inter-tidal shoals, because it is assumed that these shoals would be submerged under design storm conditions.

The project area is in close proximity to shoals and navigation channels. The shoals in the project area are generally less than 2 feet deep (at low tide), and could be emergent at times of extremely low tides. The project area is adjacent to two channels – the Atlantic Intracoastal Waterway and the Okeechobee Waterway. The water depth of the channels (waterways) is typically 12 feet (relative to MSL). For this study, the average water depth at high tide (MHW is 0.46 feet MSL) is 6 feet for typical wind conditions, and 12 feet (including tide and storm surge) during storm conditions.

The prevailing wind direction and speed varies by season (USACE, 1996). For the summer months, the prevailing wind direction is generally from the east-southeast direction. In the winter months, the prevailing wind direction is generally from the northwest direction. Engineering judgment and local knowledge show that winds commonly come from the north and northeast in the winter months. The monthly

average wind speed varies from 7.6 mph to 11.0 mph. The winds are generally stronger in the winter months and are lighter in the summer months. The highest sustained wind speed observed at West Palm Beach (through 1963) is 71 mph (USACE, 1996). From engineering judgment and knowledge of the project area, the area commonly experiences extended periods of strong winds from the north. These winds are typically associated with weather fronts, and can last for several days with speeds typically up to 20 mph.

For this study, the wind-wave conditions are estimated for typical winter conditions and storm conditions. The Automated Coastal Engineering System (ACES) software developed by the U.S. Army Corps of Engineers, which incorporates the methods described in the Coastal Engineering Manual (CEM), was used to estimate the wave height and period based on the wind speeds, fetch length, and average water depth. The wave conditions were estimated for the longest fetch (from the north). The estimated significant wave height and period for typical winter conditions are 1.0 feet and 2.1 seconds, respectively. This wave is a relatively steep wave, and can be considered as choppy conditions. Under storm conditions, the estimated significant wave height and period can up to 3.4 feet and 3.2 seconds, respectively, depending on the storm surge level and neglecting effects of the bottom. Generally, the wind-generated waves during a storm (due to the elevated water level) will not experience significant dissipation due to bottom friction. The wave conditions were estimated assuming a continuous fetch without any wave breaking on the shoals. Also, the estimated wave parameters do not account for tidal currents or wave shoaling as the incident waves approach the shoreline in the project area.

The project area is adjacent to two navigation channels (The Crossroads), and is subject to boat wakes that could be equal to or larger than the estimated typical winter wind-wave conditions. Vessel wave height and period were estimated utilizing equations developed by Weggel and Sorensen (1986). For this study it is assumed that the sport fishing boats generate the largest wakes, and the sport fishing vessel that is typical to the area has an overall length of approximately 70 feet. The resulting estimated vessel wave height and period are 3.1 feet and 3.5 seconds. It is assumed that the vessel would be traveling at 10 knots. Again, the estimated wave parameters do not account for wave shoaling as the incident waves approach the shoreline in the project area.

In summary, wave conditions were estimated for typical winter conditions, storm conditions, and boat wakes. A summary of the results is shown in the following table. For shore protection at the site, a design wave with a wave height of 3.5 feet and a period of 3.5 seconds was recommended, noting that the wave height does not account for shoaling effects. A storm surge with a 20-year return period is accounted for in the calculation of the design wave.

Table 1 – Summary of Wave Conditions

Type	Condition	Sig. Wave Height (ft.)	Period (sec.)
Wind-Wave	Typical Winter (20 mph Winds)	1.0	2.1
Wind-Wave	Storm (71 mph Winds)	3.4	3.2
Boat Wake	70-Foot Sport Fishing Boat	3.1	3.5

Other Design Considerations

As the success of the lagoon depends on adequate water exchange, careful consideration was given to the proposed grading within the lagoons. With less than a foot of tide typical for the area, gaps in the stone sill were incorporated with elevations below the typical crest elevation established for wave attenuation. These gaps are intended not only to increase the volumetric rate of water exchange within the lagoons, but also to allow for fish and shellfish to utilize the lagoons for forage and cover.

Solution

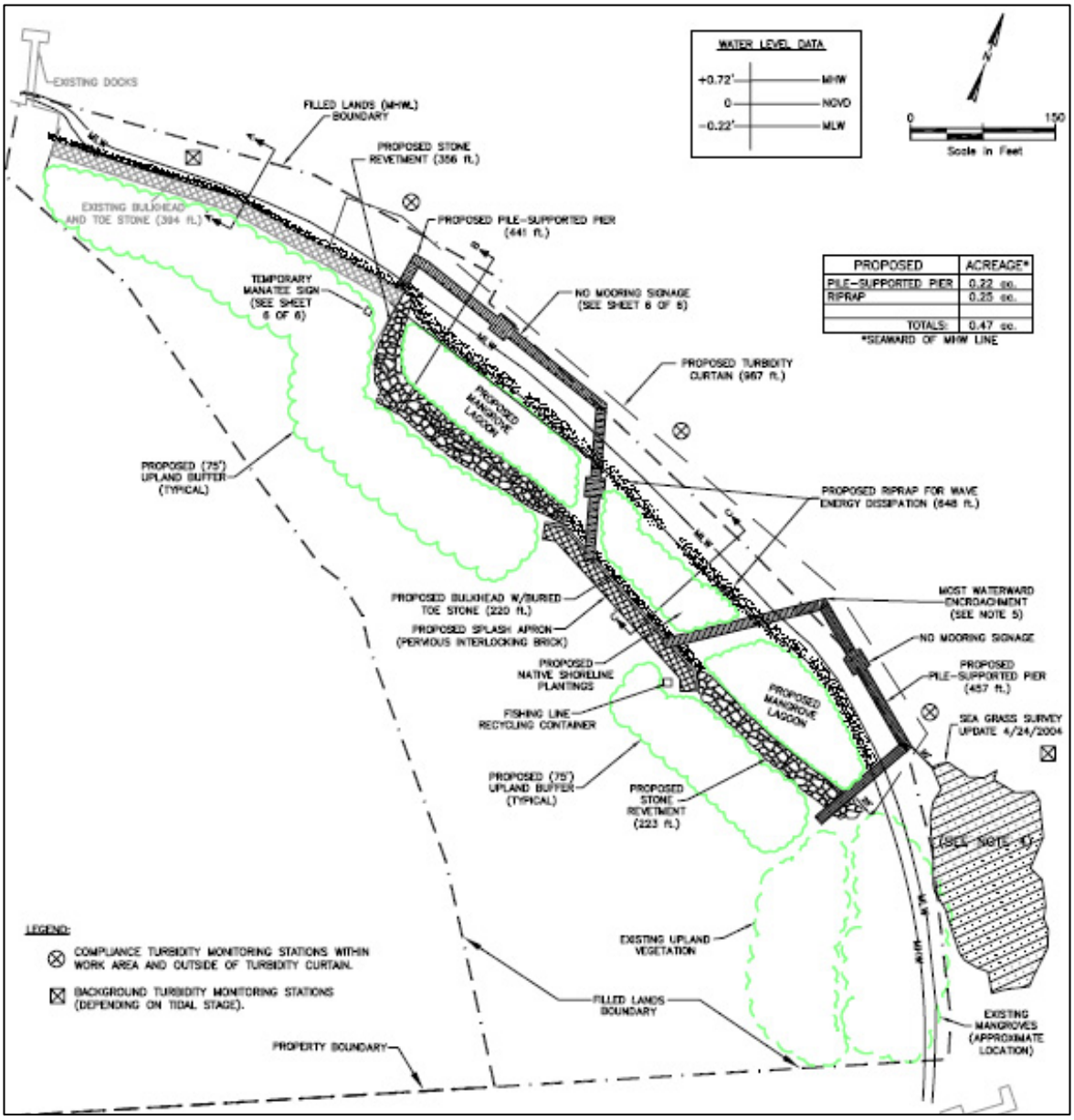
The final solution was a combination of stone revetment and bulkhead to hold the shoreline in place. The lagoon features were created utilizing low-crested rubble mound breakwaters, or stone sills, for attenuating typical wind waves and vessel wakes. Mildly sloping grades were established landward of the sills within the tide zone to maintain adequate flushing of the lagoons with breaks in the sills to further enhance water exchange. To stabilize the shoreline and provide habitat for marine organisms, red mangrove and spartina plantings were incorporated into the lagoon design.

A fixed pier designed for pedestrian use only was included to provide access over water for observation and fishing opportunities. No vessel mooring would be permitted with accompanying signage being displayed from pier structures. Refer to Figure 4 for a general project layout. Figures 5 and 6 depict typical design sections for transitions from the boardwalk and sill to the revetment and bulkhead, respectively.

Table 2, below, summarizes key components of the project.

Table 2 – Shoreline Design Summary

Shoreline Component	Type of Structure	Key Dimensions/Elevations
Revetment	Sloped riprap on geotextile fabric	1.5H:1V side slope from variable crest elevation (+5.3 ft to +10 ft NGVD) to -2 ft NGVD, total length 573 feet
Bulkhead	Anchored aluminum sheetpile with concrete cap (match original design)	Crest elevation +5.3 ft local MSL, total length 265 feet with 30-ft returns
Sill	Low-crested riprap breakwater on geotextile fabric	2H:1V side slopes, crest elevation +3.0 ft NGVD, gaps at 0.0 ft NGVD, total length 668 feet
Lagoon grades/ plantings	Graded sandy shoreline with 1 gallon mangrove and spartina plantings	variable grade from toe of revetment to stone sill, 10,000 red mangrove and 3,500 spartina plantings on staggered 18” centers
Boardwalk	Concrete / timber pier	concrete piles with reinforced concrete caps and timber superstructure, deck elevation at +6.0 ft NGVD, total length 870 feet



PROPOSED	ACREAGE*
PILE-SUPPORTED PIER	0.22 ac.
RIPRAP	0.25 ac.
TOTALS:	0.47 ac.

*SEAWARD OF MHW LINE

Figure 4 – Park Shoreline Protection Layout (Revetment, Bulkhead, Sill, Boardwalk and Plantings)

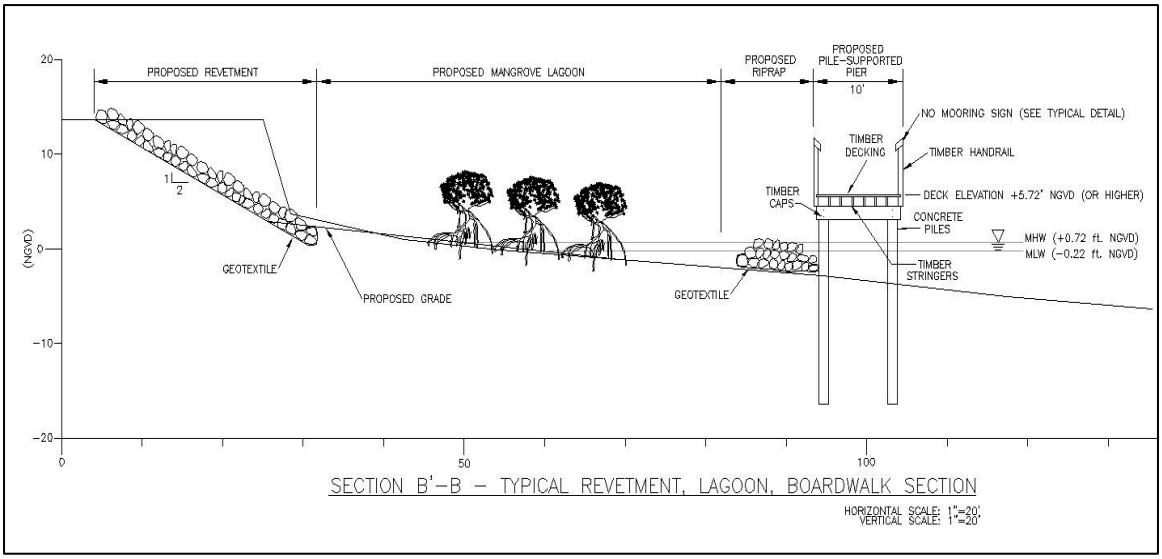


Figure 5 – Typical Section (Revetment, Sill, Boardwalk)

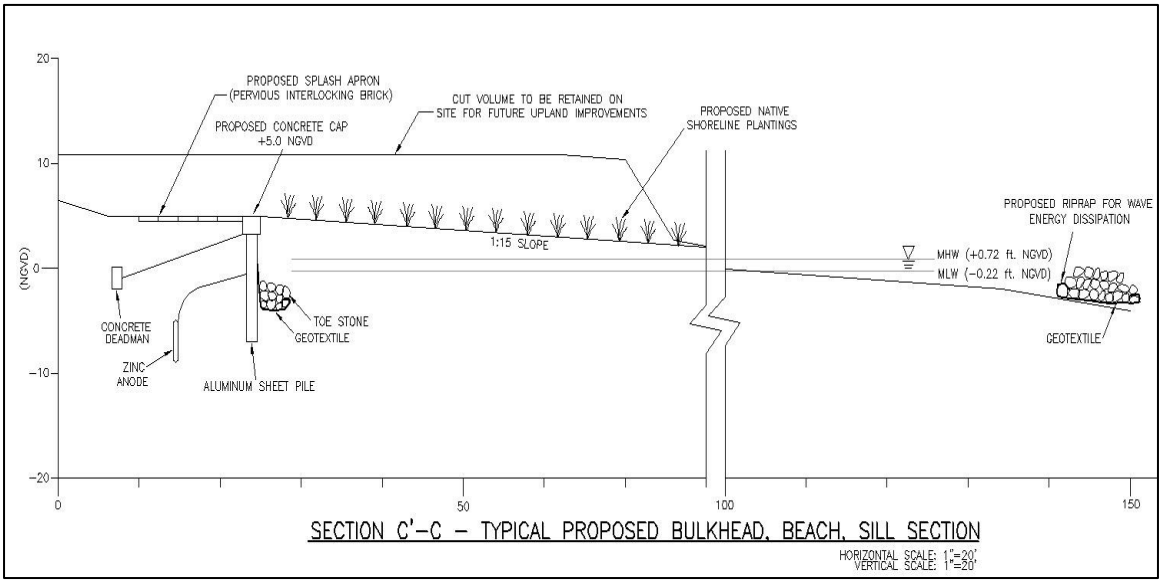


Figure 6 – Typical Section (Bulkhead, Sill)

Hurricane Impacts

Permitting approval for the project was granted in August of 2004. During that same year and prior to the start of construction, two hurricanes (Frances and Jeanne) made landfall and passed within ten miles of the project site (Figure 7). A post-hurricane survey revealed a significant recession of the upland bluff accompanied by a seaward migration of the mean high water line. While the site conditions had changed slightly, the permitted project was bid as originally designed with one slight modification.

It was noted that the existing bulkhead was significantly overtopped during the hurricanes, resulting in loss of backfill, settlement and overstressing of the articulated splash apron, as well as flanking on both ends of the structure. Additionally, a section of seawall and the boat ramp at the western end of the property were lost. Prior to construction of the new project, the County rehabilitated the existing bulkhead and constructed a new seawall to replace the western end.

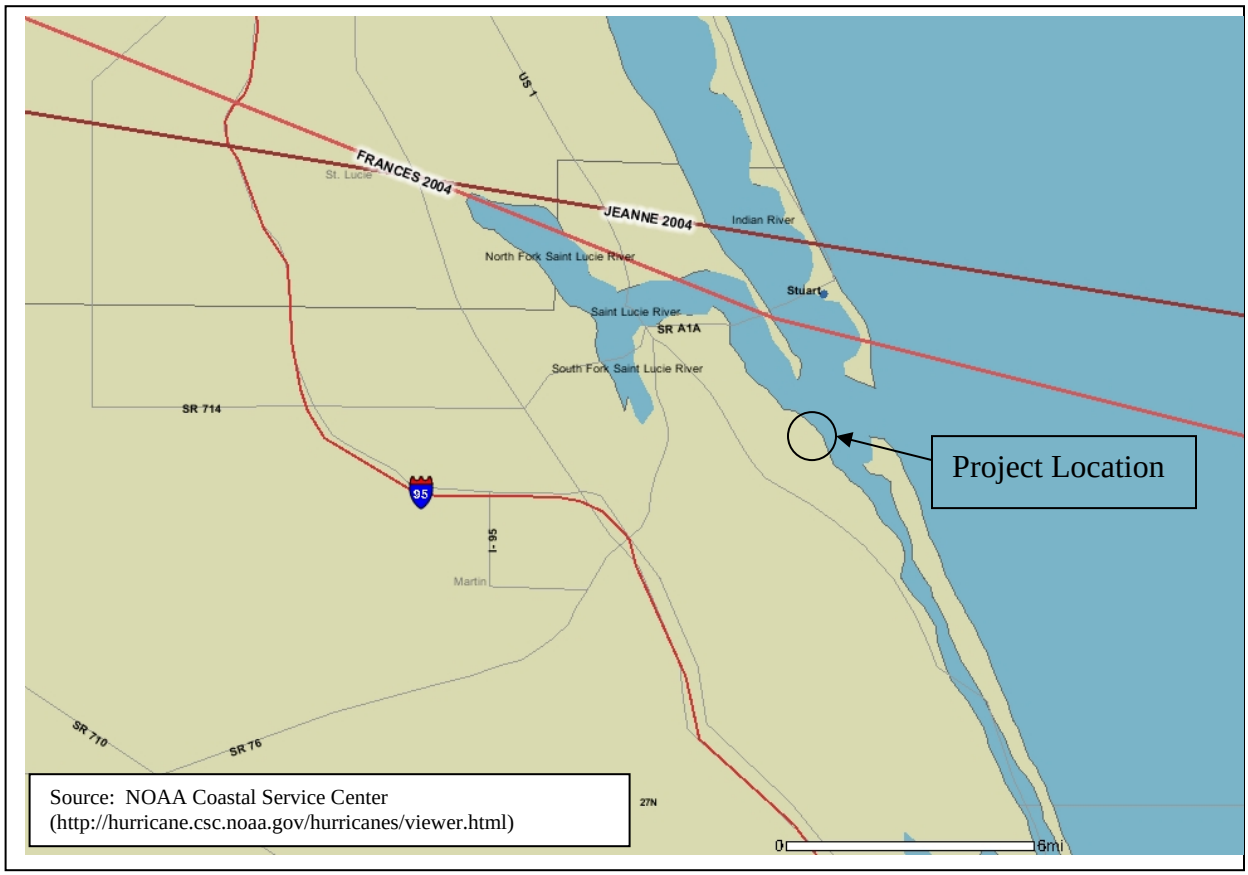


Figure 7 – 2004 Hurricane Tracks Across Martin County (Frances and Jeanne)

Project Status Summary

Project construction began in July 2005 and should be complete by April 2006. Field adjustments to the lagoon grading and sill gaps have been made to try to optimize water exchange and retain a minimum pool during low tide, while at the same time increasing accessibility to fish and shellfish. Figure 8 depicts the most recent construction progress photograph within the lagoon area. Note the partial construction of the boardwalk, with concrete piles and caps in place.

The County is currently reviewing options for upland park planning, keeping the focus on passive recreation with minimal infrastructure, small picnic areas, nature trails, etc. for public use.

Figure 8 – Construction of Lagoon (Looking East Toward St. Lucie Inlet)

Acknowledgements

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- Martin County Parks & Recreation Department
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- Florida Department of Environmental Protection
- Lucas Marine
- Sunshine Land Design

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