APPENDIX E

ADDITIONAL ALTERNATIVES

Additional Alternatives – Evaluated in Detail:

The following text is a revised version of Section 2.0 – "Alternatives Considered in Detail" from the updated Design Document (revised July 6, 2010). The Design Document is to be revised in full at a later date.

2.0 Alternatives Considered in Detail

2.1 Description of Alternatives Considered in Detail

In April 2007, a public meeting or "Charette" was held to obtain public input relative to appropriate measures to abate erosion in the South County Beaches. At the public meeting, the following alternatives were identified to be evaluated in greater detail:

- No Action
- Beach fill with "no impact" to existing hardbottom
- Beach fill to restore the 1972 beach and dune
- Another alternative as may be identified by the County, USACE, and other commenting agency staff.

By August 2009, the County identified the following two alternatives herein considered in detail:

- a 35' wide design berm width - with advance fill.
- a 70' wide design berm width - with advance fill.

On August 5, 2010, a meeting was held with USACE regulatory staff regarding the formulation of an Environmental Impact Statement for the Project. At this meeting, USACE staff requested that the following additional alternatives be considered in detail:

- Groins with Beach Fill
- Breakwaters with Beach Fill
- Dune Restoration only along the northern Project segment (R-87.7 to R-90.3) with Beach Fill along the southern Project segment (R-98 to the Martin County Line).

No Action: In general, "No Action" is expected to result in losses to the beach and dune. As the shoreline migrates landward, property owners may seek permits and construct seawalls or other armoring to protect their property; such armoring is expected to result in additional loss of beach habitat for marine turtle nesting and loss of beach for public recreational use. Where the construction of seawalls may not be feasible under current FDEP regulations, "No Action" would be expected to result in the continued loss of dune habitat and would result in existing habitable structures being located on the beach. Losses of the beach and dune, as associated with "No Action" render this alternative as unacceptable to the County. Please refer to Appendix B of this document for the documentation of modeling conducted for each of the alternatives considered in detail.

Beach Fill: The beach fill with "no impact" to existing hardbottom yields only a minimal fill project with a very low fill density (8.1cy/ft) that might be best constructed as a "truck-haul" project. The beach fill to restore the 1972 beach and dune was previously adopted as a maximum fill project but yields only a minimal fill project with a very low

fill density (10.5cy/ft) that might be best constructed as a "truck-haul" project. An assessment of a more substantial fill project is conducted to ascertain whether it may be more cost-effective and potentially the appropriate National Economic Development (NED) project. It is recognized that if a more substantive project is not assessed, it would be difficult to pursue a more substantive project in concert with a Federal Shore Protection Project at a later date. The USACE Martin County Project is considered a model for this assessment. The maximum beach fill project evaluated by the County would restore the dune to conditions that existed in 1972 with the addition of a 70' berm feature. Based on background erosion rates and a desired 10-year renourishment interval, it is assumed that the future losses will occur at a rate of about two or more times the background erosion rate – applied to also formulate advance fill requirements. Based on these assumptions, an "Advanced Nourishment" of 10-cy/ft was added to the 70' berm feature. The same was done for the beach fill to restore the 1972 dune with a 35' berm feature. The restoration to 1972 dune with a 70' berm feature and advanced nourishment is estimated to entail an average fill density of approximately 44.9cy/ft. Table 2.1 summarizes the fill densities and fill volumes associated with Alternatives assessed in detail in Appendix B of this Design Document. These design alternatives can be found in Appendix A.

Table 2.1 – Summary of Fill Volumes.

					Dune feature with			
	No Impact Template		1972 Template		35' Berm		70' Berm	
Reference Monument	Fill Density (cy/ft)	Total Fill Volume (cy)	Fill Density (cy/ft)	Total Fill Volume (cy)	Fill Density (cy/ft)	Total Fill Volume (cy)	Fill Density (cy/ft)	Total Fill Volume (cy)
R-88	17.3	8,725	17.3	8,725	36.9	18,610	50.1	25,267
R-89	2.0	1,982	13.9	13,775	34.3	33,991	45.8	45,388
R-90	9.1	7,098	12.6	9,827	38.3	29,872	43.9	34,240
R-91 to R97	0	0	0	0	0	0	0	0
R-98	26.3	12,894	26.3	12,894	46.3	22,699	62.9	30,837
R-99	16.3	16,098	16.3	16,098	38.4	37,924	55.6	54,911
R-100	16.2	16,087	16.2	16,087	29.6	29,393	43.4	43,096
R-101	12.7	12,457	12.7	12,457	26.5	25,994	42.2	41,394
R-102	9.1	8,928	15.2	14,912	27.6	27,077	39.1	38,359
R-103	8.3	8,130	8.3	8,130	23.8	23,313	36.8	36,047
R-104	3.7	3,660	3.7	3,660	27.6	27,305	41.4	40,957
R-105	9.0	8,761	9.0	8,761	25.7	25,018	43.6	42,442
R-106	6.2	6,139	6.2	6,139	32.6	32,281	47.4	46,935
R-107	2.7	2,721	2.7	2,721	30.1	30,335	44.9	45,250
R-108	9.9	10,280	9.9	10,280	32.3	33,540	46.0	47,766
R-109	4.2	4,579	4.2	4,579	21.9	23,876	39.4	42,956
R-110	10.4	9,780	10.4	9,780	24.6	23,134	40.5	38,086
R-111	7.5	7,237	7.5	7,237	24.6	23,737	35.2	33,964
R-112	0.0	0	12.0	12,826	31.3	33,455	48.6	51,946
R-113	6.0	5,389	10.4	9,341	34.2	30,718	51.5	46,257
R-114	1.5	1,335	12.5	11,125	37.1	33,019	52.5	46,725
R-115	6.7	9,894	6.7	9,894	30.3	44,744	45.2	66,747
MC Line								
Average/Total	**8.1**	**162,174**	**10.5**	**209,249**	**30.5**	**610,034**	**44.9**	**899,572**

Figure 2.1 illustrates the expected performance of the Beach Fill with 35' berm alternative; similar analysis was performed for the other Beach Fill alternatives. Based upon the analysis of alternatives, it is concluded that based upon the aerial interpreted 2008 hardbottom map:

- Restoration of the beach to 1972 dune with a 70' berm is expected to adversely affect about 1.34 acres of nearshore hardbottom – including spreading effects.
- Restoration of the beach to1972 dune with a 35' berm is expected to adversely affect about 1.08 acres of nearshore hardbottom - including spreading effects.
- Restoration of the beach to the 1972 beach and dune is expected to adversely affect about 0.14 acres of nearshore hardbottom.

The above hardbottom areas affected by the equilibrated fill represent a small percentage of the total hardbottom within the Project Area. In addition, as discussed in Appendix B, the nearshore hardbottom undergoes constant burial and exposure as a result of incident wave conditions.

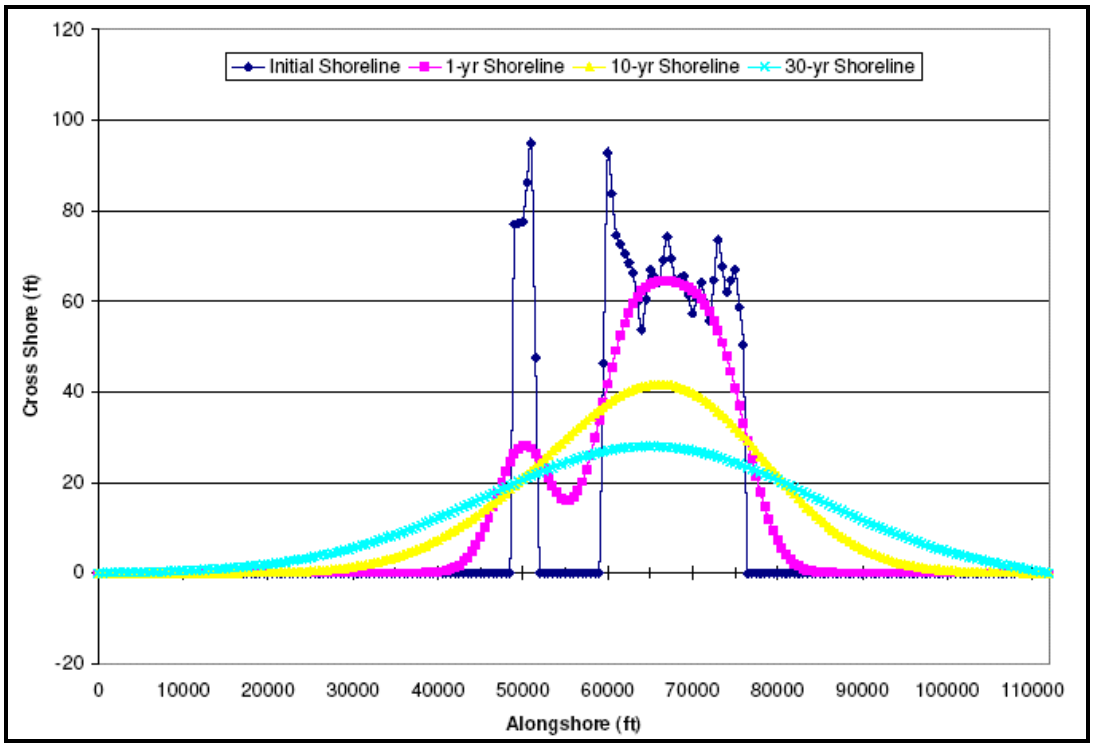

Figure 2.1 - Predicted Shorelines - "Beach Fill with 35' berm"

Groins with Beach Fill: A series of groins – to form a groin field - might be constructed along the beach to reduce sand losses and retain sand placed in the Project Area. For the alternative of Groins with Beach Fill, potential groins are conceptually designed to be similar to the T-head groins under consideration by St. Lucie County for shoreline immediately south of Ft. Pierce Inlet. The potential groins are sized per empirical methods (Bodge, 1998) to maintain the "Design MHWL" for the Equilibrated Design Template; the previously defined fill template and volumes do not change as a result of the implementation of groin field as described for the 35' berm alternative. As reflected in Figure 2.2, each of the T-head groins is assumed to have the following characteristics:

- shore normal length of 275 feet - extending from approximately 50 feet landward of the existing +3.0 feet NAVD contour to about 190 feet seaward of the Design MHWL,
- crest elevation of +3.0 feet NAVD,
- a seaward slope of 3H:1V from +3.0 feet NAVD out to a depth of approximately -5 feet NAVD,
- alongshore spacing of 200 feet (between the ends of the T-Heads),
- a "head" extending about 205 feet shore-parallel.

With construction of potential groins, no additional impacts to nearshore hardbottom are predicted to occur beyond those associated with the proposed Project with a 35' berm. It is estimated that groins would have an initial cost of about $570,000 each. For the proposed Project Area, up to 25 groins might be constructed at a total initial cost of $14.2M .

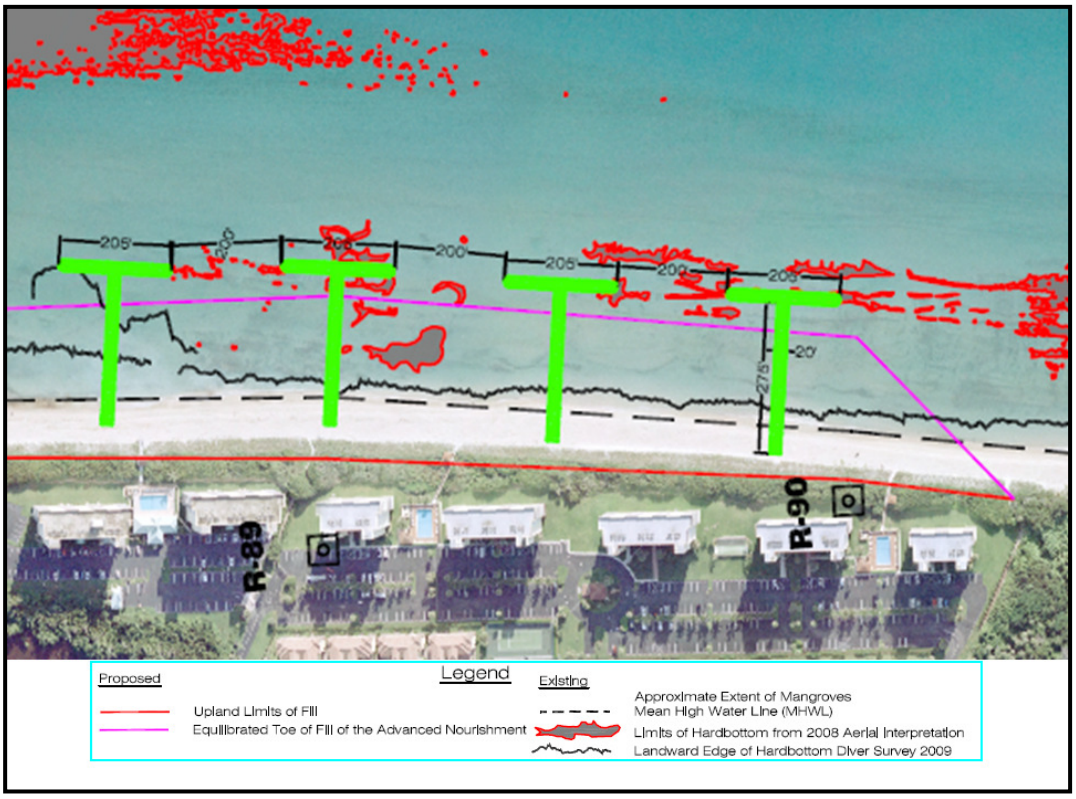

Figure 2.2 - Typical Groin field

According to the USACE (1992), the objective of constructing a groin or groin system is to stabilize a segment of beach to prevent erosion where erosion is due primarily to a net alongshore loss of sand. In theory, along sandy beaches, long-term erosion is primarily caused by an increase in littoral drift along the shoreline, where less sand enters a beach segment than the amount of sand that leaves the beach segment – per the fundamental principle of the *Conservation of Mass*. Based on this principle, in theory, groins:

- are intended to reduce littoral drift to trap or prevent erosion of a volume of sand causing accretion or reduced erosion along the shoreline updrift shoreline of each groin, but concurrently

- increase erosion of the downdrift beach by preventing an equivalent volume of sand from moving into the downdrift beach.

Although during storm events, groins may retain sand in the project area, the volume of sand retained is expected to be eroded from downdrift beaches.

FDEP rules [§62B41.005(5), F.A.C.] prescribe that:

> "Structures which interfere with the natural longshore and onshore/offshore movement of sediments shall not be allowed unless a net positive benefit to the coastal system can reasonably be expected to occur and mitigation is provided for any adverse impacts which may occur to the coastal system."

Based on these rules, FDEP permits for groins require mitigation in the form of fill placement on the downdrift beaches to offset the sand trapped by the groins.

Based upon the above, it is expected that groins would not decrease beach nourishment requirements – as any volume of trapped sand will erode the downdrift beaches and require mitigation via placement of an equivalent volume of sand on the downdrift beach – which is the northern portion of the Martin County *Shore Protection Project*. As a result of the above, the potential construction of Groins with Beach Fill is estimated to cost $11M – with no net reduction in impacts and no net reduction in future nourishment requirements.

Breakwaters with Beach Fill: A series of segmented breakwaters might be constructed along the beach to reduce sand losses and retain sand placed in the Project Area. For the Breakwaters with Beach Fill alternative, the breakwaters are conceptually designed consistent with those proposed by Palm Beach County for Singer Island; the previously defined fill template and volumes - for the 35' berm alternative - do not change as a result of the implementation of segmented breakwaters. As reflected in Figure 2.3, each breakwater has the following characteristics:

- Offshore Distance (from MHWL) – 225 feet
- Crest Length (shore parallel) – 255 feet
- Crest Width (shore normal) – 15 feet
- Crest Elevation - +2.0 feet NAVD
- Seaward slope (from crest to seaward toe) – 3H:1V
- Landward slope (from crest to landward toe) – 2H:1V
- Alongshore spacing between breakwaters – 200 feet

With construction of potential breakwaters, no additional impacts to nearshore hardbottom are predicted to occur beyond those associated with the proposed Project with a 35' berm. It is estimated that each breakwater would have an initial cost of about $493,000 each. For the proposed Project Area, up to 36 breakwaters might be constructed at a total initial cost of $17.7M.

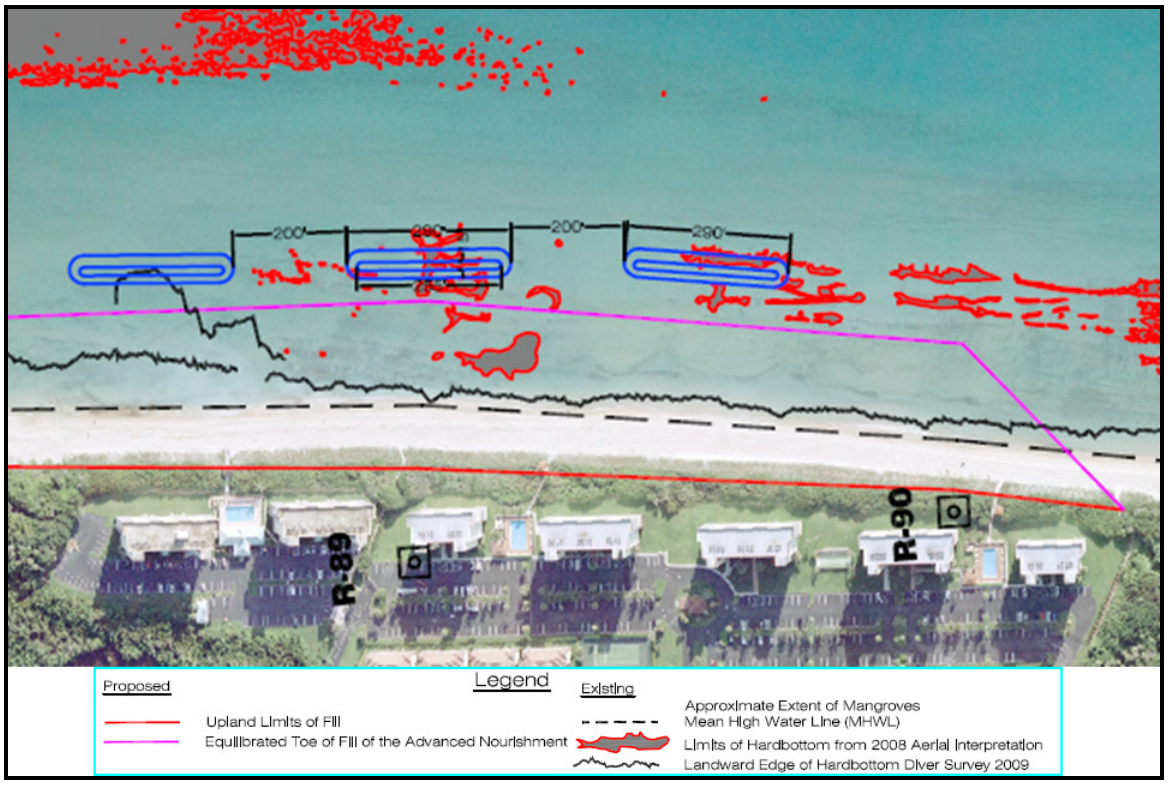

Figure 2.3 – Typical Breakwaters

According to the USACE (1992) "…breakwaters function to reduce wave energy in their lee and thus reduce the sediment carrying capacity of waves" which prompts a reduction in longshore transport and sand deposition. In theory, as for groins, the fundamental principle of the *Conservation of Mass* leads to the expectation that breakwaters:

- are intended to reduce littoral drift to trap or prevent erosion of a volume of sand causing accretion or reduced erosion in the lee of each breakwater and along the updrift shoreline, but concurrently
- increase erosion of the downdrift beach by preventing an equivalent volume of sand from moving into the downdrift beach.

As for groins:

- During storm events, breakwaters may retain sand in the Project area, but the volume of sand retained is expected to be eroded from downdrift beaches.
- FDEP rules and policies require mitigation for the effects of breakwaters in the form of fill placement on the downdrift beaches to offset the sand trapped by the breakwaters.
- It is expected that breakwaters would not decrease beach nourishment requirements – as any volume of trapped sand will erode the downdrift beaches and require mitigation via placement of an equivalent volume of sand on the downdrift beach – which is the northern portion of the Martin County *Shore Protection Project*.

Based on the above, the potential construction of Breakwaters with Beach Fill is estimated to cost $5M – with no net reduction in impacts and no net reduction in future nourishment requirements.

Dune Restoration Only – North Segment: The Project area entails two shoreline segments: the northern Project segment (R-87.7 to R-90.3) and the southern Project segment (R-98 to the Martin County Line). Nearshore hardbottom along the northern segment has greater relief and bio-diversity than the southern segment. It may be feasible to construct and maintain the dune in the northern segment and only construct a Beach Fill project in the southern segment; this approach could result in avoidance of nearshore hardbottom impacts along the northern segment. It is expected that this alternative would (a) construct and maintain the Beach Fill with 35' berm along the southern segment, and (b) maintain the existing dune in the northern segment via periodic placement of sand to restore dunes – likely after future storm events.

Based upon previous costs to restore the dune in the northern segment, it is expected that dune restoration in the northern segment is estimated to cost about $300,000 per each post-storm restoration event – estimated to occur every 6 years. Initial construction of the "Beach Fill with 35' berm" in the southern segment is estimated to cost $8.1M.

The performance of the Beach Fill in the southern segment is predicted via application of DNRBS model. The model results, as shown in Figure 2.4, indicate:

- the northern portion of the southern Project segment (R98 to Martin County Line) would erode more rapidly with only dune restoration in the northern segment – as compared to the alternative with Beach Fill in the northern segment.
- Spreading of sand from the "Beach Fill with 35' berm alternative" would significantly benefit the beaches in the "Gap"(R90.3 to R98), while this benefit would not be expected to be significant with Dune Restoration only in the northern segment.

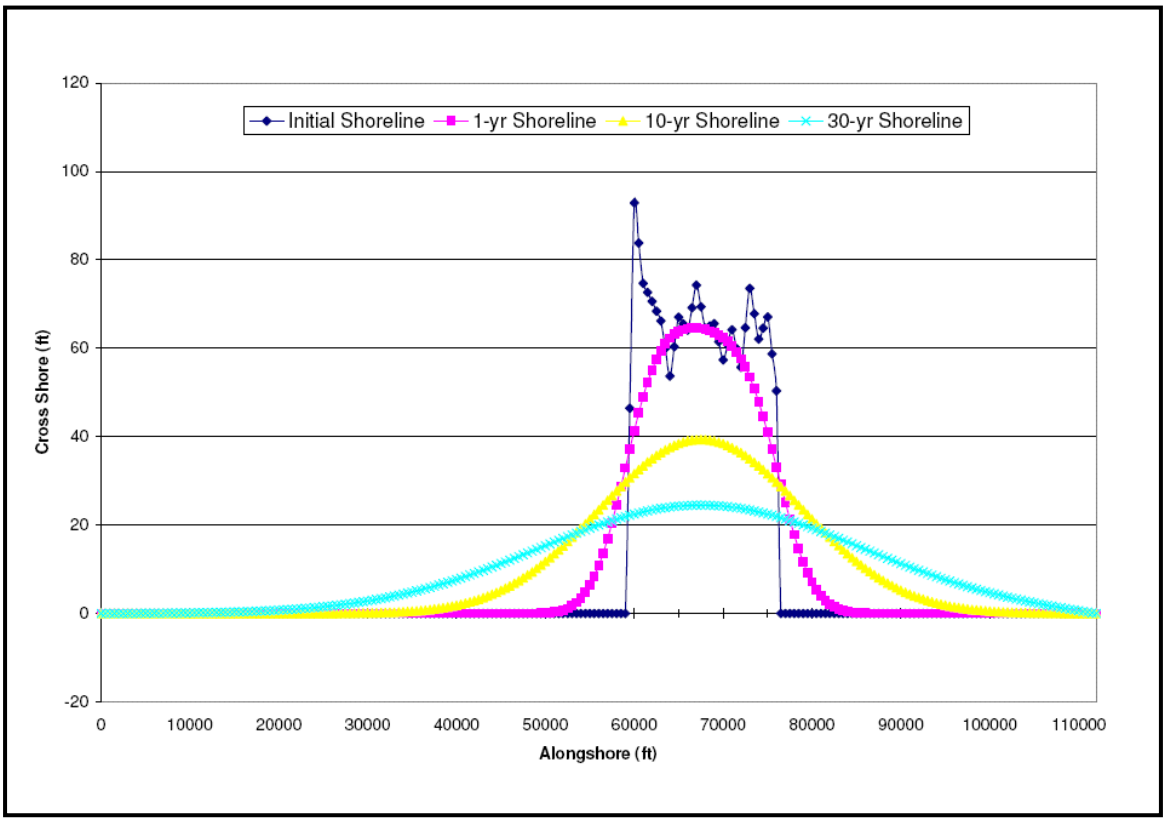

Figure 2.4 - Predicted Shorelines - "Dune Restoration Only – North Segment"

A clear benefit of the "Dune Only – North Segment alternative" is the reduction in impacts to nearshore hardbottom; specifically, for the "Beach Fill with 35' berm alternative", in the northern Project segment, the maximum potential hardbottom impact is estimated at 0.97 acres, while for the "Dune Only" alternative, no hardbottom impacts are predicted to occur along the northern segment. On the other hand, the "Dune Only" alternative" would not provide the desired level of protection to upland property fronting the northern segment - whereas upland property in the "North Segment" of the Project area is at risk of damage during a 25-year return interval storm event; although the proposed Project would reduce this risk, the "Dune Only" alternative would not significantly reduce this risk of damage.

2.2 Issues and Basis for Choice

In light of the County's main objective to "abate ongoing and historical beach erosion" and the County's specific criteria for plan formulation to "optimize project - performance and cost effectiveness", and "minimize environmental impacts to the extent feasible", the "Preferred Alternative" is herein formulated to be the "35' berm" alternative. This alternative is found to yield the maximum net benefits consistent with USACE planning regulations and associated project optimization criteria. An assessment (see Appendix C) was conducted in order to identify the National Economic Development (NED) Plan which evaluates the probable annual costs and benefits of each of the alternatives described above. In the cost/benefit assessment it was determined that the 35' "Berm"

optimizes the Project design to produce the greatest net economic benefits, while fulfilling the Project purpose and need.

The "No Impact" and "1972 Design" Alternatives were found to (a) require minimal fill quantities - suitable for a truck-haul project, and (b) at best be marginally economically justified. From 2006 to 2008, approximately 170,000cy (~5 cy/ft) has accumulated on the Project Area beaches during recovery; this natural recovery is nearly equivalent to the fill quantities placed by the County after the 2004 hurricanes. This accumulation of sand has resulted in a reduction of:

- the fill required to restore the beach,
- the expected damages associated with the "Without Project" condition, and
- the corresponding B/C ratios for the "alternatives considered in detail.

The breakwater and groin alternatives are not expected to avoid impacts, reduce impacts, or reduce future nourishment requirements. The "Dune Only – North Segment" alternative does not meet the Project purpose to "provide storm damage protection for property and infrastructure" in the northern segment.

The fundamental regulatory issues surround:

(a) whether the borrow area sediments are compatible with native beach sand,
(b) the extent and acceptability of the potential effect effects of dredging/excavation in the offshore borrow area (if used) upon resources including fisheries,
(c) whether the benefits associated with the *Project* justify the associated unavoidable impacts, which are expected to be mitigated.