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1.0 PROJECT PURPOSE AND NEED

The purpose of the Sector 7 Beach Restoration Project is to provide protection for the existing upland properties and infrastructure within the southern portion of Indian River County, Florida, from shoreline erosion associated with normal seasonal wave conditions and high frequency storm events; to furnish additional nesting habitat for threatened and endangered marine turtles by establishing a viable beach and dune system; and to provide recreational enhancement of the beaches. The County’s coastline is a valuable resource in terms of storm protection, economics, and wildlife utilization.

1.1 Project Authority

Pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, the U.S. Army Corps of Engineers (USACE) has regulatory authority to permit the discharge of dredge and fill material into waters of the United States. In compliance with its responsibilities under the National Environmental Policy Act (NEPA) of 1969, the Jacksonville District, USACE prepared this EA in response to the Section 10/Section 404 Federal Dredge and Fill Permit Application submitted by Indian River County, Florida for the Indian River County Sector 7 Beach Restoration Project (Joint Coastal Permit application number 0215960-001-JC, Indian River County).

1.2 Project Area

The proposed Project area is located in Indian River County, Florida (Figure 1-1). Indian River County features approximately 22.4 miles of barrier island beaches extending from Sebastian Inlet south to Round Island Park, 10 miles of which have been classified by the Florida Department of Environmental Protection (FDEP) as Critically Eroded.

The Indian River County shoreline was characterized and subdivided into eight distinct shoreline segments, or Sectors, for the purpose of shoreline evaluation. The Sectors are numbered from north to south. The proposed beach Project evaluated in this document includes the shoreline that is contained within Sector 7, located in the southern portion of Indian River County in the South County Beach area. The shoreline designated for restoration in Sector 7 extends from 95 feet north of Indian River County DEP Reference Monument R-97 south to 105 feet south of R-108.

The Project area includes 2.22-miles (11,730 feet) of shoreline characterized by single-family homes and private road access ways. Approximately 84 percent of this shorefront is developed and 40 percent of the Project shoreline has been characterized by the FDEP as Critically Eroded.
Source: Applied Technology & Management, Inc.
As a result of ongoing erosion, numerous homeowners have constructed seawalls to protect their property from the encroaching ocean as the beach is narrow and erosional. Currently, seawalls armor approximately 1,100 feet or 14 percent of the Project shoreline. The seawalls are concentrated between R-102 and R-105.

Several threatened or endangered species inhabit the Sector 7 Project area. The beaches provide nesting habitat for at least three species of sea turtles: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*). Sea turtles also use the nearshore habitat for foraging. The West Indian manatee (*Trichechus manatus*) occasionally can be found in the area’s open ocean, although it is more commonly found in protected lagoons and fresh water systems. In addition, the northern right whale (*Eubalaena glacialis*) has been sighted migrating south in the winter offshore of Florida. Three other threatened or endangered species may potentially occur in the proposed Project area: the least tern (*Sterna antillarum*); the piping plover (*Charadrius spp.*); and the Southeastern beach mouse (*Peromyscus polionotus niveiventris*). These species have been observed on the beach by rangers at the Sebastian Inlet State Recreation Area, in the northern portion of the County (Appendix A Biological Assessment); however, there is no information with regard to their presence within the specific Sector 7 Project area.

A prominent feature of the entire Indian River County coast is the nearshore hardbottom habitat. This limestone rock outcrop system is a substrata that becomes emergent near the -6 foot contour and extends offshore approximately 2,000 feet. These hardbottom areas are colonized by algae, sponges, mollusks, and sabellariid worms.

### 1.3 Project Need

The Sector 7 Project area shoreline has experienced a volumetric erosion rate of approximately 2.08 cubic yards per foot per year (CY/ft/yr) at 0 ft. elevation and a MHW shoreline recession rate of 2.4 ft/yr based on changes measured between 1986 and 2001; the highest in the County. The shoreline between R-103 and R-107 has been designated as a Critically Eroded Area.

Continued erosion has reduced the dry beach area and caused the increase in construction of shore protection structures to protect upland property. As the erosion continues and more hard structures are constructed, limiting the landward migration of the beach, the reduction of dry beach area will be exacerbated and the value of the beach decreased. This reduction of the dry beach also reduces the available nesting habitat for the threatened and endangered species that use the shoreline and reduces the recreational activities provided by a wide beach. Currently the volume of sea turtle nesting in Sector 7 is approximately one-third the volume of nesting in the rest of the County.

Historic attempts to artificially protect upland structures in the County include rock revetments, seawalls, a submerged breakwater (PEP reef), and sand filled tubes. The majority
of protective structures in the Sector 7 Project area are seawalls. Currently, over 1,100 feet of shorefront in the 11,730-foot Project area is armored against erosion with seawalls and revetments, and the construction of additional seawalls pending approval by the state following the passage of hurricanes Frances and Jeanne.

As a result of the encroaching shoreline and without adequate large-scale protection mechanisms in place, requests for shoreline armoring to protect upland properties at risk from erosional impacts are expected to increase due to the fact that valuable oceanfront development cannot readily be moved landward in response to long-term erosion. Prudent management decisions along the remaining undeveloped beachfront can help reduce the risk of erosional impacts to future buildings and structures, and responsible shoreline management will further reduce the risk of erosional impacts to existing buildings and structures.

The Indian River County Beach Preservation Plan Economic Analysis conducted in 1998 (ATM, 1998) examined the overall economic viability of a beach nourishment project and quantified the expected 30-year costs if no action is taken. The study area included the shoreline between T-100 and R-107. The analysis of ongoing erosional and potential storm damage determined the anticipated land loss from erosion if no additional sand is placed in the system. This economic study quantified the value of land that would be lost, the construction cost of erosion control structures that would be required if a project is not built, and the maintenance costs of the erosion control structures.

At the time of the 1998 study, 74.5 percent of the study area shoreline was developed and 9.5 percent of the shoreline was armored. The study determined that without action to prevent the loss of upland property along the Sector 7 shoreline, oceanfront property owners would suffer direct economic losses. Those properties impacted by storm damage and land losses are:

- privately owned, undeveloped, unprotected property (1,837 feet or 25.5 percent of study area frontage) experiencing continued land loss;
- privately owned, developed, unprotected property (4,510 feet or 62.5 percent of study area frontage) experiencing continued land loss due to erosional losses and storm damage, some requiring new seawall/revetment construction;
- privately owned, developed, protected property (682 feet or 9.5 percent of the study area frontage) requiring rehabilitation and/or replacement of existing shoreline armor; and
- roadways (185 feet or 2.6 percent of study area frontage) threatened or damaged as the result of continued land loss.

If the present sediment deficit is not corrected, the beaches can be expected to continue to erode, and it is assumed that the oceanfront property owners would take whatever actions are in their own economic interest to protect their properties. If the major habitable structures on the property are in jeopardy of significant structural damage from ongoing erosion or from a 15-year storm event, it can be assumed that the property owners will armor the shoreline (i.e., construct seawalls as erosion control structures). However, seawalls alone do not alleviate the erosion problems and may transfer the problems to adjacent properties, whereby it is
assumed that nearly the entire shoreline in erosional areas will eventually be armored. The study showed that only one developed property within the Sector 7 study area, comprising approximately 125 feet of frontage, is not expected to require coastal armoring over the next 30 years if no action is taken to correct the erosional trend. The study assumed that no seawalls would be constructed to protect undeveloped property or roadways.

The storm protection benefit expected with a beach nourishment project was estimated in the study area to be $7.64 million. This value represents the estimated cost of seawall construction and maintenance and land loss expected if a project is not constructed.

The recreational benefits of the beach have also been evaluated in the study area. The Indian River County Beach Preservation Plan Economic Analysis (ATM, 1999b) determined the economic value of recreational benefit resulting from the beach nourishment based on a beach user survey. Annual beach count estimates in Sector 7 for 1998 and 1999 indicate a summer use of approximately 4,030 people and a winter use of approximately 3,648 people. Visitors to the beach spend money on food, entertainment, shopping, and lodging. Based on these values, the net present value of the recreational benefits over the 30-year Project horizon is estimated at $2.53 million if a beach nourishment project is implemented.

Since these studies were conducted, several additional seawalls were constructed. Currently, seawalls armor approximately 1,110 feet or 9.5 percent of the 11,730-foot study area shoreline, with additional seawalls awaiting construction pending approval by the state following the passing of hurricanes Frances and Jeanne. As erosion threatens oceanfront properties, the anticipated result will be an increased proliferation of shoreline armoring structures and emergency stopgap measures to protect property. As the beaches continue to erode in this State-designated area of critical erosion, beaches will narrow due to the presence of seawalls and development and the encroachment of the beach on dune and upland vegetation. As a result of this beach narrowing, sea turtle nesting habitat will be degraded, and in some areas, completely lost. While very narrow beaches can continue to support limited nesting activity, under conditions where high tides reach the dune line on a daily basis the hatching success would decrease dramatically due to inundation and nest washout.

Without implementation of a beach nourishment plan, mitigation for historical and ongoing erosion will not occur; thereby the following results were determined likely to occur:

- existing, recent erosion trends and shoreline armoring of Sector 7 will continue;
- nesting habitat for threatened and endangered sea turtles will be eliminated;
- economic loss will result from decline of beach users;
- owner group litigation is likely; and,
- State of Florida cost share contribution from the Erosion Control Trust Fund will be lost.

As a response to erosion, very limited fill placement has been undertaken in the Project area. In March 2001, approximately 61,800 CY of sand was placed at eight sites throughout Indian River County to restore damage caused by hurricanes Floyd and Irene in 1999. This Emergency Dune Restoration Project was partially funded through the Federal Emergency
Management Agency (FEMA) Disaster Relief Funding Agreement. Two of these sites were within the proposed Sector 7 Project area. Approximately 2,390 CY of sand was placed between R-103 + 250 feet and R-103 + 700 feet. An additional 10,440 CY of sand was placed between R-105 -200 feet and R-107 -50 feet. This sand was used to restore the dunes to their pre-storm condition. Since then, the restored dunes in Sector 7 have lost all of the sand placed by this Emergency Dune Restoration Project.

Properties in the Sector 7 area suffered catastrophic damage from Hurricanes Frances and Jeanne in 2004. Four homes in the area were completely destroyed by storm surge and wave attack, and virtually every structure was damaged. Post-storm surveys indicated an average dune retreat in Sector 7 due to the hurricanes of 58 feet, as measured by the position change of the 10 foot elevation mark, with a loss of 3 to 5 feet of beach berm elevation. Dune washover was widespread, and in many areas the primary dune was completely washed out, leaving upland areas critically vulnerable to even a high frequency return interval storm. FEMA classified a greater proportion of structures in Sector 7 as critically threatened than in any other similar sized shoreline segment in Indian River County.

1.4 Project History

Largely in response to widespread storm damage to beaches and property in Indian River County in 1974-1975, in 1980 the U.S. Army Corps of Engineers, Jacksonville District, issued a Feasibility Report for beach erosion control in Indian River County (USACE, 1980). The Feasibility Study considered beach restoration projects south of Sebastian Inlet (Sectors 1&2) and within the City of Vero Beach (Sector 5), but did not address the Sector 7 area.

In 1988, Indian River County commissioned a Beach Preservation Plan (IRC, 1988) to analyze shoreline conditions and make recommendations for beach management strategies throughout the County. The Beach Preservation Plan also proposed beach restoration south of Sebastian Inlet and within the City of Vero Beach. The Beach Preservation Plan recommended the formation of a Dune Maintenance District to periodically place modest volumes of sand on the Sector 7 beaches to address the erosion documented there.

The Beach Preservation Plan Update (IRC, 1998), completed in 1998, further analyzed erosion rates throughout the County and proposed beach restoration at four sectors within Indian River County. In addition to the two locations considered in the earlier studies, the Update recommended beach restoration at the Wabasso Beach area (Sector 3) and at Sector 7, in recognition of the high chronic erosion rates and the large number of potentially threatened properties.

In 2000, the County prepared an Engineering Design Report (ATM, 2000a) and submitted a Joint Coastal Permit Application (ATM, 2000b) for beach restoration at all four Sectors identified in the Beach Preservation Plan, including the Sector 7 Project area. In 2001, it was decided to withdraw that application in order to more expeditiously proceed with the Sectors 1 and 2 project. In June 2003, the County submitted a Joint Coastal Permit Application for
the Sector 7 Project, with subsequent submittal of a design and permit modification in December 2004. Following design changes it was determined that an Environmental Assessment meets the intent of NEPA, as the applicants preferred design does not result in additional direct, indirect or cumulative impacts on the environment.

1.5 Project Goals and Objectives

The Project area within Sector 7 has experienced historic and recent losses due to erosion of the coastline. The background erosion rate within the Project area is the highest in Indian River County at approximately 2.08 CY/ft/yr as measured for the period from 1986-2001. The shoreline between R-103 and R-107 has been designated as a Critically Eroded Area by the FDEP.

Indian River County’s coastline is a valuable resource in terms of storm protection, economics, and wildlife utilization and the County has been evaluating the condition of its beaches for many years. In 1988, the County adopted a comprehensive beach preservation plan, which included a management strategy to address coastal erosion problems. This plan was outlined in the Beach Preservation Plan (1988) and the Beach Preservation Plan Update (1998) and recommended a two-tiered approach:

1) Restore and maintain the beaches south of Sebastian Inlet which have been adversely impacted by the Inlet’s presence; and
2) Restore and maintain areas of “critical erosion.”

The proposed Project seeks to restore and maintain the area of critical erosion along the Sector 7 Project area shoreline through the placement of sediment onto the beach. Beach restoration is recommended for this shoreline based on analyses of annual erosion rates, proximity of major development to the mean high water line, existing sandy beach width, and the local sediment budget and coastal dynamics.

The principal goals of this Project are to:

- mitigate for the historical erosion losses;
- ensure the protection of existing upland properties, infrastructure, and hurricane evacuation routes from shoreline erosion associated with typical (seasonal) wave conditions and high frequency storm events;
- furnish additional nesting habitat for threatened and endangered marine turtles by establishing a viable beach and dune system;
- minimize adverse Project-induced environmental impacts to the extensive nearshore hardbottom resources found along Indian River County’s coastline; and,
- enhance the recreational use of the County’s eroded beaches.
1.6 Related Environmental Documents

Literature or planning support documents used in the preparation of this report are listed in Section 7, References.

1.7 Decisions to be Made

This EA evaluates whether to issue a Section 404/Section 10 permit to Indian River County, Florida (permit applicant) to construct and maintain the Project to mitigate for losses to the nearshore sediment budget, provide shore protection, restore and maintain a public recreational beach, and restore marine turtle nesting habitat within Sector 7, and if so, evaluate alternatives to accomplish these goals.

1.8 Scoping and Issues

Meetings were held with the FDEP and the Corps of Engineers prior to the submittal of the Joint Coastal Permit application to discuss the needs of the Sector 7 shoreline and the goals and issues related to a beach nourishment project. In 2003, a beach restoration project was initially designed to meet the principal project goals identified above. This project, however, included direct impacts to 5.3 ac of the nearshore hardbottom habitat. Following coordination meetings with the FDEP and the hurricane events the summer of 2004, the County has redesigned the beachfill to avoid any direct, indirect, and cumulative impacts to the nearshore reefs, and to include additional fill lost due to the 2004 hurricanes. While the redesigned project does not fully meet many of the principal goals for the Sector 7 shoreline, the project eliminates most of the environmental impact issues of concern to FDEP.

1.8.1 Issues Evaluated in Detail

The following issues were identified during pre-application and scoping meetings, and determined by the County to be relevant to the proposed Project and appropriate for detailed evaluation:

a) functions and values of nearshore and offshore hardbottom resources;
b) primary, secondary and cumulative impacts of the Project on hardbottom resources;
c) compensation for hardbottom impacts and temporal losses, if needed;
d) potential impacts of the Project on Essential Fish Habitat;
e) turbidity and sedimentation impacts to hardbottom and reef communities in the vicinity of the borrow areas;
f) impacts and benefits of the Project on sea turtle nesting and foraging habitat;
g) impact of current conditions on future public recreational use;
h) need for the Project based particularly on the historical erosion rate, littoral processes, and sediment budget in and adjacent to the Project area; and,
i) public safety.
1.8.2  Impact Measurement

The following provides the means and rationale for measurement and comparison of impacts of the proposed action and alternatives.

1.8.2.1 Hardbottom Habitat and EFH Impacts

Alternatives for accomplishing the Project goals were evaluated on the basis of the potential impact to hardbottom and other EFH resources in the Project area.

The hardbottom habitat along Indian River County was extensively studied as described in Sections 3.8 and 3.9 of this report. As part of the study, the locations of hardbottom were mapped on aerial photographs and diver verified. In addition, beach profile surveys collected elevation data along select transects throughout the County. These data document the extent of hardbottom at the time of the surveys.

Based on extensive experience with beach nourishment in Indian River County and other Florida beaches, impacts to hardbottom and reefs can be reasonably predicted based on proximity to the shoreline, currents, nature of borrow material, and other factors. This study measured impacts through a number of proven coastal engineering tools including Average Profile Method, Reef-Protected Equilibrium Profile Theory, and the GENERalized model for Simulating Shoreline change (GENESIS model), a system of models capable of predicting shoreline change caused primarily by wave action. These methods, how they were applied to each alternative, and their results are described in the Alternatives sections of this report.

1.8.2.2 Sea Turtle Nesting and Foraging Habitat

Alternatives are also evaluated based upon the extent to which they accomplish the Project goals of restoring and maintaining sea turtle nesting habitat and the potential detrimental impacts of the alternatives in interfering with nesting success. Project alternatives are also evaluated based on their potential impacts on the availability of foraging habitat for sea turtles in the marine habitats adjacent to the Project area.

Currently, sea turtle nesting activity is measured in southern Indian River County sporadically through physical monitoring. The Sector 7 beaches were systematically monitored only in 1997 and 1998 in conjunction with a USACE sponsored project to remove derelict WWII structures from the beach and nearshore area. Beginning in March 2005, Indian River County has committed to comprehensive sea turtle nesting monitoring countywide as a part of its Habitat Conservation Plan. This monitoring will include calculations of nesting success and reproductive success, and will serve as a baseline for assessments of potential impacts to sea turtle nesting.
The use of the nearshore reef habitat as foraging grounds for the various species of sea turtles has been monitored by Indian River County since 2001. Surveys conducted each summer quantify the abundance of turtles in the nearshore habitats offshore of the proposed Sector 7 project area and at other control sites in the county. This information will serve as a baseline for assessments of potential impacts to sea turtle foraging. Post project monitoring will be required by the state and will provide beneficial data for evaluating the success of the project and any impacts that the project may have on foraging activity.

1.8.2.3 Public Recreation

Project alternatives are evaluated to determine the extent to which they accomplish the Project goals to restore and maintain a public recreational beach in the Project area. The recreational beach provides an important economic resource for the community and state and as the beach width decreases, the recreational area of the beach is reduced, decreasing the number of visitors to the Project beach. The recreational value of the Project beach can be measured by the number of beach visitors who spend money on food, entertainment, shopping, and lodging.

1.8.2.4 Sediment Budget Restoration (mitigation for historic erosion)

Project alternatives are evaluated to determine the extent to which they accomplish the Project goals of restoring the nearshore sediment budget deficit. If "no-action" is taken to alleviate the deficit of material within the littoral system, the beaches within the study area are expected to continue to erode which would cause a proliferation of shoreline armoring to protect upland property and public infrastructure resulting in the loss of recreational beach and turtle nesting habitat, and damage to unprotected upland property and public infrastructure.

1.8.2.5 Public Safety

Project alternatives are evaluated to determine the extent to which the alternative creates or exacerbates conditions that give rise to public safety risks. A concern has been expressed regarding the safety of children, swimmers, and surfers as a result of emergent, intertidal hardbottom. Additionally, continued erosion has the potential to expose additional derelict WWII structures and ordinance, as occurred following the 2004 hurricanes.

1.8.2.6 Other Impacts

The basis for impact measurement and comparison on environmental resources including the coastal barrier, offshore borrow area, water quality, and air quality are stated more specifically in Section 4.0, Environmental Consequences, and other sections of this document and its appendices.
1.8.3 Issues Eliminated from Detailed Analysis

The following issues were not considered important or relevant to the proposed Project based on scoping and the professional judgment of the preparers of this EA:

The proposed Project would not involve the disposal of dredged material or other substances subject to the Marine Protection Research and Sanctuaries Act (a.k.a. the Ocean Dumping Act). No issue has been raised regarding the presence of contaminants or toxic compounds in potential sand sources under consideration, as field investigations have not found contaminants within the material contained within the offshore borrow site. No other issues were specifically identified for elimination.

1.9 Permits, Licenses, and Entitlements

The proposed beach nourishment activity is subject to the Coastal Zone Management Act. Consultation with the State Historic Preservation Officer (SHPO) is also required. Since there would be a discharge of dredged or fill material into waters of the United States, the proposed Project is subject to Section 404 of the Clean Water Act (CWA). In addition, the proposed Project is subject to Section 401 of the CWA for certification of water quality by the state.

The Project applicant, Indian River County, is responsible for obtaining any real estate easements and rights of way required for this Project and establishment of the Erosion Control Line.

The Applicant’s Preferred Alternative would require the following permits and licenses:

**CWA Section 404 Permit (33 U.S.C. 1344)/Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).** The purpose of this EA is to evaluate the issues and alternatives associated with the Section 404/Section 10 permit application submitted by Indian River County.

**Consolidated Joint Coastal Permit, Florida Department of Environmental Protection.** Issued under the authority of Chapter 161 and Part IV of Chapter 373, Florida Statutes (F.S.), and Title 62 and 40, Florida Administrative Code (F.A.C.), the County will be granted by FDEP a Consolidated JCP (Permit No: 0215960-001-JC) for Indian River County Sector 7 Project.

**CMP Consistency Certification, Florida Coastal Zone Management Act.** The FDEP permit issued for the Project constitutes a finding of consistency with Florida’s Coastal Zone Management Program, as required by Section 307 of the Coastal Zone Management Act.

Proprietary Authorization, Sovereign Submerged Lands. This Project also requires and has been granted proprietary authorization for use of and construction on sovereign submerged lands owned by the Board of Trustees of the Internal Improvement Trust Fund, pursuant to Article X, Section 11 of the Florida Constitution, and Sections 253.002 and 253.77, F.S. As staff to the Board of Trustees, the FDEP has reviewed the proposed Project and has determined that the beach fill placement area and pipeline corridors qualify for a consent to use sovereign, submerged lands, as long as the work performed is located within the boundaries as described and is consistent with the terms and conditions of the issued FDEP permit. Therefore, consent has been granted, pursuant to Chapter 253.77, F.S., to perform the activity on the specified sovereign submerged lands.

Public Easement, Borrow Areas. As staff to the Board of Trustees, the FDEP has reviewed the proposed Project described herein, and has determined that the borrow area requires a Public Easement for the use of those lands, pursuant to Chapter 253.77, F.S. The Department has issued the Public Easement for the borrow areas (Instrument No. 30601, BOT File No. 500222419).

Historic Preservation. Consultation with the State Historic Preservation Officer was completed on August 23, 2001 in accordance with 36 CFR, Part 800 ("Protection of Historic Properties") and Chapter 267.061, Florida Statutes, as implemented through 1A-46 Florida Administrative Code.
2.0 PROJECT ALTERNATIVES

The goal of the beach nourishment and dune enhancement design for this Project was to optimize the performance and cost effectiveness of the Project while meeting Project goals and minimizing environmental impacts to the extensive nearshore hardbottom resources that are found along the coastline. Seven design alternatives were formulated and analyzed in 2003. These alternatives included four beachfill designs of differing fill volumes, two structural alternatives with beachfill, and one beachfill design using an upland sand source. Due to environmental impact concerns raised by the Florida Department of Environmental Protection in June 2004, another beachfill alternative was developed with the goal of avoiding all impacts to the nearshore hardbottom. For purposes of this EA, the design alternatives evaluated in detail herein will include Alternative 1: “No-Action” alternative, Alternative 2: Applicant’s preferred “No-Impact” alternative (363,600 cubic yards), and Alternative 3: Sand placement alternative (459,000 cubic yards), which was previously considered prior to June 2004 agency consultation. These three alternatives were evaluated comparing shoreline response, environmental impacts, and project cost.

In the investigation and design of these alternatives, the coastal resources were extensively evaluated and incorporated into a technically sound and environmentally sensitive project design. A significant component of this effort was focused on avoiding and/or minimizing impacts to the exposed nearshore hardbottom. Based on extensive experience with beach nourishment in Indian River County and other Florida beaches, impacts to hardbottom and reefs can be reasonably predicted based on proximity to the shoreline, currents, nature of borrow material, and other factors.

The alternatives discussed below were evaluated using numerous design tools including numerical models and aerial photos. This study measured hardbottom impacts through a number of proven coastal engineering tools including Average Profile Method, Reef-Protected Equilibrium Profile Theory, and the GENERalized model for SImulating Shoreline change (GENESIS model), a system of models capable of predicting shoreline change caused primarily by wave action.

A design optimization analysis was conducted with the goal of balancing the minimization of hardbottom coverage impacts with the effectiveness of the resulting project’s ability to meet the goals related to storm protection, habitat enhancement, and recreation features. It was found that while a reduced design volume would reduce hardbottom coverage, it would also result in significantly reduced berm width and project life. A reduction in fill volume would increase the frequency of renourishments in order to maintain the desired level of storm protection, and increase adverse environmental impacts through frequent renourishment events. Applied Technology and Management, Inc. prepared a full detailed report (and addendum) of the design evaluation of the four original beachfill designs, including Alternative 3 as presented here. The reports present the project plan view aerial drawings along the existing shoreline, the proposed beachfill project templates, construction and adjusted berm and toe of fill locations, and the distribution of the nearshore hardbottom
(ATM, 2002 and 2003b). Beach and offshore profile data (collected by Morgan & Eklund, Inc. between July and August 2001) are also presented (ATM 2003b) with the anticipated equilibrium profile template at each FDEP Reference Monument. The beachfill template configurations were developed using the USACE software BMAP version 2.0.

After presentation of these alternatives and consultation with the FDEP, a No-Impact design alternative was developed. The goal of this design is to place beachfill in the Sector 7 shoreline without any direct or indirect impacts to the nearshore hardbottom. This alternative is not designed to provide any specific level of storm protection or enhance habitat or recreation features. The details of this design are presented below.

2.1 Description of Alternatives

Two design alternatives in addition to the “No-Action” Alternative were evaluated in depth during Project development:

- Alternative 1 – “No-Action”
- Alternative 2 – Applicants Preferred “No-Impact Design”(Sand Placement of 363,600 CY)
- Alternative 3 - Sand Placement of 459,700 CY

Of these, Alternative 1, the “No-Action” Alternative, Alternative 2, the “Applicant’s Preferred Alternative” and Alternative 3, are addressed in detail in this document to evaluate their anticipated effects on the environment. Other Alternatives were eliminated from detailed analysis in this EA based on project costs and environmental impacts

2.1.1 Alternative 1 – “No-Action” Alternative

Under the No-Action Alternative, mitigation for historical and ongoing erosion would not occur. FDEP has classified the Sector 7 shoreline between R-103 and R-107 as critically eroded. The Project area has experienced average volumetric and shoreline change rates of -2.08 CY/ft/yr and –2.4 ft/yr, respectively, as measured between 1986 and 2001 survey events. If the current trend of erosion continues at its present rate without corrective action, in the next 30 years the Sector 7 shoreline may move landward more than 168 feet from its current position. A landward retreat of that magnitude would have profound consequences for both developed property and environmental resources.

In 1999, ATM conducted a study of the shoreline between T-100 and R-107 (ATM, 1999a). This study determined that without action to prevent the loss of upland property, oceanfront property owners would suffer direct economic losses. As beaches continue to erode, it is assumed that the oceanfront property owners would take whatever actions are in their own economic interest to protect their properties. If the major habitable structures on the property are in jeopardy of significant structural damage from ongoing erosion or from a 15-year storm...
event, it can be assumed that the property owners would armor the shoreline (i.e., construct a seawall as an erosion control structure). The study found that if no action is taken to control the erosion, over the next 30 years, only one developed property in the study area shoreline is not expected to be armored. This equates to an additional 4,400 feet of shorefront to be armored, of which, 430 feet have been armored since the study was conducted. The cost of seawall construction and maintenance, and land loss is expected to be $7.64 million (net present worth).

Currently, seawalls armor approximately 1,110 feet of the 11,730-foot Project area shoreline in Sector 7 with the construction of additional seawalls pending approval by the state following the passage of hurricanes Frances and Jeanne in September 2004. Properties in the Sector 7 area suffered catastrophic damage from hurricanes Frances and Jeanne. Four homes in the area were completely destroyed by storm surge and wave attack, and virtually every structure was damaged. Post-storm surveys indicated on average dune retreat in Sector 7 due to the hurricanes of 58 feet, as measured by the position change of the 10 foot elevation mark, with a loss of 3 to 5 feet of beach berm elevation. Dune washover was widespread, and in many areas the primary dune was completely washed out, leaving upland areas critically vulnerable to even a high frequency return interval storm. FEMA classified a greater proportion of structures in Sector 7 as critically threatened than in any other similar sized shoreline segment in Indian River County. Without adequate large-scale protection mechanisms in place, requests for shoreline armoring to protect upland properties at risk from erosional impact are expected to increase.

The 1999 study also evaluated the economic value of the beach based on recreational activity. The study concluded the economic value of the beach in Sector 7 is $2.53 million (net present worth).

As the erosion continues, the beaches will narrow due to the presence of seawalls and existing upland development, as well as the beach’s encroachment on dune and upland vegetation. As a result, the nesting habitat of several species of threatened or endangered sea turtles will be degraded, and in some areas completely lost. While very narrow beaches can support limited nesting, under conditions where wave runup reaches the dune or seawall on a frequent basis, hatch success would decrease dramatically due to inundation and nest washout.

Indian River County also developed a Habitat Conservation Plan to address marine turtle nesting issues related to the increased number of requests for coastal armoring in severely erosion-stressed areas of the County, which includes the Sector 7 shoreline segment considered in this study. The Plan predicts that without beach nourishment, an additional 3,495 feet of shorefront within Sector 7 would be armored within the next 30 years (Ecological Associates, 2002). Currently, nesting volume in Sector 7 is approximately one-third the volume in other areas of the County.
2.1.2 Alternative 2 – Applicant’s Preferred “No-Impact” Design Alternative

This Alternative was designed with the goal of placing beachfill along the Sector 7 shoreline while avoiding all impacts (direct and indirect) to the nearshore hardbottom resources (Figure 2-1).

The project area extends between R-97 and R-108, approximately 11,730 feet of shoreline. The proposed No-Impact Design incorporates a uniform +9 ft NGVD berm and a dune enhancement feature. The project was designed to place a total fill (nourishment) volume of 363,600 cubic yards, which includes 36,400 CY of sand for the dune enhancement. The average profile would receive 24.6 CY/ft of fill sand including 3.0 CY/ft for the dune enhancement feature. The design would advance the shoreline an average of approximately 30 feet after equilibration and the dune would have a footprint of an average of 32 feet.

The design berm elevation of +9 feet NGVD was determined based on the existing berm elevations, and guidance from other successful beach nourishment projects along the east coast of Florida. The proposed beach design includes a beach face slope of 1 vertical to 10 horizontal (1V:10H) between the +9 feet NGVD berm crest and 0 feet NGVD. This slope was chosen to closely mimic the natural slope of the beach in the Project area, and because the borrow area sand characteristics indicate the material can reasonably be configured to this geometry. The design also features tapered sections at the north and south limits of the project between T-98 and R-97 and between R-107 and R-108 to smooth the transition between the beachfill project and existing beach.

Within the critical hardbottom area (and critically eroded area) between R-102 and R-105 only approximately 57,000 cubic yards of material could be placed to avoid hardbottom impacts. This equates to a fill volume density of 15.9 cubic yards per lineal foot within this region and an average increase in the shoreline from its current location (post-hurricane) to the estimated equilibrium shoreline of 15 feet. While this volume is insufficient to provide the desired level of storm protection, it is the maximum amount that can be placed without impacts to the nearshore hardbottom.

A dune enhancement feature is proposed in this alternative to mitigate for historic dune losses, enhance protection of the upland areas, and preserve the coastal environment. The restored dune feature will provide a greater diversity of habitats for beach-associated flora and fauna and will provide additional storm protection to the upland properties. The crest elevation of the proposed dune feature in Sector 7 is +12 feet NGVD. This elevation is the average historic dune elevation in Sector 7. The average dune footprint will be 32 feet with an average volume of 3.0 CY/ft, although the southern portion of the project area is heavily armored with very narrow beaches allowing for little or no dune feature in these critical areas. The seaward slope of the proposed dune feature will be 1V:3H from the designated dune crest elevation to the +9 feet NGVD design berm contour. Where the existing dune elevation is sufficiently low to require a slope to tie into the natural backshore elevations, the landward slope will be 1 vertical to 3 horizontal.
The conceptual design is presented in Figure 2-1 overlaid onto 2001 aerial images of the project area. Additionally, beach profile data used to evaluate the design and determine the potential hardbottom impacts was collected at half stations in between R-99 and R-101, quarterly stations between R-101 and R-106, and half-stations between R-106 and R-108. This data provided a comprehensive assessment of the Sector 7 physical conditions.

The Indian River Shoal complex (which comprises the South borrow area) is the primary candidate borrow site for the initial fill Project (Figure 3-3). This site selection is based on the compatibility of its sand as compared to the existing sand in the Project and adjacent areas’ beach/dune system, an adequate volume of material to allow for the construction, and a minimal environmental impact from suspended sediment. A detailed description of the borrow area material is presented in Section 3.3 of this report.

In response to wave activity, the sediment along the seaward edge of the construction profile can be expected to adjust seaward during Project construction and subsequent to placement of the fill. As the profiles naturally redistribute the initial sand placement/construction profile shape to balance the constructive and destructive forces of the waves and currents acting on the beach, the beach profile geometry will adjust to a more natural equilibrium profile.

In a study by Munoz-Perez, et.al (1999), the slope of the beach below MHW was investigated at reef-protected beaches such as Sector 7. The researchers found that the profile shape was much steeper than that of typical sandy beaches in which no nearshore reef is present. They determined that in a reef-protected beach, the energy flux is dissipated over the reef, reducing the total energy flux that has to be dissipated by the beach, resulting in a steeper profile.

The study developed a relationship for equilibrium beach profiles for reef-protected beach based on the Dean (1977) Equilibrium Beach Profile Theory for sandy beaches using actual beach slope data. The reef-protected equilibrium profile developed from this relationship for the Sector 7 project area compares well with the measured Sector 7 profile data and was used in evaluating the cross-shore spreading of the beachfill design. For a conservative evaluation of the design equilibrium toe of fill, it was assumed that no fill volume was lost between placement and equilibrium.

The location of the landward extent of the exposed (in 2001) hardbottom as determined from the extensive hardbottom delineation effort undertaken in 2001 was used to determine the potential hardbottom coverage of the No-Impact design. The location of the 2001 hardbottom and the equilibrium toe of fill based on the Reef-Protected Equilibrium Profile Theory were used to evaluate the No-Impact beachfill design and ensure that none of the nearshore hardbottom was impacted by the construction or subsequent cross-shore spreading of the beachfill.

A longshore sediment transport study was conducted by ATM (ATM, 2004) to evaluate the shoreline evolution and response to the Project in order to verify that none of the nearshore hardbottom would be impacted by the equilibration of the Project. The study made use of the GENEralyzed model for SImulating Shoreline change (GENESIS model), a system of models capable of predicting shoreline change caused primarily by wave action. The study
determined that the Project would not cause any hardbottom impacts in the project area. The model also indicated that due to the limited fill placement in critical areas, the shoreline would erode back to its current location within 2 to 3 years in those areas.

The GENESIS model was also used to evaluate the potential secondary impacts associated with the spreading of beachfill to the beaches adjacent to the Project area. While the Project is expected to spread sand to the beaches to the north and south, modeling indicated that no Project-related impacts will occur to the nearshore hardbottom in those areas.

The level of fill placement in the project area with the No-Impact design is insufficient to maintain the 15-year level of protection originally envisioned for the project. Additionally, due to the limited fill placement allowed in the most critical areas, the performance of this project will be highly variable and does not meet the minimum performance standards originally outlined in the project goals. This design alternative does not meet the outlined design criteria mitigating for historical erosion losses and providing for increased sea turtle nesting habitat.

The total estimated initial construction cost for the Applicant’s Preferred Alternative is $3.95 million. Due to the limited fill volume placement throughout the project area, particularly in the critical areas, this design does not meet performance standards from a coastal engineering standpoint. Project performance will be highly variable and, thus, project life, renourishment interval, and 30-year project costs are indeterminable for this design alternative.

2.1.3 Alternative 3 – 459,700 Cubic Yards Sand Placement

This Alternative was designed to restore the beaches to a dynamic equilibrium along Sector 7 (Figure 2-2). This design alternative was developed according to design criteria as outlined herein, as well as in the Beach Preservation Plan (Indian River County (IRC), 1988), the Beach Preservation Plan Update (IRC, 1998), the Indian River County Economic Analysis Reports (ATM, 1998 and 1999b), the Evaluation of Alternative Designs for Sector 7 Report (ATM, 2002), and the Evaluation of Alternative Designs for Sector 7 Addendum (ATM, 2003b). It represents a compromise between meeting outlined design criteria and minimizing environmental impacts. The project area extends between 95 feet north of T-100 and 105 feet south of R-107, a total shoreline length of 7,138 ft.

This Alternative design would provide a storm protective berm sufficient to resist erosion-induced damages from a 15-year return storm event in addition to advance fill to allow for expected post-construction erosion losses and end losses, as well as an additional 10-year storm loss. A uniformly shaped fill area was designed resulting in a total fill (nourishment) volume of 459,700 cubic yards, which includes 18,900 CY of sand for the dune enhancement. The average profile would receive 62.4 CY/ft of fill sand including 2.4 CY/ft for the dune enhancement feature. The design would advance the shoreline an average of approximately 86 feet between the 2001 shoreline and the equilibration shoreline, and has an average dune footprint of 38 feet.
Renourishment would be required when erosion reduces the fill volume to the volume predicted to erode during a 15-year period storm event. This remaining fill volume quantity is considered the minimum buffer necessary to protect the existing upland structures. The USACE numerical model, SBEACH, was used to determine the potential storm impacts on the local beach profile. The SBEACH results showed that the expected erosional volume loss during a 15-year storm event to be 137,800 CY. At renourishment, then, the volume required to restore the original design volume would be 321,900 CY.

The renourishment interval was calculated based on an estimation of the ongoing volumetric losses of Project sand from the fill area expected due to annual and storm-induced erosion. It is assumed that between renourishment events, the Project will incur one relatively high-frequency storm event (10-year return interval), annual erosional losses, and end losses.

SBEACH was again used to determine the potential storm impacts on the local beach profile. The expected erosional volume loss during a 10-year storm event is 128,500 CY.

The annual erosion loss is 2.8 CY/ft/yr over the entire Project area. This is the average rate as measured from the volumetric changes in beach profiles in the Sector 7 Project area between 1986 and 1999.

End losses are material losses in the longshore direction from the design template due to natural forces (waves, currents, winds) working to smooth the Project shoreline with adjacent shorelines. End losses are the result of the beach’s alongshore Project-related shape change, not the area’s background erosion, and typically begin immediately after Project construction. Dean and Dalrymple (1997) determined that the longevity of a project is proportional to the square of the length of the project. Thus, a relatively short project, such as Sector 7, will lose sand at a relatively high rate when compared to losses from a longer project. Due to the short project length and based on experience of similar projects, the end losses are estimated to be 15 percent of the original project volume.

The assumed relationship can be described as follows:

\[
\text{renourishment volume} = \text{end losses} + \text{10-year storm} + \text{annual erosion} \times \text{project length} \times \text{maintenance interval.}
\]

Thus, the renourishment interval for the 459,700 CY design is:

\[
321,900 \text{ CY} = (15\% \text{ of } 459,700 \text{ CY}) + 128,500 \text{ CY} + (2.8 \text{ CY/ft/yr} \times 7,138 \text{ ft} \times \text{years})
\]

Renourishment (Maintenance) Interval = 6.2 years

Therefore, it is estimated that renourishment will be required at consistent six-year intervals, occurring in years 6, 12, 18, and 24 following Project construction. Monitoring the area will be the best indicator of Project performance and necessary renourishment interval.
The renourishment interval was verified by numerical modeling. A longshore sediment transport study conducted by ATM (ATM, 2003a) evaluated the shoreline evolution and response to the Project in order to predict appropriate renourishment intervals to maintain the 15-year storm buffer volume of beachfill sand on the beach. The study made use of the GENESIS model. The study determined that the renourishments for this design alternative would be necessary in years 7, 16, and 27 after Project construction over the 30-year Project horizon. The model indicated that renourishment intervals could be expected to increase over time due to Project stability resulting from a gradual widening of the beach north and south of the Project area. Thus, numerical modeling verified that a consistent six-year renourishment interval is an appropriate estimate of Project performance for design and costing purposes.

The shape of the equilibrium profile for this design alternative was estimated using the Average Profile Method (Olsen, 1992). The Average Profile Method assumes that after a beach fill project, the equilibrated profile will resemble the natural profiles in the area. An average profile is composited from the natural profiles. This allows a balance of the unsteady profile–to–profile irregularities within each profile. Average Profile Method was used because it has proven successful in areas where there is a bar, reef, or other persistent topography that does not lend itself well to the Equilibrium Profile Theory.

Using the Average Profile Method for this application, an average profile was composited from the 2001 surveyed profiles within the Project area (FDEP Reference Monuments R-101 through R-107). For a conservative analysis, it was assumed that the volume is conserved between construction and equilibrium. The estimated equilibrium (or adjusted) toe is determined from the intersection of the equilibrium/average profile with the 2001 measured profile. In many of the profiles, this toe is intercepted by hardbottom.

Due to the proximity of the hardbottom to the shoreline and based on 2001 aerial data, a total of 5.3 acres of Type 2 hardbottom habitat (algae community with low relief rock, as identified in CSA, 2000) are expected to be adversely impacted through direct sand coverage with this design alternative as the construction profile naturally adjusts seaward to profile equilibrium. The GENESIS model was also used to evaluate the potential secondary impacts associated with the spreading of beachfill to the beaches adjacent to the Project area. While the Project is expected to spread sand to the beaches to the north and south, modeling indicated that Project-related impacts over the 30-year Project horizon would be minimal compared to those expected due to natural background changes. Without the Project, the background accretion experienced by the beaches adjacent to the Sector 7 Project area is expected to cause a shoreline advancement of up to 180 feet over 30 years. The Project-related shoreline advancement in these areas is only expected to reach up to 60 feet over 30 years, adversely impacting 0.87 acres of Type 2 hardbottom (ATM, 2003a). Specific hardbottom types located in the Project area are described in detail in Section 3.8.

In addition to the economic storm and recreational benefits ($7.64 million and $2.53 million, respectively), the beach nourishment of the shoreline in Sector 7 could provide environmental benefits, which includes increased dry beach width for sea turtle nesting activities and the addition of habitat for use by a variety of shorebirds. If the current erosional trend is not
addressed, this valuable habitat will be lost. With the recent shoreline recession rate of 5.6 ft/yr in the Project area, losses to the Project area over the next 30 years could exceed 27 acres if the Project is not constructed and maintained. The economic value of the environmental benefit of protecting this habitat was not evaluated.

The total estimated initial construction cost for this Alternative is $6.45 million including an estimated cost of structural mitigation for the impacts to the nearshore hardbottom. Based on a Project horizon of 30 years, it is estimated that the Project will incur four renourishments at six-year intervals each at a cost of $3.48 million. The total 30-year net present worth cost of this Alternative is $15.55 million.

2.2 Issues and Basis for Choice

2.2.1 Project Alternatives

The alternatives were evaluated based on their ability to meet Project goals and their effects on the environment. Specific factors used as a basis for choice of the alternatives presented herein include storm protection, hardbottom impacts, sea turtle nesting and foraging habitat, public recreation, sediment budget restoration, and public safety. The Applicants Preferred “No Impact Design” Alternative was determined to be the most feasible design based on the environmental issues.

2.2.2 Sand Source Alternatives

The sand sources were evaluated based on an analysis of the quantity and quality of available sand, economic and technical feasibility of the source, and the potential environmental consequences of utilizing the sand sources.

2.3 Alternatives Eliminated from Detailed Evaluation

In order to document the effort that was made toward determining the Preferred Alternative, three additional alternatives were evaluated for the proposed beach nourishment and are presented herein. These alternatives were eliminated from consideration, but are briefly discussed in this section. These project designs were evaluated with respect to economic viability, technical performance, environmental impacts to nearshore hardbottom habitats, short-term and long-term Project costs, and recreation and storm protection benefits. Each of these alternatives was eliminated from consideration based on project costs and environmental impacts.
2.3.1 Alternative 4 – 459,700 Cubic Yards Sand Placement with 12 Groins

The Alternative 4 Project design consists of the same beachfill design as Alternative 3, in addition to 12 shore-perpendicular groins to be distributed throughout the Project area (Figure 2-3). Groin design and placement is intended to optimize the sand trapping ability of the structures, while allowing natural sand bypassing to occur.

The groin locations and dimensions were determined by applying a combination of GENESIS modeling results, engineering experience, and attention to the location of vulnerable upland structures. While final groin details require a detailed investigation into the breaking wave forces, underlying rock substrate and stone availability, preliminary dimensions were determined in order to estimate the potential cost of groin construction.

The 12 groins could be expected to reduce the longshore losses of placed fill volume. The longshore sediment transport (GENESIS) study (ATM, 2003a) determined that following construction of this Alternative, renourishment would be necessary in years 8, 18, and 29 after Project construction to meet the design goals for this alternative based on a remaining volume (storm buffer). However, for conservative engineering practice, renourishment is recommended every eight years with continued monitoring of the area to evaluate Project performance and determine renourishment need.

Alternative 4 is expected to adversely impact a total of 5.3 acres of Type 2 hardbottom habitat (algal community with low relief rock).

This alternative would be expected to require a longer construction window to accomplish the initial restoration. Cumulative negative impacts to nesting in the season immediately following sand placement would be reduced due to a longer renourishment interval when compared to the other alternatives.

The total estimated initial construction cost for Alternative 4 is $10.25 million including an estimated $3.4 million for groin construction. Some groin maintenance would likely be necessary, with cost estimated to be approximately 2.5 percent of the initial cost each year. Renourishment costs are estimated to be $3.48 million. Based on a Project horizon of 30 years, engineering estimates for the renourishments at years 8, 16, and 24, the total net present worth Project costs were estimated at $18.58 million.

Due to the high initial and 30-year Project horizon costs associated with the groin construction and annual maintenance, Alternative 4 was eliminated from consideration as a viable Project alternative.
2.3.2 Alternative 5 – 501,400 Cubic Yards Sand Placement

This design meets Project goals as outlined in the Beach Preservation Plan. A renourishment interval of eight years is sought to optimize the technical performance of the Project and provide the necessary protection. The design would place 501,400 CY of sand along 7,138 feet of shoreline within the Sector 7 Project area, between 95 feet north of T-100 and 105 feet south of R-107, and including 18,900 CY for the proposed dune enhancement (Figure 2-4). The average unit sand placement is 68.3 CY per foot of shoreline including the 2.4 CY/ft dune feature. The average additional dry beach width is estimated at 65 feet following initial adjustment.

The design maintains the same features as Alternative 3, with a berm height of +9 ft NGVD, a dune height of +12 ft NGVD, with the same level of storm protection (i.e. 15-year storm with a 10-year storm buffer); however, this increased volume alternative requires less frequent renourishment in order to maintain the desired level of storm protection and thus offers reduced cumulative environmental impacts.

End losses are estimated to be 15 percent of the original Project volume due to the volume of beachfill in the design. Thus, with an eight-year renourishment interval, the renourishment volume was calculated to be: renourishment volume = end losses + 10-year storm + annual erosion * project length * maintenance interval.

\[
\text{Renourishment Volume} = (15\% \text{ of } 501,400 \text{ CY}) + 128,500 \text{ CY} + (2.8 \text{ CY/ft/yr} \times 7,138 \text{ ft} \times 8 \text{ years})
\]

\[
\text{Renourishment Volume} = 363,600 \text{ CY}
\]

The same methods were used to determine the equilibrium profiles and hardbottom impacts as were used for Alternatives 3 and 4. Due to the proximity of the hardbottom to the shoreline and based on 2001 aerial data, a total of 14.4 acres of Type 2 hardbottom habitat (algal community with low relief rock, as identified in CSA, 2000) are expected to be adversely impacted through direct sand coverage with this design alternative as the construction profile naturally adjusts seaward to profile equilibrium.

The total estimated initial construction cost for Alternative 5 is $9.75 million including an estimated cost of $4.44 million for the construction of an artificial reef as mitigation for the impacts to the nearshore hardbottom. Renourishment costs are estimated to be $3.76 million. The net present value of the anticipated Project costs for the initial construction and renourishment events at years 8, 16, and 24 over the 30-year Project horizon is $16.92 million.

Due to the high initial and 30-year Project horizon costs and the environmental impacts resulting from this design, Alternative 5 was eliminated from consideration as a viable Project alternative.
2.3.3 Alternative 6 – Upland Sand Source

The Upland Sand Source Alternative design was developed to investigate the feasibility of building the Applicants Preferred Alternative design (Alternative 2) using an upland sand source. Thus, this design would be built to the same dimensions as the Applicants Preferred Alternative.

Three upland sand sources were investigated for this design. Upland Source 1 is located in Brevard County approximately 60 miles north of the Project area. Upland Source 2 is located approximately 21 miles from the Project area in St. Lucie County. Source 3 is located approximately 20 miles from the Project site. A detailed description of the material is presented in Section 3.3 of this report.

All facilities report that they contain a sufficient quantity of beach quality material to construct the Preferred Alternative. In the judgement of the Applicant, upland source sand would be unable to compete on a cost basis for this proposed project with offshore borrow source sand. For this reason, Alternative 6 was eliminated from consideration as a liable project alternative.

2.4 Alternatives Not Within Jurisdiction of Lead Agency

This section describes alternatives that may to some extent fulfill the Project purpose and need but which are beyond the jurisdiction of the lead agency to permit or authorize. These “extra-jurisdictional” alternatives are generally within the authority of a local government to implement and include such measures as land use controls or limitations and restrictions on construction.

2.4.1 Rezoning of Beach Area

Rezoning of the beach area to restrict or limit future upland construction could, in some areas, effectively reduce the risk of storm damage to upland structures associated with shoreline retreat. In Sector 7, upland development has already occurred and rezoning the area would not result in any substantial reduction in potential risks to upland property. Rezoning of the beach area could reduce risk of storm damage to those parcels; however, it fails to address the principle Project goals of restoring the recreational beach and creating sea turtle nesting habitat.

2.4.2 Modification of Building Codes

Existing Florida building codes include structural requirements intended to minimize potential impacts to the beach-dune system and reduce building damage in severe storm
events. Sector 7 is extensively developed and while many of the structures do not conform to current building standards, these buildings are generally exempt from existing codes unless substantially modified. Modification of the building codes could reduce storm risks associated with the current condition of the shoreline; however, it fails to address the principle Project goals of restoring the recreational beach and creating sea turtle nesting habitat.

2.4.3 Construction Setback Line

A construction setback line would not affect existing development and could only be effective in the unforeseeable future as buildings are razed and destroyed by storms and replaced, and as buildings are constructed on the remaining undeveloped land. The State of Florida has established construction control lines along the shores of coastal counties and through a construction permit program, based on this line, is controlling development along Florida's coastline. Like the modification of building codes, this alternative is insufficient to achieve the Project goals.

2.4.4 Construction Moratorium or No Growth Program

Assuming local interests would accept a moratorium on future construction, implementation of such a policy would have little impact on the level of storm risk associated with the current erosion affecting Sector 7 and would not achieve the Project purpose or need relative to the recreational beach or sea turtle nesting habitat. More importantly, a no-growth program would be ineffective in this area since the majority of the area has already been developed. This alternative is currently insufficient to fulfill the Project goals.

2.4.5 Evacuation Planning

Similar to other extra-jurisdictional alternatives, improved evacuation can potentially reduce the loss of life during severe storm events and should be pursued by appropriate state and local emergency management officials. However, this alternative does not address the Project goals.

2.4.6 Condemnation of Land and Structures

Local governments have the power, under certain prescribed conditions, to condemn land or structures as may be determined to be in the public interest. Removal of condemned structures can also be justified and legally undertaken under limited conditions. Assuming such a policy could be implemented in the upland areas adjacent to the Project area, and all structures could be removed, this alternative would allow the shoreline to erode until equilibrium is established. This alternative is typically considered along undeveloped
shorelines, but is inappropriate in this case because of the extensive development of the Sector 7 upland area.

2.4.7 Relocation or Retrofit of Structures

The relocation of the structures would allow the area to continue to erode and the land in this area would be lost until an equilibrium shoreline is reached. However, most structures within the area cannot be economically moved from the area that would be lost. In addition, implementation of this alternative would result in the loss of valuable recreational beach and would necessitate the condemnation of the land and structures in highly developed areas. This alternative is not viable. Flood proofing of existing structures and regulation of flood plain and shorefront development are appropriate, but would not fulfill the Project purpose and need.

2.5 Comparison of Alternatives

Table 2.1 provides a comparison of the No-Action Alternative, and Alternatives 2 and 3 with regard to costs and potential impacts to natural resources and human environment. A more thorough analysis of potential impacts is included in Section 4.0, Environmental Consequences.

2.6 Mitigation

As there will be no direct, indirect, or cumulative effects on the nearshore hardbottom habitat and associated biological communities with the Preferred Alternative, no mitigation is proposed or required.
## Table 2 - 1 Comparison of Alternatives

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No-Action</td>
<td>Applicant’s Preferred No-Impact Design</td>
<td>Sand Placement of 459,700 Cubic Yards</td>
</tr>
</tbody>
</table>
| **Total Cost**            | 30-year cost of anticipated land loss and the necessitated shoreline armoring = $7.64 million (Net Present Worth) and loss of recreational value of $2.53 million (net present worth) | Cost of initial fill mitigation = $3.95 million  
Renourishment Cost = $3.95 million  
30-year cost (Net Present Worth) = N/A | Cost of the initial fill = $6.45 million. Renourishment Cost = $3.48 million 30-year cost (Net Present Worth)=$15.55 million |
| **Hydrodynamics**         | No impact      | The wave climate may be slightly altered in the vicinity of the borrow area. | The wave climate may be slightly altered in the vicinity of the borrow area. |
| **Geology/Geomorphology**| Facing continued shoreline erosion without nourishment, it is anticipated that landowners will erect seawalls, which will alter sediment transport patterns.  
Reduced beach widths and erosion adjacent to seawalls can be expected. | No impact to background erosion or sediment pathways.  
Erosion impacts to the dune system will be diminished due to an increased sediment volume.  
Increased sediment in the regional system will reduce sediment deficiencies downdrift of the Project area. | No impact to background erosion or sediment pathways.  
Erosion impacts to the dune system will be diminished due to an increased sediment volume.  
Increased sediment in the regional system will reduce sediment deficiencies downdrift of the Project area. |
| **Sediment Characteristics** | The sediment on the beach in Sector 7 will represent a combination of native beach characteristics and emergency fill from upland sources. The sediment characteristics of the borrow area will be maintained. | The nourished beach will have slightly different sediment characteristics than the existing beach. The median grain size of the borrow sand is larger than that of the existing beach; however, the color and quality are similar. | The nourished beach will have slightly different sediment characteristics than the existing beach. The median grain size of the borrow sand is larger than that of the existing beach; however, the color and quality are similar. |
| **Water Quality**         | No impact      | Temporarily elevated turbidity near the borrow area and fill area along the beach.  
A turbidity variance of 2,600 ft down current will be necessary to construct the beach nourishment Project. | Temporarily elevated turbidity near the borrow area and fill area along the beach.  
A turbidity variance of 2,600 ft down current will be necessary to construct the beach nourishment Project. |
<table>
<thead>
<tr>
<th>Consideration</th>
<th>Alternative 1 No-Action</th>
<th>Alternative 2 Applicant’s Preferred No-Impact Alternative</th>
<th>Alternative 3 459,700 Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>Continued erosion of the County’s beaches and the anticipated construction of seawalls would likely result in continued loss of habitat and eventually loss of vegetated dune areas.</td>
<td>Sand placement on the beach would not directly impact the nearby dune communities but would act as a buffer to these communities from the surge associated with storm events. Additional constructed dune would be vegetated.</td>
<td>Sand placement on the beach would not directly impact the nearby dune communities but would act as a buffer to these communities from the surge associated with storm events. Additional constructed dune would be vegetated.</td>
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<tr>
<td>Protected Species</td>
<td>The continued erosion of the beaches in this critically eroded area may result in shoreline recession over the next 30 years. The resulting loss of beach habitat would negatively impact sea turtles that utilize this habitat for nesting.</td>
<td>No construction-related impacts to threatened and endangered species are expected as construction activities are scheduled outside of the nesting season of sea turtles. There may be slight decrease in the nesting and reproductive success of sea turtles in the season immediately following nourishment; however, the additional beach area will increase sea turtle nesting habitat. <strong>Note that use of similar offshore borrow area material for nourishment in Sectors 1 and 2 resulted in no decrease in nesting or reproductive success following construction.</strong></td>
<td>No construction-related impacts to threatened and endangered species are expected as construction activities are scheduled outside of the nesting season of sea turtles. There may be slight decrease in the nesting and reproductive success of sea turtles in the season immediately following nourishment; as well as continued impacts due to groin placement on nesting beaches. <strong>Note that use of similar offshore borrow area material for nourishment in Sectors 1 and 2 resulted in no decrease in nesting or reproductive success following construction.</strong></td>
</tr>
<tr>
<td>Hardbottom</td>
<td>The No-Action Alternative will likely allow sand to continue to be eroded from the beach in Sector 7. This sand could potentially expose or cover more hardbottom habitat.</td>
<td>The Applicant’s Preferred Alternative will not directly impact any hardbottom habitat. No potential indirect impacts are expected based on modeling results.</td>
<td>This alternative will directly impact a total of 5.3 acres of hardbottom habitat. Potential indirect impacts are expected to be 0.87 acres based on modeling results. The impacts to the hardbottom will be offset with the construction of an artificial reef.</td>
</tr>
<tr>
<td>Consideration</td>
<td>Alternative 1 No-Action</td>
<td>Alternative 2 Applicant’s Preferred No-Impact Alternative</td>
<td>Alternative 3 459,700 Cubic Yards</td>
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<tr>
<td>Essential Fish Habitat</td>
<td>No impact</td>
<td>No direct, indirect or cumulative impacts on hardbottom</td>
<td>Direct impact of 5.3 acres of</td>
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<td></td>
<td></td>
<td>habitat. The proposed toe of fill would also temporarily</td>
<td>hardbottom habitat and</td>
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<td></td>
<td>impact 32.53 acres of open water habitat along Sector 7</td>
<td>minimal indirect impact. The</td>
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<td>occurring from the MHW line and extending approximately</td>
<td>proposed toe of fill would also</td>
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<td></td>
<td>300 ft offshore. Temporary impacts would include possible</td>
<td>temporarily impact 57.9 acres</td>
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<tr>
<td></td>
<td></td>
<td>displacement of fishes from nearshore areas during fill</td>
<td>open water habitat along Sector 7</td>
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<tr>
<td></td>
<td></td>
<td>placement, temporary reduction of water quality due to</td>
<td>occurring from the MHW line and</td>
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<td></td>
<td>turbidity, and decreased primary and secondary production</td>
<td>extending approximately 550-825 ft</td>
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<td></td>
<td>until the completion of nourishment.</td>
<td>offshore. Temporary impacts</td>
</tr>
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<td></td>
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<td></td>
<td>would include possible</td>
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<td>displacement of fishes from</td>
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<td>nearshore areas during</td>
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<td>dredging and fill placement,</td>
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<td>temporary reduction of water</td>
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<td>quality due to turbidity, and</td>
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<td></td>
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<td>decreased primary production</td>
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<td>until the completion of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>nourishment.</td>
</tr>
<tr>
<td>Coastal Barrier Resources</td>
<td>Negative impact is likely.</td>
<td>No impact, with increased resistance to storm events.</td>
<td>No impact, with increased resistance to storm events</td>
</tr>
<tr>
<td>Hazardous, Toxic, and Radioactive Waste</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Air Quality</td>
<td>No impact</td>
<td>No impact</td>
<td>No impact</td>
</tr>
<tr>
<td>Noise</td>
<td>No impact</td>
<td>A temporary increase in the noise level during construction</td>
<td>A temporary increase in the noise level during construction from the vicinity of the discharge point on the beach and from the offshore dredge.</td>
</tr>
<tr>
<td>Aesthetic Resources</td>
<td>The aesthetics of the beach will be diminished as erosion continues and beach width and natural habitat is lost and more seawalls are erected.</td>
<td>Construction of the beach will benefit aesthetic resources through increased beach area and vegetated habitat.</td>
<td>Construction of the beach will benefit aesthetic resources through increased beach area and vegetated habitat.</td>
</tr>
</tbody>
</table>
Table 2 - 1 (concluded)

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Alternative 1 No-Action</th>
<th>Alternative 2 Applicant's Preferred No-Impact Alternative</th>
<th>Alternative 3 459,700 Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreation</td>
<td>Loss of beach due to erosion will result in less beach area available for recreation.</td>
<td>The improved beaches will provide enhanced opportunities for recreational activities. During nourishment activities, the use of the beach in the vicinity of construction would be restricted for public safety.</td>
<td>The improved beaches will provide enhanced opportunities for recreational activities. During nourishment activities, the use of the beach in the vicinity of construction would be restricted for public safety.</td>
</tr>
<tr>
<td>Navigation</td>
<td>No impact</td>
<td>Impacts to navigation would be short-term in nature and would cease following Project completion.</td>
<td>Impacts to navigation would be short-term in nature and would cease following Project completion.</td>
</tr>
<tr>
<td>Cultural Resources</td>
<td>No impact</td>
<td>No impact as there are no significant submerged cultural resources located within the designated borrow area or beach fill area.</td>
<td>No impact as there are no significant submerged cultural resources located within the designated borrow area or beach fill area.</td>
</tr>
</tbody>
</table>
3.0 AFFECTED ENVIRONMENT

3.1 Coastal Environment

Indian River County is located in south central Florida along the Atlantic Ocean. The climate of the area is subtropical with hot, humid summers and short, mild winters.

Ocean conditions in the summer time are generally calm with a low swell waves predominantly from the south, and light winds predominantly from the east to southeast. However, the area is subject to occasional tropical storms and hurricanes during the summer and fall months. These storms generally approach from the south, southeast, or southwest and generate storm waves.

Prevailing winds in the wintertime are from the northeast and the area is subject to periodic frontal activity. Occasionally, strong extratropical storms generate large, short period waves, generally approaching from the northeast direction. These storms tend to be very destructive as they are large, slow moving storms that subject the area to severe conditions for extended periods of time.

There are several gages in Indian River County and its vicinity that collect assorted coastal environment data. The National Oceanic and Atmospheric Administration (NOAA) maintains two fixed tide stations and a weather station buoy in the vicinity of the proposed Project area. The Florida Institute of Technology (FIT) operates and maintains a weather station and tide gage at Sebastian Inlet.

The two NOAA tide stations are located at the inlets adjacent to the Project beach to the north and to the south. The northern station is located on the north fender of the bridge over Sebastian Inlet, approximately 19 miles from the Sector 7 Project area. The southern station is located on the south jetty of Fort Pierce Inlet, approximately eight miles south of the Sector 7 Project area. These stations were used to determine tidal datums in the Project area.

The NOAA National Data Buoy Center also maintains a weather station buoy 20 nautical miles east of Cape Canaveral, Florida, approximately 63 miles northeast of the Sector 7 Project area. The buoy, Station 41009, collects wave data, atmospheric pressure, air and water temperature, and wind data.

The FIT wave gage at Sebastian Inlet is located approximately 1,500 feet due north of the tip of the north jetty approximately 1,000 feet offshore in a water depth of 26 feet. A November 2000 report from FIT (Harris and Carvalho, 2000) details the wave data that have been gathered from 1996 through 2000 (the first four years of the operation of the gage). This gage provides the closest measured data to the proposed Project area. The gage is operated with funding support from the Sebastian Inlet Tax District.
FIT also operates a weather station and tide gage located at the seaward end of the north jetty at Sebastian Inlet. The wave gage, tide gage, and weather station area located approximately 19 miles north of the Sector 7 Project area.

3.1.1 Tides

The tides in the region are semidiurnal with a Mean High Water level of 1.93 ft NGVD and a Mean Low Water level of –1.44 ft NGVD (FDEP Bureau of Survey and Mapping Land Boundary Information System (LABINS) data). The mean tidal range is 3.37 feet with a seasonal high water level of 6.99 ft NGVD. The Mean Lower Low Water level (MLLW) is -1.65 ft NGVD.

3.1.2 Winds

Winds with varying direction, intensity, and fetch are the primary forcing mechanism for the development of short period waves impacting the Sector 7 beach. The local winds have a large seasonal component. The prevailing winds along the coast of Indian River County are from the east to southeast during the summer and northeast during the winter. The monthly average summer wind speed of 9.4 miles per hour (mph) was measured between September 1996 and August 2000 at the FIT gauge by Harris and Carvalho (2000). The average winter wind speed measured during this period is 11.6 mph.

NOAA collected and summarized National Climatic Data Center data, Navy and Air Force climatic briefs, and other data for the period between 1930 and 1996. The average annual wind condition in Vero Beach was found to be 8 mph in the ESE direction.

3.1.3 Currents

The primary ocean current that influences the Project area is the alongshore current. The alongshore current is primarily driven by waves, with typical summer waves coming from the south and typical winter waves coming from the northeast. Preliminary data compiled by the United States Atomic Energy Commission for a 1973 study at Hutchinson Island, south of the Project area, indicated currents to be generally parallel to the coastline with maximum southerly current of 1 to 3 ft/s and maximum northerly current of 0.7 ft/s, observed (USACE, 1977).

Of secondary influence to the Project is the Gulf Stream. The Gulf Stream flows from south to north, parallel to the shoreline, and approximately 25 to 30 miles offshore of the Project area.
3.1.4 Waves

The local wave climate features an average significant height of 2.4 feet with a typical range of 0.3 to 8.7 feet as measured at the FIT gauge over the period between August 1996 and September 2000 (Harris and Carvalho, 2000). Over this period, the average significant wave height during the summer time was 1.9 feet and the wintertime average was 2.8 feet.

The central Florida coast is subject to occasional strong extratropical storms along with occasional tropical storms and hurricanes. Storm surges along the ocean-facing shoreline can exceed several feet above mean sea level, and storm generated currents over the inner continental shelf can exceed 6 feet per second during severe events. The predominant wave direction is from the east to northeast.

Wave periods were also measured between August 1996 and September 2000 at the FIT gauge and reported by Harris and Carvalho (2000). The average peak wave period measured over four years was 8.3 seconds with a range from 4.0 seconds to 16.0 seconds. The peak wave periods averaged 8.1 seconds during the summer time and 8.3 seconds in the winter.

3.2 Beach and Inlet Geomorphology

3.2.1 Geomorphic Setting of Indian River County

Knowledge of the geomorphic setting of Indian River County, in east central Florida, is significant in evaluating the stability and dynamics of County beaches and in determining the availability of sand resources. Indian River County lies within the Central or Mid Peninsular zone of Florida (White, 1970). Within this zone are several physiographic provinces that relate to the fluctuations of sea level that have occurred over the past two million years. The central highlands of this zone have a grade that is easterly and westerly to the coastal lowlands. The eastern coastal lowlands can be further subdivided into several physiographic provinces (White, 1970, Figure 3-1). The present shoreline is composed of the Atlantic Beach Ridge and Barrier Chain, which are perched on the Anastasia Formation. The Atlantic Coastal Lagoon Province (White, 1970) includes the Indian River Lagoon System.

Several sand ridges of relatively high relief and oriented more or less parallel to the present shoreline are located within the eastern valley. The beach ridges are from 5 to 15 feet in elevation. The Atlantic Coastal Ridge lies immediately west of the modern lagoon system. Further west is a series of increasingly higher and older terraces that represent ancient shorelines and barrier island systems. The origin of the terrace systems is probably related to sea level fluctuation during the Pleistocene Epoch. The distinctive ridges mark the high stands of sea level at the apex of each interglacial period, whereas the wide sandy terraces may have been generated by depositional shoreline regression during falling sea level as the climate shifted toward each glacial age in the Pleistocene Epoch. This process has been
continuing for about two million years. The modern shoreline complex now forming seaward of the Atlantic Coastal Ridge is the most recent of the shoreline series, and is considered to have been formed entirely within the Holocene Epoch. The Holocene Geologic Epoch began about 12,000 to 14,000 years BP with rising sea level and warming climate.

A hardbottom system oriented parallel to the shoreline prevails throughout Indian River County. This limestone rock begins at a water depth of between 6 and 12 feet and extends to over 3,000 feet offshore in some locations. The hardbottom system is an important benthic resource, colonized by marine life such as sabellariid worms, sponges, algae, and other benthic communities.

The modern coastal geomorphology includes the Indian River County shoreline within the old inlet and barrier island overwash zone of the east central Florida barrier island system (Figure 3-2). Along this section of coast (extending from Melbourne to Fort Pierce Inlet), the barrier island superstructure is relatively narrow. Numerous washover terraces, now coalescing to form a storm surge platform, form the landward side of the superstructure. The lower areas of this platform are vegetated wetlands or mangrove swamps. This low sandy platform was likely generated by a combination of storm surge overwash and inlet breaching of the barrier island superstructure.

Regularly migrating inlets may extend barrier island width by means of deposition of flood shoals that become incorporated in the barrier island superstructure once the inlet has closed or has migrated to another location (Zarillo and Liu, 1991). Under natural conditions, the barrier island superstructure is capped by a wind-formed dune ridge that may reach a height of 20 feet or more above sea level. Thus, the barrier island system consists of a wave-built shoreface extending seaward to a depth of -30 feet (NGVD) or more to which a series of sandy platforms, generated by tidal inlet and storm processes, become attached on the landward side.

3.2.2 Littoral Processes

A longshore sediment transport study was conducted by ATM using the GENESIS numerical model to analyze the local wave patterns and sediment transport dynamics in the vicinity of Sector 7. The net direction of littoral transport along the Atlantic coast of Indian River County is principally from north to south. The study identified a nodal point in the vicinity of R-103. The model indicates that local wave patterns cause an overall net transport pattern in which sand to the north of the nodal point generally moves toward the north, and sand to the south of the nodal point generally moves toward the south. Thus, while any particular wave event may cause transport in either direction throughout the study area, the overall wave climate incident to the area over a number of months or years seems to result in the net transport of sand away from the nodal point. The dynamics of the nodal point in this location appear to reduce or eliminate any longshore sediment supply into the area to ameliorate erosion patterns. Review of the local sediment budget supports the possible presence of this nodal point.
1. BARRIER ISLAND COAST

2. INLET OPENS

3. INLET MIGRATES

4. INLET WANES

5. INLET CLOSED

6. RIDGE DETACHMENT

Source: Applied Technology & Management, Inc
(Moody, 1964)
Shoreline and Volumetric Change Analysis

Historic data shows that the Sector 7 Project area shoreline eroded at an average rate of 2.9 ft/yr between 1948 and 1972.

Between 1986 and 2001, the Sector 7 Project area experienced volumetric erosion at a rate of approximately 2.08 CY/ft/yr and a shoreline erosion rate of 2.4 ft/yr. This region experienced the highest erosion rate in the County during this time period.

3.2.3 Sediment Budget and Sediment Transfer Mechanisms

The annual net longshore sediment transport direction on the east coast of Florida is predominately from the north to the south. Within Indian River County Sector 7 (FDEP Reference Monuments R-94 to R-113), there is one possible nodal point or reversal in the direction of the net annual sediment transport. A site-specific longshore transport study to determine these processes was conducted for this study, the results of which are provided in Appendix C. The study evaluates the nodal area and areas of wave energy focusing which effects the direction of the longshore sediment transport.

Shoreline-armoring structures (seawalls) in close proximity to the shoreline most likely interfere with sediment transport. Currently within the proposed Sector 7 Project area, seawalls are present totaling 1,110 feet of Project area shoreline. All structures are located between 20 and 110 feet landward of the mean high water line. These walls are concentrated between R-102 and R-105 with one in the vicinity of R-106. Several of these walls appear to be sufficiently close to the shoreline to influence sediment transport rates and dynamics, particularly during high wave events.

3.2.4 Influence of Nearshore Hardbottom on Sediment Pathways

The existing nearshore hardbottom, a system of rock and reef outcrop, is a dominant feature along the Indian River County coastline. The hardbottom is comprised of limestone rock colonized with marine life including algae, sponges, mollusks, and sabellariid worms. Originating just offshore and extending out approximately 3,000 feet, the hardbottom is believed to occupy 90 percent of the nearshore zone of Indian River County. The exposed hardbottom adjacent to Sector 7 is located offshore of the -12 foot contour (CSAi, 2000). The irregular, elevated bottom profile may disrupt wave patterns and reduce the wave energy as the waves refract and shoal. This quality may provide a level of protection to the shoreline it parallels.

The irregular offshore surface of the hardbottom appears to influence shoreline profile. Lower sections between the higher features within the hardbottom may provide pathways for sand movement. It is reasonable to assume that the irregular hardbottom features allow for sand loss from the beach system.
3.3 Sediment Characteristics of Borrow Areas and Existing Native Beach

In order to identify a high quality sand source for the proposed beach nourishment Project, geotechnical investigations were performed to determine the quantities of available borrow sediments, the sediment properties of the proposed borrow sands and the existing beach material, and the compatibility of the borrow sediments with the existing beach material.

An offshore borrow area was identified within the Indian River Shoal feature located offshore of the Project area. Additionally, three upland sources were also identified as alternative sand sources for the Project. Data for all sources is included in this report.

3.3.1 Native Beach

A thorough beach and nearshore sediment investigation was conducted in accordance with guidelines provided in Coastal Engineering Research Center (CERC) Coastal Engineering Technical Note II-29, “Native Beach Assessment Techniques for Beachfill Design” (USACE, 1991). A series of beach profiles in Sector 7 were sampled following the cross-shore sequencing and analysis techniques detailed in the CERC document. This effort was undertaken at the request of the FDEP Bureau of Beaches and Wetland Resource to ensure sufficient testing and documentation of existing sand characteristics for final design purposes as well as to provide additional information specifically identified to address marine turtle nesting concerns.

Scientific Environmental Applications, Inc (SEA) conducted beach and nearshore sand sampling investigations during September 2002. SEA collected samples along three cross-shore transects, corresponding to FDEP Monuments T-100, R-103, and R-106. This sampling interval was selected to comply with FDEP guidelines of one transect for approximately 3,000 feet of Project area shoreline. The sand samples were gathered at the following NGVD-referenced elevations: top of dune/dune face (~+12), toe of dune (~+9), +6, +3, 0, -3, -6, -9, and -12 feet NGVD. The samples were then evaluated for grain size variation and distribution.

In March 2001, approximately 61,800 CY of sand was placed at eight sites throughout Indian River County in response to damage caused by hurricanes Floyd and Irene in 1999. This Emergency Dune Restoration Project was partially funded through the Federal Emergency Management Agency (FEMA) Disaster Relief Funding Agreement. Two of these sites were within the proposed Sector 7 Project area. Approximately 2,390 CY of sand was placed between R-103 + 250 feet and R-103 + 700 feet. Another 10,440 CY of sand was placed between R-105 – 200 feet and R-107 – 50 feet. The fill material was trucked from an upland sand source. Testing determined the source material to have a mean grain size ranging between 0.3 and 0.4 mm with 1.4 percent fine material. Because this material was placed prior to the beach sampling, it may have affected the characterization of the native beach material. However, comparison of the profile measured at R-106 (placed upland material) to
profiles measured at T-100 and R-103 (no upland material placed) shows that effects of the upland sand placement on the beach are not easily identifiable.

### 3.3.1.1 Sand Quality

All sediment samples (including composite samples) were analyzed in accordance with ASTM Standard D-422 for mechanical particle size analysis to determine the grain size distribution for each sample. These physical composite results were then mathematically averaged to determine a composite grain size distribution for Sector 7.

Composite characteristics of the Sector 7 existing beach sand were developed using the average of the values from the composite samples collected at FDEP Monuments T-100, R-103, and R-106. Sediment analysis found the composite to contain approximately 2.06 percent silt/clay and 96 percent sand, in addition to 2.4 percent of the content, which were measured to be gravel-sized material (shell) with a median grain size ($d_{50}$) of 0.22 mm. The samples indicate that most of the material is poorly sorted, fine sand.

A notable anomaly was observed during the analysis. The material below MLW is considerably finer than the dry beach material. A composite of the “dry” (i.e., above MLW) beach samples from all three profiles results in a median grain size of 0.40 mm. A composite of the “wet” beach samples from all three profiles results in a median grain size of 0.11 mm. The cause of this disparity is unknown.

Table 3.1 presents the Unified Soils Classification characteristics of the existing beach in Sector 7.

<table>
<thead>
<tr>
<th>Unified Soils Classification (USC)</th>
<th>Existing Beach Composite Characteristics</th>
<th>Existing Dry Beach Composite Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Grain Size, $d_{50}$</td>
<td>0.22 mm</td>
<td>0.36 mm</td>
</tr>
<tr>
<td>Mean Grain Size</td>
<td>0.25 mm</td>
<td>0.40 mm</td>
</tr>
<tr>
<td>Fine Gravel (shell)</td>
<td>2.4 %</td>
<td>1.4 %</td>
</tr>
<tr>
<td>Coarse Sand</td>
<td>3.3 %</td>
<td>4.2 %</td>
</tr>
<tr>
<td>Medium Sand</td>
<td>21.7 %</td>
<td>35.6 %</td>
</tr>
<tr>
<td>Fine Sand</td>
<td>70.5 %</td>
<td>58.6 %</td>
</tr>
<tr>
<td>Silt + Clay</td>
<td>2.06 %</td>
<td>0.17 %</td>
</tr>
</tbody>
</table>

Table 3 - 1  Sector 7 Existing Beach Characteristics

All calculations were made using the Folk Graphic Method.

Appendix C of this report contains a summary of the percent silt/clay for each sample and for the composite samples for each FDEP Monument where samples were taken.
3.3.1.2 Chemical Composition

Each individual sample of the existing beach sand was tested for carbonate content through the carbonate burn method performed by SEA. Among the individual profile transect sand sample series collected in Sector 7, the existing beach samples were found to contain between 12.8 percent and 73.2 percent carbonate material. The remaining portions of the samples are quartz sand. However, this material may not reflect the true native beach in composition and color due to placement of other material onto the beach from the Emergency Dune Restoration Project of March 2001. Comparing the three profiles indicates that the native material may have lower carbonate content than the upland material. The average carbonate content of the samples collected at profile T-100 is 23.7 percent, compared to 32.8 percent average content of the samples at R-103 and 32.9 percent at R-106.

3.3.1.3 Color

The color readings of the existing beach material in Sector 7 were also performed by SEA. The composite samples were laid out on photographic board and visually inspected, and color codes were recorded with changes in lithology following Munsell® Soil Color Charts (1998, Macbeth) codes.

The Sector 7 existing beach is composed of fine to medium grained, white to light gray, shelly sand with shell fragments (Table 3-2).

<table>
<thead>
<tr>
<th>Sample # (FDEP Monument)</th>
<th>Color</th>
<th>Munsell® Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-100 COMP</td>
<td>White</td>
<td>10 YR 8/1</td>
</tr>
<tr>
<td>R-103 COMP</td>
<td>White-Light Gray</td>
<td>10 YR 8/1-7.5/1</td>
</tr>
<tr>
<td>R-106 COMP</td>
<td>White-Light gray</td>
<td>10 YR 8/1-7.5/1</td>
</tr>
</tbody>
</table>

3.3.2 Offshore Borrow Area

The South Borrow Area is the primary borrow area for sand to be used for the proposed beach nourishment Project in Sector 7. It is located in the Indian River Shoal complex which extends offshore of Riomar south to the waters offshore of St. Lucie County (Figure 3-3). The borrow area is approximately 10,000 feet offshore positioned between R-105 and R-119 just north of the Indian River County/St. Lucie County border.

A detailed geophysical and geotechnical investigation of the South Borrow Area was conducted and reported in the “Indian River County Beach Restoration Projects Report-
Geotechnical Investigation of Offshore Sand Sources” (ATM, 2001). The investigation included hydrographic surveys, subsurface jet probes, core borings, sediment testing and analysis, and a quantitative analysis of the borrow area sediments. The report presents details of the investigations and the results of the analyses.

Thirty jet probes were collected in and around the South Borrow Area to determine the depths and general characteristics of the sediment. Twenty-six vibracore borings were then collected from the area and retained for analysis in order to determine, in further detail, the characteristics of the materials contained in the South Borrow Area. These samples were subjected to color and grain size analysis, and percent silt/clay content and carbonate content determination. The sediment sample classifications were prepared in accordance with the Unified Soils Classification System as described in ASTM Standard D-2487.

The South Borrow Area was divided into three sub-areas according to disparate sediment characteristics. These sub-areas are shore parallel segments running north to south and are approximately rectangular in shape (Figure 3-3). Sub-Area 1 is the primary borrow site being considered for use in the proposed beach nourishment Project in Sector 7. Sub-Area 2 has been permitted and used in the Sectors 1 and 2 (Ambersand Beach) beach restoration project. Sub-Area 3 is being considered for use in potential future Indian River County beach restoration projects.

The geophysical investigation of the South Borrow Area identified seven magnetic anomalies in and around Sub-Area 1 (three within the proposed borrow area boundaries; four within 150 feet of the boundaries). These anomalies were considered insignificant based on their apparent mass as measured by the magnetometer and based on diver verification. Details of this investigation and assessment are presented in the report “Submerged Cultural Resources Remote Sensing Survey Pursuant to Beach Restoration of Three Sand Borrow Areas of Indian River County, Florida” (Baer, 2000). The Florida State Historic Preservation Office was consulted regarding these findings and concurred that no significant cultural resources are present in this area.

3.3.2.1 Sand Quality

Analysis of the quality of sand contained within the Sub-Area 1 borrow area is based on the composite characteristics determined in accordance with ASTM Standard D-422 for mechanical particle size analysis to determine the grain size distribution. The sediment analyses indicated that the majority of the sediments deposited on the Indian River Shoal feature are comprised of high quality, fine to medium-grained, shelly sand with shell fragments.

The sediment composite of South Borrow Area Sub-Area 1 contains a 0.97 percent silt/clay fraction and an approximately 95 percent sand fraction, in addition to a 4.4 percent
NOTES:
1. ALL ELEVATIONS REFERENCED TO NATIONAL
   GEODETIC VERTICAL DATUM OF 1929.
2. CONTOURS GENERATED FROM BATHYMETRIC
   DATA COLLECTED ON JANUARY 13, 2000 BY MORGAN & EKLAND, INC.
3. ALL HORIZONTAL VALUES ARE REFERENCED TO NORTH AMERICAN
   DATUM OF 1927, FLORIDA STATE PLANE, EAST ZONE.
gravel-sized fraction. The material displays a median grain size of 0.45 mm. Table 3.3 presents the Unified Soils Classification characteristics of Sub-Area 1.

Table 3 - 3 South Borrow Area Sub Area 1 Characteristics

<table>
<thead>
<tr>
<th>Unified Soils Classification (USC)</th>
<th>South Borrow Area Sub-Area 1 Composite Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Grain Size, d$_{50}$</td>
<td>0.45 mm</td>
</tr>
<tr>
<td>Mean Grain Size</td>
<td>0.52 mm</td>
</tr>
<tr>
<td><strong>Coarse gravel</strong></td>
<td></td>
</tr>
<tr>
<td>¾ inch sieve 75.0 mm to 19.0 mm</td>
<td>&lt; 0.06 %</td>
</tr>
<tr>
<td>Coarse Sand 4.76 mm to 2.0 mm</td>
<td>5.6 %</td>
</tr>
<tr>
<td>Medium Sand 2.0 mm to 0.42 mm</td>
<td>41.8 %</td>
</tr>
<tr>
<td>Fine Sand 0.42 mm to 0.074 mm</td>
<td>47.2 %</td>
</tr>
<tr>
<td>Silt + Clay #230 sieve Less than 0.074 mm</td>
<td>0.97 %</td>
</tr>
</tbody>
</table>

All calculations were made using the Folk Graphic Method

3.3.2.2 Sand Quantity

The results of the geotechnical evaluation of the South Borrow Area indicate that sufficient quantities of beach quality sand are available in the Indian River Shoal for the 30-year beach restoration project specified in the “Addendum to the Evaluation of Alternative Designs for Sector 7 Report” (ATM, 2003b). The South Borrow Area contains approximately 4.07 million cubic yards of beach-compatible material available for beachfill, and is comprised of Sub-Area 1 which contains approximately 1,442,000 cubic yards, Sub-Area 2 which contains approximately 1,898,400 cubic yards, and Sub-Area 3 which contains approximately 871,800 cubic yards.

3.3.2.3 Chemical Composition

Chemical composition tests were conducted on five composite samples obtained from the vibrocores collected in the South Borrow Area Sub-Area 1. Each composite sample was subjected to a carbonate burn procedure in order to determine the percentages of carbonate material in the sample. Among the individual vibrocore samples collected in Sub-Area 1, the samples were found to contain between 71.0 percent and 79.3 percent carbonate material. The remaining portions of the samples are quartz sand.
3.3.2.4  **Color**

The same five composite vibracore samples were laid out on photographic board and visually inspected for an initial exposure color analysis (Table 3-4). Color codes were recorded with changes in lithology following Munsell® Soil Color Charts (Gretag Macbeth, Inc., 1998) codes. The colors determined in the initial exposure test are similar to those found on the existing beach.

**Table 3 - 4  South Borrow Area Sub Area 1 Munsell Color Analysis**

<table>
<thead>
<tr>
<th>Sample # (Vibracore)</th>
<th>Color</th>
<th>Munsell® Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRS-1-COMP</td>
<td>Light Gray</td>
<td>10 YR 7/1</td>
</tr>
<tr>
<td>IRS-2-COMP</td>
<td>Light Gray</td>
<td>10 YR 7/1</td>
</tr>
<tr>
<td>IRS-5-COMP</td>
<td>Light Gray</td>
<td>10 YR 7/0.5</td>
</tr>
<tr>
<td>IRS-7-COMP</td>
<td>Light Gray</td>
<td>10 YR 7/1</td>
</tr>
<tr>
<td>IRS-9-COMP</td>
<td>Light Gray</td>
<td>10 YR 7.5/1</td>
</tr>
</tbody>
</table>

3.3.3  **Upland Sand Sources**

Upland Source 1 is located in Brevard County approximately 60 miles north of the Project area. Upland Source 2 is located approximately 21 miles from the Project area in St. Lucie County. Source 3 is located approximately 20 miles from the Project site.

Geotechnical data for Upland Sources 2 and 3 was provided by the facilities. A composite sand sample was obtained from Upland Source 1 and was further subjected to color and grain size analysis, and percent silt/clay content and carbonate content determination by SEA under the direction of Indian River County. All facilities report that they contain a sufficient quantity of beach quality material to construct the Preferred Alternative design.

3.3.3.1  **Sand Quality**

Analysis of the quality of sand contained within the three upland sources is presented in Table 3-5. Only Upland Source 1 was analyzed by SEA, the data for Upland Source 2 and Upland Source 3 were obtained directly from the facilities themselves. Upland Source 1 characteristics were determined in accordance with ASTM Standard D-422 for mechanical particle size analysis to determine the grain size distribution.
### Table 3 - 5 Upland Sand Source Characteristics

<table>
<thead>
<tr>
<th>Unified Soils Classification (USC)</th>
<th>Upland Source #1</th>
<th>Upland Source #2</th>
<th>Upland Source #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Grain Size, $d_{50}$</td>
<td>0.38 mm</td>
<td>0.30 mm</td>
<td>0.35 mm</td>
</tr>
<tr>
<td>Mean Grain Size</td>
<td>0.52 mm</td>
<td>0.32 mm</td>
<td>0.24 mm</td>
</tr>
<tr>
<td>Coarse Gravel (shell) ¾ inch</td>
<td>0 %</td>
<td>0 %</td>
<td>0 %</td>
</tr>
<tr>
<td>75.0 mm to 19.0 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Gravel (shell) #4 sieve</td>
<td>5 %</td>
<td>0 %</td>
<td>0.5 %</td>
</tr>
<tr>
<td>19.0 mm to 4.76 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse Sand 4.76 mm to 2.0 mm</td>
<td>11 %</td>
<td>0 %</td>
<td>1 %</td>
</tr>
<tr>
<td>Medium Sand 2.0 mm to 0.42 mm</td>
<td>31 %</td>
<td>28 %</td>
<td>10.5 %</td>
</tr>
<tr>
<td>Fine Sand 0.42 mm to 0.074 mm</td>
<td>51 %</td>
<td>72 %</td>
<td>84 %</td>
</tr>
<tr>
<td>Silt + Clay #230 sieve</td>
<td>2 %</td>
<td>0 %</td>
<td>3.7 %</td>
</tr>
<tr>
<td>Less than 0.074 mm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All calculations were made using the Folk Graphic Method.*

### 3.3.3.2 Sand Quantity

All facilities report that they contain a sufficient quantity of beach quality material to construct the 363,600 CY design.

### 3.3.3.3 Chemical Composition

The calcium carbonate material content was determined for Upland Source 1 through the carbonate burn method by SEA, Inc. Data from Upland Sources 2 and 3 were obtained directly from the facilities (Table 3-6).

### Table 3 - 6 Upland Sand Source Chemical Composition

<table>
<thead>
<tr>
<th>Calcium Carbonate Content</th>
<th>Upland Source 1</th>
<th>Upland Source 2</th>
<th>Upland Source 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>38.67%</td>
<td>0%</td>
<td>0.11% *</td>
</tr>
</tbody>
</table>

*Calcium and Magnesium carbonate*
3.3.3.4 Color

The Upland Source 1 sample was laid out on photographic board and visually inspected for an initial exposure color analysis (Table 3-7). Color codes were recorded with changes in lithology following Munsell® Soil Color Charts (Gretag Macbeth, Inc., 1998) codes. The colors determined in the initial exposure test are similar to those found on the existing beach. Again, data from Upland Sources 2 and 3 were obtained directly from the facilities.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Color</th>
<th>Munsell® Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland Source 1</td>
<td>Light gray - very pale brown</td>
<td>10 YR 7.5/2-8/2</td>
</tr>
<tr>
<td>Upland Source 2</td>
<td>Light brownish gray</td>
<td>10 YR 6/2</td>
</tr>
<tr>
<td>Upland Source 3</td>
<td>Light gray</td>
<td>2.5 YR 7/1</td>
</tr>
</tbody>
</table>

3.3.4 Compatibility with Native Beach

The Florida Department of Environmental Protection Chapter 62B-41, Florida Administrative Code was applied in evaluating the compatibility of material found within the proposed borrow area with regard to beach fill placement. Specifically, 62B-41.007 (2)(j)), states “To protect the environmental functions of Florida’s beaches, only beach compatible fill shall be placed on the beach or in any associated dune system. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system.” Further, the rule clarifies that the placed material shall: not contain greater than five percent, by weight, silt, clay or colloids passing the #230 sieve (4.0 phi, 0.06 mm), and, not contain greater than five percent, by weight, fine gravel retained on the #4 sieve (-2.25 phi, 4.750 mm). In addition, the borrow material must not contain coarse gravel, cobbles or material retained on the three-fourth inch (-4.25 phi, 19.0 mm) sieve in a percentage or size greater than that found on the native beach. The borrow material must not result in cementation of the beach and shall not contain construction debris, toxic materials or other foreign matter.

Table 3-8 provides a comparison of these classifications for the existing beach sand and the proposed borrow area material.
Table 3 - 8  Sector 7 Compatibility of Borrow Material

<table>
<thead>
<tr>
<th>Unified Soils Classification (USC)</th>
<th>Existing Beach Characteristics – entire profile</th>
<th>Existing Dry Beach Characteristics</th>
<th>South Borrow Area Sub-Area 1</th>
<th>Upland Sand Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Grain Size, $d_{50}$</td>
<td>0.22 mm</td>
<td>0.36 mm</td>
<td>0.45 mm</td>
<td>0.38 mm</td>
</tr>
<tr>
<td>Mean Grain Size</td>
<td>0.25 mm</td>
<td>0.40 mm</td>
<td>0.52 mm</td>
<td>0.52 mm</td>
</tr>
<tr>
<td>Coarse gravel ¾ inch sieve 75.0 mm to 19.0 mm</td>
<td>0 %</td>
<td>&lt; 0.31 %</td>
<td>&lt; 0.06 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Fine gravel (shell) #4 sieve 19.0 mm to 4.76 mm</td>
<td>2.4 %</td>
<td>1.4 %</td>
<td>4.4 %</td>
<td>5 %</td>
</tr>
<tr>
<td>Coarse sand 4.76 mm to 2.0 mm</td>
<td>3.3 %</td>
<td>4.2 %</td>
<td>5.6 %</td>
<td>11 %</td>
</tr>
<tr>
<td>Medium sand 2.0 mm to 0.42 mm</td>
<td>21.7 %</td>
<td>35.6 %</td>
<td>41.8 %</td>
<td>31 %</td>
</tr>
<tr>
<td>Fine sand 0.42 mm to 0.074 mm</td>
<td>70.5 %</td>
<td>58.6 %</td>
<td>47.2 %</td>
<td>51 %</td>
</tr>
<tr>
<td>Silt/clay #230 sieve Less than 0.074mm</td>
<td>2.06 %</td>
<td>0.17 %</td>
<td>0.97 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Color White to light gray</td>
<td>White to light gray</td>
<td>Light gray</td>
<td>Light gray - very pale brown</td>
<td>Light, brownish gray</td>
</tr>
<tr>
<td>Carbonate 12.8 % to 73.2 %</td>
<td>18.6 % to 73.2 %</td>
<td>71.0 % to 79.3 %</td>
<td>38.67 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Sorting (phi, $\phi$) 1.43</td>
<td>1.21</td>
<td>1.22</td>
<td>1.74</td>
<td>0.74</td>
</tr>
<tr>
<td>Sorting Categorization Poorly sorted</td>
<td>Poorly sorted</td>
<td>Poorly sorted</td>
<td>Poorly sorted</td>
<td>Poorly sorted</td>
</tr>
</tbody>
</table>

All calculations were made using the Folk Graphic Method

The material in the South Borrow Area Sub-Area 1 meets all of the Florida Administrative Code criteria for compatibility with the existing beach. The Sub-Area 1 composite material contains a 4.4 percent fine gravel fraction and a 0.97 percent silt/clay fraction, and the coarse gravel content is less than 0.06 percent.

The comparison in Table 3.8 indicates that the South Borrow Area Sub-Area 1 is an adequate and compatible sand source for beach nourishment in Sector 7.
3.4 Water Quality

3.4.1 Ambient Water Quality

The most relevant data on ambient water quality have been collected in the vicinity of Sebastian Inlet, approximately 20 miles north of the Sector 7 Project area. A water quality study entitled: “Biological Monitoring Programs: Water Quality Sebastian Inlet, Florida” was conducted in 1996-1997 of the areas of Indian River County around Sebastian Inlet. The study was undertaken by the Florida Institute of Technology to evaluate spatial and temporal trends, assess the long-term water quality trends, and establish a baseline data set of water quality conditions at Sebastian Inlet under a variety of natural conditions. Turbidity, total particulate matter, and particulate organic matter water quality data were collected between October 1, 1996 and September 31, 1997 at biweekly intervals.

The study found that all of the water quality parameter levels were higher in the surf zone than offshore due to the relatively high levels of energy dissipation. The study also found that, in general, turbidity appears to be controlled by water column turbulence (wave energy, tidal flow). The measured quantities varied throughout the summer and winter samples. Together with the long-term data accumulated since 1990, the study suggests that water quality conditions at Sebastian Inlet exhibit strong temporal and spatial variation.

The study resulted in defined expected levels of each water quality parameter under a variety of natural conditions. These data provide the most significant available baseline data set despite the fact that the factors most responsible for their magnitude or variance have not yet been isolated. Table 3-9 shows the resulting yearly baseline levels of turbidity (NTUs) (Nephelometric Turbidity Units), total particulate matter (TPM) measured in mg/l, and particulate organic matter (POM) also measured in mg/l.

Table 3 - 9 Ambient Water Quality Data from 1990-1997

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surf Zone</td>
<td>NTU</td>
<td>18.3</td>
<td>11.2</td>
<td>12.1</td>
<td>15.8</td>
<td>15.0</td>
<td>14.0</td>
<td>20.4</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>TPM mg/l</td>
<td>1940.0</td>
<td>4290.0</td>
<td>1900.0</td>
<td>1370.0</td>
<td>2850.0</td>
<td>2110.0</td>
<td>1772.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>POM mg/l</td>
<td>70.0</td>
<td>80.0</td>
<td>110.0</td>
<td>80.0</td>
<td>80.0</td>
<td>40.0</td>
<td>111.7</td>
<td></td>
</tr>
<tr>
<td>Offshore</td>
<td>NTU</td>
<td>10.2</td>
<td>7.5</td>
<td>7.5</td>
<td>12.1</td>
<td>8.6</td>
<td>10.2</td>
<td>16.5</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>TPM mg/l</td>
<td>100.0</td>
<td>280.0</td>
<td>200.0</td>
<td>90.0</td>
<td>220.0</td>
<td>200.0</td>
<td>305.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>POM mg/l</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>0.0</td>
<td>10.0</td>
<td>14.8</td>
<td></td>
</tr>
</tbody>
</table>

Source: Florida Institute of Technology 1997

These data indicate that the average background turbidity level in the surf zone is 15.0 NTUs and 10.3 NTUs offshore.
3.5 Beach and Dune Vegetation and Wildlife

The high-energy beach is a challenging environment for animal and plant life. Species diversity is typically low, although species adapted to sandy beaches may be highly abundant. Typical beach fauna in the proposed Project area includes the mole crab (*Emerita talpoida*), surf clam (*Donax variabilis*) and ghost crab (*Ocypode quadrata*). These and other beach infauna provide forage for a wide variety of shorebirds such as plovers (*Charadrius spp.*), willets (*Catoptrophorus semipalmatus*), and ruddy turnstones (*Arenaria interpres*). Drift algae and sargassum stranded on the beach may support large numbers of insects and other invertebrate life. As elevation increases, conditions become less severe for the establishment of plant life. Tendrils of various plants extend down the beach, notably the beach morning glory *Ipomoea pes-capre*. As the dune crest is approached, other salt tolerant plants are found such as sea oats (*Uniola paniculata*), sea rocket (*Cakile sp.*) and beach elder (*Iva imbricata*). This community type extends along the entire coastline of Indian River County with only occasional interruptions from seawalls or other shore armoring structures in place to prevent erosion.

Sparsely vegetated beaches are preferred nesting habitat for the least tern (*Sterna antillarum*), listed as a threatened species by the Florida Fish and Wildlife Conservation Commission. The sea oat zone high on the dune provides habitat for another threatened species, the southeastern beach mouse (*Peromyscus polionotus niveiventris*). Beaches in Indian River County also provide nesting habitat for at least three species of sea turtles, as discussed in the following section.

3.6 Threatened and Endangered Species

This section describes the biology of protected species potentially affected by the proposed Project, both generally and specifically to the Project areas.

3.6.1 Sea Turtles

Five species of sea turtle are found in the waters offshore of Indian River County, and of these, three have been documented as nesting on County beaches. The loggerhead (*Caretta caretta*) is responsible for the vast majority of the nesting, although data suggest increasing numbers of green (*Chelonia mydas*) and leatherback turtles (*Dermochelys coriacea*) nesting statewide. The green sea turtle and leatherback sea turtle are both listed under the U.S. Endangered Species Act, 1973 and Chapter 370, F.S. The loggerhead turtle is listed as a threatened species.
3.6.1.1 Nesting Habitat

There currently is no countywide sea turtle nesting survey in Indian River County, however the Florida Fish and Wildlife Conservation Commission (FFWCC) Statewide Nesting Beach Survey (SNBS) program has collected data along segments of County beaches since 1980. Indian River County is within the normal nesting range of three species of sea turtles: the loggerhead, the green sea turtle, and the leatherback. The Kemp’s ridley (*Lepidochelys kempi*) and hawksbill (*Eretmochelys imbricata*) are infrequent nesters along the east coast of Florida and have not been recorded as nesting on County beaches.

3.6.1.1.1 Loggerhead Sea Turtle

Loggerheads nest in the southeastern U.S. from April through September, with peak nesting occurring in June and July (National Marine Fisheries Service [NMFS] and United States Fish and Wildlife Service [USFWS], 1991a). The nesting process is remarkably stereotyped, as is described in Bustard et al. (1975). From 1990-1999 the average number of loggerhead nests was 154 nests/km for the beaches surveyed (FFWCC SNBS, 2000). The estimated mean number of loggerhead nests for the entire County would therefore be approximately 5,500 nests per year (35.6 km of shoreline * 154 nest/km).

3.6.1.1.2 Green Sea Turtle

Green sea turtles nest during the summer months and numbers of nests for Indian River County were determined from FFWCC SNBS (National Marine Fisheries Service and United States Fish and Wildlife Service, 1991b). The mean nesting density for areas surveyed from 1990-1999 was 4.2 nests/km. Countywide, this would be approximately 150 nests per year.

3.6.1.1.3 Leatherback Sea Turtle

FFWCC statewide nesting data show that for the same ten-year period leatherback turtle nesting density was 0.23 nests/km on the County beaches surveyed. This yields an estimate of approximately eight nests annually when applied to the entire length of the County’s beaches.

3.6.1.2 Offshore Habitat

Sea turtles use the habitats offshore of Indian River County to different degrees during different stages of their life cycle. During the summer months hatchlings utilize this habitat as a corridor to deeper waters farther off the coast. Juvenile and sub-adult turtles use the offshore habitats as a foraging area and to travel to inshore areas such as Indian River Lagoon, while adult turtles are present year round with seasonally high abundances during the
breeding season. In 2001 and 2003, a series of surveys from small vessels were conducted to determine the abundances of sea turtles in nearshore marine habitats at various locations in Indian River County (Inwater Research Group 2003). These surveys were conducted along fixed transects ranging from 300 to 1200 feet offshore, and characterized abundance as the number of individuals sighted per kilometer of transect.

3.6.1.2.1 Loggerhead Sea Turtle

Hatchlings emerge primarily at night and swim offshore in a “frenzy” until they arrive at offshore weed and debris lines (Carr, 1986) (Wyneken and Salmon, 1992). Post hatchling turtles from the Florida coast enter currents of the North Atlantic Gyre, eventually returning to the western Atlantic coastal waters (Bowen et al., 1993). When loggerheads reach a carapace length of approximately 40-60 cm, they leave the pelagic environment and move into various nearshore habitats (Carr, 1986). These juvenile and sub-adult loggerhead turtles are found throughout the year in the Indian River County Lagoon and the offshore reef habitats of Indian River County. Very few loggerhead turtles have been captured on nearshore wormrock reefs by the University of Central Florida marine turtle research program (Ehrhart et al., 1996). However, large numbers of loggerhead turtles have been captured at the Florida Power and Light Company’s (FP&L) St. Lucie Nuclear Power Plant (Quantum Resources, Inc., 1999), which suggests that juvenile loggerheads use the habitat within this general area. Adult loggerhead turtles in South Florida utilize foraging grounds in the Caribbean basin, the Gulf of Mexico, and along the U.S. east coast (Meylan et al., 1983). Abundances of adult loggerhead turtles in Florida waters increase during the nesting season (Magnuson et al., 1990). Within Indian River County nearshore waters, survey data showed loggerhead turtle abundance to average 0.2 individuals/km countywide, and was quite uniform in the three study areas (north, central and south county). Loggerhead abundance in the south county study site, which includes the area offshore of the Sector 7 Project area, was 0.2 individuals per kilometer.
3.6.1.2.2 Green Sea Turtle

Green turtles show a similar life history pattern as loggerheads, but they leave the pelagic phase and enter developmental habitats at a considerably smaller size, about 20-25 cm carapace length (Magnuson et al., 1990). Typical developmental habitats are shallow, protected waters where seagrasses are prevalent (Carr et al., 1978), but green turtles are commonly found in reef habitats where algae is present (Ehrhart et al., 1996) (Coyne, 1994). Green turtles nesting in Florida have a minimum size of 83.2 cm carapace length, but they appear to leave Florida developmental habitats by about 60-65 cm carapace length (Witherington and Ehrhart, 1989), perhaps migrating to the southeastern Caribbean. Indian River County contains two significant developmental habitats for green turtles, the Indian River Lagoon and the nearshore reef system (Ehrhart et al., 1996). There is not data on the seasonality of habitat use of juvenile green turtles within Indian River County. Dietary needs of juvenile turtles along with seasonal abundances of seagrasses and algae within the area may be factors influencing the habitat use of juvenile turtles within the area. Data from the FP&L St. Lucie Power Plant show juvenile green turtles captures offshore to be more or less consistent all year (Quantum Resources, Inc., 1999). As adults, offshore habitat utilization would be greatest during the nesting period.

Green sea turtles leave the early pelagic life stage and enter benthic foraging areas at about 20-25 cm carapace length. During this time they shift from an omnivorous diet to a more herbivorous diet. Juvenile green turtles feed primarily on seagrasses and algae during this life stage. Potential foraging habitat occurs along Sectors 1 & 2. In Florida, these turtles feed primarily on a diet of seagrasses such as *H. wrightii*, *S. filiforme*, and red and green algae (Lutz and Musick, 1997). Data from the FP&L St. Lucie Power Plant shows that juvenile turtles are present within the area offshore of the facility all year. There is some data to suggest there may be a seasonal reduction in the amount of foraging habitat present in the Indian River County offshore area. The seasonal abundances of algal species offshore may limit the offshore foraging areas in the winter months. Nelson (1988) noted a great seasonal reduction in algal species richness (56 summer vs. 16 winter) on the nearshore reefs at Sebastian Inlet.

Within Indian River County nearshore waters, survey data showed green turtle abundance to be considerably greater than loggerhead abundance, averaging 1.0 individuals/km countywide. There were marked differences in green turtle abundance between the three study areas (north, central and south county). Green turtle abundance was lowest at the south county study site, which includes the area offshore of the Sector 7 Project area, at 0.27 individuals per kilometer, as compared to 2.4 individuals per kilometer at the north study site, near Sebastian Inlet.

3.6.1.2.3 Leatherback Sea Turtle

Leatherback turtles occur worldwide in pelagic waters from the tropics to near the Arctic and Antarctic Circles. Nesting is primarily on the Pacific coast of Mexico and the Caribbean...
coast of South America, with some continental U.S. nesting in Florida. The majority of leatherback nesting activity is located within St. Lucie, Martin, and Palm Beach counties (Meylan et al., 1995). Leatherback turtles are virtually unknown from the inshore waters of Indian River County and only are known to frequent the area during nesting periods.

No leatherback turtles were observed in any of the surveys conducted in Indian River County nearshore waters.

3.6.2 West Indian Manatee

The West Indian Manatee (Trichechus manatus) is protected under both the Endangered Species Act and the Marine Mammal Protection Act and is also listed as protected under Florida State law. The manatee is generally restricted in range to the Georgia coast southward around the Florida peninsula. Manatees frequently inhabit shallow areas where seagrasses are present and are commonly found in protected lagoons and freshwater systems. Manatees occasionally use open ocean passages to travel between favored habitats (Hartman, 1979). Manatees migrate seasonally, particularly on the east coast of Florida. During the summer months manatees utilize habitats all along the coast. During winter, when water temperatures drop, manatees use warm water refuges such as springs or warm water discharges at power plants.

Within Indian River County, manatees infrequently use the nearshore waters. Manatees are found within the lagoon areas, especially during the summer months. Aerial surveys conducted in winter show that aggregations at the Vero Beach Municipal power plant were minor (Garrott et al., 1995). Overall, very few manatees would be present in the nearshore waters during the period of November through April.

3.6.3 Southeastern Beach Mouse

The southeastern beach mouse (Peromyscus polionotus neveiventris) is listed as a threatened species at both the federal and state levels. Beach mice primarily use coastal dune communities comprised of sea oats (Uniola paniculata), for habitat. Grasslands and open sandy areas in the fore-dune area may also be utilized (Humphrey, 1992). This subspecies was originally endemic to coastal dunes along the Florida coast from Ponce Inlet in Volusia County to Hollywood Beach, Broward County. Decline in beach mouse populations has been attributed to loss of habitat due to coastal development and beach erosion and to predation from feral and free-roaming cats.

Southeastern beach mice have been historically documented within Indian River County (Humphrey, 1992), have been observed within Sebastian Inlet State Recreation Area, and may use other beach areas within the County. It appears however, that the southeastern beach mouse may recently have been extirpated from its local range due to erosional habitat loss.
3.6.4 Northern Right Whale

The Northern right whale (*Eubalaena glacialis*) is a federally listed endangered species and is protected under the Marine Mammal Protection Act. The current migratory population within the Atlantic Region is less than 350 animals (Humphrey, 1992). Right whales are highly migratory and summer in the Canadian Maritime Provinces. They migrate southward in winter to the eastern coast of Florida. The breeding and calving grounds for the right whale occur off of the coast of southern Georgia and north Florida. During these winter months right whales are routinely seen close to shore and have been sighted as far south as south Florida, with isolated sightings into the Gulf of Mexico. Within Indian River County the peak occurrence of right whales would occur from December through March.

3.6.5 Piping Plover

The piping plover is a state and federally listed threatened species. Piping plovers are a migratory shore bird and are protected under the Migratory Bird Treaty Act. Piping plovers migrate to the Florida coast in September and are found through March (USFWS, 1995). Piping plovers nest on open sand, gravel, or shell-covered beaches above the high tide line and are often found on the accreting ends of barrier islands and along coastal inlets (USFWS, 1995). Foraging areas include intertidal beaches, mudflats, sandflats, lagoons, and salt marshes, where they feed on invertebrates such as marine worms, insect larvae, crustaceans, and mollusks. Within Indian River County piping plovers have been observed within Sebastian Inlet State Recreation Area and may use other beach areas within the County.

3.6.6 Least Tern

The least tern (*Stern antillarum*) is a small member of the gull family (*Laridae*). The least tern is listed by Florida as a threatened species and is protected federally under the Migratory Bird Treaty Act. Least terns breed along the east coast of the United States from Massachusetts to Florida, with the Florida populations returning each year in April. The breeding season lasts through the summer. Least terns traditionally choose open sandy substrates to form breeding colonies. Least terns forage along coastal areas feeding on small fishes, as well as some crustaceans and insects. Within Indian River County least terns are known to nest on sandbars and spoil areas in Sebastian Inlet State Recreation Area.

3.7 Offshore Borrow Area Resources

The area selected as the offshore sand source borrow site for the proposed Project (Figure 3-3) is within the Indian River Shoal feature located in about 25 to 30 feet of water less than three miles offshore. These sandbars were formed in the recent geologic past by the migration of relic inlets through the barrier island (Moody, 1964). As a tidal inlet migrates, its ebb shoal becomes elongated and eventually detaches from the shoreline due to rising sea level and the landward retreat of the shoreline. There are a number of these shoal formations along
the local coast, including St. Lucie, Pierce, and Capron Shoals in St. Lucie County, and the Indian River Shoal located offshore of southern Indian River County and northern St. Lucie County.

These offshore sand habitats support a diverse fauna, although there has been comparatively little research attention in this environment. There are several studies of invertebrates and fishes from the open sand habitat in the general proposed Project area. Johnson (1982) collected over 188 species of invertebrates in benthic grab samples from the Capron Shoal area off Fort Pierce Inlet. In a study offshore of Hutchinson Island in St. Lucie County, Futch and Dwinell (1977) collected lancelets (sand dwelling chordates in the subphylum Acrania) in densities as high as 1,750 per square meter. Gilmore et al. (1981) collected 194 species of fishes from open shelf sand habitats in the Indian River County area. Flatfishes, searobins, and cusk eels, along with an assortment of batfishes and skates, dominated the fish fauna.

3.8 Hardbottom Resources

The underlying material of the nearshore hardbottom system off Indian River County is coquina rock limestone of lithified sands and shell typical of the Anastasia formation found along much of the east central coast of Florida. Like the Atlantic Coastal Ridge and the offshore reef tracts, this formation was created during periods of sea level change and parallels the present day coastline. Some of the present nearshore system was uncovered by the recession of the shoreline in historic time. Beach profile measurements from 1972 show that some present day well developed hardbottom areas closest to shore were buried under the beach/dune system in 1972, and in some cases more recently. Apart from its biological value, the hardbottom structure helps protect the coastline from erosion and traps sediments, providing for the actual progradation of beaches in some instances (Kirtley and Tanner 1968).

Perkins et al. (1997) produced maps of the nearshore hardbottom habitat offshore of Indian River County as part of the SEAMAP program. They characterized the hardbottom habitat as being essentially continuous and up to one-half mile wide. Calculations based on digital analysis of SEAMAP aerial photography taken in the summer of 1993 yield an estimate of approximately 3,740 acres of total nearshore hardbottom habitat in Indian River County.

The hardbottom in Indian River County typically begins between the MLW location and the –6-foot NGVD contour, a few hundred feet offshore, and extends offshore approximately 2,000 feet. The hardbottom occupies approximately 90 percent of the nearshore zone of Indian River County (Figure 3-3), exceeding 1,700 acres of habitat within the first 1,500 feet off the beach (Dial Cordy and Associates Inc., 2001).

Between June and August 1999 extensive mapping and characterization of the nearshore hardbottom features within the Project area was conducted (ATM, 2001b). Diver-towed transects were conducted perpendicular and parallel to the shoreline within the designated Project area, as well as 1,000 feet north and 3,000 feet south of the proposed fill placement limits. The hardbottom locations and types along the Project area are provided in Appendix E. of the ATM report (ATM, 2001b). Five “bottom” types were identified and are defined in Tables 3-10 and 3-11 and illustrated in Figure 3-4 compiled by DC&A (2001).
### Table 3 - 10 Hardbottom Types and Related Characteristics

<table>
<thead>
<tr>
<th>Bottom Type</th>
<th>Location</th>
<th>Substrate Type</th>
<th>Biota</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sand</td>
<td>Mostly nearshore and onshore, but also patchy or in bands throughout</td>
<td>Medium-coarse sand; uncommon patches of exposed rock</td>
<td>Burrowing, transient fauna uncommon or patchily distributed; benthic algae common on exposed rock</td>
</tr>
<tr>
<td>2. Algal Community with Low Relief Rock</td>
<td>In bands parallel to the shoreline, mostly exposed or in shallow water</td>
<td>Beachrock, weathered rock</td>
<td>Benthic algae dominant; infauna, transient- and resident fishes common</td>
</tr>
<tr>
<td>3. Inshore Worm Rock</td>
<td>Nearshore bands, mostly parallel to the shoreline</td>
<td>Live (&gt;70%) reef-building worm rock; surface uneven, and with numerous holes and ledges</td>
<td>Live worm rock dominant; algae and other benthic invertebrates uncommon; transient fishes common</td>
</tr>
<tr>
<td>4. High Relief Algal/Sponge Community</td>
<td>Two or more bands, perpendicular to the shoreline, in shallow and deep water</td>
<td>Weathered rock, formerly live worm rock; surface often smooth, with ledges along the sides</td>
<td>Benthic algae dominant; infauna, epifauna (sponges, etc.), transient- and resident fishes common</td>
</tr>
<tr>
<td>5. High Relief Algal/Sponge Community with Worm Rock</td>
<td>Two or more bands, perpendicular to the shoreline, in shallow and deeper water</td>
<td>Weathered rock, patches of formerly live and live worm rock; productive ledges along the sides</td>
<td>Benthic algae dominant in most areas, but with significant amounts of live worm rock; transient and resident fishes common</td>
</tr>
</tbody>
</table>

### Table 3 - 11 Type and Location of Hardbottom Found Offshore of Sector 7

<table>
<thead>
<tr>
<th>Hardbottom Type</th>
<th>Typical FDEP Monument Reference Numbers</th>
<th>General Location on Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algal Community with Low Relief Rock (2)</td>
<td>R-97-R108</td>
<td>250-500 ft from mean high water</td>
</tr>
<tr>
<td>Inshore Worm Rock (3)</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>High Relief Algal/Sponge Community (4)</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>High Relief Algal/Sponge Community with Worm Rock (5)</td>
<td>None</td>
<td>N/A</td>
</tr>
</tbody>
</table>
A comprehensive mapping of the entire Indian River County shoreline was completed in June and July 2001. This included use of multi-spectral image analysis (ERDAS) and ArcView GIS applications to delineate hardbottom features and cover types and groundtruthing using an integrated video mapping system. Mapping was completed 1,500 feet seaward of the shoreline. The same bottom type classification as used in the ATM (2001b) was applied throughout the County. The results of the analysis are illustrated in Figure 3-4 and the Sector 7 totals compared to the countywide totals are presented in Table 3.12.

Table 3 - 12  Nearshore Hardbottom Areas Within Sector 7 and for Indian River County

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Low Relief Algal Rock</td>
<td>Sector 7</td>
</tr>
<tr>
<td>3 Inshore Worm Rock</td>
<td>Countywide</td>
</tr>
<tr>
<td>4 High Relief Algal/Sponge</td>
<td>Positive</td>
</tr>
<tr>
<td>5 High Relief Algal/Sponge with Worm Rock</td>
<td>Positive</td>
</tr>
<tr>
<td>Total</td>
<td>Positive</td>
</tr>
</tbody>
</table>

Note: Based on ERDAS multi-spectral image analysis and ground verification of signatures within 1,500 feet of the shoreline (Dial Cordy, 2001).

3.9 Essential Fish Habitat (EFH)

The South Atlantic Fisheries Management Council (SAFMC) (1998) has designated seagrass, nearshore hardbottom, and offshore reef areas within the study area as EFH (Table 3-13). The nearshore bottom and offshore reef habitats of Central Florida have also been designated as Essential Fish Habitat-Habitat Areas of Particular Concern (EFH-HAPC) (SAFMC, 1998). As many as 60 corals can occur off the coast of Florida (SAFMC, 1998) and all of these fall under the protection of the Management Plan.

Table 3 - 13 Essential Fish Habitat Areas

<table>
<thead>
<tr>
<th>Marine Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live/Hard Bottom</td>
</tr>
<tr>
<td>Coral and Coral Reef</td>
</tr>
<tr>
<td>Artificial Reefs</td>
</tr>
<tr>
<td>Sargassum</td>
</tr>
<tr>
<td>Water Column</td>
</tr>
</tbody>
</table>

Source: South Atlantic Fisheries Management Council, 1998
Managed species that commonly inhabit the study area include pink shrimp (*Penaeus duorarum*), and spiny lobster (*Panularis argus*). These shellfish utilize both the inshore and offshore habitats within the study area. Members of the 73 species Snapper-Grouper Complex include sailors choice (*Haemulon parra*), gray snapper (*Lutjanus griseus*), mahogany snapper (*Lutjanus mahogoni*), and porkfish (*Anisotremus virginicus*). These species utilize the inshore habitats of Indian River Lagoon as juveniles and sub-adults and as adults utilize the hardbottom and reef communities offshore. Other important species that utilize the inshore and nearshore areas of Indian River County include the red drum (*Sciaenops ocellatus*) and the snook (*Centropomis undecimalis*). In the offshore habitats, the number of species within the Snapper-Grouper Complex that may be encountered increases. Coastal migratory pelagic species also commonly utilize the offshore area adjacent to the study area. In particular, the king mackerel (*Scomberomorus cavalla*) and the Spanish mackerel (*Scomberomorus maculatus*) are the most common. The Biological Assessment prepared for NMFS and USFWS (United States Fish and Wildlife Service) review provides a more thorough review and evaluation of impacts (Appendix A).

### 3.10 Coastal Barrier Resources

Congress passed the Coastal Barrier Resources Act (CBRA) in 1982 to address problems caused by coastal barrier development. This Act defined a list of undeveloped coastal barriers along the Atlantic and Gulf coasts. Designated coastal barrier resources have been identified within the Project work area as shown in Figure 3-5. The area where beach nourishment is proposed falls within one of the CBRA units. It has been determined through consultation with USFWS that beach nourishment is allowed in a CBRA unit. However, the source of sand must be from outside of a CBRA unit.

### 3.11 Hazardous, Toxic, and Radioactive Waste (HTRW)

The preliminary assessment indicated no evidence of hazardous, toxic, or radioactive waste (HTRW) on the Project lands or within the borrow area. During Project construction, further HTRW awareness should be practiced.

### 3.12 Air Quality

Air quality along the Indian River County coastline is good due to the presence of either on or offshore breezes. The FDEP does not regulate marine or mobile emission sources (dredge and construction equipment) within Indian River County. No air quality permits are required for this Project.
3.13 Noise

Ambient noise levels in the Project area are low to moderate. The major noise producing sources are breaking surf and adjacent residential areas. The sources are expected to continue at their present noise levels.

3.14 Aesthetic Resources

The coastline of Indian River County possesses visually pleasing attributes including the waters of the Atlantic Ocean and existing beaches. The nourishment of the beach will maintain the natural appearance of the protective beach along the ocean.

3.15 Recreation Resources

Indian River County features a total of 22.4 miles of oceanfront beach. There are 13 public beach accesses and parks along the County shoreline. Within the proposed Sector 7 Project area, there are approximately seven private beach access points. The closest public beach access is south of the Project area at Round Island Park. The park is located on the west side of A1A at the Indian River-St. Lucie County line. Round Island Park offers a beach park area with a boardwalk, restroom facilities, picnic facilities, boat launch, canoe launch, and parking.

Annual beach count estimates in Sector 7 for 1998 and 1999 indicated a summer use of approximately 4,030 people and a winter use of approximately 3,648 people. Approximately 53.6 percent of the summer beach users and 36.2 percent of winter beach users were classified as tourists (not residents of Indian River County). Visitors to the beach spend money on food, entertainment, shopping, and lodging. The survey reported the following average daily expenditures per party (average 2.9 people per summer party and average 2.2 people per winter party) surveyed in Sector 7 (Table 3-14).

Table 3 - 14 Beach Visitor Spending

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Daily Spending (Summer)</th>
<th>Daily Spending (Winter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>$50.03</td>
<td>$63.10</td>
</tr>
<tr>
<td>Entertainment</td>
<td>$29.42</td>
<td>$35.00</td>
</tr>
<tr>
<td>Shopping</td>
<td>$51.67</td>
<td>$75.79</td>
</tr>
<tr>
<td>Lodging</td>
<td>$138.41</td>
<td>$82.73</td>
</tr>
</tbody>
</table>

Socioeconomic and Project cost and benefit analyses were conducted to assess the economic merits of the proposed Project. These studies and analyses are detailed in the documents; “Indian River County Beach Preservation Plan Economic Analysis and Cost Allocation Plan”

3.16 Navigation

The waters offshore of Sector 7 are used primarily for recreational boating traffic.

3.17 Cultural Resources

An archival and literature review, including a review of the Florida State Master Site File and the current National Register of Historic Places listing, has been conducted to determine if significant cultural resources are located within the area of impact for the proposed Project. A remote sensing survey of the South Borrow Area was conducted by Dr. Robert Baer in 2000 to locate potentially significant submerged cultural resources. Within the South Borrow Area, no side-scan sonar targets were found and 12 magnetic anomalies were recorded.

Only three magnetic anomalies (designated as CO3, CO4, and CO7) are located within Sub-Area 1. CO3 was diver verified and it was determined that it contained no ferrous materials within three feet of the bed surface which is the operational limit of the hand-held metal detector used. The report by Dr. Baer concluded that there are no significant submerged cultural resources within the South Borrow Area Sub-Area 1. The State Historic Preservation Office concurred with this finding.

In 2004, the Florida Division of Historical Resources Bureau of Historic Preservation identified a shipwreck outside the bounds of the South Borrow Area Sub-Area 1. To ensure protection for this site, a 200 foot buffer zone will be established around the site. Additionally, they identified a wreck more than 2,000 feet offshore of R-104. This wreck is not within the project area or the proposed pipeline/sail corridor for sand transportation between the beach and the borrow area.
4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Tides, Waves, Currents, and Storm Events

Sediment transport in the coastal environment is driven by tides, waves, and currents, particularly during storm events. These dynamics determine coastal sediment loss in an area.

4.1.1 Alternative 1 - “No-Action” Alternative

The No-Action Alternative will not impact tides, waves, currents or storm events. However, storm event-driven erosional losses and background erosional losses to the coastline are to be expected as a result of no action in the Project area. If no action is taken, structures in the area will become increasingly susceptible to storm damage as the beach and dune are continually eroded away. The background erosion rate of 2.08 CY/ft/yr and onshore storm losses (above MHW), predicted to be 18.1 CY/ft during a 10-year storm event and 19.3 CY/ft during a 15-year storm event are not expected to change as a result of no-action. However, with the anticipated proliferation of seawall construction as the beach erodes and seawalls are encountered by waters, changes will occur.

4.1.2 Alternative 2 - Applicant’s Preferred Alternative

Tides and storm events will not be affected by the construction of this Alternative. Large-scale changes in the wave climate or local currents are not expected as a result of the proposed design beach fill Project since the fill volume is limited and no structures will be constructed. This implies that the forces directing the sediment will remain the same and, consequently, the background erosion rates and the storm event volume loss will not be altered.

The wave climate may be altered in the vicinity of the borrow area and the adjacent shoreline following material removal. A study of the effects of borrow area excavation predicts a slight increase in wave heights in some areas landward of the northern and southern ends of the borrow area. The increase in wave height is expected to be less than 20 percent and is anticipated to occur well offshore of breaking waves. A decrease in wave heights is predicted to occur directly landward of the borrow site. The excavation of Sub-Area 1 is expected to slightly alter the longshore sediment transport rates in and around the Project area, resulting in less than 12 percent change from background longshore sediment transport rates and is considered to be insignificant. (ATM, 2003c)
4.1.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Tides and storm events will not be affected by the construction of this Alternative. Large-scale changes in the wave climate or local currents are not expected as a result of the proposed design beach fill Project since the fill volume is limited and no structures will be constructed. This implies that the forces directing the sediment will remain the same and, consequently, the background erosion rates and the storm event volume loss will not be altered.

The wave climate may be altered in the vicinity of the borrow area and the adjacent shoreline following material removal. A study of the effects of borrow area excavation predicts a slight increase in wave heights in some areas landward of the northern and southern ends of the borrow area. The increase in wave height is expected to be less than 20 percent and is anticipated to occur well offshore of breaking waves. A decrease in wave heights is predicted to occur directly landward of the borrow site. The excavation of Sub-Area 1 is expected to slightly alter the longshore sediment transport rates in and around the Project area, resulting in less than 12 percent change from background longshore sediment transport rates and is considered to be insignificant. (ATM, 2003c)

4.2 Beach Geology and Geomorphology

4.2.1 Alternative 1 - “No-Action” Alternative

Sediment will continue to erode from the shoreline. Currently, the headland in the vicinity of R-103 is believed to be supplying sediment to the beaches to the north and south, lessening the effects of the overall shoreline erosion. For example, between 1986 and 1999, the shoreline at R-103 eroded an average distance of 7.7 ft/yr while the shorelines 3,000 feet north and south of R-103 eroded an average of 5.0 ft/yr. As this headland feature continues to erode, this sediment supply may be reduced or exhausted, and as a result, an increase in the erosion rate for the overall area may occur. It is anticipated that without nourishment, landowners will erect seawalls to protect their property from the encroaching sea. Sediment transport patterns will be altered through the construction of such seawalls and other structures, after which erosion of the shorelines downdrift of the seawalls would be expected.

4.2.2 Alternative 2 - Applicant’s Preferred Alternative

Littoral processes such as background erosion and sediment pathways will remain the same; however, there will be an increased volume of sediment in the system causing the impacts of erosion to be diminished. Increased sediment in the system will reduce sediment deficiencies in the Project area and in areas adjacent to the Project area.
4.2.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Littoral processes such as background erosion and sediment pathways will remain the same; however, there will be an increased volume of sediment in the system causing the impacts of erosion to be diminished. The nourishment fill will directly impact 5.3 acres of hardbottom. Secondary impacts due to spreading of the beachfill offshore and to the north and south of the Project area are predicted to be approximately 0.87 acres. Due to the extensive hardbottom in the County (a 1993 study yielded an estimate of approximately 3,740 acres for total nearshore reef habitat in Indian River County) this minimal coverage is not expected to regionally alter the sedimentation patterns. Increased sediment in the system will reduce sediment deficiencies in the Project area and in areas adjacent to the Project area.

4.3 Sediment Characteristics of Borrow Area and Existing Beach

4.3.1 Alternative 1 - “No-Action” Alternative

If No-Action is taken, the sediment on the beach in Sector 7 will represent a combination of native beach characteristics and emergency fill from upland sources. The sediment characteristics of the borrow area will be maintained.

4.3.2 Alternative 2 - Applicant’s Preferred Alternative

The Applicants Preferred Alternative will place approximately 363,600 cubic yards of compatible material from an offshore borrow area onto the beach. As detailed in Section 3.3.3, the resulting beach will have slightly different sediment characteristics than the existing beach; however, no adverse environmental consequences are expected with regards to the placement of borrow sediment on the beach in Sector 7. The sediment characteristics of the primary borrow area conform to the provisions of Chapter 62B-41, Florida Administrative Code (specifically, 62B-41.007 (2)(j)).

4.3.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

This Alternative will place approximately 459,700 cubic yards of compatible material from an offshore borrow area onto the beach. As detailed in Section 3.3.3, the resulting beach will have slightly different sediment characteristics than the existing beach; however, no adverse environmental consequences are expected with regards to the placement of borrow sediment on the beach in Sector 7. The sediment characteristics of the primary borrow area conform to the provisions of Chapter 62B-41, Florida Administrative Code (specifically, 62B-41.007 (2)(j)).
4.4 Water Quality

4.4.1 Alternative 1 - “No-Action” Alternative

The “No-Action” Alternative would have no impact on the water quality of Sector 7.

4.4.2 Alternative 2 - Applicant’s Preferred Alternative

Alternative 2 will result in temporary impacts to the water quality surrounding the borrow area and the sand discharge areas along the beach. Sediment analysis has indicated that the material to be dredged and placed on the beach contains a very low silt-clay fraction and is predominantly sand-shell. The nature of the sediment will tend to minimize the impact of turbidity. Turbidity movement will be controlled largely by current velocity and tidal conditions. It is not anticipated that large dispersal areas will develop; however, physical factors existing at the time of operation are not fully predictable. A study of the expected turbidity generated during the construction of this Project indicated that increased turbidity levels may exceed the maximum level of 29 NTUs above background within approximately 2,600 feet (793 meters) downstream of the dredge pipe discharge. Due to the wave climate and local currents, the increased turbidity levels generated from this Project are not expected to exceed the 29 NTU limit outside of 100 feet from the point of discharge in the cross-shore direction and 2,600 feet down current. Water quality impacts may be expected only for the period of construction. In addition, dikes may be constructed to contain the turbidity plume at the discharge site if necessary.

4.4.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Alternative 3 will result in temporary impacts to the water quality surrounding the borrow area and the sand discharge areas along the beach. Sediment analysis has indicated that the material to be dredged and placed on the beach contains a very low silt-clay fraction and is predominantly sand-shell. The nature of the sediment will tend to minimize the impact of turbidity. Turbidity movement will be controlled largely by current velocity and tidal conditions. It is not anticipated that large dispersal areas will develop; however, physical factors existing at the time of operation are not fully predictable. A study of the expected turbidity generated during the construction of this Project indicated that increased turbidity levels may exceed the maximum level of 29 NTUs above background within approximately 2,600 feet (793 meters) downstream of the dredge pipe discharge. Due to the wave climate and local currents, the increased turbidity levels generated from this Project are not expected to exceed the 29 NTU limit outside of 100 feet from the point of discharge in the cross-shore direction and 2,600 feet down current. Water quality impacts may be expected only for the period of construction. In addition, dikes may be constructed to contain the turbidity plume at the discharge site if necessary.
4.5 Beach and Dune Vegetation and Wildlife

4.5.1 Alternative 1 - “No-Action” Alternative

The No-Action Alternative would have an impact on the vegetation resources within the Project area. Continued erosion of the County’s beaches would result in continued loss of habitat and eventually loss of vegetated dune areas. In addition, the armoring measures that would be taken by residents along the beaches in Sector 7 would result in impact to the plant and animal communities within these areas as the beach erodes back to these seawalls and habitat is eliminated.

4.5.2 Alternative 2 - Applicant’s Preferred Alternative

The Preferred Alternative would have no impact to the vegetation resources of the County. Sand placement on the beach would not impact the nearby dune communities. The placement of the material on the beach would act as a buffer to these communities from the surge associated with storm events. In addition, the Preferred Alternative design includes the construction of a dune feature, which will be vegetated with species native to Indian River County.

Nelson (1985) reviewed the literature on the effects of beach renourishment projects on sand beach fauna and concluded. “Minimal biological effects result from beach nourishment. Some mortality of organisms may occur where grain size is a poor match to existing sediments, however, recovery of the beach system appears to be rapid.” Nelson reviewed several studies on the most common beach invertebrates of the southeastern U.S. including the mole crab, the surf clam, and the ghost crab. None of the studies cited in Nelson showed significant or lasting impacts to any of the above species resulting from beach nourishment. Hackney et al. (1996) provide a more recent review of the effects of beach restoration projects on beach infauna in the southeastern U.S.. Hackney et al. (1996) reviewed studies on the species examined by Nelson (1985) and agree with the conclusions in the Nelson study, with the caveats that construction should take place in winter months to minimize impacts, and that the sand used should be a close match to native beach sands. In most of the studies reviewed by the previously mentioned authors, there was a considerable short-term reduction in the abundances of mole crabs, surf clams and ghost crabs attributable to direct burial. Recruitment and immigration were generally sufficient to reestablish populations within one-year of construction.

The proposed Project will be constructed in the winter season, outside the recruitment window for these species, with a high quality sand source containing a small percentage of fine material. These features operate to minimize adverse effects on most beach infauna (Hackney et al., 1996). The proposed Project will not have any significant, long lasting impacts on sand beach infaunal communities.
4.5.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Alternative 3 would have no impact to the vegetation resources of the County. Sand placement on the beach would not impact the nearby dune communities. The placement of the material on the beach would act as a buffer to these communities from the surge associated with storm events. In addition, the Alternative 3 design includes the construction of a dune feature which will be vegetated with species native to Indian River County.

Nelson (1985) reviewed the literature on the effects of beach renourishment projects on sand beach fauna and concluded...“Minimal biological effects result from beach nourishment. Some mortality of organisms may occur where grain size is a poor match to existing sediments, however, recovery of the beach system appears to be rapid.” Nelson reviewed several studies on the most common beach invertebrates of the southeastern U.S., including the mole crab, the surf clam, and the ghost crab. None of the studies cited in Nelson showed significant or lasting impacts to any of the above species resulting from beach nourishment. Hackney et al. (1996) provide a more recent review of the effects of beach restoration projects on beach infauna in the southeastern U.S. They also reviewed studies on the above species and agree with the conclusions in the Nelson study, with the caveats that construction should take place in winter months to minimize impacts, and that the sand used should be a close match to native beach sands. In most of the studies reviewed by the previously mentioned authors, there was a considerable short-term reduction in the abundances of mole crabs, surf clams and ghost crabs attributable to direct burial. Recruitment and immigration were generally sufficient to reestablish populations within one-year of construction. The proposed Project will be constructed in the winter season, outside the recruitment window for these species, with a high quality sand source containing a small percentage of fine material. These features operate to minimize adverse effects on most beach infauna (Hackney et al., 1996). The proposed Project will not have any significant, long lasting impacts on sand beach infaunal communities.

4.6 Threatened and Endangered Species

4.6.1 Alternative 1 - “No-Action” Alternative

The No-Action Alternative would negatively impact the threatened and endangered species utilizing these habitats. The continued erosion of the beaches in this critically eroded area may result in the armoring of additional shoreline over the next 30 years. The beach may be expected to erode back entirely up to these seawalls, completely eliminating the beach berm and dune. This loss of beach habitat would have the greatest impact on sea turtles that utilize this habitat for nesting. Nesting success may be diminished as the total area of suitable nesting habitat is reduced by erosion. Mosier (1998) reported that sea turtle nesting success was, on average, 69 percent lower at sites with seawalls than at sites without seawalls. In some areas, particularly in the vicinity of armoring structures, sea turtle nesting habitat may be lost completely. The hatching success of nests that are successfully laid will also be
reduced, as nests on narrow, eroded beaches are more vulnerable to repeated inundation and washout. Loss of beach width would additionally reduce the habitat for the endangered southeastern beach mouse, least tern and piping plover, which utilize these littoral and vegetated beach habitats.

4.6.2 Alternative 2 - Applicant’s Preferred Alternative

The placement of material on the County’s beaches would only temporarily impact threatened and endangered species and efforts will be taken to greatly minimize these impacts. On the Atlantic Ocean shoreline of Florida, sea turtles typically nest between April and August, with late season nest deposits resulting in emergent hatchlings extending to late October. State and federal regulatory interests require that construction be limited to a time period outside of the nesting season (from November 1 to March 1) in order to minimize impacts to nesting and hatchling sea turtles. Most Project impacts on sea turtle nesting success are expected to be limited to the first year, with some effects persisting into the second year. Since any turtles deterred from nesting in the Project area can be expected to nest elsewhere nearby, no measurable negative effect of the Project on total nesting in the County is expected.

Nests laid on renourished beaches generally hatch successfully (Nelson and Dickerson, 1988). Herren (1999) found no significant difference in hatching success in the nourished area in the northern portion of the County in the first or second season after the Sebastian Inlet sand transfer activities. Within Indian River County following the construction of the Sectors 1 and 2 beach nourishment project in the winter of 2002/2003, nesting success was not impacted by material placement (Ecological Associates, 2003). Hatching success was also very high in Sectors 1 and 2 in the first year following construction (Ecological Associates, 2003). The Sector 7 proposed Project will use a sand source very similar to that used for the Sectors 1 and 2 project. Both the Herren and EAI studies point to erosional losses of nests laid low on the newly constructed berms as the primary source of impact. A proper relocation program could largely eliminate this source of impact. The borrow source for Sector 7 is very similar in character to the material used in the Sectors 1 and 2 beach nourishment project and thus, similar results may be expected.

With all of the construction outside of the nesting season and careful selection of appropriate fill material, the effects of the proposed Project on sea turtle nesting success will be minimal. To eliminate potential impacts from erosional losses, nests laid in vulnerable areas should be relocated during the first season following construction to minimize losses.

Impacts to other species such as the southeastern beach mouse, least tern, and piping plover will be minimized by timing the construction activities outside of the main breeding season, which peaks in the late summer, limiting access points, and through the construction of temporary fencing to prevent intrusion to dune areas.

The increased area of the Sector 7 beaches after nourishment will act as a buffer and help to protect species that use the upland areas, such as the southeastern beach mouse. The
additional beach area will increase sea turtle nesting habitat and enhance the nesting and foraging areas of the piping plover and least tern.

4.6.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Impacts to threatened and endangered species with the implementation of Alternative 3 would be very similar to those previously described for Alternative 2. Impacts to other species such as the southeastern beach mouse, least tern, and piping plover will be minimized by timing the construction activities outside of the main breeding season, which peaks in the late summer, through limiting construction access points and through the construction of temporary fencing to prevent intrusion to dune areas.

The increased area of the Sector 7 beaches after nourishment will act as a buffer and help to protect species that use the upland areas, such as the southeastern beach mouse. The additional beach area will increase sea turtle nesting habitat and enhance the nesting and foraging areas of the piping plover and least tern.

4.7 Offshore Borrow Area Resources

4.7.1 Alternative 1 - “No-Action” Alternative

Implementation of the No-Action Alternative would have no impact on the resources located within the boundaries of the offshore borrow area.

4.7.2 Alternative 2 - Applicant’s Preferred Alternative

The immediate impact of excavating upper sediments from the sand borrow area would be removal of portions of benthic invertebrate populations that inhabit sediments. Offshore sand mining removes benthic habitat along with organisms incapable of avoiding the dredge, resulting in drastic reductions in the number of individuals, number of species, and biomass in dredged sites. Removed individuals would be slow-moving or sessile forms, primarily infauna. Surveys of the proposed borrow area, as well as benthic investigations of nearby waters, reveal that the sand benthos of the study area mostly includes crustaceans, echinoderms, mollusks, and polychaete annelids.

Dredging of the borrow area required to construct the beach fill Project would have temporal impacts to the benthic infaunal communities. Benthic infauna should be expected to start re-colonizing these areas within days of the end of dredging. Previous studies have shown dredging to have little long-term adverse effects on benthic habitats (Culter and Mahadevan, 1982; Saloman et al., 1982; Hammer et al., 2000). Infaunal assemblages within the study area should become re-established within one to two years following dredging.
Recolonization of a disturbed area often is initiated by infaunal organisms that have the adaptive characteristics for rapid invasion and colonization of habitats where habitat space is available due to some natural or human-induced disturbance. The recolonization process has been documented in previous studies of the effects of open-water dredged material disposal (e.g., Richardson et al., 1977; Van Dolah et al., 1984). After removal of infauna and sediments, opportunistic populations tend to colonize defaunated areas relatively quickly (Grassle and Grassle, 1974; McCall, 1977; Simon and Dauer, 1977). Later stages of colonization will be more gradual, and depend on environmental conditions after cessation of dredging. Later successional stages involve taxa that generally are less opportunistic and longer-lived.

4.7.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Impacts to the offshore borrow area resources associated with Alternative 3 would be similar to those described in Section 4.7.2., however; the amount of material removed from the South Borrow Area would be higher for this alternative, thus temporarily impacting a larger surface area.

4.8 Hardbottom Habitat

4.8.1 Alternative 1 - “No-Action” Alternative

The No-Action Alternative will allow sand to continue to be eroded from Sector 7. This continued erosion would persist in reducing the beach profile and potentially exposing additional hardbottom below the surface. Additionally, as sand from the beach face is eroded, it may be deposited on the nearshore hardbottom, reducing the amount of hardbottom habitat.

4.8.2 Alternative 2 - Applicant’s Preferred Alternative

The Applicants Preferred Alternative will have no direct, and only minimal, and temporary indirect impacts upon nearshore hardbottom habitat located seaward and downdrift of the project area (Figures 4-1 and 4-2). Modeling was conducted to assess the downdrift impacts of sand migrating from the recently nourished beach upon hardbottom resources (ATM, 2004). No hardbottom features are located within or near the proposed borrow area based on side-scan surveys and geotechnical studies (ATM, 2000).
Preferred Alternative with Hardbottom Locations

Environmental Assessment
Indian River County Sector 7 Beach Restoration Project

Scale: as shown
Date: February 2005

Legend:
- R-99: DEP Reference Monument
- Proposed Dune
- Proposed Construction BERM
- Adjusted BERM
- Construction Toe of Fill
- Adjusted Toe of Fill
- Indian River County Surveyed Seawalls

Source: Applied Technology & Management, Inc
2001 Natural Color Aerial
Source: Applied Technology & Management, Inc
Alternative 3 will impact a total of 5.3 acres of hardbottom habitat consisting entirely of Type 2 hardbottom. Type 2 hardbottom, characterized by low relief rock dominated by an algal community, is located approximately 300 feet offshore in a band parallel to the shoreline between DEP Reference Monuments R-100 and R-107.

Additional hardbottom impacts can be avoided by the proper designation of pipeline access corridors and buffer zones. These measures, along with the careful monitoring of turbidity within the borrow area and nearshore areas should not result in any other hardbottom impacts.

Lower sections between the higher features within the hardbottom provide pathways for sand movement. It is reasonable to assume that the irregular hardbottom features influence and allow for sand loss from the beach system. Hanes and Associates, Inc. (1994) found, in their Longboat Key Florida monitoring study, that the sedimentation rate at hardbottom monitoring sites significantly exceeded the sedimentation rates at the control sites prior to sand placement and following the 1993 Longboat Key beach nourishment project.

To evaluate indirect impacts to hardbottom habitat located offshore of the Alternative 3 beach fill template, sediment transport was modeled using the GENESIS model (ATM, 2003). The simulated beach shoreline evolution model shows that the most spreading to adjacent shorelines will occur as far as 0.9 miles north, 1.1 miles south, and seaward approximately 60 feet, over the 30-year Project life. Most of the impacts associated with this spreading will occur south of the Project between Monuments R-107 and R-113. The model estimates of spreading are minimal due to: relatively small average placement volume; a long taper along the ends of the Project area with reduced beachfill; and a relatively short Project length. Project-related impacts to the beaches adjacent to the Project area are not expected to be significant; however, considerable background accretion in the region is expected to have an impact. The GENESIS model predicted that the adjacent shorelines may advance seaward up to 180 feet (near R-95) over the next 30 years.

While the model predicts that the seaward advancement of material due to the Project will impact up to 0.87 acres of hardbottom outside of the Project area over the next 30 years, it is also estimated that biotic cover and biological integrity of the habitat seaward of the equilibrium toe of fill could be temporarily impacted as a result of increased turbidity. No hardbottom features are located within or near the proposed borrow area based on side-scan surveys and geotechnical studies (ATM, 2000).
4.9 Essential Fish Habitat (EFH)

4.9.1 Alternative 1 - “No-Action” Alternative

The No-Action Alternative would have no impact to EFH within Sector 7.

4.9.2 Alternative 2 - Applicant’s Preferred Alternative

Implementation of the beach nourishment associated with the Applicants Preferred Alternative will impact only 32.53 acres of open water habitat designated as EFH. No hardbottom habitat will be directly impacted by the Project, and any indirect or secondary impacts will be minimal and temporary. These temporary impacts would include displacement of fishes from nearshore areas during fill placement. Other impacts include temporary increases in turbidity levels, and decreased primary and secondary production until the completion of nourishment.

4.9.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Implementation of the beach nourishment associated with Alternative 3 will impact hardbottom areas and open water habitat designated as EFH. The hardbottom communities offshore of Indian River County have been designated as EFH-HAPC (Essential Fish Habitat-Habitat Areas of Particular Concern) by the SAFMC (South Atlantic Fisheries Management Council) (1998). In total, there would be 5.3 acres of hardbottom habitat directly impacted by the proposed nourishment. The proposed toe of fill would also temporarily impact 36.10 acres of open water habitat along Sector 7 occurring from the MHW line and extending approximately 200-1000 feet offshore. These temporary impacts would include displacement of fishes from nearshore areas during fill placement. Other impacts include temporary elevation in turbidity levels, and decreased primary and secondary production until the completion of nourishment.

4.10 Coastal Barrier Resources

4.10.1 Alternative 1 - “No-Action” Alternative

The No-Action Alternative will have a negative impact on the Coastal Barrier Resources within Sector 7. These landscape features shield the mainland from the full force of wind, waves, and tides. The sustained erosion of the beach within critically eroding areas will persist in reducing the size of the barrier island resources in Sector 7.
4.10.2 Alternative 2 - Applicant’s Preferred Alternative

The Preferred Alternative will not have a negative impact on the Coastal Barrier Resources within Sector 7. The placement of material from the offshore borrow area associated with the Preferred Alternative design will increase the size of barrier island thus increase its resistance to storm events which will protect this resource.

4.10.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Alternative 3 will not have a negative impact on the Coastal Barrier Resources within Sector 7. The placement of material from the offshore borrow area will increase the size of barrier island thus increase its resistance to storm events which will protect the Coastal Barrier Resources within Sector 7.

4.11 Hazardous, Toxic, and Radioactive Waste (HTRW)

4.11.1 Alternative 1 - “No-Action” Alternative

The “No-Action” Alternative will have no impact on HTRW within the Project area.

4.11.2 Alternative 2 - Applicant’s Preferred Alternative

Implementation of the Applicant’s Preferred Alternative will have no impacts on HTRW within the Project area.

4.11.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Implementation of Alternative 3 will have no impacts on HTRW within the Project area.

4.12 Air Quality

4.12.1 Alternative 1 - “No-Action” Alternative

The “No-Action” Alternative will have no impact on the air quality within the Project area.
4.12.2 Alternative 2 - Applicant’s Preferred Alternative

Due to the onshore and offshore breezes present within Indian River County, any reduction in air quality associated with the Applicant’s Preferred Alternative should be short-term and will not significantly impact air quality. The FDEP does not regulate marine or mobile emission sources (dredge and construction equipment) within Indian River County. No air quality permits are required for this Project.

4.12.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

Due to the onshore and offshore breezes present within Indian River County, any reduction in air quality associated with this Alternative should be short-term and will not significantly impact air quality. The FDEP does not regulate marine or mobile emission sources (dredge and construction equipment) within Indian River County. No air quality permits are required for this Project.

4.13 Noise

4.13.1 Alternative 1 - “No-Action” Alternative

The “No-Action” Alternative will have no impact on the noise levels in the Sector 7 study area.

4.13.2 Alternative 2 - Applicant’s Preferred Alternative

There would be a temporary increase in the noise level during construction. The principal noise would stem from construction equipment in the vicinity of the discharge point on the beach and from the dredge. Construction equipment will be properly maintained in order to minimize noise. Increases to the current levels of noise as a result of this Project will be localized and minor, and will be limited to the time of construction.

4.13.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

There would be a temporary increase in the noise level during construction. The principal noise would stem from construction equipment in the vicinity of the discharge point on the beach and from the dredge and from groin construction areas. Construction equipment will be properly maintained in order to minimize noise. Increases to the current levels of noise as a result of this alternative will be localized and minor, and will be limited to the time of construction.
4.14  Aesthetic Resources

4.14.1  Alternative 1 - “No-Action” Alternative

The aesthetics of the beach with the “No-Action” Alternative will be diminished as erosion continues and beach width and natural habitat is lost and more seawalls are constructed.

4.14.2  Alternative 2 - Applicant’s Preferred Alternative

There will only be a temporary reduction in aesthetics during construction. There is no expectation of long-term adverse influence to the visual environment because of construction. Construction of the Applicant’s Preferred Alternative will increase aesthetic resources through increased beach area and vegetated habitat.

4.14.3  Alternative 3 - 459,000 Cubic Yards Sand Placement

There will only be a temporary reduction in aesthetics during construction. There is no expectation of long-term adverse influence to the visual environment because of construction. Construction of this Alternative will increase aesthetic resources through increased beach area and vegetated habitat.

4.15  Recreation Resources

4.15.1  Alternative 1 - “No-Action” Alternative

Loss of beach associated with the erosion related to the “No-Action” Alternative will result in less beach area available for recreation within the County. Over the next 30 years, the current shoreline recession rate of 5.6 ft/yr could result in the proliferation of seawall construction and the loss of over 27 acres of beach along the 7,138 ft Project area.

4.15.2  Alternative 2 - Applicant’s Preferred Alternative

During nourishment activities, the use of the beach in the vicinity of construction would be restricted temporarily. Use of the beach in the immediate area of the discharge pipe and equipment staging areas will be restricted for public safety. As portions of the nourished beach become available, use by the general public will be restored. The improved beaches will provide enhanced opportunities for recreational activities.
4.15.3 Alternative 3 - 459,000 Cubic Yards Sand Placement

During nourishment activities, the use of the beach in the vicinity of construction would be restricted temporarily. Use of the beach in the immediate area of the discharge pipe and equipment staging areas will be restricted for public safety. As portions of the nourished beach become available, use by the general public will be restored. The improved beaches will provide enhanced opportunities for recreational activities.

4.16 Navigation

4.16.1 Alternative 1 - “No-Action” Alternative

The “No-Action” Alternative would not impact navigation within the Project area.

4.16.2 Alternative 2 - Applicant’s Preferred Alternative

Navigation would only be temporarily impacted during construction, as pipelines placed may interfere with local recreational vessel movement along the beach. Appropriate buoys and other navigational aids will be employed to warn vessels approaching the dredge-fill operation.

4.16.3 Alternative 3 - 459,700 Cubic Yards of Sand Placement

Navigation would only be temporarily impacted during construction as pipelines placed may interfere with local recreational vessel movement along the beach. Appropriate buoys and other navigational aids will be employed to warn vessels approaching the dredge-fill operation.

4.17 Cultural Resources

4.17.1 Alternative 1 - “No-Action” Alternative

The “No-Action” Alternative will have no impact on the archeological or historic resources within Indian River County.

4.17.2 Alternative 2 - Applicant’s Preferred Alternative

The Applicant’s Preferred Alternative will have no impact on cultural resources within the County. The cultural resource study conducted by Dr. Robert Baer (2000) indicates the presence of three magnetic anomalies within the South Borrow Area. These anomalies were
determined to be insignificant and Dr. Baer concluded that there are no significant submerged cultural resources within the South Borrow Area Sub-Area 1. Following review of the survey report by the State Historical Preservation Officer, concurrence on no affect under Section 106 was provided (Appendix B).

4.17.3 Alternative 3- 459,700 Cubic Yards of Sand Placement

This Alternative will have no impact on cultural resources within the County. The cultural resource study conducted by Dr. Robert Baer (2000) indicates the presence of three magnetic anomalies within the South Borrow Area. These anomalies were determined to be insignificant and Dr. Baer concluded that there are no significant submerged cultural resources within the South Borrow Area Sub-Area 1. Following review of the survey report by the State Historical Preservation Officer, concurrence on no affect under Section 106 was provided (Appendix B).

4.18 Health and Safety

No health or safety concerns have been identified with respect to the Preferred Alternative. During construction, appropriate signage warning of temporary conditions unsuitable for visitors will be placed as required or applicable.

4.19 Energy Requirements and Conservation

The energy requirements for this construction activity would be confined to fuel for the dredge and/or trucks, labor transportation, and other construction equipment. The expenditure of energy would be much less using the proposed offshore borrow area than obtaining material from other sources described in the alternatives section. The use of upland sand would most likely require the expenditure of additional energy to perform repairs to local roads and highways damaged by trucks hauling material to the beach. The “No-Action” Alternative would allow conditions to further develop that may endanger coastal property from storm surge and wave erosion during future storm events. On-site preventive measures and post clean up under the “No-Action” Alternative would likely demand greater energy than that required of the Preferred Alternative.

4.20 Natural or Depletable Resources

In this case, the beach quality sand used to construct the Project is a depletable resource. Using sand from the proposed offshore borrow area will deplete the sand source from the areas dredged at that site. Eventually the sand will be redistributed over nearshore areas. It is unlikely that the redistributed sand will return to the same location from which it was removed, resulting in a depletion of resources in the South Borrow Area. Using sand from the Upland Sand Source will deplete the sand source from the excavation area. This source will
not be regenerated through natural means. The gasoline and diesel fuel used by the dredge and other construction equipment is also a depletable resource.

4.21 Cumulative Impacts

For the Sector 1 and 2 Ambersand project constructed in 2003, a comprehensive cumulative impact assessment report was prepared (DC&A 2001). Since construction of this project, no additional regional or county projects have been constructed, which were not factored into the assessment prepared at that time. While other beach restoration activities are planned for this year in St Lucie, Brevard and Martin Counties, as relief from the hurricanes of 2004, additional impacts to sea turtle nesting and nearshore hardbottom habitat are not expected beyond what has been permitted previously, and thus considered in the cumulative assessment report previously prepared. Therefore, cumulative impacts evaluated in this section are based on past actions, ongoing actions, and future actions previously evaluated (DC&A 2001), and as modified based on the proposed Sector 7 project.

Other actions which have in the past or are projected to, in the present or "reasonably foreseeable future", impact nearshore hardbottom resources, and threatened and endangered species and their nesting or foraging habitat are summarized in Table 4.1 for the past, present and reasonably foreseeable future actions. For past, present and future actions, impacts were assessed within the proposed project area, elsewhere in the county, and within the central Florida east coast. The results of the analysis are described below.

Table 4 - 1 Compilation of Past, Present, and Proposed Future Projects and Direct Hardbottom Impacts Within the Central East Coast Region

<table>
<thead>
<tr>
<th>Projects</th>
<th>Type</th>
<th>Funding Approved</th>
<th>Permitted</th>
<th>Linear Distance</th>
<th>Hardbottom Impact</th>
</tr>
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<tbody>
<tr>
<td>Past (FY86-03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indian River County (86-00)</td>
<td>Inlet transfer</td>
<td>Yes</td>
<td>Yes</td>
<td>1.5 mi</td>
<td>&lt;1 ac</td>
</tr>
<tr>
<td>St. Lucie County Fort Pierce (95,99)</td>
<td>Inlet transfer Nourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A 1.3 mi</td>
<td>9 ac</td>
</tr>
<tr>
<td>Brevard County Canaveral Bypass (95, 98)</td>
<td>Bypassing</td>
<td>Yes</td>
<td>Yes</td>
<td>2 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County (Hutchinson Island)</td>
<td>Restoration</td>
<td>Yes</td>
<td>Yes</td>
<td>4.1 mi</td>
<td>1.32 ac</td>
</tr>
<tr>
<td>Martin County (Town of Jupiter Island) (87)</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>3.07 mi</td>
<td>None</td>
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<tr>
<td>Martin County (Town of Jupiter Island) (90)</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>1.82 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County (Town of Jupiter Island) (91)</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>1.67 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County (Town of Jupiter Island) (93)</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>0.8 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County (Town of Jupiter Island) (95-96)</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>4.92 mi</td>
<td>None</td>
</tr>
<tr>
<td>Projects</td>
<td>Type</td>
<td>Funding Approved</td>
<td>Permitted</td>
<td>Linear Distance</td>
<td>Hardbottom Impact</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>------------------</td>
<td>-----------</td>
<td>-----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Martin County (Jupiter -St. Lucie Inlet Dredging)</td>
<td>Bypassing</td>
<td>Yes</td>
<td>Yes</td>
<td>4.5 mi</td>
<td>None</td>
</tr>
<tr>
<td>Indian River County Sector 1 and 2 (02)</td>
<td>New</td>
<td>Yes</td>
<td>No</td>
<td>2.5 mi</td>
<td>3.8 ac</td>
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<tr>
<td>Indian River County (R12-17) FEMA Dune Restoration</td>
<td>Dune restoration</td>
<td>Yes</td>
<td>Yes</td>
<td>1.0 mi</td>
<td>None</td>
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<tr>
<td>Brevard County SPP North Reach (01)</td>
<td>New</td>
<td>Yes</td>
<td>Yes</td>
<td>9.4 mi</td>
<td>None</td>
</tr>
<tr>
<td>Brevard County Patrick AFB (01)</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>3.0 mi</td>
<td>None</td>
</tr>
<tr>
<td>Brevard County SPP South Reach (02)</td>
<td>New</td>
<td>Partial</td>
<td>Yes</td>
<td>3.8 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County Jupiter Island</td>
<td>Renourishment</td>
<td>Yes</td>
<td>Pending</td>
<td>5.9 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County St. Lucie Inlet Impl (FY02)</td>
<td>Inlet Transfer</td>
<td>Yes</td>
<td>Yes</td>
<td>2.0 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County - Hutchinson Island (FY01-02)</td>
<td>Renourishment</td>
<td>No</td>
<td>No</td>
<td>4.1 mi</td>
<td>None</td>
</tr>
<tr>
<td><strong>Present (FY 04-05)</strong></td>
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<td></td>
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<tr>
<td>Indian River County Sector 7</td>
<td>Nourishment</td>
<td>Yes</td>
<td>Pending</td>
<td>2.2 mi</td>
<td>None</td>
</tr>
<tr>
<td>Indian River County Sector 3-Hurricane Response</td>
<td>Upland Sand Placement</td>
<td>Yes</td>
<td>Pending</td>
<td>N/A</td>
<td>None</td>
</tr>
<tr>
<td>Indian River County Sector 1 and 2-Hurricane Response</td>
<td>Upland Sand Placement</td>
<td>Yes</td>
<td>Pending</td>
<td>N/A</td>
<td>None</td>
</tr>
<tr>
<td>St Lucie, Martin and Brevard Counties-Hurricane Response</td>
<td>Partial Renourishment</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td>None</td>
</tr>
<tr>
<td><strong>Proposed Future (FY06-12)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Indian River County Sector 3 (07)</td>
<td>New</td>
<td>Pending</td>
<td>No</td>
<td>2.2 mi</td>
<td>16.7 ac</td>
</tr>
<tr>
<td>Indian River County Sector 5 (07)</td>
<td>New</td>
<td>Pending</td>
<td>No</td>
<td>2.2 mi</td>
<td>13 ac</td>
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<td>Indian River County Sectors 1&amp;2 (10)</td>
<td>Renourishment</td>
<td>No</td>
<td>No</td>
<td>2.75 mi</td>
<td>None</td>
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<tr>
<td>Indian River County Sector 7 (10)</td>
<td>Renourishment</td>
<td>No</td>
<td>No</td>
<td>N/A</td>
<td>None</td>
</tr>
<tr>
<td>Brevard County SPP North Reach (07)</td>
<td>Renourishment</td>
<td>No</td>
<td>Yes</td>
<td>9.4 mi</td>
<td>None</td>
</tr>
<tr>
<td>Brevard County SPP South Reach (08)</td>
<td>Renourishment</td>
<td>No</td>
<td>Yes</td>
<td>3.8 mi</td>
<td>None</td>
</tr>
<tr>
<td>St. Lucie County Fort Pierce (07)</td>
<td>Renourishment</td>
<td>No</td>
<td>No</td>
<td>2.3 mi</td>
<td>None</td>
</tr>
<tr>
<td>Martin County Jupiter Island SPP (08)</td>
<td>Renourishment</td>
<td>No</td>
<td>Pending</td>
<td>5.9 mi</td>
<td>None</td>
</tr>
</tbody>
</table>
The only projects which have either directly or indirectly affecting living marine resources either in Indian River County or the adjoining three counties include the Sector 1 and 2 Ambersand project (3.8 ac), the Ft. Pierce SPP in St. Lucie County (9 acres), and the renourishment of beaches on Jupiter Island and Hutchinson Island (1.34 acres). The Fort Pierce SPP was constructed in 1995 and 1999. Jupiter Island has been nourished on the average every two to four years since 1986. Martin County first nourished Hutchinson Island in 1996, with renourishment in 2000. Direct impacts to hardbottom habitats from past actions have resulted in the loss of 14 to 15 acres throughout the central coast region. It should be noted; however, that due to the ephemeral nature of the habitat, the actual area of exposed hardbottom changes seasonally, and as such the actual permitted loss of habitat for each specific project may not be a true picture of what is actually present throughout the range of the hardbottom habitat.

Projects which are proposed to be built in 2004 through 2005 include the present Sector 7 project, upland placement of trucked in sand in Sectors 1, 2, 3, and 5 associated with a response to erosive actions caused by the 2004 hurricanes, and similar partial renourishment of Martin, St Lucie and Brevard County beaches by the Corps of Engineers for hurricane relief. None of the present projects are expected to impact additional nearshore hardbottom habitat, but will likely cause short-term impacts to fisheries, water quality, and sea turtle nesting activity.

Proposed future projects within the county will include impacts to approximately 30 acres of hardbottom habitat, if Sector 3 and 5 are permitted, funded, and constructed as conceptually envisioned. No additional hardbottom impacts within the region as a whole are expected.

4.21.1 Magnitude of Cumulative Affects

If all the sectors were approved and funded, approximately 30 acres of nearshore hardbottom would be directly impacted within the county over the next seven years. Little impacts have occurred in the past as a result of man's activities, and in fact due to the influence of Sebastian Inlet there has been a net gain of nearshore hardbottom habitat downdrift of the inlet since 1972 (CTC 1988). Losses in the region from past actions have been 14-15 acres in Indian River County and the three other counties since 1986 (Table 4.1). No new impacts are anticipated to occur in the region through 2012 (Table 4.1). Renourishment is not considered as an additional impact in the analysis as the habitat is more than likely permanently lost after the first restoration. Determining the magnitude of impacts on a regional basis is difficult due to the lack of comprehensive mapping in all the counties. Table 4.2 illustrates the magnitude of impacts both in the County and regionally for the four types of hardbottom habitat types. Based on this analysis, the majority of impacts will occur to the low relief Type 2 (18.8%) and inshore worm rock Type 3 (53.1%) habitats. Impacts to Type 4 and 5 habitat types, generally considered the more ecologically valuable, account for the remaining 28.1% of the total cumulative impact.
A summary of the acreages impacted per habitat type for all sectors in the county and summary of remaining habitat in each sector and countywide is shown in Table 4.2. The cumulative impact of past, present and future beach restoration activities on the total amount of resource mapped in the county is approximately 1.9% of the resource, based on recent mapping to 1500 feet offshore (DC&A, 2001) and less than 1% based on the SEAMAP mapping in 1997 (Perkins, 1997). Alone, Sectors 1 and 2 impacts did not result in a cumulative effect on the nearshore resource on a County or regional basis, accounting for only 0.2% of the resource base. In fact, more recent review of 2003 aerial photography by multi-spectral analysis indicates that only a total of 0.6 ac of habitat was lost in the Sector 1 and 2 area, as opposed to the projected loss of 3.8 ac from the Sector 1 and 2 project in 2003 (DC&A 2005). While there was direct burial of habitat as a result of the project, some of the area has uncovered and additional areas of rock habitat that were not present when analyzed in 2001 were present in 2004.

4.2.1.2 Significance of Cumulative Affects

Due to the paucity of actual research and long term monitoring on nearshore hardbottom communities, determining what amount of cumulative impact is significant is difficult. Past impacts within the region do not appear to have had any adverse or significant cumulative impact on the resource, even when combined with present actions proposed to occur within two years (Table 4.2). Proposed future actions within the county do add cumulatively to the impact and are adverse. Due to the significant amount of adjacent habitat remaining; however, it is unlikely that the amount of hardbottom habitat will become a limiting resource. With the addition of Sector 7, which will be scheduled in 2005, the cumulative impacts are not likely to be considered adverse or significant, since the adjacent habitat is clearly not limited and no additional direct or indirect impacts are anticipated. Monitoring of Sectors 1 and 2, by remote sensing and trend analysis of hardbottom location and cover, has shown that understanding large-scale spatial changes in the overall extent and structure of the habitat may be more important than the actual minor loss of habitat as a result of beach restoration. The response of the hardbottom community to major storm events and hurricanes may be actually more detrimental and result in changes in cover and habitat quality on a much larger spatial scale than small events such as the Sector 1 and 2 project. As no direct or indirect impacts are anticipated for the Sector 7 project, this project alone should not change the conclusion drawn for the Sector 1 and 2 project in 2001. Reassessment of cumulative affects should be performed based on scientific monitoring prior to implementation of Sectors 3 or 5.

As no new impacts to these resources has occurred regionally since construction of Section 1 and 2 in 2002, and no new impacts are proposed for the Preferred Alternative in Sector 7, or regionally for the foreseeable future, there will be no cumulative impacts to hardbottom resources. It is expected that the Preferred Alternative will have a positive cumulative effect on sea turtle nesting, in conjunction with other emergency projects proposed for fiscal years 2004 and 2005. There will be no cumulative effects of this project with others proposed regionally on sea turtle foraging habitat. Since the preferred plan involving restoration of Sector 7 does not by itself result in an adverse or significant cumulative impact, mitigation is not warranted.
Table 4 - 2  Cumulative Hardbottom Impacts for All Proposed and Future Beach Sectors, and Remaining Hardbottom Areas in Indian River County

<table>
<thead>
<tr>
<th>Type</th>
<th>Sectors 1 &amp; 2</th>
<th>Sector 3</th>
<th>Sector 5</th>
<th>Sector 7</th>
<th>Total Remaining in Sectors (Ac)</th>
<th>Total Remaining in County (Ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - Low Relief Algal Rock</td>
<td>0.2</td>
<td>3.7</td>
<td>2.4</td>
<td>---</td>
<td>210.3</td>
<td>376.5</td>
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<tr>
<td></td>
<td>81.2</td>
<td>55.7</td>
<td>29.3</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - Inshore Worm Rock</td>
<td>3.6</td>
<td>6.1</td>
<td>8.1</td>
<td>---</td>
<td>---</td>
<td>37.4</td>
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<tr>
<td></td>
<td>18.5</td>
<td>3.3</td>
<td>15.6</td>
<td>---</td>
<td></td>
<td>54.2</td>
</tr>
<tr>
<td>4 - High Relief Algal/Sponge</td>
<td>---</td>
<td>13.8</td>
<td>---</td>
<td>0.8</td>
<td>---</td>
<td>130.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>115.6</td>
<td>---</td>
<td>---</td>
<td></td>
<td>431.0</td>
</tr>
<tr>
<td>5 - High Relief Algal/Sponge with Worm Rock</td>
<td>---</td>
<td>6.9</td>
<td>2.5</td>
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<td>---</td>
<td>187.0</td>
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<td>55.7</td>
<td>131.3</td>
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<td>240.1</td>
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<tr>
<td>Total</td>
<td>3.8</td>
<td>16.7</td>
<td>13.0</td>
<td>---</td>
<td>210.3</td>
<td>731.1</td>
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<td>230.3</td>
<td>77.0</td>
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<td>1745.9</td>
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<tr>
<td>%</td>
<td>3.2%</td>
<td>6.8%</td>
<td>6.8%</td>
<td>93.2%</td>
<td>93.2%</td>
<td>0%</td>
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<tr>
<td></td>
<td>96.8%</td>
<td>93.2%</td>
<td>93.2%</td>
<td>0%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Note: All acreages based on ERDAS multi-spectral image analysis and field verification of hardbottom signatures 1,500 feet from shore by Dial Cordy and Associates Inc. and ATM (2000).
4.22 Irreversible and Irretrievable Commitment of Resources

4.22.1 Irreversible

An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever (e.g., mining of a mineral resource). The relocation of sand resources from the offshore and upland sources to the placement areas may irreversibly deplete offshore and upland sand reserves to some unknown extent. Depending on longshore transport rates, storm condition and other factors, the offshore sand resources may not replenish fast enough for use in future nourishment projects. The energy and fuel used during construction would also be an irreversible commitment of resources.

4.22.2 Irretrievable

An irretrievable commitment of resources is one in which, due to decisions to manage the resource for another purpose, opportunities to use or enjoy the resource, as they presently exist, are lost for a period of time. An irretrievable loss, for example would be a type of vegetation lost due to road construction. Benthic organisms within the offshore borrow area and beach fill area that would be impacted during construction would be irretrievably lost. However, the high rate of repopulation expected from these organisms reduces the significance of the loss.

4.23 Unavoidable Adverse Environmental Effects

Species of relatively non-motile infaunal invertebrates that inhabit the offshore borrow area will unavoidably be lost during dredging. Those species that are not able to escape the construction area are expected to recolonize after Project completion. There would be a temporary unavoidable reduction in water clarity and increased turbidity and sedimentation during the period of construction. This would be limited to the immediate areas of dredging, beach fill operations, and mitigation reef construction. This impact will be temporary and should disappear shortly after construction activities cease.

4.24 Local Short-Term Uses and Maintenance/Enhancement of Long-Term Productivity

The Applicant and USACE recognize that protection of the shoreline is a continual effort. No acceptable and permanent one-time fix has been identified (see Section 2.0 on alternatives). Renourishment for the Project is an ongoing effort expected to approach a mean four year cycle for beach renourishment for the Preferred Alternative. Renourishment efforts may have
a temporary and short-term impact on the biological resources on and near the shore. Removal of material from the offshore borrow site has a long-term impact on the nature of the borrow site. However, these impacts are not substantial since no significant resources within the borrow site have been identified.

4.25 Conflicts and Controversy

In recent years, resource agencies, scientists and some environmental organizations have expressed concern about the impact of beach restoration and maintenance activities on nearshore hardbottom resources. The controversy tends to surround three broad issues areas: (1) the extent to which beach nourishment activities impact reefs and hardbottom features, and biotic communities in the borrow and placement areas, (2) the duration or permanency of the impact and the capacity of the resource to recover from perturbations caused by beach restoration activities; and (3) the cumulative effect of multiple but unrelated projects in a region of the coast. In response to this controversy, the USACE has subjected the regulatory compliance determination for the Sector 7 Project for the applicant, Indian River County, to full review under the National Environmental Policy Act (NEPA). As there will not be any significant impacts to the physical, social and natural resources within the Project area, and EA was warranted to satisfy the NEPA requirement. The issues of concern are closely examined and the sufficiency of measures to avoid, minimize, and mitigate for impacts to hardbottom resources are reviewed. While no compensatory mitigation is required, it is anticipated that both physical and biological monitoring will be undertaken to document the effects of the fill activities on the nearshore habitat.

4.26 Uncertain, Unique, or Unknown Risks

Restoration of eroding sandy shorelines through periodic placement of sand from offshore borrow areas is a long established practice in Florida. Consequently, with respect to the means and methods for constructing the Project, general performance of the beach nourishment, and expected range of impacts, few, if any, risks are uncertain, unique, or unknown. The presence of hardbottom features offshore of the fill area, while not unique to this Project, is important and noteworthy, although no impacts upon them are anticipated.

4.27 Precedent and Principle for Future Actions

Neither the decision evaluated in this EA, nor the proposed Project is likely to create or establish new precedents or principles for future action. The USACE has an established record of decisions and actions with respect to all of the essential elements of the Project, including the environmental considerations, evaluation of alternatives, and the means and methods for mitigation of any impacted hardbottom resources.
4.28 Environmental Justice

No minority or low-income populations would be disproportionately affected by either the Preferred Alternative or the No-Action Alternative. The Preferred Alternative will not cause the displacement of any residents, nor will it eliminate jobs, low wage or otherwise. Therefore, the Preferred Alternative is in compliance with Executive Order 12898 as it pertains to Environmental Justice.

4.29 Environmental Commitments (Mitigation)

No mitigation is proposed since there will no direct, minimal indirect, and no cumulative loss of hardbottom habitat or other EFH resources in the project area.

4.30 Compliance with Environmental Requirements

<table>
<thead>
<tr>
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<td>Protection of Children (E.O. 13045)</td>
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<td>Environmental Justice (E.O. 12898)</td>
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<td>FC</td>
<td>FC</td>
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</tbody>
</table>

FC - full compliance; PC – partial compliance; NA - not applicable
5.0 LIST OF PREPARERS

5.1 Preparers

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Information</th>
</tr>
</thead>
<tbody>
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<td>Marine Biologist - Principal Author</td>
</tr>
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<td>Jason Croop, M.S.</td>
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<td>Coastal Engineer</td>
</tr>
</tbody>
</table>
6.0 PUBLIC INVOLVEMENT

6.1 Scoping and Draft EA

Since the project was designed to avoid any direct impacts on hardbottom habitat and EFH, minimize any downdrift indirect impacts, and result in no significant cumulative impacts on hardbottom habitat and EFH, an EA was determined by the Corps to satisfy the NEPA requirements. While pre-application meetings were held, no formal scoping meetings were required or conducted with the public or agencies. This EA fulfills the corps requirements under the NEPA.

6.2 Agency Coordination

The proposed Project has been coordinated with the following agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida State Clearinghouse, Florida State Historic Preservation Officer, Florida Game and Fresh Water Fish Commission, and the Florida Department of Environmental Protection.
7.0 REFERENCES

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BIOLOGICAL ASSESSMENT OF THE IMPACTS OF THE PROPOSED INDIAN RIVER COUNTY SECTOR 7 BEACH RESTORATION PROJECT ON COASTAL ENVIRONMENTS

DRAFT
February 2004
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1.0 EXECUTIVE SUMMARY

The Indian River County Board of County Commissioners has submitted an application to the U.S. Army Corps of Engineers and the State of Florida to request regulatory authorization to construct a beach restoration project along a portion of the County’s Atlantic shoreline. In order to comply with provisions of Federal law, the Corps of Engineers must consult with Federal wildlife agencies regarding the potential impacts of the proposed project on protected species and fishery resources. This Biological Assessment reviews the expected impacts of the proposed project and project alternatives on a wide variety of biological resources, including invertebrates, fishes, sea turtles, mammals and birds. The Biological Assessment is intended to serve as a summary of existing biological resources and anticipated potential impacts and is provided to the Federal agencies that must issue a biological opinion on the proposed project, ant to the state for state environmental regulatory review.

A brief introduction describes the regulatory and jurisdictional background of the reviewing Federal agencies, followed by an overview of the proposed project. Background information on the environments that may potentially be impacted by the project is found in section four, followed by a section summarizing the Federally protected species that may be impacted by the project. The remainder of the assessment outlines the anticipated effects of the project on sea turtles, sand beach environments, nearshore reef environments, offshore areas, and the anticipated impacts on fisheries and fish populations.

The proposed project is expected to impact sea turtle nesting, but the impacts are expected to be largely limited to the first sea turtle nesting season following project construction. The effect of the project on nesting turtles may be reflected primarily in a reduction of sea turtle nesting success (the proportion of turtles coming ashore that successfully nest) rather than hatch success (the proportion of eggs laid that hatch). Effects on sea turtle developmental habitat (the nearshore reef feeding areas for green turtles) are not expected to be significant due to the small percentage of the available feeding habitat that will be impacted by the proposed project.

The impacts of projects of this type on the biological communities of the sandy beach and the offshore sand borrow areas were reviewed. The prevailing opinion in the literature is that the most of such impacts are temporary in nature and limited in scope. Therefore no significant project impacts in these areas are expected.

The preferred alternative project is not anticipated to have any direct impact on nearshore reef habitat. There may be indirect impacts on reef habitat outside the direct impact area from turbid water resulting from project construction. Construction plans will include a fill containment dike and dewatering system to minimize the extent of this impact. This indirect impact is difficult to quantify, but is expected to be limited by the high tolerances of nearshore reef organisms to turbidity and the resilient nature of the major reef species. There is not expected to be an adverse impact on the structure and function of the nearshore reef environment.

Direct and indirect effects on fish and fisheries were also reviewed. In some cases it was possible to generate quantitative estimates of the level of impact. From these estimates it was
concluded that the proposed project would not result in a significant effect on the fish resources of Indian River County, or on recreational or commercial fisheries.

In summary, the proposed Indian River County beach restoration project will result in some adverse biological impacts that must be weighed against the project benefits to the mitigation of historical erosion losses, coastal property protection, preservation of endangered species habitat, recreational use, and tourism. In cooperation with State and Federal agencies, and with public input, it is expected that reasonable measures to minimize or mitigate unavoidable project impacts can be developed.
2.0 INTRODUCTION

2.1 Events Leading to this Assessment

The Indian River County Board of County Commissioners, in accordance with its Beach Preservation Plan, has made application to the Florida Department of Environmental Protection (FDEP) and the U.S. Army Corps of Engineers (USACOE) for a beach restoration projects along a portion of the County’s Atlantic coastline. The project location has experienced well-documented severe chronic erosion and suffered severe erosion damage and the total loss of several homes in the Hurricanes of 2004. Unless corrective measures are implemented, the County’s coastal resources will continue to diminish. The County’s immediate coastal area provides sea turtle nesting and southeastern beach mouse habitat (beaches and dunes), sea turtle foraging habitat (nearshore reefs), and ecologically important reef formations. Therefore, the County has prepared this Biological Assessment to submit to the USACOE in order to initiate consultation with the relevant Federal agencies responsible for evaluating the environmental impacts of the proposed project.

2.2 Purpose

This Biological Assessment was prepared for the USACOE for submission to the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). The Assessment provides information necessary for compliance with Section 7 of the Endangered Species Act of 1973 (as amended) and the Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

2.3 Endangered Species Act

Section 7 of the Endangered Species Act provides for interagency cooperation in that, “… each federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency does not jeopardize the continued existence of any endangered species or threatened species or result in destruction or adverse modification of habitat of such species…”

2.4 Essential Fish Habitat

The EFH provision of the MSFCMA requires that Federal agencies consult with NMFS when any activity proposed to be permitted, funded, or undertaken by a Federal agency may have adverse impacts on designated EFH.

2.5 Jurisdiction of the National Marine Fisheries Service

Under a memorandum of agreement with USFWS, the NMFS Office of Protected Resources has jurisdiction over all species of sea turtles within the waters of the United States. In the context of this assessment, potential adverse and beneficial impacts to foraging turtles and their developmental habitats are the purview of NMFS. The Habitat Conservation Division of NMFS
is the lead agency for EFH consultation. This consultation consists of an assessment of the impacts of a proposed action on federally managed fisheries and fish habitats.

2.6 Jurisdiction of the U.S. Fish and Wildlife Service

USFWS has jurisdiction over terrestrial wildlife and habitat issues, and for sea turtles when sea turtles move from the water on to land, and during the incubation and hatching of eggs. In the context of this assessment, USFWS will evaluate potential impacts of the proposed project that may affect sea turtle nesting, incubation and hatching.
3.0 PROJECT DESCRIPTION

This section is intended to provide a brief overview of the nature and extent of the proposed project. Detailed information is available in the documents cited herein. This section also contains a description of the project alternatives that are evaluated for potential impacts in Sections 6 through 10.

3.1 Project Areas

The proposed project area is located in Indian River County, Florida (Figure 1). The Indian River County shoreline was characterized and subdivided into seven distinct shoreline segments, or Sectors, numbered from north to south, for the purpose of shoreline evaluation. This Biological Assessment pertains to the proposed beach project along the shoreline contained within Sector 7. Sector 7 is located in southern Indian River County, from FDEP Reference monument R-94 to monument R-113. The Florida DEP Bureau of Beaches and Wetland Resources (BBWR) has designated the shoreline segment from R-103 to R-107 as a Critically Eroded Area.

The shoreline designated for restoration in the preferred alternative for Sector 7 extends from Indian River County DEP Reference monument R-97 south to R-108. The Sector 7 preferred alternative project area is 11,730 feet in length and is characterized by developed single-family properties and vacant single-family zoned parcels. The shoreline segment proposed for restoration has experienced recent volumetric erosion rates averaging 2.08 cubic yards per foot per year (cy/ft/yr) and shoreline erosion rates averaging 2.4 feet per year at 0 ft NGVD, based on shoreline change analyses conducted between 1986 and 2001. Sector 7 contains the highest erosion rates identified anywhere in Indian River County. A summary the preferred alternative project design features is provided in the following table. The Evaluation of Alternative Designs for Sector 7 Report (Applied Technology and Management 2002) and the Evaluation of Alternative Designs for Sector 7 Indian River County, Florida Addendum (Applied Technology and Management 2003), and the No-Impact Design Submittal dated December 29, 2004 provides detailed information on the project design and rationale, including quantities and distribution of beach fill material.

<table>
<thead>
<tr>
<th>PROJECT SECTOR</th>
<th>SHORELINE LENGTH (FEET)</th>
<th>FILL AMOUNT (CUBIC YARDS) *</th>
<th>FILL AMOUNT (CUBIC YARDS/FT) *</th>
<th>AVERAGE DRY BEACH WIDTH AT EQUILIBRIUM (FEET) *</th>
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<td>7</td>
<td>11,730</td>
<td>363,600</td>
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* Preferred Alternative

3.2 Offshore Sand Source

The location of the proposed offshore borrow area is shown in Figure 1. The criteria used for borrow area selection included: beach sand compatibility, adequate available volume, absence
of hardbottom habitats or cultural resources, and proximity to the fill areas. Extensive core sampling was conducted to determine the sedimentary characteristics of the site. The designated sites will be used only if sediment grain size analysis results indicate the sand is compatible with the native beach material. Analysis of a composite of the sediment cores indicates that the proposed primary borrow area could potentially provide 1.4 million cubic yards of beach quality sand (Applied Technology and Management 2001). The mean grain size of the proposed borrow area is 0.52 mm and the expected fine fraction of the borrow material is only 0.97 percent. Side scan sonar and magnetometer surveys have been completed and have revealed no hardbottom features or cultural resources in or immediately adjacent to the proposed borrow areas. Additionally, a towed video survey was conducted of the entire borrow area and a 400 foot buffer zone around the area in the summer of 2002. These surveys revealed no hardbottom, submerged aquatic vegetation, or other resources of concern (Dial-Cordy 2002).

3.3 Project Schedule

Restoration of beach Sector 7 is scheduled to begin in November 2005. All construction activities are scheduled to take place outside of the main part of the marine turtle nesting season.

3.4 Socioeconomic Studies

Socioeconomic and project cost and benefit analyses were conducted to assess the economic merits of the proposed project. These studies and analyses are contained in the documents “Indian River County Beach Preservation Plan Economic Analysis and Cost Allocation Plan” (Applied Technology and Management 1998) and “Indian River County Beach Preservation Plan Economic Analysis- Phase II: Funding Sources and Financing Plan” (Applied Technology and Management 1999b).

The storm protection benefit resulting from the beach nourishment project was computed for each parcel of property over a 30-year project horizon. The following factors were taken into consideration: 1) anticipated acreage and value of land loss if no action is taken to control erosion, and 2) construction and maintenance cost of erosion control structures which would be required if no action is taken. The aggregate net present value of the storm protection benefit for all properties within the project area is estimated at $7.64 million.

Recreation benefits associated with the proposed beach nourishment project were determined based on surveys of beach users on the Indian River County beaches. The total recreational benefit value is estimated as the average value of a day at the beach multiplied by the number of days spent on average at the beach. Over the projected 30-year project horizon, the net present value of the recreational benefits to the Sector 7 beaches is estimated at $2.53 million.

The total 30-year net present worth benefit associated with storm protection and recreational use of the nourished beach in Sector 7 is $10.17 million.
3.5 Project Alternatives Considered

This Assessment will evaluate the anticipated impacts of the preferred alternative design of the project and also the potential adverse and beneficial impacts for a full range of alternatives. The “no-action” alternative, a “full volume” alternative, a “reduced fill” alternative, a “six groin” alternative, and an “upland sand” alternative will be discussed for anticipated impacts in Sections 6 through 10.

3.5.1 The Preferred Alternative – No Reef Impact

The Preferred Alternative eliminates all projected direct impact to nearshore reef habitats while still providing some useful degree of storm protection and preservation of recreational and wildlife benefits. The level of fill placement is insufficient to maintain the 15 year level of protection originally envisioned for the project. Additionally, due to limited fill placement allowed in the most critical areas, the performance of this project will be highly variable.

The shoreline designated for restoration in the Preferred Alternative for Sector 7 extends from Indian River County DEP Reference monument R-97 south to R-108. The Sector 7 Preferred Alternative project area is 11,730 feet in length and is characterized by developed single-family properties and vacant single-family zoned parcels. The shoreline segment proposed for restoration has experienced recent volumetric erosion rates averaging 2.08 cubic yards per foot per year (CY/ft/yr) and shoreline erosion rates averaging 2.4 feet per year at 0 ft NGVD, based on shoreline change analyses conducted between 1986 and 2001 (Woods Hole Group Inc. 2002).

The Preferred Alternative design incorporates a uniform +9 ft NGVD berm, based on the existing berm elevation, and a dune enhancement feature. The design includes a total beachfill volume of approximately 363,000 cy, which includes the placement of 36,400 cy of sand for the dune enhancement feature. The design features tapered sections at the north and south limits of the project between T-98 and R-97 and between R-107 and R-108. The average volumetric placement is 24.6 cy/ft along the shoreline and the average increase in the shoreline from its current (post-hurricane) location to the estimated equilibrium shoreline is 30 feet. Within the area between R-102 and R-105, where hardbottom is closest to shore, only approximately 57,000 cubic yards of material could be placed to avoid hardbottom impacts. This equates to a fill volume density of 15.9 cy/ft and an average increase in shoreline position of 15 feet.

The dune crest elevation is +12 ft NGVD with a design 1V: 3H slope to the beach berm, and an average horizontal dune footprint of 32 feet. The average volume placement is 2.8 cy/ft, as the southern portion of the project area is heavily armored with very narrow beaches, allowing for little or no dune feature in these critical areas.

No fixed renourishment interval for the Preferred Alternative is proposed. The project is proposed to be rebuilt when the beach fill has eroded back to pre construction conditions. Unlike the other alternatives, no attempt would be made to maintain an increased beach width over the 30 year planning period.
3.5.2 The No-Action Alternative

The Indian River County Beach Preservation Plan Economic Analysis conducted in 1998 (Applied Technology and Management, 1998) examined the overall economic viability of the proposed beach nourishment project and quantified the expected 30-year costs if no action is taken. This analysis of storm damage and land losses determined the anticipated land loss from erosion if no additional sand, other than the sediment that is placed by the Sebastian Inlet Tax District, is placed into the system. This economic study quantified the value of land that would be lost, the construction cost of erosion control structures that would be required if the project is not built, and the maintenance costs of the erosion control structures. The study determined that without action to prevent the loss of upland property along the Sector 7 shoreline, oceanfront property owners will suffer direct economic losses. Those properties impacted by storm damage and land losses are:

- Privately owned, undeveloped, unprotected property (1,837 feet of project frontage) experiencing continued land loss;
- Privately owned, developed, unprotected, property (4,510 feet of project frontage) experiencing continued land loss due to erosional losses and storm damage, some requiring new seawall/revetment construction;
- Privately owned, developed, protected property, (682 feet of project frontage) requiring rehabilitation and/or replacement of existing shoreline armor; and,
- Roadways (185 ft of frontage) threatened or damaged as the result of continued land loss.

If the present sediment deficit is not corrected, the beaches will continue to erode and it is assumed that the oceanfront property owners will take whatever actions are in their own economic interest to protect their properties. If the major habitable structures on the property are in jeopardy of significant structural damage from yearly landward erosion or a 15-year storm event, it can be assumed that the property owners will armor the shoreline (i.e. construct an erosion control structure). However, seawalls alone do not alleviate the erosion problems and may transfer the problems to adjacent properties, whereby the entire shoreline in erosional areas will eventually be armored – thus fixing the shoreline position and potentially reducing marine turtle nesting habitat.

The Economic Analysis concluded that over the next 30 years, 7.1 percent of the project shoreline would be armored, costing $6.17 million (net present worth). Without the implementation of a beach nourishment plan, historical sand losses will not be mitigated and thereby the following results were determined to likely occur:

- Existing, recent erosion trends and shoreline armoring at Sector 7 will continue;
- Owner group litigation is likely; and,
- State of Florida cost share contribution from the Erosion Control Trust Fund will be lost.
As the beaches continue to erode in this State-designated Critical Erosion Area, beaches will narrow due to the presence of seawalls and development, as well as the beach’s encroachment on dune and upland vegetation. As erosion threatens waterfront properties, the anticipated result will be a proliferation of shoreline armoring structures and emergency stopgap measures to protect property. It is estimated that no action to control this erosion will result in additional shoreline armoring over what is expected with the project. As a result of this beach narrowing, sea turtle nesting habitat will be degraded, and in some areas, completely lost. While very narrow beaches are expected to still support nesting, under conditions where high tides reach the dune line on a daily basis, hatchling success would decrease dramatically due to inundation and nest washout.

3.5.3 The Full Volume Alternative

The Full Volume Alternative was designed to restore the beaches to a dynamic equilibrium along the project shoreline within Sector 7 and provide the highest possible shoreline protection level consistent with reasonable impacts to offshore resources. The Project area for the Full Volume Alternative and the other alternatives that follow extends from 95 feet north of DEP reference monument T-100 south to 105 feet south of T-107, for a total of 7,138 shoreline feet. Historic shoreline change data indicate that between 1972 and 1986, this project area shoreline was eroding at a rate of approximately 0.8 CY/ft/yr. More recent shoreline data show a trend of increasing erosion rates. Between 1986 and 2001 this project area shoreline was eroding at a mean rate of approximately 2.8 CY/ft/yr. (Woods Hole Group, 2002).

The Full Volume Alternative calls for a project design to provide a storm protective berm sufficient to sustain erosion-induced damages from a 15-year design storm event, advance fill to allow for expected post-construction erosion losses, an additional 10-year storm loss, and expected end losses. The 7,138-foot project length is based on a 6-year renourishment schedule, which was sought for cost effectiveness and realistic sand placement volumes.

A uniformly shaped fill area was designed resulting in a total fill (nourishment) volume of 459,700 cubic yards. The design calls for renourishment when the fill has been reduced to the amount expected to erode during a 15-year period storm event (i.e. 137,800 cubic yards). This is considered the minimum buffer to protect the existing upland structures. The renourishment volume was calculated to be 321,900 cubic yards (end losses + 10-year storm + annual erosion * 6-year maintenance interval). The results of the longshore sediment transport study conducted by ATM confirmed that a renourishment interval of 6 years is appropriate to meet design goals with respect to remaining volume (storm buffer). Continued monitoring of the area following project construction will be the best indicator of project performance and hence the optimal renourishment interval.

The volume of sand in the proposed beachfill template averages 62.4 cubic yards per foot which was determined according to design criteria as outlined herein as well as in the Beach Preservation Plan (BPP) (1988), the BPP Update (1998), the IRC Economic Analysis Reports (ATM, 1998 and 1999), and the Evaluation of Alternative Designs for Sector 7 Report (ATM, 2002), and Addendum (ATM 2003). The proposed beach fill project will result in an initial average dry beach width (from the toe of the dune feature to MHW) of 75 feet after equilibrium.
The uniform berm elevation of +9 feet NGVD was determined based on the existing berm elevations, the need for volume contained within the prescribed berm, and other successful beach nourishment projects along the east coast of Florida with similar seasonal high water and storm impact characteristics. The proposed beach design includes a beach face slope of 1 vertical to 10 horizontal (1V:10H) between the +9 feet NGVD berm crest and mean low water (MLW). This slope was chosen because it closely approximates the natural slope of the beach in the project area, and because the borrow area sand characteristics indicate the material can reasonably be expected to adjust to this geometry.

The sediment along the seaward edge of the construction profile will adjust seaward during the project construction and subsequent to placement of the fill. Profile geometry will adjust to a more natural equilibrium profile approximately coincident with the grain size characteristics of the nourishment material and based on the wave climate of the area. The profiles will naturally redistribute the initial sand placement/construction profiles to balance the constructive and destructive forces of the waves and currents acting on the beach. The mean grain size of the beachfill used in this analysis of the beach in Sector 7 was 0.52 mm, corresponding to the primary borrow area, the South Sub–Area 1 borrow area, which is found on the Indian River Shoal complex in the southern portion of the County.

A dune enhancement feature is also proposed to mitigate for historic dune losses, enhance protection of the upland areas, and preserve the coastal environment. The dune feature will tie into the natural backshore elevations with a landward slope of 1 vertical to 3 horizontal to the existing backshore where the existing dune elevation is below the proposed dune crest elevation. The seaward slope of the dune feature will also be 1V:3H from the designated dune crest elevation to the +9 feet NGVD design berm contour. The crest elevation of the proposed dune feature in Sector 7 is +12 feet NGVD. The average horizontal dune footprint will be 38 feet with an average volume of 2.4 CY/ft. The restored dune feature will provide a greater diversity of habitats for beach-associated flora and fauna, including the southeastern beach mouse, and will provide additional storm protection to the upland properties.

Numerous design iterations were performed to balance the minimization of hardbottom coverage impacts and the effectiveness of the resulting profile’s ability to meet the project goals. Applying the characteristics of the South borrow area material, the natural shape of the nearshore area corresponds extremely well to the predicted shape of the equilibrium profile in most of the project area. Alternatives which reduce the proposed design volume reduce the potential for hardbottom coverage, but also result in significant reduction of the design fill volume and berm width. This reduction in fill volume increases the frequency of renourishments in order to maintain storm protection, and increases adverse environmental impacts due to the more frequent renourishment events.

The total estimated construction cost for the Full Volume Alternative is $6.5 million. This total includes the estimated cost of the construction of an artificial reef to mitigate for an expected direct impact of 5.3 acres to the nearshore hardbottom. Based on a project horizon of 30 years, it is estimated that the project will incur 4 renourishments at 6-year intervals each at a cost of $3.5 million. The total 30-year net present worth cost of the Full Volume Alternative is $15.55
million. The total volume of sand placement over the 30-year planning period for the Sector 7 project under the Full Volume Alternative is 1,747,300 cubic yards.

The Full Volume Alternative would provide the greatest degree of shoreline protection, and reduce cumulative impacts to sea turtle nesting over the 30 year planning period, due to less frequent renourishment. The direct impact to an estimated 5.3 acres of nearshore hardbottom is significant, although this amount of reef represents less than 0.2% of the approximately 4,000 acres of total habitat of this type in Indian River County.

3.5.4 The Reduced Fill Alternative

The design for the Reduced Fill Alternative calls for the placement of 376,100 cubic yards of sand along the 7,138 ft project area within Sector 7. The average unit sand placement is 50.5 cubic yards per foot of shoreline, which includes a dune feature at +12 feet above mean sea level (NGVD) and material placement for upland structure protection from a 15-year return period storm event. Applying the same design principles as with the Full Volume Alternative, the project is expected to require renourishment every 4 years. Thus the remaining sand quantity prior to each maintenance event is approximately equal to the 15-year design storm event (i.e. 137,800 cubic yards). This is considered the minimum buffer to protect the upland structures. The renourishment volume is 238,300 cubic yards. The average additional dry beach width is estimated at 55 feet following initial adjustment of the profile following restoration.

Smaller sand placement quantities in the beachfill template associated with this alternative would be expected to result in less coverage of juvenile turtle foraging habitat, will make possible sedimentation of feeding areas and interstitial spaces in the reef structure less likely. In addition, this alternative is expected to require a slightly shorter construction window to accomplish the initial restoration. Cumulative impacts to sea turtle nesting over the 30-year project life would be increased due to the short 4-year renourishment interval.

The total estimated construction cost for the 376,100 cubic yards Alternative is $5.2 million. Based on a project horizon of 30 years, it is estimated that the project will incur 7 renourishments at 4-year intervals each at a cost of $2.9 million. The total 30-year net present worth cost of the Reduced Fill Alternative is $18.15 million. The total sand volume anticipated to be placed under the reduced fill alternative over the 30-year planning period is 2,044,200 cubic yards. It should be noted that, due to the short renourishment interval associated with this alternative, the total sand volume placement is actually higher than for the preferred alternative, even though a smaller beach is being constructed and maintained.

The reduced fill volume would result in a reduction of direct impact to nearshore hardbottom habitat, estimated at 3.2 acres.
3.5.5 The Six Groin Alternative

The six groin alternative specifies 459,700 cubic yards of sand placement, in the same template as the Full Volume Alternative, but with the addition of six shore-perpendicular groins spaced strategically throughout the project area. Groin design and placement locations are optimized to trap sand being transported along the shoreline, while allowing some natural sand bypassing to occur. The Sector 7 Evaluation of Alternative Designs for Sector 7 Indian River County, Florida Addendum (Applied Technology and Management 2003) provides figures showing the proposed groin locations and details of groin materials and design. Groins would vary in length from 80 to 132 feet. The landward terminus of the groins would be at the dune line or erosion control structure, and the seaward terminus of the groins would be landward of the construction Mean High Water (MHW) shoreline, but somewhat seaward of the predicted equilibrium shoreline. Groins would be constructed of natural limestone rock, with a crest width of about 12 feet, a crest elevation of about 10 feet, and side slopes of 3:1.

The total estimated construction cost for the six groin alternative is $8.0 million. Annual groin maintenance will likely be necessary, with costs estimated to be approximately $35,000 per year. Based on a project horizon of 30 years, it is estimated that the project will incur 4 renourishments, at 7-year intervals, each at a cost of $3.5 million. The total 30-year net present worth cost of the six groin alternative is $17.20 million. The total sand volume requirement over the 30-year planning period for the six groin alternative is 1,747,300 cubic yards.

Impacts to nearshore hardbottom areas would be approximately 5.3 acres, equal to the impacts for the Full Volume Alternative. The increase in the renourishment interval in the six groin alternative, from 6 to 7 years, would decrease the cumulative impacts of repeated beach fills to nesting sea turtles; however, the groins themselves would eliminate some nesting habitat and possibly interfere with nesting behavior and/or hatchling dispersal.

3.5.6 The Upland Sand Alternative

The Upland Sand alternative specifies 459,700 cubic yards of sand placement, in the same template as the Full Volume Alternative, but with a sand source from upland areas (sand mines) rather than offshore borrow areas. The accompanying Environmental Assessment (EA) provides a characterization of three potential upland sand sources for the project. Sand would be delivered to the project area by truck, and transported along the beach and placed by bulldozers and other heavy equipment.

The total construction cost for the upland sand alternative has not been estimated, but is assumed to be similar to that for offshore dredged material. Assuming a similar grain size and therefore a similar renourishment interval, the total sand volume requirement for the upland sand alternative over the 30 year planning period is 1,747,300 cubic yards.

Impacts to nearshore hardbottom areas would be approximately 5.3 acres, equal to those of the Full Volume Alternative.
4.0 DESCRIPTION OF ENVIRONMENTS

This section characterizes the nature of the environments found near the proposed project area, which may be impacted by the project.

4.1 Location

Indian River County is located on the east central coast of Florida. The oceanfront portion of the County is a barrier island (Orchid Island) separated from the mainland by the Indian River Lagoon. The County has 22.4 miles of Atlantic Ocean coastline, consisting of high-energy sand beaches with extensive shallow reef formations immediately offshore. A coastal inlet (Sebastian Inlet) defines the northern boundary of the County. Typical of most inlets, the interruption of longshore sand transport has resulted in severe erosion of the downdrift beaches.

4.2 The Beach Environment

4.2.1 Geological

Indian River County beaches are composed of unconsolidated sediments deposited along the Atlantic Beach Ridge in recent times (less than 12,000 years before present). Beaches are geologically very dynamic environments, with sand moving inshore and offshore seasonally. Sand is transported parallel to the coast by longshore currents, and influenced by the migration of ephemeral natural inlets through the barrier island (Zarillo and Liu 1990). Recent stabilization of inlets along the barrier island coast, including Sebastian Inlet, have resulted in significant adverse impacts on sand transport quantities and shoreline erosion along the coastline, contributing to beach losses “downstream” of the inlet.

4.2.2 Biological

The high-energy beach is a challenging environment for animal and plant life. Species diversity is typically low, although species adapted to sandy beaches may be highly abundant. Typical beach fauna in the proposed project area includes the mole crab (*Emerita talpoida*), surf clam (*Donax variabilis*) and ghost crab (*Ocypode quadrata*). These and other beach infauna provide forage for a wide variety of shorebirds such as plovers (*Charadrius spp.*), willets (*Catoptrophorus semipalmatus*), and ruddy turnstones (*Arenaria interpres*). Drift algae and sargassum stranded on the beach may support large numbers of insect and other invertebrate life. As elevation increases, conditions become less severe for the establishment of plant life. Tendrils of various plants extend down the beach, notably the beach morning glory (*Ipomoea pes-capre*). As the dune crest is approached, other salt tolerant plants are found such as sea oats (*Uniola paniculata*), sea rocket (*Cakile sp.*) and beach elder (*Iva imbricata*). Sparsely vegetated beaches are preferred nesting habitat for the least tern (*Sterna antillarum*), listed as a threatened species by the Florida Fish and Wildlife Conservation Commission. Although there is no positive evidence of their occurrence in the Sector 7 project area, the sea oat zone high on the dune provides appropriate habitat for another threatened species, the southeastern beach mouse (*Peromyscus polionotus niveiventris*).
Beaches in Indian River County also provide nesting habitat for at least three species of sea turtles, as will be discussed in Section 5.

4.3 Offshore Borrow Areas

4.3.1 Geological

The area selected as the sand source for the proposed project (Figure 1) is located on an offshore sand shoal in about 25 to 30 feet of water three miles or less offshore. This sand shoal was formed in the recent geologic past by the migration of relic inlets through the barrier island (Moody 1964). As a tidal inlet migrates, its ebb shoal becomes elongated and eventually detaches from the shoreline due to rising sea level and the landward retreat of the shoreline. There are a number of these shoal formations along the local coast, including St. Lucie, Pierce, and Capron Shoals in St. Lucie County, and Indian River Shoal located offshore of southern Indian River County and northern St. Lucie County. The shoal sediments are mostly beach-compatible sands, as might be expected from their geological origins. Deposits consist of deep layers of high quality sands (core samples from Indian River Shoal indicate unconsolidated sand over 15 feet deep), making this shoal a viable sand source for beach restoration.

4.3.2 Biological

These offshore sand habitats support a diverse fauna, although there has been comparatively little research attention in this environment. There are several studies of invertebrates and fishes from the open sand habitat in the general proposed project area. Johnson (1982) collected over 188 species of invertebrates in benthic grab samples from the Capron Shoal area off Fort Pierce Inlet. In a study offshore of Hutchinson Island in St. Lucie County, Futch and Dwinell (1977) collected lanclets (sand dwelling chordates in the subphylum Acrania) in densities as high as 1,750 per square meter. Gilmore et al. (1981) collected 194 species of fishes from open shelf sand habitats in the Indian River County area. Flatfishes, searobins, and cusk eels, along with an assortment of batfishes and skates, dominated the fish fauna.

There is some information on the extent to which offshore sand shoals like the proposed borrow areas differ from the open sand habitat in general. In the early 70’s, extensive baseline ecological monitoring was conducted offshore of Hutchinson Island in St. Lucie County in conjunction with the licensing of the St. Lucie Nuclear Power Plant. These studies included physical and chemical analyses, and phytoplankton, zooplankton, invertebrate, and fish studies. The results were published in a series of Florida Department of Natural Resources publications. The offshore stations established for these studies included one station on Pierce Shoal, an offshore sand shoal similar in origin, depth, and offshore position to the proposed borrow areas on Indian River Shoals. Three other stations were located in sand habitats off the shoal. Phytoplankton studies (Tester and Steidinger 1979) showed that of the four offshore stations, the shoals station had the lowest chlorophyll a levels, the lowest rate of primary productivity, and the lowest phytoplankton diversity. The shoals station ranked third out of four in total zooplankton abundance (Walker et al. 1979). Arthropod populations were sampled extensively over a three year period using both grabs and trawls and including both day and night samples (Camp et al.
The 34 species collected at the shoals station had arthropod populations less than half of any of the other offshore stations. The arthropod density in the grab samples was significantly lower at the shoal station than at the other stations. Fishes were also sampled over a three-year period at the same stations, using a 3.7m otter trawl capable of sampling both benthic and water-column fishes. The shoal site had the lowest number of species and the lowest fish density of any of the offshore stations. The authors attributed the paucity of fishes at the shoals site to the relative lack of invertebrate prey on the shoals (Futch and Dwinell 1977).

4.4 Nearshore Hardbottom Reefs

4.4.1 Geological

The underlying material of the nearshore reef system off Indian River County is coquina rock limestone of lithified sands and shell typical of the Anastasia formation found along much of the east central coast of Florida. Like the Atlantic Coastal Ridge and the offshore reef tracts, this formation was created during periods of sea level change and parallels the present day coastline.

Some of the present nearshore reef system was uncovered by the recession of the shoreline in historic time. Beach profile measurements from 1972 show that some present day well developed reef areas closest to shore were buried under the beach/dune system in 1972, and in some cases more recently.

Apart from its biological value, the reef structure itself may help protect the coastline from erosion and traps sediments, providing for the actual progradation of beaches in some instances (Kirtley and Tanner 1968). Perkins et al. (1997) produced maps of the nearshore hardbottom habitat offshore of Indian River County as part of the SEAMAP program. They characterize the reef habitat as being essentially continuous and up to ½ mile wide. Calculations based on digital analysis of SEAMAP aerial photography taken in the summer of 1993 yield an estimate of approximately 3,740 acres for total nearshore reef habitat in Indian River County.

4.4.2 Biological

The keystone species for the nearshore reef community is the reef building tube worm *Phragmatopoma caudata (= lapidosa)*. These animals construct much of the reef habitat, using coquinoid rock outcroppings as substrate. Zale and Merrifield (1989) provide a review of the species and its ecology. Both the rock substrate and the worm reef provide the foundation for a diverse community of algae, invertebrates, and fishes. Nelson (1989) found 62 species of algae and 263 species of invertebrates on the nearshore reefs near Sebastian Inlet, and suggested that this number may be conservative. Nelson also found extraordinary densities of invertebrates associated with the *Phragmatopoma* community, with densities of 40,000 to 50,000 individuals per square meter of isopods and amphipods. More extensive sampling by Gore et al. (1978) focused on crustaceans on reefs adjacent to the proposed project area. They found 96 species of decapod and stomatopod crustaceans within or adjacent to the worm rock reef. The Nelson study found species richness ranged from 45-93 on the most inshore reefs, from 36-83 in the intermediate zone, and 53-119 on the most offshore reefs. Nelson concluded that while considerable biodiversity was present in all areas, greater sediment movement and increased
turbidity may keep the inshore an intermediate reefs somewhat less developed than those of higher relief located farther offshore.

Environmental surveys in the Indian River County nearshore area have identified four distinct hardbottom habitat classification types (Applied Technology and Management 2001). The types include:

- Type 1 – Non-hardbottom sand habitat in the mapping areas
- Type 2 – Algal community with low relief rock
- Type 3 – Inshore worm rock
- Type 4 – High relief algal/sponge community
- Type 5 – High relief algal/sponge community with worm rock

It is likely that the hardbottom habitat subsets have different habitat values for fish and invertebrate fauna. For example, the high relief Type 5 community may be the most appropriate for adult fishes and spiny lobster, while the lower relief communities may be ecologically important primarily as juvenile fish and invertebrate settling and developmental habitat.

Gilmore et al. (1981), Futch and Dwinell (1977), and Lindeman and Snyder (1999) studied fish communities on nearshore hardbottom habitat in the general area of the proposed project. The most comprehensive study is Gilmore et al. (1981), who used a variety of methods, including ichthyocides, to develop a comprehensive inventory of species. Gilmore et al. found a total of 107 species of fishes on “surf zone” reefs (coquinoid-sabellariid reefs 0-3m deep, equivalent to those adjacent to the project area) between Sebastian and St. Lucie Inlets. Five species dominated the total number of individuals. These include two blennys, *Labrisomus nuchipinnis* and *Scartella cristata*, two grunts, *Anisotremus virginicus* and *Haemulon parrai*, and one porgy, *Diplodus holbrooki*. Species were tabulated semi-quantitatively, with each species ranked as unknown, rare, occasional, frequent, common, or abundant. The seventy-six species that were ranked as frequent, common, or abundant are listed in Table 1.

4.5 Water Column Habitat

4.5.1 Oceanographic

The water column, or neritic, habitat consists of the waters overlying benthic habitats to the edge of the continental shelf. Coastal waters offshore of central Florida are an admixture of shelf waters and Florida Current (Gulf Stream) water, and variations in the path of the Florida Current dramatically affect water column habitats (South Atlantic Fishery Management Council 1998). Upwelling of deep water along Florida Current frontal boundaries is an important source of nutrients to continental shelf waters (SAFMC 1998).

4.5.2 Biological

Since most marine species spawn pelagic eggs, the neritic habitat is important to a wide variety of fish and invertebrate species at some point in their life history. The Florida Current serves as an important source of continual replenishment for local waters, as many larval and juvenile
fishes and invertebrates are transported into the neritic zone from tropical waters to the south. There are also large numbers of species that inhabit the water column as adults. 200 species of adult fishes have been documented from neritic habitats off the east central Florida coast (Gilmore et.al. 1981). Many of the larger species, such as mackerels, tunas, and billfishes, make seasonal migrations north and south along the coast in the neritic zone.
5.0 BIOLOGICAL INFORMATION ON PROTECTED SPECIES

This section summarizes available information on the biology of protected species potentially affected by the proposed project, both generally and specifically to the project area.

5.1 Sea Turtles

Five species of sea turtles are found in the waters off Indian River County, and three species have been documented as nesting on Indian River County beaches. The loggerhead is responsible for the vast majority of the nesting, although recent data shows an increasing statewide trend for nesting by the green turtle and particularly by the leatherback.

5.1.1. Loggerhead Sea Turtle (Caretta caretta)

5.1.1.1 General Information

The loggerhead sea turtle has been Federally listed as a threatened species since 1978. Loggerheads are circumglobal in distribution in tropical and temperate waters. The southeast U.S. coast, and particularly Florida, is considered to be the most important rookery in the western hemisphere for loggerheads (NMFS and USFWS 1991a). Recent studies have revealed three genetically distinct nesting populations in the southeast U.S.: the northern nesting population (North Carolina to Cape Canaveral), the South Florida population (Cape Canaveral to Collier County), and the Florida Panhandle population (Franklin to Escambia Counties, Florida) (Bowen et al. 1993). Trends in Florida nesting were assessed by Witherington and Koppel (in press), who analyzed loggerhead nesting for thirty nesting beach sites in Florida, included in the Florida Index Nesting Beach program, and concluded that loggerhead nesting appeared to be stable or increasing over the period from 1989-1998.

Loggerheads nest in the southeast U.S. from April through September, with the peak nesting in June and July (NMFS and USFWS 1991a). The nesting process is remarkably stereotyped, and is described in Bustard et al. (1975). Hatchlings emerge primarily at night, and swim offshore in a “frenzy” until they arrive at offshore weed and debris lines (Carr 1986) (Wyneken and Salmon, 1992). Post hatching turtles from the Florida coast enter the currents of the North Atlantic Gyre, eventually returning to the western Atlantic coastal waters (Bowen et al. 1993). When loggerheads reach a carapace length of approximately 40-60 cm, they leave the pelagic environment and move into various nearshore habitats (Carr, 1986). In the United States, developmental habitats for loggerheads are found from Texas to Nova Scotia (Turtle Expert Working Group 1998). As they approach adult size of about 83 cm carapace length (Ehrhart et al. 1996) loggerheads leave the developmental habitats. Adult loggerhead foraging grounds for the South Florida nesting population are found in the Caribbean basin, the Gulf of Mexico, and along the eastern seaboard of the U.S. (Meylan et al. 1983). Abundances of adult loggerheads in Florida coastal waters are much lower in months outside of the nesting season (Magnuson et al. 1990).
5.1.1.2 Site Specific Information

Juvenile and subadult loggerheads are found throughout the year in the Indian River Lagoon and the offshore reef areas of Indian River County. In 1989, Dr. Llewellyn Ehrhart with the University of Central Florida (UCF) began conducting turtle netting during the summer over a sabellariid worm reef near Sebastian Inlet. In the ongoing netting study by the University of Central Florida marine turtle research program (Ehrhart et al. 1996) very few loggerhead turtles have been captured on the nearshore wormrock reefs. However, large numbers of captures at the Florida Power and Light Company St. Lucie Nuclear Power Plant (Quantum Resources, Inc. 1999), suggest that juvenile loggerheads use the nearshore habitat in this general area. In 2001 and 2003, offshore surveys were conducted in the nearshore area to collect information on the abundance of sea turtles in Indian River County waters (Inwater Research Group, 2003). This survey used observers in a small boat to enumerate turtles observed at three different locations (north, central, and south county) and at three different distances offshore (300, 600, and 1200 feet). Abundances were expressed as observations per kilometer of transect. The survey found loggerhead abundance was relatively evenly distributed throughout the county, with about 0.2 observations per kilometer. The south study site, which includes the Sector 7 project area, had an average loggerhead abundance of 0.2 observations per kilometer. A summary Table of the results of the surveys is provided below.

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<th>TRANSECT</th>
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<th>2003</th>
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</table>
There is no countywide sea turtle nesting survey in Indian River County, but the Florida Fish and Wildlife Conservation Commission (FFWCC) Statewide Nesting Beach Survey (SNBS) program has data collected from a variable number of kilometers of beach in the County since 1980. In the last decade (1990-1999) the average number of loggerhead nests per kilometer of beach surveyed in the County was 154 nests/km. With 35.6 km of Indian River County shoreline, this figure yields an estimate of mean annual loggerhead nesting within the County of 5,482 nests. As discussed in Section 6.1.1, the limited data available for the Sector 7 project area suggest an average annual nesting level for loggerheads in Sector 7 of 167 nests.

5.1.2  Green Sea Turtle (*Chelonia mydas*)

5.1.2.1 General Information

The green turtle was listed under the Endangered Species Act (ESA) in 1978, and the Florida nesting population is currently listed as endangered. Green turtles are found worldwide in tropical and subtropical waters. Major green turtle rookeries in the Western Hemisphere occur on South Atlantic islands and the Caribbean basin. Most continental U.S. nesting of the green turtle takes place on the Florida East Coast south of Cape Canaveral (NMFS and USFWS 1991b). Green turtles show a similar life history pattern as loggerheads, but they leave the pelagic phase and enter developmental habitats at a considerably smaller size, about 20-25 cm carapace length (Magnuson et al. 1990). Typical developmental habitats are shallow, protected waters where seagrasses are prevalent (Carr et al. 1978), but small green turtles are also commonly found in reef environments where attached algae is present (Ehrhart et al. 1996) (Coyne 1994). It has been suggested that green turtles in foraging habitats may tend to specialize in either algae or seagrass forage, as individual turtles with intestinal microbial flora adapted to aid in seagrass digestion would digest algae less efficiently, and vice versa (Bjorndal 1985).

Green turtles nesting in Florida have a minimum size of 83.2 cm carapace length, but they appear to leave Florida developmental habitats by about 60-65 cm carapace length (Witherington and Ehrhart 1989), perhaps migrating to the southeastern Caribbean. The majority of green turtle nesting in Florida takes place in July, August, and early September. Witherington and Koppel (2000) reviewed green turtle nesting on thirty beach sites included in the Florida Index Nesting Beach program. They concluded that green turtle nesting in Florida was stable or increasing over the period from 1989-1998.

5.1.2.2 Site Specific Information

Indian River County contains two significant developmental habitats for green turtles, the Indian River Lagoon and the nearshore reef system (Ehrhart et al. 1996). In 1989, Dr. Llewellyn Ehrhart with the University of Central Florida (UCF) began conducting turtle netting during the summer over a sabellariid worm reef near Sebastian Inlet. More juvenile green turtles were caught per unit effort (CPUE) on the reef than at a nearby site in the Lagoon. CPUEs recorded on the nearshore reef were the highest recorded for any capture program on record (L. Ehrhart, pers. comm.).
These data suggest that there might be a higher number of turtles inhabiting the reef than the lagoon, at least during the summer. An alternative explanation is that capture rates on the reef may be higher because the foraging area is more concentrated over the reef and therefore capture techniques are more effective. Statistically significant differences in CPUE were found between years in the reef turtle captures, but the authors suggested that differences among years might reflect differences in surf conditions and water clarity, which affect netting success, rather than differences in actual turtle abundance. Although turtles captured on the reef were similar in size to those captured in the lagoon, migration between the two habitats appears to be minimal, despite the presence of a nearby inlet (D. Bagley, unpublished data).

In 2001 and 2003, offshore surveys were conducted in the nearshore area to collect information on the abundance of sea turtles in Indian River County waters (Inwater Research Group, 2003). This survey used observers in a small boat to enumerate turtles observed at three different locations (north, central, and south county) and at three different distances offshore (300, 600, and 1200 feet). Abundances were expressed as observations per kilometer of transect. The survey found marked differences in green turtle abundance throughout the county, with 2.4 observations per kilometer in the north study site, near Sebastian Inlet. The south study site, which includes the Sector 7 project area, had a much lower average green turtle abundance of 0.27 observations per kilometer. Data from the surveys is summarized below.

**INDIAN RIVER COUNTY NEARSHORE TURTLE ABUNDANCE SURVEY**

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<tr>
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<td>0.33</td>
</tr>
<tr>
<td>South 300</td>
<td>0.42</td>
<td>0.17</td>
</tr>
<tr>
<td>South 600</td>
<td>0.75</td>
<td>0.08</td>
</tr>
<tr>
<td>South 1200</td>
<td>0.25</td>
<td>0.0</td>
</tr>
<tr>
<td>Total South</td>
<td>0.47</td>
<td>0.08</td>
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</tbody>
</table>
Some limited dietary analysis has been done on green turtles captured on the reef by Karen Holloway-Adkins of UCF. The major food of these turtles was found to include marine algae of the genera *Bryothamnion, Gelidum, Gigartina, Hypnea, Rhodymenia, Bryocladia,* and *Soliera* (red algae) and *Caulerpa* and *Ulva* (green algae).

There is no data available on the seasonality of use of this habitat by juvenile green turtles. The Florida Power and Light Company St. Lucie Power Plant, located approximately 60 km south of the UCF study site, also samples turtles from the nearshore ocean environment. FPL data show juvenile green turtle captures tend to be distributed more or less evenly throughout the year (Quantum Resources, Inc. 1999). The UCF researchers also capture juvenile green turtles at the Trident submarine basin in Port Canaveral (approximately 100 km to the north of Sebastian Inlet). This area is thought to be an adjunct of the nearshore developmental habitat. Juvenile green turtles are present in the Trident basin all year.

There is some indirect evidence that suggests that the suitability of nearshore reefs in the proposed project area for juvenile green turtle foraging may be limited to part of the year. Nelson (1989) noted a great seasonal reduction in algal species richness (56 summer vs. 16 winter) on the nearshore hardbottom reefs at Sebastian Inlet. Also, the hardbottom mapping and characterization study conducted for this proposed project showed a considerable reduction in algal standing crop in the winter months (B. Baca, pers. comm.). An examination of Sea Turtle Stranding and Salvage Network (STSSN) data might be used to infer seasonal use patterns, but variations in stranding levels may be confounded by seasonal variation in wind patterns, fishing seasons and patterns of recreational use of beaches, which affects reporting levels.

Nesting activity of the green turtle in Indian River County was estimated from FFWCC Statewide Nesting Beach Survey data in the same manner as that reported in Section 5.1.1.2 for loggerheads. Data for 1990-1999 yields a mean nesting density of 4.2 nests per kilometer of beach surveyed, for an overall countywide annual nesting estimate of 150 nests. As discussed in Section 6.1.1, the limited data available for the Sector 7 preferred alternative project area suggest an average annual nesting level for green turtles in Sector 7 of four nests.

5.1.3 Leatherback Sea Turtle (*Dermochelys coriacea*)

5.1.3.1 General Information

The leatherback sea turtle was Federally listed as endangered in 1970. Leatherbacks are found worldwide in pelagic waters from the tropics to near the Arctic and Antarctic Circles. Nesting primarily occurs on the Pacific coast of Mexico and the Caribbean coast of South America, with some continental US nesting in Florida. During the period from 1979 to 1992, over 90% of Florida leatherback nesting occurred in St. Lucie, Martin, and Palm Beach counties (Meylan et al. 1995). An analysis of Florida Index Nesting Beach Survey data indicates a statistically significant increase in Florida leatherback nesting over the period from 1989-1998 (Witherington and Koppel, 2000).
5.1.3.2 Site Specific Information.

Leatherback turtles are virtually unknown from the inshore waters of Indian River County, apart from nesting females. Nearshore turtle abundance surveys conducted in Indian River County did not have any leatherback observations. FFWCC statewide nesting beach survey data for 1990-1999 show a mean leatherback nesting density of 0.23 nests per kilometer. This yields an estimate for annual leatherback nesting in Indian River County of 8 nests. As discussed in Section 6.1.1, the limited data available for the Sector 7 preferred alternative project area suggest an average annual nesting level for leatherbacks in Sector 7 of two nests.

5.2 Other Protected Species

Other protected marine turtle and marine mammal species potentially found in Indian River County either occur in very low abundances or cannot reasonably be expected to be significantly impacted by the proposed project, and are not reviewed here. A search of the US Fish and Wildlife Service GIS database for occurrence of protected species in the proposed project sectors revealed no protected plants or terrestrial animals, and 4 species of non-listed shorebirds (T. Adams, pers. comm.). Five protected species of vertebrates, the piping plover, the least tern, the southeastern beach mouse, the northern right whale, and the West Indian manatee, may potentially occur in the proposed project area and will be discussed briefly herein.

5.2.1 Piping Plover (*Charadrius melodus*)

The piping plover is listed as a threatened species at both the state and Federal level. The piping plover is also protected under the Migratory Bird Treaty Act. Piping plovers are migratory, and are found in Florida from September through March (USFWS 1995). Piping plovers use the sandy shore as a feeding area, appearing to prefer more sheltered beach environments rather than the high-energy Atlantic coast beaches. Surveys have found that the plover is most often observed at the accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets (USFWS 1995). Piping plovers have been observed by rangers at the Sebastian Inlet State Recreation Area on the beach south of the inlet (Gayle Stewart, SISRA, pers. comm.).

5.2.2 Least Tern (*Sterna antillarum*)

The least tern is a small member of the gull family (Laridae) that is listed by the state as a threatened species and is federally protected under the Migratory Bird Treaty Act. The least tern winters in South America and nests in Florida in the summer. Terns arrive in Florida each year in late March or early April and nesting usually begins in late April. Least terns are colonial nesters and traditionally choose open sandy areas on beaches and sand spits, although they may also use flat, gravel-topped roofs in many areas. Terns feed diurnally on small fish near the surface by diving, and, as a result, require reasonably clear water for successful foraging. As a ground nesting bird, least terns are impacted by high levels of human activity on beaches and predation from wild and domestic animals. Locally, least terns are known to nest on sandbars and spoil areas in Sebastian Inlet State Recreation Area.
5.2.3 Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)

The southeastern beach mouse is listed as a threatened species at both the Federal and state levels. The species has been found on barrier islands on the Florida East Coast from Palm Beach through Volusia Counties. Preferred habitat for the mouse appears to be the dune crest and backdune habitat dominated by the sea oat *Uniola paniculata*. The decline of the beach mouse has been attributed to loss of habitat from beach erosion and coastal development, as well as from predation by domestic pets. Southeastern beach mice have historically been documented within the primary dune area in several locations in the County, including Sebastian Inlet State Recreation Area, Treasure Shores Park, and several private properties. Populations have declined steadily throughout the 1990’s in most areas of the County. Annual trap surveys conducted in the Indian River County portion of the Sebastian Inlet State Recreation Area from 1995 through 1999 have fluctuated between 1 and 6 individuals (Alice Bard, pers. comm). It appears that the species may have become recently extirpated in the beach habitat throughout much of its local range, presumably due to erosional habitat loss (L. Ehrhart, pers. comm.). There is no information specific to the Sector 7 project area on the possible presence of the beach mouse. The fact that the area is largely built out, and little native pioneer dune vegetation remains due to erosion and seawalling, reduces the likelihood that the southeastern beach mouse occurs in Sector 7.

5.2.4 Northern right whale (*Eubalaena glacialis*)

The northern right whale is a Federally listed endangered species, and is also protected under the Marine Mammal Protection Act. This is a highly migratory species, summering in the Canadian Maritime Provinces and wintering in the Southeastern Atlantic and Caribbean. Adults and dependant calves routinely travel close to shore off the Florida coast (Schmidly 1981). The time of peak occurrence in the waters off Indian River County (December through March) corresponds to the construction period of the proposed project.

5.2.5 West Indian Manatee (*Trichechus manatus*)

Manatees are Federally protected under both the Endangered Species Act and the Marine Mammal Protection Act, as well as under Florida law. Manatees are generally restricted to the Florida peninsula and Georgia coast, although they occasionally wander as far as Louisiana and Virginia (Geraci and Lounsbury 1993). Manatee habitat includes shallow, protected lagoons and freshwater systems. Manatee use of the open ocean is infrequent and generally limited to travel between favored habitats (Hartman 1979). In summer months, manatees range widely between habitats (particularly on the Florida East Coast), while from November to April, they are generally concentrated in areas near warm water refuges (Reid et al. 1991). Manatee presence in nearshore ocean areas off Indian River County during the November through April period is unlikely (John Morris, Florida Tech, pers. comm.).
6.0 ANTICIPATED EFFECTS ON MARINE TURTLES

This section provides a general discussion of the nature of potential effects of beach restoration projects on marine turtles, and a specific discussion of the anticipated effects of the proposed projects and the alternatives.

Restored beaches often differ from natural beaches in several important features that affect their suitability for sea turtle nesting. If sands used for restoration differ markedly from natural beach sands in grain size distribution and color, then sediment temperature, moisture content, and gas exchange may be affected, all of which affect the nest incubation environment. Renourished beaches may show high levels of sand compaction, which affects the ability of turtles to nest, the incubation environment, and hatchling emergence success. These changes in physical characteristics, together with the unnatural “as-built” profile of the restored beach, may result in reduced reproductive success during one or more nesting seasons following construction.

As restored beaches equilibrate to a more natural profile, steep vertical escarpments often form along the seaward edge of the constructed beach berm. These “scarps” present a physical barrier to nesting turtles. Additionally, as beach profiles equilibrate, losses of nests laid in the seaward portions of the renourished beach due to erosion may be high. A review of these potential impacts is provided by Crain et al. (1995). Steinitz et al. (1998) have postulated a cyclical trend of impacts on nesting based on long-term observations from a renourished beach at Jupiter Island, Florida. They found that nesting densities were low on highly eroded beaches, as might be expected. Following the construction of a beach restoration project, although the number of crawls increased, low nesting success caused the nest density to remain low. After two years post construction, nesting density was considerably higher than pre-construction levels and was similar to the nesting density found for a non-eroded control beach. As the renourished beach eroded and narrowed, nest densities declined until they approached pre-construction levels. The next renourishment episode began the cycle again.

Most of the detrimental effects of beach renourishment projects have been limited to effects on nesting success (the proportion of turtles emerging from the sea that successfully nest) (Nelson and Dickerson 1988). Reductions in hatching success (the proportion of eggs laid that hatch or result in emergent hatchlings) have been reported less frequently (Ehrhart 1995; Ecological Associates 1998). Trindell et al. (1998) provide a comprehensive review of sea turtle monitoring data associated with 27 beach restoration projects constructed in Florida since 1987. Where appropriate, data were pooled for statistical comparison with available background nesting data. Overall, they found that nesting success was significantly reduced in the first post construction nesting season, but a significant difference was absent in the second nesting season post-construction. No significant differences in hatching success levels were evident in either the first or second year post construction between background levels and pooled project beaches.
6.1 Effects of Proposed Project on Nesting Success

6.1.1 Estimates of Nesting in the Project Sector

Two different approaches can be used to estimate the levels of marine turtle nesting that occur in the proposed project sector. Countywide estimates include a number of survey years but do not reflect variation in nesting between different areas of the County. The proposed Sector 7 project area is not regularly surveyed for sea turtle nesting. The only systematic nesting surveys in the area were conducted in 1997 and 1998. Basing estimates of nesting on just two survey years is less than ideal, but this represents the best available data for the area. Using this best available data for Sector 7, the preferred alternative for the proposed project (3.55 km of shoreline) will affect an amount of nesting habitat that would be expected to support 167 loggerhead nests, 4 green turtle nests, and 2 leatherback nests. In the County’s Habitat Conservation Plan for sea turtles, Ecological Associates Inc. (EAI) have compiled and summarized the best available nesting data broken down into 8 segments covering the entire County (EAI 2002). Estimates of nesting in the proposed project area was generated by converting EAI nesting density data into nests per linear foot, then multiplying by the number of linear feet of project sector contained in that EAI beach segment.

| LOGGERHEAD NESTING ESTIMATES BY PROJECT SECTOR |
|-------------------------------|-----------|-----------------|-----------------|-----------------|
| BEACH SECTOR                  | EXTENT   | NESTING DENSITY | ANNUAL ESTIMATED | SURVEY YEARS IN |
|                               | (KM)     | (NESTS/KM)      | NESTS            | ANALYSIS        |
| Countywide mean               | 35.6 km  | 154             | 5482             | 1990-1999       |
| Sector 7 (Preferred Alternative) | 3.35 km  | 47              | 167              | 1997-1998       |
| Sector 7 (Other Alternatives) | 2.17 km  | 47              | 127              | 1997-1998       |

| GREEN TURTLE NESTING ESTIMATES BY PROJECT SECTOR |
|-------------------------------|-----------|-----------------|-----------------|-----------------|
| BEACH SECTOR                  | EXTENT   | NESTING DENSITY | ANNUAL ESTIMATED | SURVEY YEARS IN |
|                               | (KM)     | (NESTS/KM)      | NESTS            | ANALYSIS        |
| Countywide mean               | 35.6 km  | 4.2             | 150              | 1990-1999       |
| Sector 7 (Preferred Alternative) | 3.35 km  | 1.2             | 4                | 1997-1998       |
| Sector 7 (Other Alternatives) | 2.17 km  | 1.2             | 3                | 1997-1998       |
From the three previous tables it is apparent that, due to differences in nesting densities, the proposed Sector 7 supports much lower nesting levels than the County average for loggerheads and green turtles and thus predicted nesting using best available data is less than would be expected from considering countywide data. Leatherback nesting levels using best available data for Sector 7 are higher than the countywide mean, but this is quite possibly a statistical artifact resulting from the rarity of leatherback nests and from just two sample years.

6.1.2 Review of Effects of Relevant Projects

There are two specific studies that have particular relevance to the proposed project. Ecological Associates Inc. of Jensen Beach, Florida conducted a comprehensive assessment of the effects of a 1.2 million cubic yard beach restoration project in Martin County (EAI 1999). Herren (1999) studied the effects of sand transfer renourishment on loggerhead nesting and reproductive success along the shoreline adjacent to Sebastian Inlet. Both these studies include pre- and post-nourishment data at the treatment sites and proper control sites. The fact that the two studies come to rather different conclusions regarding the impact of the respective projects on turtle nesting reflects the variable nature of beach restoration project impacts on marine turtles. Differences in design, management, and objectives between the two projects may have been in large part responsible for the differences in the observed effects on marine turtles. The Martin County beach restoration was carefully designed and managed to result in a natural beach profile.

In contrast, the Sebastian Inlet project was not a beach restoration project per se, but rather a sand transfer operation designed to replace the sand deficit caused by the inlets interruption of longshore sand transport. There was little design effort to create a beach, and relatively little regulatory oversight of the project. The 1999 Herren study also came to different conclusions than an earlier study by Ryder (1993) who examined the 1989-1990 sand transfer renourishment at Sebastian Inlet. While Herren found a substantial reduction in nesting that was attributable to the 1997 project, Ryder found no reduction in nesting success attributable to the 1989-1990 project. Thus, even successive renourishments of the same beach may have different project effects.

In the Sebastian Inlet study, Herren (1999) found nesting success was reduced by 33 percentage points and the total number of nests in the renourished treatment area reduced by 81% the first nesting season after construction, with both parameters recovering by the second nesting season.
The EAI study found nesting success was reduced significantly in the first post construction season in one of the two treatment areas (EAI 1999).

The two studies found different project effects on the total number of turtles emerging on renourished beaches. At Sebastian Inlet, Herren found a 53% reduction in loggerhead emergences in the first post-construction nesting season, while EAI found no reduction in the number of emergences attributable to the Martin County renourishment project. Since there was no effect on emergences, but there was reduction in nesting success, EAI concluded that the project reduced the relative attractiveness of the beach to post emergent turtles. EAI found no evidence to suggest that scarp formation was responsible for reducing nesting success in the Martin County project, and felt that differences in overall beach profile may have been responsible. In contrast, Herren (1999) concluded that scarp formation played a significant role in reducing nesting success at Sebastian Inlet. Scarp formation at the Sebastian Inlet site was probably exacerbated by the manner of sand placement on the beach in that project.

A reduction in nesting in a project area does not imply that those nests are lost. Bagley et al. (1994) and Ehrhart et al. (1994) have noted increased nesting on beaches adjacent to badly scarped beaches, suggesting that turtles deterred from nesting on one portion of beach are able to successfully nest on nearby beaches. It is important to note that this displacement is not without impact, since the metabolic cost of even a short non-nesting emergence is not trivial. This metabolic cost may lower the overall reproductive output over the season (fewer eggs per clutch or fewer clutches). Frequently deterred turtles may finally place their nests in sub-optimal environments. The extent of occurrence of these effects has never been quantified, yet are logical consequences of nest site deterrence.

6.1.3 Anticipated Effects of the Preferred Alternative on Nesting Success

The proposed project has several features that are expected to minimize impacts on turtle nesting success. The very modest fill template of the Preferred Alternative is designed to change the shoreline profile as little as possible, minimizing the potential for escarpment formation. The small volume fill template will reduce initial impacts on turtle nest success, but reducing the fill schedule reduces the design life of the project. Since nourishment effects are most prominent in the first year following construction, the small fill volume may result in additional rounds of construction over the project lifespan which would likely result in more total impact than a design with a larger placement volume which would require less renourishments.

Selection of fill material that resembles native beach sand as closely as possible minimizes adverse impacts. The sand source for the proposed projects will come from an offshore site. Offshore borrow sites are generally the most suitable for beach fill (Crain et al.1995). Sediment contained within the proposed borrow area has been found to be suitable in terms of grain size and percentages of very fine and very coarse material. Results of grain size analysis of the proposed sand sources indicate an average percentage of fine material of only 0.97 percent, indicating excellent quality beach material. Compaction monitoring and tilling (if warranted) and scarp reduction will be included in the construction and monitoring plans.
Results of the first and second season of nesting monitoring at the recently completed Sectors 1&2 beach restoration project have shown no measurable impact on loggerhead turtle nesting success in the first year post construction (R. Ernest, personal communication). Nesting success in the first post construction year was slightly higher than the average for the three years preceding construction, and that trend was also shown in the second year post construction. The proposed borrow material for the Preferred Alternative Sector 7 project is essentially identical to the material used for the Sectors 1&2 project, so there is reason to anticipate that effects on nesting success will be minimal.

Overall, most project impacts on sea turtle nesting success are expected to be limited to the first year, with some measurable effect persisting into the second year. Since any turtles deterred from nesting in the project areas can be expected to nest elsewhere nearby, no measurable negative effect of the project on total nesting within Indian River County is expected.

There are also significant positive potential effects of the proposed projects on marine turtle nesting success. The Sector 7 project area is prone to a proliferation of coastal armoring in the absence of a beach restoration project. As a part of the County’s Habitat Conservation Plan for take associated with coastal armoring (seawalls), the County and its consultant, Ecological Associates Inc. have calculated the potential for new armoring structures in the County both with and without the proposed beach restoration project. It is anticipated that the construction of the Sector 7 project will result in 1,044 fewer feet of armoring being constructed under emergency permitting in Sector 7 over the next 30 years (EAI 2002). This total does not include an unknown number of eligible structures whose owners would choose to apply for seawall permits through the standard permitting procedure, and who would be enjoined from doing so by Statute if the project were to be built. Although results from a recent study must be considered preliminary, (Mosier 1998) has documented a clear reduction in nesting success in front of seawalled properties. The Mosier study also found that as the proportion of the total available shoreline that is armored increases, the cumulative effects become more and more severe. Thus, the proposed project will have a documented and quantifiable long-term positive impact on marine turtle nesting success in Indian River County.

The positive potential effect of increasing available nesting habitat for marine turtles has often been cited for beach restoration projects. Although it is generally felt that the temporary negative effects largely offset these benefits, where nesting habitat was nonexistent before restoration, restoration projects clearly have a net positive effect. (Lebuff et al. 1990) (Flynn 1992).

6.2 Effects of the Preferred Alternative on Hatching and Emergence Success

Nelson and Dickerson (1988) found that nests laid on restored beaches generally hatched successfully. In the Sebastian Inlet sand transfer renourishment area, Herren (1999) found no significant difference in hatching success in the renourished area in the first or second season after renourishment compared to pre-renourishment levels. EAI (1999) found lower overall hatch success on nourished beaches following construction compared to controls, but the differences were not statistically significant. When nests lost due to erosion were excluded from the statistical analysis, reproductive success on nourished beaches equaled or exceeded values for the control beach in both post construction years. The EAI study did find changes in the
incubation environment on the nourished beaches, but there was no apparent effect on the percentage of eggs laid that hatched or the emergence success of hatchlings. In the EAI study, there were significant differences between renourished and natural beaches in terms of grain size, carbonate content, moisture content, and sand color. Despite these clear differences, reproductive success, exclusive of washouts, was not significantly different on renourished beaches. This indicates that, within rather wide parameters, differences in sand characteristics between natural and renourished beaches do not affect their suitability as marine turtle incubation substrates.

Results of the first two seasons of nesting monitoring at the recently completed Sectors 1&2 beach restoration project have shown generally good loggerhead turtle hatching success in the first year post construction (R. Ernest, personal communication). Hatching success in the first post construction year was 82.7%. The proposed borrow material for the preferred alternative Sector 7 project is essentially identical to the material used for the Sectors 1&2 project, so there is reason to anticipate that effects on hatching success will be minimal.

Both the Martin County study and the Sebastian Inlet study point to erosional losses of nests laid low on the newly constructed berms as a primary source of impact from the construction project. EAI recommended that consideration be given to relocating nests, located on seaward portions of nourished beaches, which would be expected to be lost in the first post construction nesting season as the beach equilibrates to a more natural profile. The extremely modest fill template of the Preferred Alternative will serve to greatly minimize the potential for escarpment formation, thereby minimizing this potential impact.

With all construction occurring outside the nesting season and careful selection of appropriate fill material, and a very modest fill template, the effects of the Preferred Alternative project on sea turtle nest hatching success is not expected to be significant.

6.3 Effects of the Preferred Alternative on Marine Turtle Developmental Habitat

Effects of the Preferred Alternative project on the juvenile green turtles that have been documented to use nearshore reefs as foraging habitat will be limited to the potential effect of indirect impacts of the project (such as temporarily elevated turbidity levels) on nearshore reef habitat, since do direct burial of nearshore reef is anticipated. It is assumed, for impact assessment purposes, use of this habitat is Countywide and that the habitat is used year-round.

Hardbottom habitats with high algae abundance provide the most valuable habitat for foraging green turtles. Of the specific hardbottom types identified in the 1999 hardbottom mapping and characterization effort (ATM 2001), Types 2, 4, and 5 are dominated by algae and share algal genera with reported diet items from juvenile green turtles in this habitat (Ehrhart et al. 1996). Type 3 hardbottom is dominated by the sabellariid worm Phragmatopoma and would not be expected to be as suitable for green turtle foraging. The Sector 7 proposed project area contains only Type 2 habitat.

The primary indirect effect anticipated will be elevated turbidity levels associated with fill placement and the subsequent sorting out of fine material as the fill weathers. Elevated turbidity decreases light penetration, limiting algal primary production, in turn limiting available forage
for juvenile green turtles. The extent and duration of this impact depends on many factors, some of which are unpredictable, but the most intense impacts can reasonably be expected in the months immediately following fill placement (in winter). As noted in Section 5.1.2.2, the winter season is when algae biomass and diversity in this habitat are at a minimum, and background turbidity is typically much higher than in the summer. The construction plans for the projects include a fill containment dike and dewatering system to minimize the release of turbid water. The expected fine fraction in the borrow material is 0.97 percent, which will limit the extent and severity of turbidity effects. Together with the extremely modest fill template proposed in the Preferred Alternative, these factors minimize the anticipated indirect effect of the proposed projects on foraging habitat. Indirect impacts to marine turtle foraging habitat are not expected to be significant, due to their restricted extent in both space and time.

UCF data provide some indications of the potential for beach restoration projects to affect foraging turtles. UCF has collected data and calculated the CPUE for juvenile green turtles each year since 1989. The sampling area has presumably been subject to the influence of the Sebastian Inlet sand transfer renourishments, as it is quite nearshore and just south of the beach segment where over 850,000 cubic yards of sand have been placed over the last 10 years. The following table presents green turtle CPUE data for the nearshore reef from 1989-1999 (Holloway-Adkins et al. 2000). Years in boldface type represent the years (summers) immediately following a sand transfer renourishment project.

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</thead>
<tbody>
<tr>
<td>CPUE</td>
<td>5.44</td>
<td>0.72</td>
<td>4.32</td>
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<td>8.55</td>
<td>23.78</td>
<td>12.58</td>
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<td>43.81</td>
</tr>
</tbody>
</table>

The mean CPUE in summers following a sand transfer renourishment was not statistically different from the mean CPUE in summers not following a sand transfer renourishment (where statistical significance was determined through use of the two tailed t-test). UCF has also conducted directed studies on the effects of the Sectors 1&2 project on Green turtle CPUE. They did not find any depression of CPUE in the two summers following the construction of the Sectors 1&2 beach restoration.

Preliminary results for the first year of monitoring the Sectors 1&2 beach renourishment project for nearshore turtle abundance (Inwater Research Group 2003) have found no marked differences in abundances of green turtles in preconstruction vs. postconstruction surveys in the north study area, which includes the Sectors 1&2 beach restoration. It was suggested that perhaps green turtles were displaced offshore by the project, as postconstruction data showed fewer green turtles at the 300 foot offshore distance in the postconstruction survey, and a concomitant increase in abundance at the 600 foot offshore distance, but virtually no change in abundance at the north study site as a whole. Loggerhead turtle abundance showed an increase in the postconstruction survey. A summary Table of the data is included in Section 5.1.1.2 above.

Overall, impacts to marine turtle foraging habitat are not expected to be significant.
6.4 Anticipated Effects of Project Alternatives

6.4.1 The No-Action Alternative

The no-action alternative would eliminate any negative impacts of the proposed project on nesting and hatching success. However, as the beaches continue to erode in the critical erosion areas selected for restoration, the nesting habitat will be degraded, and in some areas completely lost. While very narrow beaches will be expected to still support nesting, under conditions were high tides reach the dune line on a daily basis, hatch success may decrease dramatically due to inundation and nest washout.

As erosion threatens waterfront properties, the inevitable result will be a proliferation of shoreline armoring structures and emergency, stop-gap measures to protect property that will have negative impacts on turtle nesting and hatching success. As noted in Section 3.5.1, failure to build the proposed beach nourishment project will result in an estimated 1,044 feet of additional shoreline armoring over the next 30 years, under emergency permitting rules alone.

The proliferation of seawalls has a documented negative effect on sea turtle nesting. In Volusia County, nesting turtles were found to encounter armoring structures on 16.7 percent of all emergences in 1999 (EAI, 2000). Fully 91% of those encounters resulted in a false crawl (the turtle failing to nest). Overall, armoring was responsible for nearly a third of all recorded false crawls, and the false crawl percentage was particularly high in the portions of the County where armoring was most prevalent. Quantitative data for the impact of armoring structures is only available for loggerheads. From FFWCC data from 1990-1999, the “background” nesting success in Indian River County is 54%. Mosier (1998) reported that nesting success was, on average, 69% lower at sites with seawalls than at sites without seawalls. The reduction in nesting success attributable to 1,044 shoreline feet of seawalls (0.317 km), results in a displacement of 13 nests every year in Sector 7 (EAI, 2002). Unlike the effects of beach nourishment, this effect is permanent and does not decrease over time.

When high tides reach the base of armoring structures, nests deposited in front of these structures are often subject to tidal inundation. This and other negative effects of seawalls become more pronounced the closer the seawalls are to the surf zone. Thus, in the absence of beach restoration, the impacts that both existing and future seawalls will have on nesting habitat are exacerbated.

The no-action alternative would result in no impacts to marine turtle foraging habitat. No adverse effects to marine turtle foraging habitat are anticipated under the no-action alternative.

6.4.2 The Full Volume Alternative

The Full Volume Alternative will result in an average dry beach width (from the toe of the dune to MHW) of 75 feet after equilibration. This will greatly increase the total amount of potential sea turtle nesting habitat available compared to the Preferred and No Action alternatives, and provides an additional 20 feet of dry beach width over the Reduced Fill Alternative. This
additional nesting habitat has the potential to positively impact nesting levels. The Full Volume Alternative has a design renourishment interval of 6 years. As most negative impacts to sea turtle nesting and reproductive success are confined to the first one or two nesting seasons following construction, longer renourishment intervals are preferred because they result in fewer renourishment events over the 30 year planning period for the project. The Full Volume Alternative offers greater potential for escarpment formation than the Preferred or No Action Alternatives, possibly impacting nesting success, but no increases in the potential effects on hatching and emergence success are anticipated from the increased fill volume.

The Full Volume Alternative would result in direct impacts to an anticipated 5.3 acres of nearshore hardbottom habitat. Based on an estimate of total hardbottom habitat from Section 4.4.1, the Full Volume Alternative is expected to directly impact less than 0.2% of the total hardbottom habitat in Indian River County. Direct impacts to turtle foraging habitat are not expected to be significant, due to the small proportion of total available foraging habitat that will be directly affected.

The Full Volume Alternative will also cause indirect effects on turtle foraging habitat. The primary effect anticipated will be elevated turbidity levels associated with fill placement and the subsequent sorting out of fine material as the fill weathers. The extent of this impact is roughly proportional to the fill volume, but is not expected to be significant, due to the restricted extent in space and time.

6.4.3 The Reduced Fill Alternative

The effects of reducing the fill volume on marine turtle nesting and hatch success is difficult to quantify. The resulting beach berm as constructed would be narrower and the number of non-nesting emergences and would be expected to decrease somewhat, slightly increasing nesting success. A narrower berm is not expected to affect the incidence or average height of scarps. Aspects of the nest incubation environment that are influenced by renourishment such as compaction, water content, and temperature shall be the same as the other alternatives given that characteristics of the sand are the same. Thus, a change in fill volume will have little effect on the influence of these factors on hatching and emergence success.

The reduced fill volume compared to the Full Volume Alternative will result in greater cumulative adverse effects on marine turtle nesting from a decrease in the renourishment interval. Since the negative effects of beach renourishment on turtle nesting for the first and sometimes second year following construction are well documented, projects with a long lifespan are preferred over projects that require more frequent reconstruction. A consequence of the cyclical pattern of nesting impacts, observed by Steinitz et al. (1998) (see Section 6.0), is that the shorter the renourishment interval, the longer the unattractive, low density nesting periods become relative to the more attractive state that is more conducive to successful nesting. The decreased fill alternative is calculated to have a renourishment interval of 4 years, whereas the Full Volume Alternative has a renourishment interval of 6 years. Decreases in fill volumes that require more frequent renourishment also significantly increase the total costs of the project over the 30-year lifespan.
Compared to the Full Volume Alternative, the Reduced Fill Alternative would decrease the extent of direct impacts to juvenile green turtle foraging habitat (see Section 8.2 for anticipated changes in direct hardbottom habitat impacts). Indirect impacts to foraging habitats would be decreased due to the reduced fill volume which will minimize the extent and severity of turbidity plumes associated with the project construction. However, the shortened renourishment intervals associated with the Decreased Fill Alternative would increase the frequency of turbidity related impacts to marine turtle foraging habitat. The total cumulative indirect effects of the Reduced Fill Alternative on marine turtle foraging habitat may actually be greater than for the Full Volume Alternative, since the Reduced Fill Alternative would actually result in the placement of slightly more sand on the Sector 7 beaches over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3.

6.4.4 The Six Groin Alternative

The Six Groin Alternative would result in the same beach widths as the Full Volume Alternative proposed, and beach characteristic related affects on sea turtle nesting and hatching success are expected to be similar. This alternative is associated with a 7-year renourishment interval, as opposed to the 6-year renourishment interval of the Full Volume Alternative. The beneficial effect of a reduction in the demand for coastal armoring would be approximately the same as for the Full Volume Alternative. There would however, be a permanent loss of some nesting habitat as a result of the area of dry beach occupied by the groins themselves. The “footprint” of each groin is approximately 42 feet alongshore, and it is assumed that the groin would occupy all the dry beach area between the dune or seawall and the tide line for that 42-foot width.

The potential magnitude of this impact may be estimated by totaling the beach width occupied by the six groins (252 feet), and dividing that quantity into the nesting density estimate for Sector 7 provided in Section 6.1.1. This calculation indicates that the six groin alternative would permanently remove a quantity of sea turtle nesting habitat that would be expected to support 3.6 loggerhead nests, 0.1 green turtle nests, and 0.04 leatherback turtle nests annually. There is also the distinct possibility that the presence of groins on a nesting beach may interfere with nesting behavior or the sea-finding ability of sea turtle hatchlings.

6.4.5 The Upland Sand Alternative

The upland sand alternative would result in the same beach widths as the Full Volume Alternative, and beach characteristic related affects on sea turtle nesting and hatching success are expected to be similar, assuming that the sand source used is compatible with the existing beach. The beneficial effect of a reduction in the demand for coastal armoring would be approximately the same as for the preferred alternative.
7.0 EFFECTS ON SAND BEACH COMMUNITIES

This section summarizes the anticipated effects of the proposed project on animals residing on or in the beach itself, or that use the beach as a foraging habitat.

7.1 Effects of the Preferred Alternative on Infaunal Communities

Nelson (1985) reviewed the literature on the effects of beach renourishment projects on sand beach fauna and concluded…“Minimal biological effects result from beach nourishment. Some mortality of organisms may occur where grain size is a poor match to existing sediments, however, recovery of the beach system appears to be rapid”. Nelson reviewed several studies on the most common beach invertebrates of the southeastern US, including the mole crab, *Emerita talpoida*, the surf clam, *Donax sp*, and the ghost crab *Ocypode quadrata*. None of the studies cited in Nelson showed significant or lasting impacts to any of these species resulting from beach nourishment. Hackney et al. (1996) provide a more recent review of the effects of beach restoration projects on beach infauna in the southeastern US. They also reviewed studies on the above species and agree with the conclusions in the Nelson study, with the caveats that construction should take place in the winter months to minimize impacts, and that the sand used should be a close match to native beach sands. In most of the studies reviewed by these authors, there was a considerable short-term reduction in the abundance of mole crabs, surf clams, and ghost crabs attributable to direct burial. Recruitment and immigration were generally sufficient to reestablish populations within one year of construction.

The Preferred Alternative features a very modest fill template, and the proposed project will be constructed in the winter season, outside the recruitment window for these species, and the sand source is of high quality with a small percentage of fine material. These features operate to minimize adverse effects on most beach infauna (Hackney et al. 1996). We therefore do not expect the proposed project to have significant, long lasting impacts on sand beach infaunal communities.

7.2 Effects of the Preferred Alternative on Other Beach Associated Fauna

In addition to marine turtles, three beach associated protected species, the piping plover, least tern, and the southeastern beach mouse, discussed in Sections 5.2.1, 5.2.2, and 5.2.3, have the potential to be affected by the proposed project. The piping plover may be displaced to other feeding habitats during construction. The slightly wider beach berm resulting from the project may make the restored beaches more favorable habitat for the plover in the short term, but this effect will diminish as the beach erodes.

Potential least tern nesting will not be affected by project construction since construction will occur in winter and the tern nests in summer. There may be some interference with least tern foraging immediately following construction if turbid water persists through April, when terns arrive from South America.
Any remnant population of the southeastern beach mouse in the project areas will not be adversely affected by the proposed projects. Existing back dune habitat will not be disturbed, and unlike beach restoration using terrestrial sand sources, extensive equipment access points through back dune habitats will not be necessary. Although there is no positive evidence the species occurs in Sector 7, the result of the proposed project will be an improvement in habitat suitability for the southeastern beach mouse.

7.3 Anticipated Effects of Project Alternatives

7.3.1 The No-Action Alternative

The no-action alternative would not impact beach-associated infauna. There may be some adverse effects on the least tern, piping plover, and other shorebird populations, as continued beach erosion reduces the total habitat area available.

7.3.2 The Full Volume Alternative

The Full Volume Alternative has a design renourishment interval of 6 years. Although the initial placement of 459,700 cubic yards may have some temporary impact on sandy beach communities, a greater renourishment interval results in less cumulative impact, since fewer renourishment events will occur over the 30 year plan period. The Preferred Alternative and the Full Volume Alternative both have a similar proposed vegetated dune feature, so the Full Volume Alternative would have similar benefits for the southeastern beach mouse.

7.3.3 The Reduced Fill Alternative

A decreased fill volume of approximately 376,100 cubic yards would result in incrementally lesser impacts to the sand beach communities, however the 4-year renourishment interval associated with this option would increase the frequency of these impacts, when compared to the 6-year renourishment interval for the Full Volume Alternative. The total cumulative effects of the reduced fill alternative on sand beach communities may actually be greater, since the reduced fill alternative would result in the placement of slightly more sand on the Sector 7 beaches over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3. The Reduced Fill Alternative would have the same benefits for the southeastern beach mouse as the Preferred Alternative.

7.3.4 The Six Groin Alternative

The six groin alternative would have approximately the same impacts from the initial beach fill as the Full Volume Alternative. There would, however, be slightly less cumulative impacts to beach associated fauna over the 30 year planning period due to the increase in the renourishment interval from 6 to 7 years. There would be the additional impact on the loss of open beach habit from the presence of the groins themselves. The six groin alternative would result in the loss a total of 252 feet of open beach habitat, from the dune line or erosion control structure to slightly seaward of the water line.
7.3.5 The Upland Sand Alternative

The Upland Sand Alternative would have approximately the same impacts on beach associated fauna as the Full Volume Alternative considered above.
8.0 EFFECTS ON NEARSHORE HARDBOTTOM COMMUNITIES

This section summarizes the anticipated effects of the preferred alternative project and the project alternatives on nearshore reefs and their associated biotic communities.

Nature of potential effects
Direct effects on nearshore reef habitats are due to physical burial by the dredged material and to a lesser extent by the potential physical damage to reefs from dredge pipelines and other equipment operating in the nearshore environment. Potential indirect effects are related to the impacts of turbidity resulting from construction of the project and from the subsequent weathering of the material by rain and waves.

Direct effects
The Preferred Alternative design would result in no direct burial of nearshore hardbottom habitat. Direct hardbottom impacts of the project alternatives are summarized in the following table. Reef habitat types in the table are discussed in Section 4.4.2.

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>TYPE 2</th>
<th>TYPE 3</th>
<th>TYPE 4</th>
<th>TYPE 5</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO ACTION</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>PREFERRED</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>FULL VOLUME</td>
<td>5.3 acres</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>5.3 acres</td>
</tr>
<tr>
<td>SIX GROIN</td>
<td>5.3 acres</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>5.3 acres</td>
</tr>
<tr>
<td>UPLAND SAND</td>
<td>5.3 acres</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>5.3 acres</td>
</tr>
<tr>
<td>REDUCED FILL</td>
<td>3.2 acres</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>3.2 acres</td>
</tr>
</tbody>
</table>

In assessing the impacts associated with these projects, the ephemeral and resilient nature of this habitat should be considered. To a large extent, the reefs impacted by the proposed projects were formed on substrate exposed by the recession of the beach over the last few decades, and reef habitat very near shore typically covers and uncovers with sand seasonally or in response to storm events. The major species in this immediate nearshore environment is the reef building tube worm *Phragmatopoma caudata*. *Phragmatopoma* is capable of rapid colonization and recovery. Gore et al. (1978) reported that 6 months after settlement, new colonies of *Phragmatopoma* were indistinguishable from long established colonies. However, *Phragmatopoma* reefs also support a diverse community of invertebrates (Nelson 1989) (Gore et al. 1978), which may not be able to recover as rapidly as *Phragmatopoma* itself. Although eventual recovery is likely, we assume for impact assessment that the directly impacted habitat and all associated fauna are permanently lost. Using the estimate of total nearshore hardbottom in the County given in Section 4.4.1, we estimate that the most impactive alternatives will cause a direct loss of less than 0.2% of Indian River County nearshore hardbottom habitat. The hardbottom habitats that will be directly impacted will obviously be those closest to shore. As noted in Section 4.4.2, these areas, although diverse, are significantly less so than the high relief offshore reefs.
Indirect effects
The major potential indirect effect of the proposed projects on nearshore hardbottom habitat is increased turbidity and siltation, which may impact habitats at some distance from the project site itself. The most important variable controlling the duration and severity of turbidity impacts is the fine material content of the fill material. Analysis of the material from the candidate sand source borrow areas yields an estimated fine fraction of only 0.97 percent. This high quality fill material will limit the potential for adverse turbidity effects from the proposed projects. Release of turbid water associated with project construction will be minimized by the use of a fill containment dike and dewatering system.

Abundant references exist on impacts of turbidity to corals and impacts to corals from dredging and beach renourishment (Dodge and Vaisnys 1977, Marszalek 1981) but there is very little specific information on the turbidity tolerances of members of the coquinoid rock–sabellariid reef community. Main and Nelson (1988) report that *Phragmatopoma* is tolerant of extremely high silt loads over the short term (6 grams per liter for 4 days, over 100 times typical background levels). Although specific information for other species is unavailable, most reef fauna inhabiting a high-energy beach environment would be expected to have high tolerances for turbidity. The algal component of the nearshore reef community may be more sensitive. Algal species are a major component of the reefs, and may be particularly affected by reduced light penetration associated with increased turbidity. Nelson (1989) noted a great reduction in algal species richness (56 summer vs. 16 winter) on wormrock reefs at Sebastian Inlet, possibly due to increased turbidity typical of winter months. The most intense turbidity effects associated with these projects will take place in the winter due to construction timing, when algal diversity is low and background turbidities are high.

Another possible indirect effect of the proposed projects relates to changes in the position of the shoreline. The projects will cause a temporary seaward shift of the shoreline. This shift may change the physical conditions (wave exposure etc.) that hardbottom habitats very near shore, but outside the area of direct impact, are exposed to. This may change the ecological development of those areas, for example, favoring worm rock over algal communities. It should be noted that this potential effect is purely conjectural and is undocumented.

Unlike tropical coral reef communities that are predicated on long-term stability in environmental conditions and community structure, nearshore reefs are adapted to a continual cycle of disturbance and recovery. The nearshore reef structure closest to the beach repeatedly covers and uncovers with sand. The algal and fouling communities change radically seasonally and in response to scour associated with storm events. This community is adapted to periodic catastrophic disturbance as a consequence of the exposed high-energy beach environment. Nearshore reef communities are adapted to the precise sorts of impacts associated with beach restoration projects (turbidity and siltation). This increased tolerance minimizes the ecological effects from project impacts. Overall, it is expected that the projects will have some limited adverse indirect effects on nearshore hardbottom habitat adjacent to the project area.

Cumulative impacts
The erosional history of the project area must be evaluated as part of the cumulative impact assessment. To a large extent, the reef structure nearest the shoreline that is subject to direct
burial was exposed in the last few decades by the recession of the beaches. Since beach recession is at least in part an artifact of modern shoreline management practices, the amount of habitat existing today is greater than what would be expected under natural conditions. This does not reduce the level of direct impact, since these extreme nearshore reefs, whatever their origin, support significant biological communities. However, the assessment of cumulative impacts requires a longer-term perspective and focuses on larger scale ecosystem effects. At this level of analysis, the erosional origin and history of the extreme nearshore reefs must be taken into account. Since the total amount of nearshore reef habitat has been, in essence, artificially enhanced, the cumulative impacts of beach restoration are considerably less than would be estimated from a consideration of the acreage of habitat impacted alone.

The Preferred Alternative project will result in no direct impact to nearshore hardbottom habitats, and the extent of indirect impacts will be very greatly reduced by the modest fill templates and the low silt content of the proposed borrow material.

8.1 Anticipated Effects of Project Alternatives

8.1.1 The No Action Alternative

The No Action Alternative eliminates all direct and indirect impacts to the nearshore hardbottom habitat. Continued recession of the beach in the absence of restoration is expected to result in the exposure of additional bedrock, which may develop into a reef community. It is possible that the extensive seawall construction that will be the inevitable result of not restoring the beaches may affect the nearshore wave dynamics and sand transport to a degree that nearshore reef environments could be affected.

8.1.2 The Full Volume Alternative

The Full Volume Alternative results in a total of 5.3 acres of direct impact to nearshore hardbottom habitat. Indirect impacts to hardbottom habitat are expected to be limited by the high quality of the proposed borrow material and by the resilient nature of the nearshore reef biota.

8.1.3 The Reduced Fill Alternative

A primary objective in the consideration of fill alternatives was the reduction of direct impacts to nearshore hardbottom habitats relative to the Full Volume Alternative. The reduced fill alternative, while resulting in a narrower beach and substantially decreasing the renourishment interval, does result in a large decrease of direct hardbottom habitat impacts.

Decreases in fill volumes are expected to decrease indirect effects on nearshore hardbottom habitat caused by turbidity and siltation to some extent, since the total amount of sediment placed on the beaches will be less.

Potential adverse impacts to nearshore hardbottom habitats, as a result of the reduced fill alternative, are expected to be present, but small, relative to the positive factor of directly
burying less acreage. As a result of the decreased renourishment interval, construction impacts will occur more often, increasing the cumulative impacts, particularly the cumulative indirect impacts of repeated siltation and turbidity events that may interrupt community recovery in areas adjacent to the direct impact areas. The total cumulative indirect effects of the reduced fill alternative on nearshore hardbottom may actually be greater than for the Full Volume Alternative, since the Reduced Fill Alternative would result in the placement of slightly more sand on the Sector 7 shoreline over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3. In addition, as projects are renourished more often, there is increased opportunity for damage to the reef from dredge pipelines and grounding of construction vessels.

8.1.4 The Six Groin Alternative

Direct and indirect impacts to hardbottom communities at initial construction from the Six Groin Alternative are expected to be the same as those for the Full Volume Alternative. As a result of the increase in the renourishment interval from 6 to 7 years, construction impacts will occur less often, decreasing the cumulative impacts, particularly the cumulative indirect impacts of repeated siltation and turbidity events that may interrupt community recovery in areas adjacent to the direct impact areas. In addition, as projects are renourished less often, there is decreased opportunity for damage to the reef from dredge pipelines and grounding of construction vessels.

8.1.5 The Upland Sand Alternative

Direct Impacts to hardbottom communities under this alternative are expected to be similar to the Full Volume Alternative. Indirect impacts to hardbottom communities at initial construction from the Upland Sand Alternative are expected to be the somewhat less than the Full Volume Alternative, although the volume of sand placed is identical. Mechanical placement of dry upland sand typically results in considerably less turbidity generation than the hydraulic placement of offshore source sand. There is also no potential for ship grounding and pipeline damage.
9.0 EFFECTS ON OFFSHORE BORROW AREA COMMUNITIES

This section addresses the direct and indirect effects of the removal of sand from the offshore sand sources on offshore biological resources.

9.1 Anticipated Effects of the Preferred Alternative

The removal of sand from offshore borrow areas results in a disturbance of the sand bottom animal communities as a fraction of the existing habitat is removed and the bottom topography is changed. However, most studies on the infauna of sand borrow areas have shown little lasting impact in terms of species diversity and total abundance or density. Johnson and Nelson (1985) found that abundance and species richness returned to near normal between 9 and 12 months after dredging off Fort Pierce Inlet in the same general location as the proposed project. Similar results were reported by Saloman et al. (1982) off Panama City Beach, Florida and by Tuberville and Marsh (1982) in Broward County. Wilber and Stern (1992) have criticized the limited focus of these studies on species richness or diversity and total numbers of individuals. They reviewed several studies and concluded that impacts on community structure, particularly impacts on larger deeper burrowing species, were not properly documented and that these impacts may last 2-3 years or longer.

More recently, Schaffner et al. (1996) have applied a more comprehensive assessment technique, the Benthic Index of Biotic Integrity (B-IBI) to a borrow area in Chesapeake Bay. The B-IBI takes into account abundance, biomass, species diversity, and Guild parameters such as the percentage of deposit feeders and compares them in a weighted scale between impacted and reference communities. It was concluded that the sand mining activities in the Chesapeake Bay study did not have negative or adverse impacts on benthic biotic integrity.

Properly sited projects will not have any direct impacts on reef environments, but there can be indirect effects from turbidity and siltation that may extend away from the borrow site. Extensive side scan sonar surveys in the proposed borrow sites have not revealed any discernable reef structure within or immediately adjacent to the sites. No direct impacts on reef habitat in the offshore borrow area are expected, and indirect effects will be minimal due to the remote location of significant reef structure.

Significant effects on fishes are not considered likely, due to the mobile nature and low site fidelity typical of fishes native to open sand habitats. Courtney et al. (1974) and Applied Biology (1979) found no negative impacts to fishes in offshore dredge areas off Broward and Duval Counties, respectively.

Dredging in harbors and channels has been documented to cause mortalities to sea turtles, with an estimated annual mortality of 50-500 turtles annually (Magnuson et al. 1990). While turtles often concentrate in harbors and entrance channels, the open unvegetated, non-reef habitat of offshore sand borrow areas has little attraction for sea turtles. Nelson and Dickerson (1988) conclude that sea turtle mortalities associated with sand source dredging either do not occur or are very rare. Few mortalities have been documented in Florida despite requirements for 24 hour
a day hopper dredge observers that have been included in NMFS Biological Opinions for beach restoration projects.

Collisions between large vessels and right whales are a major concern. There is some potential for the proposed project to affect the northern right whale, due to offshore operation of hopper dredges.

In areas near Jacksonville, Florida where northern right whale abundance is seasonally high, hopper dredge vessels are required to limit their speed to five knots. It is believed that vessels moving at five knots or slower pose little threat to right whales (Scott Kraus, New England Aquarium pers. comm.)

No impacts to the West Indian manatee are expected in the offshore or nearshore project areas due to the lack of manatees in these habitats in the winter months, when construction is scheduled.

Overall, no significant, long-lasting effects on benthic fauna in the borrow areas are expected from the Preferred Alternative. No impact to fishes, marine turtles, or marine mammals as a result of operations in the offshore borrow areas are expected.

9.2 Anticipated Effects of Project Alternatives

9.2.1 The No-Action Alternative

This alternative eliminates all direct and indirect impacts on offshore borrow area communities.

9.2.2 The Full Volume Alternative

The Full Volume Alternative proposes the dredging of 459,7000 cubic yards from the offshore borrow area. While this alternative would have the largest potential initial impact on borrow area communities, the renourishment interval of 6 years would allow for significant recovery between dredging events.

9.2.3 The Reduced Fill Alternative

Decreasing the amount of sediment dredged from the borrow areas by approximately 20% is expected to proportionately decrease the amount of direct and indirect impact from initial construction to borrow area communities. The total cumulative effects of the Reduced Fill Alternative on borrow area communities may actually be greater than those of the Full Volume Alternative, since the Reduced Fill Alternative would result in the excavation of slightly more sand from the borrow area over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3. The reduced fill alternative would also increase the frequency of disturbance to benthic communities in the borrow areas due to the shorter renourishment interval. However, no significant effects on benthic fauna in the borrow areas are expected from the Reduced Fill Alternative. Under the this alternative, there would be an increased opportunity for sea turtles
and marine mammals to encounter dredge equipment due to more frequent renourishment intervals, but no impact to fishes, marine turtles, or marine mammals as a result of operations in the offshore borrow areas are expected.

9.2.4 The Six Groin Alternative

The anticipated impacts of the six groin alternative on borrow area communities at initial construction are expected to be the same as those of the preferred alternative, since both alternatives call for the excavation of the same volumes of sand from the borrow areas. The increase in the expected renourishment interval for the six groin alternative, from 6 to 7 years, will result in less frequent disturbances to borrow area benthic communities and less total volume excavated over the 30 year planning period, reducing the cumulative impacts.

9.2.5 The Upland Sand Alternative

This alternative eliminates all direct and indirect impacts on offshore borrow area communities.
10.0 EFFECTS ON FISH AND FISHERIES

This section summarizes the anticipated effects of the proposed project on fish and fishery resources. Potential direct and indirect effects on reef fish population levels and reef fish recruitment potential are considered, and a discussion of ecosystem level effects on fish habitat is included. This section also contains a consideration of potential project effects on recreational and commercial fisheries in the local area.

10.1 Anticipated Effects of the Preferred Alternative on Reef Fishes

Direct effects
The elimination of reef habitat clearly has an impact on reef-associated fishes. An example is found in Lindeman and Snyder (1999), who conducted pre- and post-impact censuses of fishes in similar nearshore hardbottom habitat where 12-14 acres of reef were buried by a beach renourishment project near Jupiter Inlet. After the renourishment, they found very little hardbottom remaining and very few fish remaining. Before renourishment fish abundance averaged 38 individuals per transect and after renourishment the mean abundance was less than 1 individual per transect. It was assumed that mortality was high on displaced fishes as there was little other suitable habitat within 0.8km and 80% of fishes censused were juveniles, expected to suffer high losses to predation.

We expect survival of displaced fishes to be much higher in the proposed project, since abundant habitat will remain in the immediate vicinity of the impact area, both along adjacent non-nourished beaches and offshore of the fill placement area. Since there is no reliable estimate of percent survival, it will be assumed for impact assessment that mortality is total. With this assumption, a loss of X acres nearshore hardbottom habitat will result in the loss of the fish biomass that X acres of such habitat can support. In order to quantify the impact, an estimate of fish biomass density is required, but biomass estimates are not available for project area reefs. On hard bottom habitats in South Carolina, Sedberry and Van Dolah (1984) estimated fish biomass density at 168 kilograms per hectare. This figure is used below to quantify expected direct impacts as a consequence of the project alternatives that will have direct impact on nearshore hardbottom habitat.

The Preferred Alternative is not expected to have any direct impact on nearshore hardbottom habitat, and therefore no direct impact to reef fishes from loss of habitat is anticipated.

Indirect effects
Indirect effects on fish populations are difficult to predict or quantify. Increased turbidity on the reefs surrounding the project area may decrease the foraging efficiency of visual oriented predators. Fish displaced by direct impacts may increase competition for space or food resources on nearby reefs where they attempt to relocate. Physical stress from elevated turbidity is a possibility for less mobile fishes that will not move to escape turbidity. Many prey items for fishes, particularly small and juvenile fishes, are the small inconspicuous crustaceans often associated with macroalgae (Nelson 1989). Accordingly, a loss of algae biomass due to turbidity increases may affect foraging of even non-herbivorous species of fishes. The high
quality fill material proposed for these projects and the use of fill containment dikes and
dewatering systems in the construction process will minimize potential adverse indirect effects
on fish populations.

The very modest fill template of the Preferred Alternative, in combination with the quality of
the fill material and the transient nature of indirect impact from turbidity, is not expected to
have any significant indirect impact on reef fishes.

10.2 Effects of the Preferred Alternative on Reef Fish Recruitment Potential

Direct effects
The permanent loss of habitat due to the proposed projects implies a permanent loss of the fish,
invertebrates, and plants supported by that habitat. Thus the project impacts not only the
existing fauna, but also the entire fauna the habitat could be expected to support in the future (or
in practice until the beach erodes and the habitat is uncovered again and reestablishes itself). In
order to quantify the magnitude of this impact, information on the density of reef fish
recruitment and the number of potential recruits to impacted habitat that could be expected to
settle successfully elsewhere is required. The percentage of recruits to impacted habitat that will
successfully settle elsewhere is likely considerable, given the mechanics of recruitment from the
plankton. This assessment is based on the extremely conservative assumption that all potential
recruits to impacted habitats are lost.

Shulman and Ogden (1987) provide recruitment rates in individuals per square meter for 48
species of coral reef fish in the Caribbean and Australia. Fourteen families were included in the
study, 13 of which are also found on the project area reefs. The mean recruitment rate for the 48
species in Shulman and Ogden is 17.5 individuals/m²/yr. This figure will be used to quantify the
potential impacts of project alternatives that have direct impact to nearshore hardbottom
habitats.

The potential loss of larval fish recruits may be considered in the context of power plant
entrapment effects. Although the numbers are not directly comparable because planktonic
larvae rather than settling larvae are considered, fish larvae mortality due to the operation of the
nearby St. Lucie Nuclear Power Plant was estimated at 650 million per year (Applied Biology
Inc. 1977).

There are a few caveats to consider in this analysis. The recruitment rate estimates used were
taken from coral reef ecosystems and may not be the same as local recruitment rates. There is
also considerable debate on whether adult fish population levels are controlled by the amount of
available habitat (including settling habitat) or by fluctuations in the availability of larval
recruits. In the latter view, termed the “recruitment limitation hypothesis” or “supply-side
ecology” (Victor 1983, Doherty 1991), the amount of habitat available for settling recruits is
less important than the variations in the size of recruitment classes in determining adult fish
populations.

Ruple (1984) provided some data on the occurrence of 69 larval fish taxa in surf zone areas in
the Gulf of Mexico that Courtney et al. (1996) felt was applicable to Atlantic coast habitats as
well. Ruple found clear differences between the inner surf zone (less than 1 meter deep) and the outer surf zone (between 4 to 7 meters deep). More larval fishes occurred in the outer surf zone, with a peak in May and June. The inner surf zone had a lower abundance and a peak in December. Two species commonly found in the surf zone as juveniles and adults (Florida pompano and whiting) were absent or uncommon as larvae. The winter construction window for the proposed projects is expected to minimize potential effects on recruitment of both reef and non-reef fishes in nearshore habitats.

The Preferred Alternative has no anticipated direct impacts to nearshore hardbottom habitats; therefore no impact to the recruitment potential of reef fishes is anticipated.

**Indirect effects**
A potential indirect effect of the proposed project on reef fish recruitment is related to the possible impact of turbidity on algae abundance. If turbidity from the project reduces algae cover on reefs outside the area of direct impact, fish recruitment may be reduced in those areas. In an algae dominated reef system in New Zealand, it was demonstrated that algal abundance was crucial in the recruitment of juvenile fish, providing both shelter and epifaunal food resources. When all algae were experimentally completely removed, recruitment was decreased by 87% (Jones, 1984). The extent of this potential effect is unknown, but the duration is expected to be short (less than one year following construction).

The very modest fill template of the Preferred Alternative, combined with the high quality of the proposed borrow material and the transient nature of the impact from elevated turbidity, is expected to result in no significant indirect impact to reef fish recruitment potential.

**10.3 Anticipated Effects of the Preferred Alternative on Non-Reef Fishes**
Hackney et al. (1996) reviewed biological data on the common species of surf zone sand dwelling fish in the South Atlantic Bight and the potential impacts from beach restoration projects. They were not able to document significant impacts to surf zone fishes as a result of beach restoration projects, which they attribute mostly to a lack of studies that addressed the issue. Their general conclusion was that the diversity and abundance of surf zone fishes reaches a minimum in winter and diversity reaches a maximum in late summer. They found the peak in abundance most often occurs in the fall when large schools are migrating along beaches. The major recruitment period for juveniles to surf zone habitats was in late spring to early summer.

The Sebastian Inlet Tax District has commissioned long-term studies on surf zone fishes near Sebastian Inlet. Those studies, using monthly beach seines, also found a very pronounced peak in fish population in mid to late summer and a minimum in winter (Irlandi 1999).

The general lack of strong site fidelity of non-reef fishes lessens the potential for direct impacts, since these fish can more successfully relocate to avoid unfavorable conditions. The well-documented short-term negative impacts of beach restoration projects on important prey items for surf zone fishes (for example mole crabs and surf clams) may be transmitted to the fish community through the food chain. Hackney et al. (1996) recommend that beach construction take place in the winter (November through March) to minimize effects on surf zone fish communities and their invertebrate prey. They also recommend beach fill with a small
percentage of fine-grained material to minimize turbidity related effects. The proposed project incorporates both these features. No significant or long lasting effects of the Preferred Alternative project or the project alternatives are anticipated for non-reef fishes.

10.4 Anticipated Ecosystem Level Effects of the Preferred Alternative on Fish Habitat

The nearshore reef within the project area may have important overall ecosystem roles. A nearly continuous stretch of reef habitat just off the coastline may be an important “corridor” for the movement and dispersal of reef fishes up and down the coast. Such a corridor may also provide important resources for non-reef species, such as bluefish, *Pomatomus saltatrix* and Spanish mackerel *Scomberomorus maculates*, which regularly migrate up and down the coast in the immediate offshore zone. Lindeman and Snyder (1999) postulate that the nearshore hardbottom plays an important role due to its cross shelf positioning, lying between estuarine developmental habitats and adult marine habitats. The Preferred Alternative is not anticipated to have any ecosystem level, since there will not be any direct impact to nearshore hardbottom habitat. The effects of the proposed alternatives on these large scale ecological roles is expected to be minimal and not significant, due to the small amount of total available hardbottom habitat that will be impacted.

10.5 Anticipated Effects of Project Alternatives

10.5.1 The No-Action Alternative

This alternative would eliminate all direct and indirect effects on fish and fisheries. Some negative effect on recreational fisheries will accrue from the no-action alternative, as eroded beaches become less attractive for surf fishermen and divers.

10.5.2 The Full Volume Alternative

Direct impacts to reef fishes can be estimated using the method outlined in Section 10.1 above. This estimate can be applied to reefs in the proposed project area. The Full Volume Alternative project directly impacts 5.3 acres (= 2.14 hectares), giving a potential loss of 360 kg of fish biomass, with the highly conservative assumption of zero survival of displaced fishes. Given the magnitude of commercial and recreational fish landings, this level of impact is unlikely to be significant.

The potential impact of the Full Volume Alternative on reef fish recruitment potential can be estimated using the method outlined in Section 10.2 above. Applying this mean to the direct reef impact area of the Full Volume Alternative project, (5.3 acres = 21,400 m²) gives a potential loss of 374,500 fish recruits per year, applying the unrealistic assumption that none of the recruits are able to settle elsewhere. Using a survival rate to first reproduction of 0.01% given for the grunt *Haemulon flavolineatum* by Shulman and Ogden (1987), the proposed projects would, in total, result in a yearly equivalent loss to the fishery of 37.4 adult fish.
Indirect impacts of the Full Volume Alternative are difficult to quantify, but are expected to be limited by the wintertime construction window and by the high quality of the proposed borrow material.

10.5.3 The Reduced Fill Alternative

The reduction in the amount of affected nearshore reef habitat associated with the reduced fill alternative decreases the magnitude of the estimated direct effects on fish populations. The same calculations used previously may be applied to the acreage resulting from the reduced fill alternative (3.2 acres of direct impact). The estimate for anticipated loss of fish biomass becomes 217kg. The estimated potential loss of fish recruits per year is also decreased proportionately to the decrease in acreage of habitat directly impacted. The reduced fill alternative results in an annual recruitment loss of 225,750 larval fish.

Although more difficult to quantify, indirect effects of initial construction of the proposed project on fish and fisheries are expected to be decreased by the reduced fill alternative roughly proportionally to the decrease in fill volumes. The total cumulative indirect effects of the reduced fill alternative may actually be greater than for the preferred alternative, since the reduced fill alternative would result in the placement of slightly more sand on the Sector 7 beaches over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3.

10.5.4 The Six Groin Alternative

The magnitude of the direct and indirect impacts resulting from initial construction under the six groin alternative is expected to be the same as experienced with the Full Volume Alternative discussed above. The increase in the renourishment interval provided by the six groin alternative would decrease the frequency of impacts, and reduce the total volume of sand placement over the 30 year planning period.

Groins that extend somewhat into the nearshore zone may themselves provide significant habitat for reef-associated fishes. Hay and Sutherland (1988) reviewed the ecology of rocky structures, including groins, jetties, and breakwaters, in the southeast U.S. They concluded that these rocky structures support diverse fish communities typical of the area in general, and noted that these structures often support exceptionally high densities of juveniles. The design for the groin elements specifies that they will be entirely above water at first construction, but as the beachfill equilibrates and the project erodes over time, the groins will extend farther into the nearshore waters, providing some variable amount of habitat that is difficult to quantify.

10.5.5 The Upland Sand Alternative

The magnitude of the direct impacts resulting from initial construction under the Upland Sand Alternative are expected to be the same as those for the Full Volume Alternative discussed above. Indirect impacts under the Upland Sand Alternative are expected to somewhat less, due to less turbidity associated with mechanical placement of upland sand compared to the hydraulic placement of offshore sand.
10.6 Anticipated Effects on Managed Fisheries

Nearshore habitats in the proposed project areas contain members of three Fishery Management Plans (FMPs) administered by the South Atlantic Fishery Management Council (SAFMC 1998).

The South Atlantic Snapper-Grouper complex is a group of 73 species of primarily reef fishes. Twenty-four of those species are listed in Table 1 as being frequent, common, or abundant in local nearshore hardbottom habitats. Species in common are listed here:

Serranidae – Groupers and Sea Basses
  \textit{Centropristis striata}
  \textit{Epinephelus itajara}
  \textit{Epinephelus morio}
  \textit{Mycteroperca microlepis}

Ephippidae – Spadefishes
  \textit{Chaetodipterus faber}

Lutjanidae – Snappers
  \textit{Lutjanus analis}
  \textit{Lutjanus apodus}
  \textit{Lutjanus griseus}
  \textit{Lutjanus jocu}
  \textit{Lutjanus mahogoni}
  \textit{Lutjanus synagris}
  \textit{Ocyurus chrysurus}

Pomadasyidae – Grunts
  \textit{Anisotremus surinamensis}
  \textit{Anisotremus virginicus}
  \textit{Haemulon aurolineatum}
  \textit{Haemulon chrysargyreum}
  \textit{Haemulon parrai}
  \textit{Haemulon plumeri}

Carangidae – Jacks and Pompanos
  \textit{Caranx bartholomaei}
  \textit{Caranx cryos}
  \textit{Caranx hippos}
  \textit{Caranx rubber}

Sparidae – Porgies
  \textit{Archosargus probatocephalus}
  \textit{Calamus bajonado}
The sole member of the Spiny Lobster FMP is the spiny lobster, *Panulirus argus*. This species is found in nearshore hardbottom habitats in the proposed project areas.

As has been discussed at length, considerable live rock (living marine organisms attached to a hard substrate) is found in the proposed project areas, which falls under the Coral, Coral Reefs, and Live/Hard Bottom Habitat FMP. There are also some scleractinian corals present in low abundance in the proposed project areas that would fall under this Management Plan.

Neritic habitats in the vicinity of the proposed offshore borrow areas may be expected to contain all six species comprising the Coastal Migratory Pelagics FMP, except possibly the dolphin, *Coryphaena hippurus*, which occurs at very low abundance in such shallow water.

The proposed project areas are included in Habitat Areas of Particular Concern (HAPCs) for two Fishery Management Plans administered by SAFMC. HAPCs for the snapper-grouper complex FMP include nearshore hard bottom areas (with no other geographic references). HAPCs for the coral, coral reefs, and live/hard bottom FMP includes *Phragmatopoma* reefs off the east central Florida coast, and nearshore hard bottom (0-12 feet depth) from Cape Canaveral to Broward County. The proposed project area does not contain any HAPC for the spiny lobster FMP.

10.6.1 Local Commercial Fisheries

The only commercial fishery in the nearshore zone is a minor hook and line fishery for pompano (*Trachinotus carolinus*), supporting mostly part time fishermen. Short-term effects from local increases in turbidity will affect this fishery, but no long-term effect is expected, as the pompano is not a reef-associated species. No significant impact to commercial fisheries is expected to result from the proposed project.

10.6.2 Local Recreational Fisheries

Significant shoreline recreational fisheries exist for pompano and whiting (*Menticirrhus spp.* ) in the general project areas. Impacts to this fishery are expected to be limited to short-term turbidity effects, since neither is a reef-associated species. The abundance of the sand flea *Emerita talpoida*, a favored live bait for this fishery, may be negatively impacted by the proposed project over the short to mid term. There is a significant recreational fishery for spiny lobster on the nearshore reefs. Indian River County is one of the few areas where beach diving for lobster is productive which becomes particularly important to divers without access to boats. Increases in turbidity over the short term in and around the project areas may limit diving opportunities immediately adjacent to discreet fill areas. Long-term effects are expected to be minimal, due to the small proportion of available habitat affected by the proposed project.
LITERATURE CITED


Applied Technology and Management. 1999a. Indian River County 1999 pre-engineering design project geotechnical investigation core borings (vol. 1-3) ATM Inc. Gainesville, Florida.


TABLE 1. LIST OF FISHES FROM NEARSHORE HARDBOTTOM HABITATS
(Modified from Gilmore et al. 1981)
Abundance classes – F= Frequent, C= Common, A= Abundant
Fishery status – C= Commercial fishery value, S= Sport fishery value

<table>
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<th>SPECIES</th>
<th>ABUNDANCE CLASS</th>
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<tr>
<td>Muraenidae – Moray Eels</td>
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<tr>
<td>Gymnothorax funebris</td>
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<tr>
<td>Gymnothorax moringa</td>
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<tr>
<td>Clupeidae – Herrings</td>
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<tr>
<td>Harengula jaguana</td>
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<td>C</td>
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<tr>
<td>Opisthonema oglinum</td>
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<td>C</td>
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<tr>
<td>Sardinella aurita</td>
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<tr>
<td>Anchoa cubana</td>
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<td>Anchoa lyolepis</td>
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<td>Gobiesocidae – Clingfishes</td>
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<td>Centropristis striata</td>
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<td>Stephanolepis hispidus</td>
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INSERT FIGURES HERE:

FIGURE 1 : Sector 7 location map. ATM file: 04-933 Sector 7 RAI – location map.dwg
SHEET 1 12/13/04
APPENDIX B

Section 106 Concurrence Letter
Dear Ms. Smith:

Our office has received and reviewed the above referenced project in accordance with Section 106 of the National Historic Preservation Act of 1966 (Public Law 89-665), as amended in 1992, and 36 C.F.R., Part 800: Protection of Historic Properties, Chapters 267 and 373, Florida Statutes, Florida's Coastal Management Program, and implementing state regulations, for possible impact to historic properties listed, or eligible for listing, in the National Register of Historic Places, or otherwise of historical, architectural or archaeological value. The State Historic Preservation Officer is to advise and assist state and federal agencies when identifying historic properties (listed or eligible for listing, in the National Register of Historic Places), assessing effects upon them, and considering alternatives to avoid or minimize adverse effects.

We have received the additional information for the above referenced project and concur with the responses by John Morgan of Morgan & Eklund. However, in the future, please refer to the enclosed Florida Division of Historical Resources, Performance Standards for Submerged Remote Sensing Surveys, for survey requirements and reports submitted to this office.

If you have any questions concerning our comments, please contact Mary Rowley, Historic Sites Specialist, at mrowley@mail.dos.state.fl.us. Your interest in protecting Florida's historic properties is appreciated.

Sincerely,

Janet Snyder Matthews, Ph.D., Director
State Historic Preservation Officer

JSM/Rmr
Enc.: (4)
Xc: DEP-Office of Beaches and Coastal Systems, Tallahassee, Florida
APPENDIX C

Modeling Report
Sector 7 GENESIS Modeling update for 2004 Shoreline

The Indian River County Sector 7 GENESIS modeling study has been updated as per FDEP request to review a No-Impact beachfill design alternative for the Sector 7 shoreline. Previous Sector 7 modeling studies used the 1986, 1997, 1999, and 2001 shorelines for model calibration and validation while the 1999 and 2001 shorelines were used as the baselines for alternative analysis. This study now uses the July 2004 shoreline as the baseline. Please refer to the previous studies for more in-depth analysis of methodology and calibration/validation. This study will briefly recapitulate some of the previous Sector 7 shoreline modeling as well as present new analysis which includes the 2004 shoreline, seawalls, etc.

Model Setup

The one-dimensional model grid used in GENESIS includes 60,000 feet of shoreline (900 grid cells, each 66.666 feet long). The GENESIS shoreline model grid encompasses a smaller length of shoreline than the REFDIF1 wave model grid, and it is located such that lateral boundary effects from the REFDIF1 model will not affect the wave inputs to the GENESIS model. The GENESIS model uses a one-dimensional grid that extends in the alongshore direction, and is referred to as the model baseline. The baseline was set landward of the DEP monuments and rotated 73 degrees, which is approximately parallel to the study area shoreline. The northern boundary of the GENESIS grid is near monument T-60 and the southern boundary is near monument R-119. This study will only focus on the southern most 30,000 feet of the model grid, which includes Sector 7 and the adjacent shorelines to the north and south, which is shown in Figures 1 and 2.

Input Beach Characteristics

The beach characteristics used for the model simulations of the existing beach include a berm height of 6 feet and a depth of closure of 28 feet. The depth of closure was selected based on equations using wave period and height. Hallermeier (1983) and Houston (1996) depth of closure equations were both implemented.

Along most of the Sector 7 shorelines, significant profile change does not occur below a depth of 16 feet due to the presence of hardbottom, however GENESIS cannot model hardbottom. Because of this deficiency, the 28-foot depth of closure was chosen.
Consequently, measured shoreline to volume ratios that were calculated at each DEP monument (which include hardbottom features) were translated to a GENESIS shoreline to volume ratio (which does not explicitly include hardbottom features).

**Input Seawalls**

Seawall and revetment locations were surveyed by Indian River County in 1999 and 2001. Most seawalls in Sector 7 average between 20 and 30 feet landward of MHW. The proximity of the seawalls to the MHW line necessitates their inclusion in the GENESIS model, however, with beach nourishments they should not interfere with normal sand transport. Seawalls do significantly effect shoreline position and sediment transport for the no action alternative and any model runs where shoreline erosion recedes past the 2004 shoreline.

**Model Calibration and Validation**

Shoreline MHW positions from 1986, 1997, 1999, 2001 and 2004 and sediment transport rate from 1986 to 1997 were involved in calibration and validation. The primary factor in calibrating and validating a shoreline change model is the shoreline position, which represents change in length. Also important is change in volume and this was calibrated from measured sediment transport rate. Very good agreement was obtained between the measured and modeled shorelines and the measured and modeled transport rates. For more information on calibration and validation, please refer to the previous ATM Sector 7 reports.

**Alternatives Modeling**

The proposed alternative is a No-Impact beach fill template designed to avoid all direct and indirect hardbottom impacts. Therefore, fill volume placement was chosen carefully in order to optimize the two opposing factors (beach protection and hardbottom impact). A no-action alternative was also run for comparison.

Alternatives are:

1. No-Impact alternative: 363,600 CY
2. No Action
The proposed fill alternative is presented in Figure 3. Figures 1 and 2 present measured shorelines from different years and it can be seen from these figures that the most significant erosion is occurring between DEP monuments 101 and 108. Ideally, the most fill would be placed in this region; however nearshore hardbottom limits the amount of fill placement in this area.

Shoreline evolution results for the proposed design after two and four years can be seen in Figure 4. After 2 years, the proposed alternative shoreline has retreated back to the measured 2004 shoreline at DEP monument 105. The beachfill north of DEP monument 102 performs rather well in maintaining the shoreline. Figure 5 shows the No-Action results where continued erosion occurs between DEP monuments 100 and 106.

Figure 6 presents maximum shoreline positions of both alternatives in an effort to more precisely gage any potential hardbottom impacts. Maximum shoreline advancement was developed by comparing initial, yearly, and final shoreline model output and selecting the largest value in each grid cell. This was performed from year 0 to year 10. Note that the maximum shoreline position is almost identical to equilibrated shoreline due the overall erosional nature of Sector 7. Thus, the design is not expected to cause any adverse impacts to the nearshore hardbottom. For this same reason, the No-Action maximum shoreline advancement and the 2004 measured shoreline are also virtually identical in Sector 7.

Figure 7 presents downdrift shoreline evolution due to the proposed project. Minor effects are evidenced through DEP monument 111 after 4 years. Figure 8 presents maximum shoreline positions for the same area and minor effects here are seen down to DEP monument 113. Minor effects are also seen updrift of the project area through DEP monument 95 (Figure 9).

The major conclusions drawn from the GENESIS modeling are:

- Shoreline evolution modeling verified that the No-Impact beachfill design will not cause any direct impacts to the nearshore hardbottom
- The modeling also showed that the No-Impact beachfill design will not cause any secondary hardbottom impacts due to project spreading to the updrift and downdrift beaches.
- Renourishment of the No-Impact design will be required in 2-4 years after project construction.
Figure 1: IRC Sector 7 shorelines from 1986, 2001, and 2004 (undistorted).
Figure 2: IRC Sector 7 shorelines from 1986, 2001, and 2004. Image is distorted to more easily view trends.
Figure 3: 2004 shoreline, No-Impact design equilibrated shoreline (MHW), and landward extent of hardbottom (distorted).
Figure 4: No-Impact design shoreline evolution GENESIS results
Figure 5: GENESIS No-Action shoreline evolution results.
Figure 6: Maximum shoreline positions from years 0 through 10 of shoreline evolution GENESIS output.
Figure 7: Downdrift shoreline evolution GENESIS results for the No-Impact design.
Figure 8: Minimum and maximum shoreline positions downdrift of project area. Minima and maxima are taken from years 0 through 10 of model run.
Figure 9: Updrift shoreline evolution GENESIS model results for the No-Impact design.