4. ENVIRONMENTAL EFFECTS

This section is the scientific and analytic basis for the comparisons of the alternatives. See Table 3 in Section 2.0 for a summary of impacts. The following includes anticipated changes to the existing environment including direct, indirect, and cumulative effects.

4.1. GENERAL ENVIRONMENTAL EFFECTS.

The beneficial effects from the placement of sand fill along the proposed project areas include the establishment of a larger buffer area for protection against storms and flooding and creation of additional dry beach for recreational activities. The placement of sand may increase sea turtle nesting habitat provided that the sand is highly compatible with naturally occurring beach sediments and that compaction and escarpment remediation measures are incorporated into the project.

Potential negative effects to sea turtles include possible destruction of nests deposited within the boundaries of the proposed project, harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches, disorientation of hatchlings on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of project lighting, and behavior modification of nesting females due to escarpment formation within the project area during a nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs. The quality and color of the sand could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest. The proposed placement of three groins within the northern end of John U. Lloyd State Park south of Port Everglades Inlet will help stabilize this erosional hot-spot, but may negatively impact sea turtles by causing hatchling disorientation during transit to the ocean.

Protective measures can alleviate the potential for some of these negative impacts (i.e. nest monitoring and relocation, using minimum lighting and/or shielding construction lighting, compaction monitoring and tilling activities to reduce sand compaction, and leveling escarpments prior to nesting season).

The presence of construction equipment and personnel will temporarily detract from the aesthetics of the beach. Best management practices will be implemented to ensure efficient construction and the minimization of extended presence of equipment and personnel on project area habitats. Immediately after placement, the color of the dredged sand will most likely be darker than the sediments on the existing beach, which may detract from the aesthetic quality of the beaches. However, natural working of the dredged sediments by sunlight, rain, and wind will lighten the color of the sediments in a relatively short time.

The five proposed borrow areas lie adjacent to reef communities of varying species composition, diversity, and density. Buffer zones have been established based upon the adjacent community characteristics to protect mature reef communities and reefs with dense epibenthic assemblages from mechanical damage and sedimentation/turbidity impacts. Construction reef edge sedimentation monitoring and a dredging pattern of alternating borrow areas will minimize the potential for negative impacts. The use of hopper dredges will eliminate impacts associated with hydraulic dredge swing anchors and cables.

The primary impacts to hardbottom areas seaward of the equilibrium toe of fill will be mechanical damage from the pipeline used to transfer material from the dredge to the beach fill areas. Biological communities within the eight proposed pipeline corridors have been documented with DGPS integrated digital video. Bottom features were mapped from the video tracklines to identify the least impactive corridors feasible given the limitations of the dredging equipment. The 100-foot wide corridors were investigated using boat-towed divers during the spring/summer of 2002. Two, east-west transects were performed at approximately 25-foot spacing to visually ground-truth the entire corridor. Areas of significant stony coral coverage and size along the tracklines were identified. The results of the pipeline corridor investigations are presented in the GIS database. The corridor location originally proposed near R-66.5 was investigated on April 23, 2002. This corridor will not be used due to the presence of irreplaceable stony coral and soft coral. An alternative corridor was located approximately 200 feet south of R-68. Prior to construction, Broward DPEP staff will determine the least impactive routes through the corridors for actual pipeline placement and site the placement locations with buoys to avoid the areas of significant stony coral coverage and size.

The 3-foot diameter pipelines will be collared to minimize contact with the ocean bottom. Pumpout terminal anchors or spuds will be sited by Broward County DPEP SCUBA divers. Anchors or spuds will be located entirely in sand bottom. Weekly monitoring of all pipelines to shore will be performed to check for sand movement and leaks. Continuous leak monitoring will be required by the dredging contractor through fluctuation in pressure through the pipelines.

The proposed project will cover a gross total of approximately 13.6 acres of nearshore hardbottom habitat after the beach reaches equilibrium. Evaluation of two shore-parallel video transects within the project areas was conducted to differentiate between hardbottom habitats and sand pockets interspersed within the equilibrium toe of fill (ETOF). The results of video transect evaluation revealed that within the ETOF, there exists 2.5 acres of area comprised of only unconsolidated sediments. Therefore, a net total of 10.1 acres of hardbottom is located inshore of the equilibrium toe of fill. Approximately 2.0 of the 10.1 acres of net impact will occur as direct burial at the time of construction. The preferred mitigation for the loss of nearshore hardbottom habitat will provide for “in-kind” habitat replacement by the creation of 11.9 acres of nearshore artificial reef using limestone boulders. The 10.1 acres of net hardbottom impact were anticipated to require 12.4 acres of compensatory mitigative reef. To offset the temporal lag in habitat functionality, scleractinian corals greater than 15 cm diameter within the ETOF will be transplanted to the mitigative reef. Project construction of the mitigative artificial reefs will also occur prior to project fill placement within each segment. The reduction of the temporal lag by coral transplantation reduced the required 12.4 acres to 11.9 acres of compensatory mitigative reef for both Segments II and III combined. Detailed biological characterizations of the impacted nearshore hardbottom communities have determined the mitigatability of this habitat. The potential exists for secondary impacts to epibenthic communities seaward of the equilibrium toe of fill resulting from sedimentation and/or chronic turbidity. The post-construction monitoring plan includes assessment of potential impacts to these communities to determine appropriate mitigation measures for any loss of productivity and/or shift in community structure.

4.2. VEGETATION.

4.2.1. PROPOSED ACTION, BEACH FILL WITH PERIODIC RENOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK.

4.2.1.1. Upland vegetative communities.

Most of the native dune habitat in Broward County has been lost to either urban development, beach erosion, or a combination of the two. Upland areas along Fort Lauderdale beach have been impacted by coastal development and are generally devoid of dune and hardwood hammock habitat. South of Port Everglades Inlet, at John U. Lloyd State Park, mostly exotic invasive species such as Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*) dominate the uplands areas. Many of these upland areas were created by filling with dredge spoil. However, there are areas within the park where native species of the coastal dune and hammock region remain (Coastal Technology Corporation, 1994).

Beach nourishment activities in Broward County will likely be required by State and Federal resource protection agencies to limit, to the greatest extent practical, disturbance to existing beach and dune vegetation. Protective measures included in the plans and specifications will limit construction activities to those areas of unvegetated beach and dune, unless expressly authorized by the project permits. No vegetation exists on the beach in John U. Lloyd State Park where the three groins are proposed.

4.2.1.2. Seagrass communities.

Biological investigations performed during the summer of 2001 revealed the presence of scattered patches of *Halophila decipiens* throughout the offshore, sandy areas proposed as borrow sites, as well as in sandy bottom areas in Broward County removed from the borrow sites. Most of these scattered patches consisted of less than 50 shoots. Contiguous areas of *H. decipiens* were documented in the southeastern portion of Borrow Area VI and in Borrow Area VII. Borrow Area VII has been deleted from the proposed project design, thereby eliminating associated impacts to contiguous *H. decipiens* beds. Borrow Area VI was reconfigured to remove the portion of the borrow area that contained significant coverage of *H. decipiens*. No direct impacts to contiguous seagrass areas from dredging operations are expected.

There is a buffer of approximately 400 feet to the documented area of *H. decipiens* south of Borrow Area VI (see Broward County GIS for documentation). Ground-truthing SCUBA dives in July 2001 revealed contiguous patches from 400 feet to 900 feet south of the revised Borrow Area VI limits. This buffer should alleviate potential secondary impacts associated with turbidity from dredging operations; however the potential for short-term decreases in primary productivity exists. Impacts to primary production should be minimal as *H. decipiens* possesses specific morphological and structural features that allow it to maximize its light harvesting ability at low light levels (Josselyn et al., 1986). A study by Kenworthy et al. (1989) in St. Croix, US Virgin Islands, investigated the trophic link between benthic primary production and bacterial decomposition of *H. decipiens* in similar water depths to Broward County (14 and 32 meters). The study estimated that only 0.26% of the daily detrital input from *H. decipiens* is converted daily into bacterial biomass attached to the degrading plant material (Kenworthy et al., 1989). The study concluded that, unless the heterotrophic bacteria utilized the organic matter more efficiently and high levels of grazing occurred, attached bacteria would not make a significant contribution to the energy demands of deposit-feeding detrivores (Kenworthy et. al. 1989). The results of this study suggest that secondary impacts to trophic levels associated with the offshore *H. decipiens* communities in Broward County would be minimal.

There are no known seagrass beds located within or adjacent to the proposed beach fill areas. Seagrass beds consisting of *Halophila decipiens* have been observed in the Port Everglades Inlet Channel and Intracoastal Waterway adjacent to Port Everglades (Ken Banks, personal communication, 1999). Since these seagrass communities are mostly restricted to the vicinity of the inlets, impacts should be minimal. Inlet communities should generally not be adversely affected by the proposed project activities.

4.2.2. JANUARY 2001 GRR BEACH FILL DESIGN WITH PERIODIC RENOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK

The project design as originally proposed in the January 2001 General Reevaluation Report would directly impact a minimum of 3,000 square feet of *H.decipiens* located within Borrow Areas VI and VII during dredging operations. There would be an increased likelihood of secondary impacts of turbidity to the *H. decipiens* area adjacent to Borrow Area VI as no buffer zone would protect adjacent seagrass communities.

4.2.3. BEACH FILL WITH PERIODIC RENOURISHMENT.

Impacts would be the same as for the proposed renourishment action.

4.2.4. ALTERNATIVE SAND SOURCES.

4.2.4.1. Distant Domestic Sand Sources.

No distant domestic sources have been identified or evaluated for the initial renourishment activity. Therefore, impacts associated with using distant domestic sources cannot be predicted at this time. It is possible that distant domestic sand sources may be identified in the future.

4.2.4.2. Foreign Sand Sources.

The effects of dredging sand from a foreign source, such as oolitic aragonite from the Bahamas, are not known. Further investigations would be needed to determine the effects upon marine resources in the vicinity of the sand source. It is expected that the use of foreign borrow areas would incorporate the proper precautions to ensure that seagrasses would not be impacted (USACE, 1998).

4.2.4.3. Upland Sand Source.

Sand from an upland source would be obtained from a commercial quarry. There would likely be some terrestrial vegetation lost at the quarry site due to sand excavation activities (USACE, 1998). The Lake Wales Ridge sand ridges are situated in xeric sand pine and scrub oak habitats. If new mines or mine expansions are proposed in these habitats, impacts to upland plant species, many of which are listed as threatened or endangered by the Federal government and State of Florida, may occur. Impacts to dune vegetation at the beach fill site would be the same as for the proposed action and permit conditions and contract specifications would involve the same protective measures for dune vegetation. There would be no impacts to offshore seagrass communities associated with the use of an upland sand source.

4.2.5. NO ACTION ALTERNATIVE (STATUS QUO).

The no-action alternative would have no impact on seagrass communities. The shoreline would continue to erode under the no-action alternative, which could eventually result in the loss of adjacent upland and dune vegetation.

4.3. THREATENED AND ENDANGERED SPECIES.

4.3.1. PROPOSED ACTION, BEACH FILL WITH PERIODIC RENOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK.

4.3.1.1. Sea turtles.

4.3.1.1.(a) Nesting Habitat.

Of the threatened and endangered species found in coastal Broward County, sea turtles are most likely to be impacted by nourishment activities. Concerns include the timing of construction activities and potential burial of sea turtle nests and increased beach sand compaction due to the presence of heavy equipment and sand deposition. Specific measures as defined in the reasonable and prudent measures and terms and conditions of the Biological Opinion for the proposed Broward County Shore Protection Project will be implemented. The potential impacts associated with beach nourishment projects that are described below would apply to any of the alternative sand sources discussed, including use of the proposed offshore borrow areas.

The Broward County Department of Planning and Environmental Protection has maintained a continuous sea turtle conservation program since 1978. All nests in danger of negative impacts from natural and human activities are relocated. Broward County defines at-risk nests as those that: are located within 20 feet of the previous evening wrack line; are located near a highway or artificially lighted area defined as a beach area where a worker can see their shadow on a clear night; or are located in an area subject to beach nourishment activities (Burney and Margolis, 1999).

The 2000 Broward County Sea Turtle Conservation Report (Burney and Margolis, 2000) documented 2,118 sea turtle nests within or in the immediate vicinity of the proposed beach nourishment project areas. All nests discovered at Pompano Beach, Deerfield Beach, Hollywood-Hallandale, and Fort Lauderdale were relocated during the 2000 nesting season (and have been each year since 1978, mainly due to lighting).

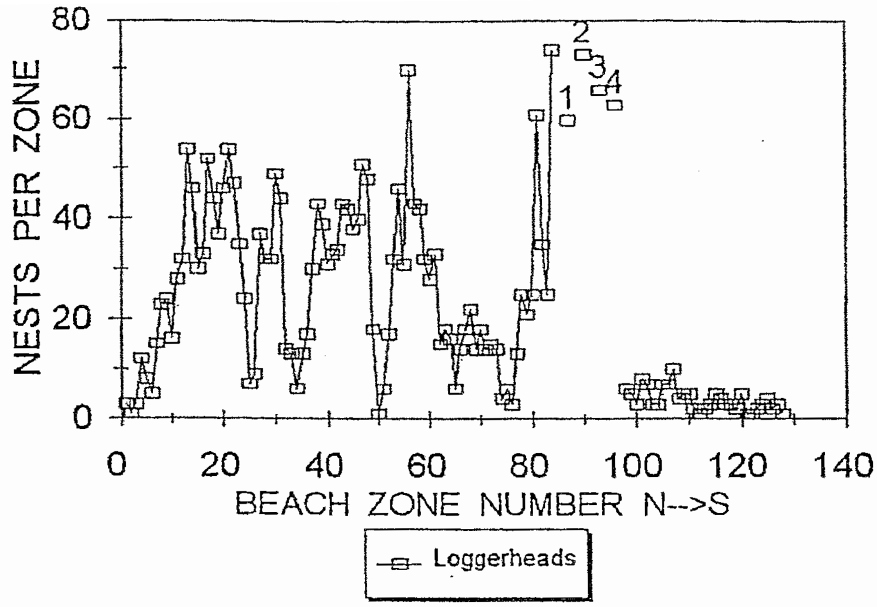
Physical alterations of sea turtle nesting habitat due to beach nourishment include changes in sand compaction, density, sheer resistance, color, moisture content and gas exchange of beach sand (Nelson & Dickerson, 1988; D.A. Nelson, 1991; Ackerman, 1991; Ackerman et al., 1991, 1992). Some of these alterations with the potential to negatively impact nesting success can be mitigated. The effects of increased sand compaction and scarp formation can be greatly reduced or eliminated through compaction monitoring, mechanical tilling, and grading of the beach. Compaction monitoring is a State and Federal permit requirement following nourishment activities, prior to nesting season commencement, and for two years following project completion. Tilling of project area beaches is currently required by State and Federal agencies if penetrometer testing demonstrates compaction in excess of 500 pounds per square inch at any two adjacent sampling stations or depths. Additionally, escarpments greater than 18 inches in height or 100 feet in length must be leveled prior to nesting season commencement.

Monitoring results of several nest relocation programs in association with beach restoration projects in Florida have documented no significant difference in hatching and emergence success of turtles on nourished versus non-nourished beaches (Raymond, 1984; Nelson et al., 1987; LeBuff and Haverfield, 1990; Steinitz, 1990; Ryder, 1992). Broadwell (1991) found no difference between the hatching success for restored and natural beaches for *in situ* nests in Boca Raton and she also reported that hatchling emergence success and hatchling weights were significantly greater for nests incubated on the nourished beach compared to the adjacent natural beach.

Data from the 1998 Ocean Ridge project in Palm Beach County suggested substantial negative effects in nesting, nesting success, and hatching/emergence success during the nesting season immediately following beach renourishment (Palm Beach County Department of Environmental Resource Management, 2001). Ernest and Martin (1999) also found that the principal effect on sea turtle reproduction was a reduction in nesting success during the first year after project construction in Martin County. Data from both projects suggest that the negative effects of beach renourishment on nesting and hatching success persist for approximately two years after construction (Palm Beach County Department of Environmental Resource Management, 2001).

Burney and Margolis (2000) examined the impact of the Deerfield Beach/Hillsboro Beach Project on nesting and hatching success during the three year post-construction period. Immediately after the 1998 renourishment project, loggerhead mean nesting success was low on the project area beach (DEP monument R-6 through R-12). It steadily increased during the three-year post-construction period, and was not statistically different in 2000 compared to the 1991 level when severe beach erosion was not evident (Burney and Margolis, 2000). Comparison of the three zones (R-1 to R-5, R-6 to R-12, and R-13 to R-24) demonstrated that 1998 mean loggerhead nesting success was significantly lower in the project area than on the less eroded beach to the south (R-13 to R-24) but was not statistically different from the more adversely impacted region of Deerfield Beach to the north. This situation was reversed in 1999 and, in 2000, there were no significant differences between the three zones (similar to 1991). There was also no significant difference in the hatching successes for loggerhead nests that incubated on the nourished and unnourished sections of Hillsboro Beach and Deerfield Beach (Burney and Margolis, 2000).

Figure 12 graphically depicts the distribution of all three species nesting in each 1000-foot zone of Broward County beaches (1 km zones in John U. Lloyd State Park) during 2000. The distribution of



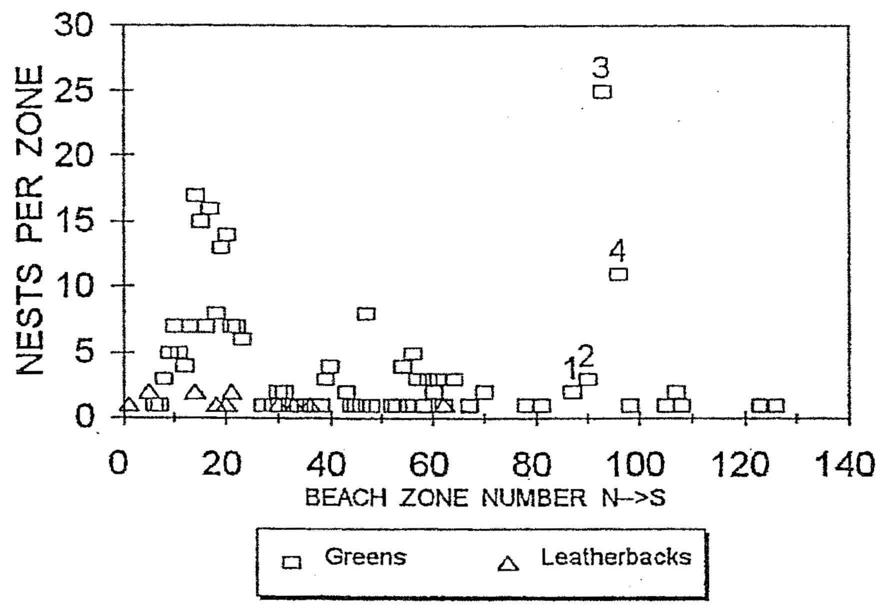


FIGURE 12: Locations of loggerhead, green, and leatherback nests in Broward County, 2000. Numbers 1-4 indicate the four beach zones of John U. Lloyd State Park.

Source: Burney, C., and W. Margolis. 2000. Sea Turtle Conservation Report (Technical Report 01-02). Nova Southeastern University.

loggerhead nests in the 128 survey zones correspond to the same shoreline features that have been identifiable since 1981. As in past surveys, beaches near the Deerfield Beach and Commercial Boulevard piers, Hillsboro Inlet, the Fort Lauderdale strip and throughout Dania Beach, Hollywood, and Hallandale remained lightly nested (Burney and Margolis, 1998, 1997; Burney and Mattison, 1992; Mattison, Burney and Fisher, 1993). Also, as in previous years, green sea turtles nested most heavily at Hillsboro Beach and John U. Lloyd State Park in 2000, possibly because of the lower levels of beachfront lighting and other nocturnal disturbance (Burney and Margolis, 2000). Leatherback sea turtles nested most heavily on Hillsboro Beach, and there were no leatherback nests in John U. Lloyd State Park or Hollywood (Burney and Margolis, 2000). Figure 12 demonstrates that nesting activity and nest distribution south of John U. Lloyd State Park (southern 30,000 feet of the Broward County shoreline) are significantly reduced when compared to nesting in the central and northern portions of the county.

Beach restoration projects which have been constructed during turtle nesting season generally have not been detrimental to sea turtles (Fletemeyer, 1983; Wolf, 1988; Burney and Mattison, 1989). Nesting sea turtles tend to avoid the immediate construction area during beach restoration projects (Fletemeyer, 1983; Wolf, 1988; Burney and Mattison, 1989). It appears that nesting turtles easily adapt to areas away from the actual construction site (Fletemeyer, 1983; Burney and Mattison, 1989). Monitoring data from several beach nourishment projects indicates that the average number of nests/mile laid during beach restoration projects is either significantly higher than nesting densities recorded for the year prior to beach restoration (Captiva Island, 1988; South Boca Raton, 1985; Pompano/Lauderdale-By-The-Sea, 1983); or is not significantly different than the previous year (South Seas Plantation, 1981; John U. Lloyd, 1989) (Spadoni and Cummings, 1992).

Low pressure sodium lights or screening/shielding of lights have been identified by the resource protection agencies as measures to minimize impact to nesting sea turtles from necessary lighting. In order to ameliorate sea turtle nesting conditions on stretches of Broward County shoreline, the cities of Pompano Beach and Deerfield Beach each adopted a light ordinance with compliance dates of March 1, 2000 and 2001, respectively. The City of Hallandale has also enacted a sea turtle protection lighting ordinance. In Pompano Beach, the light ordinance was in effect during the 2000 and 2001 sea turtle nesting seasons (March 1 through October 31); however, no sections of beach achieved a sufficient level of compliance to allow for *in situ* hatching. In 2002, approximately 2,500 feet near the southern end of Pompano Beach was in compliance with the lighting ordinance. The remainder of Pompano Beach, Deerfield Beach and Hallandale have not achieved sufficient compliance to allow for *in situ* hatching. Lauderdale-by-the-Sea passed a lighting ordinance in 2002 and the full compliance date mandated in the regulation is March 1, 2004. Ft. Lauderdale also passed a lighting ordinance in February 2003, with a full compliance date of April 21, 2004.

Groin construction at John U. Lloyd State Park would have no direct adverse impacts to sea turtles if construction is completed outside of the nesting season. A groin field installed as part of the Ocean Ridge, Florida, Shore Protection Project was documented to impact hatchling sea turtles during the 1998 nesting season, immediately after groin construction. Specifically, hatchling disorientation was observed as the turtles intersected the rock stem of the T-head groins before accessing the water. Palm Beach County sea turtle specialists believed that the primary cause of hatchling disorientation was the presence of several lighting sources that directed the turtles away from the water and into the structures. Palm Beach County modified the light source and implemented two additional measures to mitigate for impacts: personnel caged and released hatchlings at night; and a fence was erected to direct hatchlings to the water (Olsen, 1999).

Hatchling encounters with the groins during entrance into the ocean continued to be problematic at Ocean Ridge during the 1999 and 2000 nesting seasons. In 2000, the dry beach remained wide in the groin field, allowing for successful nesting behind the groin heads. Although the beach in the vicinity of the groins was intended to have a narrower fill section to maintain the T-heads seaward of the mean high water line, more fill was placed in this section than designed. A narrower beach would allow the hatchlings to encounter water prior to running into the T-head. The discharge point for the south pipe was moved further south in an attempt to improve the downdrift transport of the sand transfer plant and reduce the accumulation of sand in the groin field. To date, this has not been effective in reducing the beach to its narrower design width in the groin field (Palm Beach County Department of Environmental Resources Management, 2001).

Unresolved light management issues with streetlights just south of the Boynton Inlet have resulted in the perpetuation of hatchling disorientation and entrapment within the structures. Due to the difficulty with maintaining fencing in the intertidal zone, nest caging has been primarily used to minimize disorientation impacts. Caging has been effective in protecting hatchlings from encountering the groins; however, it is extremely labor-intensive and involves potential stress to hatchlings. Recommendations for reducing negative effects include moving the sand transfer pipe discharge further south and implementing shields on the streetlights near the inlet (Palm Beach County Department of Environmental Resources Management, 2001).

Given these observations, hatchling disorientation in the John U. Lloyd State Park groin field is possible, but may be less likely than observed in Ocean Ridge as lighting issues are not as problematic within the Park. The groin field is also substantially smaller, thereby reducing the labor involved with nest relocation and/or caging efforts. The potential for increased likelihood of hatchlings encountering the T-head prior to the water due to increased beach widths would have to be examined during the feasibility study for planned sand by-passing activities at Port Everglades. It is anticipated that sand placement associated with the bypassing facility will primarily be south of the structure field, potentially avoiding the problems of hatchling disorientation/ entrapment encountered at Ocean Ridge.

4.3.1.1.(b) Offshore Habitat.

Hopper dredging may cause incidental takes of sea turtles, which is minimized by the proper use of rigid deflecting dragheads (USACE, 1996). The sea turtle deflecting draghead is required for all hopper dredging projects during the months that turtles may be present, unless a waiver is granted by the USACE in consultation with NMFS. Compliance with all recommendations of the 1997 NMFS Biological Opinion will be implemented to assure that incidental takes are minimized during hopper dredging operations. The 1997 amended Biological Opinion regarding hopper dredging operations mandates that year round, one hundred percent observer coverage is necessary for beach nourishment projects in southeast Florida. One hundred percent inflow screening is required, and one hundred percent overflow screening is recommended when observers are required on hopper dredges. If conditions prevent one hundred percent inflow screening, inflow screening can be reduced, but one hundred percent outflow screening is required and an explanation must be included in the preliminary dredging report. Preliminary dredging reports which summarize the results of the dredging and any sea turtle take must be submitted within 30 working days of completion of any given dredging project. Logs of any sea turtle injuries or deaths due to hopper dredging activities will be maintained, with immediate notification to the USACE, Jacksonville District, the USFWS or NMFS as appropriate, and Florida Fish and Wildlife Conservation Commission (FWCC).

4.3.1.1.(c) Nearshore Habitat.

The results of the 2001 Broward County sea turtle survey support earlier studies by Wershoven and Wershoven (1989;1990) which indicated that the reefs offshore of Broward County serve as developmental habitat for juvenile green sea turtles (*Chelonia mydas*). The results of the surveys also suggested that sea state conditions may influence sea turtle density in the nearshore zone. It is possible that the hardbottom located slightly further offshore (ETOF+300) provides more refuge from wave activity due to increased vertical complexity of the hardbottom, and that juveniles move offshore during periods of intense wave activity. Algal species documented as food sources include turf algae of the Family Gelidiaceae, and the red macroalgae, *Gracilaria* sp., *Bryothamnion* sp., and *Hypnea* sp. (Wershoven and Wershoven, 1989; 1990). During the 2001 Broward County macroalgal survey, *Gelidium* sp. was common along the hardbottom edge in Pompano Beach between R-38 and R-44 (Table 10). *Bryothamnion triquetrum* was common along the nearshore hardbottom edge in Fort Lauderdale between R-54 and R-72. This corresponded to an area where more than half of the total green sea turtle sightings occurred (19 of 33); and seven of the nineteen (19) were observed along the ETOF+300 transect.

Foraging activities of juvenile sea turtles may be temporarily impacted in the immediate vicinity of construction activities (i.e. pipeline placement and beach fill deposition) during project construction. These impacts would be short-term and restricted to the immediate vicinity of the activity. Foraging sea turtles would most likely be displaced to adjacent areas of nearshore hardbottom. Considering the abundance of alternative foraging sites in the vicinity of the project and relatively low numbers of individuals observed, the proposed summer construction in Segment III would also result in minimal displacement impacts to foraging juvenile sea turtles. Although the nesting season months appear to correlate with higher densities of juvenile green sea turtles on the nearshore hardbottom, the 2001 survey results suggest that the hardbottom areas in Segment III do not provide significant foraging habitat. Only six (6) of the sightings

during the four surveys occurred offshore of Segment III, and two of the six turtles were observed at the water surface from the boat.
Approximately 13.6 acres of nearshore hardbottom habitat are located inshore of the projected equilibrium toe of fill. Evaluation of two shore-parallel video transects within the project areas was conducted to differentiate between hardbottom habitats and sand pockets interspersed within the equilibrium toe of fill (ETOF). The results of video transect evaluation revealed that within the ETOF, there exists 2.5 acres of area comprised of only unconsolidated sediments. Therefore, a net total of 10.1 acres of hardbottom occurs inshore of the equilibrium toe of fill. The epibenthic community is dominated by macroalgae and blue-green algae, which together comprised 88% of the cumulative community composition during the 2001 nearshore characterization study. The hardbottom communities within this impact area will be gradually buried by the movement of sand during equilibrium profile translation, resulting in mortality of macroalgae and other epibenthic species. In turn, foraging juvenile sea turtles may move further offshore to areas documented during the ETOF+300 transect (Refer to Section 3.3.1.3). The potential exists for long-term, secondary impacts to hardbottom communities adjacent to the equilibrium toe of fill resulting from sedimentation and/or chronic turbidity. Secondary impacts to sea turtle foraging habitat include reductions in photosynthetic rates of macroalgae, as well as potential burial of macroalgal species. Overall, the secondary impacts to the foraging habitat of green sea turtles adjacent to equilibrium toe of fill should be minimal.

Pursuant to Federal and State mitigation compensatory requirements, Broward County is creating 11.9 acres of nearshore mitigative reef using limestone boulders as compensation for nearshore resource losses (See Section 4.34 Environmental Commitments and Appendix E for the proposed nearshore hardbottom mitigation plan). Construction of the mitigative artificial reefs will occur prior to beach fill placement in compliance with State and Federal resource protection agency directives. Limestone boulders replicate the rough surface and calcareous nature of the natural nearshore hardbottom formations. Previous studies of limestone mitigative boulder reefs in southeast Florida have found that the reefs provide suitable mitigation for nearshore, low-relief habitat lost to beach renourishment (Cummings, 1994).

Interim results of nearshore mitigative reef monitoring in Jupiter/Carlin demonstrate rapid colonization of the limestone boulders by benthic invertebrates and algae, and colonization by key nearshore reef indicator species such as wormrock and hairy blenny (Palm Beach County ERM, 2000). Subsequent investigations of the natural and mitigative reefs in August 2001 and May 2002 documented turf algae, hydroids, sponges, and worm rock (*Phragmatopoma* sp.) as the primary benthic species colonizing the mitigative reef structures.

Data collected thus far provide an initial view of the efficacy of using artificial structures to mitigate for losses of nearshore hardbottom in Palm Beach County, Florida. A considerable diversity and abundance of fishes have colonized the mitigation reefs over a time span of 2 to 4 years. Analysis of life stage abundances indicated that proportionally more individuals were recorded as juveniles than adults on natural reefs, and proportionately more individuals were recorded as adults than juveniles on mitigation reefs. The difference here was driven by the presence of abundant adults on mitigation reefs rather than a lack of juvenile stages (Palm Beach County ERM, 2002). Relative age of the mitigation reefs as well as the ephemeral and persistent nature of the natural reefs also influenced the observed fish assemblages to varying degrees. These factors also appear to be correlated with water depth (Palm Beach County ERM, 2002).

A total of 21.8 acres of suitable sandy bottom in nearshore reef sand pockets have been identified for boulder placement. Boulders will be approximately 4 to 6 feet in diameter and are expected to provide two to three feet of residual relief following settlement. The proposed time frame for construction of the boulder reefs is to begin deployments at Mitigation Area 8 offshore of a DEP monument R-103 beginning in spring, 2003. Deployment will be carried out from April 1 through September 30. Areas not completed in 2003 will be completed in 2004, but it is anticipated that all deployments within Segment III will be completed in the first year. Segment II artificial reef construction will also occur prior to beach fill placement and will likely commence in 2005. The placement of limestone boulders in immediate proximity to areas supportive of known food sources and higher concentrations of juvenile sea turtles should provide suitable replacement foraging habitat. Suitable replacement habitat is proposed for mitigation at a 1.2:1 ratio, providing 11.9 acres of substrate within a 13.5-acre footprint. The monitoring program for mitigation reefs includes an assessment of algal recruitment with an emphasis upon replacement of sea turtle foraging habitat. Two stations, each consisting of three (3), 30 meter long transects spaced at 1 meter intervals, will be established over a 0.5 acre area of the artificial reef in Fort Lauderdale

(Mitigation Area 5 between R-70 and R-71), located in the close proximity to the natural nearshore hardbottom with the highest number of juvenile green sea turtle sightings recorded in the summer of 2001 (R-52 to R-74). Additional in-water sea turtle surveys will be performed before construction commences and once each year for 2 years after construction. In Segment III, two control stations will be established over a 0.5 acre area of the artificial reef located between FDEP control monuments R-101 and R-104. The 30 meter transect will be established following the rugosity of the boulders so that algal recruitment on both horizontal surfaces and boulder slopes will be assessed. The same methodology survey will be used in two control stations on natural hardbottom. The 30 meter long transects will be documented using digital video sampling (Sony TRV-900 or comparable equipment) in progressive scan mode. Macroalgae abundance will be assessed by percent cover using frame grabbing and PointCount'99 software. Species identification within the stations will be performed *in situ* by a second, qualified diver/biologist (M.S. degree or higher). The biologist will swim two 1-meter wide corridors within the station and record a comprehensive taxonomic list of species present on the entire 60 square meter box. The algae surveys will be conducted on a semi-annual basis (spring/summer and fall/winter) for a period of 4 years in compliance with the FDEP permit.

4.3.1.2. Manatees.

Manatees are most likely to be impacted by support boats moving from dock areas through channels to the dredge vehicles (USACE, 1996). Based on information from the Florida Marine Research Institute, Florida DEP, for the period between 1976 to 2001, 4,332 manatee fatalities were reported statewide. Of this number, 24.5% were watercraft related, 7.2% were attributed to flood gates/canals; another 2.6% were due to other human factors such as poaching, vandalism, monofilament line, litter, and culverts; approximately 20.9% were due to perinatal causes; 17.1% to other natural causes such as cold stress and disease; and 31.1% were undetermined causes. In 2001, 2.5% of the reported Florida manatee fatalities occurred in Broward County; and in 2000, 1.5% occurred in Broward County. According to USACE, Jacksonville District, no manatee fatalities have ever occurred from dredge operations or nourishment operations of the District (USACE, 1996).

No significant adverse impacts to manatees are anticipated with proper mitigative precautions that generally include the standard manatee protection construction conditions outlined in Section 4.34 Environmental Commitments.

4.3.2. JANUARY 2001 GRR BEACH FILL DESIGN WITH PERIODIC RENOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK.

This alternative involves the same potential impacts to sea turtles and manatees. All of the above described impacts, protective, and mitigative measures would apply to this alternative.

4.3.3. BEACH FILL WITH PERIODIC RENOURISHMENT.

The absence of the groin field in John U. Lloyd State Park would provide a positive benefit by elimination of incidental take of sea turtle hatchlings from accidental entrapment in the structures. Absence of groins would also mean a smaller beach, which results in reduced sea turtle nesting habitat. All other above described impacts, protective, and mitigative measures regarding sea turtles and manatees would apply to this alternative.

4.3.4. ALTERNATIVE SAND SOURCES.

4.3.4.1. Distant Domestic Sand Sources.

Depending upon the location and the type and quality of material, use of sand from these distant offshore sources may have biological impacts similar to the use of the proposed borrow areas. Provided that a hopper dredge is utilized during construction, all above-described protective and mitigative measures would apply to this alternative.

4.3.4.2. Foreign Sand Sources.

Oolitic aragonite from the Bahamas has been used on a limited basis for a small beach renourishment on Fisher Island, Dade County, Florida. The USACE Waterways Experiment Station, in consultation with the USFWS, FDEP, and Miami-Dade County Department of Environmental Resources Management, established a sea turtle nesting environmental study in 1995 to explore the potential impacts of foreign carbonate sand on nesting sea turtles. The current studies are being conducted in the Miami-Dade County Sea Turtle Hatchery in Miami Beach using different sand types, including native beach, renourished beach, upland, and aragonite sands (Blair & Henderson, 1998). To date, preliminary findings indicate that there is no statistically significant difference in turtle hatching and emergence in all five sand types, however, differences in sand temperature are sufficient to affect incubation temperature. Incubation periods were longer and nest temperatures were cooler for the nests incubated in aragonite (Blair and Henderson, 1998, Nelson et al.,1996). The reduction in incubation temperature on aragonite could result in production of more males vs. female turtles.

A test beach involving approximately 500,000 cubic yards of Bahamian oolitic aragonite fill was scheduled for construction in 2000 by USACE/Miami-Dade County to determine engineering properties of the sand, effects on sea turtle nesting behavior, and impacts to beach benthic infaunal communities. However, this test beach has not been constructed to date due to lack of Congressional authority for use of non-domestic sources of beach fill when economically and environmentally acceptable domestic sources exist. Large scale use of Bahamian aragonite as beach fill would require approval by the USFWS and FWCC pursuant to NEPA guidelines. However, until results from test studies have been examined, and additional studies and testing have been performed, large scale use of aragonite or other foreign sand on sea turtle nesting beaches is not acceptable to the USFWS and the FWCC (USACE, 1998).

4.3.4.3. Upland Sand Source.

Upland sand quarries are located on the Lake Wales Ridge of the Central highlands area of south Florida. Two quarries with barge access to the Okeechobee Waterway are located in Ortona, Florida, southwest of Lake Okeechobee (USACE, 1998). Sand would be transported by barge or rail and dump trucks, hauled to the beach, and dumped at the designated access sites for redistribution along the beach. The negative impacts previously described (sand compaction, possible scarp formation, and lighting impacts) would apply to the use of upland sand as a source for beach renourishment. Indirect impacts to sea turtle nesting, nest success, and hatchling sex ratios may also occur.

4.3.5. NO ACTION ALTERNATIVE (STATUS QUO).

The no action alternative would allow for continued erosion of the beach. This would result in the reduction of sea turtle nesting habitat and possible poor site selection by nesting females. If more frequent, smaller-scale, “interim” renourishments are proposed and implemented in the future to maintain the storm protective beaches along the Broward County shoreline, there could be a corresponding increase in potential effects to sea turtles from increased construction activities. Furthermore, the goals of storm damage reduction, reestablishment of suitable recreational resources, and maintenance of the beach-related commerce associated with recreation in Broward County are not supported by the no action alternative.

4.4. HARDGROUNDS.

4.4.1. PROPOSED ACTION, BEACH FILL WITH PERIODIC RENOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK.

4.4.1.1. Nearshore Hardbottom Habitat.

Extensive areas of nearshore hardbottom exist along the coastline of Broward County. Digitization of the 2001 Laser Airborne Depth Soundings (LADS) survey data estimated that the nearshore hardbottom tract in Segment II extends from -10 to -34 feet (NGVD) and covers approximately 5,000 acres. In Segment III, the LADS survey digitization estimated that the nearshore hardbottom extends from about -5 to -34 feet (NGVD) between the beach and the first reef tract offshore and covers approximately 5,200 acres. In general, the nearshore edge of the reef is approximately 200 to 800 feet from shore, and the corresponding seaward edge of these formations is located an additional 700 to 1,500 offshore.

Several studies have shown that the nearshore hardbottom areas along Florida's southeast coast are ephemeral in nature, being alternately covered and uncovered by shifting beach sand (Ginsburg 1953, Gore et al. 1978, Goldberg 1982, Arthur V. Strock and Associates, Inc. 1983, and Continental Shelf Associates, Inc., 1984, 1985, 1987). Nearshore hardbottom burial events have been documented by Broward County both seasonally and over an extended period of time. The ephemeral nature of the nearshore hardbottom edge was also documented during mapping performed in July/August of 2001 by CPE/Olsen (J-V). For example, in the area of R-40 in Pompano Beach, the hardbottom edge as mapped in July 2001 had migrated approximately 50 feet seaward when biologists returned in August to characterize the epibenthic community. The shore-parallel video transects document this movement of sand over the hardbottom during the one month period (See Broward GIS for video documentation). The epibenthic community composition at Site 2-40 (Figure 8.2 and Table 12) reflects this unstable habitat characterized by patches of feather hydroids emerging from the four inch sand layer over hardbottom.

The proposed project is expected to impact a gross total of 13.6 acres of nearshore hardbottom (12.5 acres of hardbottom and 1.1 acres of wormrock). Project construction will result in the direct burial of approximately 2.0 acres: 0.9 acres of low profile hardbottom dominated
by macroalgae (*Caulerpa prolifera*) and blue-green algae (*Lyngbya* sp.) in John U. Lloyd State Park and 1.1 acres of wormrock habitat in Hollywood in

Segment III. No hardbottom will be directly buried at the time of construction in Segment II. The gross total impact to nearshore hardbottom habitat in Segment II is 6.0 acres, and will be the result of the gradual transition of the construction beach to the more stable equilibrium profile. The net total hardbottom impact in Segment II is 2.5 acres. These impacts represent approximately 0.2% of the hardbottom in the 10 to 17 foot range in Segment II. The net total impact to nearshore hardbottom in Segment III is 7.6 acres, which includes 2.0 acres of direct impact and 4.6 acres of impact resulting from beach fill equilibration. These impacts represent approximately 0.1% of the nearshore hardbottom area in Segment III.

Biological investigations performed during the summer of 2001 documented the variability in epibenthic species composition, habitat complexity, and habitat stability of the nearshore hardbottom. Classification of the impact areas (areas inshore of the equilibrium toe of fill) revealed that 88% of the cumulative community composition consisted of macroalgae and blue-green algae. Comparison of inshore ETOF locations to areas seaward of the equilibrium toe of fill suggests that the survivability of soft corals, sponges, and stony corals increases along the distance gradient from the fluctuating hardbottom edge, and with the increase in habitat stability, a corresponding increase in biodiversity is observed. The potential exists for long-term, secondary impacts to hardbottom communities adjacent to the equilibrium toe of fill resulting from sedimentation and/or chronic turbidity generated from the advancement of the beach swash zone. In the U.S. Fish & Wildlife Final Coordination Act Report - June 2002 (Appendix C-1), the Service expresses concern that the more stable epibenthic communities located further offshore may gradually shift in community structure to resemble the less diverse, more stressed ephemeral communities typical of the hardbottom edge.

The 2001 nearshore biological investigations indicate that suitable replacement habitat can be created for impacted epibenthic species. Table 12 provides a summary of epibenthic community characteristics of the habitat located landward of the equilibrium toe of fill (inshore ETOF). Average epibenthic species density at the impacted, inshore ETOF sites was 2.7 organisms/square meter, and average algal coverage was 24.1%. Dominant organisms include feather hydroids, young individuals of the soft coral, *Pterogorgia anceps*, and the small stony coral, *Siderastrea radians*. Just over one-third of the overall 55 nearshore sites exhibited stony coral coverage greater than 1%; and only two of the sites were located inshore of the proposed equilibrium toe of fill.

The small star coral species, *Siderastrea radians*, was the numerically dominant stony coral within the impact areas with an average density of 0.47 individuals/square meter. This species is tolerant of wave surge, sandy and silty conditions, and temperature fluctuations (Humann and Deloach, 2002). *S. radians* was also the most frequently observed juvenile coral species (defined as stony corals less than 2 cm in diameter), accounting for more than 90% of all juvenile corals observed at the nearshore sites. Relatively large individuals of *Solenastrea bournoni* were common along the hardbottom edge in south Hollywood, and were the second most common coral observed at the offshore ETOF sites (0.08 individuals/square meter). The hardbottom edge in south Hollywood/Hallandale is located further seaward compared to other areas of Segment III, which may account for the increased density of adult corals. Sedimentation and burial stresses were observed on these *S. bournoni* colonies; and the density of this species in this area is suggestive of a higher sedimentation stress threshold compared to other common stony coral species on south Florida reefs. In general, larger (i.e. adult) corals are more tolerant of sedimentation than newly settled colonies; and if the hardbottom edge has migrated offshore due to sand movement, the *S. bournoni* colonies may have achieved sufficient size to withstand periodic sedimentation loads adjacent to their attachment points.

The overall community structure of the nearshore impact areas indicates that the physical stresses of the habitat limit the biodiversity and survivability of epibenthic species. Coral recruitment on Broward County nearshore hardbottom is limited by high suspended sediment levels and competition with algae for space. A limited number of stony corals of significant size were observed within the nearshore impact areas. There were a few observations of very large stony coral colonies (*M. cavernosa*) within 100 feet seaward of the equilibrium toe of fill, just outside the areas of impact (see GIS database, macroalgal transect at R-40+250 and hardbottom edge notation at R-68.5 for examples). Potential secondary impacts to these communities will be addressed during the Nearshore Biological Monitoring Program presented in Appendix E. Overall, the observations indicate that the nearshore hardbottom epibenthic communities landward of the equilibrium toe of fill do not represent irreplaceable resources; and with proper placement of mitigative artificial reefs, suitable replacement habitat can be created for epibenthic species.

Nearshore hardbottom habitat in the project area vicinity is determined to be significant as defined by the U.S. Fish and Wildlife Service's Mitigation Policy. The nearshore hardbottom habitats in Broward County are considered Resource Category 2 habitats, and no net loss of in-kind habitat value is recommended (U.S. Fish & Wildlife Service Final Coordination Act Report, June 2002, Appendix C-1). Following the goals of the Service's Mitigation Policy and guidelines of the South Atlantic Fishery Management Council (SAFMC) for habitat mitigation, Broward County is proposing the creation of 11.9 acres of nearshore mitigative reef using limestone boulders as compensation for resource losses. Limestone boulders replicate the rough surface and calcareous nature of the natural nearshore hardbottom formations. Previous studies of limestone mitigative boulder reefs in southeast Florida have found that the reefs provide suitable mitigation for nearshore, low-relief habitat lost to beach renourishment (Cummings, 1994). Interim results of nearshore mitigative reef monitoring in Jupiter/Carlin demonstrate rapid colonization of the limestone boulders by benthic invertebrates and algae, and colonization by key nearshore reef indicator species such as wormrock and hairy blenny (Palm Beach County ERM, 2000).

A total of 21.8 acres of suitable sandy bottom in nearshore reef sand pockets have been identified for boulder placement. Boulders will be approximately 4 to 6 feet in diameter and are expected to provide two to three feet of residual relief following settlement. The eleven proposed placement sites are located inshore of the nearshore hardbottom, offshore of the predicted equilibrium toe of fill, and in water depths of 15 to 20 feet (Figure 13). A 50-foot buffer from all significant nearshore hardbottom will be maintained during boulder placement. The proposed time frame for construction of the boulder reefs is to begin deployments at Mitigation Area 8 offshore of a DEP monument R-103 beginning in spring, 2003, prior to commencement of beach fill activities in Segment III. Deployment will be carried out from April 1 through September 30. Areas not completed in 2003 will be completed in 2004, but it is anticipated that all deployments will be completed in the first year.

The 10.1 acres of net hardbottom impact were anticipated to require 12.4 acres of compensatory mitigative reef. To offset the temporal lag in habitat functionality scleractinian corals greater than 15 cm diameter will be transplanted to the mitigative reef. Project construction of the artificial reefs will also occur prior to beach project commencement. The reduction of the temporal lag by coral transplantation reduced the required 12.4 acres to 11.9 acres of compensatory mitigative reef for both Segments II and III combined.

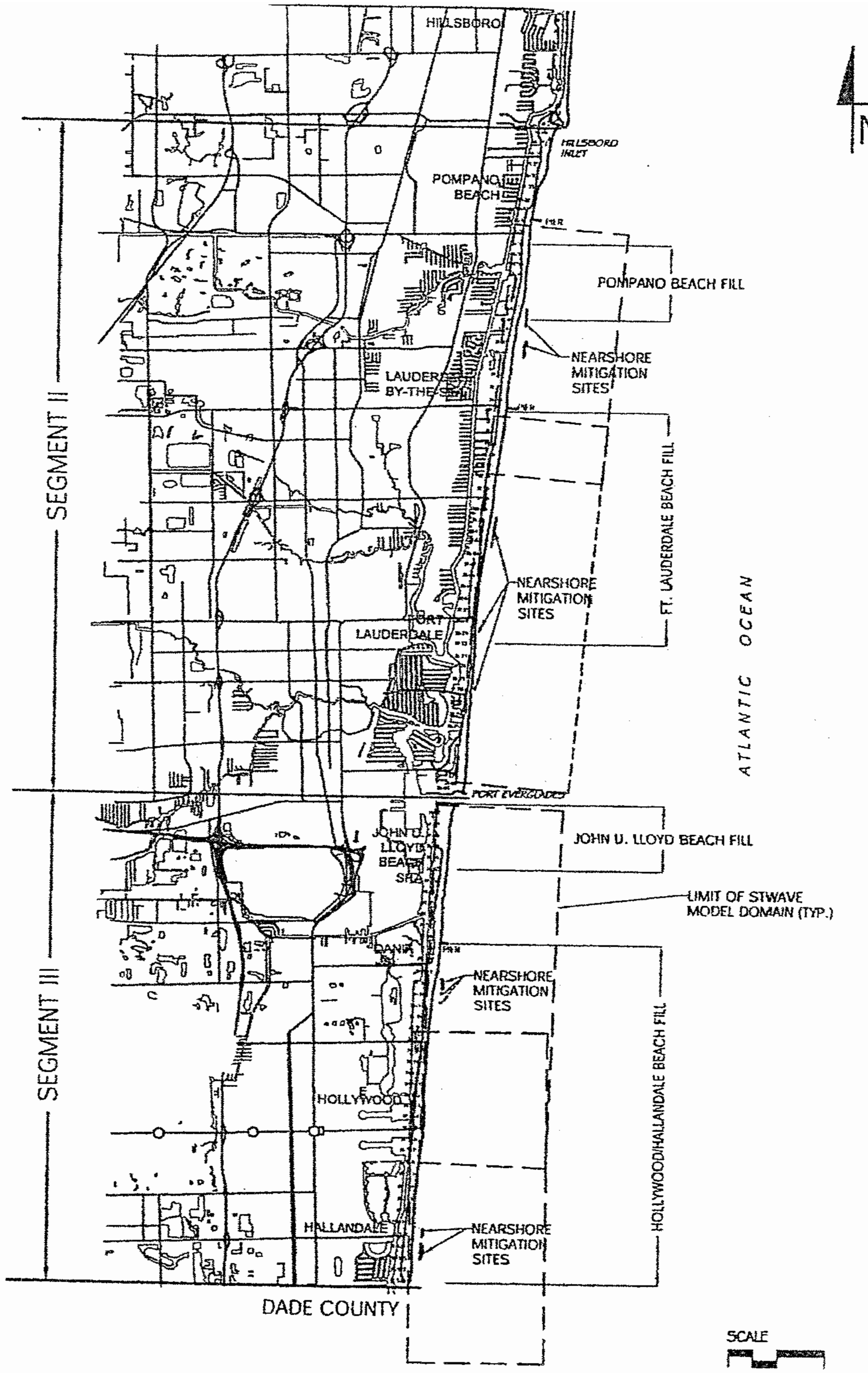


FIGURE 13: Locations of Broward County nearshore mitigation sites

The 2002 Habitat Equivalency Analysis (HEA) indicates that the mitigation boulders with transplanted corals will recover to 100% full service in 15 years (Appendix H). Most flora and fauna are anticipated to recover quickly within less than 8 to 10 years; the reef building coral fauna is the slowest component and will require longer recovery time. A linear increase from 10% to 100% over the 15 years is assumed (Dodge, unpublished). Replacement habitat will be provided prior to the beach project commencement to compensate for productivity loss associated with reduced growth and settlement rates of stony corals and other epibenthic invertebrate species. The locations for boulder placement fulfill SAFMC guidelines that recommend mitigation be sited as closely as possible to the impacted habitat. A four-year monitoring program will be established to document the replacement habitat value of the mitigative reefs (See Appendix F).

Nearshore turbidity monitoring will be performed during construction as outlined in Section 4.34.1. Recent projects in Miami-Dade County produced turbidities, sedimentation, and siltation levels that stressed stony and soft corals to levels where excessive amounts of mucous and polyp extension were observed during the weekly reef surveys (U.S. Fish & Wildlife Final Coordination Act Report, June 2002). Corresponding NTUs were well below the 29 NTU State threshold (Blair et al., 2001). To assess the potential for sedimentation and turbidity damage to hardbottom communities adjacent to the equilibrium toe of fill impact area, the U.S. Fish & Wildlife Services proposes the establishment of monitoring stations that are no more than 200 yards offshore of the proposed equilibrium toe of fill. Weekly visual assessments of sedimentation and siltation will be performed upon nearshore epibenthic communities seaward of the projected equilibrium toe of fill during fill placement activities. Standing sediment upon epibenthos that is not removed by normal currents or wave action will be used as a visual indicator of potential sedimentation impact. Stress indicators on coral species will be used in conjunction with standing sediment levels to trigger implementation of Best Management Practices (BMP) which include construction and/or extension of parallel berms on the beach in the areas of fill placement, cessation of sand pumping until the discharge plume dissipates, and/or shifting the dredge to an alternate sand source within the approved borrow sites.

A total of 124 monitoring transects along the project area fill areas (DEP Control Monuments R-36 to R-43, R-51 to R-72, R-86 to R-92, and R-98 to R-128) will be established during the duration of project construction. Transects will be established at 500 foot intervals along the length of the project (referenced to DEP intermediate control monuments). If a turbidity or sedimentation violation/impact is documented at a particular transect during construction monitoring, the location will be added to the long-term post-construction monitoring.

Comparison of the 2001 epibenthic data from previously nourished sites to never nourished sites did not show clear, site-dependent differences in species diversity and stony coral coverage. The highest faunal species richness at the inshore ETOF sites was at the Pompano Beach sites, adjacent to a renourished beach. The Pompano Beach sites also exhibited the lowest overall algal coverages for both the inshore and offshore ETOF sites. Although overall faunal species richness was highest at the offshore sites in Fort Lauderdale, adjacent to a never nourished beach, examination of species richness at the individual sites revealed similar individual station values for Pompano Beach and Fort Lauderdale. Comparison of Shannon-Wiener diversity index values also revealed little difference between Pompano Beach and Fort Lauderdale at the offshore sites, while one of the inshore sites in Pompano Beach recorded the highest S-W index and faunal species richness of all inshore ETOF sites in the study area. However, faunal density (individuals/square meter) was slightly higher at the Fort Lauderdale sites than Pompano Beach and Lauderdale-By-The-Sea (Table 16).

Of the nineteen (19) sites with stony coral coverage greater than 1%, seven (7) were adjacent to never nourished beaches and twelve (12) were adjacent to previously nourished beaches (Table 14). The two inshore ETOF sites with the highest stony coral coverage (4.6% and 4.4%) were located adjacent to previously nourished beaches. Likewise, the two offshore ETOF sites with the highest stony coral percent cover were located adjacent to previously nourished beaches (28.3% and 13.0% in Hollywood/Hallandale) (Table 14). The hardbottom edge in Hollywood and Hallandale is located slightly further offshore than in other areas, possibly pushed offshore due to sand movement from past nourishment projects and storm activity. The unusually high stony coral density, along with the observations of accumulated sediment on the stony corals within the station and buried stony coral skeletons west of the site, are suggestive of a migrating hardbottom edge.

Overall, the 2001 data from the nearshore characterization sites does not suggest that the nearshore hardbottom communities adjacent to never nourished beaches are higher in epibenthic species richness and stony coral coverage than communities adjacent to previously nourished areas. However, the data does suggest a high degree of variability among and between the nourished/never-nourished sites at both the inshore and offshore ETOF locations. The data from the John U. Lloyd stations is difficult to evaluate from a beach nourishment perspective due to possible Port Everglades Inlet related influences upon the epibenthic habitat.

The potential exists for long-term impacts to hardbottom communities adjacent to the equilibrium toe of fill resulting from sedimentation and/or chronic turbidity generated from the advancement of the beach swash zone. A long-term, nearshore hardbottom monitoring program will be implemented to assess the potential for a gradual shift in community structure and corresponding reduction in biodiversity related to sedimentation impacts. (Refer to Section 4.34 and Appendix E for the nearshore hardbottom biological monitoring program).

4.4.1.2. Offshore Hardbottom Habitat.

The Corps and Broward County have demonstrated their commitment to avoidance and minimization of impacts to offshore hardbottom communities deemed significant by the U.S. Fish & Wildlife Service's mitigation policies. These avoidance efforts include elimination of two borrow areas, BA-V and BA-VII, from the project design due to the discovery of significant biological resources within and adjacent to the proposed borrow areas. The boundaries of the remaining five borrow areas have been redefined to avoid small patch reef formations, rubble areas with dense reef benthic assemblages, and areas of seagrass beds (*Halophila decipiens*). The revised buffer zones vary between approximately 200 feet to the inshore reef edge to more than 1,200 to the offshore reef edge. Average buffer zones between the inshore (west) and offshore (east) edges of the borrow areas are shown in Figure 6 through 6.5. The average buffer on the inshore edge ranges from 235 feet for Borrow Area VI to 375 feet for Borrow Area III. The average buffer on the offshore edge ranges from 512 feet for Borrow Area IV to 718 feet for Borrow Area II. The buffer zone distance is dependent upon the habitat quality of the adjacent reef edges, and the diverse, mature benthic communities found on the reef crests are protected by greater buffer distances than the less stable, rubble communities.

During dredging operations, offshore reefs may be impacted by turbidity and sediment plumes generated from filling of the hopper dredge. The dredge suction arms hydraulically remove sediment from the sand flat and discharge the material into the storage hoppers on the dredge. Material larger than 1 inch is screened out, stored on the dredge, and periodically dumped in an offshore disposal area. The screened material, which fills the hopper, is transferred to the pump station for beach placement. During filling, any fine sediments (primarily silt, clays, and fine-sands) are washed overboard. This washing is the source of turbidity plumes and siltation generated by the hopper dredge.

The distance that sediment plumes may extend is dependent upon the type of dredge, how it is operated, currents, and the nature of the sediments within the borrow area. Elevated sediment levels were recorded 1,100 feet from the borrow area in the 1990 Bal Harbor project, and were estimated to continue to 1,200 feet (Blair et al. 1990). During the recent Sunny Isles and 63rd Street nourishment projects in Miami-Dade County, elevated sediment levels were recorded 800 to 1,200 feet from the borrow area (USFWS Final Coordination Act Report, June 2002).

The composition of the fill material is believed to be a significant cause of the extended plume distance and elevated sedimentation levels in the Miami-Dade County projects. The sand source for the proposed Broward County project has a reduced silt/clay component (average of 2.6% with a mean range of 1.9% to 4.4%) compared to the Miami-Dade County projects. The beaches of Broward County are composed of a silicate/carbonate mix with the carbonate content primarily derived from shell and shell fragments. It is anticipated that the sand source for the proposed Broward County Shore Protection Project will generate less turbidity during washing on the hopper dredge, thereby reducing the potential for extended turbidity plumes. On average, the diverse, mature benthic communities found on the reef crests adjacent to the proposed borrow areas are protected by buffer distances of 400 feet or greater, thereby decreasing the likelihood of turbidity and sedimentation impacts to these communities. Construction specifications shall also require that the borrow areas are dredged in an alternating pattern, thereby reducing the volume and duration of sediment deposition on adjacent hardbottom communities.

During project construction, turbidity monitoring will be conducted at the dredge site by Broward County as outlined in Section 4.34.1. Should turbidity plume measurements exceed the 29 NTU threshold above ambient levels, dredging actions will cease until plume values are in compliance with state guidelines. Turbidity impacts are chronic perturbations that cause long-term reductions in primary and secondary productivity of reef epibenthic communities by reducing the amount of light available for photosynthesis. Siltation/sedimentation can be detrimental to the growth and survival of reefs, especially filter-feeding organisms such as brachiopods, bryozoans, crinoids, and sponges. Most effects of sedimentation upon stony corals are sublethal, causing excessive mucous production and increased respiration rates (Porter & Tougas, 2001; Rogers, 1990). Depending upon the species and life stage of the stony coral, direct mortality can result if the sedimentation load is excessive or if sediments accumulate in depressions of large, massive colonies, causing death in patches of the colony. Stony coral recruitment can also be negatively effected by sedimentation through increased mortality of juvenile corals less tolerant to sedimentation and reduced coral larvae settlement rates (Rogers, 1990).

The relationship between NTU and sedimentation has no biological or physical derivation. Turbidity measurements associated with past projects have not always accurately reflected the amount of sedimentation/siltation that settles on adjacent reefs, nor have secondary impacts to biological resources been assessed. Past studies have also demonstrated that some species of stony corals are adversely affected at levels below the current Florida administrative threshold of 29 NTUs (Teleniski and Goldberg, 1995). In the Bal Harbor project, turbidity levels were seldom greater than 3 NTUs; however one to five inches of sediment were deposited over 24.8 acres of hardbottom (Blair et al., 1990). During the Sunny Isles and 63rd Street nourishment projects in Miami-Dade County, several stony coral biological stress indicators were observed, including excessive mucous production and polyp extension. Sediment accumulation was also observed on the epibenthic communities (sponges, gorgonians, tunicates, and bryozoans and other epibenthic organisms with less capability than stony corals to remove accumulated sediment). The Sunny Isles and 63rd Street project dredging began on March 29, 1997 and less than two weeks later divers began to see sediment accumulation. The average reef sediment depth at one monitoring station (E-3) adjacent to a borrow area was 2.0 cm, compared to surrounding levels of <0.5 cm at additional areas. Dredging practices were then modified within the borrow area to avoid excess sediment accumulation over the reef. Toward the end of project construction limited sand was available within the borrow area and the contractor was forced to utilized the sand that previously buried the reef. By the end of the project sediment levels reached a high of 2.9 cm at the monitoring station. When dredging ceased the added sediment rapidly cleared off of the reef and its associated biota at this monitoring station. The same trend occurred at another monitoring (E-5) south of the above station. Before dredging commenced sediment levels on the reef averaged <0.5 cm. Sediment levels at this station reached a high of 1.8 cm by the last week of project construction. Sediment levels were reduced to 0.9 cm immediately subsequent to project completion. A one-year post monitoring survey showed that sediment depths on the reef at this station returned to pre-construction levels (0.3 cm) (Welch, 2002). Corresponding NTUs were well below the 29 NTU State threshold (Blair et al. 2001).

Past monitoring of Broward County nourishment projects (John U. Lloyd State Park 1989 and Hollywood/Hallandale 1991) did not document any turbidity and sedimentation rates on adjacent hardbottom communities that produced statistically significant long-term resource affects directly attributable to nourishment actions (Dodge et al., 1991, 1995).

In a study done in 1984, Goldberg found that 14 months after a beach nourishment project in northern Broward County, a decline to the coral population was noted although the locations of the affected stations did not correspond to any of the dredging locations. Therefore, stresses other than dredging may have occurred causing tissue reduction and scleractinian losses (Goldberg, 1984).

The reef damage survey of John U. Lloyd State Recreation Area waters following the 1976-1977-beach renourishment project showed that weather was the most important factor in coral survival under heavy sedimentation stress. High sedimentation rates may result in coral mortality when the seas are relatively calm. Waves can assist corals in removing excess sediment even at depths in 20 meters of water (D.E. Britt Associates Inc., 1979).

A study done by Courtenay et al (1972) comparing ecological aspects of two beach nourishment projects in Broward found that sedimentation damage can reduce species diversity degrading the health of a reef habitat. Results showed that many aquatic organisms could quickly repopulate an area after a dredge event. This was not the case for large reef building corals. These larger corals are slow-growing and small stresses can inhibit growth and reestablishment.

In 1980 and 1981, Goldberg characterized reef areas one and two years after a beach restoration project (1979) to assess any impacts to the community and its associated marine life. Of the ten stations monitored in the 1980 survey, three showed a decrease in diversity since the initial 1979 survey. Two of the three stations (1 and 10) were in close proximity to the shore and were described as having extremely poor visibility from increased turbidity resulting from suspended sediment. The scleractinians and sponges were adversely affected at these stations post-construction. The stations located offshore were not as negatively impacted as the previous two and recovery was predicted to occur rapidly.

Changes in coral composition at one of the stations (8) were attributed to taxonomic differences rather than environmental stress. In 1981 the same reef areas were characterized for a second re-survey to note additional changes which may have occurred between February 1980 and June
1981 from the 1979 restoration. The 1981 characterization indicates that coral communities close to shore will suffer immediate damage due to the presence of suspended sediments. The damage did not persist. Sixteen months after the restoration project re-colonization and re-growth were evident. Damage was also noted at the offshore stations that were near borrow areas. The damage to the station (7) that was in close proximity to the borrow area (<50 m) did not recover at the time of this survey. The offshore stations at least 136 m from the borrow sited showed much less damage to the reef habitat.

A study by Richard E. Dodge, titled Growth Rates of Stony Corals of Broward County, Florida: Effects From Past Beach Renourishment Projects, was completed in 1987. The growth of hermatypic corals has been used as an indicator of environmental conditions in previous studies. Stressful conditions, such as excessive sedimentation and turbidity, are environmental factors associated with beach renourishment projects that have negative impacts on coral growth. Over a 16-year period growth rates of stony corals, located in areas that had a close proximity to increased sedimentation and turbidity from renourishment projects, were examined. Results showed that stony corals living both near and offshore (9 m and18 m water depth) had negligible impacts from renourishment projects.

In 1998 sand was placed along Hillsboro and Deerfield Beach, which were two chronically eroding locations in Broward County. One year following project construction, no significant sedimentation or burial had occurred on the nearshore hardbottom bordering to the renourished beaches. A decrease in the density of sponges did occur but it may have been the result of large scale natural occurrences such as the 1998 El Nino Southern Oscillation (ENSO).

However, to minimize the potential impacts of turbidity and sedimentation observed during Miami-Dade County projects, Broward County has proposed a detailed sedimentation monitoring plan adjacent to the borrow areas which incorporates real time measurement of accumulated sediments and observations of biological stress indicators for stony and soft coral species (See Appendix E – Biological Monitoring Program)

Preventative measures to minimize potential sedimentation impacts to hardbottom communities are included in the County's monitoring plan. During each of the weekly surveys, should the average daily measure of sediment exceed 1.5 mm in any two of the weekly sediment collection plates adjacent to a particular borrow area, usage of that borrow area will be prohibited for one week. Upon the next week's remeasure, if the accumulated sediment is less than the 1.5 mm average, use of the borrow area can resume. The 1.5 mm depth threshold is based upon the sedimentation and siltation experiments by S.E. Kolemainen (1978). Biological stress indicators will be used to evaluate the level of stress upon the epibenthic communities and to provide a check for the proposed sedimentation monitoring protocol. Index values will range between a value of 0 to 4, where 0 represents no observed bleaching, mucous, or polyp extension and 4 represents the maximum observed. The indicator stony corals are *Montastrea cavernosa* and/or *Solenastrea bournoni*, and the octocorals are *Erythropodium caribaeorum* and/or *Briareum asbestinum*. Should weekly stress indicator index values for any two of the borrow area monitoring sites equal or exceed 2.5 and the accumulated daily average sediment values are below the 1.5 mm threshold, histological tissues analyses of the corals will be conducted by Nova Southeastern University/National Coral Reef Institute. Research by Riegl (1995), Riegl and Branch (1995), and Riegl and Bloomer (1995) has demonstrated that corals subject to stress display definable changes in the thickness of the mucous secreting cells, the presence or absence of these cells, and the presence or absence of zooxanthellae. The intent of these histological tissue analyses of the corals is to provide a mechanism to judge the effectiveness of the sediment accumulation rate value and to provide a scientifically valid justification for changes in sedimentation rate monitoring. One additional sediment accumulator plate will be installed at each of the four sediment monitoring sites surrounding Borrow Area 6. The four monitoring sites will be visited every day or every other day during the first twenty-eight days of beach construction dredge and fill activity utilizing Borrow Area 6. The daily or bi-daily sediment accumulator monitoring will be compared to the weekly monitoring during the same time period (See Appendix E).

Expected direct impacts to offshore hardbottom habitat are restricted to the hardbottom areas within the eight proposed pipeline corridors. Use of a hopper dredge for project construction minimizes pipeline impacts across hardbottom communities and eliminates the impacts associated with hydraulic dredge swing anchors and cables. The pipeline placement is from the sand transfer pump station to shore and will cross both the second and nearshore reefs in Broward County. Although eight corridors are proposed, one is an alternative location at R-120 or R-121 in Hollywood. It will be determined at the time of project construction if the alternative pipeline is necessary for fill to the southernmost limit of the project.

Immediately prior to pipeline placement, the preferred route will be marked with buoys to facilitate placement by the contractor. Each route will be documented with still/video photography prior to placement and following placement to document hardbottom impacts. Hardbottom impacts will be minimized through the use of pipeline support using either tires and/or H frames when needed. Impacts from pipeline placement have been estimated at 190 square feet per corridor. This damage estimate is based on a 2,500 foot distance to shore, a 50 percent hardbottom coverage with a 15 percent resource damage. For seven corridors, hardbottom resource impacts are estimated to be 1,330 square feet (0.03 acres). If eight corridors are necessary for project construction, hardbottom impacts would increase by 190 square feet to 1,520 square feet. Mitigation for hardbottom communities from pipeline placement is proposed by the placement of limestone boulders in nearshore reef sand pockets (See Appendix F).

The potential exists for pipeline impacts from sand leakage at the joints during operation and from accident breakage of the pipe during project construction. Pipelines will be visually surveyed weekly during operation to check for sand leakage. Accidental breakage will be monitored continuously during operation through visual observation of flow from the discharge point and through electronic monitoring of the pipeline pressure at the pump station. No significant impacts are expected to occur from pipeline leakage or accidental breakage. A damage assessment protocol has been proposed by Broward County with Nova Southeastern University/National Coral Reef Institute in the unlikely event that leakage or a pipeline break occurs. A reef damage assessment will be performed to determine the extent of damage and/or amount of necessary remediation. The pipeline corridors will also be monitored after pipeline removal to assess damage during dredging operations and pipeline removal.

The potential exists for direct mechanical damage to offshore hardbottom communities adjacent to the borrow areas during dredging operations. Proper controls and procedures will be used to avoid mechanical damage; and no significant impacts are expected to occur from the mechanical operation of the dredge. Broward County has proposed implementing a stringent environmental protection program designed to minimize the potential that construction related equipment will encounter sensitive marine habitats. A series of corridors and operational zones have been delineated to avoid high-value habitats and the contractor will be restricted from operating or anchoring equipment outside of these designated areas around the borrow and transfer station sites. Construction specifications proposed by the USACE and Broward County include the use of recording and real-time precision electronic location equipment during dredging operations. The equipment will include exact position of the dredge to the operator and allow continuous monitoring of the dredge location during operations. A damage assessment protocol has been proposed by Broward County with Nova Southeastern University/National Coral Reef Institute in the unlikely event that a misalignment occurs. A reef damage assessment will be performed to determine the full areal extent of irreversible loss and/or amount of necessary remediation.

There has been a high level of recruitment of staghorn coral, *Acropora cervicornis*, along the southeast Florida coast during the past three years and patches of staghorn coral are common in Broward County (Causey et al., 2000; CPE/Olsen (J-V) 2001 field investigations). Growth rates of *A. cervicornis* can exceed 10 cm/year under optimal conditions (Porter and Tougas, 2001). An extensive area of staghorn coral is located on the seaward edge of the first reef offshore of Fort Lauderdale (in the vicinity of FDEP monument R-66). This area of hermatypic coral coverage is located approximately 1,500 feet from shore, and is approximately 700 feet seaward the equilibrium toe of fill (Refer to the Broward County GIS for exact location and photographic documentation). This habitat is considered Resource Category I by the U.S. Fish & Wildlife Service, as such, no loss of habitat value is recommended, as these unique areas cannot be replaced. No impacts to this community are anticipated from project construction. Appropriate buffer distances will protect this area from the proposed Fort Lauderdale pipelines. Potential secondary impacts from turbidity are also not anticipated due to its distance offshore of the equilibrium toe of fill. In order to address any potential, long-term turbidity impacts to this community, two County monitoring stations, FTL-5 and FTL-6, will be included in the offshore monitoring program described in Appendix E.

4.4.2 JANUARY 2001 GRR BEACH FILL DESIGN WITH PERIODIC NOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK.

The project fill design as originally proposed in the January 2001 General Reevaluation Report would impact approximately 28.4 acres of nearshore hardbottom habitat designated as Essential Fish Habitat. In Segment II (Pompano Beach, Lauderdale-By-The-Sea, and Fort Lauderdale), approximately 12.1 acres of nearshore hardbottom would be impacted by construction and beach fill equilibration. In Segment III, 16.3 acres of nearshore hardbottom would be impacted. The nearshore biological communities within the areas of impact would be the same as described for the proposed project design. However, the additional 14.9 acres of impact involved with this alternative would affect areas of increased structural complexity and biological diversity, and higher concentrations of epibenthic organisms, including an increased number of stony corals.

4.4.3 BEACH FILL WITH PERIODIC RENOURISHMENT.

Since groin construction in John U. Lloyd State Park is not expected to impact any existing hardbottom communities, absence of the groins in this alternative would involve the same impacts to nearshore and offshore hardbottom communities as the proposed project.

4.4.4 ALTERNATIVE SAND SOURCES.

Nearshore hardbottom impacts from fill placement using an upland or alternative sand source are identical to the proposed project. The placement of fill will directly result in the burial of 0.9 acres of hardbottom in John U. Lloyd State Park, and 1.1 acres of wormrock in Hollywood; and indirectly impact 11.6 acres of nearshore hardbottom after completion of beach fill equilibration. Potential secondary impacts related to fill equilibration are also similar to the proposed alternative. The nearshore mitigation and monitoring programs would be identical to the proposed alternative.

The major impact difference with the use of an upland sand source is the elimination of potential impacts to offshore hardbottom communities adjacent to the proposed borrow areas. The upland sand alternative would require the use of an offshore pumping station for the placement of fill material. The expected mode of fill material delivery is from rail car to either barge traffic on the Caloosahatchee River or directly from rail car to Port Everglades. Both delivery options are existing active material transport systems. Expected resource impacts with the offshore pumping station are the same as those proposed for the proposed action.

Use of local or distant offshore sources would involve dredging at the location of the sand source, and the impacts of dredging cannot be predicted without knowing the exact location and habitats of the areas that would be dredged. It is expected that any hardbottom habitat would be avoided to the greatest extent possible and unavoidable impacts would be mitigated.

4.4.5 NO ACTION ALTERNATIVE (STATUS QUO).

The no-action alternative would not result in any adverse impacts to the nearshore and offshore hardbottom community. It is probable that maintenance of status-quo conditions would result in increased exposure of nearshore rock outcrops as the shoreline continues to erode at its present rate.

4.5 FISH AND WILDLIFE RESOURCES.

4.5.1 PROPOSED ACTION, BEACH FILL WITH PERIODIC RENOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK.

The placement of sand on the beach will result in the burial and subsequent loss of most of the beach infauna. Sandy beaches are generally populated by small, short-lived organisms with great reproductive potential. Common beach and surf zone invertebrate inhabitants include ghost crabs, coquina clams and other bivalves, amphipods, polychaetes, and gastropods. Several studies have investigated the recolonization of beach infauna following nourishment and found that beach and surf zone populations recover to prenourishment levels within one year after completion of nourishment (Reilly and Bellis, 1983; Gorzelany and Nelson, 1987; Hurme and Pullen, 1988; and Dodge et al, 1991; 1995). The results of a beach invertebrate study following renourishment on the beaches of Bogue Banks, NC indicate that invertebrate populations decreased by 86-99% five to ten weeks following sand placement. The extreme decrease in the population of beach infauna was attributed to the poor match in grain size of the added sand to the natural beach. The sand source utilized in the Bogue Bank project provided sand with a very high shell content that was not comparable to the natural beach (Peterson et al, 2000). The sand source for the proposed project is compatible with the existing beach sediments and contains a relatively low silt/clay content (average of 2.6%), which should promote rapid recovery of beach infauna within one year after sand placement. Impacts to beach infauna are therefore expected to be short-term.

Groin construction within John U. Lloyd State Park will also result in the burial and subsequent loss of most beach and surf zone infauna within the construction area. As stated above, impacts are expected to be short-term and recolonization should occur in areas adjacent to the structures within one year after placement.

No direct impacts to shorebirds are expected from project construction as birds are motile and can avoid construction activities. The disposal of sand on the beach may temporarily interrupt foraging and resting activities of shorebirds that utilize the project area beach. This impact would be limited to the immediate area of disposal and the duration of construction. The prey base for many shorebirds, which includes the organisms listed above, would be temporarily reduced in the areas of project fill. This impact would be
short-term as recovery of beach infauna is expected within one year after sand placement.

The benthic infaunal communities within the five proposed borrow areas will be negatively impacted by dredging activities. Numerous studies have documented that macroinfaunal organisms rapidly colonize offshore borrow pits after completion of dredging activities (Saloman and Naughton, 1984; Cutler and Mahadevan, 1982; Naqvi and Pullen, 1982; Gorzelany, 1983; Reilly and Bellis, 1983; Gorzelany and Nelson, 1987; Hurme and Pullen, 1988). Bowen and Marsh (1988) observed recovery of the macroinfaunal communities in a borrow area offshore of Delray Beach, Florida within one year of construction. Other studies have suggested that recovery to pre-dredging macroinfaunal community structure may take from two to three years (Goldberg, 1985; Wilber and Stern, 1992). Benthic infauna monitoring performed during previous beach nourishment projects in Broward County indicated that, although the borrow areas were rapidly colonized following dredging, individual species recovered at different rates based upon their generation time, ability to disperse, and reproductive strategies (Dodge et al., 1995).

Based upon the results of these studies, it is expected that recolonization of the borrow areas by benthic macroinfaunal species will occur within one to two years after completion of dredging for the proposed project. Changes in infaunal community structure are anticipated based upon differences in generation time and reproductive strategies of infaunal organisms; and these changes may persist for two to more than three years. Grazers and detrivores that feed upon the macroinvertebrate communities within the proposed borrow areas will be temporarily displaced during dredging activities. If infaunal community structure changes persist for a period of years, short-term impacts to selective bottom feeders may also occur due to loss of specific prey species within the dredged borrow sites. Adjacent sandy areas within the intrareefal sand flats, which vary in width from several hundred feet to several thousand feet, would provide alternative feeding habitat for grazers and detritivores during infaunal recolonization of the borrow areas. Therefore, changes in macroinfaunal community assemblages should result in a minimal loss of productivity.

Direct impacts to fish communities within and adjacent to the offshore borrow areas during dredging activities should be minimal. The motility of most reef fish species should allow these species to leave the disturbed area during dredging and return when conditions approximate previous levels. However, mortality of demersal and burrowing fish species inhabiting open sand, such as jawfish, garden eels, and hovering gobies, is likely during dredging activities, as these species are limited in their mobility and may not be able to flee the area prior to disturbance. Ground-truthing dives during the summer of 2001 indicated limited utilization of the sand flats within the proposed borrow areas by these species, suggesting that mortality levels due to dredging may be low. Secondary impacts to fish species may occur as a result of sedimentation/siltation adjacent to the borrow areas. Suspension of sediment has been shown to cause mortality of eggs and larvae of marine and estuarine fish (Newcombe and Jensen, 1996), and a reduction in feeding in juvenile and adult fish. These impacts would be short-term, limited to the vicinity of the borrow areas, and primarily limited to the duration of the project. The alternating dredging pattern for utilization of the borrow areas, buffer distances to adjacent hardbottom communities, and the reef edge sedimentation monitoring plan described in Section 4.34 and Appendix E should minimize sedimentation impacts to the reproductive and feeding success of fishes.

4.5.2 JANUARY 2001 GRR BEACH DESIGN WITH PERIODIC NOURISHMENT AND GROIN FIELD AT JOHN U. LLOYD STATE PARK

As stated in Section 4.4.2, the project fill design as proposed in the January 2001 General Reevaluation Report would impact an additional 14.9 acres of nearshore hardbottom habitat designated as Essential Fish Habitat, and affect hardbottom areas of increased structural complexity and biological diversity. Higher concentrations of hardbottom epibenthic organisms, beach and offshore benthic macroinfauna, and fish would be impacted due to the increase in hardbottom burial, increase in project area beach, and the use of the two additional borrow areas that were proposed in the original project design.

4.5.3 BEACH FILL WITH PERIODIC RENOURISHMENT.

Implementation of this alternative would avoid the temporary negative impacts on the macroinfaunal beach community within the groin construction area. The remaining impacts are the same as for the proposed action described above.

4.5.4 ALTERNATIVE SAND SOURCES.

The use of an upland sand source would eliminate the negative impacts to benthic infauna associated with the dredging offshore borrow areas and also eliminate potential sedimentation and turbidity impacts to the reproductive success of reef fishes. This alternative would also avoid impacts to feeding strategies of grazers and detrivores within the offshore borrow areas, as well as avoid direct mortality of burrowing fish species inhabiting open sand areas. Beach renourishment utilizing an upland sand source would have the same negative impacts of temporary burial of beach and nearshore infauna.

The protective measures for dune habitat would be included as stated for the proposed renourishment action. Use of other local or distant offshore sources would involve dredging at the location of the sand source and therefore most likely include the potential for impacts to fish. The impacts of dredging cannot be predicted without knowing the exact location and habitats of the areas that would be dredged.

4.5.5 NO ACTION ALTERNATIVE (STATUS QUO).

No adverse impacts to fish are expected under the no-action alternative. It is probable that maintenance of status-quo conditions would result in increased exposure of nearshore rock outcrops as the shoreline continues to erode at its present rate. This could provide increased habitat for surf zone fishes. Continued shoreline erosion would jeopardize the remaining dune habitat along the Broward County shoreline, potentially decreasing the available habitat for migratory birds, and dune species.

4.6 ESSENTIAL FISH HABITAT.

The proposed Broward County Shore Protection Project will include activities which will temporarily and permanently impact Essential Fish Habitat (EFH). Categories of affected Essential Fish Habitat include marine water column, live hardbottom, coral, coral reefs, artificial/manmade reefs, and wormrock. The proposed project will affect approximately 13.6 acres of coastal habitat identified as EFH. A net total of 10.1 acres of nearshore hardbottom will be impacted by project construction. In addition to EFH for the Federally managed species listed in Section 3.6, hardbottom, coral, and shallow nearshore hardbottom habitats provide nursery, foraging, and refuge habitat for other commercially and recreationally important fish and shellfish. Species such as blue crab, shrimp, flounder, red drum, pompano, snook, striped mullet and tarpon are among the many species that utilize this habitat (NMFS, 2000). Several of these species are recognized as being of "national economic importance" in Section 906(e)(1) of the Water Resources Development Act of 1986 (PL 99-602), and are therefore considered aquatic resources of national importance (ARNI). These include blue crab, shrimp, snapper, red drum, bluefish, Spanish and king mackerel, tarpon, and flounder. Although direct impacts to these species due to project construction are unlikely, secondary impacts to these species, such as reductions in feeding and reproductive success of game fish species due to elimination of juvenile prey life stages and decreased substrate for larval settlement, are probable. However, the results of the nearshore fish assemblage study suggest that impacts to these species and their habitat should be minimal, provided implementation of appropriate compensatory mitigation, and should not negatively impact the sustainability of these populations.

The designation of Habitat Areas of Particular Concern (EFH-HAPC) identified subsets of EFH Habitat that are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Offshore areas of high habitat value or vertical relief, and habitats used for migration, spawning, and rearing of fish and shellfish have been included within HAPC (NMFS, 2000). Categories of HAPC in the vicinity of the proposed project include hermatypic coral habitat and reefs and hardbottom habitats including wormrock. The nearshore hardbottom habitat in the project area and offshore reefs adjacent to the borrow areas are designated as EFH-HAPC for the snapper-grouper complex (EFH-HAPC). Thirty-three species of the snapper/grouper management unit and one coastal migratory pelagic species were recorded on the Broward County nearshore hardbottom during the 2001 study (Spieler, 2001b).

Most motile surf zone fishes should be able to flee the nearshore fill sites and return after construction. Placement of sand fill at the beach disposal sites will result in the direct burial of 2.0 acres of nearshore hardbottom habitat, 1.1 acres of which is wormrock habitat. Approximately 90% of this habitat consists of unattached wormrock rubble on the seaward side of the solid reef. Most of the demersal fish community within the impacted nearshore hardbottom in John U. Lloyd State Park (0.9 acres) and the 1.1 acres of wormrock habitat will be eliminated by direct burial, particularly early ontogenetic life stages which are mostly represented by juvenile grunts (*Haemulon* spp.). The 2001 nearshore fish study documented the importance of Broward County nearshore hardbottom as settlement habitat for juvenile grunts (Family Haemulidae). A total of 72,723 fish were recorded during the study, of which more than 80+% were juvenile grunts. Within the areas of direct impact, overall abundance of fish along the wormrock transects (R-103 and R-103.5) was 1,961; of which 1,800 were newly settled, juvenile grunts, 0 to 2 cm in size (Spieler, 2001b). Significantly lower numbers of fish were recorded along the five transects within the impact area in John U. Lloyd State Park (R-88, R-88.5, R-89, R-89.5, and R-90). Total abundance was 438; of which 180 were juvenile grunts, 0 to 2 cm in size. These populations roughly approximate the potential for direct mortality of newly settled life stages by fill placement.

Previous studies clearly have shown that there will be significant short-term effects of beach renourishment and habitat burial on associated fish assemblages. The gradual burial of the remaining 11.6 acres of nearshore hardbottom habitat will negatively impact the settlement rates of juvenile fish, as well as eliminate foraging resources for juvenile fish and invertebrates. Reduced feeding success may influence survival, year-class strength, and recruitment of juvenile fish that inhabit nearshore hardbottom (Wilber and Clarke, draft manuscript). In turn, the feeding success of larger predatory game fishes could be affected by a decrease in their prey. However, given the extensive areas of nearshore hardbottom in Broward County, significant reductions in feeding success are not anticipated. The nearshore hardbottom tract in Segment II extends from -10 to -34 feet (NGVD) and covers approximately 5,000 acres. In Segment III, the nearshore hardbottom extends from about -5 to -34 feet (NGVD) between the beach and the first reef tract offshore and covers approximately 5,200 acres. Previous substrate/recruit availability and settlement studies of Broward County hardbottom have suggested that the marine environment is not substrate limited, but rather, that reef fish assemblages are recruitment limited and primarily structured by predation (Spieler, 2000b). The results of this study also suggested that since the hardbottom in Broward County may be refuge limited, the placement of artificial reefs aimed at increasing juvenile refuge could increase the forage base for game fish, and depending upon site selection, may also increase the number of game fish (Spieler, 2000b).

The major component of the Broward County inshore fish assemblages is juvenile grunts, both in species numbers as well as individuals, and these fish appear to quickly recruit to newly uncovered hardbottom (Lindeman and Snyder 1999). In addition, the Broward nearshore hardbottom does not appear to provide a unique habitat for some fish species that is unavailable at other hardbottom sites. The major discernable impact of any hardbottom burial will be on the loss of juvenile grunt habitat, primarily refuge (Spieler, 2001b). It appears that the proposed beach renourishment will have minimal qualitative impact on the nearshore fish assemblages; and from the perspectives of either richness, abundance, or predominant species commonality, nearshore hardbottom loss can be mitigated with artificial refuge (Spieler, 2001b).

Comparisons of the fish data from previously renourished beaches within Broward County to never renourished sites or of sites proposed to be buried by the equilibrium toe of fill to those not to be affected did not show clear, site-dependant differences in fish assemblages. A comparison of the nearshore hardbottom assemblage with reports on the fishes of the middle and offshore reef indicated, for the most part, that the inshore reef had lower abundance and richness than the other reef tracts; and that the majority of the nearshore species are also found at deeper hardbottom sites. Although juvenile grunts are not unique to the nearshore reef, they are more abundant on the nearshore hardbottom than on the other reef tracts. Juvenile grunts are not typically found on the offshore reef tract or the eastern edge of the middle reef in Broward County.

Comparison of the inshore assemblage with fishes found on local artificial reefs indicates that loss of the hardbottom refuge of the predominant fish assemblage can be mitigated with artificial structure (Spieler, 2001). In a previous artificial reef study, concrete reefs, $1m^3$, were placed on sandy substrate between the nearshore and middle reef (7 m depth) and between the middle and offshore reef (21 m depth) (Spieler, 1999; 2000a). The shallow reefs consisted of 40 reefs divided into four treatments, involving increasing refuge with caging, and the fish were counted monthly. During the period of June-August, the same months of the 2001 study, the juvenile grunts made up 72-85% of the fish assemblage, depending on treatment. At the offshore site of 20 reefs, the juvenile grunts ranged from 49-58%. In addition, at the shallow site fish abundance ranged from 69-249 fish/m^3 and richness from 6.4-7.2 species/m^3. At the offshore site for the same period, the numbers were: 59-114 fish/m^3 and 11-13 species/m^3. The potential for mitigation becomes clear when these numbers are compared with the mean abundance and richness from either this study or that of Lindeman and Snyder (1999) both of which found less than 4 fish and less than 1 species/m^3 or m^2 of natural substrate. In addition, the species makeup of the artificial reef assemblages resembled the natural nearshore hardbottom. As mentioned, juvenile grunts predominated, but labrids, scarids, acanthurids, and gobies made up the next most represented families. In contrast to the natural hardbottom, the damsel fish (Pomacentridae) were rare on the artificial reefs.

The proposed timeframe for construction of the boulder reefs is to begin deployments at Mitigation Area 8 offshore of a DEP monument R-103 beginning in spring, 2003. Segment III mitigative artificial reef deployment will be carried out from April 1 through September 30. Areas within Segment III not completed in 2003 will be completed in 2004, but it is anticipated that all deployments within Segment III will be completed in 2003. Segment II mitigative artificial reef deployment will be performed prior to commencement of beach fill activities in 2005 or 2006.

The 10.1 acres of net hardbottom impact were anticipated to require 12.4 acres of compensatory mitigative reef. To offset the temporal lag in habitat functionality scleractinian corals greater than 15 cm diameter will be transplanted to the mitigative reef. Project construction of the artificial reefs will also occur prior to project fill placement impacts. The reduction of the temporal lag by coral transplantation reduced the required 12.4 acres to 11.9 acres of compensatory mitigative reef for both Segments II and III combined. Lindeman and Snyder (1999) advocated the up-front construction of nearshore artificial reefs as mitigation for beach renourishment impacts to fishes, stating that "If constructed before burial and at similar depths, mitigation reefs may have provided a refuge for a sizeable fraction of the thousands of displaced fishes during the burial of the hardbottom reef, as well as thousands of subsequent new recruits."

In addition to the creation of refuge for juvenile grunt species, the proposed mitigative limestone boulder reefs should provide suitable replacement refuge for spiny lobster (*Panulirus argus*). Although no spiny lobsters were observed within the nearshore characterization stations, the nearshore hardbottom in Broward County is documented as habitat for juvenile and adult spiny lobsters. Approximately two to three feet of residual relief is expected after boulder settlement, and the spaces between the boulders should create appropriate refuge for spiny lobsters.

The overall community structure of the nearshore hardbottom impact areas indicates that the physical stresses of the habitat limit the biodiversity and survivability of epibenthic species. Coral recruitment on Broward County nearshore hardbottom is limited by competition with algae for space and high suspended sediment levels. Very few stony corals of significant size were observed within the nearshore impact areas. These observations indicate that the nearshore hardbottom epibenthic communities do not represent irreplaceable resources; and with proper placement of mitigative artificial reefs, suitable replacement essential fish habitat can be created for stony corals and other epibenthic species. The mitigatability of the nearshore epibenthic community, including stony coral species, is discussed in detail in Section 4.4.1.1.

An extensive area of staghorn coral (*Acropora cervicornis*) has been identified on the seaward edge of the first reef offshore of Fort Lauderdale (in the vicinity of FDEP monument R-66). This area of hermatypic coral coverage is located approximately 1,500 from shore, and is approximately 700 feet seaward the equilibrium toe of fill (Refer to the Broward County GIS for exact location and photographic documentation). This habitat is considered as Resource Category I by the U.S. Fish & Wildlife Service, in as such, no loss of habitat value is recommended, as these unique areas cannot be replaced. No impacts to this community are anticipated from project construction. Appropriate buffer distances will protect this area from the proposed Fort Lauderdale pipelines. Potential secondary impacts from turbidity are also not anticipated due to its distance offshore of the equilibrium toe of fill. In order to address any potential, long-term turbidity impacts to this community, two County monitoring stations, FTL-5 and FTL-6, will be included in the offshore monitoring program in Appendix E. Potential impacts of turbidity and sedimentation to offshore hardbottom habitat adjacent to the borrow areas and proposed biological monitoring to minimize impacts are described in detail in Section 4.34 and Appendix E. Implementation of the proposed monitoring plans should result in the avoidance and minimization of impacts to Essential Fish Habitat, and the proposed mitigation plan should fully compensate for the unavoidable loss of 13.6 acres of nearshore hardbottom habitat.

4.7 HISTORIC PROPERTIES.

Cultural Resource compliance includes coordination with the U.S. Army Corps of Engineers (USACE) and Florida State Historic Preservation (SHPO) to analyze the proposed alternatives, determine which resources may be present, and estimate the possible effects on these resources. No significant impacts to historical properties are expected from construction of the proposed Broward County Shore Protection

Project based upon the results of this coordination. Subsequent SCUBA investigations were undertaken for Broward County by Baer (1999) and Gifford (2001). A magnetometer survey for underwater cultural resources was conducted by Coastal Planning & Engineering (Baer, 1999). This survey identified 27 magnetic anomalies within the area of potential effects for the project. SCUBA divers investigated nineteen (19) of the 27 magnetic anomalies, three of which were not visually identified. In January 2000, the State Historic Preservation Officer specified that the magnetic anomalies not visually identified during the survey be ground-truthed prior to dredging activities (Letter dated January 26, 2000, see Appendix C).

Results of the 2001 surveys indicated that thirteen (13) of the fifteen (15) magnetic anomalies were modern debris (Gifford 2001). Two of the anomalies were identified as relatively large anchors of probable post-1950 vintage. Four anomalies were identified as modern wire rope cable; and two anomalies were identified as a possible sunken dredge or deck machinery. The remaining five anomalies are modern debris described as “small and innocuous” (Gifford, 2001). These investigations identified Anomaly 27 as the bow section of the *S.S. Copenhagen*, located 300 feet north of Borrow Area VI. Of the 27 magnetic anomalies, only Anomaly 27 represents a known submerged cultural resource. In a letter dated June 20, 2001, the State Historic Preservation Officer recommended that three of the anomalies be avoided by establishing a 100-foot buffer around the center of the vessel. After further review, the Division of Historical Resources State Historic Preservation Officer approved a 300-foot buffer around the *S.S. Copenhagen* bow (letter of August 20, 2001 from Dr. Janet Snyder Matthews, SHPO, Tallahassee to Mr. Stephen Higgins, Department of Planning and Environmental Protection, Broward County in Appendix C).

On April 24, 2003 (copy included in Appendix C) James C. Duck, Chief of the USACE Planning Division requested that the State Historic Preservation (SHPO) concur with the USACE finding that no significant historic properties will be affected by the project. Final SHPO approval is expected before the USACE issues their Record of Decision on the FEIS.

4.8 SOCIO-ECONOMIC.

In general, socio-economic losses result from potential storm damages to buildings and land along the Atlantic coastline, as well as losses in revenue to Broward County. The shoreline recession can potentially undermine the oceanfront structures. In addition, a part of Highway A-1-A is susceptible to severe damage and closure. If the shoreline recession is allowed to continue, there will be incidental repercussions to tourism and the local economy.

Storm damage reduction benefits are the dollar amounts of potential storm damage that is prevented by the addition of beach extensions. The nearshore land value for the project area shoreline was determined using the 1998 Broward County Tax Appraiser database. The average nearshore land value for the project area is $25,000/square foot. The total annualized primary benefits of storm damage and land loss reduction from the proposed project design in Segment II are $25,533,000 (Appendix C of the February 2002 GRR). In Segment III, the total primary benefits of storm damage and land loss reduction are $13,288,900 (Appendix D of the February 2002 GRR).

In a socio-economic study completed from June 2000 to May 2001, the net economic value was determined for southeast Florida's natural and artificial reef resources to the local economies and reef users. Broward County, one of the four counties comprising southeast Florida, was included in this study. The reefs in Broward County hosted 9.44 million person-days (person-day= one person participating in an activity for a portion or all of a day) during this study. This is the largest number of the three other counties in southeast Florida: Miami-Dade 9.17 million person-days, Monroe 5.11 million person-days, and Palm Beach 4.24 million person-days. In addition to providing a place for tourists and residence to fish, snorkel, and SCUBA dive, the reefs in Broward County contribute 36,000 full-time and part-time jobs and generated $2.1 billion in sales during the 12-month study. Of the $2.1 billion, artificial reefs generated $961 million, and the natural reefs generated $1.1 billion (Hazen and Sawyer, 2001).

To obtain demographic characteristics of the reef users in southeast Florida, resident and visitor boater surveys were completed. The median age of respondents in Broward County who were resident reef users was 48, and the median age was 39 for visitor reef users. Ninety-two percent of the resident reef users were male and 8% were female. Seventy-seven percent of the visitor reef users were male and 23% were female. On average, residents have been boating in Broward County for 22 years, while visitors have only been boating for 7 years. The average length of boats used for salt-water activities was 25 feet for residents and 27 feet for visitors. The median household income for resident reef users was $72,310 and $87,500 for visitor reef users. Both resident and visitor reef users were willing to spend $126 million per year for reef maintenance via water quality monitoring, means to prevent damage to reefs from anchoring, and preventing reef overuse (Hazen and Sawyer, 2001)

4.9 AESTHETICS.

The presence of construction equipment would temporarily detract from the aesthetics of the environment. The sand color of the post-construction beach may be different from the sand color of the current beach, and may detract from the aesthetic quality of the project beaches. This impact would be short-term as natural working of the dredged sediments by sunlight, rain, and wind will lighten the sediments with time. Increased beach area and restoration of the natural shoreline would result in an overall improved aesthetic quality. With the no-action alternative, the shoreline would continue to erode, resulting in the loss of existing shoreline and reducing the visual aesthetics of the area.

4.10 RECREATION.

In the nourishment area, beach use would be temporarily restricted over short lengths of beach for safety reasons, but would resume after construction. Recreational fishing would also be temporarily curtailed by turbidity near the dredging sites. Nearshore snorkeling and offshore SCUBA activities would be temporarily affected by increased turbidity and the presence of dredging equipment would create a public safety risk. Recreational boating may be detoured during construction and restricted from the dredging areas. Long-term effects are not anticipated. These are temporary effects and no mitigation is suggested. The no-action alternative would assume continued erosion and reduction of recreational beaches. No offshore recreational impacts are associated with the no-action alternative.

Recreational benefits are the most common incidental benefit produced by a shore protection project. These benefits result from an increased capacity for recreational activity by the new beach surface. The total annualized recreational benefit in Segment II is $9,121,000, and in Segment III is $12,716,900 (Appendices C and D of the February 2002 GRR).

4.11 COASTAL BARRIER RESOURCES.

The following history and the applicability of the Coastal Barrier Resources Act (CBRA) of 1982 and the Coastal Barrier Resources Improvement Act (CBRIA) of 1990 to the Broward County Shore Protection Project located in Broward County, Florida was provided by the U.S. Fish and Wildlife Service in a letter dated April 30, 2003. The proposed project will overlap the boundaries of two “otherwise protected areas” (OPAs) (Birch Park, FL-19P and Lloyd Beach, FL-20P) and one CBRA unit (North Beach, P-14A) (USFWS, 2003).

Historically, some Federal expenditures (e.g., Federal flood insurance and other Federal financial assistance) had the effect of encouraging development in fragile, high-risk coastal barrier systems (e.g., barrier islands, sand spits, and mangrove forests). The CBRA and CBRIA limit federally-subsidized development within a defined Coastal Barrier Resources Unit. Three important goals of these acts are to: (1) minimize loss of human life by discouraging development in high-risk areas; (2) reduce wasteful expenditure of Federal resources; and (3) protect the natural resources associated with coastal barriers. In addition, CBRIA also provided development goals for undeveloped coastal property held in public ownership, such as wildlife refuges, parks, or other lands set aside for conservation, which are identified as OPAs. The only restriction applied to an OPA prohibits the expenditure of Federal Flood Insurance to new construction of structures (buildings) in an OPA, as stated in Section 9, Prohibitions of Flood Insurance Coverage In Certain Coastal Barriers. There are no other restrictions placed on Federal expenditures in an OPA (USFWS, 2003).

Federal monies can be spent within the Coastal Barrier Resource System for certain activities, which are exempted under Section 6, Exceptions To Limitations On Expenditures. These activities include: (1) projects for the study, management, protection, and enhancement of fish and wildlife resources and habitats; (2) establishment of navigation aids; (3) projects funded under the Land and Water Conservation Fund Act of 1965; (4) scientific research; (5) assistance for emergency actions essential to saving lives and the protection of property and the public health and safety, if preferred pursuant to the Disaster Relief, Emergency Assistance Act, and National Flood Insurance Act and are necessary to alleviate the emergency; (6) maintenance, repair, reconstruction, or repair, but not expansion of publicly owned or publicly operated roads, structures, or facilities; (7) nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system; (8) any use or facility necessary for the exploration, extraction, or transportation of energy resources; (9) maintenance or construction of improvements of existing Federal navigation channels, including the disposal of dredge materials related to such projects; and (10) military activities essential to national security (USFWS, 2003).

Since the proposed Broward County Shore Protection Project does not include the construction of structures that would require Federal Flood Insurance, then Federal expenditures for the proposed project are not restricted in the FL-19P, Birch Park and FL-20P, Lloyd Beach OPAs. The Service has determined that the construction activities proposed within CBRA Unit, P-14A, North Beach are consistent with the intent of the Act and are exempt pursuant to section 6(a)(G) which authorizes “nonstructural projects for shoreline stabilization that is designed to mimic, enhance, or restore a natural stabilization system” (USFWS, 2003).

There are two parcels near Dania Beach listed as undeveloped coastal barriers as defined by the Coastal Barriers Resources Act. These parcels require coordination with the U.S. Fish and Wildlife Service prior to nourishment activities. This coordination will be accomplished by Broward County during project review by the resource protection agencies.

4.12 WATER QUALITY.

The potential effects of dredging include sedimentation during dredging, which stresses the growth and reproductive energies of benthic organisms, and an increase in turbidity, which reduces the penetration of light, required by photosynthetic organisms. The identified borrow areas contain up to 4.8% silt, which can cause temporary turbidity plumes alongshore during dredging (CPE, 1997). Goldberg (1985) determined the long-term effects of chronic turbidity on hard corals. This study was performed fifteen months after completion of the 1983 Pompano Beach/Lauderdale-By-The-Sea Beach Restoration Project. The source of chronic turbidity was a combination of dredging related activities and natural, seasonal resuspension of sediment associated with storm events (Goldberg, 1985). Goldberg observed a decrease in photosynthetic light, clogging of filter feeding mechanisms, and increased energy losses due to continuous shedding of mucus. Varying degrees of biological changes were recorded at some stations, but this could not be correlated to the dredging activities (CPE, 1987).

The relationship between NTU and sedimentation has no biological or physical derivation. Turbidity measurements associated with past projects have not always accurately reflected the amount of sedimentation/siltation that settles on adjacent reefs, nor have secondary impacts to biological resources been assessed. Past studies have also demonstrated that some species of stony corals are adversely affected at levels below the current Florida administrative threshold of 29 NTUs (Teleniski and Goldberg, 1995). Telesnicki and Goldberg (1995) studied the effects of turbidity on the photosynthesis and respiration of two South Florida coral reef species, *Dichocoenia stokesii* and *Meandrina meandrites*. They found that for these two particular coral species, turbidity ranges of 28-30 NTU (the current Florida standard for coastal water turbidity) produced physiological stress related to increased respiration rather than decreased photosynthesis. Telesnicki and Goldberg (1995) acknowledged that other species of scleractinians may have different reactions to turbidity, but that adherence to present turbidity-related water quality standards may result in short term stress in some coral species. Dompe (1993) studied the influence of beach nourishment on turbidity levels, and found that many turbidity measurements during natural storm events were higher than the limits set by the State of Florida, as well as during and after nourishment activities.

4.13 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE.

There are no known hazardous, toxic or radioactive wastes in the project areas that would be affected by the chosen alternative actions. There is a potential for hydrocarbon spills with dredging and construction equipment in the area, but accident and spill prevention plans delineated in the contract specifications should prevent most spills. The no-action alternative would not create situations to cause these potential impacts.

4.14 AIR QUALITY.

The short-term impact from emissions by the dredge and other construction equipment associated with the project will not significantly impact air quality.

Exhaust emissions of the construction equipment, both onshore and offshore, would have a temporary effect on the air quality, but no permanent impacts are expected. The no-action alternative would have no impact upon air quality.

4.15 NOISE.

Construction based on the recommended alternatives would temporarily raise the noise level in the areas of the dredge and the discharge point on the beach. Construction equipment would be properly maintained to minimize these effects in compliance with local laws. There would be no noise impacts from the no-action alternative.

4.16 PUBLIC SAFETY.

As a public safety measure, beach and water related recreation in the immediate vicinity of the discharge pipe will be prohibited during project construction. Likewise, water related activities near the dredge site will also be prohibited during project construction. Recreational access to these areas will return to pre-construction conditions following completion of the project. Long-term effects are not anticipated. The no-action alternative would assume continued erosion, allowing the surf zone to advance landward, with the potential of negative impacts to public safety due to storm damage.

4.17 ENERGY REQUIREMENTS AND CONSERVATION.

Energy requirements for the proposed alternatives would be confined to fuel for the dredge, labor transportation, and other construction equipment. The use of sand from the proposed borrow areas would require less energy expenditure than obtaining sand from any other distant sources. The no-action alternative would allow erosion to continue, and may require a greater energy expenditure of on-site preventative measures and post-storm clean-up in the event of a storm event (USACE, 1996).

4.18 NATURAL OR DEPLETABLE RESOURCES.

The beach quality sand obtained from the borrow areas is the depletable resource and the proposed alternative will most likely cause a permanent removal of sand from these borrow areas. Sand will eventually redistribute over nearshore areas, but the amount of beach quality sand in the borrow areas will be significantly reduced. The no-action alternative will allow the sand in the borrow areas to remain relatively intact, although redistribution will occur with natural cycles and storm events.

4.19 SCIENTIFIC RESOURCES.

There are no known impacts to scientific resources associated with the proposed project or the no-action alternative.

4.20 NATIVE AMERICANS.

None of the proposed project activities occur on land belonging to Native Americans, therefore implementation of the proposed project will not result in any impacts to Native Americans or land belonging to Native Americans.

4.21 REUSE AND CONSERVATION POTENTIAL.

There is no potential for reuse associated with the proposed project activities, therefore this is not applicable to the proposed renourishment project. Energy requirements for the proposed alternatives would be confined to fuel for the dredge, labor transportation, and other construction equipment. The energy conservation potential of the use of sand from the proposed borrow areas is greater (requires less energy expenditure) than obtaining sand from any other distant sources.

4.22 URBAN QUALITY.

No direct permanent impacts related to urban quality are expected as a result of the proposed project. Implementation of the proposed project would indirectly positively impact urban quality by restoration of lost land due to shoreline recession and an increase in the capacity for recreational beach activity, which would then lead to an increase in tax revenue and tourism commerce. The commercial business and residential properties along State Road A-1-A would benefit from the storm protection afforded by the project and incur less risk of property damage. The presence of construction equipment would temporarily detract from the aesthetics of the environment, thereby possibly temporarily affecting the visual aesthetics associated with urban quality in the Broward County metropolitan area. The no-action alternative would assume continued shoreline erosion and reduction of storm protection, and continued loss of recreational beach area with repercussions to tax revenue and tourism commerce.

4.23 SOLID WASTE.

No impacts related to solid waste are expected as a result of this project. Precautionary measures will be included in the contract specifications for proper disposal of solid wastes. These precautionary measures included proper containment and avoidance of overflow conditions by emptying containers on a regular schedule. Disposal of any solid waste material into Atlantic waters will not be permitted.

4.24 DRINKING WATER.

No municipal or private water supplies are located in or near the project site, therefore drinking water supplies will not be impacted by the implementation of the proposed project.

4.25 CUMULATIVE IMPACTS.

Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (40 CFR 1508.7). The proposed action, in addition to past projects and any future actions, primarily impacts the beach, nearshore hardbottom epibenthic and fish communities, and the offshore sand borrow areas and adjacent reef epibenthic communities. The beach will continue to be maintained as an area suitable for shoreline protection, recreation, and wildlife habitat. The current offshore borrow areas will likely be depleted over the life of the authorized project, and alternative sand sources will have to be explored. Utilization of upland sources for future renourishment use may also involve natural resource impacts to habitats adjacent to the sand mines, such as xeric sand pine and scrub oak habitats adjacent to the Lake Wales Ridge. Repeated placement of pipeline with periodic renourishment (authorized twice more in Segment II, and three more times in Segment III), will have a direct negative impact on nearshore hardbottom communities. Careful placement of pipelines during the proposed project and adherence to the protective measures described in Section 4.34 will minimize direct impacts to hardbottom biological resources. The establishment of permanent pipeline corridors for future renourishment use will minimize impacts and avoid foreseeable future impacts. Future nourishment actions will be evaluated separately with respect to the present impact analyses and monitoring of the initial nourishment project. The GIS database will be used as the primary tool to analyze cumulative impacts based upon the baseline conditions recorded during 2001. The creation of the GIS to document pre-project conditions significantly reduces the effort needed to analyze the effects of future projects by overlaying data layers from post-construction monitoring events for comparison to the baseline data set.

The no-action alternative will allow for continued erosion of beaches, increasing the potential for storm related property damage and decreasing property values. No adverse environmental impacts to nearshore and offshore hardbottom habitats and fish communities are anticipated due to the no-action alternative. An increased exposure of nearshore hardbottom due to continued beach erosion is probable which, in turn, could provide increased habitat for surf zone fishes. Continued erosion of the beach could threaten the existence of the remaining dune vegetation and adjacent scrub habitat in Broward County, potential decreasing available habitat for birds and dune species. Continued shoreline recession would also reduce the amount of dry beach available for sea turtle nesting and may result in poor site selection by nesting females.

Table 22 summarizes the impact of cumulative actions by identifying the past, present, and reasonably foreseeable future condition of the various resources which are directly or indirectly impacted by the proposed project and its alternatives. Appendix D contains more detailed information of how the cumulative impacts were examined using the eleven steps identified by the Council of Environmental Quality (1997).

4.25.1 PROTECTED SPECIES

Overall, approximately 4% of the sea turtle nests laid annually in Florida are in Broward County. In 2001, 2,385 nests were laid on Broward County beaches, the lowest overall total during the past seven nesting seasons. Total nests in 2000, 1999, 1998, 1997, 1996, and 1995 were 2,942; 2,620; 2,857; 2,288; 2,810; and 2,634, respectively. All discovered sea turtle nests in Deerfield Beach, Pompano Beach, Hollywood/Hallandale and Fort Lauderdale have been relocated since 1978, mainly due to lighting. The beaches within the proposed project area have been nourished/renourished several times since 1970 with the exception of Fort Lauderdale (R-53 to R-84) and the southern portion of John U. Lloyd State Park/Dania Beach (R-94 to R-101). Nearshore hardbottom was documented as developmental habitat for juvenile green sea turtles during a study in the late 1980s (Wershoven and Wershoven, 1989). Thirty-three juvenile green sea turtles were observed over the nearshore hardbottom during surveys in the summer of 2001.

TABLE 22. SUMMARY OF CUMULATIVE IMPACTS

Resource	Boundary (same for all resources)	Past	Present (existing condition)	Future Without Project	Future With Proposed Action	Future with Sand Bypassing at Port Everglades	Future without Groin Construction at John U. Lloyd State Park
Protected Species	11.8 miles of Broward County, FL shoreline proposed for dredge and fill beginning in April 2003. Construction timeframe: 8 months. Fill areas: FDEP monuments R-36 and R-43 in Pompano Beach; R-51 and R-72 in Lauderdale-by-the-Sea and northern Fort Lauderdale; R-86 and R-92 in John U. Lloyd State Park; and R-99 and R-128 in Hollywood/Hallandale. Renourishment interval is 6 years. Project is authorized until 2020 in Segment II, and 2026 in Segment III.	Majority of the shoreline has been renourished using offshore sand sources. All discovered sea turtle nests in Deerfield Beach, Pompano Beach, Hollywood/Hallandale and Fort Lauderdale have been relocated since 1978. Approximately 4% of nests laid annually in Florida are on Broward County beaches. Total nests in 2000, 1999, 1998, 1997, 1996, and 1995 were 2,942; 2,620; 2,857; 2,288; 2,810; and 2,634. Nearshore hardbottom documented as developmental habitat for juvenile green sea turtles.	In 2001, 2,385 nests were laid on Broward County beaches, the lowest overall total during the past seven nesting seasons. Nesting within the proposed groin field in John U. Lloyd State Park was 2 nests in 2001 compared to a high of 18 nests in 1999. 33 juvenile green sea turtles were observed over the nearshore hardbottom in the summer of 2001.	Continued erosion of the beach would result in reduction of sea turtle nesting habitat and possible poor site selection by nesting females. No impact to nearshore hardbottom foraging habitat.	Potential "take" of sea turtles by nest destruction, reduced nesting, and hatching success. Dry beach maintained as suitable nesting habitat provided appropriate remediative measures. Approximately 13.6 acres of nearshore foraging habitat for juvenile sea turtles will be gradually buried. Negative effects on nesting and hatching success would persist for 2 years. Need for nest relocation would continue unless lighting problems are rectified. Groin construction may result in entrapment and/or hatchling disorientation. Future Federal actions unrelated to the proposed action require separate consultation pursuant to Section 7 of the ESA.	Sand bypassing would maintain dry beach as potential nesting habitat within John U. Lloyd State Park. Potential of increased hatchling disorientation if appropriate beach width is not maintained in the structure field. This action will require separate consultation pursuant to Section 7 of the ESA.	Past projects indicate that elimination of the groins will undermine the ability to maintain the design beach at John U. Lloyd State Park. Amount of available dry beach for nesting habitat would be significantly reduced within the Park over time. Potential negative impacts to hatchlings and nesting sea turtles would be avoided.
Water Quality Water Quality (cont.)		Turbidity varies significantly under natural conditions with values during storms sometimes exceeding 29 NTU. No statistically significant long-term resource effects were directly attributable to turbidity/ sedimentation from past beach projects.	Rapid population growth rates in South Florida have increased the potential for coastal water quality degradation. Blue-green algae (*Lyngbya* sp.) covered up to 90% of the nearshore hardbottom south	Local, short-term impacts and potential long-term chronic turbidity impacts would be avoided. Natural sedimentation and turbidity rates would continue to vary based upon storm activity, rainfall, currents, and other natural	Local, short-term impacts of turbidity and sedimentation will occur adjacent to the beach fill sites and offshore borrow areas. Preventative measures and monitoring during construction should minimize short-term impacts. Water quality may deteriorate due to unrelated anthropogenic sources such as pollution,	Local, short-term turbidity and sedimentation plumes would reduce primary productivity on the nearshore hardbottom south of the Port. Given the relatively depauperate faunal structure of the nearshore	Avoidance of short-term turbidity impacts in the surf zone associated with groin construction. Natural sedimentation and turbidity rates would continue to vary based upon storm activity, rainfall, currents, and other natural phenomenon. Water quality may deteriorate due to unrelated anthropogenic sources such as pollution,

TABLE 22. SUMMARY OF CUMULATIVE IMPACTS (CONT.)

Resource	Boundary (same for all resources)	Past	Present (existing condition)	Future Without Project	Future With Proposed Action	Future with Sand Bypassing at Port Everglades	Future without Groin Construction at John U. Lloyd State Park
		Evidence of eutrophication has been documented during the past several decades.	of Port Everglades during the summer of 2001. Macroalgae and blue-green algae composed 88% of the cumulative community composition on the nearshore hardbottom impact areas.	phenomenon. Water quality may deteriorate due to unrelated anthropogenic sources such as pollution, and nutrient and freshwater input. Future local increases in turbidity and sedimentation associated with authorized renourishment projects would be avoided.	and nutrient and freshwater input. Concurrent beach renourishment projects in southeast Florida include Delray Beach and South Boca Raton (Winter 2002) and the Town of Palm Beach Mid-Town renourishment (Winter 2003). Local, short-term impacts of turbidity and sedimentation would occur during authorized renourishments. Long-term monitoring should provide data to predict the future impacts of turbidity and sedimentation.	community in J.U. Lloyd State Park, there would be limited impacts to biodiversity and stony corals. May eliminate the need for larger scale renourishments, thereby reducing associated turbidity and sedimentation impacts upon offshore resources.	and nutrient and freshwater input.
Nearshore Hardbottom Nearshore Hardbottom (cont.)		Nearshore hardbottom burial events have been documented by Broward County. The 2001 nearshore data set represents the baseline condition. No comprehensive nearshore reef baseline survey exists for comparative purposes.	2001 LADS survey is the first comprehensive remote sensing survey of Broward County. Nearshore hardbottom tract covers ca. 5,000 acres in Segment II, and ca, 5,200 acres in Segment III. 88% of the cumulative community composition within nearshore impact areas consists of macroalgae and blue-green algae. Coral bleaching and sedimentation damage were common at the 2001 nearshore	No direct, secondary or cumulative impacts of sedimentation and turbidity related to beach nourishment activities would occur. Nearshore hardbottom edge would fluctuate with natural sand movement. Likely increase in hardbottom exposure with continued erosion of the beach. Natural physical stresses would continue to limit biodiversity. Eliminates potential for	Approximately 10.1 acres of nearshore reef unavoidably impacted, 2.0 acres directly buried during construction, 8.1 acres impacted during fill equilibration. Approximately 11.9 acres of limestone boulder mitigative reefs will be placed in nearshore reef sand pockets, 6.1 acres will be constructed up-front. Limited cumulative impact upon nearshore epibenthic communities if mitigative reefs function as designed. Construction of concurrent beach renourishment projects in Delray Beach, South Boca Raton, and Town of Palm Beach should result in minimal cumulative impacts on nearshore	Impacts to J.U. Lloyd State Park nearshore hardbottom will be mitigated during the proposed project. Replacement habitat should support higher epifaunal densities than current habitat. Sand bypassing activities may eliminate need for larger scale renourishments.	No cumulative impacts to existing nearshore hardbottom habitat would be associated with elimination of groin construction from the proposed project.

TABLE 22. SUMMARY OF CUMULATIVE IMPACTS (CONT.)

Resource	Boundary (same for all resources)	Past	Present (existing condition)	Future Without Project	Future With Proposed Action	Future with Sand Bypassing at Port Everglades	Future without Groin Construction at John U. Lloyd State Park
			hardbottom stations. Natural physical stresses include wave energy, turbidity, and temperature extremes. Anthropogenic stresses of eutrophication and pollution affect the nearshore habitat quality, particularly in areas south of Port Everglades, in areas in close proximity to the fishing piers, and adjacent to beaches of intense recreational usage.	secondary and cumulative impacts of chronic sedimentation to nearshore hardbottom communities.	hardbottom habitat provided appropriate monitoring and mitigation.		
Offshore Hardbottom Offshore Hardbottom (cont.)		Past Broward County nourishment projects did not document turbidity and sedimentation rates that produced statistically significant long-term resource effects directly attributable to beach nourishment. General degradation in the quality of the benthic resources was observed, likely the result of cumulative effects of nutrient enrichment, sedimentation/ turbidity, temperature fluctuations, storm activity, and freshwater inflow.	Sedimentation analysis of County monitoring sites from 10/97 to 12/00 indicates that the first reef typically has the highest sedimentation, followed by the second, and then third reef sites. Sedimentation rate and average grain size from the sampling interval were consistent with data collected from previous years. Data recorded at the monitoring stations suggests	Local, short-term impacts of turbidity and sedimentation at the proposed offshore dredge sites would be avoided. Potential secondary impacts of chronic turbidity, would be avoided. Natural sedimentation and turbidity rates would vary based upon storm activity, rainfall, currents, etc. Water quality may deteriorate due to unrelated anthropogenic sources, potentially	Buffer zones and adherence to construction specifications should avoid cumulative impacts of direct mechanical damage. Direct hardbottom impacts from pipeline placement are ~190 sq ft/corridor. No significant impacts are expected from pipeline leakage. Establishment of permanent pipeline corridors will minimize cumulative impacts of repeated placement. Mitigation is proposed for unavoidable impacts. Potential added effect of localized, short-term turbidity/sedimentation may cumulatively impact stony corals which already exhibit signs of disease or	Sand bypassing activities may eliminate the need for larger scale renourishments using an offshore sand source, thereby reducing associated turbidity and sedimentation impacts.	No cumulative impacts associated with elimination of groin construction from the proposed project.

TABLE 22. SUMMARY OF CUMULATIVE IMPACTS (CONT.)

Resource	Boundary (same for all resources)	Past	Present (existing condition)	Future Without Project	Future With Proposed Action	Future with Sand Bypassing at Port Everglades	Future without Groin Construction at John U. Lloyd State Park
		Similar average stony coral cover was observed at the County monitoring sites in 1997 and 1998 (1.43% and 1.46% respectively).	chronically high, natural sedimentation rates. Comparison of offshore reef data from 1997 to 2000 revealed minor differences in stony coral, soft coral, and sponge populations. Intense recreational usage represents a potential cumulative threat to overall reef health on south Florida reefs. Coral diseases and bleaching are an increasing threat.	contributing to the incidence of coral disease and mortality.	bioerosion, possibly resulting in low levels of mortality. Wave and current action should dissipate elevated sediment levels, provided appropriate monitoring and remediative actions are undertaken to prevent excessive accumulation.		
Fish and Wildlife Resources		Benthic infaunal populations rapidly recolonized the beach and borrow areas following dredging during past projects, but individual species recovered at different rates. Substrate availability and settlement studies suggest that reef fish assemblages are recruitment limited and primarily structured by predation in Broward County.	Major component of the Broward County inshore fish assemblages is juvenile grunts. Nearshore reef has lower abundance and richness than the middle and third reef tracts. Majority of nearshore species are also found at deeper hardbottom sites. Reef fish kills occur during cold-water upwelling events. Over-fishing represents a potential threat to	Continued exposure of nearshore hardbottom may provide increased habitat for surf zone fishes and refuge for juvenile fishes. No direct, secondary or cumulative impacts related to beach nourishment activities. Nearshore habitat for juvenile fishes may degrade without unrelated improvements in local pollution	Changes in infaunal community structure may persist for more than 3 years but should result in minimal loss of productivity. Low mortality of demersal and burrowing fish species is likely. Minimal secondary impacts to reproductive and feeding success of reef fishes. No significant cumulative effects to sustainability of offshore reef fish populations. No significant reductions in feeding success. Major impact of hardbottom burial will be loss of juvenile grunt refuge. 6.1 acres of up-front mitigative	Impacts to J.U. Lloyd State Park nearshore hardbottom will be mitigated during the proposed project. Replacement habitat should support higher epifaunal densities. Sand bypassing activities may eliminate need for larger scale renourishments using an offshore sand source, thereby reducing secondary impacts to feeding and	Direct impacts to benthic infauna in the areas of the structures would be avoided. No cumulative impact upon fish and wildlife resources, although groins provide increased shelter areas for fish.

TABLE 22. SUMMARY OF CUMULATIVE IMPACTS (CONT.)

Resource	Boundary (same for all resources)	Past	Present (existing condition)	Future Without Project	Future With Proposed Action	Future with Sand Bypassing at Port Everglades	Future without Groin Construction at John U. Lloyd State Park
			certain species.	prevention measures and waste water management.	reef should provide refuge for displaced fishes and habitat for new recruits prior to the loss of habitat.	reproductive success of reef fishes.	

The proposed Broward County Shore Protection Project may result in the "take" of sea turtles by possible nest destruction, reduced hatching success, and reduced nesting success. Refer to the U.S. Fish & Wildlife Biological Opinion in Appendix C for a complete analysis of direct, indirect, and cumulative effects of the proposed action. In the Biological Opinion, the U.S. Fish & Wildlife Service determined that the level of anticipated take is not likely to result in jeopardy to the continued existence of the loggerhead, green, and leatherback sea turtles. As during previous nourishment projects in Broward County, the proposed sand source is compatible with existing beach sediment, thereby maintaining the beach as suitable nesting habitat, provided appropriate protective and remediative measures, such as beach tilling and escarpment leveling, are implemented. Approximately 10.1 acres of potential nearshore hardbottom foraging habitat for juvenile sea turtles will be gradually buried by beach construction and gradual beach fill equilibration. Suitable replacement habitat is proposed for mitigation at a 1:1.2 ratio, providing 11.9 acres of substrate within a 13.5-acre footprint. The monitoring program for mitigation reefs includes an assessment of algal recruitment with an emphasis upon replacement of sea turtle foraging habitat. Two stations, each consisting of three (3), 30 meter long transects spaced at 1 meter intervals, will be established over a 0.5 acre area of the artificial reef in Fort Lauderdale (Migration Area V between R-70 and R-71), located in the close proximity to the natural nearshore hardbottom with the highest number of juvenile green sea turtle sightings recorded in the summer of 2001 (R-52 to R-74). In Segment III, two control stations will be established over a 0.5 acre area of the artificial reef located between FDEP control monuments R-101 and R-104. The 30 meter transect will be established following the rugosity of the boulders so that algal recruitment on both horizontal surfaces and boulder slopes will be assessed. The same methodology survey will be used in two control stations on natural hardbottom. The 30 meter long transects will be documented using digital video sampling (Sony TRV-900) in progressive scan mode. Macroalgae abundance will be assessed by percent cover using frame grabbing and PointCount'99 software. Species identification within the stations will be performed *in situ* by a second, qualified diver/biologist (M.S. degree or higher). The biologist will swim two 1-meter wide corridors within the station and record a comprehensive taxonomic list of species present on the entire 60 square meter box. The algae surveys will be conducted on a semi-annual basis (spring/summer and fall/winter) for a period of 4 years in compliance with the FDEP permit. Nest relocation activities will likely continue in the future unless lighting problems are rectified. Groin construction may result in entrapment and/or hatchling disorientation.

Future authorized renourishments (twice more in Segment II and three more times in Segment III) would continue to maintain the beach as nesting habitat provided suitable sediment is used. Future Federal actions unrelated to the proposed action require separate consultation pursuant to Section 7 of the ESA. Sand bypassing at Port Everglades would maintain a dry beach as potential nesting habitat within John U. Lloyd State Park. Sand bypassing has the potential to increase hatchling disorientation if appropriate beach width is not maintained by discharge pipe placement. This action would require separate consultation pursuant to Section 7 of the ESA.

4.25.2 WATER QUALITY

Evidence for eutrophication along the coastal waters of Broward County has been documented during the past several decades. Recurrent blooms of the green macroalgae, *Codium isthmocladum*, occurred on Broward County and Palm Beach County reefs in depths from 20 to 60 meters in 1989/90 and 1996/97 (Lapointe and Hanisak, 1997). The excessive biomass of these blooms causes hypoxia/anoxia on the reef surface, leading to relocation of motile fish and suffocation of epibenthic organisms. Rapid population growth rates and corresponding urbanization of south Florida has increased the potential for coastal water quality degradation. During the summer of 2001, the blue-green algae, *Lyngbya* sp., was very common along stretches of the Broward County shoreline south of Port Everglades, covering up to 90% of the benthic community. Immediately south of the Port, the highest coverages of *Lyngbya* sp. corresponded to the areas of lowest biodiversity. The proliferance of *Lyngbya* sp. may be suggestive of eutrophication (Richardson, 1996), and its growth pattern densities generally parallel the flow of nutrient rich waters from Port Everglades. With the projected population growth rate for south Florida, water quality may deteriorate due to unrelated anthropogenic sources such as pollution and nutrient and freshwater input. In 1990, the total population of Miami-Dade, Broward, and Palm Beach counties combined was approximately 4.06 million (1.26 million in Broward County). In 2000, the total population of the three counties mentioned above was approximately 5.01 million (1.62 million in Broward County). By 2010, the population in Broward County is projected to increase by 46% to approximately 1.77 million, and the overall tri-county population is expected to reach 5.93 million (South Florida Water Management District, 1995).

Turbidity impacts are chronic perturbations that cause long-term reductions in primary and secondary productivity of reef epibenthic communities by reducing the amount of light available for photosynthesis and increasing respiration rates of stony corals. Natural turbidity values are generally lowest in summer and highest in winter. Turbidity measurements were collected at water depths of approximately 10 meters and 5 meters in Hollywood from 1/90 to 4/92. Turbidity was found to vary significantly under natural conditions with values during storms sometimes exceeding 29 NTU. Turbidity measurements associated with past nourishment projects in southeast Florida have rarely exceeded Florida State guidelines of 29 NTU above ambient levels outside the turbidity mixing zone. Overall average turbidity during the 1989 JUL project was 5.2 NTU at the dredge site and 4.9 NTU at the discharge site. Overall average background turbidity during the 1991 Hollywood/Hallandale project ranged from 2.67 to 2.79 NTU, and the highest overall average turbidity recorded at the compliance stations was 8.01 NTU.

Turbidity measurements associated with past projects have not always accurately reflected the amount of sedimentation/siltation on adjacent reefs. Elevated sedimentation levels were observed up to 1,200 feet from the borrow area during offshore dredging projects in Miami-Dade County (1990 Bal Harbor & 2001 Sunny Isles/63rd Street nourishment projects). Sedimentation monitoring over nearshore hardbottom [-6.8 to -12.0 (NGVD] during the 1996 South Boca Raton project recorded significantly higher pre-construction values compared to the six month and one year-post-construction values (6,869.6 versus 690.0 and 544.3 $mg/cm^2/day$, respectively) due to the passages of Hurricane Lili and Tropical Storm Josephine in October 1996 (CPE, 1998). No State water quality violations were recorded during construction of any of the above mentioned projects.

Local, short-term impacts of turbidity and sedimentation will occur adjacent to the beach fill sites and offshore borrow areas during project construction. Preventative measures and monitoring during construction should minimize short-term impacts. Wave and current action should dissipate elevated sediment levels and assist in removing accumulated sediment from the reef epibenthic communities adjacent to the borrow sites, provided appropriate monitoring and remediative actions are undertaken to prevent excessive accumulation. Healthy corals are relatively resilient (Bryant et al., 1998) and able to withstand acute pulses of turbidity and sedimentation. Therefore, most of the effects of sedimentation upon stony corals should be sublethal. Turbidity and sedimentation monitoring associated with past nourishment projects in Broward County did not document any statistically significant long-term resource affects directly attributable to the beach projects (Dodge et al. 1991, 1995). The proposed sedimentation monitoring program and alternating dredging pattern should minimize turbidity/sedimentation impacts upon adjacent, offshore reef communities. The potential exists for long-term chronic turbidity and sedimentation impacts adjacent to the borrow and nearshore fill areas. The suitability of the proposed sediment source should minimize these impacts.

Concurrent construction of beach renourishment projects along the coast of southeast Florida could generate several localized turbidity plumes. These projects include Delray Beach and South Boca Raton (Winter 2002) and the proposed Town of Palm Beach Mid-Town renourishment (Winter 2003). The cumulative impacts of localized, turbidity plumes generated from these projects should minimally impact the sustainability of adjacent reef epibenthic communities, provided appropriate protective and mitigative measures and monitoring are applied during these unrelated projects. Future authorized renourishments (twice more in Segment II and three more times in Segment III) would generate local, short-term impacts of turbidity and sedimentation. The construction sedimentation and long-term monitoring for the proposed project will provide the data to accurately judge the effectiveness of the sediment rate value and predict the future impacts of turbidity and sedimentation related to authorized renourishments.

4.25.3 NEARSHORE HARDBOTTOM

The 2001 Laser Airborne Depth Soundings (LADS) survey represents the first comprehensive remote sensing survey of the reef tracts offshore of Broward County. Digitization of the LADS survey data estimated that the nearshore hardbottom tract in Segment II extends from -10 to -34 feet (NGVD) and covers approximately 5,000 acres. In Segment III, the LADS survey digitization estimated that the nearshore hardbottom extends from about -5 to -34 feet (NGVD) between the beach and the first reef tract and covers approximately 5,200 acres. In general, the nearshore edge of the reef is approximately 200 to 800 feet from shore, and the corresponding seaward edge of these formations is located an additional 700 to 1,500 offshore.

Several studies have shown that the nearshore hardbottom areas along Florida's southeast coast are ephemeral in nature, being alternately covered and uncovered by shifting beach sand (Ginsburg 1953, Gore et al. 1978, Goldberg 1982, Arthur V. Strock and Associates, Inc. 1983, and Continental Shelf Associates, Inc., 1984, 1985, 1987). Nearshore hardbottom burial events have been documented by Broward County both seasonally and over an extended period of time. More recently, the ephemeral nature of the nearshore hardbottom edge was documented during mapping performed in July/August of 2001 by CPE/Olsen (J-V).

Project design alternatives considered minimization of nearshore hardbottom habitat impacts as a project objective. Beach widths and fill extents were reduced from the original project design to avoid impacts to 14.9 acres of nearshore hardbottom habitat. The proposed project is expected to unavoidably impact 10.1 net acres of nearshore reef (9.0 acres of hardbottom and 1.1 acres of wormrock habitat). In Segment III, project construction will result in the direct burial of approximately 2.0 acres: 0.9 acres of low profile hardbottom dominated by macroalgae and blue-green algae in John U. Lloyd State Park, and 1.1 acres of wormrock habitat in Hollywood. The remaining 11.6 acres of impact will be the result of the gradual transition of the construction beach to the more stable equilibrium profile.

The 2001 nearshore biological investigations suggest that suitable replacement habitat can be created for impacted epibenthic species. Average epibenthic species density at the impacted, inshore ETOF sites was 2.7 organisms/square meter, and average algal coverage was 24.1%. Classification of the impact areas inshore of the equilibrium toe of fill revealed that 88% of the cumulative community composition consisted of macroalgae and blue-green algae. Comparison of these locations to areas seaward of the equilibrium toe of fill suggests that the survivability of soft corals, sponges, and stony corals increases along the distance gradient from the fluctuating hardbottom edge, and with the increase in habitat stability, a corresponding increase in biodiversity is observed.

The overall community structure of the nearshore impact areas indicates that the physical stresses of the habitat limit the biodiversity and survivability of epibenthic species. The natural stresses of this environment include wave energy, turbidity, and temperature extremes. Bleaching and sedimentation were the most common stony corals stressors observed at the 2001 nearshore hardbottom stations. Coral recruitment is limited by competition with algae for space and high suspended sediment levels. Very few stony corals of significant size or uniqueness were observed within the nearshore impact areas. Just over one-third of the overall 55 nearshore sites exhibited stony coral coverage greater than 1%; and only two of the sites were located inshore of the proposed equilibrium toe of fill. These observations indicate that the nearshore hardbottom epibenthic communities within the impact areas do not represent irreplaceable resources; and with proper placement of mitigative artificial reefs, suitable replacement habitat can be created for epibenthic species.

Pursuant to Federal and State compensatory mitigation requirements, Broward County is creating 11.9 acres of nearshore mitigative reef using limestone boulders prior to beach fill project commencement. Limestone boulders replicate the rough surface and calcareous nature of the natural nearshore hardbottom formations. Previous studies of limestone mitigative boulder reefs in southeast Florida have found that the reefs provide suitable mitigation for nearshore, low-relief habitat lost to beach renourishment (Cummings, 1994). Interim results of nearshore mitigative reef monitoring in Jupiter/Carlin demonstrate rapid colonization of the limestone boulders by benthic invertebrates and algae, and colonization by key nearshore reef indicator species such as wormrock and hairy blenny (Palm Beach County ERM, 2000).

The proposed timeframe for construction of the boulder reefs is to begin deployments at Mitigation Area 8 offshore of a DEP monument R-103 beginning in spring, 2003. Segment III mitigative artificial reef deployment will be carried out from April 1 through September 30. Areas not completed in 2003 will be completed in 2004, but it is anticipated that all deployments will be completed in 2003. Segment II mitigbative artificial reef deployment will also occur prior to beach fill project commencement and is anticipated to occur in 2005 or 2006.

The 10.1 acres of net hardbottom impact were anticipated to require 12.4 acres of compensatory mitigative reef. To offset the temporal lag in habitat functionality scleractinian corals greater than 15 cm diameter will be transplanted to the mitigative reef. Project construction of the artificial reefs will also occur prior to project fill placement impacts. The reduction of the temporal lag by coral transplantation reduced the required 12.4 acres to 11.9 acres of compensatory mitigative reef for both Segments II and III combined.

During beach project construction, a nearshore turbidity monitoring program with a plume mixing zone of 150 meters from the discharge site will be implemented to minimize turbidity impacts. Sedimentation monitoring and corrective measures during project construction should minimize potential secondary impacts of sedimentation and siltation upon adjacent hardbottom communities. In the U.S. Fish & Wildlife Draft Coordination Act Report (January 2002), the Service expresses concern that the more stable epibenthic communities located further offshore may gradually shift in community structure to resemble the less diverse, more stressed ephemeral communities typical of the hardbottom edge. In order to assess the potential for a gradual shift in community structure and corresponding reduction in biodiversity, a long-term, nearshore hardbottom monitoring program will be implemented. A network of beach fill stations and control stations will be established offshore of the expected equilibrium toe of fill to assess changes in epibenthic community structure and fish utilization and provide long-term sedimentation data.

The results of the long-term nearshore and mitigation reef monitoring will provide the information necessary to assess the overall cumulative impacts of nearshore hardbottom burial in Broward County. Additionally, since no comprehensive nearshore reef baseline survey exists for comparative purposes, the 2001 data set represents the baseline condition. The findings of the 2001 baseline surveys will be verified with limited pre-construction monitoring to be conducted prior to project commencement. The GIS database will be used as the primary tool to analyze cumulative impacts based upon the 2001 baseline conditions, allowing for analysis of the effects of future projects by overlaying data layers from post-construction monitoring events. Provided that the mitigative reefs function as designed, there should be limited cumulative impacts upon nearshore epibenthic communities from implementation of the proposed project and authorized renourishment projects. However, it must be noted that in order to truly determine cumulative impacts of beach renourishment upon the trophic dynamics of nearshore hardbottom habitat, one would need to know the feeding habits of each predator species and the impact of each renourishment action upon each prey/food resource, a Herculean task requiring years (Spieler, 2001b). Therefore, when examining the cumulative impacts of the proposed project, it is necessary to examine them from an overall habitat sustainability perspective.

The cumulative impacts of previous beach renourishment projects within Broward County can be estimated from examination of the 2001 data collected from the 55 nearshore characterization sites. It is important to reiterate that the scope of the 2001 *in-situ* nearshore hardbottom characterization was to a distance of approximately 100 feet seaward of the equilibrium toe of fill, and therefore, areas of the first reef tract seaward of this distance were not compared. Overall, the 2001 data does not suggest that the Broward County nearshore hardbottom communities adjacent to never nourished beaches are higher in epibenthic species richness and stony coral coverage than communities adjacent to previously nourished areas. However, the data does suggest a high degree of variability among and between the nourished/never-nourished sites at both the inshore and offshore equilibrium toe of fill locations.

Comparison of the epibenthic data from previously nourished sites to never nourished sites did not show clear, site-dependent differences in species diversity and stony coral coverage. The highest faunal species richness at the inshore ETOF sites was at the Pompano Beach sites, adjacent to a renourished beach. The Pompano Beach sites also exhibited the lowest overall algal coverages for both the inshore and offshore ETOF sites. Although overall faunal species richness was highest at the offshore sites in Fort Lauderdale, adjacent to a never nourished beach, examination of species richness at the individual sites revealed similar values for Pompano Beach and Fort Lauderdale. However, faunal density (individuals/square meter) was slightly higher at the Fort Lauderdale sites than Pompano Beach and Lauderdale-By-The-Sea. The data from the John U. Lloyd stations is difficult to evaluate from a beach nourishment perspective due to apparent Port Everglades Inlet related influences upon the epibenthic habitat.

Of the nineteen (19) sites with stony coral coverage greater than 1%, seven (7) were adjacent to never nourished beaches and twelve (12) were adjacent to previously nourished beaches. The two inshore ETOF sites with the highest stony coral coverage were located adjacent to previously nourished beaches. Likewise, the two offshore sites with the highest stony coral percent cover were located adjacent to previously nourished beaches. The hardbottom edge in Hollywood and Hallandale is located slightly further offshore than other areas, possibly pushed offshore due to sand movement from past nourishment projects and storm activity. The unusually high stony coral density, along with observations of accumulated sediment on the stony corals within the station and buried stony coral skeletons west of the site, are suggestive of a migrating hardbottom edge.

In addition to the natural stresses that influence nearshore hardbottom habitat, anthropogenic stresses of eutrophication and pollution affect the quality of nearshore hardbottom habitat. These human-induced pressures are particularly evident in areas south of Port Everglades, in areas in close proximity to the fishing piers, and adjacent to beaches of intense recreational usage. The cumulative impacts of these pressures have resulted in a possible degradation of nearshore hardbottom habitat quality and overall dominance by macroalgae and blue-green algae. The blue-green algae, *Lyngbya* sp. covered up to 90% of the benthic community immediately south of Port Everglades in the summer of 2001, and the highest coverages corresponded to the areas of lowest biodiversity. Evidence of fishing gear impacts (balls of line, fishing reels and rods, and hooks) was observed in the stations adjacent to the Pompano Beach and Commercial Piers, as well as during the towed-diver video transects. Trash (beer cans, sneakers, clothing, beach chairs) was commonly observed along the hardbottom edge adjacent to beaches of intense recreational usage, particularly along the hardbottom edge in Fort Lauderdale and Pompano Beach. Implementation of local pollution prevention measures and improvements in stormwater and waste water management, unrelated to the proposed renourishment project, will assist in curtailing the cumulative impacts of these stresses upon nearshore hardbottom habitat. The long-term monitoring for the project will provide information regarding the alleviation or persistence of anthropogenic impacts to nearshore hardbottom habitat, and assist in evaluating the overall cumulative impacts to this habitat.

Construction of beach renourishment projects in Delray Beach and south Boca Raton in 2002 should have resulted in minimal cumulative impacts to nearshore hardbottom habitat in South Florida. No areas of nearshore hardbottom exist within the Delray Beach project area, therefore no direct or significant cumulative impacts to nearshore hardbottom communities were expected from project construction. The nearshore hardbottom within the south Boca Raton project area has been previously impacted during nourishment projects in 1985 and 1996; and the monitoring for the 1996 project indicated limited project-related impacts upon the nearshore hardbottom biological communities. The biodiversity and species density of the hardbottom biological communities south of Boca Raton Inlet are influenced by inlet-related influxes of nutrient and freshwater flow, causing sudden temperature and salinity fluctuations and increased turbidity, particularly during continuous maintenance dredging of the inlet interior by the City. Limestone boulder reefs will be placed in the nearshore environment in 2003 as mitigation for impacts to 2.4 acres of nearshore hardbottom habitat during the 2002 South Boca Raton Renourishment Project. Provided the mitigative reefs function as designed and create suitable replacement habitat, no significant cumulative impacts to nearshore hardbottom communities are anticipated from project construction.

Construction of the Central Boca Raton Beach Nourishment Project is scheduled to begin November 1, 2003. It is anticipated that beach fill will result in direct burial of 0.32 acres of low relief surfzone hardbottom habitat in central Boca Raton. The city proposes to mitigate for impact to nearshore hardbottom habitat by creating 0.32 acres (1:1 compensatory mitigation ratio) of suitable replacement habitat for colonization by impacted species. The mitigative artificial reef will be constructed within one year of project completion, and will consist of limestone boulders nominally 3 to 5 feet in diameter. A single layer of boulders will cover the entire 0.32-acre mitigation area. To replicate the low relief habitat of the impacted hardbottom and provide the most stable orientation, the reef will consist of one layer of boulders. The biological colonization of the mitigative artificial reef will be monitored for a period of one year after reef placement to determine if the structure functions as a suitable replacement habitat for the 0.32-acre area of low relief hardbottom that will be impacted by beach fill.

Construction of the beach renourishment project in the Town of Palm Beach was completed in February of 2003. No impacts to the hardbottom habitat are anticipated as a result of beach fill; therefore, no mitigation was proposed. In conjunction with the Broward County monitoring, the results of the South and Central Boca Raton mitigation reef monitoring will provide the information necessary to assess the overall cumulative impacts of nearshore hardbottom burial.

4.25.4 OFFSHORE HARDBOTTOM

The potential exists for direct mechanical damage to offshore hardbottom communities adjacent to the borrow areas during dredging operations. Buffer distances of varying lengths (approximately 200 to more than 1,200 feet depending upon the adjacent hardbottom biological communities) reduce the potential for direct damage to these resources. Proper controls and procedures will be used to avoid mechanical damage; and no significant impacts are expected to occur from the mechanical operation of the dredge. Construction specifications proposed by the Corps and Broward County include the use of recording and real-time precision electronic location equipment during dredging operations. The equipment will provide exact position of the dredge to the operator and allow continuous monitoring of the dredge location during operations. Avoidance of direct mechanical damage during dredging activities should prevent the devastating cumulative impacts of direct impact to these sensitive habitats. In the highly unlikely event of a misalignment, a reef damage assessment will be performed to determine the full areal extent of irreversible loss and/or amount of necessary remediation.

Direct impacts associated with pipeline placement will be minimized by determining the least impactive routes feasible and the use of pipeline support with either tires and/or H frames when needed. Direct impacts from pipeline placement have been estimated at 190 square feet per corridor. For seven corridors, hardbottom resource impacts are estimated to be 1,330 square feet (0.03 acres). If eight corridors are necessary for project construction, hardbottom impacts would increase by 190 square feet to 1,520 square feet. Immediately prior to construction, the preferred route will be marked with buoys to facilitate placement by the contractor. Pipelines will be visually surveyed weekly during operation to check for sand leakage. Accidental breakage is monitored continuously during operation through visual observation of flow from the discharge point and through electronic monitoring of the pipeline pressure at the pump station. No significant impacts are expected to occur from pipeline leakage or accidental breakage. In the unlikely event that leakage or a pipeline breaks occurs, a reef damage assessment will be performed to determine the extent of damage and/or amount of necessary remediation.

Careful placement of pipelines during the proposed project and adherence to the above protective measures will minimize direct impacts to hardbottom biological resources. The establishment of permanent pipeline corridors for future renourishment use will minimize the cumulative impacts of direct damage associated with repeated placement and avoid foreseeable future impacts from establishment of alternative pipeline corridors. Future nourishment actions will be evaluated separately with respect to the present impact analyses and monitoring of the initial nourishment project. Mitigation for unavoidable direct impacts to hardbottom communities from pipeline placement is proposed by the placement of limestone boulders in nearshore reef sand pockets. A four-year monitoring program will be established to document the replacement habitat value of the mitigative reefs and assess cumulative impacts.

The expected cumulative effects of turbidity and related sedimentation upon offshore water quality and adjacent hardbottom communities are referred to above in Section 4.25.2. The sand source for the proposed Broward County Shore Protection Project is a silicate/carbonate mix with the carbonate content primarily derived from shell. It is anticipated that this sand source will generate less turbidity during washing on the hopper dredge, thereby reducing the potential for extended turbidity plumes. On average, the diverse, mature benthic communities found on the reef crests adjacent to the proposed borrow areas are protected by buffer distances of 400 feet or greater, thereby decreasing the likelihood of significant turbidity and sedimentation impacts. Construction specifications shall require that the borrow areas are dredged in an alternating pattern, thereby reducing the volume and duration of sediment deposition on adjacent hardbottom communities. The proposed sedimentation monitoring program and alternating dredging pattern should minimize turbidity/sedimentation impacts upon adjacent, offshore reef communities (Appendix E). Although the potential exists for long-term chronic turbidity and sedimentation impacts adjacent to the borrow areas, monitoring and preventative measures should reduce the potential for significant long-term impacts. Observations of biological stress indicators will be used to evaluate the level of stress upon the stony and soft corals and to provide a check for the proposed sedimentation monitoring protocol.

Past monitoring reports of Broward County nourishment projects, i.e. John U. Lloyd State Park 1989 and Hollywood/Hallandale, 1991, did not document turbidity and sedimentation rates on adjacent reef system that produced any statistically significant long-term resource affects that could be directly attributed to the nourishment actions (Dodge et al. 1991, 1995). However, the reports documented a general degradation in the quality of the benthic resources on the offshore reefs throughout the County. No specific anthropogenic or natural phenomena were identified that would suggest a particular action or event as the primary contributing factor. However, references were made to nutrient enrichment, sedimentation and turbidity, temperature fluctuations, freshwater inflows, and other regional and global climatic changes as possible contributing factors.

In a study done in 1984, Goldberg found that 14 months after a beach nourishment project in northern Broward County, a decline to the coral population was noted although the locations of the affected stations did not correspond to any of the dredging locations. Therefore, stresses other than dredging may have occurred causing tissue reduction and scleractinian losses (Goldberg, 1984).

The reef damage survey of John U. Lloyd State Recreation Area waters following the 1976-1977-beach renourishment project showed that weather was the most important factor in coral survival under heavy sedimentation stress. High sedimentation rates may result in coral mortality when the seas are relatively calm. Waves can assist corals in removing excess sediment even at depths in 20 meters of water (D.E. Britt Associates Inc., 1979).

A study done by Courtenay et al. (1972) comparing ecological aspects of two beach nourishment projects in Broward found that sedimentation damage can reduce species diversity degrading the health of a reef habitat. Results showed that many aquatic organisms could quickly repopulate an area after a dredge event. This was not the case for large reef building corals. These larger corals are slow-growing and small stresses can inhibit growth and reestablishment.

In 1980 and 1981, Goldberg characterized reef areas one and two years after a beach restoration project (1979) to assess any impacts to the community and its associated marine life. Of the ten stations monitored in the 1980 survey, three showed a decrease in diversity since the initial 1979 survey. Two of the three stations (1 and 10) were in close proximity to the shore and were described as having extremely poor visibility from increased turbidity resulting from suspended sediment. The scleractinians and sponges were adversely affected at these stations post-construction. The stations located offshore were not as negatively impacted as the previous two and recovery was predicted to occur rapidly. Changes in coral composition at one of the stations (8) were attributed to taxonomic differences rather than environmental stress. In 1981 the same reef areas were characterized for a second re-survey to note additional changes which may have occurred between February 1980 and June 1981 from the 1979 restoration. The 1981 characterization indicates that coral communities close to shore will suffer immediate damage due to the presence of suspended sediments. The damage did not persist. Sixteen months after the restoration project re-colonization and re-growth were evident. Damage was also noted at the offshore stations that were near borrow areas. The damage to the station (7) that was in close proximity to the borrow area (<50 m) did not recover at the time of this survey. The offshore stations at least 136 m from the borrow sited showed much less damage to the reef habitat.

A study by Richard E. Dodge titled Growth Rates of Stony Corals of Broward County, Florida: Effects From Past Beach Renourishment Projects was completed in 1987. The growth of hermatypic corals has been used as an indicator of environmental conditions in previous studies. Stressful conditions, such as excessive sedimentation and turbidity, are environmental factors associated with beach renourishment projects that have negative impacts on coral growth. Over a 16-year period growth rates of stony corals, located in areas that had a close proximity to increased sedimentation and turbidity from renourishment projects, were examined. Results showed that stony corals living both near and offshore (9 m and18 m water depth) had negligible impacts from renourishment projects.

In 1998 sand was placed along Hillsboro and Deerfield Beach, which were two chronically eroding locations in Broward County. One year following project construction, no significant sedimentation or burial had occurred on the nearshore hardbottom bordering to the renourished beaches. A decrease in the density of sponges did occur but it may have been the result of large scale natural occurrences such as the 1998 El Nino Southern Oscillation (ENSO).

Recreational usage is intense with evidence of fishing gear impacts and anchor damage observed on south Florida reefs. In 1997, the total number of registered vessels in Miami-Dade, Broward, and Palm Beach Counties was 124,189. In 2000, this number had increased to 137,880, of which 41,900 was in Broward County (FWCC, 2001), increasing the potential for cumulative impacts to these habitats. Broward County has established mooring buoys in areas of heavy recreational usage to alleviate the potential for anchor damage. Shipping from large ports (Port Everglades, Miami, and Palm Beach) also increases the potential for ships to run aground or anchor on reefs (Causey et al., 2000).

Coral diseases are becoming an increasing threat to the overall health of the south Florida reef system with over 10 coral diseases observed in the Florida Keys (Causey et al., 2000). Most are due to unknown pathogens; however, a human connection has been suggested for the fungal pathogen, *Aspergillus sydowii*, in sea fans. Harvell et al. (1999) proposed that this marine pathogen is a terrestrial fungus that has secondarily invaded the marine environment via sediment runoff from land. More recently, studies have established African dust storms as the source of *A. sydowii* on reefs (Shinn et al., 2000). An increase in frequency and duration of coral bleaching events has also occurred during the past 20 years (Causey et al., 2000). Corals which are subjected to increased levels of stress from chronic sedimentation, eutrophication, and higher temperatures and salinities are more susceptible to disease. Subsequently, due to their lowered stress thresholds, diseased corals are less able to resist the usually sublethal effects of sedimentation and eutrophication, and are more susceptible to damage from bioeroders and storm activity. Healthy corals are more resilient and able to withstand acute pulses of turbidity, sedimentation, and/or recover from bleaching after sustained increased temperatures.

The potential added effect of localized, short-term turbidity and sedimentation upon stony corals adjacent to the borrow area sites may cumulatively impact a number of stony corals which already exhibit signs of disease or bioerosion, possibly resulting in low levels of mortality. Wave and current action should dissipate elevated sediment levels and assist in removing accumulated sediment from the reef epibenthic communities adjacent to the borrow sites, provided appropriate monitoring and remediative actions are undertaken to prevent excessive accumulation.

Rogers (1990) stated that mean sediment rates for reefs not subject to anthropogenic stresses are <1 to approximately 10 mg/cm^2/day. This study, conducted in the U.S. Virgin Islands, suggested that chronic rates above these values are "high." However, it is important to note that this standard may not universally apply to reef communities due to geographical differences in natural sedimentation rates. Heavy sedimentation is associated with reduced coral species richness and live coral cover, lower coral growth rates, greater abundance of branching forms, reduced coral recruitment, decreased calcification, decreased net productivity of corals, and slower rates of reef accretion (Rogers, 1990). Rogers (1990) acknowledged the species-specific ability of corals to clear themselves of sediment or survive in lower light, and that larger (i.e. adult) corals are more tolerant to sedimentation than newly settled coral colonies.

Sedimentation analysis of the twenty-three reef monitoring sites in Broward County from October 1997 to December 2000 indicates that the first reef typically has the highest sedimentation, followed by the second reef, and then the third reef sites (Gilliam et al., 2001). Overall average sedimentation rates were: 252.2 mg/cm^2/day, 23.3 mg/cm^2/day, and 4.6 mg/cm^2/day for the first, second, and third reef sites respectively. Average grain size was significantly highest on the first reef sites. Both sedimentation rate and average grain size from the sampling interval were apparently consistent with data collected from previous years during the same sampling interval (late fall/winter) (Gilliam et al., 2001). Comparison of these values to the 10 mg/cm^2/day standard proposed by Rogers (1990) suggests that the natural sedimentation rates observed in Broward County are chronically high, which may contribute to the low stony coral abundance and epifaunal species richness observed on Broward County reefs as compared to reef communities located further south (Dodge et al., 1991). In Broward County, the stony corals are dominated by species known as competent sediment removers such as *Montastrea cavernosa* (Dodge et al. 1991, 1995). Based upon these observations, most of the effects of sedimentation upon stony and soft corals should be sublethal and cause temporary decreases in productivity, growth rates, and reproductive success.

Broward County has established 23 permanent monitoring sites along the first, second, and third reef tracts along the 24 miles of coastline. Two additional sites, FTL5 and FTL 6, will be added to the program in 2002 to address resource protection agency concerns for secondary impacts of turbidity/sedimentation to areas of high stony coral coverage. These stations will be monitored through the four year post-construction period to assess any potential long-term effects from the proposed Broward County Shore Protection Project. Eighteen of the twenty-three sites were previously monitored from 1997 through 1999 and five additional sites were established in December 2000. Comparison of 1997 to 1998 data revealed similar average stony coral coverage at the 18 original stations: 1.43% and 1.46% respectively (Broward DPEP, 1999). Comparison of offshore reef data from 1997 to 2000 also revealed minor differences in stony coral, soft coral (gorgonian), and sponge populations. In 2000, mean stony coral density for the 23 sites was 2.30 ±0.95 colonies/m^2(± 1 S.D.), and mean stony coral coverage was 2.25 ±3.41%. These values were comparable to the 1997, 1998, and 1999 values for the original eighteen stations. A slight increase in percent cover was observed, but no trends in density or evenness were suggested. Mean gorgonian density was 9.27±11.75 colonies/m^2 and mean sponge density was 19.81±10.44 colonies/m^2. Overall, gorgonian density did not differ greatly from 1997 to 2000, and sponge density increased from 1997 to 1998, and decreased from 1998 to 2000 on all three reefs (Gilliam et al., 2001).

The above observations indicate that the reef communities in these locations have remained relatively stable during the past four years. Implementation of the protective and preventative measures described in this section and in Appendices E and F should provide the means necessary to minimize potential cumulative impacts related to project construction. The long-term monitoring for the proposed project will provide the data to determine the cumulative impacts of turbidity and sedimentation upon adjacent hardbottom resources, and predict the future impacts of turbidity and sedimentation related to authorized renourishment projects.

4.4.2. 4.25.5 FISH AND WILDLIFE RESOURCES

Based upon the results of studies associated with previous nourishment projects in south Florida, no significant cumulative impacts to benthic infauna are expected at the beach fill sites and offshore borrow sites. The results of these studies indicate that recolonization of the borrow areas by benthic macroinfaunal species will occur within one to two years after completion of dredging for the proposed project due to recruitment from adjacent sandy areas. Changes in infaunal community structure are anticipated based upon differences in generation time and reproductive strategies of infaunal organisms; and these changes may persist for two to more than three years (Dodge et al., 1995). Grazers and detrivores that feed upon the macroinvertebrate communities within the proposed borrow areas will be temporarily displaced during dredging activities. If infaunal community structure changes persist for a period of years, short-term impacts to selective bottom feeders may also occur due to loss of specific prey species within the dredged borrow sites. Adjacent sandy areas within the intrareefal sand flats, which vary in width from several hundred feet to several thousand feet, would provide alternative feeding habitat for grazers and detritivores during infaunal recolonization of the borrow areas. Therefore, changes in macroinfaunal community assemblages should result in a minimal loss of productivity and no cumulative impacts are anticipated.

Direct impacts to fish communities within and adjacent to the offshore borrow areas during dredging activities should be minimal. The motility of most reef fish species should allow these species to leave the disturbed area during dredging and return when conditions return to previous levels. However, mortality of demersal and burrowing fish species inhabiting open sand is likely during dredging activities, as these species are limited in their mobility and may not be able to flee the area prior to disturbance. Secondary impacts to fish species may occur as a result of sedimentation/siltation adjacent to the borrow areas. Suspension of sediment has been shown to cause mortality of eggs and larvae of marine and estuarine fish (Newcombe and Jensen, 1996), and a reduction in feeding in juvenile and adult fish. These impacts would be short-term, limited to the vicinity of the borrow areas, and primarily limited to the duration of the project. The alternating dredging pattern for utilization of the borrow areas, buffer distances to adjacent hardbottom communities, and the construction sedimentation monitoring plan should minimize sedimentation impacts to the reproductive and feeding success of reef fishes. No significant cumulative effects to the sustainability of offshore reef fish populations are anticipated. In 2000, an encouraging report was released that indicated that some Florida southeast reef fish populations are in relatively good condition based upon recent observations (*2000 Status of Coral Reefs of the U.S. Caribbean and Gulf of* Mexico, Causey et al. 2000).

Previous studies clearly have shown there will be significant short-term effects of beach renourishment and habitat burial on associated fish assemblages. The gradual burial of the remaining 10.1 acres of nearshore hardbottom habitat may potentially negatively impact the settlement of juvenile fish, as well as eliminate foraging resources for juvenile fish and invertebrates. Reduced feeding success may influence survival, year-class strength, and recruitment of juvenile fish that inhabit nearshore hardbottom (Wilber and Clarke, draft manuscript). In turn, the feeding success of larger predatory game fishes could be affected by a decrease in their prey. The major component of the Broward County inshore fish assemblages is juvenile grunts, both in species numbers as well as individuals (Spieler, 2000b). Juvenile grunts serve as an important food source for many game fish (Spieler, 2000a), therefore reductions in their populations could reduce the feeding success of predatory reef fish that migrate inshore to feed upon them. However, given the extensive areas of nearshore hardbottom in Broward County, significant reductions in feeding success are not anticipated. Previous substrate/recruit availability and settlement studies of Broward County hardbottom have suggested that the marine environment is not substrate limited, but rather, that reef fish assemblages are recruitment limited and primarily structured by predation (Spieler, 2000). The results of this study also suggested that since the hardbottom in Broward County may be refuge limited, the placement of artificial reefs aimed at increasing juvenile refuge could increase the forage base for game fish, and depending upon site selection, may also increase the number of game fish (Spieler, 2000b).

The cumulative impacts of previous beach renourishment projects within Broward County (Table 23) can be estimated from examination of the data collected during the 2001 nearshore fish assemblage study and comparison to previous studies. Comparison of previously renourished beaches within Broward County to never renourished sites or of sites proposed to be buried by the equilibrium toe of fill to those not to be affected did not show clear, site-dependant differences in fish assemblages. A comparison of the nearshore hardbottom assemblage with reports on the fishes of the middle and offshore reef indicated, for the most part, that the inshore reef had lower abundance and richness than the other reef tracts; and that the majority of the nearshore species are also found at deeper hardbottom sites. Although juvenile grunts are not unique to the nearshore reef, they are more abundant there than on the other reef tracts. With rare exception (a single count of 2000, 3-cm grunts), juvenile grunts are not found on the offshore reef tract or the eastern edge of the middle reef in Broward County. However, as noted above, in order to determine the cumulative impacts of beach renourishment upon the trophic dynamics, one would need to know the feeding habits of each predator species and the impact of each renourishment action upon each prey/food resource, a Herculean task requiring years (Spieler, 2001b). Therefore, when examining the cumulative impacts of the proposed project, it is necessary to examine them from an overall habitat sustainability perspective.

TABLE 23
PAST BEACH NOURISHMENT PROJECTS IN BROWARD COUNTY

Year	Project	Quantity (cy.)	Length (mi.)	Location	Funding Entities
Summer 1970	Pompano (Seg. II)	1,080,000	2.8	R33 to R48	Federal, State, County, Cities
Summer 1971	Hallandale (Seg. III)	360,000	.75	R124 to R128	Federal, State, County, Cities
Summer 1972	Hillsboro Beach (Seg. I)	380,000	1.0	R7 to R12	City
Summer 1976	John U. Lloyd SRA (Seg. III)	1,090,000	1.5	R86 to R94	Federal, State, County
Summer/ Fall 1979	Hollywood-Hallandale (Seg. III)	2,000,000	5.2	R100+800 to R128	Federal, State, County, Cities
Summer 1983	Pompano/ Lauderdale-By-The-Sea (Seg. II)	1,800,000	5.3	R25 to R53	Federal, State, County, Cities
Summer 1989	John U. Lloyd SRA (Seg. III)	604,000	1.6	R86 to R94	Federal, State
Summer 1991	Hollywood-Hallandale (Seg. III)	1,100,000	5.2	R100+800 to R128	Federal, State, County, Cities
Spring 1998	Deerfield Beach-Hillsboro Beach (Seg. I)	555,000	1.1	R6 to R12	State, Cities
2002	Hillsboro Inlet Channel Deepening	N/A	N/A	N/A	N/A
Totals		8,969,000	24.45		

The Broward County nearshore hardbottom does not appear to provide a unique habitat for some fish species that is unavailable at other hardbottom sites. The major discernable impact of any hardbottom burial will be on the loss of juvenile grunt habitat, primarily refuge (Spieler, 2001). It appears that the proposed beach renourishment will have minimal qualitative impact on the nearshore fish assemblages; and from the perspectives of either richness, abundance, or predominant species commonality, nearshore hardbottom loss can be mitigated with artificial refuge (Spieler, 2001b). Comparison of the inshore assemblage with fishes found on local artificial reefs indicates that loss of the hardbottom refuge of the predominant fish assemblage can be mitigated with artificial structure (Spieler, 2001b).

The mitigation plan, as mandated by State and Federal resource protection agencies, is based on a 1:1.2 mitigation ratio, providing 11.9 acres of substrate within a 13.5-acre footprint. A total of 21.8 acres of suitable sites have been identified to allow some flexibility in construction. The proposed time frame for construction of the boulder reefs is to begin deployments at Mitigation Area 8 offshore of a DEP monument R-103 beginning in spring, 2003. Segment III mitigative artificial reef deployment will be carried out from April 1 through September 30. Areas not completed in 2003 will be completed in 2004, but it is anticipated that all Segment III deployments will be completed in 2003. Mitigative artificial reef deployment in Segment II will occur prior to beach fill project commencement.

The 2002 Habitat Equivalency Analysis (HEA) indicates that the mitigation boulders with transplanted corals will recover to 100% full service in 15 years. Most flora and fauna are anticipated to recover quickly within less than 8 to 10 years; the reef building coral fauna is the slowest component and will require longer recovery time. A linear increase from 10% to 100% over the 15 years is assumed (Dodge, unpublished).

The 10.1 acres of net hardbottom impact were anticipated to require 12.4 acres of compensatory mitigative reef. To offset the temporal lag in habitat functionality scleractinian corals greater than 15 cm diameter will be transplanted to the mitigative reef. Project construction of the artificial reefs will also occur prior to project fill commencement. The reduction of the temporal lag by coral transplantation reduced the required 12.4 acres to 11.9 acres of compensatory mitigative reef for both Segments II and III combined.

Lindeman and Snyder (1999) advocated the up-front construction of nearshore artificial reefs as mitigation for beach renourishment impacts to fishes, stating that “If constructed before burial and at similar depths, mitigation reefs may have provided a refuge for a sizeable fraction of the thousands of displaced fishes during the burial of the hardbottom reef, as well as thousands of subsequent new recruits." The results of the long-term mitigation reef monitoring will provide the information necessary to assess the overall cumulative impacts of nearshore hardbottom burial upon the nearshore fish assemblages in Broward County.

4.26 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES.

4.26.1 IRREVERSIBLE.

An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever. Cyclical coverage and exposure of nearshore hardbottom and seasonal beach profile cycles illustrate that the effects from the proposed alternatives are reversible, provided appropriate mitigation to compensate for temporal loses. The use of sand from the proposed borrow areas would irreversibly deplete the immediate suitable sand reserves for future nourishment projects. There will be sufficient sand reserves remaining for recolonization of benthic organisms. Since the impacts to any relatively large stony coral colonies would be essentially irreversible given the time required for growth, measures will be taken to avoid any impacts. Mitigation for any loss by moving, reattaching or salvaging damaged stony corals will be included in post-project evaluations conducted by coral reef scientists with Nova Southeastern University in conjunction with Broward County and the resource protection agencies.

4.26.2 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. Irretrievable loss of nearshore resources resulting from the project will be mitigated through the implementation of a program of nearshore artificial reef construction. The mitigative reef program resulted from extensive agency and local sponsor coordination to identify the finite period for which the resource would be lost. Replacement habitat, located in similar water depths and geographic locations will allow motile species to migrate to the installations or adjacent natural resources; while providing colonization opportunities for benthic invertebrates and macroalgae. Bell and Leeworthy (2002) state that when considering the economic cost associated with the loss of nearshore habitat; the benefits from project implementation and the provision of replacement habitat in the form of mitigative artificial reefs justify the loss in use opportunities. Measures will be taken to avoid or minimize any irretrievable impacts. Mitigation for any loss by moving, reattaching or salvaging any damaged stony corals will be included in post-project evaluations conducted by coral reef scientists with Nova Southeastern University in conjunction with Broward County and the resource protection agencies.

4.27 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS.

Most of the infauna inhabiting the borrow area and fill site will be unavoidably lost as a result of dredging and sand placement activities. However, these losses are not expected to have a long-term, significant adverse impact on the surrounding environment since infauna outside of the fill areas and borrow areas will recolonize the disturbed sandy areas within one to three years after construction, and changes in macroinfaunal community assemblages should result in a minimal loss of productivity. No long-term (greater than five years) adverse impacts are expected.

Approximately 13.6 acres of nearshore hardbottom habitat will be impacted by project construction and beach fill equilibration during the three-year post-construction period. A net total of 10.1 acres of nearshore hardbottom outcrops occur inshore of the equilibrium toe of fill. Most of these nearshore outcrops are ephemeral in nature, generally varying from 0 to 2 feet above the ocean floor, and periodically experience sand inundation for short periods of time. Biological diversity is relatively limited on these outcrops due to the periodic inundation by sand. The preferred mitigation for the permanent loss of nearshore hardbottom habitat will provide "in-kind" habitat creation of 11.9 acres of nearshore artificial reef using limestone boulders. To offset the temporal lag in habitat functionality scleractinian corals greater than 15 cm diameter will be transplanted to the mitigative reef. Project construction of the artificial reefs will also occur prior to project fill commencement. The reduction of the temporal lag by coral transplantation reduced the required 12.4 acres to 11.9 acres of compensatory mitigative reef for both Segments II and III combined. In compliance with directives from State and Federal resource protection agencies, all mitigative reef will be constructed prior to beach project construction to compensate for the temporal lag in replacement habitat functionality. The complete nearshore hardbottom mitigation plan is provided in Appendix F.

Several measures will be implemented to minimize impacts to hardbottom areas adjacent to the borrow and fill sites. A detailed sedimentation monitoring plan, which includes biological stress indicators for stony and soft coral species, has been developed to assess and minimize impacts to adjacent reef communities during construction. Biological communities within the eight proposed pipeline corridors have been documented with DGPS integrated digital video. Bottom features were mapped from the video tracklines to identify the least impactive corridors feasible given the limitations of the dredging equipment. Prior to construction, Broward County DPEP staff will determine the least impactive routes through these corridors for pipeline placement and site the pipelines
through these routes using buoys. Pumpout terminal anchors or spuds will be sited by Broward County DPEP SCUBA divers so that anchors or spuds are located

entirely in sand bottom. Weekly monitoring of all pipelines to shore will be performed to check for sand movement and leaks. Continuous leak monitoring will be required by the dredging contractor through fluctuations in pressure through the pipelines. A detailed mitigation plan has been developed to compensate for unavoidable impacts to nearshore hardbottom habitat located inshore of the project equilibrium toe of fill.

4.28 LOCAL SHORT-TERM USES AND MAINTENANCE/ENHANCEMENT OF LONG-TERM PRODUCTIVITY.

Shoreline protection using beach fill with periodic renourishment is an ongoing effort. Beach renourishment projects have a temporary and short-term impact on local offshore and nearshore biological resources. Most motile organisms (fishes, crabs, and some sand dwelling organisms) within the borrow area and nearshore zone should be able to escape these areas during construction. Some less-motile individuals that are unable to escape from construction will be lost, but are expected to recolonize after project completion. Short-term reductions in primary productivity and reproductive and feeding success of invertebrate species and fish are expected. The sustainability of these populations should not be negatively affected provided the creation of suitable replacement habitat prior to project impacts.

4.29 INDIRECT EFFECTS.

A 1995 study for the U.S. Army Corps of Engineers Institute for Water Resources found no evidence that beach nourishment projects induce development along the protected shoreline (Cordes and Yezer, 1995). Pilkey and Dixon (1996) state that beach replenishment frequently leads to more development in greater density within shorefront communities, necessitating future replenishment or more drastic stabilization measures. Dean (1999) also notes that the very existence of a beach nourishment project can encourage more development in coastal areas. Following completion of a beach nourishment project in Miami during 1982, investment in new and updated facilities substantially increased tourism (National Research Council, 1995). Increased building density immediately adjacent to the beach often resulted as older buildings were replaced by much larger ones that accommodated more beach users. Overall, shoreline management creates an upward spiral of initial protective measures resulting in more expensive development which leads to the need for more and larger protective measures. Increased shoreline development may adversely affect sea turtle nesting success. Greater development may support larger populations of mammalian predators, such as foxes and raccoons (National Research Council, 1990a), and can also result in greater adverse effects due to artificial lighting.

4.30 COMPATIBILITY WITH FEDERAL, STATE, AND LOCAL OBJECTIVES.

The Federal objective is to contribute to national economic development consistent with protecting the nation’s environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Federal planning concerns other than economic include environmental protection and enhancement, human safety, social well being, and cultural and historical resources.

Federal and County objectives include (1) the reduction of expected storm damages through beach nourishment and other project alternatives; (2) maintaining beaches as suitable recreational areas; (3) maintaining suitable beach habitat for nesting sea turtles, invertebrate species, and shorebirds; and (4) maintaining commerce associated with beach recreation in Broward County. The proposed Broward County Shore Protection Project is consistent with Federal and Local objectives and with the State’s Coastal Zone Management Plan.

4.31 CONFLICTS AND CONTROVERSY.

Issues of concern raised by respondents to the Notice of Intent were: use of buffer zones to protect dune systems; minimization of impacts to natural systems to the greatest extent feasible; and protection and/or mitigation of sensitive marine life and vegetative communities. Issues of concern raised by the State and Federal resource protection agencies relevant to the proposed renourishment project have been addressed in this Draft Environmental Impact Statement. Requests made by the resource protection agencies included mapping and assessment inside the boundaries and within a 500 foot radius of the borrow areas; detailed evaluation of the biological communities associated with the nearshore hardbottom; biological surveys of the proposed rock dump sites; development of a detailed monitoring plan for the reefs adjacent to the borrow areas to avoid/minimize damage during dredging operations; cumulative impact assessment which addresses the productivity loss of impacted communities for the projected lifespan of the project; and a proposal for a mitigation plan to fully compensate for unavoidable adverse impacts to hardbottom communities. These concerns were addressed during extensive biological investigations performed during the summer/fall of 2001, and the results of these investigations have been incorporated into a comprehensive Geographic Information System (GIS) for Broward County.

The National Marine Fisheries Service (NMFS) and the Florida Fish and Wildlife Conservation Commission’s (FWCC) comments regarding the Draft Environmental Impact Statement (DEIS) have been addressed and resolved in the Habitat Equivalence Analysis (HEA) and in the updated monitoring plan (Appendix H and E, respectively).

The Department of Environmental Protection, Division of Recreation and Parks, and Florida Fish and Wildlife Conservation Commission have expressed concern regarding the negative impact of the structures upon sea turtle nesting success and hatchling behavior, and the potential public safety hazard to recreational beach users. The groin field at John U. Lloyd State Park has been modified from eleven T-head groins to three (3) groins: two T-head structures and one spur. Appropriate sea turtle protection measures have been implemented in Broward County to minimize impacts to sea turtle hatchlings and nesting female sea turtles. All proposed pipeline corridors will be investigated by qualified professionals to identify the least impactive routes feasible. Turbidity monitoring, hardbottom surveys, and sedimentation rate monitoring will assure protection of hardbottom resources within and adjacent to the fill and borrow sites. Project design alternatives considered minimization of nearshore, hardbottom habitat impacts as a project objective. The nearshore hardbottom mitigation plan and sedimentation monitoring plan for the offshore reefs adjacent to the borrow areas are included in Appendices E and F.

4.32 UNCERTAIN, UNIQUE, OR UNKNOWN RISKS.

The proposed Broward County Shore Protection Project does not involve any activities that have not been previously utilized during past renourishment activities performed in Broward County or along the south Florida Atlantic Coast shoreline. Precautionary measures will be included in the contract specifications to ensure that there are no impacts related to hazardous, toxic or solid waste; and necessary corrective measures will be undertaken as required by the permits and law in the unlikely event that any unacceptable impacts occur.

4.33 PRECEDENT AND PRINCIPLE FOR FUTURE ACTIONS.

As stated above, the proposed Broward County Shore Protection Project does not involve any activities that have not been previously utilized during past renourishment activities performed in Broward County. These beach nourishment projects include Hollywood/Hallandale (1971, 1979, 1991); John U. Lloyd State Park (1976/77, 1989); Pompano Beach (1970); Pompano Beach/Lauderdale-By-The-Sea (1983) or along the south Florida Atlantic Coast shoreline (Palm Beach and Dade Counties).

4.34 ENVIRONMENTAL COMMITMENTS.

The U.S. Army Corps of Engineers and Broward County are committed to avoiding, minimizing or mitigating for adverse effects during construction activities by including the following commitments in the contract specifications.

4.34.1 ENVIRONMENTAL MONITORING.

Turbidity monitoring, hardbottom surveys, and sedimentation monitoring protocols will be mandated in the project permits to assure protection of hardbottom resources within and adjacent to the borrow and fill sites. Biological and sedimentation monitoring of the adjacent hardbottom habitats will occur during the pre-construction phase; construction phase; immediately after construction; and post-construction monitoring. During construction, weekly observations of sedimentation/siltation impacts will be performed in the nearshore zone via a series of cross-shore transects that extend 300 feet seaward of the equilibrium toe of fill. Stress indicators on scleractinian (stony) and soft coral species will be used in conjunction with standing sediment levels to trigger implementation of corrective actions that include construction and/or extension of shore-parallel dykes on the beach, cessation of sand pumping until the discharge plume dissipates, and/or shifting the dredge to an alternate sand source within the approved borrow sites. A network of nearshore monitoring stations/cross shore permanent transects will be maintained to specifically identify and address potential effects from sediment and turbidity movement to the adjacent, deeper and more stable nearshore hardbottom communities. Semi-annual surveys will be conducted at the end of the third and fourth year (Years 3 and 4) post-construction. Fish populations will also be assessed at the epibenthos monitoring sites within the impact areas according the same monitoring schedule. Three hardbottom edge surveys will also be conducted using diver propelled via scooter with attached DGPS antennae: an immediate pre-construction survey, one and one-half years after project completion, and a three-year post-construction survey. The monitoring of the nearshore hardbottom edge at the end of Year 3 will represent the final impact of fill equilibration. A four-year post-construction monitoring program will be established to assess secondary impacts of turbidity and sedimentation, and evaluate possible shifts in community structure and biodiversity attributable to the beach renourishment project (Appendix E).

4.34.2 TURBIDITY.

The following measures shall be implemented to avoid/minimize turbidity related impacts:

(1) Turbidity in Nephelometric Turbidity Units (NTUs), shall be monitored every six hours during dredging. The samples shall be analyzed on site within two hours of collection at the following locations:

a. Borrow Sites

Location: Background: Mid-depth, at least 300 meters upcurrent from the dredge site, clearly outside of any turbidity generated by the project.

Compliance: Mid-depth, no more than 150 meters downcurrent from the dredge site, within the densest portion of any visible turbidity plume.

b. Beach Nourishment and Groin Construction Sites

Location: Background: Mid-depth, at a point approximately 150 meters offshore and 300 meters upcurrent from the discharge point, clearly outside of any turbidity generated by the project.

Compliance: Mid-depth, at a point approximately 150 meters offshore and no more than 150 meters downcurrent from the discharge point, within the densest portion of any visible turbidity plume.

If monitoring shows turbidity at any of the compliance stations exceeds the counterpart background station by more than 29 NTUs, construction activities shall cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels.

4.34.3 SEA TURTLES.

Considering that hopper dredging will be utilized in Broward County, compliance with all recommendations of the 1997 NMFS Biological Opinion regarding hopper dredging will be required to assure that incidental take of sea turtles are minimized during hopper dredging operations. The sea turtle deflecting draghead is required for all hopper dredging projects during the months that turtles may be present, unless a waiver is granted by the USACE in consultation with NMFS. The 1997 amended Biological Opinion mandates that year round, one-hundred percent observer coverage is necessary for beach nourishment project in southeast Florida. One hundred percent inflow screening is required, and one-hundred percent overflow screening is recommended when observers are required on hopper dredges. If conditions prevent one hundred percent inflow screening, inflow screening can be reduced, but one hundred percent outflow screening is required, and an explanation must be included in the preliminary dredging report. Preliminary dredging reports which summarize the results of the dredging and any sea turtle take must be submitted within 30 working days of completion of any given dredging project. Logs of any sea turtle injuries or deaths due to hopper dredging activities will be maintained, with immediate notification to the USACE, Jacksonville District, the USFWS and NMFS as appropriate, and the FWCC.

The Corps and Broward County agree to comply with the reasonable and prudent measures and non-discretionary terms and conditions stated in the U.S. Fish and Wildlife Biological Opinion for the proposed Broward County Shore Protection Project (dated March 11, 2002 – copy provided in Appendix C, Sub-Appendix C-1). The reasonable and prudent measures and terms and conditions as stated in the Biological Opinion will be implemented to minimize take of the loggerhead, leatherback, and green sea turtle.

Past studies have indicated diet selectivity in green sea turtles with genera *Bryothamnion*, *Gracilaria*, *Hypnea*, and turf algae of the Family Gelidiaceae documented as food sources in Broward County nearshore waters (Wershoven and Wershoven, 1990). The algae data collected during the County's 2001 study suggests that the red macroalgal community in the nearshore area between R-54 through R-72 often consists of a mat-like mix of species consisting of Bryothamnion sp., Gracilaria sp., Hypnea musciformis, and Dasya sp. In certain areas, the algal community consists of a monoculture of Bryothamnion sp. on sand covered hardbottom with bottom cover ranging from 30 to 75%.

Target bottom coverages for these select red macroalgae species on the artificial reef test site in Fort Lauderdale have been established in the FDEP permit conditions. If these target bottom coverages are not achieved after one year of monitoring, transplantation of select algal species from the equilibrium toe of fill impact areas between R-52 and R-72 to the artificial reef test site will be performed to achieve the target abundance. If the transplantation of select algal species is required, the transplanted algae will be monitored semi-annually in conjunction with the macroalgae assessment during the 4 year post-construction period.

4.34.4 MANATEES.

The following standard protection measures will be implemented to minimize potential impacts to manatees:

(1) The contractor will instruct all personnel associated with the construction of the project about the presence of manatees in the area and the need to avoid collisions with manatees. All construction personnel shall be responsible for observing water-related activities for the presence of manatees and shall implement appropriate precautions to ensure the protection of manatees.

(2) All construction personnel shall be advised that there are civil and criminal penalties for harming, harassing or killing manatees which are

protected under the Marine Mammals Protection Act of 1972, the Endangered Species Act of 1973, and the Florida Sanctuary Act. The contractor shall be held responsible for any manatee harmed, harassed, or killed as a result of the construction of the project.

(3) Prior to the commencement of construction, the construction contractor shall construct and install at least two temporary signs concerning manatees. These signs shall read "Caution: Manatee Habitat. Idle Speed is Required if Operating a Vessel in the Construction Area" and "Caution: Manatee Habitat. Equipment Must be Shutdown Immediately if a Manatee Comes Within 50 Feet of Operation".

(4) All vessels associated with the project will be required to operate at "no wake" speeds at all times while in waters where the draft of the vessel provides less than four feet of clearance from the bottom. All vessels shall follow routes of deep water whenever possible.

(5) If a manatee is sighted within a hundred yards of the construction area, appropriate safeguards will be taken, including suspension of construction activities, if necessary, to avoid injury to manatees. These precautions shall include the operation of all moving equipment no closer than 50 feet of a manatee.

(6) The contractor shall maintain a log detailing sightings, collisions, or injuries to manatees should they occur during the contract. Any collision with and/or injury to a manatee shall be reported immediately to the Florida Marine Patrol at 1-800-DIAL-FMP (1-800-342-5367) and U.S. Fish and Wildlife Service in Vero Beach.

4.35 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS.

4.35.1 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969.

The Draft Environmental Impact Statement for the Broward County Shore Protection Project Segments II and III, dated March 2002, and/or Notice of Availability was prepared and circulated to Federal, State, and local agencies, interest groups, and individuals for review and comment. Segments II and III will receive separate Joint Coastal permits and water quality certifications from the State of Florida. The Notice of Availability of the DEIS was published in the Federal Register on April 5, 2002. Announcement of the public meeting to hear comments on the Draft EIS was published in the South Florida Sun-Sentinel and Miami Herald newspapers and in the Broward Review on April 22, 2002. The public meeting on the DEIS was held at the Hollywood Beach Community Center on April 30, 2002. The Final EIS has been prepared based on the results of this coordination. The project will be in compliance with the National Environmental Policy Act.

4.35.2 ENDANGERED SPECIES ACT OF 1973.

Coordination with the U.S. Fish and Wildlife Service and National Marine Fisheries Service has been accomplished for the proposed project through consultation under Section 7 of the Endangered Species Act of 1973, as amended. The Corps determined that the proposed project will have no effect on whales, but may affect sea turtles. The Corps initiated consultation with NMFS through submittal of a letter dated February 28, 2002. By letter dated March 10, 2000, the National Marine Fisheries Service concurred with the Corps determination of no adverse impacts to listed species under NMFS purview, provided adherence to the terms and conditions of the Regional Biological Opinion on Hopper Dredging-South Atlantic, issued under Section 7 of the Endangered Species Act by NMFS in 1995, and amended on September 25, 1997. The terms and conditions of the USFWS Biological Opinion for Region III of the Coast of Florida Erosion and Storm Effects Study, issued October 24, 1996 apply to the proposed project and will be adhered to. This project will be coordinated fully under the Endangered Species Act.

The Corps initiated consultation with the U.S. Fish and Wildlife Service (FWS) via a letter dated September 24, 1999. The proposed project adheres to the FWS Biological Opinion (BO) (March 2002), which includes Terms and Conditions and Reasonable and Prudent Measures sufficient to allow dredge and beach fill activities south of Dania Pier and groin construction at John U. Lloyd Beach State Park during the turtle nesting season. The FWS BO addresses both Segments II and III of the proposed project and contains specific requirements in regard to construction lighting, fill compaction, sea turtle nesting monitoring, escarpment leveling, and groin construction.

4.35.3 FISH AND WILDLIFE COORDINATION ACT OF 1958.

This project has been coordinated with the U.S. Fish and Wildlife Service. A Final Coordination Act Report (CAR) was submitted to the Corps in June, 2002. A copy of the Final CAR is included in Appendix C, Sub-Appendix C-1. This project will be in full compliance with the Act.

4.35.4 NATIONAL HISTORIC PRESERVATION ACT OF 1966. (AS AMENDED)

Archival research, field work, and coordination with the Florida State Historic Preservation Officer (SHPO), have been conducted in accordance with the National Historic Preservation Act, as amended; the Archeological and Historic Preservation Act, as amended, Executive Order 11593, and Advisory Council's revised 36 CFR Part 800 Regulations. Cultural resources magnetometer and side scan sonar surveys were completed for the proposed borrow areas in Broward County. Twenty-seven anomalies were located during the course of field investigations. Archeological diver investigations were performed to identify and evaluate the anomalies to determine National Register significance. Only one of the anomalies, the bow section of the *S.S. Copenhagen*, represents a known submerged cultural resource. Consultation with SHPO granted approval of a 300-foot buffer around the *S.S. Copenhagen* bow, and a 100-foot buffer around three additional anomalies. The project is consistent with the goals of this chapter. Pertinent SHPO correspondence is included in Appendix C. The project will be in compliance with each of these Federal laws.

4.35.5 CLEAN WATER ACT OF 1972.

Application for a Section 401 water quality certification has been submitted to the Florida Department of Environmental Protection. All State water quality standards will be met. A Section 404(b) evaluation is included in this report as Appendix A. The project will be in compliance with this Act.

4.35.6 CLEAN AIR ACT OF 1972.

No air quality permits would be required for this project. Exhaust emissions from labor transport and dredge equipment would likely be well under the *de minimus* levels for ozone non-attainment areas (Fort Lauderdale) as cited in 40 CFR 91.853 (projects implemented cannot produce total emissions greater or equal to 100 tons per year of Volatile Organic Compounds (VOCs). Any indirect emissions as a result of the proposed action are beyond the control and maintenance of the USACE; therefore, a conformity determination with the Florida State Implementation Plan is inappropriate for increases of indirect emissions from the proposed action (USACE, 1998).

This project is being coordinated with the U.S. Environmental Protection Agency (EPA) and will be in compliance with Section 309 of the Act. The Draft EIS was reviewed by EPA and their comments have been addressed in this Final EIS. The Final EIS will be forwarded to EPA for their review.

4.35.7 COASTAL ZONE MANAGEMENT ACT OF 1972.

A Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as Appendix B. State consistency review was performed during the coordination of the Draft EIS to ensure that the project is consistent with the Florida Coastal Zone Management. The project will be in compliance with this act.

4.35.8 FARMLAND PROTECTION POLICY ACT OF 1981.

No prime or unique farmland would be impacted by implementation of this project. This act is not applicable.

4.35.9 WILD AND SCENIC RIVER ACT OF 1968.

No designated Wild and Scenic river reaches would be affected by project related activities. This act is not applicable.

4.35.10 MARINE MAMMAL PROTECTION ACT OF 1972.

Incorporation of the safe guards used to protect threatened or endangered species during dredging and disposal operations would also protect any marine mammals in the area, therefore, this project is in compliance with the Act. The Corps does not anticipate the take of any marine mammal during any activities associated with the project. A trained and government certified sea turtle and marine mammal observer will be stationed on the dredge during all water-related construction activities. Appropriate actions will be taken to avoid listed sea turtle and marine mammal species effects during project construction. If a marine mammal is identified within the project boundaries, they will be provided protections equal the ESA species that have had consultations completed, and as a result of this the project sponsor is in compliance with the Act.

4.35.11 ESTUARY PROTECTION ACT OF 1968.

No designated estuary would be affected by project activities. This act is not applicable.

4.35.12 FEDERAL WATER PROJECT RECREATION ACT.

The principles of the Federal Water Project Recreation Act, (Public Law 89-72) as amended, have been fulfilled by complying with the recreation cost sharing criteria as outlined in Section 2 (a), paragraph (2). Another area of compliance includes the public beach access requirement on which the renourishment project hinges (Section 1, (b)).

4.35.13 FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976.

Coordination with the National Marine Fisheries Service (NMFS) has been accomplished during review of the DEIS. The project will be in compliance with this Act.

4.35.14 SUBMERGED LANDS ACT OF 1953.

The project will occur on submerged lands of the State of Florida. The project has been coordinated with the State and will be in compliance with the act. The FDEP released a notice of intent to issue for Segment III on October 17, 2002.

4.35.15 COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990.

There are two parcels near Dania Beach listed as undeveloped coastal barriers as defined by the Coastal Barriers Resources Act. These parcels require coordination with the U.S. Fish and Wildlife Service prior to nourishment activities. This coordination will be accomplished by the local sponsor during the EIS review process.

4.35.16 RIVERS AND HARBORS ACT OF 1899.

The proposed work would not obstruct navigable waters of the United States. The proposed action has been subject to the public notice, public hearing, and other evaluations normally conducted for activities subject to the act. The project will be in full compliance.

4.35.17 ANADROMOUS FISH CONSERVATION ACT.

Anadromous fish species would not be affected. The project will be coordinated with the National Marine Fisheries Service and will be in compliance with the act.

4.35.18 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT.

No migratory birds would be affected by project activities. The project will be in compliance with these acts.

4.35.19 MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT.

The term "dumping" as defined in the Act (3[33 U.S.C. 1402](f)) does not apply to the disposal of material for beach nourishment or to the placement of material for a purpose other than disposal (i.e. placement of rock material as an artificial reef or the construction of artificial reefs as mitigation). Therefore, the Marine Protection, Research and Sanctuaries Act does not apply to this project. The disposal activities addressed in this DEIS have been evaluated under Section 404 of the Clean Water Act.

4.35.20 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT.

This act requires preparation of an Essential Fish Habitat (EFH) Assessment and coordination with the National Marine Fisheries Service (NMFS). Pursuant to the Magnuson-Stevens Act, Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service for the project was initiated by coordination of the FEIS. The project will be in full compliance with this act.

4.35.21 E.O. 11990, PROTECTION OF WETLANDS.

No wetlands would be affected by project activities. This project is in compliance with the goals of this Executive Order.

4.35.22 E.O. 11988, FLOOD PLAIN MANAGEMENT.

The project is in the base flood plain (100-year flood) and is being evaluated in accordance with this Executive Order. Project will be in compliance with this Act.

4.35.23 E.O. 12898, ENVIRONMENTAL JUSTICE.

The proposed project would not result in adverse human health or environmental effects, nor would the activity impact subsistence consumption of fish and wildlife. The project is in compliance with this Executive Order.

4.35.24 E.O. 13089, CORAL REEF PROTECTION.

This EO refers to "those species, habitats, and other natural resources associated with coral reefs."

The reef distribution pattern for southeast Florida north of Key Biscayne consists of three separate parallel reef flats. The proposed sand borrow areas lie in the second and third intrareefal flats. To minimize the potential for impacts to adjacent offshore reef communities, the borrow areas have been designed to avoid impacts to the most diverse and dense reef benthic assemblages. Buffer distances have been determined based upon the habitat quality of the adjacent reef edge. The average buffer distances along the inshore edges range from 235 feet to 375 feet; and the average buffer distances along the offshore edges range from 512 feet to 718 feet. Several protective measures will be implemented to minimize impacts to adjacent hardbottom communities, including alternating use of borrow areas during dredging operations; turbidity monitoring with cessation of construction activities if turbidity exceeds the State limit of 29 NTUs above background; real-time sedimentation monitoring during project construction which incorporates biological stress indicators for stony and soft coral species; and post-construction monitoring of nearshore hardbottom communities adjacent to the beach fill areas to evaluate potential long-term impacts of turbidity and sedimentation. A mitigation plan has been developed in coordination with Federal, State, and County agencies to fully compensate for unavoidable impacts to nearshore hardbottom habitat. The nearshore hardbottom epibenthic communities landward of the equilibrium toe of fill do not represent irreplaceable resources; and with proper placement of mitigative artificial reefs, suitable replacement habitat can be created for nearshore epibenthic species. The proposed project will be in compliance with this Executive Order.