MITIGATION PLAN

INDIAN RIVER COUNTY
SECTORS 1&2 BEACH RESTORATION PROJECT

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1.0 INTRODUCTION

Indian River County intends to mitigate for unavoidable impacts to nearshore hardbottom habitats occurring as a result of beach restoration by a kind for kind replacement of lost habitat with nearshore artificial reef structures. The goal of this mitigation plan is to replace habitat lost to direct project impacts at a 1:1 ratio with fully functioning mitigation habitat. Due to temporal lag associated with post-project mitigation reef construction and time to biological maturity, reef construction at an increased ratio will be required, in accordance with Specific Condition 6 of DEP permit No. 0166929-001-JC.

2.0 MITIGATION REQUIREMENTS

Based on analysis of direct and indirect impacts, the following level of impact to nearshore hardbottom habitat and associated fauna are anticipated. Based on nearshore reef mapping and calculations of the extent of the equilibrium toe of fill, the direct impact (burial) of nearshore reef habitat is estimated at 3.8 acres for the preferred design alternative of 574,400 cubic yards of beach fill (Applied Technology and Management 2001). It is estimated that 3.6 acres of the direct impact will be to high relief, worm rock dominated reef designated as Type 3 reef in the nearshore reef mapping effort (ATM 2000). The remaining 0.2 acres of direct reef impact will be to low relief, algae dominated reef designated as Type 2 reef.

Indirect impacts were estimated based on the results of transport modeling by ATM (2001) for Sectors 1 and 2. Indirect impacts include a reduction in biotic cover on nearshore hardbottom habitat adjacent to the limits of direct impact such as that documented through biological monitoring of the Fort Pierce Beach Restoration Project (Dial Cordy, 2000). Results of the ATM analysis predict no indirect impacts from the Sectors 1 and 2 Project. The actual level of indirect impact, if any, will be assessed through project monitoring, as outlined in the Biological Monitoring Plan.

2.1 SECTOR 1&2 PROPOSED MITIGATION

Direct impacts to reef habitats will be mitigated for by the creation of artificial reef habitat at a 1:1 ratio. Additional acreage will be constructed to address temporal lag associated with mitigation reef construction in the summer of 2003 and an conservative estimate of 4 years for the mitigation reefs to achieve an equilibrium community structure similar to nearby natural reefs. The total reef acreage constructed will be in accordance with Specific Condition 6 of DEP permit No. 0166929-001-JC. Mitigation reefs will be constructed in two different designs, to reflect the differences in the habitat structure of the two types of nearshore hardbottom habitat to be impacted. The proposed mitigation will be type for type, to reflect the ecological differences between the different reef types impacted. Thus, 0.2 acres of Low Complexity-Low Relief (LCLR) reef will be required to mitigate for the low relief Type 2 reef impact, and 3.6 acres of High Complexity-High Relief (HCHR) reef will be created to mitigate for the high relief Type 3 impact (see Section 3.1.2 for reef design). The proposed location for Sector 1&2 mitigation reefs is found in Figure 1 and design drawings for LCLR and HCHR types are found in Figures 2 and 3, respectively.

3.0 GENERAL DESIGN CONSIDERATIONS

3.1 ARTIFICIAL REEFS

Artificial reefs are often proposed for mitigating impacts to natural hardbottom habitats as a result of beach restoration (Lutz 1998). Mitigation reefs differ in several ways from traditional artificial reefs for fishing enhancement. Traditional artificial reefs are usually constructed offshore, are generally of high relief, are promoted as fishing destinations, and often utilize vessels or other non-natural substrate to offer divers an interesting alternative to natural reefs. In contrast, mitigation reefs should be designed to mimic the lost habitat as closely as possible in terms of relief and structural complexity. They should be placed in the same nearshore habitats as the impacted natural hardbottom, and consumptive use of the reefs should be discouraged.

Artificial reefs have been used successfully for many years to mitigate impacts in sheltered waters (Duffy, 1985) (Davis, 1985) or in relatively deep water offshore (Mostkoff, 1993). Reef deployments in shallow, open coastal areas present special challenges in the wave stability of materials and burial by sand movements in this very dynamic habitat. Palm Beach County has had considerable success with deploying shallow water artificial reefs as mitigation measures (D. Bates, personal comm.) and many features of this proposed design are drawn from the Palm Beach County experience. This proposed design reflects the limitations on design and placement imposed by navigation regulations, liability issues, construction limitations, and stability concerns.

3.1.1 Site Selection

The "Vero Cove" area offshore of South Beach Park in the City of Vero Beach has been selected as the general location for nearshore reef development (Figure 1). This area was selected based on a number of siting criteria including depth, shoreline proximity, proximity to natural reef habitat, and substrate characteristics.

A strict interpretation of “in-kind” mitigation would require that mitigation reefs be placed in the same very shallow depths as the reefs that were impacted. This policy is counterproductive for both engineering and biological reasons. Very shallow reefs (shallower than 12 feet) are often subject to episodic burial from continual sand movement, which limits their habitat value. Low profile reefs are especially vulnerable in this regard. Higher relief structures are more resistant to burial, but in shallow water are subjected to extreme wave forces that can scatter or strand materials and modify sediment movement. When a high relief reef structure is placed so shallow that it begins to “trip” incoming waves, it may be functioning as a breakwater, with the potential to interfere with littoral transport. Indian River County’s experience with the PEP erosion control reefs has made it clear that there would also be significant regulatory concern about interference with nesting sea turtle access to the beach and hatchling dispersal with any reef structure that extends to near the surface. Maintaining adequate clearance for vessel navigation and allowing for the limitations of barge and tug drafts is also difficult in shallow water. For the above reasons, no reef site will be selected that is in less than 12 feet of water and all reef structures will incorporate a minimum of 6 feet of navigational clearance at Mean Lower Low Water, in accordance with FDEP rule (17-312.807 F.A.C.). The experience of Palm Beach County clearly supports these criteria. In 1994, the County deployed a mitigation reef at R.G. Kreusler Memorial Park in a depth of 10 feet. The reef initially developed a substantial biological community, but was buried by sand in 1995 and the reef units remain below the sand substrate at this writing. Obviously, such a reef does not represent successful mitigation.

Consistent with the depth constraints outlined above, mitigation reefs should be located as near to the shoreline as possible. Candidate sites for mitigation reef deployment will have a depth of 12-15 feet located within 600 feet of the shoreline.

Mitigation reefs have often been required to be built in the immediate vicinity of the natural reefs impacted by construction activities. In areas were the habitat that was impacted was the only habitat in the area, this approach has merit. In the case of the Indian River County Sectors 1&2 project, where abundant habitat will remain outside the area of direct impact, building mitigation reefs close to impacted natural reefs has serious drawbacks. A guiding principle of artificial reef development has always been that reefs should not be deployed adjacent to productive reef habitats. From a fisheries standpoint, reefs placed in non-reef habitats are biologically more productive as they are trophically coupled with foraging habitats that are unexploited by other reef fishes (Bortone 1998). More importantly, the shifting of reef materials in storms may severely damage adjacent natural habitats. For this reason, the Florida Artificial Reef Development Plan prohibits material from being placed within 100 yards of “live bottom” areas, such as nearshore hardbottom (Myatt and Myatt, 1992). Following Hurricanes Andrew, Opal, and Erin, it was found that even massive materials in relatively deep water were moved or broken up by tremendous wave forces (Lin 1998), (Turpin 1998). The possibility that less massive materials in much shallower water could shift and damage adjacent natural habitats is clear. For the above reasons, sites selected for mitigation reef construction should have no significant areas of natural reef within 100 yards and no reefs should be placed directly seaward of any significant area of natural reef.

The most desirable areas for deployment of reefs are areas that have a thin veneer of sand over bedrock, which limits the extent that deployed materials will settle. Candidate areas will be surveyed with towed array seismic sonar equipment to evaluate sand layer thickness and ground-truthed by diver-operated jet probes. If the sand thickness of otherwise suitable areas is such that the expected settling would compromise the desired relief of the reef, geogrid materials may be used to provide a foundation for the materials. The use of geotextile filter cloth has proven satisfactory in the short term in Palm Beach County (D. Bates, personal communication), but its long-term durability as a component of nearshore artificial reefs remains in question. Additionally, the tight weave characteristic of such materials may interfere with gas exchange in the underlying sediment, causing anoxic conditions to develop. Geogrid materials, being rigid having much larger open spaces, would not share the shortcomings of geotextiles. However, geogrid materials will only be used if no suitable candidate sites with an acceptably thin veneer of sand can be identified.

A general area that appears to meet the site selection criteria has been identified in the "Vero Cove" area (approximately R-86 to R-96). This area is the only significant coastal segment in Indian River County without extensive emergent nearshore hardbottom present, and a fairly steep profile allows for reefs to be deployed in suitably deep water while still being close to shore. A potential ecological benefit of deploying reefs in this area is that mitigation reefs, deployed in a shore parallel configuration, would serve as a habitat corridor. Such a corridor would connect the extensive Round Island to Fort Pierce Inlet nearshore reef system to the south with the Riomar to Sebastian Inlet nearshore reef system to the north. Such habitat corridors are a cornerstone of terrestrial conservation biology, and have begun to attract some attention in the marine environment as well. A secondary potential use of mitigation reefs is as recreational resources. If the proposed mitigation reefs can be located near the South County Park in the Vero Cove area, significant recreational use by snorkelers could be expected.

It is important to note that several transcontinental fiber optic cables are present in the Vero Cove area. They originate onshore (from a location in the vicinity of South Beach Park) and extend out across the area in a general east-west direction. The exact locations and orientations of these cables are unknown. At this writing, it is understood that an additional, new cable landing is proposed for this same area. Before construction of the artificial reef, the cables will be located and a 400-foot avoidance buffer zone will be established around them to avoid damage to the cables by vessels, cable/anchor drags, or reef materials.

3.1.2 Reef Design

Two types of mitigation reefs will be constructed; High Relief, High Complexity (HRHC) reefs and Low Relief, Low Complexity (LRLC) reefs. The HRHC reefs are intended to mitigate for impacts to nearshore hardbottom habitat Types 3 and 5 and the LRLC reefs are intended to mitigate for impacts to lower relief Type 2 habitat. A full description of these habitat types and maps of their occurrence in the project area are found in the Engineering Design Report (Applied Technology and Management, Inc. 2000). The two reef types will be deployed in acreages proportional to direct impacts expected on each type of natural reef habitat in the final project design.

HRHC reefs will consist of limestone rock boulders from 0.75 to 1.5 ton each, having a minimum density of 140 pounds per cubic foot. The material will be deployed in shore-parallel strips 50-100 feet wide to mimic the orientation of typical natural nearshore reefs. This reef design will have a vertical relief of 3-6 feet and boulders will be partially stacked to provide the maximum structural complexity and to provide refugia for cryptic and reclusive species. As interstitial sand patches associated with reef habitat are thought to be important in the ecological function of the reef habitat, the reef footprint will contain approximately 20% open sand surface. Temporary buoys delineating the deployment strip will mark areas for deployment. Corner buoys for the sites shall be placed using DGPS with sub-meter accuracy. Materials will be placed by a contractor experienced in precision deployment of reef material.

If deemed necessary to prevent excessive settling of the reef material, the use of geogrid materials will be considered to support the reef materials. If used, the geogrid will be laid flat and secured to the substrate before material placement. There shall be no more than one foot of geogrid exposed along the perimeter of the reef. Natural limestone provides an ideal substrate for the establishment of a fouling community, and if extensive colonization by the sabellariid worm *Phragmatopoma lapidosa* occurs, the surface area and complexity of the reef may be substantially enhanced. An additional advantage of limestone rock boulders is aesthetic. Once colonized by the fouling community, the reef is almost indistinguishable from a natural reef, enhancing its value as a recreational resource. HDHC reefs are intended to provide persistent habitat with higher complexity and habitat diversity than typical natural nearshore hardbottom reefs.

LRLC reefs will have a vertical relief of 1-2 feet and will be placed inshore of, and shallower than, HRHC reefs. It is recognized that the LRLC reefs may be periodically buried by shifting sands, like the low relief natural reefs they are intended to mimic. This does limit their habitat value to some extent, but it has been suggested (albeit without much empirical evidence) that this sort of ephemeral, low relief habitat may be particularly important in supporting the recruitment and post settlement survival of juvenile fishes. It is for this reason, and in an effort to achieve “in-kind” mitigation, that LRLC reefs are included in the mitigation design. Limestone boulders as described above, but with no stacking and placed in sites were they may be expected to partially settle in the substrate, should provide LRLC habitat. To provide interstitial sand habitat, approximately 20% of the LRLC reef footprint shall be open sand. All materials will be lowered individually from a backhoe on the barge to insure that they are placed in a stable configuration. Deployment sites will be delineated as outlined above for HRHC reefs.

Due to project scheduling and the necessity for calm conditions for reef deployment, construction of mitigation reefs will take place in the summer following the initial construction of the Sectors 1&2 project. The cost of deploying reefs of the above design is estimated at $150,000 to $200,000 per acre.

3.1.3 Reef Monitoring

The monitoring program for the mitigation reefs will consist of both physical and biological components. Physical monitoring will assess the degree of settling of the reef materials, and biological monitoring will assess populations of algae, invertebrates, and fishes, as compared with concurrent control sampling of natural nearshore hardbottom reefs. Monitoring will be conducted annually in the summer months. In order to supplement quantitative monitoring efforts and provide a permanent record of reef conditions and biota, each sampling effort will include a video transect swim covering the entire area of the mitigation reefs. Results of both physical and biological monitoring will be used to assess the success of the mitigation reefs in replacing the lost habitat.

The degree of settling and/or sand covering will be assessed by measuring the relief at each of the permanent quadrat stations established as outlined below. Measurements will be taken with a weighted flexible tape from a point one meter shoreward of the quadrat benchmark to the surface of the water and from the top of the reef structure at the benchmark to the surface of the water, with the difference being the relief. The mean of five such measurements will be used to assess the degree of settling and/or sand covering of the materials. Changes in relief at the control reef quadrat benchmarks will be assessed by the same method.

Five randomly selected locations on each type of mitigation reef will be chosen and benchmarked for permanent photoquadrat stations to assess sessile invertebrate and algae abundance. Randomly selected stations on high and low relief natural hardbottom reefs will also be established to serve as controls. Locations for ½ square meter photoquadrats will be established by driving two steel pins into the reef that will precisely locate the quadrat frame. The sites will be benchmarked using a DGPS system with sub-meter accuracy. Invertebrate and algal abundance will be evaluated from digital photography of each quadrat. Species will be identified to the lowest practical taxon and ranked in order of abundance. Superimposing a grid over the digital image and counting bare and colonized grid squares, or use of a random-dot technique, will assess overall percent cover (Bohnsack 1979). Criteria for success of the mitigation reef will be a total percent cover of algae and invertebrates not more than 25% less than that of the control reefs of corresponding relief type. The criteria for success of the mitigation reefs in establishing a similar fouling community structure will be a finding of no significant difference in the rank abundance orders of species between mitigation and control reefs of each type. Statistical comparisons between mitigation and control reefs will be made using the Wilcoxon Rank-Sum (Zar 1984) or similar nonparametric test at $p=0.05$.

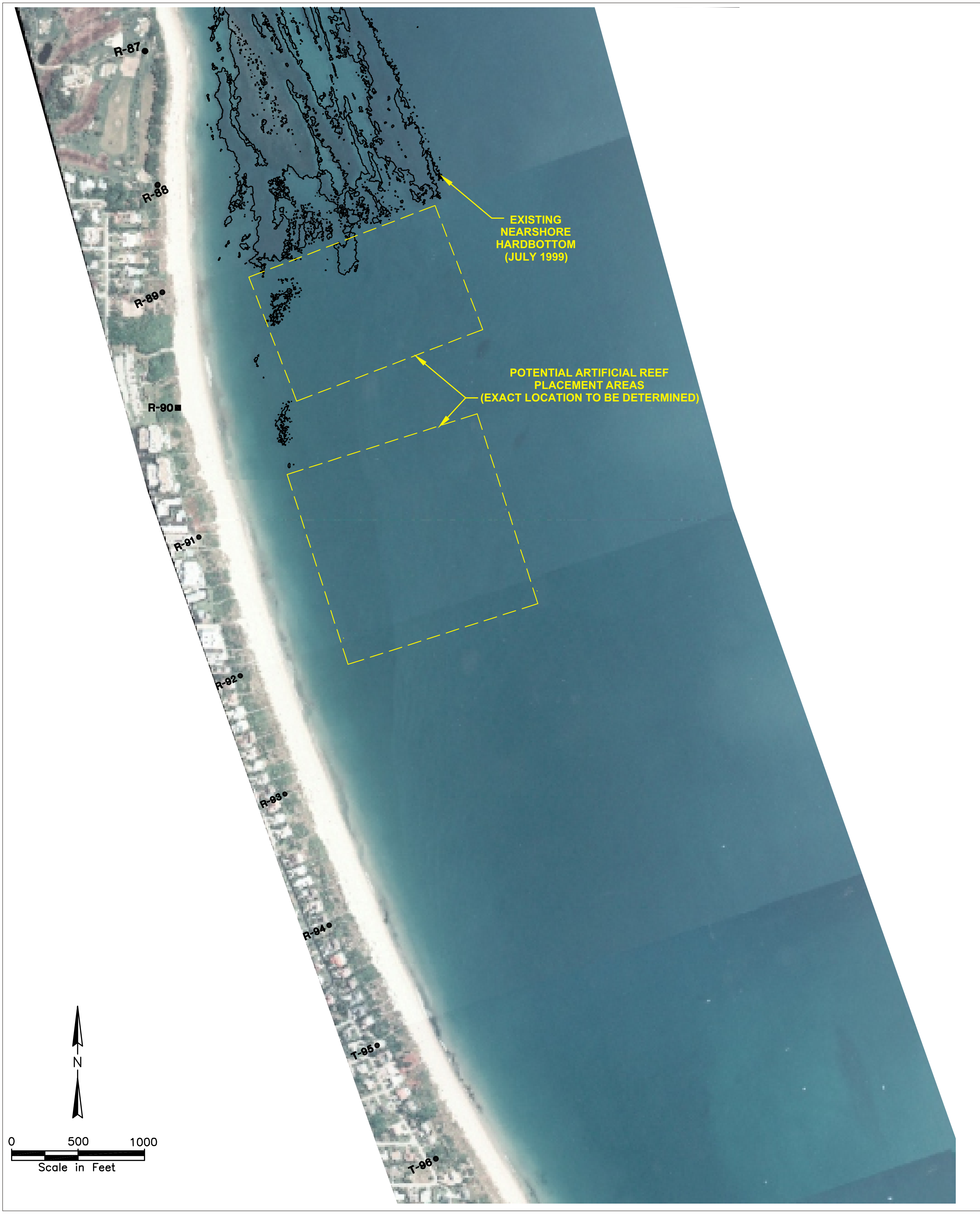
Fish population evaluations will be based on visual censuses conducted separately on HRHC and LRLC mitigation reefs and high and low relief control reefs. The point-count method (Bohnsack and Bannerot 1986) will be used for fish assessment. This method has the advantage of gathering quantitative data in a relatively short time in a very repeatable pattern that is relatively insensitive to differences in habitat structure. Each census will have a duration of 5 minutes and a radius (the distance from the stationary observer) of 10 feet. Ten censuses will be collected on each of the four reef types. Data from these types of censuses is rarely normally distributed, so the Wilcoxon Rank-Sum or a similar nonparametric test will be used for significance testing. The criteria for mitigation reef success will be a finding of no significant difference at $p=0.05$ between reef type pairs (HRHC vs. high relief control and LRLC vs. low relief control).

Results of all mitigation reef monitoring efforts will be summarized in an annual report to be completed by December 31 of each year the monitoring program is in place. Copies of the report will be supplied to the Florida Department of Environmental Protection and the U.S. Army Corps of Engineers for distribution to interested parties.

At the request of the Florida Fish and Wildlife Conservation Commission (FWCC), mitigation reef monitoring will include the following protocol to assess the degree to which sea turtles, particularly juvenile green turtles, use the mitigation reefs. At each reef monitoring event, the vessel will anchor in the center of the mitigation reef array. For a period of 30 minutes, two observers, positioned in a tower or otherwise at the highest point on the vessel, shall search the 360 degree area around the boat and count all surfacings of marine turtles in the vicinity and identify the species and life history stage. These data shall be graphically compared with both previous results for the mitigation reef and with concurrent sampling at the mitigation reef monitoring control reef areas.

3.1.4 Mitigation Reef Maintenance

The proposed mitigation reefs will be periodically inspected (at least annually) over the life of the beach fill project. If inspection reveals that the acreage or typical relief of the reef has been significantly reduced by subsidence, scour or sand accretion, additional materials will be added as necessary to restore the reef to the as-built design.



Artificial Reef Sectors 1 & 2.CDR 10/11/02

Figure 1

Artificial Reef
Site Location
Indian River County Sectors 1 & 2 Mitigation Plan

ATM
APPLIED TECHNOLOGY & MANAGEMENT, INC.

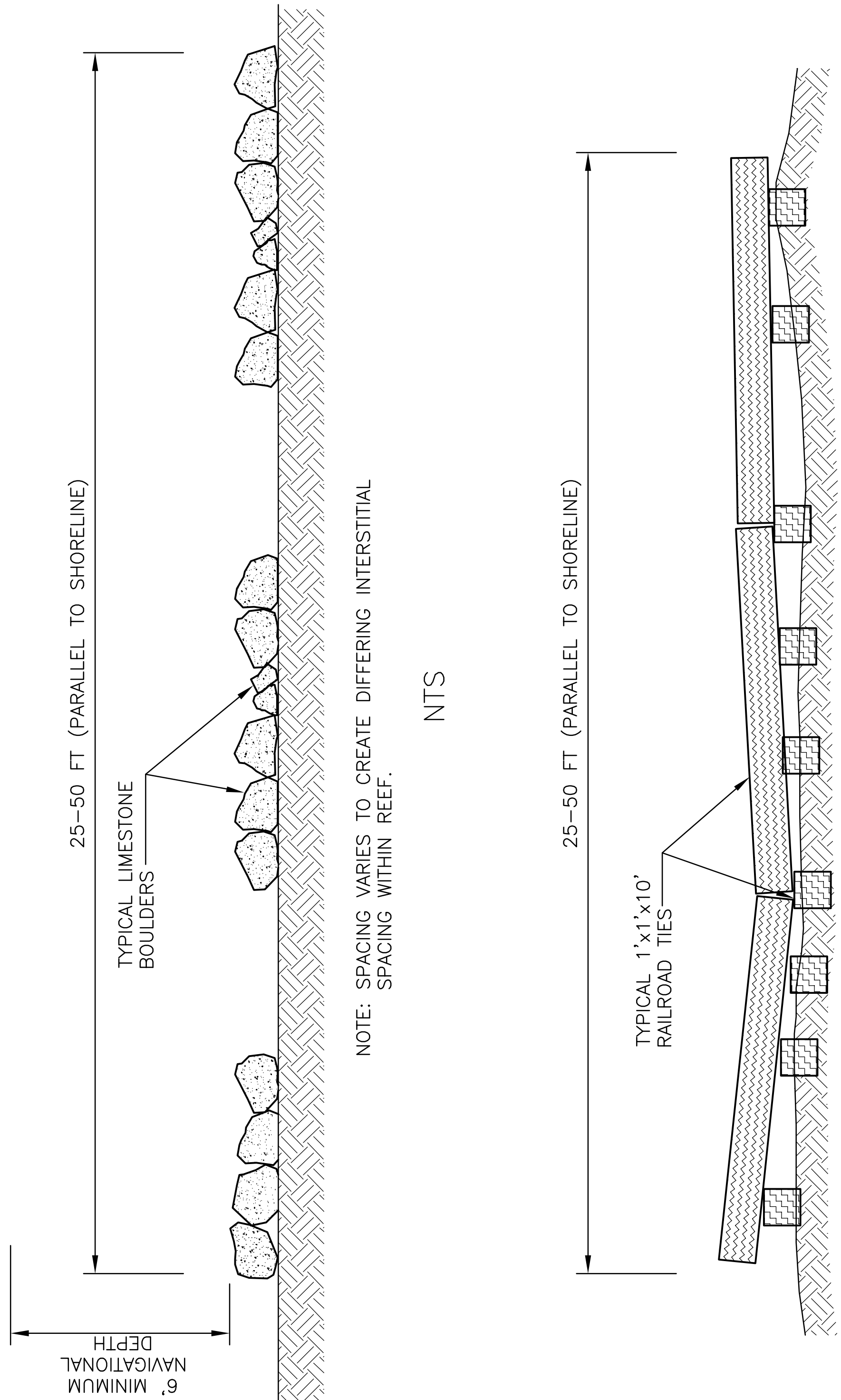


Figure 2
Typical LRLC Artificial Reef Cross–Section
Indian River County
Sectors 1 & 2 Mitigation Plan

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99–219 REEF DETAILS.dwg LRLC 10/11/2002

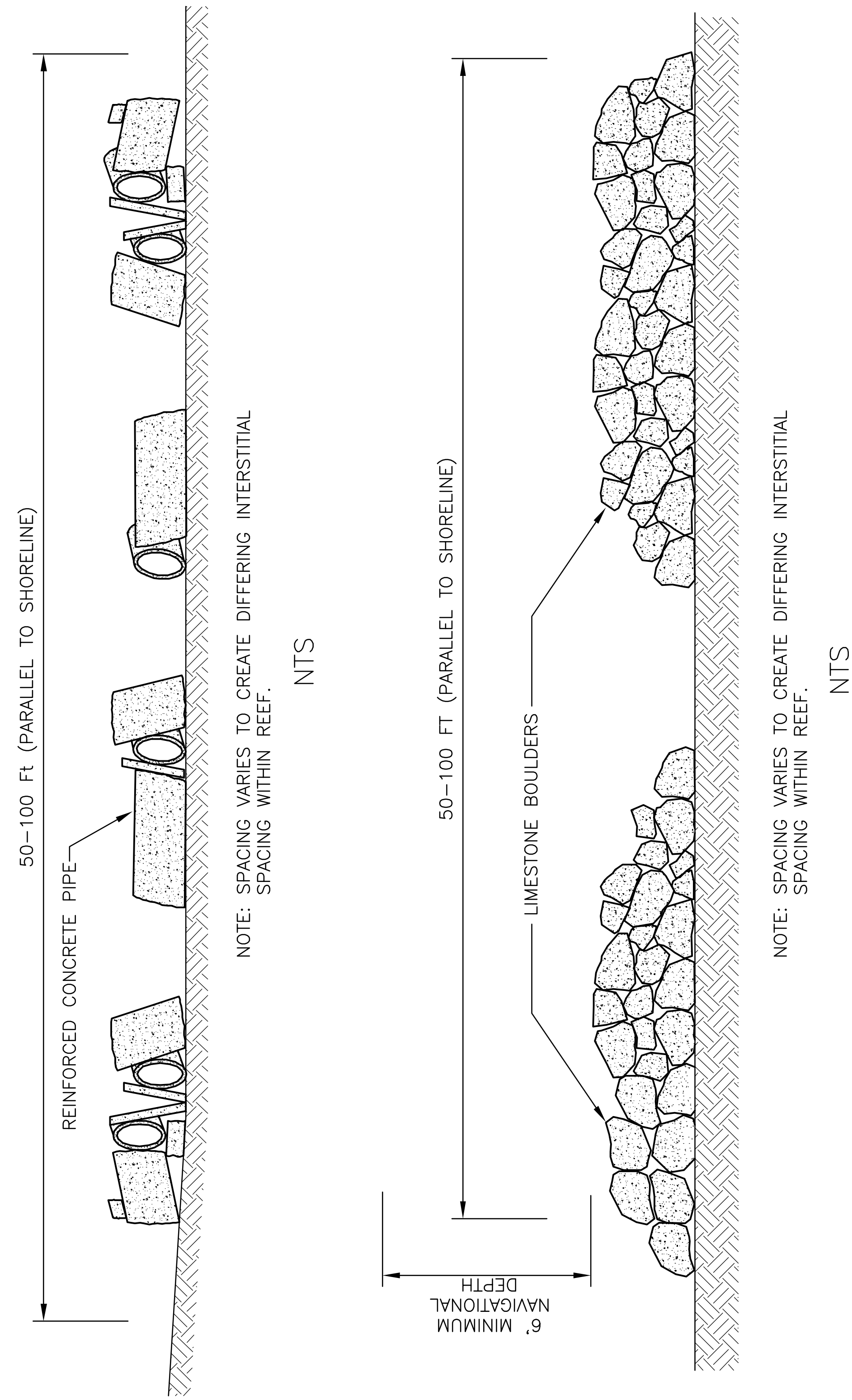

Figure 3
Typical HRHC Artificial Reef Cross–Section
Indian River County
Sectors 1 & 2 Mitigation Plan

APPLIED TECHNOLOGY & MANAGEMENT, INC

99–219 REEF DETAILS.dwg HRHC 10/11/2002

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